Package 3

INSTRUCTION SHEET, DATA SHEET AND RESULTS REPORTING FORM FOR THE STEP 2A AUDIT

This package contains the following forms:

Instruction Sheet for TLD postal dose quality audit for Co-60 and megavoltage X-ray beams in reference and non-reference conditions on-axis;

Data Sheet for TLD postal dose quality audit for Co-60 beams in reference and non-reference conditions on-axis;

Data Sheet for TLD postal dose quality audit megavoltage X-ray beams in reference and non-reference conditions on-axis;

Certificate for the step 2a audit.

[DAN LETTERHEAD]

TLD POSTAL DOSE QUALITY AUDIT FOR Co-60 AND MEGAVOLTAGE X-RAY BEAMS

INSTRUCTION SHEET

Step 2a: Reference and non-reference conditions on-axis

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

Eight TLD capsules for one beam energy for this audit are stored in the box: seven of them are to be irradiated, while the TLD with a white mark, ***must not be irradiated***; it is used to record environmental influences during transport and storage.

1. Irradiate the TLDs as instructed in the Technical Instruction (parts B-D). Ensure that the treatment unit is functioning properly and is the one that is being used clinically or is ready for clinical use.

NOTE: If more than one beam is being checked on a linac, it is recommended to complete all measurements of the audit for one energy before going on to the next energy, in order to decrease manipulation errors.

2. After the TLD irradiation, if possible, measure the dose delivered to the reference TLDs (part E) using local ionization chamber dosimetry procedures.
3. Fill in the Data Sheet.
4. Return the TLDs and the Data Sheet within ONE WEEK after the irradiation.

SPECIAL NOTE

After each irradiation, carefully replace the TLD in its original position in its storage box. Please protect the TLD capsules from accidental irradiation, heat (e.g. sunshine) and excessive humidity during storage.

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 INSTRUCTIONS FOR HOSPITAL STAFF
(physicists, oncologists, technicians)

A. Aim of the TLD audit

The purpose of this TLD audit is to check the dose delivered by the radiotherapy unit for cobalt-60 or megavoltage X-rays. It includes measurements on the central (collimator) axis, with and without wedges, at 10 cm depth in water, and at your usual source-to-surface (SSD) or source-to-axis (SAD) distance. The measured fields are listed below:

- Reference field: 10 cm × 10 cm;
- Symmetric open fields: 7 cm × 7 cm, 20 cm × 20 cm, 7 cm × 20 cm;
- Symmetric wedged fields: for the thickest wedge clinically used; field sizes: 10 cm × 10 cm, 7 cm × 20 cm.

The checks will be performed by irradiating TLD capsules in a water phantom (using a standard IAEA TLD holder) to a specified dose.

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

1. Assemble the TLD holder, with the lead weight, as in Fig.1.
2. Place the holder in a water tank on the treatment table (Fig. 2). If needed, cut the red holder legs (Fig. 1) to fit the holder into the tank. (*Note that if you have no access to a dosimetry water phantom you can still use a large container*).
3. Set your therapy unit for a vertical beam, with a 10 cm × 10 cm field size (Fig. 2).
4. Adjust the water level by filling the water tank **exactly** to the level of the top of the holder (Fig. 2).
5. Adjust the table height so that the water surface is at the standard distance to the source, according to the set-up selected (SSD or isocentric, see Fig. 2).

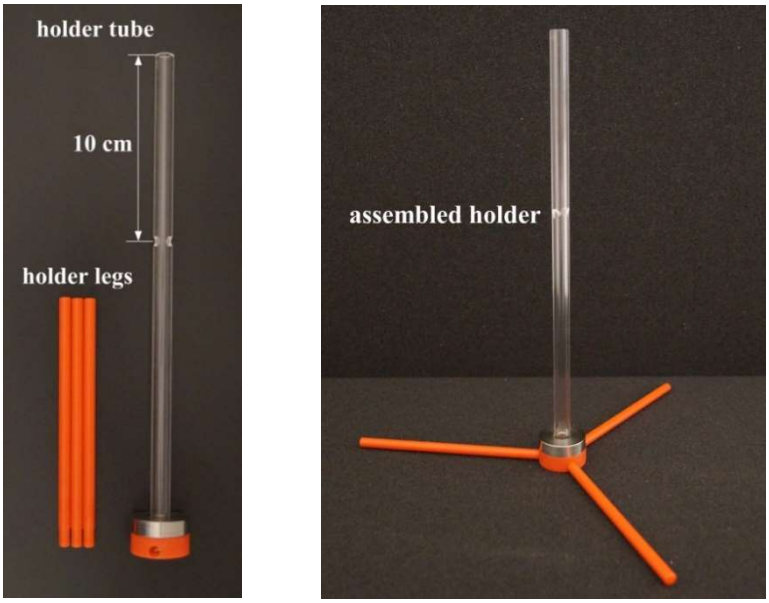

FIG.1. Assembling the IAEA standard holder for the TLD irradiations in reference conditions

SSD set-up
The TLD capsule is at 10 cm depth; the SSD is set to your usual value

OR

Isocentric set-up
The TLD capsule is positioned at your usual SAD and also at 10 cm depth.

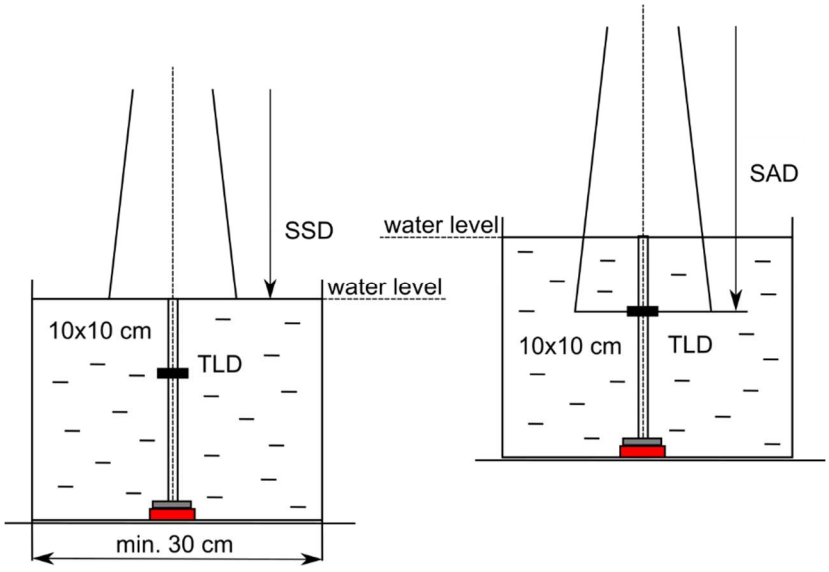

FIG. 2. Two alternative geometry set-ups for the TLD irradiation in reference conditions.

C. Irradiation of the TLD capsules for the reference measurement

NOTE: *The capsule with white mark* ***must not*** *be irradiated; it is used for monitoring environmental influences during transport and storage.*

1. Calculate the irradiation time or monitor units to deliver 2 Gy (200 cGy) to the TLD capsule as you would do for a 'tumour' whose centre would be at 10 cm depth, for a 10 cm × 10 cm field. The delivered dose is not a 'given dose' at the depth of maximum dose, but a dose at 10 cm depth (Fig. 3).
2. Choose TLD number '1'.
3. Insert this capsule into the hole of the holder (Fig. 4).
4. Position the holder, with the TLD inserted, in water, making sure that the tube of the holder is completely filled with water (no air bubbles).
5. Align the holder tube with the central (collimator) axis (Fig. 2).
6. Before irradiation recheck whether the alignment, field size, water level and distance are correct (Fig. 2).
7. Irradiate the first capsule with the time or the number of monitor units as calculated above.

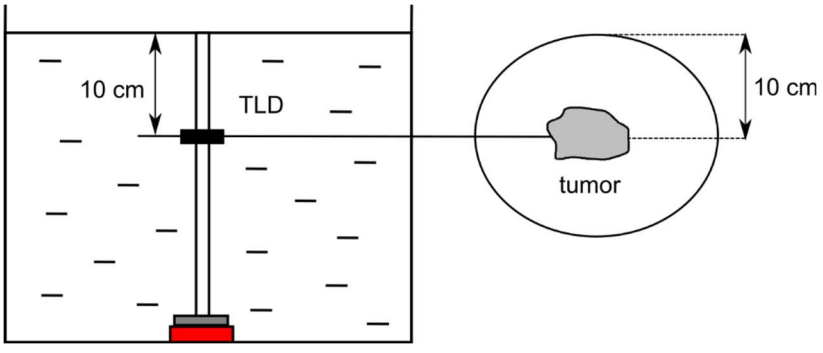

FIG. 3. Irradiation geometry for the TLD (see text in point 1).

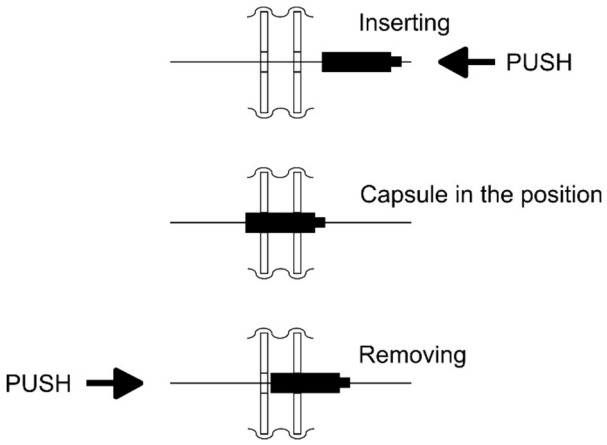

FIG.4. Inserting, positioning and removing the TLD capsule.

8. Remove the capsule from the holder (Fig.4.), wipe it dry.
9. Replace in its position in the box.
10. Choose TLD number '2'.
11. Repeat the procedure, steps 3 to 9, for the second capsule (2 TLD capsules per beam for reference measurements).

D. Irradiation of the TLD capsules for the non-reference on-axis measurements

NOTE: *All TLD measurements are to be carried out at the standard depth of 10 cm and using a consistent SSD or isocentric set-up, according to the participant's selection (Fig. 2).*

D.1. Check of relative output factor

1. Calculate the irradiation time or monitor units to deliver 2 Gy (200 cGy) to the TLD capsule on central (collimator) axis at 10 cm depth, for a 7 cm × 7 cm field.
2. Choose TLD number '3'.
3. Insert this TLD capsule into the hole of the holder.
4. Position the holder, with the TLD inserted, in water, making sure that the tube of the holder is completely filled with water (no air bubbles).
5. Align the holder tube with the central (collimator) axis (Fig. 2).
6. Before irradiation recheck that the alignment, field size, water level and distance are correct.
7. Irradiate the TLD capsule with the time or the number of monitor units as calculated above to deliver 2 Gy to the capsule.
8. Remove the capsule from the holder, wipe it dry and replace in its position in the box.
9. Calculate the irradiation time or monitor units to deliver 2 Gy (200 cGy) to the TLD capsule on central (collimator) axis at 10 cm depth, for a 20 cm × 20 cm field.
10. Choose TLD number '4'.
11. Repeat the procedure, steps 3 to 8, using the irradiation time or monitor units for this field, with this TLD.
12. Calculate the irradiation time or monitor units to deliver 2 Gy (200 cGy) to the TLD capsule on central (collimator) axis at 10 cm depth, for a 7 cm × 20 cm field.
13. Choose TLD number '5'.
14. Repeat the procedure, steps 3 to 8, using the irradiation time or monitor units for this field, with this TLD.

D.2. Check of wedge transmission factor

1. Select the thickest wedge which is used in clinical practice in your department for this treatment unit.

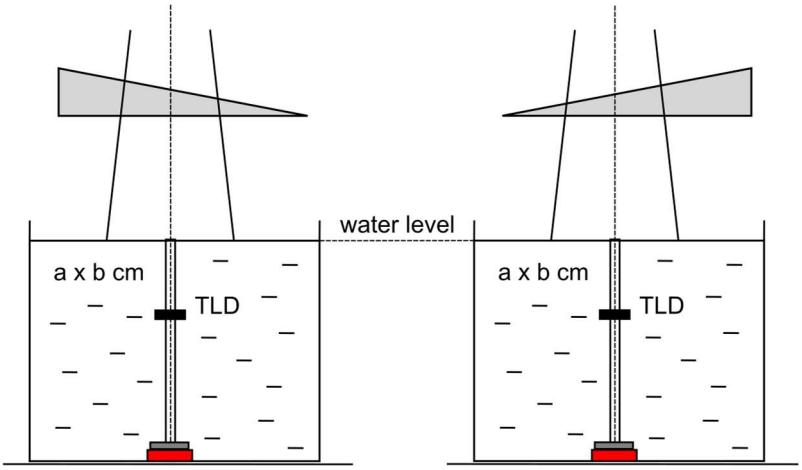

FIG. 5. Schematic diagram of irradiation set-up for wedge transmission factor measurements. The wedge should be the thickest one used in clinical practice on that unit. The set-up can be SSD or isocentric.

2. Calculate the irradiation time or monitor units to deliver 2 Gy (200 cGy) to the TLD capsule on central (collimator) axis at 10 cm depth, for a 10 cm × 10 cm field, with the wedge selected.
3. Choose TLD number '6'.
4. Insert this TLD capsule into the hole of the holder.
5. Position the holder, with the TLD inserted, in water, making sure that the tube of the holder is completely filled with water (no air bubbles).
6. Align the holder tube with the central (collimator) axis (Fig. 2); ensuring also that the long axis of the TLD capsule is perpendicular to the direction of the slope of the wedge in order to obtain homogeneous irradiation of the entire volume of TLD powder contained in the capsule.
7. Before irradiation recheck that the alignment, field size, water level and distance are correct.
8. The irradiation must be performed by delivering **half the dose (1 Gy)** with a 0° (or 90°) collimator rotation and **half the dose (1 Gy)** with a 180° (or 270°) collimator rotation. This is to minimize the risk of error related to misalignment of the TLD holder in relation to the wedge position. Thus, the total dose delivered to the capsule should be 2 Gy, but delivered in two fractions (see Fig. 5).
9. Remove the capsule from the holder, wipe it dry and replace it in its position in the box.
10. Calculate the irradiation time or monitor units to deliver 2 Gy (200 cGy) to the TLD capsule on the central (collimator) axis at 10 cm depth, for a 7 cm × 20 cm field, with the wedge selected.
11. Choose TLD number '7'.
12. Repeat the procedure, steps 4 to 9, using the irradiation time or monitor units for this field, with this TLD.

E. Absorbed dose measurements with an ionization chamber (additional request for medical physicists)

Determine experimentally the absorbed dose to water in the beam for the reference measurements (field size 10 cm × 10 cm) according to your usual dosimetry protocol and complete the data sheet.

[DAN letterhead]

TLD POSTAL DOSE QUALITY AUDIT FOR Co-60 BEAMS

DATA SHEET

Step 2a: Reference and non-reference conditions on-axis

It is of great importance for the TLD evaluation that the information 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 Co-60 treatment unit used for this audit is of the type

.....

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

installed in the year .....

and the date of the last source replacement is .....

B. Irradiation of the TLD capsules for the reference measurement

(see Sections B and C of the Instruction Sheet)

The TLD capsules were irradiated on the following date:

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

day *month* *year*

SSD = ... cm
fixed source surface distance
SSD set-up

OR

SAD = ... cm
fixed source axis distance
Isocentric set-up

The TLD capsules were irradiated at 10 cm depth in water using a 10 cm × 10 cm field at:

For the different TLD capsules, the irradiation time (in minutes) and the dose delivered[1] (in grays) were :

TLD 1 t = ... min D = ...Gy

TLD 2 t = ... min D = ...Gy

C. Calculation of time setting for the reference measurement

Provide the data used for calculation of time setting for the TLD irradiation.

Please give detailed explanation of your procedure for the above time and dose calculation. Please provide all factors (beam output, any conversion or correction factors, etc.) you have used:

.....

.....

.....

.....

.....

Beam output (*units*) as stated for your clinical data: ..... [.....] |__|__| |__|__| |__|__|__|__|

day *month* *year*

Please explain in detail the irradiation conditions for which this clinical beam output applies (e.g. in-air or depth in water, SAD or SSD, field size):

.....

.....

.....

.....

[1] Please adjust your irradiation time to get absorbed dose to the TLD capsule as close as possible to 2 Gy (200 cGy).

D. Irradiation of the TLD capsules for non-reference on-axis measurements

D.1. Relative output factor measurements

(see section D.1. of the Instruction Sheet)

The TLD capsules were irradiated on the following date:

|__|__| |__|__| |__|__|__|__|
day *month* *year*

The TLD capsules were irradiated at 10 cm depth in water at:

SSD = ……cm
fixed source surface distance
SSD set-up

OR

SAD = ……...cm
fixed source axis distance
Isocentric set-up

For the TLD capsules below the irradiation time (in minutes) and the dose delivered[2] (in grays) on the central (collimator) axis were:

TLD 3: 7 cm × 7 cm t = ... min D =..... Gy
TLD 4: 20 cm × 20 cm t = ... min D =..... Gy
TLD 5: 7 cm × 20 cm t = ... min D =..... Gy

D.2. Wedge transmission factor measurements

(see section D.2 of the Instruction Sheet)

The TLD capsules were irradiated on the following date:

|__|__| |__|__| |__|__|__|__|
day *month* *year*

The TLD capsules were irradiated at 10 cm depth in water at:

SSD = ……cm
fixed source surface distance
SSD set-up

OR

SAD = ……...cm
fixed source axis distance
Isocentric set-up

Nominal wedge angle: ……degrees

For the TLD capsules below the irradiation time (in minutes) and the dose delivered (in grays) on the central (collimator) axis were.

TLD 6: 10 cm × 10 cm t = ... min D = ... Gy
TLD 7: 7 cm × 20 cm t = ... min D =..... Gy

E. Calculation of doses for the open and wedged non-reference field irradiations

Provide the data used for calculation of the irradiation times and doses for the TLD irradiations.

Please give detailed explanation of your procedure for the above calculations. Please provide data from the TPS or factors (relative beam output, wedge factor, etc.), you have used in the manual calculation:

Open fields:

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

[2] Please adjust your irradiation time to get the absorbed dose to each TLD capsule as close as possible to 2 Gy (200 cGy).

Wedged fields:

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

ADDITIONAL REQUEST FOR MEDICAL PHYSICISTS

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

Measurements were performed by

.....

name *position*

On the day |__|__| |__|__| |__|__|__|__|
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 $N_{D,w}$).

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:

(a) for measurement in phantom

☐ 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.

(b) for measurement in air:
build-up cap .....
material *thickness*

Please give your reading results:

Average reading ..... [*scale units*]
Measurement performed during ..... min
Temperature.....°c
Pressure [*units*] ..... [.....]
Electrometer scale .....
Polarizing voltage .....

The absorbed dose rate to water in this beam was determined using 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:

.....
.....
.....
.....
.....
.....
.....
.....
.....
and, if any, the shutter correction (timer error) applied was .....

[DAN LETTERHEAD]

TLD POSTAL DOSE QUALITY AUDIT FOR MEGAVOLTAGE X-RAY BEAMS

DATA SHEET

Step 2a: Reference and non-reference conditions on-axis

It is of great importance for the TLD evaluation that the information 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: .....

B. Irradiation of the TLD capsules for the reference measurement

The TLD capsules were irradiated on the following date:

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

day *month* *year*

The TLD capsules were irradiated at 10 cm depth in water using a 10 cm × 10 cm field at:

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

For the different TLD capsules, the monitor setting (in MU) and the dose delivered[3] (in grays) were:

TLD 1: ..... MU D = ... Gy

TLD 2: ..... MU D = ... Gy

C. Calculation of monitor setting for the reference measurement

Provide the data used for calculation of monitor unit (MU) setting for the TLD irradiation.

Please give a detailed explanation of your procedure for the above MU and dose calculation. Please provide all factors (beam output, any conversion or correction factors, etc.) you have used:

.....

.....

.....

.....

.....

Beam output as stated for your clinical data: ..... [Gy/100 MU] |__|__| |__|__| |__|__|__|__|

day *month* *year*

Please explain in detail the irradiation conditions for which this clinical beam output applies (e.g. depth in water, SAD or SSD, field size):

.....

.....

.....

[3] Please adjust your monitor unit (MU) setting to get the absorbed dose to the TLD capsule as close as possible to 2 Gy (200 cGy).

D. Irradiation of the TLD capsules for non-reference on-axis measurements

D.1. Relative output factor measurements

(see section D.1. of the Instruction Sheet)

The TLD capsules were irradiated on the following date: |__|__| |__|__| |__|__|__|__|
day *month* *year*

The TLD capsules were irradiated at 10 cm depth in water at:

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

For the TLD capsules below the monitor unit (MU) settings and the dose delivered[4] (in grays) were:

TLD 3: 7 cm × 7 cm ..... MU D =..... Gy
TLD 4: 20 cm × 20 cm ..... MU D =..... Gy
TLD 5: 7 cm × 20 cm ..... MU D =..... Gy

D.2. Wedge transmission factor measurements

(see section D.2 of the Instruction Sheet)

The TLD capsules were irradiated on the following date:

|__|__| |__|__| |__|__|__|__|
day *month* *year*

The TLD capsules were irradiated at 10 cm depth in water at:

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

Nominal wedge angle:……degrees

For TLD capsules below the monitor unit (MU) settings and the dose delivered (in grays) were:

TLD 6: 10 cm × 10 cm : ..... MU D =..... Gy
TLD 7: 7 cm × 20 cm : ..... MU D =..... Gy

E. Calculation of doses for the open and wedged non-reference field irradiations

Provide the data used for calculation of the monitor unit (MU) settings and doses for the TLD irradiations.

Please give detailed explanation of your procedure for the above calculations. Please provide data from the TPS or factors (relative beam output, wedge factor, etc.) you have used in the manual calculation:

Open fields:

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

Wedged fields:

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

[4] Please adjust your monitor unit (MU) setting to get the absorbed dose to the TLD capsule as close as possible to 2 Gy (200 cGy).

ADDITIONAL REQUEST FOR MEDICAL PHYSICISTS

A. **Determination of the absorbed dose to water by ionization chamber in 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 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:

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

STEP 2A 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 2A: RESULTS OF TLD MEASUREMENTS FOR Co-60 AND HIGH-ENERGY PHOTON BEAMS

Radiation unit	Beam	Field [cm × cm]	TLD set #	User stated dose [Gy]	DAN (measured) dose [Gy]*	DAN mean dose [Gy]*	% deviation relative** to DAN mean dose	DAN mean dose / User stated dose
		10 × 10	*1*					
			2					
		7 × 7	*3*					
		20 × 20	*4*					
		7 × 20	*5*					
		10w × 10	*6*					
		7w × 20	*7*					

* 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 mean measured dose)/ DAN mean 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. **IT DOES NOT CONSTITUTE A STATEMENT WITH REGARD TO THE QUALITY OF RADIOTHERAPY TREATMENTS.**