Shielding Requirements for a Halcyon Linac in a High-Throughput Clinic

Robert Kaderka[1], Kristen McConnell[1], Daniel Scanderbeg[1], Ryan Manger[1]

[1]UC San Diego Health

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RETHINKING MEDICAL PHYSICS

INTRODUCTION

Halcyon™ is a new linac differing from the more common c-arm design. Changes from the c-arm design can have an effect on shielding requirements as seen with tomotherapy units.

Halcyon™ offers a 6X flattening filter-free beam. It was designed to deliver high dose rate with streamlined workflows to enable high-throughput. NCRP151 [1] assumes a workload of 40 patients per day. In our experience, the efficient delivery enables up to 80 patients treated per day, increasing needs for primary and secondary barrier. To reduce room shielding, the linac is equipped with a beam stopper.

The purpose of this study is to assess the shielding requirements for the Halcyon linac, taking into account the beam stopper and the high-throughput.

AIM

- Assess primary and secondary barrier requirements for a Halcyon™ vault
- Evaluate effect of increased workload on shielding requirements

METHOD

NCRP151 [1] was used to calculate primary and secondary barriers with geometric parameters, use and occupancy factors as well as dose estimates to determine workload.

We datamined treatment records for 2019 to determine primary and leakage workload. The secondary barrier for linac leakage was assumed sufficient for the scatter component. The beam stopper was verified in earlier studies to reduce primary barrier needs by 1000 [2].

RESULTS

- Up to 80 patients per day
- Primary workload assumes 3 Gy/patient
- Primary workload 1200 Gy/week
- Beam stopper reduces primary barrier requirements by 1000
- 20,339,982 monitor units delivered in 2019
  - Conservative average of 4000 Sv/week for leakage workload
- Primary barriers of 2.43, 1.73 and 0.60 tenth-value layers (TVLs)
- Secondary barriers for same walls 3.55, 2.86 and 1.73 TVLs
- Other secondary barriers 2.39-3.65 TVLs
- Secondary barriers are sufficient to shield primary beam as per NCRP's two-source rule

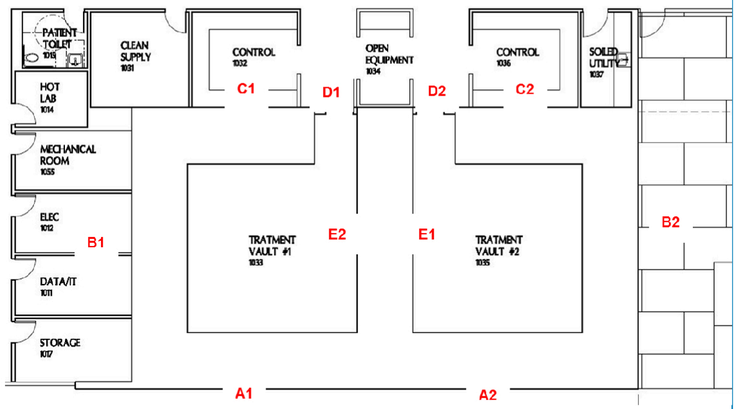

Diagram of Halcyon vault #1 and adjacent rooms and barriers

Diagram	Description	Type	P (mSv/wk)	d (m)	W (Gy/wk)	U	T	B_{pri}	TVL
B1	Right primary	Public	0.02	7.47	1200	0.25	1	3.72E-3	2.43
E1	Left primary	Control	0.1	7.47	1200	0.25	1	1.86E-2	1.73
F1	Roof primary	Control	0.1	6.86	1200	0.25	0.0625	2.51E-1	0.60

Diagram	Description	Type	P (mSv/wk)	d_L (m)	W_L (Sv/wk)	U	T	B_L	TVL
B1	Right secondary	Public	0.02	6.7	4000	1	1	2.24E-4	3.65
C1	Control area	Control	0.1	6.4	4000	1	1	1.02E-3	2.99
D1	Door	Control	0.1	7.3	4000	1	0.5	2.66E-3	2.57
E1	Left secondary	Control	0.1	6.7	4000	1	1	1.40E-3	2.86
A1	Rear wall secondary	Public	0.02	7.16	4000	1	0.0625	4.10E-3	2.39
G1	Roof secondary	Public	0.02	3.14	4000	1	0.0625	7.89E-4	3.10

Overview of shielding parameters with P being the design goal, d/d_L the distance, W/W_L the workload, U the Use factor, T the occupancy factor and TVL the number of tenth-value layers needed for adequate shielding.

CONCLUSIONS

The dominant contributor to shielding requirements for Halcyon™ is the leakage component. Due to the beam-stopper, the primary barrier requirements are more than one TVL lower than secondary barriers.

Therefore, following NCRP's two source rule, the secondary barriers are sufficient to shield the primary component as well.

We found that for the dimensions of our vault, even with a high assumption of 80 patients per day, a maximum of 4 TVLs are required for shielding.

This substantially reduces construction costs for clinics looking to implement a Halcyon™ or the upcoming Halcyon™-based Ethos™ system.

REFERENCES

[1] **NCRP Report No. 151,** Structural Shielding Design and Evaluation for Megavoltage X- and Gamma-Ray Radiotherapy Facilities. 2005, *Bethesda, MD*

[2] **Caravani K. et al.** EP-1684 Radiation isocontour levels for shielding considerations of the Varian Halcyon linear accelerator. *ePoster, ESTRO 38, April 2018, Milan, Italy*

CONTACT INFORMATION

rkaderka@health.ucsd.edu