

QUESTION TO ERPAN MEMBERS: LIMITS TO INSTANTANEOUS DOSE RATE

ERPAN meeting - Paris

June 16th - 2016

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1 | **THE PROBLEM**

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1 | THE PROBLEM

THE SITUATION

Old Radiotherapy Linear Accelerators (LINAC) are being upgraded/substituted, in particular looking to perform SBRT, which demands higher doses per session in smaller fields.

New configurations:

- Higher Dose Rates (2x)
- Removable Flattening Filter -> Higher Dose Rates (2x-4x)

Same treatment rooms & shielding

1 | THE PROBLEM

THE SITUATION

Dose rate variation: 600 UM/min -> 2400 UM/min

The monitor chamber reads 100 MU when an absorbed dose of 1 Gy (100 rad) is delivered to a point at a given depth in the phantom with the surface of the phantom positioned so that the specified point is at the isocentre of the machine and the field size is 10 cm × 10 cm at the isocentre

Dose rate variation: 6 Gy/min -> 24 Gy/min

DO THIS HAVE ANY IMPACT IN WORKERS OR PUBLIC DOSE?

1 | THE PROBLEM

DOSE LIMITS

- Typical dose limits are expressed YEARLY
- Typical calculation methods average 1 week limits for 2000 yearly hours and 50 weeks a year – For radiotherapy typical workload is 500-1000 Gy/sem

SPAIN	YEARLY DOSE	WEEKLY DOSE
PUBLIC	1 mSv	0,02 mSv
WORKER	50/20 mSv	1/0,4 mSv

SPAIN	YEARLY DOSE	WEEKLY DOSE
FREE	< 1 mSv	< 0,02 mSv
SUPERVISED	1 mSv < 6 mSv	0,02 < 0,12 mSv
CONTROLLED	6 mSv < 50 mSv	0,12 < 1 mSv

1 | **THE PROBLEM**

DEFINITIONS

- IDR – Instantaneous dose rate [Sv/h] (direct measure average during 20s through 60s).
- $TADR_t$ – Time Averaged Dose Rate (in time ‘t’) [Sv] (defined, for example in NCRP-151. Typical usage 1 one hour).

* IDR is the instantaneous dose-rate, averaged over 1 min.

† TADR is the time-averaged dose-rate, estimated over 8 h taking into account use and workload for the typical worst day case scenario (an occupancy factor of one is assumed).

‡ TADR2000 is the time-averaged dose-rate estimated over 2000 hours taking into account occupancy in addition to use and workload.

- “in any hour” TADR – Realistic calculation of dose given the “worst” possible combination of treatments within one hour

1 | THE PROBLEM

DOSE LIMITS

- US-NRC: Pulic (NRC – CFT 02.1301 – Subpart D)
“in any hour” $TADR < 20 \mu\text{Sv [h]}$
- UK (IRR99 & ACoP 249 -Aproved Code of Practice-)
 - $TADR_{h(8 \text{ hours})} < 0,5 \mu\text{Sv [public]}$
 - $TADR_{h(8 \text{ hours})} < 7,5 \mu\text{Sv [workers]}$
 - controlled zones of IDR below $7,5 \mu\text{Sv/h}$

2 | **THE QUESTION**

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2 | THE QUESTION

[...] We would really appreciate to have your insights on this topic:

- Are there IDR and/or $TADR_h$ limits in your legislation?
 - If YES, which are they, and what's the rationale behind the numbers used?
 - If NO, are IDR and/or $TADR_h$ considered in the licensing process somehow?

And of course, we'd appreciate any additional discussion on this topic.

3 | **THE ANSWERS**

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3 | NICOLAS STRITT (SWITZERLAND)

In Switzerland, bunkers in radiotherapy facilities must be shielded such that the weekly ambient dose must not exceed 0.02 mSv in adjacent spaces outside controlled areas and 0.1 mSv in adjacent spaces within controlled areas. [...]. IDR and TADR are not part of the radiation protection concept in Swiss legislation.

[...] Since FFF treatments provide an increased dose rate compared to conventional FF treatments it would be theoretically feasible to treat more patients. This in turn would result in an increased workload and thus to increased shielding requirements.

In order to prove or refute this assumption, the Radiation Protection Division of the Federal Office of Public Health in collaboration with the Swiss Society of Radiobiology and Medical Physics and with the manufacturers Elekta and Varian launched a survey in Swiss radiotherapy centers to assess the actual radio-oncological practice. It has been shown (data not yet published) that the indications for FFF treatments are limited and that the time requirement for planning and performing FFF treatments are much more higher than for FF treatments. This leads to the observation that the workload for FFF treatments is generally lower than for FF treatments.

3 | HELENA JANZEKOVIC (SLOVENIA)

[...].

In the legislation:

- maximum instantaneous dose rate is used as well as
- averaged dose rate using average over 8 hours.

The quantities are used in definition of controlled areas and supervised areas, i.e. in the licensing documentation these values shall be used.

E.g. definition of the **controlled area**:

- annual effective dose might be above 6 mSv,
- annual eq. dose for the lens of the eye might be above 45 mSv etc...
- **averaged dose rate over 8 hours might be equal or larger than 3 micro Sv/h etc... [TADR_h]**
- **maximum instantaneous dose rate might be equal or larger than 60 micro Sv/h etc. [IDR]**

While ratio for some of the quantities is well understood, i.e. approx 1/3 of the dose limit, we can discuss the selection of the 60 micro Sv/h. There are some practices where we need such values. E.g. for industrial radiography on site a controlled area could be very difficult to be defined without a maximum dose rate in the definition of the controlled area. So such approach is actually necessary [...]

3 | STEPHEN FENNELL (IRELAND)

In our legislation (S.I. No. 125 of 2000) which enacts the 1996 BSS, Article 9 (5) states that “*The undertaking shall, where appropriate, use dose constraints in restricting exposure to ionising radiation .*” There are no values set for dose limits in the legislation but we use **annual dose constraints of 0.3 mSv/yr and 1 mSv/year** for public/workers that have to be used when designing a new facility (Section 2.4 of our Code of Practice on the design of diagnostic medical facilities where ionising radiation is used provides further detail :

[https://www.epa.ie/pubs/advice/radiation/RPII Code Design Medical Facilities 09.pdf](https://www.epa.ie/pubs/advice/radiation/RPII_Code_Design_Medical_Facilities_09.pdf))

For the design of **new radiotherapy facilities** we have developed a guidance note on how dose constraints should be used – this includes guidance on how IDR dose constraints should be used.

[https://www.epa.ie/pubs/advice/radiation/RPII Dose constraints in radiotherapy 2006.pdf](https://www.epa.ie/pubs/advice/radiation/RPII_Dose_constraints_in_radiotherapy_2006.pdf))

3 | STEPHEN FENNELL (IRELAND) – 2 –

However in general for **areas** that are occupied by **exposed workers**, or to which they have access, the IDR should be restricted to ensure that the annual dose constraint of 1 mSv per year is met, **with an upper limit set at 20 μ Sv/hr**. If the IDR is above this general value access to the area may need to be restricted or prohibited.

For areas with uncontrollable access, in which members of the **public** may be present, the IDR should be restricted to ensure that the annual dose constraint of 0.3 mSv per year is met, **with an upper limit set at 7.5 μ Sv/hr**

with the support of
National Radiological Protection Board
Health and Safety Executive
The Health Departments
The Environment Agencies



0 | CONCLUSIONS

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0 | STEPHEN FENNELL (IRELAND)

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Hope this helps

0 | STEPHEN FENNELL (IRELAND) – 2 –

Medical and Dental Guidance Notes

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Table 1.2 Guideline dose rates ($\mu\text{Sv h}^{-1}$) used to designate areas

	Controlled areas	Supervised areas	Unsupervised public areas
IDR	>2000	>7.5	<7.5
TADR	>7.5	>2.5	<0.5
TADR2000	> 3 (6mSv/yr)	>0.5 (1mSv/yr)	<0.15* (300 $\mu\text{Sv/yr}$)

* 0.15 $\mu\text{Sv h}^{-1}$ is 3/10 of 0.5 $\mu\text{Sv h}^{-1}$ or 300 $\mu\text{Sv year}^{-1}$ – this is an appropriate dose constraint for an office worker, assuming an occupancy of 2000 h year⁻¹.

Institute of Physics and Engineering in Medicine

with the support of
National Radiological Protection Board
Health and Safety Executive
The Health Departments
The Environment Agencies



0 | CAMILIA LARSSON (SWEDEN)

I have passed your question regarding dose rate restrictions or limits in radiotherapy on to a colleague of mine, Mauricio Alvarez.

0 | CAMILIA LARSSON (SWEDEN)

What is Stereotactic Body Radiation Therapy (SBRT)?

Stereotactic Body **Radiation Therapy** (SBRT) is a treatment procedure similar to central nervous system (CNS) [stereotactic radiosurgery](#), except that it deals with tumors outside of the CNS.

A stereotactic **radiation treatment** for the body means that a specially designed coordinate-system is used for the exact localization of the tumors in the body ([Figure 1](#)) in order to treat it with limited but highly precise treatment fields. **SBRT involves the delivery of a single high dose radiation treatment or a few fractionated radiation treatments (usually up to 5 treatments)**. A high potent biological dose of radiation is delivered to the tumor, improving the cure rates for the tumor, in a manner previously not achievable by standard conventional radiation therapy ([Figure 2](#)).

Similarly, because this specialized form of radiation involves the use of multiple radiation beam angles, expert Radiation Oncologists specialized in this technique are able to safely deliver high doses of radiation, with very sharp dose gradient outside the tumor and into the surrounding normal tissue ([Figure 3](#)).