Package 6

INSTRUCTION SHEET, DATA SHEET AND RESULTS REPORTING FORM FOR THE STEP 4 AUDIT

This package contains the following forms:

Instruction Sheet for TLD postal dose quality audit for megavoltage X ray beams shaped with a multileaf collimator (MLC);

Data Sheet for TLD postal dose quality audit for megavoltage X ray beams shaped with a multileaf collimator (MLC);

Certificate for the step 4 audit.

[DAN LETTERHEAD]

TLD POSTAL DOSE QUALITY AUDIT FOR MEGAVOLTAGE X RAY BEAMS

INSTRUCTION SHEET

Step 4: TLD quality audits for photon beams shaped with a multileaf collimator (MLC)

Please irradiate the TLDs during the period:

_____

_____

and return them to the address given in the covering letter. Timely response will improve the accuracy of your results. Should the TLDs arrive late, please irradiate them as soon as possible but no later than one month after their receipt. If you are unable to carry out the irradiation, please **RETURN** the TLD set, marking it '**UNEXPOSED**'.

GENERAL INSTRUCTIONS

1. Irradiate the TLDs as instructed in the Technical Instruction (Sections B and C) as if they were inside a patient. Ensure that the treatment unit is functioning properly. Identify each TLD with irradiation conditions used (use labels or similar).
2. It is recommended to irradiate all TLDs in the same session. If this is not possible, please provide the irradiation dates for each TLD.
3. After the TLD irradiation, measure the beam output in the reference conditions (Section D).
4. Fill in the Data Sheet. An evaluation of the TLD results is only possible if these forms are complete.
5. Return TLDs and the Data Sheet to the [DAN] within ONE WEEK after the irradiation.

SPECIAL NOTE:

Please protect the TLD capsules from accidental irradiation, heat (e.g. sunshine) and excessive humidity during storage. Do not store TLDs in a place where accidental exposure to radiation cannot be excluded.

CONFIDENTIALITY

The results of this TLD audit will be kept confidential by [DAN] and will not be disseminated without the written permission of the participating radiotherapy centre.

The TLD equipment sent to you represents a significant investment in cost, time and effort to the [DAN]. Failure to return the TLDs may be reported to your local authorities.

TECHNICAL INSTRUCTION

A. Aim of the MLC TLD audit

The purpose of the TLD audit is to check dosimetric data related to a radiotherapy treatment unit equipped with an MLC as used for patient treatments. The extension of the [DAN] programme to MLC fields, including irregular fields with and without wedges takes into account the increasing use of these tools in conformal photon beam radiotherapy. An independent experimental verification of the dose calculated by treatment planning systems is an essential step in the improvement of quality assurance in radiotherapy and therefore an important extension of the [DAN] programme.

The absorbed dose to water at 10 cm depth for a reference 10 cm × 10 cm field along with six other fields set with the MLC whose shapes and dimensions are defined below is checked using TLDs.

You are requested to calculate the number of monitor units required to irradiate the TLDs to the specified dose, according to the procedure used in your clinical practice for patients.

B. Preparation of the TLD holder, water phantom and therapy unit

1. Assemble the TLD holder, with the metal weight, as in Fig. 1.
2. Place the holder in a water tank on the treatment table. If needed, cut the holder legs (Fig. 1) to fit the holder into the tank.
3. Set your therapy unit for a vertical beam, with a 10 cm × 10 cm field size (Fig. 2).
4. Align the holder tube with the central axis of the beam (Fig. 2)
5. Adjust the water level by filling the water tank exactly to the level of the top of the holder (Fig. 2). This will place TLD at a depth of 10 cm.
6. Adjust the table height so that the water surface is at the correct distance to the source, according to the set-up selected (SSD or isocentric, see Fig. 2).
7. Insert the TLD capsule to be irradiated into the hole of the TLD holder. Insert, position and remove the capsule as illustrated in Fig. 3. Never pull the capsule's plug otherwise TLD may be opened under water. Place the capsule in the holder tube so that the centre of the capsule corresponds to the middle of the tube holder.

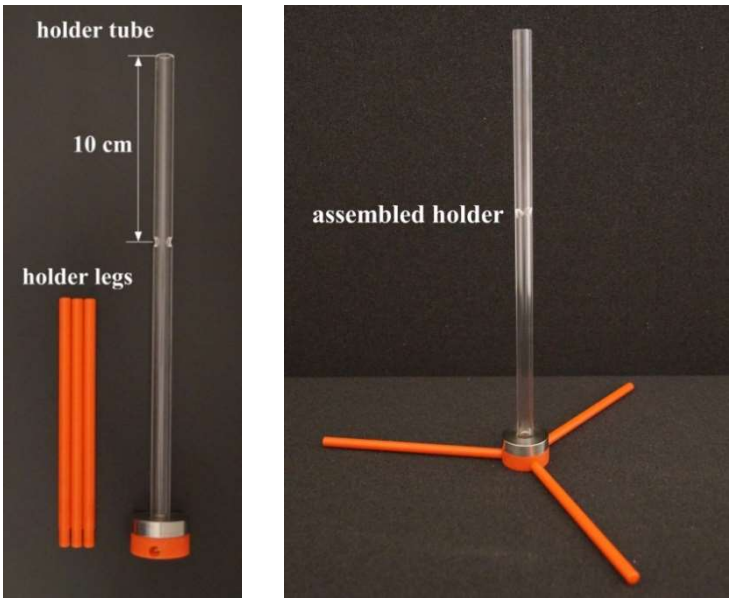

FIG. 1. Assembling of the IAEA standard holder for the TLD irradiations.

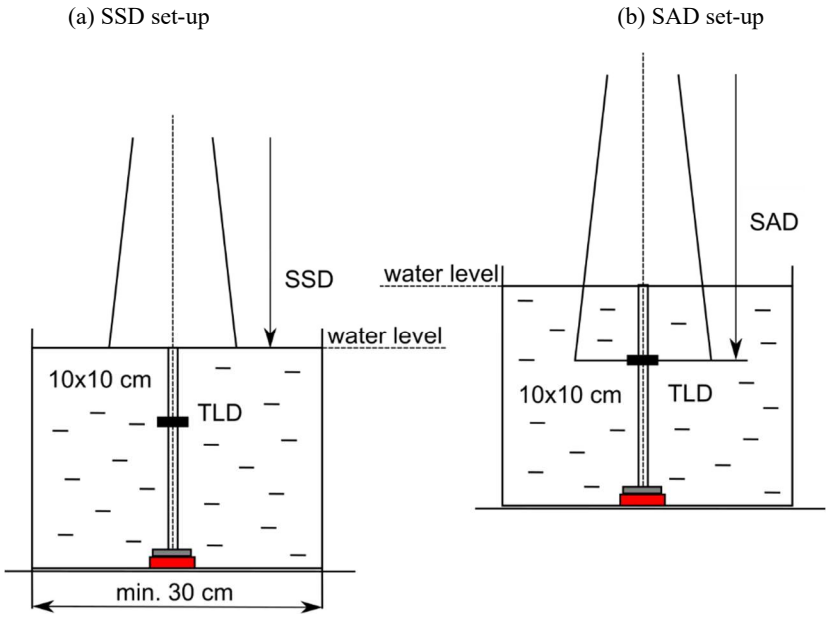

FIG. 2. Two alternative geometry set-ups for the TLD irradiation.

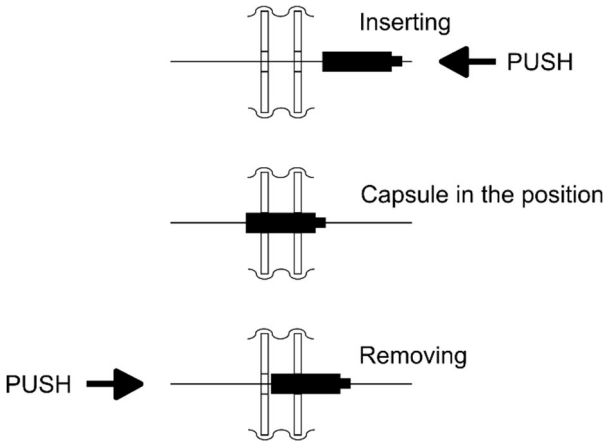

FIG. 3. Inserting, positioning and removing the TLD capsule.

C. Irradiation of TLD capsules

1. Calculate the number of monitor units (MU) to deliver a dose of 2 Gy to water at the centre of the TLD capsule (at 10 cm depth) for each field. This calculation must be made according to the method used in your daily practice for patient treatments. The list of fields is given in Table 1.
2. Before irradiation, recheck whether the alignment, field size, water level and the distance are correct (Fig. 2).
3. Irradiate the TLD capsule with the number of monitor units as calculated above.
4. Remove the capsule from the holder, wipe it dry and place a label with the appropriate field number.
5. Repeat steps 2 to 4 for each field indicated in Table 1.

TABLE 1. IRRADIATION CONDITIONS TO BE USED. THESE ARE A REFERENCE FIELD AND SIX DIFFERENT FIELDS WITH SHAPES AND DIMENSIONS DEFINED BY THE MLC

Field No.	Field	Depth in water	Irradiation distance	Field size (Maximum length and width)	Delivered dose	See figure
1	Beam output in reference conditions	10 cm	SAD or SSD	10 cm × 10 cm	2 Gy	4
2	Small square MLC field	10 cm	SAD or SSD	5 cm × 5 cm with MLC	2 Gy	5
3	'Circular' MLC field	10 cm	SAD or SSD	5.6 cm diameter with MLC	2 Gy	6
4	'Inverted Y' MLC field	10 cm	SAD or SSD	15 cm × 10 cm with MLC	2 Gy	7
5	'Irregular' MLC field	10 cm	SAD or SSD	10 cm × 7.5 cm with MLC	2 Gy	8
6	'Irregular' MLC field with wedge* filter	10 cm	SAD or SSD	10 cm × 7.5 cm with MLC	2 Gy	9
7	Small rectangular MLC field	10 cm	SAD or SSD	2 cm × 5 cm with MLC	2 Gy	10

(*) The wedge angle most commonly used in your clinical practice.

NOTE: *Each of the fields listed in Table 1 is represented graphically in Figs 4–10. The position of the leaves in these figures is only given for illustration. These positions depend on leaf width and other technical features of the MLC. MLC positions should be chosen to correspond as closely as possible to the setup procedures required as if being asked to treat a patient with these fields.*

For fields from 2 to 7, please provide the [DAN] with a printout copy of the MLC fields given by your Treatment Planning System. If this is not available, please provide a small sketch with the relevant indications of leaf positions and field sizes.

Field 1: Beam Output in Reference Conditions

For the beam output in the reference conditions adjust the field to a 10 cm × 10 cm, see Fig. 4. Adjust the distance from the source as used in your clinical practice (SAD or SSD), see Fig. 2. Deliver 2 Gy to a TLD placed at the 10 cm depth. Label the TLD as TLD #1.

At the end of the irradiation session with all MLC settings, repeat the irradiation in the reference conditions and deliver 2 Gy to another TLD. Label it as TLD #8.

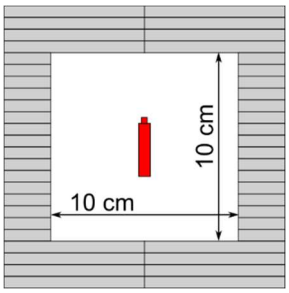

FIG. 4. Beam output in the reference conditions.

Field 2: Small square MLC field

Deliver 2 Gy to a TLD placed at 10 cm depth in the small square MLC shaped field (Fig. 5); field size 5 cm × 5 cm at the previously set distance from the source (see above). Label it as TLD #2.

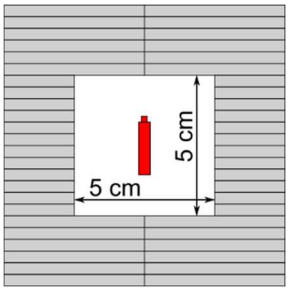

FIG. 5. Small MLC field.

Field 3: 'Circular' MLC field

Deliver 2 Gy to a TLD placed at 10 cm depth in the 'circular' MLC shaped field (Fig. 6); field size 5.6 cm diameter at the previously set distance from the source. Label it as TLD #3.

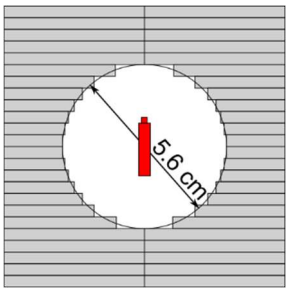

FIG. 6. 'Circular' MLC field.

Field 4: 'Inverted Y' MLC field

Deliver 2 Gy to a TLD placed at 10 cm depth in the 'inverted Y' MLC shaped field (Fig. 7); maximum field size 15 cm × 10 cm at the previously set distance from the source. Label it as TLD #4.

NOTE: The longitudinal axis of the TLD capsule must be parallel to the longest dimension of the field.

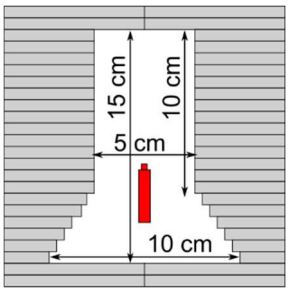

FIG. 7. 'Inverted Y' MLC field.

Field 5: 'Irregular' MLC field (open beam)

Deliver 2 Gy to a TLD placed at 10 cm depth in the 'irregular' MLC shaped field (Fig. 8); field size 10 cm × 7.5 cm at the previously set distance from the source. Label it as TLD #5.

NOTE: Figs 8a and 8b represent possible MLC orientations and not two irradiations. Ensure that the MLC leaves used for Field 5 are in the same direction as for Field 6.

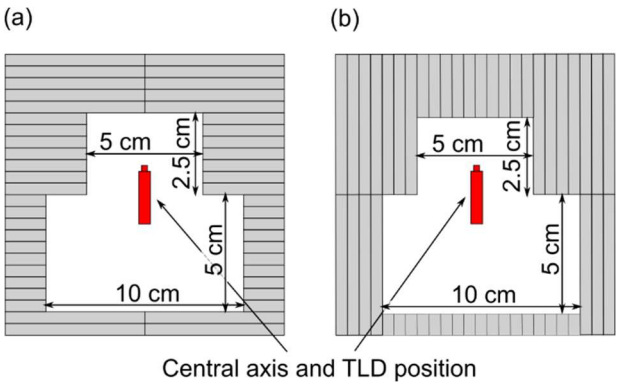

FIG. 8. 'Irregular' MLC field (The leaf orientation depends on the technical features of the MLC).

Field 6: 'Irregular' MLC field with a wedge filter

Deliver 2 Gy to a TLD placed at 10 cm depth in the 'irregular' MLC shaped field (Fig. 9); maximum field size 10 cm × 7.5 cm at the previously set distance from the source. Irradiate the TLD in two steps of 1 Gy each, with the wedge rotated 180° between the irradiations as shown in Fig. 9. Label it as TLD #6.

NOTE: The TLD capsule must be placed so that its axis is perpendicular to the slope of the wedge in order to obtain a homogeneous irradiation of the entire volume of TLD powder contained in the capsule. Figs 9a and 9b represent possible MLC orientations and not two irradiations.

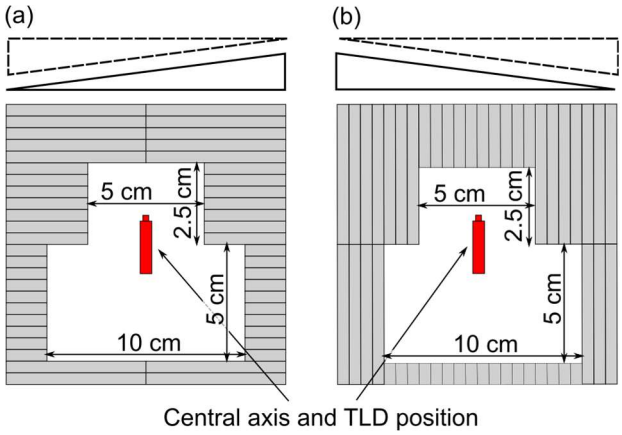

FIG. 9. 'Irregular' MLC field with wedge (The leaf and wedge orientation depend on the technical features of the linac).

Field 7: Small rectangular MLC field

Deliver 2 Gy to a TLD placed at 10 cm depth in the small rectangular MLC shaped field (Fig. 10); field size 2 cm × 5 cm at the previously set distance from the source. Label it as TLD #7.

NOTE: The TLD capsule must be placed so that its axis is perpendicular to the direction of leaf movements in order to obtain homogeneous irradiation of the entire volume of TLD powder contained in the capsule.

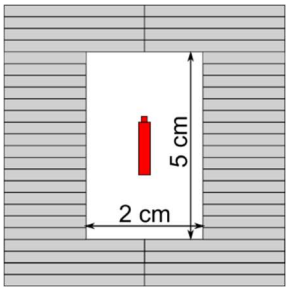

FIG. 10. Small rectangular MLC field.

D. Absorbed dose measurements with an ionization chamber

Determine experimentally the absorbed dose to water in the reference conditions for the radiation beam used for the TLD measurements above according to your usual dosimetry code of practice (dosimetry protocol) and complete the data sheet.

[DAN LETTERHEAD]

TLD POSTAL DOSE QUALITY AUDIT FOR X RAY BEAMS

DATA SHEET

Step 4: TLD quality audits for photon beams shaped with a multileaf collimator (MLC)

It is of great importance for the TLD evaluation that the infor3mation requested below be completed. Please complete Part II if additional absorbed dose to water determination was made by ionization chamber measurements.

Individuals responsible

Radiation oncologist .....
name *position*

Medical physicist: .....
name *position*

Name of institution .....
.....

Address .....
.....

Telephone number .....

Fax number .....:

E-mail .....

Form completed by

Name .....

Position ☐ Medical physicist ☐ Radiation oncologist ☐ Technician
Other: .....

On the day |__|__| |__|__| |__|__|__|__|
day month year

TLD irradiation performed by

Name .....

Position ☐ Medical physicist ☐ Radiation oncologist ☐ Technician
Other:

Previous participation in an external audit or inter-institution comparison for this beam

Has Step 1, TLD audit for photon beams in reference conditions been successfully completed before?

No ☐
Yes ☐ Date .....

Please also give information on participation in any other audit

FOR HOSPITAL STAFF (physicist, oncologist, technician)

A. Specifications of the treatment unit

The treatment unit used for this audit is of the type

.....

model *manufacturer* *serial number* *production year*

installed in the year .....

The manufacturer's stated beam energy is.....

The beam is ☐ with ☐ without the flattening filter and is commissioned as ☐ standard ☐ SRS ☐ SRT beam.

The beam quality is characterized by one of the following:

☐ D_{20}/D_{10} =..... (10 cm × 10 cm at SSD = 1 m)

☐ TPR $^{20}/_{10}$ = ... (10 cm × 10 cm at a constant source detector distance of ..... cm)

other ..... conditions: .....

MLC model:.....

Number of leaves per leaf bank: .....

Width of leaf projected at the isocentre: .....

B. Beam output used for patient treatment planning

Treatment Planning System used is: ..... Software version: .....

The reference absorbed dose to water per monitor unit which is used for treatment planning for patients in daily routine is: ..... Gy/MU.

It refers to a depth of ..... cm in water for a ..... cm × .....cm field size at:

SSD = ……cm		SAD = ……...cm
fixed source surface distance	**OR**	fixed source axis distance
SSD set-up		*Isocentric set-up*

C. Irradiation of the TLD capsules

(see Sections B and C of the Instruction Sheet)

The TLD capsules were irradiated on the following date :

|__|__| |__|__| |__|__|__|__|

day *month* *year*

The TLD capsules were irradiated at:

SSD = ……cm		SAD = ……...cm
fixed source surface distance	**OR**	fixed source to centre of the TLD distance
SSD set-up		*Isocentric set-up*

***NOTE**: For fields from #2 to 7, please provide the [DAN] with a printout copy of the MLC fields given by your Treatment Planning System. If this is not available, please provide a small sketch with the relevant indications of leaf positions and field sizes.*

C1. Beam output in the reference conditions

TLD #1 and #8 were irradiated using a …… cm × …..…. cm field, with an absorbed dose rate of …… Gy/MU at the 10 cm irradiation depth.

TLD # 1:
MU = ...
TPS Dose (Gy) = ...
Ion Chamber Dose (Gy) = ...

TLD # 8:
MU = ...
TPS Dose (Gy) = ...
Ion Chamber Dose (Gy) = ...

C2. Small square MLC field

TLD # 2 was irradiated using a …… cm × …..…. cm MLC field, with an absorbed dose rate of …… Gy/MU at the 10 cm irradiation depth.

TLD # 2:
MU = ...
TPS Dose (Gy) = ...
Ion Chamber Dose (Gy) = ...

C3. 'Circular' MLC field

TLD # 3 was irradiated using a 'circular' MLC field with an estimated diameter of …..…… cm, with an absorbed dose rate of …… Gy/MU at the 10 cm irradiation depth.

TLD # 3:
MU = ...
TPS Dose (Gy) = ...
Ion Chamber Dose (Gy) = ...

C4. 'Inverted Y' MLC field

TLD # 4 was irradiated using an 'inverted' Y MLC field of estimated maximum size …… cm × ..…. cm, with an absorbed dose rate of …… Gy/MU at the 10 cm irradiation depth.

TLD # 4:
MU = ...
TPS Dose (Gy) = ...
Ion Chamber Dose (Gy) = ...

C5. 'Irregular' MLC open field

TLD # 5 was irradiated using an "irregular" MLC field of the maximum size …… cm × ….. cm, with an absorbed dose rate of …… Gy/MU at the 10 cm irradiation depth.

TLD # 5:
MU = ...
TPS Dose (Gy) = ...
Ion Chamber Dose (Gy) = ...

C6. 'Irregular' MLC wedged field

TLD # 6 was irradiated using an "irregular" MLC field with wedge filter of maximum size …… cm × …..…. cm, with an absorbed dose rate of …… Gy/MU at the 10 cm irradiation depth. The wedge type was:

☐ dynamic/virtual ☐ internal (motorized) ☐ physical (manual)
with an angle of ……. and the wedge transmission factor used was……..

TLD # 6:
MU = ...
TPS Dose (Gy) = ...
Ion Chamber Dose (Gy) = ...

C7. Small rectangular MLC field

TLD # 7 was irradiated using a…… cm × ….…. cm MLC field, with an absorbed dose rate of …… Gy/MU at the 10 cm irradiation depth.

TLD # 7
MU = ...
TPS Dose (Gy) = ...
Ion Chamber Dose (Gy) = ...

ADDITIONAL REQUEST FOR MEDICAL PHYSICISTS

A. Determination of the absorbed dose to water by ionization chamber in the reference conditions

Measurements were performed by

.....

Name *position*

on the following date: |__|__| |__|__| |__|__|__|__|
day *month* *year*

The absorbed dose rate to water in this beam was determined by using a dosimeter system composed of an ionization chamber.....
manufacturer *model*

and an electrometer .....
manufacturer *model*

The Co-60 calibration factor of the dosimeter system (**ionization chamber TOGETHER with electrometer**) was:
..... R/scale unit (exposure calibration factor N_X)
or ..... Gy/scale unit (air kerma calibration factor N_K)
or ..... Gy/scale unit (absorbed dose to water calibration factor $N_{D,w}$).

If any other calibration factor is used please specify:
.....

The above stated calibration factor was determined by the following laboratory/manufacturer
.....on the following date .....
and refers to a temperature of ..... °C and a pressure [*units*] of .....[.....].

The absorbed dose to water in this beam was measured under the following conditions:
☐ water ☐ plastic – *please specify material* .....
field size: ..... cm × ..... cm
distance:
SSD = …… **OR** SAD = ……...
SSD set-up *Isocentric set-up*

The depth of ☐ the geometrical centre **or** ☐ the P_{eff} of the ionization chamber in phantom was ……. cm.

Please give your reading results:
average reading ..... [*scale units*]
measurement performed during ..... MU
temperature .....°C
pressure [*units*]..... [.....]
electrometer scale.....
electrometer voltage.....

The absorbed dose to water per MU in this beam was determined by the following code of practice (dosimetry protocol):
.....
.....
.....
.....
.....
.....

Please give a detailed explanation of your procedure to determine the dose at the position of the centre of the TLD capsule based on the measurement described above. Please provide all factors you have used:

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

The resulting dose rate in the reference conditions was: ..... Gy/MU.

STEP 4 AUDIT CERTIFICATE

[DAN letterhead]

RESTRICTED

[DAN] TLD POSTAL DOSE QUALITY AUDIT

Institution: *Institution name*
Address: *Institution address*

Country: *Country name*

TLD batch no: *xxx*
TLDs irradiated by: *Name*
Date of irradiation: *yyyy-mm-dd*
Evaluation: *yyyy-mm-dd*

STEP 4: RESULTS OF TLD MEASUREMENTS FOR HIGH-ENERGY X RAY BEAMS

Radiation unit	Beam	Field no.	Field size	TLD set #	User stated dose [Gy]	DAN (measured) dose [Gy]*	% deviation relative** to DAN dose	DAN dose / User stated dose
		1						
		2						
		3						
		4						
		5						
		6						
		7						
		8						

* The uncertainty in the TLD measurement of the dose is *x.x*% (1 standard deviation); this does not include the uncertainty intrinsic to the dosimetry protocol (see IAEA TRS-398).
** % deviation relative to DAN measured dose = 100 × (User stated dose - DAN measured dose)/DAN measured dose. A relative deviation with negative (positive) sign indicates that the user estimates lower (higher) dose than what is measured; a patient would therefore receive higher (lower) dose than what is intended by the factor given in the last column.
Agreement within ±*x*% between the user stated dose and the [DAN] measured dose is considered satisfactory.

Signature
……...
[TLD Officer] – [DAN]

Date:
yyyy-mm-dd

Signature
…….
Head – [DAN]

IMPORTANT NOTICE: This information is provided only as an independent verification of the hospital dosimetry practices. **IT DOES NOT CONSTITUTE A STATEMENT WITH REGARD TO THE QUALITY OF RADIOTHERAPY TREATMENTS.**