6.2 MEASUREMENT OF TISSUE AIR RATIO

The ratio of the dose at a point in tissue to the dose at that same point in air is known as the Tissue-Air Ratio. A TAR against depth curve is plotted by measuring the dose in air with an ionisation chamber and then measuring the dose at the same point, while varying the thickness of the overlying tissue.

6.2.1 Training Goal

6.2.1.1 The submodule deals with the problem of measuring the Tissue-Air Ratio (TAR) for a set of square fields and depths. As well as direct measurement, the TAR can also be calculated using a specific formula involving the phantom scatter factors S_p in order to compare the resulting values to those calculated from the PDDs.

6.2.1.2 Minimum time to be spent on the task: 0.5 day.

6.2.2 Competencies Addressed

Skill in measuring the TAR for a set of ^{60}Co square fields and depths.
Technique of measuring ^{60}Co photons in air.

6.2.3 Equipment, Materials Needed for the Task

6.2.3.1

-Water phantom;
-small cylindrical ion chamber (ex. FARMER type 0.6 cc) with a buildup cap for ^{60}Co and associated electrometer;
-calculator or computer with electronic worksheet (e.g. LOTUS or EXCEL).
- PDD table and S_p factors for verification (optional).
- thermometer, barometer.

6.2.3.2 **Important Notes**

The use of equipment must be supervised by a qualified medical physicist.
The chambers must be waterproof or placed in a waterproof shielding.
The connection between the chambers and the electrometer must always be made with the power off.
The machine and the detectors and the electrometer must be warmed up before their use.
The temperature of air and water can vary. It is necessary to monitor the temperature in air and water.

6.2.4 Procedures

6.2.4.1 The TAR for a set of fields and depths is directly found from an intercomparison of the doses measured in water and in air at fixed distance from the source. The fields and the depths choosen for the measurement are shown in Table 1.

6.2.4.2 Notice that since in the TAR evaluation a ratio between readings obtained in different moments is made, temperature and pression must be monitored during the measurement. If any change occurs, the readings must be corrected for the corresponding temperature-pressure factor.

6.2.4.3 Perform the in-air measurement for each field using the technique illustrated in 6.2.5.1.

6.2.4.4 Perform the in-water measurement for each field and depth using the technique illustrated in 6.2.5.2.

6.2.5 Measurements

6.2.5.1 **In-air measurements** (see fig. 2 (a))
Place the chamber with its buildup cap at the center of the beam at standard source-to-axis distance SAD. Ensure that any scattering radiation source, such as walls or floor, are as far away as possible from the chamber. Make a charge measurement in air with fixed irradiation time (repeat at least three times and average the results). Report the results in Table I.

6.2.5.2 **In-water measurement** (see fig. 2 (b))
Place the chamber in the water phantom at the center of the beam at the smallest depth $d=d_{min}$ and the phantom surface at SSD=(SAD-d) . Make a charge measurement in water for all the fields with the same irradiation time used in 6.2.5.1 (repeat at least three times and average the results). Report the results in Table I. Increase the level of water over the chamber in order to achieve the next depth, then repeat the measurements. Repeat for the depths.

6.2.6 Calculations

Enter the values of Table I into a worksheet, then use the mathematical operators available from the worksheet to divide the charge measured in water by the corresponding charge measured in air for all fields and depths. Enter the results in Table II. These ratios can be assumed to be equal to the ratio of doses and therefore represent the TAR.

6.2.7 Observations, Interpretations and Conclusions

6.2.7.1 Compare results with published TAR results for a ^{60}Co machine.

6.2.7.2 Notice that the TAR at fixed depth increases with increasing the field size and that this effect is more visible as the depth increases. Comment on this effect.

6.2.7.3 Discuss the accuracy obtained with the adopted procedure.

6.2.7.3 Derive the conversion formula from PDD to TAR. Calculate the TAR of some fields and depths from the corresponding PDD, then compare the resulted values with those measured. Express the difference as a percentage.

6.2.7.3 Discuss the limitation of TAR.

6.2.8 Optional

Nothing optional is suggested.

6.2.9 References

F.M.Khan, The Physics of Radiation Therapy, 2nd ed., William & William, Baltimore, 1992

H.E.Johns, J.R.Cunningham, The Physics of Radiology, 4th ed., Springfield, Charles C.Thomas, 1984

W.R. Hendee, G.S. Ibbott, Radiation Therapy Physics, 2nd ed., Mosby, 1996

J.R. Williams, D.I. Twaites, "Radiotherapy Physics", Oxford Medical Publications, 1993

Johns H.E., Whitmore G.F., Watson T.A., Humberg F.H., A system of dosimetry for rotation therapy with typical rotation distributions, J. Canad. Assn. Radiol., 4, 1, 1953

6.2.10 Verification

Signature and date by the trainer:

Name of the trainee:____
Comments:____
____
____

Date:________________Trainer's signature:___________________________

Table I Measurements

	4 x 4	6 x 6	8 x 8	10 x 10	15 x 15	20 x 20
air						
water d=0.5 cm						
water d=1 cm						
water d=2 cm						
water d=4 cm						
water d=6 cm						
water d=10 cm						
water d=15 cm						
water d=20 cm						

Table II Calculated TAR

	4 x 4	6 x 6	8 x 8	10 x 10	15 x 15	20 x 20
water d=0.5 cm						
water d=1 cm						
water d=2 cm						
water d=4 cm						
water d=6 cm						
water d=10 cm						
water d=15 cm						
water d=20 cm						

6.3 MEASUREMENT OF TPR

6.3.1 Training Goal

6.3.1.1 The TPR is a basic quantity for high energy photon beams. As well as direct measurement, the TPR can also be calculated from a specific formula involving the phantom scatter factors S_p. This submodule deals with the measurement of TPR for a set of square fields and depths and an optional comparison of the resulting values with those calculated from the PDDs.

6.3.1.2 Minimum time to be spent on the task: 1 day.

6.3.2 Competencies Addressed

Skill in measuring the TPR table for a set of square fields of high energy photons.

6.3.3 Equipment, Materials Needed for the Task

6.3.3.1 See fig. 3)
-Water phantom;
-small cyclindrical ion chamber (ex. FARMER 0.6 cc type) and associated electrometer;
-calculator or computer with electronic spreadsheet (e.g. LOTUS or EXCEL);
- thermometer, barometer.
- PDD table and S_p factors for verification (optional).

6.3.3.2 Important Notes
The use of equipment must be supervised by a qualified medical physicist.
The chambers must be waterproof or placed in a waterproof shielding.
The connection between the chambers and the electrometer must always be made with the power off.
The machine, the detectors and the electrometer must be warmed up before their use.

6.3.4 Procedure

6.3.4.1 The TPR is calculated for the fields and depths shown in Table III, from the ratio between the dose measured at depth d and that measured at the reference depth.

6.3.4.2 Note that in the TPR evaluation, a ratio between readings obtained at different times is made, the temperature and pressure must be monitored during the measurement. If any change occurs, the readings must be corrected using the corresponding temperature-pressure factor.

6.3.4.3 Perform the charge measurement for each field as shown in 6.3.5.1 and then calculate the TPR as indicated in 6.3.6.

6.3.5 Measurements

6.3.5.1 (See fig. 3) Set the chamber in the water phantom at the center of the beam at the reference depth d_{ref} according to the adopted protocol. Be careful that the side and backscatter material is appropriate for all the fields to be measured. Set the phantom surface at SSD=(SAD-d_{ref}). Make a charge measurement in water for all fields with a fixed irradiation time (typically 200 MU). Repeat at least three times and average the results. Report the results in table III.

6.3.5.2 Modify water depth over the chamber in order to achieve the next depth, then repeat the measurements using the method described in 6.3.5.1.

6.3.6 Calculations

Enter the values of Table III in a spreadsheet. Use the mathematical operators available in the program to divide all the charges measured at different depths by those measured at the reference depth for the same field. Report the results in Table IV. These ratios can be assumed to be equal to the ratio of doses and therefore represent the TPR.

6.3.7 Observations, Interpretations and Conclusions

6.3.7.1 Find the values of TPR for the reference field size at depths 20 cm and 10 cm and calculate their ratio TPR(20)/TPR(10). The result, TPR^{20}_{10}, is an index of beam quality.

6.3.7.2 Show the difference between ionisation and dose to water.

6.3.8 Optional

Search for the conversion formula from PDD to TPR. Calculate the TPR of some fields and depths from the corresponding PDD, then compare the resulted values with those measured. Express the difference as percentage.

6.3.9 References

F.M.Khan, The Physics of Radiation Therapy, 2nd ed., William & William, Baltimore, 1992
H.E.Johns, J.R.Cunningham, The Physics of Radiology, 4th ed., Springfield, Charles C.Thomas, 1984
W.R. Hendee, G.S. Ibbott, Radiation Therapy Physics, 2nd ed., Mosby, 1996
J.R. Williams, D.I. Twaites, Radiotherapy Physics, Oxford Medical Publications, 1993
Bjarngard B.E., Zhu T.C., Ceberg C.C., Tissue phantom ratios from percentage depth-dose, Med. Phys., 23 (5) ,629,1996

6.3.10 Verification

Signature and date by the trainer:

Name of the trainee:____

Comments:____

____

____

Date:________________Trainer's signature:____________________________

Table III Measurements

	4 x 4	6 x 6	8 x 8	10 x 10	15 x 15	20 x 20
water $d=d_{ref}$						
water d_1						
water d_2						
water d_3						
water d_4						
water d_5						
water d_6						
water d_7						
water d_8						

Table IV Calculated TPR

	4 x 4	6 x 6	8 x 8	10 x 10	15 x 15	20 x 20
water d_1						
water d_2						
water d_3						
water d_4						
water d_5						
water d_6						
water d_7						
water d_8						