VOID SHEET

TO: License Fee Management Branch

FROM: Region III

SUBJECT: VOIDED APPLICATION

Control Number: 89918

Applicant: Dtocks Medical Center

Date Voided: 9/10/90

Reason for Void: License is not required to submit their full calibration report.

Kim G. Nell 9/10/90
Signature Date

Attachment:
Official Record Copy of
Voided Action

FOR LFMB USE ONLY

Final Review of VOID Completed:

- ☐ Refund Authorized and processed
- ☐ No Refund Due
- ☐ Fee Exempt or Fee Not Required

Comments:

Log completed ☐

Processed by:

SEP 13 1990

Ozarks Medical Center
Radiation Oncology Center
ATTN: Liep T. Tio, M.D.
1103 Alaska Avenue
West Plains, MO 65775

Gentlemen:

Please note that the submittal of your full calibration measurements (10 CFR 35.632) for your cobalt-60 teletherapy unit is not required by regulation. As per 10 CFR 35.645, only the measured output as determined in accordance with 35.632 must be included with records submitted relative to 35.636, 35.641 and 35.643.

In light of the above, we have voided your letter dated July 25, 1990, and therefore have not issued an amendment to your license. The documentation that you submitted with the above mentioned letter will be placed in your file.

If you have any questions or require clarification on any of the information stated above, you may contact us at (708) 790-5625.

Sincerely,

Original Signed By
Kevin G. Null
Materials Licensing Section

RIII

NULL/da
09/13/90

BETWEEN:

LICENSE FEE MANAGEMENT BRANCH, ARM
AND
REGIONAL LICENSING SECTIONS

(FOR LFMS USE)
INFORMATION FROM LTS

PROGRAM CODE: 02300
STATUS CODE: 0
FEE CATEGORY: _____
EXP. DATE: 19941031
FEE COMMENTS: _____

LICENSE FEE TRANSMITTAL

A. REGION

1. APPLICATION ATTACHED
APPLICANT/LICENSEE: OZARKS MEDICAL CENTER
RECEIVED DATE: 900726
DOCKET NO: 3031197
CONTROL NO.: 389918
LICENSE NO.: 24-18733-02
ACTION TYPE: AMENDMENT

2. FEE ATTACHED
AMOUNT: ---0---
CHECK NO.: ---0---

3. COMMENTS

SIGNED P. Hustlak
DATE 7-27-90

B. LICENSE FEE MANAGEMENT BRANCH (CHECK WHEN MILESTONE 03 IS ENTERED /✓/)

1. FEE CATEGORY AND AMOUNT: _____ FEE EXEMPT

2. CORRECT FEE PAID. APPLICATION MAY BE PROCESSED. ✓
AMENDMENT _____
RENEWAL _____
LICENSE _____

3. OTHER add'l Edits.

SIGNED _____
DATE 8/1/90

1

Radiation Oncology Center

Liep T. Tio, M.D.

July 29, 1990

Nuclear Regulatory Commission
Region III
799 Roosevelt Road
Glen Ellyn, Illinois 60137

Re: NRC License No. 24-18733-02

Dear Sirs:

In accordance with Title 10 CFR Part 35.645, please find enclosed a copy of the recently performed yearly calibration of our cobalt-60 unit.

If there are any questions or problems, please do not hesitate to contact us at (417) 257-7082.

Sincerely,

Liep T. Tio, M.D.
Radiation Oncologist

FEE EXEMPT
8/1/90

RECEIVED
JUL 26 1990
REGION III
CONTROL NO. 89318

Doctors' Pavillion • 1115 Alaska Avenue, Suite 116 • West Plains, Missouri 65775 • (417) 257-7082

CALIBRATION REPORT

Theratron 780 Cobalt 60 Teletherapy Unit
Radiation Oncology Center
West Plains, Missouri

On July 1 and 2, 1990, a complete calibration was performed on the A.E.C.L. Theratron 780 Teletherapy unit, serial no. 86, located in the Radiation Oncology Center, West Plains, Missouri. This unit is an isocentric Cobalt 60 teletherapy unit with a rotational isocenter of 80 centimeters. The unit has a Cobalt 60 source, serial no. S-3903, issued under NRC license no. 24-18733-02 with an initial activity of 7946 curies on July 17, 1986. The unit is located in the Radiation Oncology Center, Doctors' Pavilion, 1115 Alaska Avenue, Suite 116, West Plains, Missouri 65775, phone (417) 257-7082. The unit is under the supervision of Liep Tiong Tio, M.D.

This report is a complete calibration of the above unit performed by Dennis Frieda, Ph.D. The calibration was performed using an Keithley Model 35617 Dosimeter, serial no. 22828, with an NEL (Farmer) Chamber Model 2571, serial no. 912, which were last calibrated at the Accredited Dosimetry Calibration Laboratory, M. D. Anderson Hospital and Tumor Institute, Houston, Texas, on April 10, 1990.

A summary of the calibration findings follows with a copy of complete calibration data included in the appendix.

I. Equipment Evaluation

A. Control Console

1. The control console is located in an adjacent room with means provided for visual observation of the patient and control console from the same position. Means is also provided for oral communication between the patient and the control room. Patients are not to be treated unless visual and oral contact can be made with the patient at all times.

2. A key lock is provided on the control console to prevent unauthorized use. It is also not possible to activate the unit or beam from inside the treatment room.

3. Lights are located on the control console to indicate when the console is ON and when the source is in the ON position.

4. The control console has a timer to terminate exposure after a preset time. Means is also provided on the control console for the operator to terminate exposure at any time.

5. Emergency procedures are posted at the control console.

6. Emergency shut-off push buttons are provided on the control console and in the treatment room.

7. The teletherapy room door is posted with a "Caution - High Radiation Area" sign.

B. Interlocks and other warning lights and devices.

1. Lights are located on the control console, above the door to the treatment room and in the treatment room on the gantry head that indicate when the control console in ON and when the source is in the ON position.

2. Interlocks are provided such that the beam cannot be turned on if the door is open. If the door to the treatment room is opened while the beam is ON, the source will automatically return to the OFF position and cannot be turned ON until reset at the control console.

3. A radiation monitor is provided in the treatment room that emits a flashing red light that can be seen from the treatment room entrance when the source is ON. The monitor is provided with a working battery back-up.

4. An interlock is provided such that the source can only be moved to the ON position when the port is directed at the beam stopper, or within a 90 degree angle between the floor and the west (maze) wall.

5. No interlocks are provided for the wedges or blocking trays.

C. Mechanical Alignment

1. The coincidence of the central axis of the light field, the cross hairs, and the mechanical axis of the collimator assembly were checked and found to agree within 1.5 mm.

2. The field size indicators are analog and were found to be accurate to within 2 mm of the light field at 80 centimenters over the range of use.

3. The mechanical and optical distance indicators were checked and found to agree to within 1.5 mm. with the rotational isocenter of the unit. The optical distance indicator was found to be accurate to within 2 mm. with actual distances from the source for distances of 60 to 100 centimeters.

4. Films were exposed at 80 cm. SSD with 0.5 cm. of acrylic over the film and the edges of the actual radiation field was defined as the 50% isodensity as compared to the central axis isodensity. The radiation field edge verses light field edge were found to agree to within 1.5 mm. on all sides over the range of use.

D. Leakage of Radioactive Material

A wipe test of the source portal and collimator surfaces was performed on June 5, 1990. Analysis by Assay Services, Inc., Friendswood, Texas indicate the source is not leaking.

II. Measurements

A. Beam Direction Dependence.

The source output was found to exhibit a negilible variation (±0.1%) with beam (gantry) direction.

B. Field Flatness/Symmetry

Scans were performed in both the in-plane and cross-plane directions. Field flatness and symmetry were found to be satisfactory.

C. Timer

1. The timer constancy and linearity over the useful clinical range were found to be satisfactory.

2. The source was found to exhibit a timer error of -0.015 minute. Thus 0.015 minute should be added to the calculated timer setting for each OFF-ON-OFF movement of the source.

D. Central Axis Depth Dose

The table of Percentage Depth Dose data in use was taken from Supplement No. 17, "Central Axis Depth Dose Data for Use in Radiotherapy", *British Journal of Radiology*, 1983. The data was checked with measurements at depths of 5, 10, and 15 centimeters in a water phantom for field sizes of 6×6, 10×10 and 20×20 centimeters. The normalized calculated percent depth dose values were found to agree with table values to within 0.5% and indicate that the data is an appropriate choice for the unit. A table of the Tissue-Air Ratios (**TAR**) in use and also taken from Supplement No. 17 is also provided. A table of Tissue-Maximum Ratios (**TMR**) calculated from the Tissue-Air Ratio data is also provided.

E. Field Size Dependence

The variation in output was measured over the range of field sizes at 80 cm SSD. Measurements were made at 5 cm depth in water, corrected for percent depth dose to d_{max}, and normalized to a 10×10 cm^2 field. A table of measured output factors vs. field sizes is provided. These new values vary from previous calibrated values by 0.2% or less. A table for clinical use that uses the TAR(0.5) values provided in the Tissue-Air Ratio table to separate out a normalized collimator (S_c) and treatment area factor (S_p) is also provided.

F. Dose Rate Calibration

The absorbed dose rate at d_{max} (depth of maximal dose) was determined from measurements at 5 centimeters in water for a 10×10 cm^2 field with an 80 centimeter source to surface distance (SSD). Using calculation methods of AAPM Protocol Task Group 21 (Dec., '83), the dose rate at d_{max} is given by:

$$\dot{D}_{max} = (M/U)\ N_{gas}\ (L/\rho)^{water}_{air}\ P_{wall}\ P_{ion}\ P_{repl}\ (100/P_{\%})$$

where

M is the average of readings of the field instrument corrected for temperature and pressure;

U is the monitor unit, in this case time (minutes), corrected for any end errors;

N_{gas} is the cavity-gas calibration factor;

$(L/\rho)^{water}_{air}$ is the mean restricted collision mass stopping power for medium (water) to air for Cobalt 60;

P_{wall} is the correction for attenuation and scatter for the wall of the chamber;

P_{ion} is the correction for ion-collection efficiency;

P_{repl} is the factor that corrects for replacement of phantom material by an ionization chamber; and

$P_{\%}$ is the percent depth dose at the point of measurement for selected field size and SSD.

Using this formulation, the measured absorbed dose rate to water at d_{max} for a 10X10 cm^2 field at 80 cm SSD is:

$$\dot{D}_{max} = 126.8 \text{ rads/min.}$$
on July 2, 1990

The previous calibrated output at d_{max} for a 10X10 cm^2 field at 80 cm SSD when corrected for decay to July 2, 1990, would have been 127.5 rads/minute. The percent difference between the current measured value and this decay corrected value is -0.6%.

A table of decay corrected dose rates at d_{max} for a 10X10 cm^2 field at 80 cm SSD, for the next 12 months (July, 1990 thru July, 1991) is provided.

G. Beam Off Head Leakage

The beam off head leakage was measured at points on the surface of an imaginary sphere with a radius of one meter from the source. Measurements were made with a Keithley 36150 Survey Meter, serial no. 22530 which was last calibrated on August 30, 1989 by the University of Wisconsin Radiation Calibration Service. An average reading of 0.9 mR/hr was found with a maximum value of 4.4 mR/hr.

H. Inverse Square Correction

The virtual source position was determined and found to agree to within 0.65 cm of the expected source position. Using inverse square values based on a source to isocenter distance of 80 cm is appropriate and accurate to within 0.3% for source to surface distances between 70 and 100 cm.

I. Transmission Factors

Transmission factors for the solid acrlyic and slotted acrlyic blocking trays and the large (10w) 30, 45 and 60 degree wedges were measured in water at 5.0 cm depth. A table of measured values is provided. Factors agreed with previous values to within ±0.2%.

J. Arm Speed Calibration

The actual degrees rotated per minute verse arm speed setting was determined. The rotational speeds were found to differ slightly for motion in the counterclockwise direction verses clockwise motion. For arm speed settings between 0.2 to 0.9, the following equations may be use to determine the arc speed setting:

CW: $y = 0.00251x + 0.0340$ for $0.2 \leq y \leq 0.9$
CCW: $y = 0.00247x + 0.0513$

where x = degree/min.
y = arm speed setting

Dennis Frieda

Dennis Frieda, Ph.D.
Radiological Physicist (ABR)

CONTROL NO. 89918

DECAY CORRECTED DOSE RATES*
AECL Theratron 780 Cobalt 60 Teletherapy
Radiation Oncology Center
West Plains, Missouri

10 X 10 CM FIELD, 80 CM SSD
CALIBRATED OUTPUT*=126.8 rads/minute
at D_{max} in water on July 2, 1990

Month	Decay Corrected† Output* (rads/minute)
July-1990	126.2
August-1990	124.8
September-1990	123.4
October-1990	122.0
November-1990	120.7
December-1990	119.4
January-1991	118.1
February-1991	116.8
March-1991	115.6
April-1991	114.3
May-1991	113.1
June-1991	111.8
July-1991	110.6

* Includes timer error of -0.015 minute.

† Decay corrected to the 15th of each month.

July 1, 1990

TRANSMISSION FACTORS*

Theratron 780
Cobalt 60 Teletherapy
Radiation Oncology Center
West Plains, Missouri

BLOCKING TRAYS

Solid Plastic Tray	0.958
Slotted Plastic Tray	0.975

WEDGES

30° Wedge (10W x 15)	0.713
45° Wedge (10W x 15)	0.578
60° Wedge (10W x 15)	0.412

* Transmission factor = $\frac{\text{Dose rate with absorber}}{\text{Dose rate without absorber}}$

Measurement made at 5 cm depth in water phantom

NORMALIZED MEASURED OUTPUT FACTORS
Theratron 780 Cobalt 60 Teletherapy
Radiation Oncology Center
West Plains, Missouri

Field Size (cm x cm)	Output Factor *
5.0 x 5.7	0.956
6.0 x 6.0	0.966
7.0 X 7.0	0.973
8.0 x 8.0	0.983
9.0 x 9.0	0.993
10.0 x 10.0	1.000
12.0 x 12.0	1.017
14.0 x 14.0	1.031
16.0 x 16.0	1.042
18.0 x 18.0	1.052
20.0 x 20.0	1.059
22.0 x 22.0	1.067
25.0 x 25.0	1.076
30.0 x 30.0	1.081
35.0 x 35.0	1.080

* Measurements made at 5 cm depth in water phantom with 80 cm SSD and normalized to 10 x 10 cm^2 field.

OUTPUT FACTORS
AECL Theratron 780 Cobalt 60 Teletherapy
Radiation Oncology Center
West Plains, Missouri

Field Size (cm x cm)	Collimator Factor (S_c)	Treatment Area Factor (S_p)	Total Output Factor ($S_{c,p}$)
5.0 x 5.7	0.971	0.985	0.956
6.0 x 6.0	0.978	0.987	0.966
7.0 x 7.0	0.983	0.990	0.973
8.0 x 8.0	0.989	0.994	0.983
9.0 x 9.0	0.995	0.998	0.993
10.0 x 10.0	1.000	1.000	1.000
11.0 x 11.0	1.006	1.003	1.009
12.0 x 12.0	1.011	1.006	1.017
13.0 x 13.0	1.016	1.008	1.024
14.0 x 14.0	1.020	1.011	1.031
15.0 x 15.0	1.023	1.014	1.037
16.0 x 16.0	1.026	1.015	1.042
17.0 x 17.0	1.029	1.017	1.047
18.0 x 18.0	1.032	1.019	1.052
19.0 x 19.0	1.034	1.021	1.056
20.0 x 20.0	1.035	1.023	1.059
21.0 x 21.0	1.038	1.025	1.063
22.0 x 22.0	1.040	1.026	1.067
23.0 x 23.0	1.042	1.027	1.070
24.0 x 24.0	1.043	1.029	1.073
25.0 x 25.0	1.045	1.030	1.076
30.0 x 30.0	1.046	1.034	1.081
35.0 x 35.0	1.041	1.038	1.080

AECL THERATRON 780 COBALT-60 PERCENT DEPTH DOSE (80 CM SSD)

Field Size Depth, cm	4 x 4	5 x 5	6 x 6	7 x 7	8 x 8	9 x 9	10x10	11X11	12x12	13X13	14x14	15x15	16x16	17x17	18x18	19x19	20x20	Field Size Depth, cm
0.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.5
1.0	97.2	97.5	97.7	97.8	97.9	98.0	98.1	98.2	98.2	98.2	98.3	98.3	98.3	98.3	98.3	98.3	98.3	1.0
2.0	91.4	92.1	92.6	93.0	93.2	93.4	93.7	93.8	93.9	94.0	94.0	94.1	94.1	94.2	94.2	94.3	94.3	2.0
3.0	85.4	86.3	87.0	87.6	88.0	88.4	88.7	88.9	89.1	89.2	89.4	89.5	89.6	89.7	89.9	90.0	90.1	3.0
4.0	79.7	80.7	81.6	82.3	82.8	83.2	83.7	84.0	84.3	84.5	84.7	84.9	85.0	85.2	85.3	85.5	85.6	4.0
5.0	73.9	75.2	76.2	77.1	77.8	78.3	78.8	79.2	79.5	79.8	80.0	80.3	80.5	80.7	80.9	81.1	81.3	5.0
6.0	68.4	69.7	70.8	71.9	72.6	73.3	73.9	74.4	74.9	75.2	75.6	75.9	76.1	76.3	76.5	76.7	76.9	6.0
7.0	63.3	64.7	66.0	67.0	67.9	68.6	69.3	69.8	70.3	70.7	71.1	71.5	71.7	71.9	72.2	72.4	72.6	7.0
8.0	58.5	59.9	61.2	62.3	63.2	64.0	64.7	65.3	65.8	66.2	66.7	67.1	67.4	67.7	68.0	68.3	68.6	8.0
9.0	53.9	55.5	56.8	57.9	58.8	59.7	60.5	61.1	61.7	62.1	62.6	63.0	63.3	63.6	64.0	64.3	64.6	9.0
10.0	49.7	51.2	52.5	53.8	54.8	55.7	56.4	57.1	57.7	58.2	58.7	59.2	59.5	59.8	60.2	60.5	60.8	10.0
11.0	45.9	47.4	48.7	49.8	50.7	51.6	52.5	53.2	53.8	54.3	54.8	55.3	55.7	56.1	56.4	56.8	57.2	11.0
12.0	42.4	43.8	45.0	46.2	47.2	48.1	48.9	49.6	50.3	50.8	51.4	51.9	52.3	52.6	53.0	53.3	53.7	12.0
13.0	39.1	40.4	41.6	42.8	43.8	44.7	45.6	46.3	47.0	47.5	48.1	48.6	49.0	49.4	49.7	50.1	50.5	13.0
14.0	36.1	37.3	38.7	39.7	40.7	41.6	42.4	43.1	43.7	44.3	44.8	45.4	45.8	46.2	46.6	47.0	47.4	14.0
15.0	33.2	34.5	35.7	36.7	37.6	38.5	39.4	40.1	40.8	41.4	41.9	42.5	42.9	43.3	43.7	44.1	44.5	15.0
16.0	30.8	31.9	33.0	34.0	35.0	35.9	36.8	37.5	38.1	38.6	39.2	39.7	40.1	40.5	41.0	41.4	41.8	16.0
17.0	28.3	29.5	30.5	31.5	32.5	33.3	34.1	34.8	35.5	36.0	36.6	37.1	37.5	37.9	38.4	38.8	39.2	17.0
18.0	26.2	27.3	28.3	29.3	30.2	30.9	31.7	32.4	33.1	33.6	34.2	34.7	35.1	35.5	35.9	36.3	36.7	18.0
19.0	24.1	25.1	26.1	27.1	28.0	28.8	29.5	30.2	30.8	31.3	31.9	32.4	32.8	33.2	33.6	34.0	34.4	19.0
20.0	22.2	23.2	24.1	25.0	25.8	26.6	27.4	28.1	28.7	29.2	29.7	30.2	30.6	31.0	31.4	31.8	32.2	20.0
21.0	20.6	21.6	22.4	23.3	24.1	24.8	25.6	26.2	26.9	27.4	27.9	28.4	28.7	29.1	29.5	29.9	30.3	21.0
22.0	19.0	19.9	20.7	21.5	22.3	23.0	23.7	24.4	25.0	25.5	26.0	26.5	26.9	27.3	27.6	28.0	28.4	22.0
23.0	17.6	18.5	19.2	20.0	20.8	21.5	22.1	22.7	23.4	23.8	24.3	24.8	25.2	25.5	25.9	26.3	26.7	23.0
24.0	16.2	17.0	17.7	18.5	19.2	19.9	20.5	21.1	21.7	22.2	22.6	23.1	23.5	23.8	24.2	24.5	24.9	24.0
25.0	15.0	15.8	16.5	17.2	17.9	18.6	19.2	19.7	20.3	20.8	21.2	21.7	22.0	22.4	22.7	23.1	23.4	25.0
26.0	13.8	14.5	15.2	15.9	16.6	17.2	17.8	18.4	18.9	19.3	19.8	20.2	20.5	20.9	21.2	21.6	21.9	26.0
27.0	12.8	13.5	14.2	14.9	15.5	16.1	16.6	17.1	17.7	18.1	18.5	19.0	19.3	19.6	19.9	20.3	20.6	27.0
28.0	11.8	12.5	13.1	13.8	14.4	14.9	15.4	15.9	16.4	16.8	17.3	17.7	18.0	18.3	18.7	19.0	19.3	28.0
29.0	11.0	11.6	12.2	12.8	13.4	13.9	14.4	14.8	15.3	15.7	16.1	16.6	16.9	17.2	17.5	17.8	18.2	29.0
30.0	10.1	10.7	11.2	11.8	12.3	12.8	13.3	13.8	14.2	14.6	15.0	15.4	15.7	16.0	16.4	16.7	17.0	30.0

AECL THERATRON 780 COBALT-60 PERCENT DEPTH DOSE (80 CM SSD)

Field Size	20x20	21x21	22x22	23x23	24x24	25x25	26x26	27x27	28x28	29x29	30x30	31X31	32x32	33X33	34X34	35x35	Field Size
Depth, cm	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	Depth, cm
0.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.5
1.0	98.3	98.3	98.3	98.4	98.4	98.4	98.4	98.4	98.5	98.5	98.5	98.5	98.5	98.5	98.5	98.5	1.0
2.0	94.3	94.3	94.4	94.4	94.5	94.5	94.5	94.6	94.6	94.7	94.7	94.7	94.7	94.8	94.8	94.8	2.0
3.0	90.1	90.1	90.2	90.2	90.3	90.3	90.3	90.4	90.4	90.5	90.5	90.5	90.5	90.6	90.6	90.6	3.0
4.0	85.6	85.7	85.8	85.8	85.9	86.0	86.1	86.1	86.2	86.2	86.3	86.3	86.4	86.4	86.5	86.5	4.0
5.0	81.3	81.4	81.5	81.5	81.6	81.7	81.8	81.9	81.9	82.0	82.1	82.2	82.2	82.3	82.3	82.4	5.0
6.0	76.9	77.0	77.1	77.3	77.4	77.5	77.6	77.7	77.9	78.0	78.1	78.2	78.2	78.3	78.3	78.4	6.0
7.0	72.6	72.7	72.9	73.0	73.2	73.3	73.4	73.5	73.7	73.8	73.9	74.0	74.1	74.1	74.2	74.3	7.0
8.0	68.6	68.8	69.0	69.1	69.3	69.5	69.6	69.7	69.9	70.0	70.1	70.2	70.3	70.3	70.4	70.5	8.0
9.0	64.6	64.8	65.0	65.2	65.4	65.6	65.7	65.9	66.0	66.2	66.3	66.4	66.5	66.6	66.7	66.8	9.0
10.0	60.8	61.0	61.2	61.5	61.7	61.9	62.0	62.2	62.3	62.5	62.6	62.7	62.8	63.0	63.1	63.2	10.0
11.0	57.2	57.4	57.6	57.9	58.1	58.3	58.5	58.6	58.8	58.9	59.1	59.2	59.4	59.5	59.7	59.8	11.0
12.0	53.7	54.0	54.2	54.5	54.7	55.0	55.2	55.3	55.5	55.6	55.8	55.9	56.1	56.2	56.4	56.5	12.0
13.0	50.5	50.8	51.0	51.3	51.5	51.8	52.0	52.2	52.4	52.6	52.8	52.9	53.0	53.2	53.3	53.4	13.0
14.0	47.4	47.7	47.9	48.2	48.4	48.7	48.9	49.1	49.4	49.6	49.8	49.9	50.1	50.2	50.4	50.5	14.0
15.0	44.5	44.8	45.1	45.3	45.6	45.9	46.1	46.3	46.5	46.7	46.9	47.0	47.2	47.3	47.5	47.6	15.0
16.0	41.8	42.1	42.4	42.6	42.9	43.2	43.4	43.6	43.8	44.0	44.2	44.4	44.5	44.7	44.8	45.0	16.0
17.0	39.2	39.5	39.7	40.0	40.2	40.5	40.7	40.9	41.2	41.4	41.6	41.8	41.9	42.1	42.2	42.4	17.0
18.0	36.7	37.0	37.3	37.5	37.8	38.1	38.3	38.5	38.8	39.0	39.2	39.3	39.5	39.6	39.8	39.9	18.0
19.0	34.4	34.7	35.0	35.2	35.5	35.8	36.0	36.2	36.5	36.7	36.9	37.1	37.2	37.4	37.5	37.7	19.0
20.0	32.2	32.5	32.7	33.0	33.2	33.5	33.7	34.0	34.2	34.5	34.7	34.9	35.0	35.2	35.3	35.5	20.0
21.0	30.3	30.6	30.8	31.1	31.4	31.7	31.9	32.1	32.3	32.5	32.8	32.9	33.1	33.2	33.4	33.5	21.0
22.0	28.4	28.7	29.0	29.2	29.5	29.8	30.0	30.2	30.4	30.6	30.8	30.9	31.1	31.2	31.4	31.5	22.0
23.0	26.7	26.9	27.2	27.5	27.7	28.0	28.2	28.4	28.6	28.8	29.1	29.2	29.4	29.5	29.7	29.8	23.0
24.0	24.9	25.2	25.4	25.7	25.9	26.2	26.4	26.6	26.9	27.1	27.3	27.5	27.6	27.8	27.9	28.1	24.0
25.0	23.4	23.7	23.9	24.2	24.4	24.7	24.9	25.1	25.3	25.5	25.8	25.9	26.1	26.2	26.4	26.5	25.0
26.0	21.9	22.2	22.4	22.7	22.9	23.2	23.4	23.6	23.8	24.0	24.2	24.3	24.5	24.6	24.8	24.9	26.0
27.0	20.6	20.9	21.1	21.4	21.6	21.9	22.1	22.3	22.5	22.7	22.9	23.0	23.1	23.2	23.4	23.5	27.0
28.0	19.3	19.6	19.8	20.1	20.3	20.6	20.8	21.0	21.1	21.3	21.5	21.6	21.7	21.9	22.0	22.1	28.0
29.0	18.2	18.4	18.7	18.9	19.2	19.4	19.6	19.7	19.9	20.1	20.3	20.4	20.5	20.6	20.7	20.9	29.0
30.0	17.0	17.2	17.5	17.7	18.0	18.2	18.4	18.5	18.7	18.8	19.0	19.1	19.2	19.4	19.5	19.6	30.0

AECL THERATRON 780 COBALT-60 TAR TABLE

Field Size Depth, cm	4 x 4	5 x 5	6 x 6	7 x 7	8 x 8	9 x 9	10x10	11x11	12x12	13x13	14x14	15x15	16x16	17x17	18x18	19x19	20x20	Field Size Depth, cm
0.5	1.014	1.018	1.022	1.025	1.029	1.033	1.035	1.038	1.041	1.044	1.046	1.049	1.051	1.053	1.055	1.057	1.059	0.5
1.0	0.998	1.004	1.011	1.016	1.021	1.025	1.029	1.032	1.035	1.038	1.041	1.044	1.046	1.048	1.050	1.052	1.054	1.0
2.0	0.961	0.972	0.981	0.988	0.994	0.999	1.005	1.009	1.013	1.017	1.020	1.024	1.026	1.029	1.031	1.034	1.036	2.0
3.0	0.919	0.932	0.944	0.953	0.961	0.968	0.974	0.979	0.984	0.988	0.992	0.996	0.999	1.003	1.006	1.010	1.013	3.0
4.0	0.877	0.892	0.905	0.915	0.925	0.933	0.940	0.947	0.953	0.958	0.962	0.967	0.971	0.974	0.978	0.981	0.985	4.0
5.0	0.832	0.849	0.864	0.876	0.888	0.897	0.905	0.912	0.919	0.925	0.930	0.936	0.940	0.944	0.949	0.953	0.957	5.0
6.0	0.787	0.805	0.820	0.835	0.847	0.858	0.868	0.876	0.884	0.891	0.897	0.904	0.908	0.912	0.917	0.921	0.925	6.0
7.0	0.743	0.763	0.780	0.795	0.808	0.820	0.830	0.839	0.848	0.855	0.863	0.870	0.875	0.879	0.884	0.888	0.893	7.0
8.0	0.702	0.721	0.738	0.754	0.768	0.780	0.791	0.801	0.810	0.818	0.826	0.834	0.839	0.845	0.850	0.856	0.861	8.0
9.0	0.660	0.680	0.699	0.715	0.729	0.742	0.755	0.765	0.775	0.783	0.791	0.799	0.805	0.811	0.816	0.822	0.828	9.0
10.0	0.620	0.642	0.659	0.676	0.692	0.706	0.718	0.728	0.738	0.747	0.756	0.765	0.771	0.777	0.783	0.789	0.795	10.0
11.0	0.585	0.604	0.623	0.639	0.654	0.663	0.680	0.691	0.702	0.711	0.720	0.729	0.736	0.742	0.749	0.755	0.762	11.0
12.0	0.550	0.570	0.587	0.603	0.618	0.632	0.646	0.657	0.668	0.677	0.687	0.696	0.703	0.710	0.716	0.723	0.730	12.0
13.0	0.517	0.536	0.553	0.569	0.584	0.598	0.612	0.624	0.635	0.644	0.654	0.663	0.670	0.677	0.685	0.692	0.699	13.0
14.0	0.487	0.505	0.521	0.539	0.553	0.566	0.579	0.591	0.602	0.611	0.621	0.630	0.638	0.645	0.653	0.660	0.668	14.0
15.0	0.457	0.474	0.491	0.507	0.520	0.533	0.547	0.559	0.571	0.581	0.590	0.600	0.608	0.615	0.623	0.630	0.638	15.0
16.0	0.431	0.448	0.463	0.477	0.491	0.505	0.518	0.530	0.542	0.552	0.561	0.571	0.579	0.586	0.594	0.601	0.609	16.0
17.0	0.403	0.420	0.436	0.450	0.463	0.477	0.490	0.501	0.512	0.522	0.532	0.542	0.550	0.557	0.565	0.572	0.580	17.0
18.0	0.380	0.395	0.410	0.425	0.439	0.451	0.463	0.474	0.485	0.495	0.504	0.514	0.522	0.530	0.537	0.545	0.553	18.0
19.0	0.356	0.370	0.385	0.399	0.412	0.425	0.438	0.449	0.459	0.469	0.478	0.488	0.496	0.503	0.511	0.518	0.526	19.0
20.0	0.335	0.348	0.362	0.375	0.387	0.399	0.411	0.422	0.433	0.443	0.452	0.462	0.470	0.477	0.485	0.492	0.500	20.0
21.0	0.316	0.328	0.342	0.354	0.366	0.378	0.389	0.400	0.411	0.420	0.430	0.439	0.447	0.454	0.462	0.469	0.477	21.0
22.0	0.297	0.308	0.321	0.333	0.344	0.356	0.367	0.378	0.388	0.397	0.407	0.416	0.423	0.431	0.438	0.446	0.453	22.0
23.0	0.279	0.290	0.303	0.314	0.325	0.336	0.347	0.357	0.367	0.376	0.385	0.395	0.402	0.409	0.416	0.424	0.431	23.0
24.0	0.260	0.272	0.284	0.295	0.305	0.316	0.326	0.336	0.346	0.355	0.364	0.373	0.380	0.387	0.395	0.402	0.409	24.0
25.0	0.245	0.256	0.267	0.278	0.288	0.299	0.309	0.318	0.328	0.336	0.345	0.354	0.361	0.368	0.375	0.382	0.390	25.0
26.0	0.230	0.239	0.250	0.261	0.270	0.281	0.291	0.300	0.309	0.318	0.326	0.335	0.342	0.349	0.356	0.363	0.370	26.0
27.0	0.217	0.226	0.236	0.246	0.255	0.266	0.276	0.284	0.293	0.301	0.309	0.317	0.324	0.331	0.338	0.345	0.352	27.0
28.0	0.203	0.212	0.222	0.231	0.240	0.250	0.260	0.268	0.276	0.284	0.291	0.299	0.306	0.313	0.320	0.327	0.334	28.0
29.0	0.191	0.200	0.209	0.218	0.227	0.236	0.245	0.253	0.261	0.268	0.276	0.284	0.290	0.297	0.304	0.310	0.317	29.0
30.0	0.178	0.187	0.196	0.205	0.213	0.221	0.229	0.237	0.245	0.253	0.260	0.268	0.274	0.281	0.287	0.294	0.300	30.0

AECL THERATRON 780 COBALT-60 TAR TABLE

Field Size Depth, cm	20x20	21x21	22x22	23x23	24x24	25x25	26x26	27x27	28x28	29x29	30x30	31x31	32x32	33x33	34x34	35x35	Field Size Depth, cm
0.5	1.059	1.060	1.062	1.063	1.065	1.066	1.067	1.068	1.068	1.069	1.070	1.071	1.072	1.072	1.073	1.074	0.5
1.0	1.054	1.056	1.057	1.059	1.060	1.062	1.063	1.064	1.065	1.066	1.067	1.068	1.069	1.069	1.070	1.071	1.0
2.0	1.036	1.038	1.040	1.041	1.043	1.045	1.046	1.047	1.049	1.050	1.051	1.052	1.053	1.054	1.055	1.056	2.0
3.0	1.013	1.015	1.017	1.018	1.020	1.022	1.023	1.025	1.026	1.028	1.029	1.030	1.031	1.032	1.033	1.034	3.0
4.0	0.985	0.987	0.989	0.992	0.994	0.996	0.998	0.999	1.001	1.002	1.004	1.005	1.006	1.008	1.009	1.010	4.0
5.0	0.957	0.959	0.962	0.964	0.967	0.969	0.971	0.973	0.974	0.976	0.978	0.979	0.980	0.982	0.983	0.984	5.0
6.0	0.925	0.928	0.931	0.934	0.937	0.940	0.942	0.944	0.946	0.948	0.950	0.952	0.953	0.955	0.956	0.958	6.0
7.0	0.893	0.896	0.899	0.902	0.905	0.908	0.910	0.913	0.915	0.918	0.920	0.922	0.923	0.925	0.926	0.928	7.0
8.0	0.861	0.865	0.868	0.872	0.875	0.879	0.882	0.884	0.887	0.889	0.892	0.894	0.895	0.897	0.898	0.900	8.0
9.0	0.828	0.832	0.836	0.839	0.843	0.847	0.850	0.853	0.855	0.858	0.861	0.863	0.865	0.867	0.869	0.871	9.0
10.0	0.795	0.799	0.803	0.808	0.812	0.816	0.819	0.822	0.824	0.827	0.830	0.832	0.834	0.837	0.839	0.841	10.0
11.0	0.762	0.766	0.771	0.775	0.780	0.784	0.787	0.790	0.794	0.797	0.800	0.802	0.804	0.807	0.809	0.811	11.0
12.0	0.730	0.735	0.739	0.744	0.748	0.753	0.756	0.760	0.763	0.767	0.770	0.772	0.775	0.777	0.780	0.782	12.0
13.0	0.699	0.704	0.709	0.713	0.718	0.723	0.727	0.730	0.734	0.737	0.741	0.744	0.747	0.749	0.752	0.755	13.0
14.0	0.668	0.673	0.678	0.683	0.688	0.693	0.697	0.700	0.704	0.707	0.711	0.714	0.717	0.720	0.723	0.726	14.0
15.0	0.638	0.643	0.648	0.654	0.659	0.664	0.668	0.672	0.675	0.679	0.683	0.686	0.689	0.692	0.695	0.698	15.0
16.0	0.609	0.614	0.620	0.625	0.631	0.636	0.640	0.644	0.647	0.651	0.655	0.658	0.661	0.665	0.668	0.671	16.0
17.0	0.580	0.585	0.591	0.596	0.602	0.607	0.611	0.615	0.619	0.623	0.627	0.630	0.634	0.637	0.641	0.644	17.0
18.0	0.553	0.558	0.564	0.569	0.575	0.580	0.584	0.588	0.592	0.596	0.600	0.604	0.607	0.611	0.614	0.618	18.0
19.0	0.526	0.531	0.537	0.542	0.548	0.553	0.557	0.562	0.566	0.571	0.575	0.578	0.582	0.585	0.589	0.592	19.0
20.0	0.500	0.505	0.511	0.516	0.522	0.527	0.531	0.535	0.540	0.544	0.548	0.552	0.555	0.559	0.562	0.566	20.0
21.0	0.477	0.482	0.488	0.493	0.499	0.504	0.508	0.513	0.517	0.521	0.526	0.529	0.533	0.537	0.540	0.544	21.0
22.0	0.453	0.459	0.464	0.470	0.475	0.481	0.485	0.490	0.494	0.499	0.503	0.507	0.511	0.514	0.518	0.522	22.0
23.0	0.431	0.437	0.442	0.448	0.453	0.459	0.463	0.468	0.472	0.476	0.481	0.484	0.488	0.492	0.496	0.500	23.0
24.0	0.409	0.415	0.420	0.426	0.431	0.437	0.441	0.445	0.450	0.454	0.458	0.462	0.466	0.469	0.473	0.477	24.0
25.0	0.390	0.395	0.400	0.406	0.411	0.417	0.421	0.425	0.429	0.433	0.438	0.441	0.445	0.449	0.453	0.457	25.0
26.0	0.370	0.375	0.380	0.386	0.391	0.396	0.400	0.404	0.409	0.413	0.417	0.421	0.425	0.428	0.432	0.436	26.0
27.0	0.352	0.357	0.362	0.368	0.373	0.378	0.382	0.387	0.391	0.395	0.400	0.403	0.407	0.411	0.414	0.418	27.0
28.0	0.334	0.339	0.344	0.350	0.355	0.360	0.364	0.369	0.373	0.378	0.382	0.386	0.389	0.393	0.396	0.400	28.0
29.0	0.317	0.322	0.327	0.333	0.338	0.343	0.347	0.352	0.356	0.360	0.365	0.368	0.372	0.375	0.379	0.383	29.0
30.0	0.300	0.305	0.310	0.316	0.321	0.326	0.330	0.334	0.339	0.343	0.347	0.351	0.354	0.358	0.361	0.365	30.0

AECL THERATRON 780 COBALT-60 TMR TABLE

Field Size / Depth, cm	4 x 4	5 x 5	6 x 6	7 x 7	8 x 8	9 x 9	10x10	11x11	12x12	13x13	14x14	15x15	16x16	17x17	18x18	19x19	20x20	Field Size Depth, cm
0.5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.5
1.0	0.984	0.986	0.989	0.991	0.992	0.992	0.994	0.994	0.994	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	1.0
2.0	0.948	0.955	0.960	0.964	0.966	0.967	0.971	0.972	0.973	0.974	0.975	0.976	0.977	0.977	0.977	0.978	0.978	2.0
3.0	0.906	0.916	0.924	0.930	0.934	0.937	0.941	0.943	0.945	0.947	0.948	0.949	0.951	0.952	0.954	0.955	0.957	3.0
4.0	0.865	0.876	0.886	0.893	0.899	0.903	0.908	0.912	0.915	0.918	0.920	0.922	0.924	0.925	0.927	0.928	0.930	4.0
5.0	0.821	0.834	0.845	0.855	0.863	0.868	0.874	0.879	0.883	0.886	0.889	0.892	0.895	0.897	0.899	0.901	0.904	5.0
6.0	0.776	0.791	0.802	0.815	0.823	0.831	0.839	0.844	0.849	0.853	0.858	0.862	0.864	0.866	0.869	0.871	0.873	6.0
7.0	0.733	0.750	0.763	0.776	0.785	0.794	0.802	0.808	0.815	0.820	0.824	0.829	0.832	0.835	0.838	0.840	0.843	7.0
8.0	0.692	0.708	0.722	0.736	0.746	0.755	0.764	0.771	0.778	0.784	0.789	0.795	0.799	0.802	0.806	0.809	0.813	8.0
9.0	0.651	0.668	0.684	0.698	0.708	0.718	0.729	0.737	0.744	0.750	0.756	0.762	0.766	0.770	0.774	0.778	0.782	9.0
10.0	0.611	0.631	0.645	0.660	0.672	0.683	0.694	0.701	0.709	0.716	0.723	0.729	0.734	0.738	0.742	0.746	0.751	10.0
11.0	0.577	0.593	0.610	0.623	0.636	0.642	0.657	0.666	0.674	0.681	0.688	0.695	0.700	0.705	0.710	0.715	0.720	11.0
12.0	0.542	0.560	0.574	0.588	0.601	0.612	0.624	0.633	0.642	0.649	0.656	0.663	0.669	0.674	0.679	0.684	0.689	12.0
13.0	0.510	0.527	0.541	0.555	0.568	0.579	0.591	0.601	0.610	0.617	0.625	0.632	0.638	0.643	0.649	0.654	0.660	13.0
14.0	0.480	0.496	0.510	0.526	0.537	0.548	0.559	0.569	0.578	0.586	0.593	0.601	0.607	0.613	0.619	0.625	0.631	14.0
15.0	0.451	0.466	0.480	0.495	0.505	0.516	0.529	0.539	0.549	0.556	0.564	0.572	0.578	0.584	0.590	0.596	0.602	15.0
16.0	0.425	0.440	0.453	0.465	0.477	0.489	0.500	0.511	0.521	0.529	0.536	0.544	0.551	0.557	0.563	0.569	0.575	16.0
17.0	0.397	0.413	0.427	0.439	0.450	0.462	0.473	0.483	0.492	0.500	0.508	0.517	0.523	0.529	0.535	0.542	0.548	17.0
18.0	0.375	0.388	0.401	0.415	0.427	0.437	0.447	0.457	0.466	0.474	0.482	0.490	0.496	0.503	0.509	0.516	0.522	18.0
19.0	0.351	0.363	0.377	0.389	0.400	0.411	0.423	0.432	0.441	0.449	0.457	0.465	0.472	0.478	0.484	0.490	0.497	19.0
20.0	0.330	0.342	0.354	0.366	0.376	0.386	0.397	0.407	0.416	0.424	0.432	0.440	0.447	0.453	0.460	0.466	0.472	20.0
21.0	0.312	0.322	0.334	0.345	0.355	0.365	0.376	0.385	0.394	0.402	0.410	0.418	0.425	0.431	0.437	0.444	0.450	21.0
22.0	0.293	0.303	0.314	0.325	0.334	0.345	0.355	0.364	0.373	0.381	0.389	0.397	0.403	0.409	0.415	0.422	0.428	22.0
23.0	0.275	0.285	0.296	0.306	0.315	0.325	0.335	0.344	0.353	0.360	0.368	0.376	0.382	0.389	0.395	0.401	0.407	23.0
24.0	0.256	0.267	0.278	0.288	0.296	0.306	0.315	0.324	0.332	0.340	0.348	0.356	0.362	0.368	0.374	0.380	0.386	24.0
25.0	0.242	0.251	0.261	0.271	0.279	0.289	0.298	0.306	0.315	0.322	0.330	0.337	0.344	0.350	0.356	0.362	0.368	25.0
26.0	0.227	0.235	0.245	0.255	0.262	0.272	0.281	0.289	0.297	0.304	0.312	0.319	0.325	0.331	0.337	0.343	0.349	26.0
27.0	0.214	0.222	0.231	0.240	0.248	0.257	0.266	0.274	0.281	0.288	0.295	0.302	0.308	0.314	0.320	0.326	0.332	27.0
28.0	0.200	0.208	0.217	0.225	0.233	0.242	0.251	0.258	0.265	0.272	0.278	0.285	0.291	0.297	0.303	0.309	0.315	28.0
29.0	0.188	0.196	0.205	0.213	0.220	0.228	0.236	0.243	0.250	0.257	0.264	0.270	0.276	0.282	0.288	0.294	0.299	29.0
30.0	0.176	0.184	0.192	0.200	0.207	0.214	0.221	0.228	0.235	0.242	0.249	0.255	0.261	0.267	0.272	0.278	0.283	30.0

AECL THERATRON 780 COBALT-60 TMR TABLE

Field Size Depth, cm	20x20	21x21	22x22	23x23	24x24	25x25	26x26	27x27	28x28	29x29	30x30	31x31	32x32	33x33	34x34	35x35	Field Size Depth, cm
0.5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.5
1.0	0.995	0.995	0.996	0.996	0.996	0.996	0.996	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	1.0
2.0	0.978	0.979	0.979	0.979	0.980	0.980	0.981	0.981	0.981	0.982	0.982	0.982	0.983	0.983	0.983	0.983	2.0
3.0	0.957	0.957	0.957	0.958	0.958	0.959	0.959	0.960	0.961	0.961	0.962	0.962	0.962	0.962	0.963	0.963	3.0
4.0	0.930	0.931	0.932	0.933	0.933	0.934	0.935	0.936	0.937	0.938	0.938	0.939	0.939	0.940	0.940	0.940	4.0
5.0	0.904	0.905	0.906	0.907	0.908	0.909	0.910	0.911	0.912	0.913	0.914	0.914	0.915	0.915	0.916	0.916	5.0
6.0	0.873	0.875	0.877	0.878	0.880	0.882	0.883	0.884	0.885	0.887	0.888	0.889	0.890	0.890	0.891	0.892	6.0
7.0	0.843	0.845	0.847	0.848	0.850	0.852	0.853	0.855	0.857	0.858	0.860	0.861	0.862	0.862	0.863	0.864	7.0
8.0	0.813	0.815	0.818	0.820	0.822	0.825	0.826	0.828	0.830	0.832	0.834	0.835	0.835	0.836	0.837	0.838	8.0
9.0	0.782	0.784	0.787	0.790	0.792	0.795	0.797	0.799	0.801	0.803	0.805	0.806	0.807	0.808	0.810	0.811	9.0
10.0	0.751	0.754	0.757	0.760	0.763	0.765	0.768	0.770	0.772	0.774	0.776	0.777	0.779	0.780	0.782	0.783	10.0
11.0	0.720	0.723	0.726	0.729	0.732	0.735	0.738	0.740	0.743	0.745	0.748	0.749	0.751	0.752	0.754	0.755	11.0
12.0	0.689	0.693	0.696	0.700	0.703	0.706	0.709	0.712	0.714	0.717	0.720	0.721	0.723	0.725	0.726	0.728	12.0
13.0	0.660	0.664	0.667	0.671	0.675	0.678	0.681	0.684	0.687	0.690	0.693	0.695	0.697	0.699	0.701	0.703	13.0
14.0	0.631	0.635	0.639	0.642	0.646	0.650	0.653	0.656	0.659	0.662	0.664	0.667	0.669	0.671	0.674	0.676	14.0
15.0	0.602	0.607	0.611	0.615	0.619	0.623	0.626	0.629	0.632	0.635	0.638	0.641	0.643	0.645	0.648	0.650	15.0
16.0	0.575	0.579	0.584	0.588	0.592	0.597	0.600	0.603	0.606	0.609	0.612	0.615	0.617	0.620	0.622	0.625	16.0
17.0	0.548	0.552	0.556	0.561	0.565	0.569	0.573	0.576	0.579	0.583	0.586	0.589	0.591	0.594	0.597	0.600	17.0
18.0	0.522	0.527	0.531	0.535	0.540	0.544	0.547	0.551	0.554	0.557	0.561	0.564	0.567	0.570	0.572	0.575	18.0
19.0	0.497	0.501	0.506	0.510	0.514	0.519	0.522	0.526	0.530	0.534	0.537	0.540	0.543	0.546	0.548	0.551	19.0
20.0	0.472	0.477	0.481	0.486	0.490	0.494	0.498	0.501	0.505	0.509	0.512	0.515	0.518	0.521	0.524	0.527	20.0
21.0	0.450	0.455	0.459	0.464	0.468	0.473	0.476	0.480	0.484	0.487	0.491	0.494	0.497	0.500	0.503	0.507	21.0
22.0	0.428	0.432	0.437	0.442	0.447	0.451	0.455	0.459	0.463	0.466	0.470	0.473	0.476	0.480	0.483	0.486	22.0
23.0	0.407	0.412	0.416	0.421	0.426	0.431	0.434	0.438	0.442	0.445	0.449	0.452	0.455	0.459	0.462	0.465	23.0
24.0	0.386	0.391	0.396	0.400	0.405	0.410	0.414	0.417	0.421	0.424	0.428	0.431	0.434	0.438	0.441	0.444	24.0
25.0	0.368	0.372	0.377	0.382	0.386	0.391	0.394	0.398	0.402	0.405	0.409	0.412	0.415	0.419	0.422	0.425	25.0
26.0	0.349	0.354	0.358	0.363	0.367	0.371	0.375	0.379	0.382	0.386	0.390	0.393	0.396	0.399	0.403	0.406	26.0
27.0	0.332	0.337	0.341	0.346	0.350	0.355	0.358	0.362	0.366	0.370	0.373	0.377	0.380	0.383	0.386	0.389	27.0
28.0	0.315	0.320	0.324	0.329	0.333	0.338	0.342	0.345	0.349	0.353	0.357	0.360	0.363	0.366	0.369	0.372	28.0
29.0	0.299	0.304	0.308	0.313	0.317	0.322	0.326	0.329	0.333	0.337	0.341	0.344	0.347	0.350	0.353	0.356	29.0
30.0	0.283	0.288	0.292	0.297	0.301	0.306	0.310	0.313	0.317	0.321	0.324	0.327	0.331	0.334	0.337	0.340	30.0

APPENDIX

Calibration Report Survey

Name of Facility: Rapidan Oncology Center Date: 7/1/90

Address: Doctors' Pavilion
1115 Alaska Ave, Suite 116
West Plains, MO 65775

Telephone: (417) 256-7282

Type of Unit: AECL Theratron 780

Manufacturer: Atomic Energy of Canada, Ltd

Equipment Identification: AECL Theratron 780 (S/N 86)
Source is AECL Model C-146 (S/N S-3903) with 774 Curies
on 7/17/86

Room Location: _____

Description: Cobalt-60 Isocenter Rotational Unit

Person(s) Responsible, include title:

A. Liep Tjong Tio, M.D

B. _____

C. _____

Assigned Operating Personnel:

A. _____

B. _____

C. _____

Physicist(s) Making Report:

A. Dennis Frieda, Ph.D., Radiological Physicist

B. _____

Instruments Used:

A. Keithley 35617 Dosimeter, Serial # 22828

B. NEL Farmer Chamber, Model 2571, Serial # 912

C. Keithley Survey Meter, Model 36150, Serial # 22530

Dennis Frieda

Physicist

Radiation Protection Survey Date: 7/1/90

Institution: Radiation Oncology Center
West Plains

Unit: AECL Theratron 780

Room Location: _____

Type of Treatment: Fixed and Rotational

Adequate interlock system (doors, filters, wedges) Interlocks for door to treatment room, No interlock for wedges

Patient and control observed simultaneously yes, TV monitor at control console

Patient - operator communication available yes, intercom system to room

Radiation Area Posted yes

Primary Beam shield present (with interlocks) yes, interlocks allow beam to point only at floor or west wall

Emergency Procedures Posted yes.

Control Panel Lock yes

Emergency Shut OFF yes, on control panel and in room on hand control and on side of treatment stand

Indication that control console is ON yes, on control panel, above door to treatment room and on gantry head.

Indication that beam in ON yes, on control panel, above door to treatment room and on gantry head

Means provided for operator to terminate exposure at any time yes.

Timer terminates exposure yes

Leak Test Performed yes, wipes taken 6/5/90

Personnel monitored by film badges from Tech/Ops Landauer, Inc., 2 Science Road, Glenwood, IL

Monitoring records Acceptable low exposure

Physicist

Operational Performance Evaluation Date: 7/1/90

Institution: Radiation Oncology Center
West Plains, MO

Unit: AECL Theratron 780

Room Location: _____

Coincidence of the mechanical axis of the collimator assembly, the central axis of the light beam, and the cross hairs: OK

Coincidence of the light beam with the useful x-ray beam (acceptable: 1.5 mm) OK, checked for 6X6, 8X8, 10X10, 12X12, 16X16, 20X20 and 30X30 - all agree to within 1 mm.

Coincidence of light field, collimator dial setting, and x-ray beam sizes at the SAD or SSD distance (acceptable: agree within 1.5 mm) OK

Determination of the mechanical isocenter (acceptable: sphere of 2 mm) OK

Determination of the isocenter of the radiation beam

1) Collimation (acceptable: 1.5 mm in diameter circle) OK

2) Treatment table (acceptable: 1.5 mm in diameter circle) Table has too much play, does not meet criteria

3) Gantry (acceptable: 2 mm diameter circle) OK

Timer: Accuracy and linearity OK

SSD Indicators: Mechanical indicator within 1mm. Optical Indicator within 2mm for distances between 60 - 100 cm.

Beam Flatness (acceptable: Manufacture specifications - typically + 3% over central 80% of the largest field area at isocenter) OK, see scans

Beam Direction Dependence: Negligible

Jennifer Fowler
Physicist

CONTROL NO. 89918

Percentage Depth Dose Data Check Date: 7/1/90

Institution: Radiation Oncology Center
West Plains, MO

Unit: AECL Theratron 780

Room Location: _____

Using Keithley 35617 with NEL 2571 (#912) Chamber in water phantom.

Field Size 6x6 SSD 80 cm

Readings for 1.0 minute at indicated depth in water phantom.

5 cm depth with reported % depth dose 76.2.
20.19 20.20 20.20 Ave. 20.197.

10 cm depth with reported % depth dose 52.5.
13.930 13.932 13.937 Ave. 13.933. Cal. % D.D.* 52.0
9.Daff = +0.27

15 cm depth with reported % depth dose 35.7.
9.482 9.484 9.482 Ave. 9.483. Cal. % D.D.* 35.3
9.Daff = +0.37

Field size 10x10 SSD 80

Readings for 1.00 minute at ind'cated depth in water phantom.

5 cm depth with reported % depth dose 78.8.
21.64 21.66 21.67 Ave. 21.657.

10 cm depth with reported % depth dose 56.4.
15.548 15.552 15.555 Ave. 15.552. Cal. % D.D.* 56.6
9.Daff = +0.47

15 cm depth with reported % depth dose 39.4.
10.891 10.896 10.894 Ave. 10.894. Cal. % D.D.* 39.6
9.Daff = +0.57

Field size 20x20 SSD 80 cm

Readings for 1.00 minute at indicated depth in water phantom.

5cm depth with reported % depth dose 81.3.
23.66 23.67 23.68 Ave. 23.67.

10 cm depth with reported % depth dose 60.8.
17.732 17.729 17.732 Ave. 17.731. Cal. %D.D.* 60.9
9.Daff = +0.27

15 cm depth with reported % depth dose 44.5.
12.998 12.996 12.994 Ave. 12.996. Cal. % D.D.* 44.6
9.Daff = +0.27

* The dose measured at 5 cm depth has been normalized to the reported depth dose for the field size and the corresponding depth doses at 10 and 15 cm calculated.

9.Dd Table is appropriate for unit.

Dennis Farrell
Physicist

Timer and Linearity Evaluation: Date: 7/2/90

Institution: Radiation Oncology Center
West Plains, MO

Unit: AECL THERATRON 780

Room Location: _____

Measuring Instrument: Keithley 35617 with NFL 2571 (#9,12)

Technique: 10×10 cm² field, 32 cm SSD

Measurements at 5.0 cm depth in water phantom

Setting Time	Instrument Reading	Measured Time
0.5	10.636 10.647	30 17/20" 30 21/20"
1.00	21.64	1' 00 22/20"
1.50	32.64	1' 30 17/20"
2.00	43.64	2' 00 19/20"
3.00	65.64	3' 00 23/20"
5.00	109.62	5' 00 21/20"

Comments:

$f(1.00) = 21.641$

$r = 1.0000$

Time + Linearity - OK

Dennis Knuckles

Physicist

Solid Tray

Tray Factor

Date: 7/1/90

Institution: Radiation Oncology Center
West Plains, MO

Unit: AECL Theratron 780

Room Location: _____

Technique: 10×10 cm² field, 80 cm SSD

Measurements at 5.0 cm depth in water phantom

Measuring Instrument: Keithley 35617 with NEL 2571 (#912)

Setting: 2.00 minute

Readings without Tray

21.59
21.60
21.61
21.60

Average 21.60

Readings with Tray Solid Tray (~¼" Acrylic)

20.68
20.70
20.70
20.69

Average 20.69

Tray Factor = $\frac{\text{Average Reading with Tray}}{\text{Average Reading without Tray}}$

$TF = \frac{20.69}{21.60} = .958$

Previous Tray Factor: .958

% Diff = 0.0%

Physicist

Slotted Tray

Tray Factor

Date: 7/1/90

Institution: Radiation Oncology Center
West Plains, MO

Unit: AECL Theratron 780

Room Location: _____

Technique: 10 x 10 cm² Field

Measurements at 5.0 cm depth in water phantom

Measuring Instrument: Keithley 35617 with NE 2571 (#912)

Setting: 1.00 min

Readings without Tray

21.61
21.60
21.62
21.61

Average 21.610

Readings with Tray Slotted Trays

21.05
21.05
21.10
21.11

Average 21.078

Tray Factor = $\frac{\text{Average Reading with Tray}}{\text{Average Reading without Tray}}$

$TF = \frac{21.078}{21.610} = 0.975$

Previous Tray Factor: 0.976

0.976 - 0.975 = 0.1%

Physicist

CONTROL NO. 89918

30° WEDGE

Wedge Factor Date: 7/1/90

Institution: RADIATION ONCOLOGY CENTER
WEST PLAINS, MO

Unit: AECL THERATRON 780

Room Location: _____

Wedge Description: FIELD: 10 W X 15
SSD: 80 cm
SDD: 45 cm
CAT. NO. 622-151C

Technique: 80 cm SSD, 8 X 13 cm^2 field

Measurements at: 5.0 cm depth in WATER

Measuring Instrument: Keithley 35617 with NEL 2571 (#917) Chamber

Setting: 1.00 MIN-1E

Collimator Angle	Readings Without Wedge	Readings With Wedge (30°) Wedge Code: NA	
270	21.61	15.437	
270	21.59	15.436	
270	21.60	15.435	
90	21.59	15.348	
90	21.60	15.351	
90	21.61	15.352	
Average of Readings:	21.60	15.393	

Wedge Factor = $\frac{\text{Average of readings with wedge filter}}{\text{Average of readings without wedge filter}}$

$$WF = \frac{15.393}{21.60} = .713$$

Previous Wedge Factor: 0.713

% Diff = 0.0%

Dennis Fowler
Physicist

45° WEDGE

Wedge Factor Date: 7/1/90

Institution: RADIATION Oncology Center
West Plains, MO

Unit: AECL THERATRON 780

Room Location:

Wedge Description: Field: 10 W X 15
SSD: 80 cm
SDD: 45° cm
Cal. No. G22-152C

Technique: 8X13 cm² field, 80 cm SSD

Measurements at: 5.0 cm depth in WATER

Measuring Instrument: Keithley 35617 with NE 2571 (# 912) Chamber

Setting: 1.00 mm

Collimator Angle	Readings Without Wedge	Readings With Wedge (45°) Wedge Code: NA	
90	21.59	12.422	
90	21.61	12.426	
90	21.60	12.427	
270	21.61	12.562	
270	~~21.63~~ 21.63	12.562	
270	21.63	12.565	
Average of Readings:	21.612	12.494	

Wedge Factor = Average of readings with wedge filter / Average of readings without wedge filter

$$WF = \frac{12.494}{21.612} = .578$$

Previous Wedge Factor: 0.579

% Diff = -0.2%

Dennis Friedl
Physicist

60° WEDGE

Wedge Factor Date: 7/1/90

Institution: RADIATION ONCOLOGY CENTER
WEST PLAINS, MO

Unit: AECL THERATRON 780

Room Location: _____

Wedge Description: Field: 10 x 15
SSD: 80 cm
SPD: 45 cm
Cat. No. 622-153C

Technique: 8 X 13 cm² field, 80 cm SSD

Measurements at: 5.0 cm depth in water

Measuring Instrument: Keithley 35617 with NEL 2571 (#91) Chamber

Setting: 1.00 min

Collimator Angle	Readings Without Wedge	Readings With Wedge (60°) Wedge Code: NA	
270	21.61	8.979	
270	21.63	8.978	
270	21.63	8.979	
90	21.61	8.844	
90	21.61	8.839	
90	21.62	8.837	
Average of Readings:	21.618	8.909	

Wedge Factor = Average of readings with wedge filter / Average of readings without wedge filter

$$WF. = \frac{8.909}{21.618} = 0.412$$

Previous Wedge Factor: 0.411

% Diff = 0.27

Dennis Lovelace
Physicist

Output Determination (PAGE 1) Date: 7/2/90

Institution: RADIATION ONCOLOGY CENTER
WEST PLAINS, MO

Unit: AECL THERATRON 780

Location: _____

Technique: 80 cm SSD

Measuring Instrument: KEITHLEY 35617
with 2571 #912

Measurements at: 5.0 cm depth in WATER phantom

Beam Size square (a)	Instrument Readings for setting 1.00 (b)	Mean (c)	Associated 10 cm square valve (d)	Ratio (e)	% DD at 5 / 80 for SSD (f)	Relative output (g)	Output Normalized to 10x10 (h)
10 X 10	21.67 21.65 21.64	21.637	21.635		78.8	1.2690	1.00
5 X 5.7 (minimum field) (Cell @ 135°)	19.817 19.820 19.817	19.818	21.635	0.9160	75.5	1.2133	.956
6 X 6 (Cell @ 135°)	20.18 20.21 20.21	20.200	21.635	0.9337	76.2	1.2253	.966
7 X 7 (Cell @ 135°)	20.60 20.60 20.61	20.603	21.635	0.9523	77.1	1.2351	.973
8 X 8 (Cell @ 135°)	20.99 21.00 21.00	20.997	21.635	0.9705	77.8	1.2474	.983

Output Determination (page 2)

Date: 7/2/90

Institution: Radiation Oncology Center
West Plains, MO

Unit: AECL Theratron 780

Location: _____

Technique: 80 cm SSD

Measuring Instrument: Keithley 35617 with NEL 2571 (#912)

Measurements at: 5.0 cm depth in water phantom

Beam Size square (a)	Instrument Readings for setting 1.00 (b)	Mean (c)	Associated 10 cm square valve (d)	Ratio (e)	% DD at 5.0 for SSD 80 (f)	Relative output (g)	Output Normalized to 10x10 (h)
10 X10	21.61 21.65 21.64	21.633	21.630		79.8	1.2690	1.00
9X 9	21.34 21.36 21.35	21.350	21.630	.9871	78.3	1.2606	.993
12X12	22.18 22.20 22.17	22.183	21.630	1.0256	79.5	1.2900	1.017
14X 14	22.64 22.65 22.66	22.650	21.630	1.0472	80.0	1.3059	1.031
16X16	23.02 23.04 23.03	23.030	21.630	1.0647	80.5	1.3226	1.042

CONTROL NO 81668

Output Determination (Page 3)

Date: 7/2/90

Institution: Radiation Oncology Center
West Plains, MO

Unit: AECL Theratron 780

Location: _____

Technique: 80 cm SSD

Measuring Instrument: Keithley 35617 with NEL 2571 (#912) Chamber

Measurements at: 5.0 cm depth in water phantom

Beam Size square (a)	Instrument Readings for setting 1.00 minute (b)	Mean (c)	Associated 10 cm square valve (d)	Ratio (e)	% DD at 5 / 80 for SSD (f)	Relative output (g)	Output Normalized to 10x10 (h)
10x10	21.63 21.63 21.62	21.627			78.8	1.2690	
18x18	23.35 23.37 23.36	23.360	21.630	1.0800	80.9	1.3350	1.052
20x20	23.63 23.64 23.64	23.637	21.630	1.9280	813	1.3441	1.059
22x22	23.85 23.87 23.86	23.860	21.630	1.1031	81.5	1.3535	1.067
25x25	24.12 24.12 24.13	24.123	21.630	1.1153	81.7	1.3651	1.076

Output Determination (Page 4)

Date: 7/2/90

Institution: Radiation Oncology Center
West Plains MO

Unit: AECL Theratron 780

Location: _____

Technique: 80 cm SSD

Measuring Instrument: Keithley 35617
with NEL 2571 #912

Measurements at: 5.0 cm depth in water

Beam Size square (a)	Instrument Readings for setting 1.00 min (b)	Mean (c)	Associated 10 cm square valve (d)	Ratio (e)	% DD at 5.0 for SSD 80 (f)	Relative output (g)	Output Normalized to 10 x 10 (h)
10 x 10	21.62 21.65 21.63	21.633			78.8	1.2690	1.000
28 x 28	24.29 24.31 24.30	24.300	21.633	1.1233	81.9	1.3715	1.081
30 x 30	24.37 24.38 24.37	24.373	21633	1.1267	82.1	1.3723	1081
35 x 35	24.42 24.42 24.42	24.420	21.633	1.1288	82.4	1.3699	1.080
10 x 10	21.62 21.64 21.64	21.633			78.8		

Calibrated Measurement of Peak Dose Rate for 10 cm Square Beam

Date: 7/2/90

Institution: RADIATION ONCOLOGY CENTER

Unit: AECL THERATRON 780

Room Location: _____

Technique: 10×10 cm² field, 80 cm SSD

Measurements at: 5.0 cm depth in WATER phantom

Measuring Instrument: Keithley 35617 with NEL 2571 (#912)

Instrument Readings:

Setting: 1.00 minute	2 × 0.5 min	1.00 min ($V = V_{1/2}$)
21.62	21.31	21.61
21.64	21.29	21.61
21.62	21.31	21.60
21.64	21.31	21.61
21.64	21.305	21.61
Average = 21.632		21.608

$P_{TP} = 1.0004$

Expected 'true' reading for _____

$= \text{Endpoint} = \frac{21.305 - 21.632}{2(21.632) - 21.305}(1.00) = -0.015$ min

Instrument Calibration factor (Roentgen per scale division)

$N_x = 4.653 \times 10^{9}$ R/C $N_{gas} = 3.966 \times 10^{7}$ Gy/C $N_m = 1.000$

Ambient Pressure = 29.30" = 744 mm $\rightarrow N_{TP} = 1.0219$

Ambient Temperature = 22.1

% D.D. at 5.0 deep for 10 cm square beam = 78.3%

Other factors : $N_{gas}(N_x A_{wall}) = 8.54 \times 10^{3}$ Gy/R

Peak Dose Rate: $A_{wall} = .998$

Chamber Co + Meter calibrated 4/10/90
by ADCL, Houston, Texas

Physicist

CONTROL NO. 89918

Worksheet (2) for calculating the dose to water at d_{max} from photon beams

Name: VEEVERS FRIEDA Date: 7/2/90

1. Radiation source: AECL THERATRON 780; Stated energy: Co-60 MeV
   Ionization ratio: _____ (Sec. IV B) Nominal accelerating potential: _____ MV (Fig. 3)
2. Phantom material (med): WATER SSD: 80.0 cm
   Collimator field size: 10×10 cm²; Depth of measurement: 5.0 cm
3.1. Dose to phantom material per monitor unit [Eq. (9)]:

$$D_{med}/U = (\bar{M}/U)\, N_{gas} (\bar{L}/\rho)^{med}_{air} P_{wall} P_{ion} P_{repl},$$

where U refers to accelerator monitor units, or time for a ^{60}Co unit.

3.2. The chamber temperature T = 22.1 °C and pressure P = 744 mmHg at the time of measurement. The chamber signal M is normalized to 22 °C and 1 atmosphere using the factor:

$$\frac{T + 273\,°C}{295\,°C} \times \frac{760\ \text{mmHg}}{P} = 1.0219 \qquad N_{TM} = 1.000$$

3.3. Mean chamber signal per monitor unit (at the higher collecting potential, and normalized to 22 °C and 760 mmHg)

$$\frac{(21.632\times10^{-9})}{(1.00 - .015)}(1.0219)(1.000) \qquad (\bar{M}/U) = 2.2442\times10^{-8}\ \text{C/monitor unit}$$

or $(\bar{M}/U)$ = _____ scale division/monitor unit

3.4. Cavity-gas calibration factor:
Chamber model: NEL 2571 (#911) Wall material: Graphite
Inner diameter: 6.3 mm Wall thickness: 0.065 g/cm²
$N_{gas}/(N_x A_{wall}) = 8.54\times10^{-3}$ Gy/R; $N_x = 4.653\times10^{7}$ R/C $N_{gas} = 3.966\times10^{7}$ Gy/C or Gy/scale division.

3.5. Stopping-power ratio (Fig. 2, Table IV): $A_{wall} = .953$ $(\bar{L}/\rho)^{med}_{air} = 1.134$

3.6. Wall correction factor [Eq. (10)]:

$$P_{wall} = \frac{[\alpha(\bar{L}/\rho)^{wall}_{air}(\bar{\mu}_{en}/\rho)^{med}_{wall} + (1-\alpha)(\bar{L}/\rho)^{med}_{air}]}{(\bar{L}/\rho)^{med}_{air}} = .9975$$

Fraction of ionization from chamber wall (Fig. 7): α = 0.45

If $\alpha \geq 0.25$, enter α and $(1-\alpha)$. $(1-\alpha)$ = 0.55

If $\alpha < 0.25$, enter $\alpha = 0$ and proceed to 4.

Stopping-power ratio (Fig. 2, Table IV): $(\bar{L}/\rho)^{wall}_{air}$ = 1.012

Energy-absorption coefficient ratio (Table IX):

$(\bar{\mu}_{en}/\rho)^{med}_{air}$ 1.111 + $(\bar{\mu}_{en}/\rho)^{wall}_{air}$ 0.997 = $(\bar{\mu}_{en}/\rho)^{med}_{wall}$ 1.1143

4. Ionization recombination correction (Sec. IV C and Fig. 4): P_{ion} = 1.0004
5. Replacement (gradient) correction (Fig. 5): P_{repl} = 0.9917
6. Dose to phantom material per monitor unit or per unit time,[a] at point of measurement: D_{med}/U = .9989 Gy/monitor unit
7.1. Dose to water per monitor unit, at d_{max} [Eq. (17)]:

$$D_{water}(\text{at } d_{max})/U = \frac{(D_{med}/U) \times ESC \times (\bar{\mu}_{en}/\rho)^{water}_{med}}{P/100}$$

7.2. Correction for excess scatter from acrylic phantoms (Table XIV): ESC = _____
7.3. Energy-absorption coefficient ratio (Table XII): $(\bar{\mu}_{en}/\rho)^{water}_{med}$ = 1.00
7.4. Percent depth dose at depth of measurement: P = 78.8 %
7.5. Dose to water per monitor unit, at d_{max}: $D_{water}(\text{at } d_{max})/U$ = 1.2676 Gy/monitor unit
126.8 rad/min

[a] Cobalt-60 units may have a nonlinear relationship between dose per unit time and time, especially for short exposure times. Corrections should be made using the method of Orton and Siebert (Ref. 58).

DECAY CORRECTED FROM PREVIOUS CALIBRATION AT 7/1/89

D_{RATE} = 127.5 RAD/MIN ?Diff = -0.6%

Beam Direction Dependence Date: 7/2/90

Institution Radiation Oncology Center
West Plains, MO

Unit: AECL Theratron 780

Room Location: _____

Technique: 10×10 cm² field, 80 cm SCD

Measurement at Isocenter, Chamber in Air with build-up cap

Measuring Instrument Keithley 35617 with NE 2571 (#912)

Setting: 1.00 min

Head Angle	Reading
0° (pointed down)	26.50
270°	26.52
180° (pointed up)	26.50
20°	26.49
315°	26.50
46°	26.50
80°	26.49
150°	26.49
180° (pointed up)	26.53

Comments:

$$\pm \frac{26.53 - 26.49}{26.53 + 26.49} \times 100\% = \pm 0.08\%$$

Negligible

Dennis Vavala
Physicist

Beam Flatness Date: 7/1/90

Institution: Radiation Oncology Center
West Plains, MO

Unit: AECL Theratron 780

Room Location: _____

Technique: 10x10 cm² and 20x20 cm² field, 80 cm SCD

Measurements at In air with build-up cap

Measuring instrument EMI Radiation Field Scanner

Setting: _____

Cross Plane			In Plane		
Readings (-)	Location	Readings (+)	Readings (-)	Location	Readings (+)

SEE SCANS

Comments:

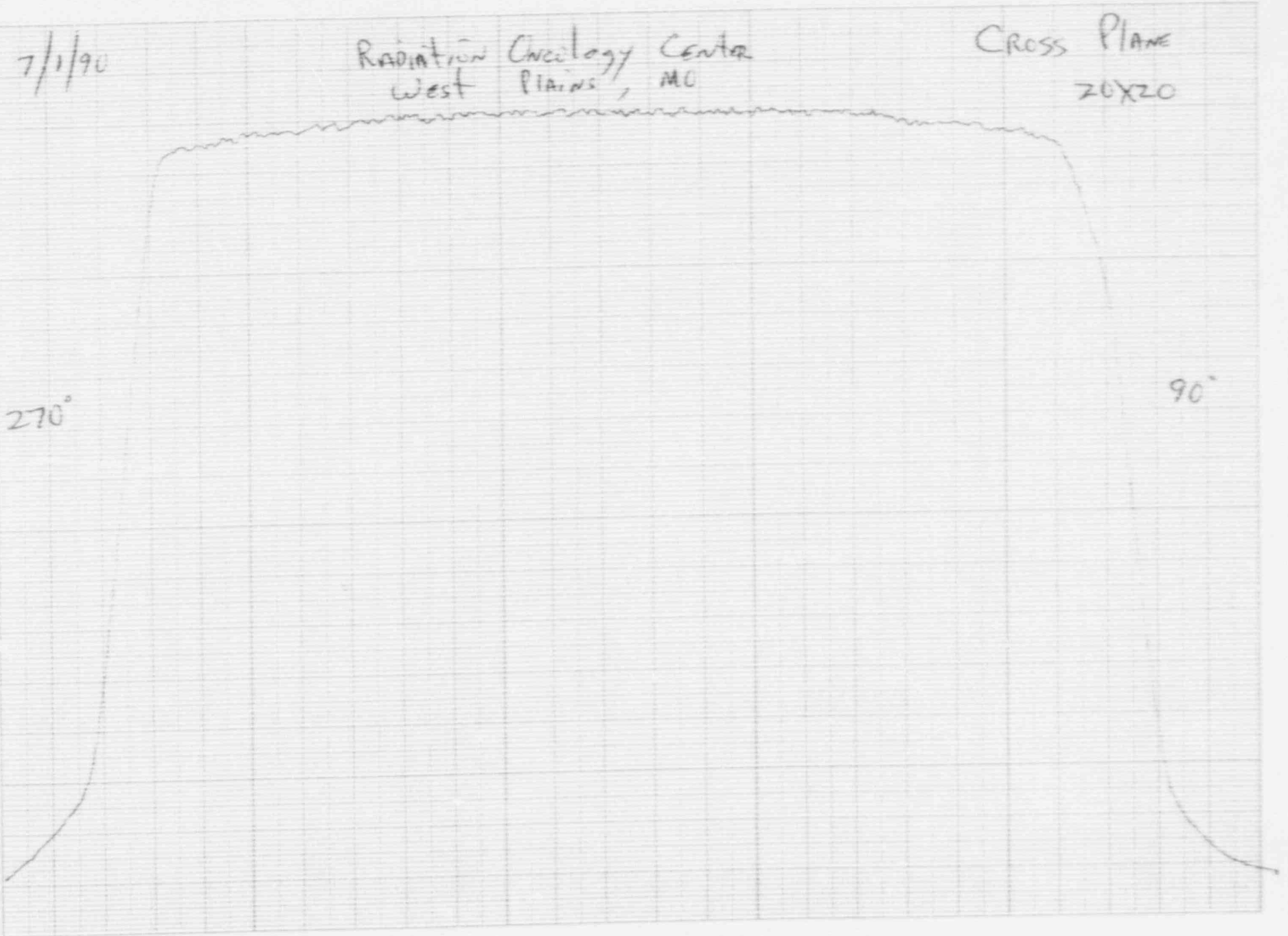
Physicist

CONTROL NO. 89918

7/1/90

Radiation Oncology Center
West Plains, MO

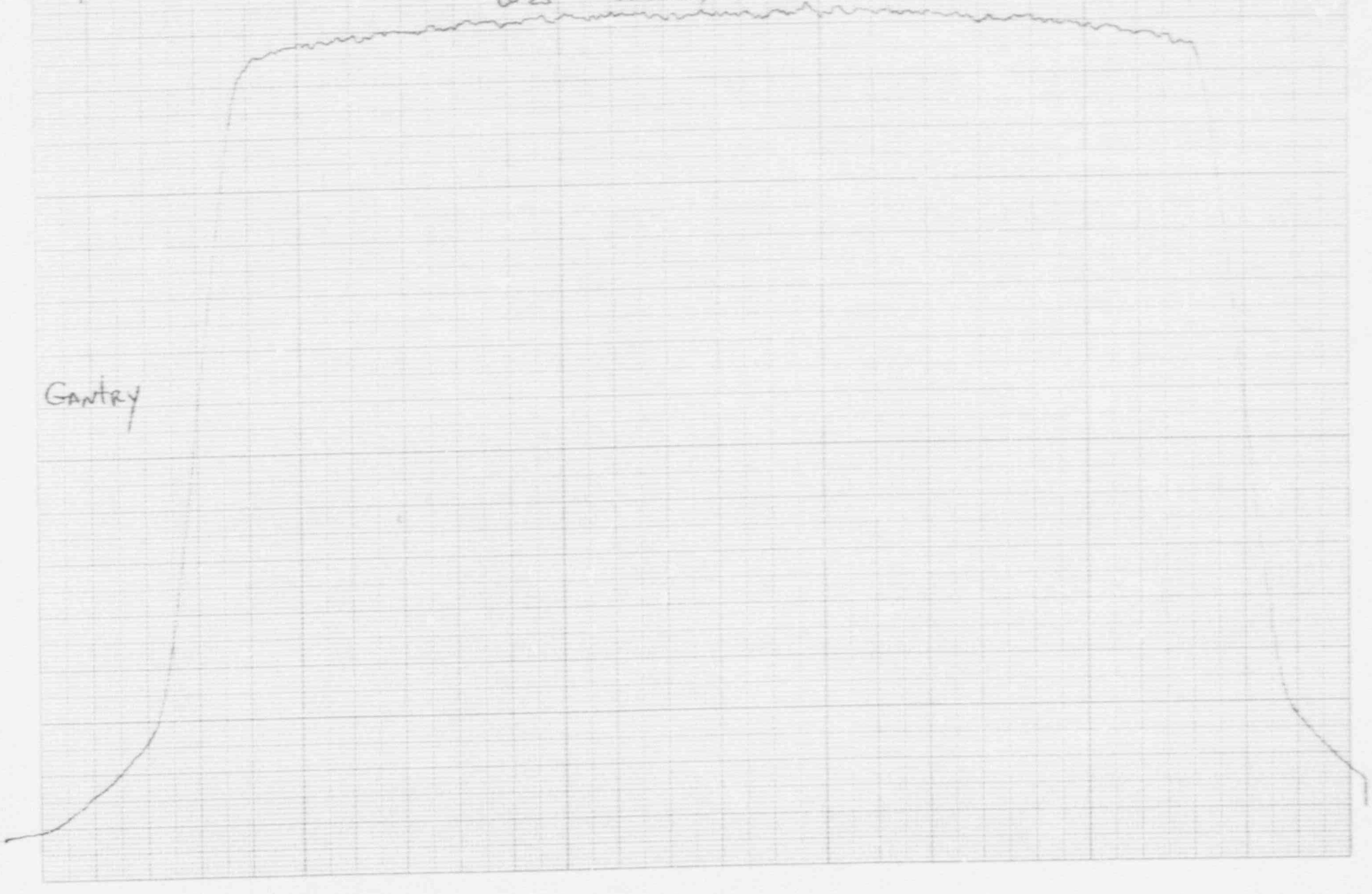
Cross Plane
20X20



7/1/96

Radiation Oncology Center
West Plains, MO

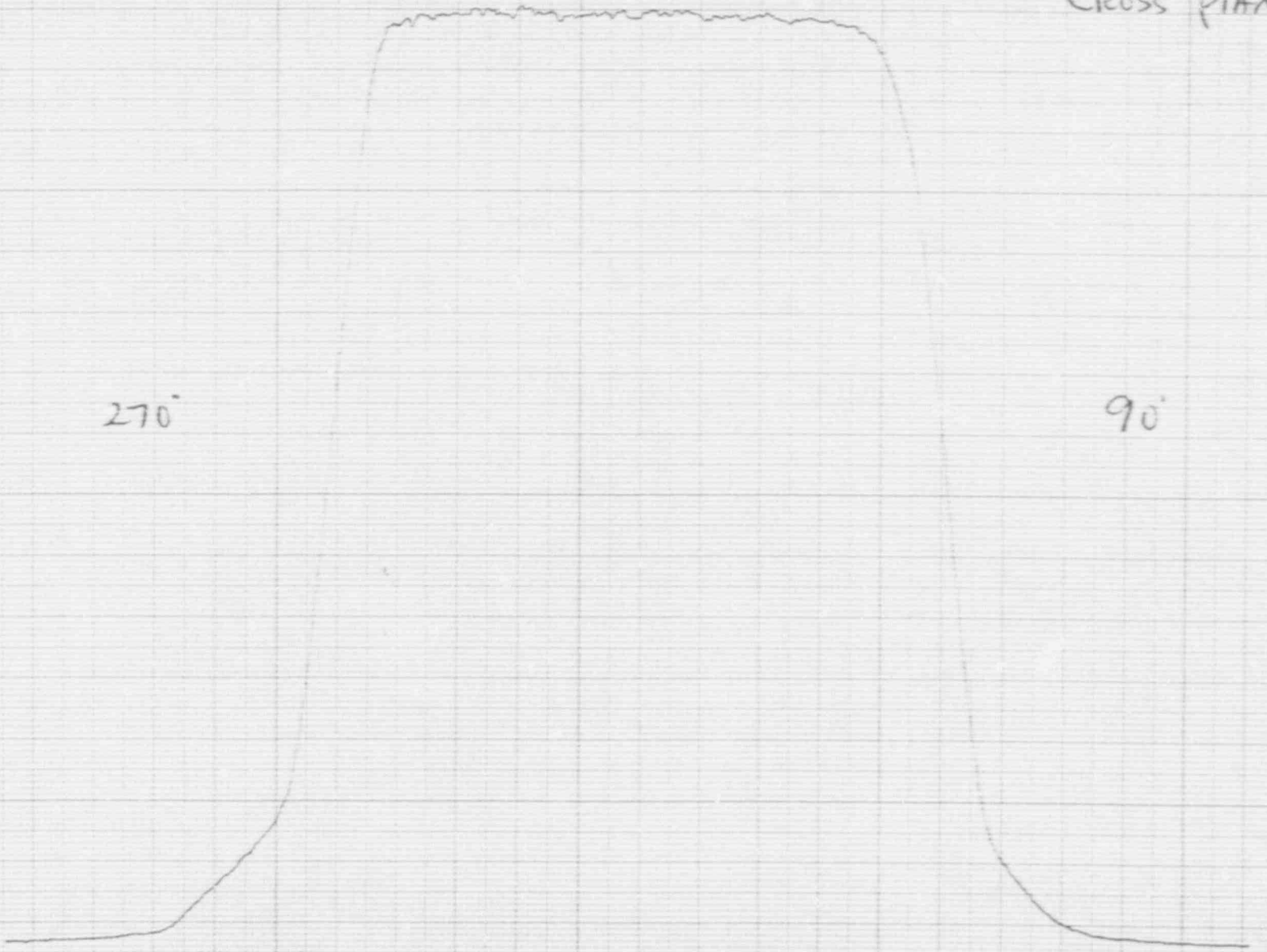
In Plane 20x20



7/1/90

Radiation Oncology Center
West Plains, MO

Cross plane -10x10

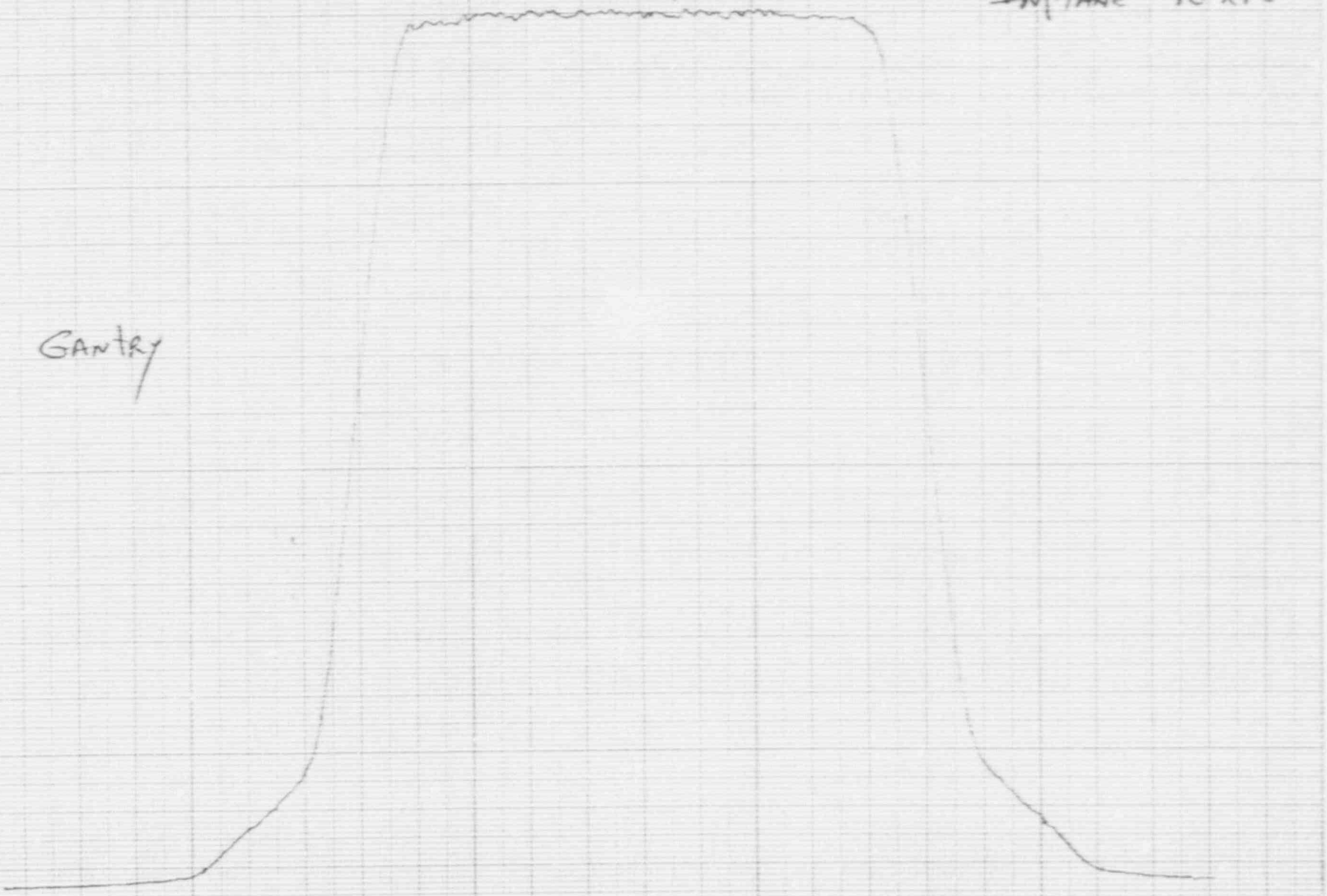


7/1/90

RADIATION ONCOLOGY CENTER
WEST PLAINS, MO

INPLANE - 10 X 10

GANTRY



Dose/Degree Calibration

Date: 7/1/90

Institution Radiation Oncology Center
West Plains, MO

Unit: AECL Theratron 780

Room Location: _____

Technique: 10 X 10 cm^2 field

Arm Speed ~~Dose/Degree~~ Selector Setting	Arc length	Direction ~~Monitor~~ Dose	Monitor Time	Dose/Degree Deg./Minute
1.00	280	CW	0.82	341
	281	CCW	0.82	341
0.9	263	CW	0.78	337
	281	CCW	0.84	335
0.8	282	CW	0.90	313
	281	CCW	0.91	309
0.7	280	CW	1.05	267
	282	CCW	1.07	264
0.6	281	CW	1.24	227
	280	CCW	1.25	224
0.5	281	CW	1.53	184
	284	CCW	1.57	181
0.4	282	CW	1.97	1,43
	281	CCW	2.00	1640
0.3	200	CW	1.90	105
	200	CCW	2.04	98
0.2	200	CW	2.94	68
	200	CCW	3.30	61
0.1	121	CW	4.13	29
	120	CCW	6.94	17

CW: $y = .00251x + 0.0340$
CCW: $y = .00247x + 0.0513$
} for $0.2 \leq y \leq 0.9$

where x = deg/min and y = arm speed setting

Jennifer Fowler
Physicist

Rotational Speed is not the same for CW and CCW motion. The gantry turns slightly faster in the CW direction for a given arm speed setting.

Apparent Source Position

Date: 9/2/90

Unit: AECL Theratron 780 Location:

Measuring Instrument: Keithley 35617 Dosimeter with NEL 2571(#917) Chamber

Technique: In-Air, chamber with build-up cap

$N_{gp} = 1.0229$

Field Size at 80 cm. (cm.xcm)	Nominal Dist.	Temp. Pressure	Reading For 1.00 min	Average Reading	Ave. rad. corrected for T-P	(Ave. Rad. Corrected For T-P)$^{-\frac{1}{2}}$	Apparent* Source Position
10x10 cm.	70	22 743	34.91 34.89 34.90	34.90	35.699	.16737	
	80	22 743	26.50 26.51	26.505	21.111	.19205	.65cm (r = 1.0000
	90	22 743	21.00 21.01	21.005	21.486	.21574	
	95	22 743	18.822 18.822 18.824	18.822	19.253	.22791	
Maximum Field 35x35	70	22 743	36.64 36.63	36.635	37.473	.16336	
	80	22 743	27.94 27.95	27.945	28.584	.18704	-.40 cm (r = 1.0000
	90	22 743	22.19 22.20	22.195	22.703	.20987	
	95	22 743	19.924 19.920 19.916	19.920	20.376	.22154	

* Apparent Source Position determined by least squares linear regression.

Notes: Use 80 cm for Source Isocenter distance

Physicist

Date: 7/2/90

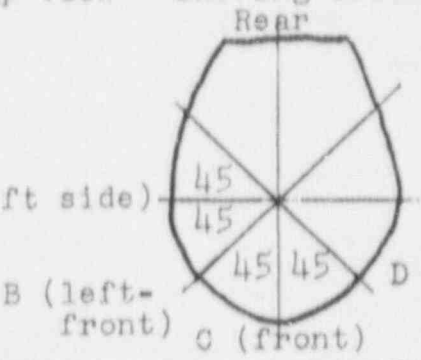
Therapeutic Type Protective Source Housing Data

Instituiton: Radiation Oncology Center West Plains, MO

Unit: AECL Theratron 780

Room Location: _____

Top View - Showing Orientations



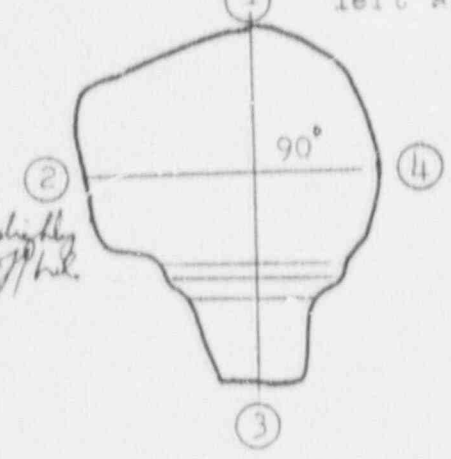
Measurements at 1 meter

Measuring Instrument: Keithley ~~5356~~ 36150 Survey Meter/Serial # 22:

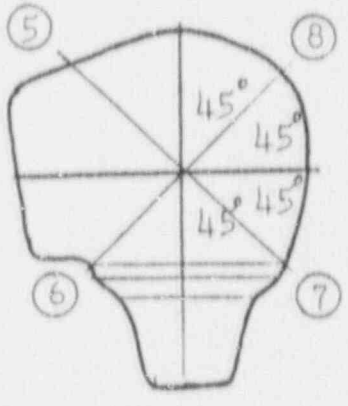
All measurements taken at 1 meter from center of source housing with measuring instrument in stable position.

Position No.	Radiation Level (mR/hr)
1	0.7
2	0.8
3	0.9
4	4.4 on source hole, 1.2 slightly off hole
5	0.3
6	0.8
7	0.5
8	0.3
9	0.7
10	0.7
11	0.4
12	0.4
13	0.7
14	0.7

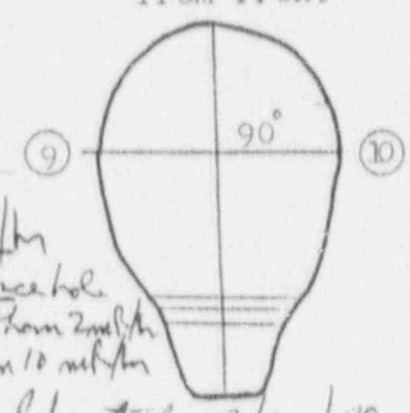
View A - Vertical from left side



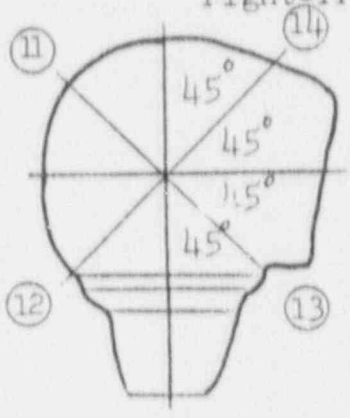
View B - Vertical from left-front



View C - Vertical from front



View D - Vertical from right-front



Average Value 0.9 mR/hr

Maximum Value 4.4 on source hole

Remarks: Average less than 2 mR/hr
Max less than 10 mR/hr

Survey Instrument Calibrated 8/30/89 by University of Wisconsin Radiation Calibration Service

Dennis Vanek
Radiation Physicist

CONTROL NO. 89918

Leak Test

Date: 7/1/90

Institution: Radiation Oncology Center
West Plains, MO

Unit: AECL Theratron 780

Room Location: _____

Counting instrument: _____
Wipes sent to Assay Services, Inc for counting

Settings: _____

Wipe	Counts

Wipes taken 6/5/90

Copy of results attached.

Comments:

Results indicate source not leaking.

Dennis Frank
Physicist

ASSAY SERVICES INC.

P.O. BOX 580648 • HOUSTON, TEXAS 77258-0648 • AREA CODE 713/841-0391 • FAX 713/841-6153

SEALED SOURCE LEAK TEST CERTIFICATE

RADIATION ONCOLOGY CENTER
1115 ALASKA AVE SUITE 11A
WEST PLAINS ,MO 65775
ATTN OF: DENNIS FRIEDO

C FILE 252

S FILE 1304

N FILE 951

INVOICE NO. _____ DATE _____

RADIONUCLIDE CO-60

ACTIVITY 7946 CI SERIAL NO. 53903

WIPE DATE 060590 WIPED BY _____

EFF. 00A

GROSS CPM 0 BKG. CPM. 10 NET CPM. 10

NET CPM / EFFX2.22X10^6 DPM/μ CI = MICROCURIE

THE ABOVE SOURCE WIPE TEST HAS BEEN ASSAYED IN ACCORDANCE WITH OUR RADIOACTIVE MATERIAL LICENSE AND THE APPROPRIATE REGULATORY REQUIREMENTS. THE REGULATIONS DEFINE A LEAKING SOURCE AS ONE FROM WHICH AN APPROPRIATE WIPE TEST HAS REMOVED 0.005 MICROCURIE OR MORE OF ACTIVITY.

THE REMOVABLE ACTIVITY WAS 4.74E-07 MICROCURIE

ASSAY NO. 061590 27 DATE 06 13 12 90

ASSAYED BY RDG

CUSTOMER REPORT

THE UNIVERSITY OF TEXAS
MD ANDERSON
CANCER CENTER

Instrument submitted by:

Dennis Frieda, Ph.D.
St. John's Regional Health Center
Radiation Oncology
North Wing, Suite 1960
Springfield, MO 65804

Accredited Dosimetry Calibration Laboratory

ACCREDITED DOSIMETRY CALIBRATION LABORATORY

Report of Calibration

Date instrument received for calibration: April 5, 1990

Date Instrument calibration completed: April 10, 1990

Date calibration report mailed: May 18, 1990

Description of Instrument:

Keithley Programmable Dosimeter Model 35617; Serial #22828
NEL* Chamber Model 2571, (0.6 cc, graphite), Serial #912
Delrin Buildup Cap #912
PTW Chamber Model N233643**, (0.125 cc, acrylic): Serial #112
Acrylic Buildup Cap #112
*Nuclear Enterprises, LTD

NOTE: Proper function and reliability of the radiation measuring devices described in this document are highly dependent upon handling and use. Therefore, the duration of responsibility of The University of Texas M. D. Anderson Cancer Center, and its employees for the calibration results extends only to the time the instruments leave the M. D. Anderson Cancer Center premises. It is recommended that the instrument user establish an appropriate technique of monitoring the constancy of the instrument response before and after its submission to the Accredited Dosimetry Calibration Laboratory and on a regular basis thereafter. In addition, it is the express responsibility of the instrument user to assure himself (by personal communication, if necessary) that his interpretation of the information in this document is consistent with interpretation intended by the Accredited Dosimetry Calibration Laboratory.

CALIBRATION FACTORS:

Chamber Factors: Gy/C. This factor applies to the ion chamber alone. The calibration factors given in this report are quotients of the x-ray or gamma-ray air kerma in air and the charge generated by that radiation in the ionization chamber. The average charge used to compute the calibration factor is based on measurements with the wall of the ionization chamber at the stated polarity and potential. Leakage corrections were applied if necessary.

Electrometer Factors: C/rdg. This factor applies to the electrometer alone for the scale, switch setting and output mode specified. This factor is the quotient of the charge collected on the internal capacitor of the electrometer to the reading indicated on the display.

System Factor: Gy/rdg. This factor applies to chamber-electrometer readout systems as a unit with scale, switch setting and output mode specified. This factor is the quotient of x or gamma ray air kerma and the reading indicated on the display.

A system factor can be obtained by multiplying the chamber and electrometer factors.

$$Gy/rdg = (Gy/C)\ (C/rdg)$$

To obtain air kerma at the effective measurement point, in the absence of the chamber, the system factor is multiplied by the reading on the display corrected for temperature and pressure and ion collection efficiency (P_{ion}). Some dosimetry systems may also need a non-linearity correction.

$$\text{Air Kerma} = (rdg)\ (Gy/rdg)\ (TPC)\ (P_{ion})\ (\text{non-linearity correction})$$

As of May 1, 1989 the official radiation quantity for ion chamber calibrations used by the National Institute of Standards and Technology is air kerma in Gray (1 Gy = 1 J/kg). The AAPM (1983) calibration protocol uses calibration factors in units of exposure. This report gives calibration factors in both units (air kerma and exposure) to be compatible with both NIST and the AAPM protocol. Air Kerma is related to exposure as follows:

To obtain exposure in Roentgen, divide air kerma in Gray by

8.79×10^{-3} Gy/R for cobalt 60 gamma rays
8.76×10^{-3} Gy/R for x-rays

ENVIRONMENTAL CONDITIONS:

Prior to calibration all chambers are tested to assure communication with the atmosphere. All chamber measurements were normalized to 760 millimeters of mercury and 22 degrees Celsius. Use of the chamber at other pressures and temperatures requires correction by the multiplicative factor:

$$(T + 273.15)/295.15 \times 760/P$$

where T is the temperature in degrees Celsius, and P is the chamber pressure in millimeters of mercury. No correction is made for the effect of water vapor on the instrument being calibrated since it is assumed that both the calibration and the use of the instrument take place in air with a relative humidity between 10% and 70%, where the humidity correction is nearly constant.

CALIBRATION CONDITIONS:

Field size is defined by the distance between the opposing 50-percent intensity lines, measured at the calibration distance, perpendicular to the center line of the calibration beam. Unless otherwise indicated, the calibration field size is 10 cm by 10 cm. Stem effect was not investigated; the calibration factor applies only to the field size stated.

During calibration, cylindrical or spherical chambers are centered in the beam with the stem perpendicular to the beam direction. The effective point of measurement is assumed to be the geometric center of the cavity.

A parallel plate chamber is centered in the beam with the plates perpendicular to the beam direction. The effective point of measurement is assumed to be the inner surface of the entrance window at the center of the window. Manufacturer's markings are assumed to indicate this position.

All chambers (cylindrical, spherical or parallel plate) are calibrated by suspension free in space with no additional scattering material (other than adequate buildup for Cobalt-60).

BEAM QUALITY:

Medium energy x-ray beam quality is described in terms of the peak kilovoltage, the first half-value thickness in millimeters of aluminum and copper and the homogeneity coefficient (the ratio of the first and second half-value thickness). The half-value thicknesses were determined with a 2 cm diameter aperture and high purity aluminum and copper absorber . The aperture and ion chamber were positioned at 50 cm and 100 cm, respectively, from the target.

X-Ray Beam Qualities Available

BEAM CODE	kVp	ADDED FILTERS (mm Al)	BEAM QUALITY HVT(mm) (Al)	(CU)	HOMOGENEITY (Al)	(CU)
M1	75	0.2	2.04	0.066	66	60
M2	100	2.4	4.14	0.156	71	57
M3	125	4.0	6.03	0.268	74	54
M4	250	0.8 Thoreaus	17.8	2.92	98a	85

a) Estimated.

ACCURACY:

The air kerma rate at the calibration position was measured with a transfer-quality ionization chamber which was calibrated at the National Institute of Standards and Technology. Electrometers are calibrated with a standard capacitor, regulated high voltage power supply and precision digital voltmeter all with calibrations traceable to NIST.

The precision of the calibration factors assigned by the Accredited Dosimetry Calibration Laboratory is believed to be within ± 0.5% (cobalt-60) and ± 1.0% (x-rays) of the current standards of NIST. The NIST states an overall uncertainty of 1% of which 0.7% is assigned to the uncertainty in the air kerma of their beam. The overall uncertainty is therefore, 1.2% for Cobalt-60 and 1.5% for x-rays. The overall uncertainty is considered to have the approximate significance of a 95% confidence limit.

The calibration factors is given to four digits to prevent rounding errors up to 0.5% when the first digit is unity.

COLLECTION EFFICIENCY:

The collection efficiency, Aion, under the conditions of calibration was determined on the cobalt 60 beam using the two voltage technique described by Almond (1981) for continuous radiation. The ratio of current (charge) produced in the chamber with the full polarizing voltage divided by that with 1/2 polarizing voltage was measured.

$N_{gas}/(N_x\ A_{ion})$:

The AAPM calibration protocol converts the exposure calibration factor, N_x, into the cavity gas calibration factor, N_{gas}. This report provides the ratio $N_{gas}/(N_x\ A_{ion})$ for cylindrical chambers published by a Task Group of the ADCL's (Gastorf, 1986). For parallel plate chambers, this ratio is calculated from the AAPM protocol guidelines using data by Nath & Schulz (1981).

References

1. Task Group 21, Radiation Therapy Committee, American Association of Physicists in Medicine, Med. Phys., vol 10, p 742 (1983).

2. Almond, Peter R., Med Phys., vol 8, p. 901 (1981).

3. Gastorf, R., Humphries, L., and Rosenfeld, M., Med. Phys., vol 13, p. 751 (1986).

4. Nath, R. and R. J. Schulz, Med. Phys., vol 8 p. 85, (1981).

ACCREDITED DOSIMETRY CALIBRATION LABORATORY
M. D. ANDERSON CANCER CENTER

Report of Chamber Calibration
Cobalt-60

INSTRUMENT:

PTW Chamber Model N233643, (0.125 cc, acrylic), Serial #112
Acrylic Buildup Cap #112 (For Co-60 only)

CALIBRATION CONDITIONS:

Chamber Only: irradiated free in space with no additional scatter material (except for adequate buildup)

Preirrad. Leakage: -1×10^{-14} A

Orientation: Black line toward

Polarizing Voltage: -312 V (on thimble)

Ion collection efficiency (A_{ion})=1.000 $N_{gas}/(N_x A_{ion})=8.49 \times 10^{-3}$ Gy/R

AIR KERMA

BEAM QUALITY	AIR KERMA RATE (Gy/min)	CALIBRATION* FACTOR (Gy/C
Cobalt 60	0.18	2.266×10^{8}

EXPOSURE

BEAM QUALITY	EXPOSURE RATE (R/min)	CALIBRATION* FACTOR (R/C)
Cobalt 60	21	2.578×10^{10}

* At 22° C, 760 mm Hg

DATA BOOK 23 ; PAGE(s): 344

William F. Hanson 5/15/90
William F. Hanson DATE

CONTROL NO. 89918

ACCREDITED DOSIMETRY CALIBRATION LABORATORY
M. D. ANDERSON CANCER CENTER

Report of Chamber Calibration
Cobalt-60

INSTRUMENT:

NEL Chamber Model 2571, (0.6 cc, graphite), Serial #912
Delrin Buildup Cap #912 (For Co-60 only)

CALIBRATION CONDITIONS:

Chamber Only: irradiated free in space with no additional scatter material (except for adequate build-up)

Preirrad. Leakage: -1×10^{-14} A

Orientation: Black line toward beam

Polarizing Voltage: -312 V (on thimble)

Ion collection efficiency (A_{ion})=0.998 $N_{gas}/(N_x A_{ion})=8.54 \times 10^{-3}$ Gy/R

AIR KERMA

BEAM QUALITY	AIR KERMA RATE (Gy/min)	CALIBRATION* FACTOR (Gy/C)
Cobalt 60	0.18	4.090×10^7

EXPOSURE

BEAM QUALITY	EXPOSURE RATE (R/min)	CALIBRATION* FACTOR (R/C)
Cobalt 60	21	4.653×10^9

* At 22° C, 760 mm Hg

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William F. Hanson 5/18/90
William F. Hanson Date

ACCREDITED DOSIMETRY CALIBRATION LABORATORY
M. D. ANDERSON CANCER CENTER

Report of Electrometer Calibration
Electrometer Factor

St. John's Regional Health Center

Report #90-23

INSTRUMENT:

Keithley Programmable Dosimeter Model 35617; Serial #22828

SCALES, SWITCH POSITIONS, AND CONDITIONS:

Electrometer Switch: Position

Range: Auto (199.99 full scale)
Zero Correct: OFF
Suppress: OFF
Trig: OFF
Function: Coul
Bias: 0%, Neg (Back Panel)

ELECTROMETER CALIBRATION FACTOR:

1.000×10^{-9} C/Unit of reading

NOTE: Charge sensitivity (rdg/C) was constant to within ±0.1% or the precision of the reading (whichever is greater) over the range of readings from 10.018 to 199.09. The calibration factors in this report may not be reliable outside this range.

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William F. Hanson 5/15/90

William F. Hanson Date

CONTROL NO. 89918