Package 7

INSTRUCTION SHEET, DATA SHEET AND RESULTS REPORTING FORM FOR THE STEP 5 AUDIT

This package contains the following forms:

Instruction Sheet for TLD postal dose quality audit for megavoltage X-ray beams in the presence of heterogeneities;

Data Sheet for TLD postal dose quality audit for megavoltage X-ray beams in the presence of heterogeneities;

Certificate for the step 5 audit.

[DAN LETTERHEAD]

TLD POSTAL DOSE QUALITY AUDIT FOR MEGAVOLTAGE X RAY BEAMS

INSTRUCTION SHEET

Step 5: TLD quality audit for photon beams in the presence of heterogeneities

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. Each phantom configuration will be required to be CT-scanned, images exported to the treatment planning system (TPS) and monitor units (MU) calculated as if for a patient to deliver 2 Gy to the TLD.
2. 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. Label each TLD for irradiation conditions used (use labels or similar).
3. It is recommended to irradiate all TLDs in the same session. If this is not possible, please provide the irradiation dates for each TLD.
4. After the TLD irradiation, measure the beam output in the reference conditions (Section D).
5. Fill in the Data Sheet. An evaluation of the TLD results is only possible if these forms are complete.
6. Return TLDs and the Data Sheet to the [DAN] within ONE WEEK after the irradiation.

SPECIAL NOTE

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

CONFIDENTIALITY

The TLD results of individual centres are kept confidential by the DAN staff and will not be disseminated without the written permission of the participating radiotherapy centre. The statistical distribution of the results may be reported anonymously to the relevant authorities and/or published.

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 TLD audit in the presence of heterogeneities

The purpose of this TLD audit is to check the heterogeneity corrected dose calculations performed by the treatment planning system (TPS) as used for patient treatments. Increasingly complex treatments require more sophisticated modelling by the TPS for the differences in radiation dose deposition due to heterogeneities in body composition. This is particularly relevant for lung, but also applicable to bone, in order to make optimal use of the capabilities of more complex treatments and equipment. An independent experimental verification of the heterogeneity corrected dose calculated by treatment planning systems is an important step in the improvement of quality assurance in radiotherapy and therefore an important extension of the [DAN] programme.

The absorbed dose to water at a 10 cm depth in a solid phantom (with and without heterogeneities) for a 6 cm × 6 cm field is checked using TLDs. There is an additional TLD located in the lung material. There are three solid phantom compositions: polystyrene only, polystyrene plus lung equivalent material and polystyrene plus bone equivalent material.

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

B. Preparation of the solid phantom configurations and TPS dose calculations

As seen in Fig. 1, to perform this quality audit, it is necessary to use the solid polystyrene phantom provided by [DAN]. This phantom has an overall dimension of 15 cm × 15 cm × 15 cm and one of the 2 cm slabs accommodates TLD on the central axis. In addition to the polystyrene slabs, a 15 cm × 15 cm × 5 cm slab of lung equivalent material and a 15 cm × 15 cm × 2 cm slab of bone equivalent material are included. There is also 5 cm of phantom beyond the TLD for adequate scatter conditions.

1. The three solid phantom configurations shown in Fig. 1; polystyrene only, polystyrene/lung equivalent material and polystyrene/bone equivalent material, will each be imaged with a CT scanner with the polystyrene plug inserted in each phantom configuration where a TLD would be located.
2. The CT images for each phantom configuration will be exported to the TPS.

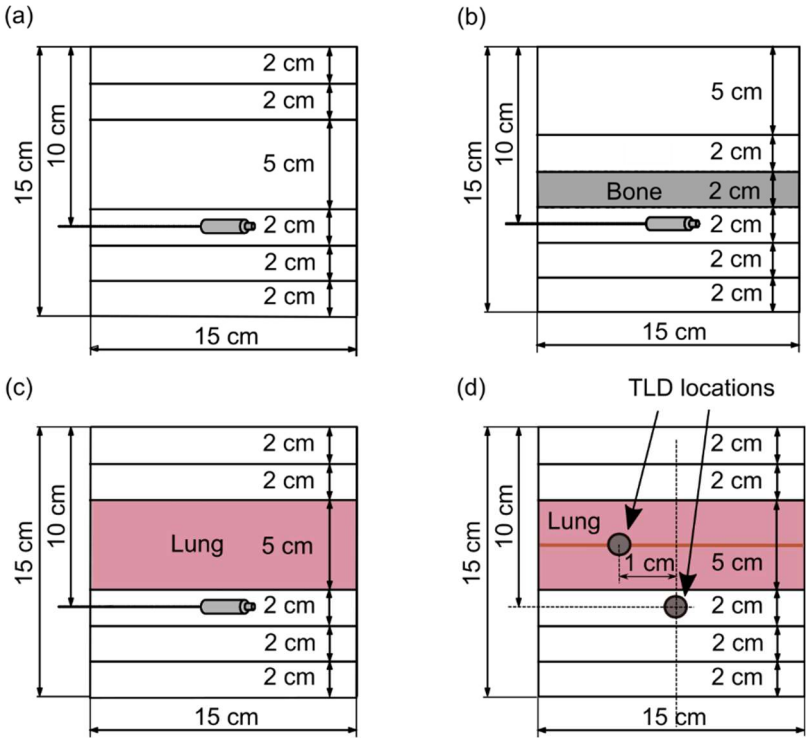

FIG. 1. Three polystyrene/heterogeneity solid phantom configurations for the quality audit of complex treatments in the presence of a heterogeneity (a)-(c); positioning of TLDs in lung equivalent material (d).

3. A treatment plan with a single 6 cm × 6 cm field will be generated to deliver 2 Gy to the location of the TLD on the central axis at a physical depth of 10 cm for each phantom configuration. The plan can be generated either using an SSD or SAD technique as long as the TLD irradiation setup is consistent with the plan. The dose calculation will include the TPS heterogeneity correction. The photon beam energy (<12 MV) most often used clinically for treatments in the thorax should be used. The same energy must be used for the bone heterogeneity test.
4. Calculate the number of monitor units to deliver the dose of 2 Gy to water at the centre of the TLD capsule for each phantom configuration. This calculation must be made by the TPS used in your daily practice for patient treatments. For the lung phantom configuration also calculate the dose delivered to the TLD in lung equivalent material for the monitor units given in this configuration.

C. Irradiation of TLD capsules

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

1. Assemble the appropriate solid phantom configuration as illustrated below prior to each TLD irradiation.
2. Insert TLD(s) into the appropriate slab(s) depending on the phantom configuration.
3. Before irradiation, recheck whether the alignment, field size and distance are correct.
4. Irradiate the TLD capsule with the number of monitor units as calculated above by the TPS.
5. Remove the capsule(s) from the phantom and place a label with the appropriate solid phantom configuration.
6. Repeat steps 1 to 5 for each solid phantom configuration indicated below.
7. The TLD measured absorbed doses will be compared to the dose calculations from your TPS at the location of the TLD for each of the phantom setups.

C1. Solid phantom #1. Homogeneous polystyrene phantom

Deliver 2 Gy to a TLD placed at 10 cm physical depth in a homogeneous polystyrene solid phantom (Fig. 2); field size 6 cm × 6 cm at the distance from the source used in the treatment plan above. This irradiation should be performed twice using two different TLDs. Label the TLDs as ‘P#1’ and ‘P#2’.

C2. Solid phantom #2. Heterogeneous polystyrene/lung phantom.

Deliver 2 Gy to a TLD placed at 10 cm physical depth in a solid heterogeneous polystyrene/lung phantom (Fig. 3); field size 6 cm × 6 cm at the distance from the source used in the treatment plan above. This irradiation will be performed twice using two different sets of TLDs. For the first irradiation and first set of TLDs, label the upper off-axis TLD as ‘LL#1’ and the lower on-axis TLD as ‘LP#1’. For the second irradiation and the second set of TLD, label the upper off-axis TLD as ‘LL#2’ and the lower on-axis TLD as ‘LP#2’.

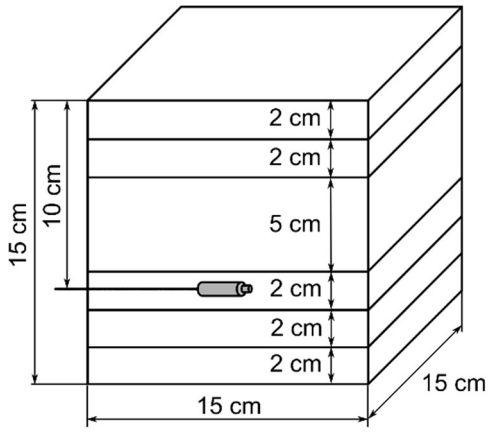

FIG. 2. Homogeneous polystyrene solid phantom with TLD configuration.

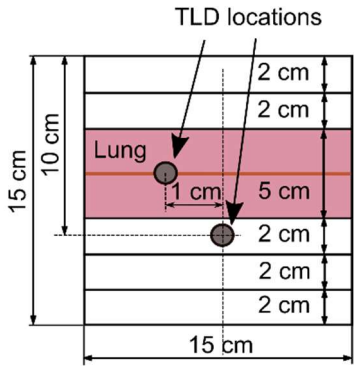

FIG. 3. Polystyrene/lung solid phantom with TLD configuration

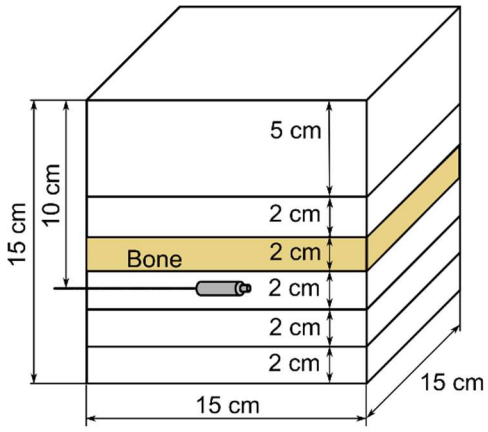

FIG. 4. Polystyrene/bone solid phantom with TLD configuration.

C3. Solid phantom #3. Heterogeneous polystyrene/bone phantom

Deliver 2 Gy to a TLD placed at the 10 cm physical depth in a solid heterogeneous polystyrene/bone phantom (Fig. 4); field size 6 cm × 6 cm at the distance from the source used in the treatment plan above. This irradiation will be performed twice using two different TLDs. Label the TLDs as ’BP#1’ and ‘BP#2’.

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 5: TLD quality audit for photon beams in the presence of heterogeneities

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. Beam output used for patient treatment planning

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

Heterogeneity correction algorithm used for the calculation:

……

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 Section 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 the solid phantom configurations from #1 to #3, please provide the [DAN] with a printout copy of the treatment plan summary including the MU calculation and the isodose distribution showing the isodose line going through the centre of the TLD(s).*

C.1. Homogeneous Polystyrene Phantom

Homogeneous Phantom, TLDs P#1 and P#2 were irradiated using a 6 cm × 6 cm field, with an absorbed dose rate of …….. Gy/MU at the 10 cm irradiation depth.

Monitor units for TLD P#1:	……...	MU,	TPS Dose = ……... Gy
Monitor units for TLD P#2:	……...	MU,	TPS Dose = ……... Gy

C.2. Heterogeneous Polystyrene/Lung Phantom

Lung Phantom TLDs LP# 1 and LP#2 were each irradiated using a 6 cm × 6 cm field, with an absorbed dose rate of …….. Gy/MU at the 10 cm irradiation depth.

Monitor units for TLD LP#1: .....MU, TPS Dose = ...Gy
Monitor units for TLD LP#2: .....MU, TPS Dose = ...Gy

The calculated dose from the treatment plan at the off-axis position of **Lung TLD LL# 1 and LL#2** was:

TLD LL#1: TPS Dose = ... Gy
TLD LL#2: TPS Dose = ... Gy

C.3. Heterogeneous Polystyrene/Bone Phantom

Bone Phantom TLDs BP#1 and BP#2 were each irradiated using a 6 cm × 6 cm field with an absorbed dose rate of ..... Gy/MU at the 10 cm irradiation depth.

Monitor units for TLD BP#1 ..... MU, TPS Dose = ... Gy
Monitor units for TLD BP#2 ..... MU, TPS Dose = ... Gy

ADDITIONAL REQUEST FOR MEDICAL PHYSICISTS

Determination of the absorbed dose to water by ionization chamber in the 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 $N_{D,w}$).

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 rate to water 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 P#1 and P#2 based on the measurement described above. Please provide all factors you have used:

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

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

STEP 5 AUDIT CERTIFICATE

RESTRICTED

[DAN letterhead]

[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 5: RESULTS OF TLD MEASUREMENTS FOR HIGH-ENERGY X-RAY BEAMS IN HETEROGENEITY SITUATIONS

Radiation unit	Beam	TLD set #	User stated dose [Gy]	DAN (measured) dose [Gy]*	% deviation relative** to DAN dose	DAN dose / User stated dose
		P				
		LP				
		LL				
		BP				

* 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 Date: *Signature*
……... ….
[TLD Officer] – [DAN] *yyyy-mm-dd* 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.**