



TELETHERAPY RADIATION SURVEY REPORT

THERATRON-780

NAVAL HOSPITAL  
PORTSMOUTH, VIRGINIA 23708

SUBMITTED BY:  
G. J. ADLER, CDR, MSC, USN  
RADIOLOGY DEPARTMENT  
NAVAL HOSPITAL  
PORTSMOUTH, VIRGINIA 23708

DATE: 2 JULY 1985

8508280389 850821  
NMSS LIC30  
45-01121-04 PDR



## TELETHERAPY RADIATION SURVEY REPORT

On June 6, 1985, the Cobalt-60 source in the AECL Theratron-780, Serial #182, located at the Naval Hospital, Portsmouth, VA, NRC License No. 45-01121-04, was changed by AECL personnel. During the source change, the unit received a 5-year service and inspection (attachment 1) in accordance with NRC guidelines. The radiation safety survey and calibration were performed June 7 to June 14, 1985, by CDR G. J. Adler, MSC, USN, board certified in therapeutic radiologic physics by the American Board of Radiology, assisted by LCDR George Snyder, MSC, USN. The results of measurements taken for the radiation survey are given below.

A. NEW SOURCE: AECL Cobalt-60 Source, Model C-146, Serial No. S-3743, containing 10461 curies as of 24 April 1985. Certificate of measurement included as attachment 2.

B. OLD SOURCE: AECL Cobalt-60 Source, Model C-146, Serial No. 2652, transferred to AECL (License No. 54-00300-04). Source Disposal Certificate included as attachment 3.

### C. INSTRUMENTATION:

1. Standard Navy AN/PDR-27R Serial Nos. C29 (calibrated 22 February 1985) and C68 (calibrated 14 March 1985). Calibrated by NAVELEX, Portsmouth, VA. Manufactured by Technical Industries Associates, Inc.

2. Keithley 602 Electrometer, Serial No. 52586A, with a Data Precision Digital Multimeter, Model 248, Serial No. 9624, calibrated by K&S Associates, Nashville, Tennessee, on 15 November 1984.

3. PTW 0.6cc ion chamber with buildup cap, model N23333, Serial No. A172. Calibrated by K&S Associates on 16 November 1984.

### D. PRIMARY BEAM OUTPUT

1. 11509 RHM - as measured in air at 100cm in a 35.7x35.7cm field at 80cm on 7 June 1985.

2. 10962 RHM - as measured in a 10x10cm field at 80cm on 7 June 1985.

### E. HEAD LEAKAGE IN "OFF" POSITION: See attachment 4

Average Value of 14 points: 0.83 MR

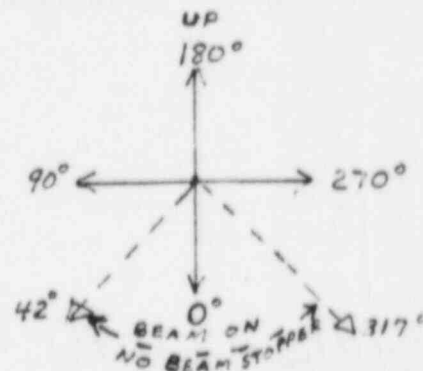
Maximum Value : 2.5 MR

Date of Survey: 14 June 1985

F. LIMITS OF BEAM ORIENTATION: (See diagram for orientation - arrows indicate direction of primary beam.)

1. Primary beam directed at Integral Beam Stopper - no beam direction limitation.

2. Primary beam directed away from Integral Beam Stopper. Beam on from 317° to +42° (see diagram)



# G. RADIATION SURVEY

1. Phantom: 30x30x18cm plexiglas block.
2. Field size: 35.7x35.7cm at 80cm.
3. Diagrams of the cobalt therapy facility indicating measurement areas are included as attachments 5 and 6.
4. Primary beam directed at integral beam stopper.
  - a. Phantom positioned such that the center of the phantom was 80cm from the source, i.e.,

SSD = 71cm for gantry angles 0° and 180°.  
SSD = 65cm for gantry angles 90° and 270°.

- b. Maximum radiation levels measured - mR/hr\*

Measurement Position : Gantry Angle:	SW Wall	S Wall	TX Room Door	W Wall	N Wall	NW Wall	Lab Space Above
	A	B	C	D**	E	F	G
0	4.5	0.02	1.5	.45	1.5	0.3	0.02
30	1.5	0.02	1.0	0.7	4.3	1.1	-
60	1.0	0.02	0.4	1.2	4.0	4.0	-
90	1.0	0.02	0.8	1.1/4.5	4.3	4.2	-
120	1.1	0.02	0.5	0.5/1.0	3.3	4.0	-
140	1.2	0.02	0.8	0.9/1.0	2.6	2.1	2.5
145	-	-	-	-	-	-	6.0
150	2.4	0.02	0.8	0.7	2.4	1.0	6.0
180	3.0	-	1.5	0.5	0.9	0.25	1.6
210	12	0.02	2.5	0.35	-	0.15	-
215	-	-	-	-	-	-	0.9
220	-	-	-	-	-	-	0.8
240	35	0.04	4.0	0.4	-	0.2	0.8
270	45	0.02	3.5	0.4	0.08	0.15	-
300	37	0.04	3.5	0.4	-	0.15	-
330	12	0.02	4.0	0.4	-	0.15	-

max. 4.5 mR/hr  
6.9 mR/hr  
(0.115 hr)  
could have  
2.19 mR/hr

\* Background radiation: 0.02 mR/hr

\*\* Level along wall/Level at observation window if higher

- J. Primary beam directed away from beam stopper

- a. Beam orientation

Maximum angles allowed

Orientation	Beam Direction	Gantry Angle
1	42°	0°
2	317°	0°



b. Phantom at 270cm SSD

c. Maximum Levels (mR/Hr)\*

Orientation	Locations						
	A	B	C	D	E	F	G
1	0.7	0.02	-	0.5	0.8	0.1	0.4
2	12	0.02	14	0.35	-	-	0.1

\*Background 0.02 mR/hr

H. The highest radiation levels were found at location A for beam angles between 210-330° and at location G for beam angles of 145-150° with the beam stopper in place. With the beam directed away from the beam stopper, the highest level was at location C for beam orientation 2. These levels, being the highest, were evaluated to ensure compliance with NRC requirements 10 CFR 20.105(b)(1) and (2) for unrestricted areas as follows:

1. Maximum number of patients treated in any one day during 1984: 27.
2. Average number of patients treated/day during 1984: 18.5.
3. Total Co-60 patient treatments (1984): 4575.
4. Total Co-60 prescribed tumor dose treated (1984): 1,010,363 rads.
5. No significant change in workload is expected.
6. Assumptions utilized in calculations.
  - a. Maximum patients treated/day: 32 (4/hr x 8 hrs/day)
  - b. Maximum patients treated/week: 160 (32/day x 5 days)
  - c. Average equivalent exposure/patient treatment at 1 meter: 221 R.
    - (1) 221 rads/day to tumor:  $\frac{1,010,363 \text{ rads}}{4,575 \text{ treatments}}$
    - (2) % DD = .665 (depth = 8.0cm for 10x10cm field)
    - (3) Back scatter factor = 1.036 (10x10cm field)
    - (4) Inv Sq correction =  $(80/80.5)^2 = .9876$
    - (5) Rad/R = 0.94
    - (6) Exposure at 80cm: 346 R

$$\frac{221 \text{ Rad to tumor}}{0.665 \times 1.036 \times 0.9876 \times 0.94}$$



(7) Exposure at 1 meter: 221 R

$$346 \times (80/100)^2$$

(8) Analysis for larger field sizes result in treatments to larger depths for same conclusion.

d. Exposure levels of concern

Location	Condition	mR/hr of "On Time"
A	Beam Dir: 210-330 at beam stopper	45 (max)
C	Beam Dir: 317° no beam stopper	14
G	Beam Dir: 145-150° at beam stopper	6

e. Output: 11509 RHM

7. On Time

a. Per hour: 0.115 hrs

$$\frac{6 \text{ patients/hr} \times 221 \text{ R at 1 meter/patient}}{11509 \text{ RHM}}$$

b. Per week: 3.07 hrs

$$\frac{160 \text{ patients/wk} \times 221 \text{ R at 1 meter/patient}}{11509}$$

8. Projected maximum exposure at

A: per hour:  $0.115 \times 45 \text{ mR/hr} = 5.2 \text{ mR}$   
per week:  $3.07 \times 45 \text{ mR/hr} = 138 \text{ mR}$

C: per hour:  $0.115 \times 14 = 1.6 \text{ mR}$   
per week:  $3.07 \times 14 = 43 \text{ mR}$

G: per hour:  $0.115 \times 6 = 0.7 \text{ mR}$   
per week:  $3.07 \times 6 = 18.4 \text{ mR}$

9. The maximum expected exposure levels calculated for locations C and G comply with 20.105(b), (1) and (2) for unrestricted areas.

I. The maximum expected exposure level calculated for location A above does not comply with 20.105 (b), (1) and (2) for unrestricted areas. However, the following analysis shows that it does comply with the requirements of 20.105(a).

1. Total exposure at 1 meter for 1984: 1,010,363 R  
(paragraph H6 shows 1 rad tumor dose = 1 R at 1 meter)



2. Total "On Time" at current output:  $\frac{1,010,363\text{R}}{11509 \text{ RHM}} = 87.8 \text{ hours}$

3. Average expected dose to PT A per hour of "On Time" = 11.8 mR (see Table I).

4. Occupancy Factor = 1/4 (NCRP Report 49). Area is a corridor and stretcher patient waiting area.

5. Average expected yearly exposure at PT A: 259 mR  
 $11.8 \text{ mR/hr} \times 87.8 \text{ hrs} \times 1/4$

6. Film badges located at position A have indicated a total accumulated dose of 16 mR for period 30 Nov 1984 through 30 May 1985.

7. Based on above information, it is highly unlikely that an individual would receive a dose to the whole body in any period of one calendar year in excess of 0.5 rem.

J. The following tests were conducted to ensure proper operation of the safety systems described below:

1. Teletherapy Room Door Interlock: With a radiation survey meter in the room to detect the "source on" condition, the door was opened while the machine was on. The machine immediately terminated the exposure as verified by on/off lights, room monitor and the radiation survey meter.

2. Teletherapy "On/Off" Indicators: With the survey meter in the treatment room to indicate the "source on" condition, the machine was turned on then off several times. The status of all indicators - lights, rod and radiation room monitor were checked for proper operation against the survey meter indications. The radiation room monitor was also checked when unplugged from AC power and operating on battery power backup. All indicators were found to be functioning properly except for one green "beam off" light on the treatment machine's head. A replacement has been ordered by AECL.

3. Electrical stops (mercury switches) installed to limit the primary beam of radiation as listed in item F: with a radiation monitor in the room, attempts were made to operate the unit when not directed at the beam stopper for angles within the limits of operation, for angles just beyond the limits, and for several angles well beyond the limits. For angles within the limits the unit could be turned "on" as verified by the radiation monitor and beam "on" indicators. For all angles tested beyond the limits of operation, the unit could not be turned "on" as verified by the radiation monitor.

4. Teletherapy treatment timing device: Two tests were performed:

a. Using the primary calibration system the end error was evaluated comparing multiple short exposures to one long exposure. An end error of -0.02 min was determined.



b. Using a stop watch, digital timer and ion chamber the elapsed time versus set clock time was evaluated for 30 and 60 second exposures. Exposures were confirmed with the ion chamber. Timer was found to be reproducible and accurate.

K. The source was wipe tested by AECL personnel on 6 June 1985. Reports are included as attachments 7 and 8. Attachment 9 is the AECL Leak Test Certificate.

TABLE I

BEAM ANGLE	TOTAL R AT 1 METER* FROM BEAM DIRECTION	FRACTION OF "ON TIME"	MAX DOSE RATE AT PT A FOR SPECIFIED ANGLE	AVERAGE EXPECTED DOSE TO PT A
0°	428,443	0.424	4.5	1.91
90°	196,705	0.195	1.0	0.2
180°	140,150	0.139	3	0.42
270°	184,505	0.183	45	8.2
100-150° **	38,930	0.0385	2.4	0.09
210°-350° ***	21,630	0.021	45	<u>0.96</u>

TOTAL = 11.8 mR/hr of "on time"

Total R at 1 meter all directions = 1010363R (1984)

$$\text{Fraction of total "on time"} = \frac{\text{Total R for Beam Dir}}{\text{Total R all directions}}$$

Average expected dose = max rate for beam direction x fraction of on time

\* Based on 1984 data

\*\* Does not include beam angle 90°

\*\*\* Does not include beam angle 270°





## Atomic Energy of Canada Limited Commercial Products

### INSPECTION CERTIFICATE

AUTHORIZED INSPECTION AND SERVICING OF AECL TELETHERAPY UNIT

MODEL NO. 780 SERIAL NO. 182  
TELETHERAPY SOURCE SERIAL NO. S3743 CURIES 109.61 DATE 24 JUL 85  
CUSTOMER NAVAL HOSPITAL

This teletherapy unit was inspected and serviced in accordance with Atomic Energy of Canada Limited USNRC License No. 54-00300-04.

Date of Inspection 6 JUNE 1985

This is to certify that the unit was inspected and serviced in accordance with the conditions of the License. Each teletherapy machine shall be fully inspected and serviced during source replacement or at intervals not to exceed five years.

By [Signature] Authorized Source Handler (date) 6 JUNE 85



# Certificate Of Measurement

of

TELETHERAPY SOURCE S-3743

for

CUSTOMER

NAVAL HOSPITAL  
PORTSMOUTH VIRGINIA

AECL ORDER No. P&S 43408

THERAPY UNIT  
OUTPUT

When installed in THERATRON 780#182 (at maximum field size) the exposure rate will be 197.1 Rmm ( $\pm 5\%$ ) based on the source measurement (below), and the equipment conversion ratio described on sheet 3.

MEASUREMENT  
OF SOURCE

Source S-3743 is a 2.0 cm diameter standard source, type C-146, containing 10461 curies cobalt 60. The source exposure rate was 172.6 Rmm ( $\pm 3\%$ ) at the one metre position of the measurement cell.

DATE OF MEASUREMENT 1985 APRIL 24

MEASUREMENT METHOD

The source exposure rate was measured in the cell described on the following sheet (Form QC 9 Sheet 2). The exposure rate was measured with an air wall cavity ionization chamber having a volume of 0.6 cm<sup>3</sup> and fitted with a 4.6 mm lucite equilibrium cap. The instrument is calibrated in a cobalt-60 exposure rate certified by the National Research Council of Canada.

ACCURACY

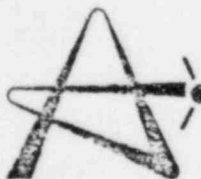
The uncertainty in the source exposure rate applies only to measurement of this source in the AECL Measurement Cell. It represents the maximum total uncertainty due to all causes including the calibration of the Council's primary exposure rate, the calibration of their instrumentation and the precision of measurement in the Measurement Cell. Additional uncertainty due to the comparative measurements involved, has been included in the statement of unit output.

EXCERPT FROM THE RECOMMENDATIONS OF THE INTERNATIONAL COMMISSION ON RADIATION UNITS & MEASUREMENTS, REPORT ICRU-18, OCTOBER 1970. "It must be emphasized the measurement of exposure rate and/or absorbed dose for treatment purposes should be made locally by the user himself. The statement of equipment conversion ratio by the manufacturer should not be regarded as a substitute for this."

ISSUED 1985 MAY 2

APPROVED P.D. Lanoue  
Measurement

G.R. Malkoske  
Authorization



Atomic Energy of Canada Limited • Radiochemical Company

Kanata • Ontario

NOTE: Rmm stands for roentgens per minute at one metre.



## Atomic Energy of Canada Limited

### SOURCE DISPOSAL CERTIFICATE

#### TO WHOM IT MAY CONCERN:

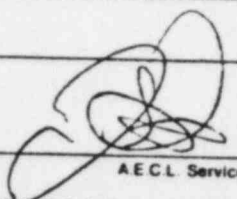
This is to certify that the following source has been removed from the unit described herein, and returned to Atomic Energy of Canada Limited, Commercial Products, Ottawa, Ontario, Canada for disposal:

COBALT 60 OR CAESIUM 137 SEALED SOURCE	SERIAL NO. <u>2652</u>	DEPLETED URANIUM ID.	UNIT <u>780 H</u>	UNIT SERIAL NO. <u>182</u>
LOCATION OF UNIT <u>NAVAL HOSPITAL PORTSMOUTH VIRGINIA</u>				

Date:

6 June 1985

Signed:

  
A.E.C.L. Service Representative

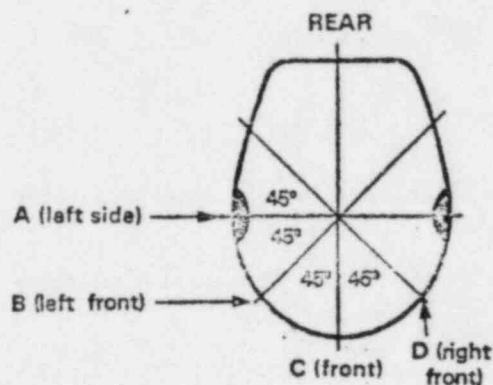
# Figure F-1 TELETHERAPY HEAD SURVEY



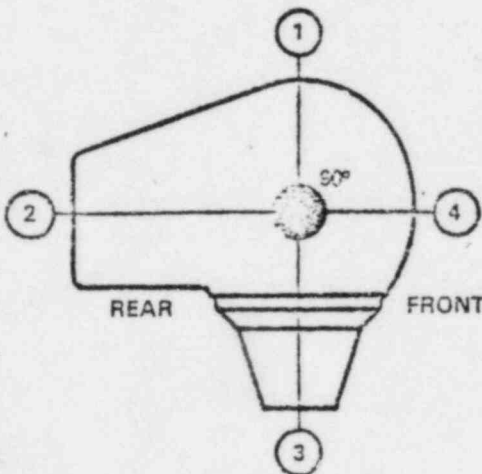
(Source in "OFF" position.  
Measurements taken one meter  
from source)

Top View-Showing  
orientation  
of Views A through D

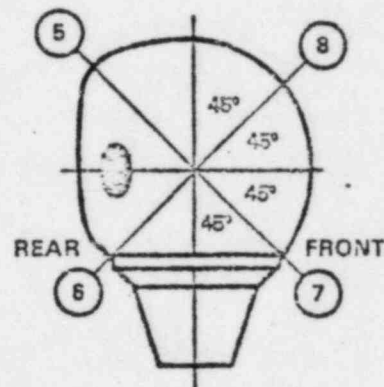
Position No.	Radiation Level (mr/hr)
View A	
1	.9
2	.9
3	.9
4	2.5
View B	
5	.6
6	1.1
7	.8
8	.1
View C	
9	.7
10	.6
View D	
11	.1
12	.85
13	1.1
14	.45
Average value	0.83
Maximum value	2.5



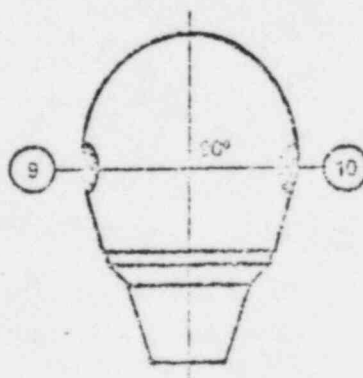
View A-Vertical  
from left side



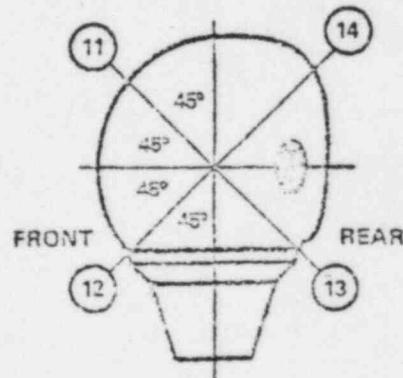
View B-Vertical  
from left front



View C-Vertical  
from front



View D-Vertical  
from right front



Date of survey 14 Jun 85

Instrument used AN/PDR-27

Manufacturer's  
name & model number AECL  
of teletherapy source MODEL C146

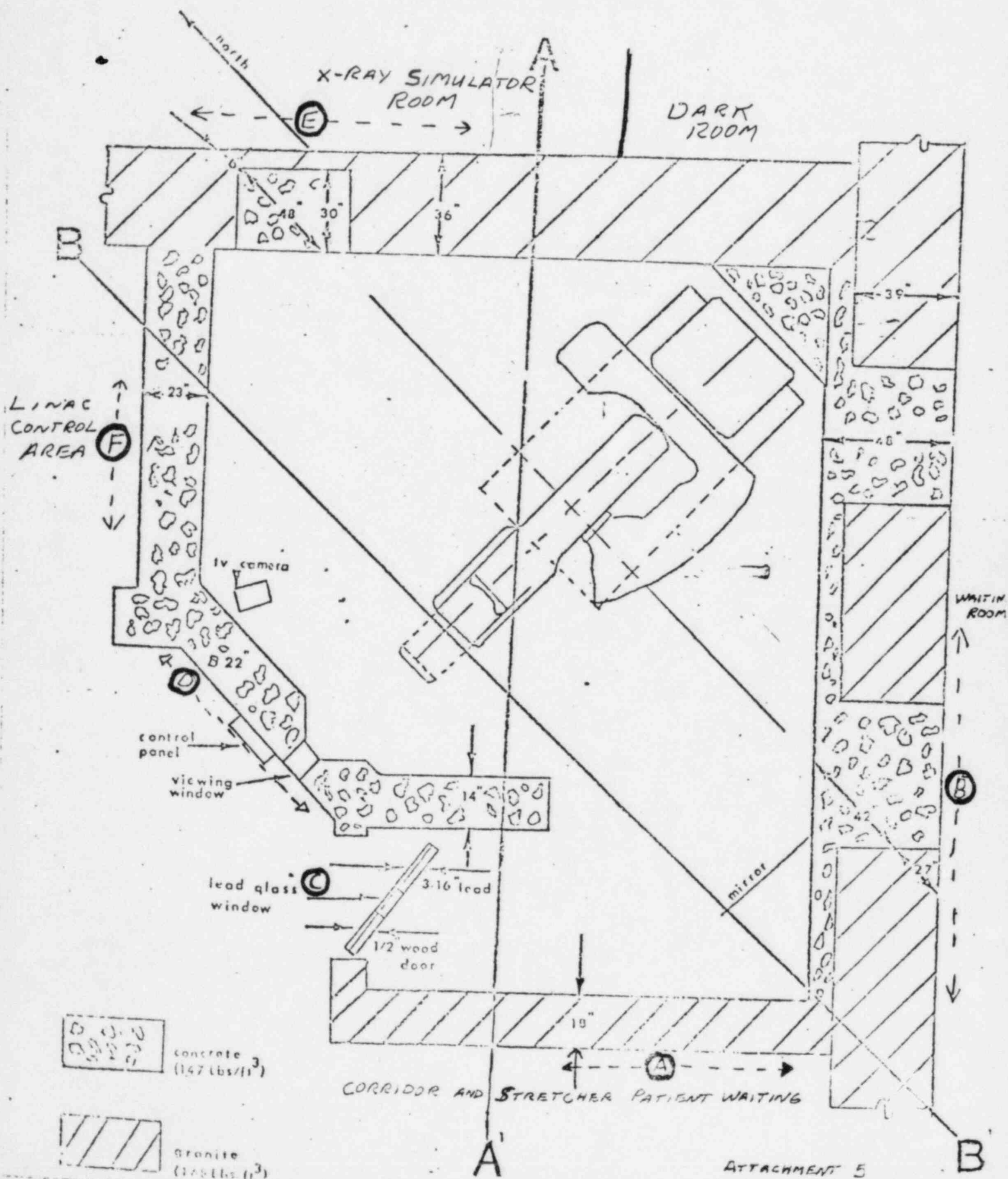
Date of installation 6 Jun 85

OUTPUT 11509 ☒ RHM  
☐ RMM

Date of output  
measurement 7 Jun 85

Attachment 4

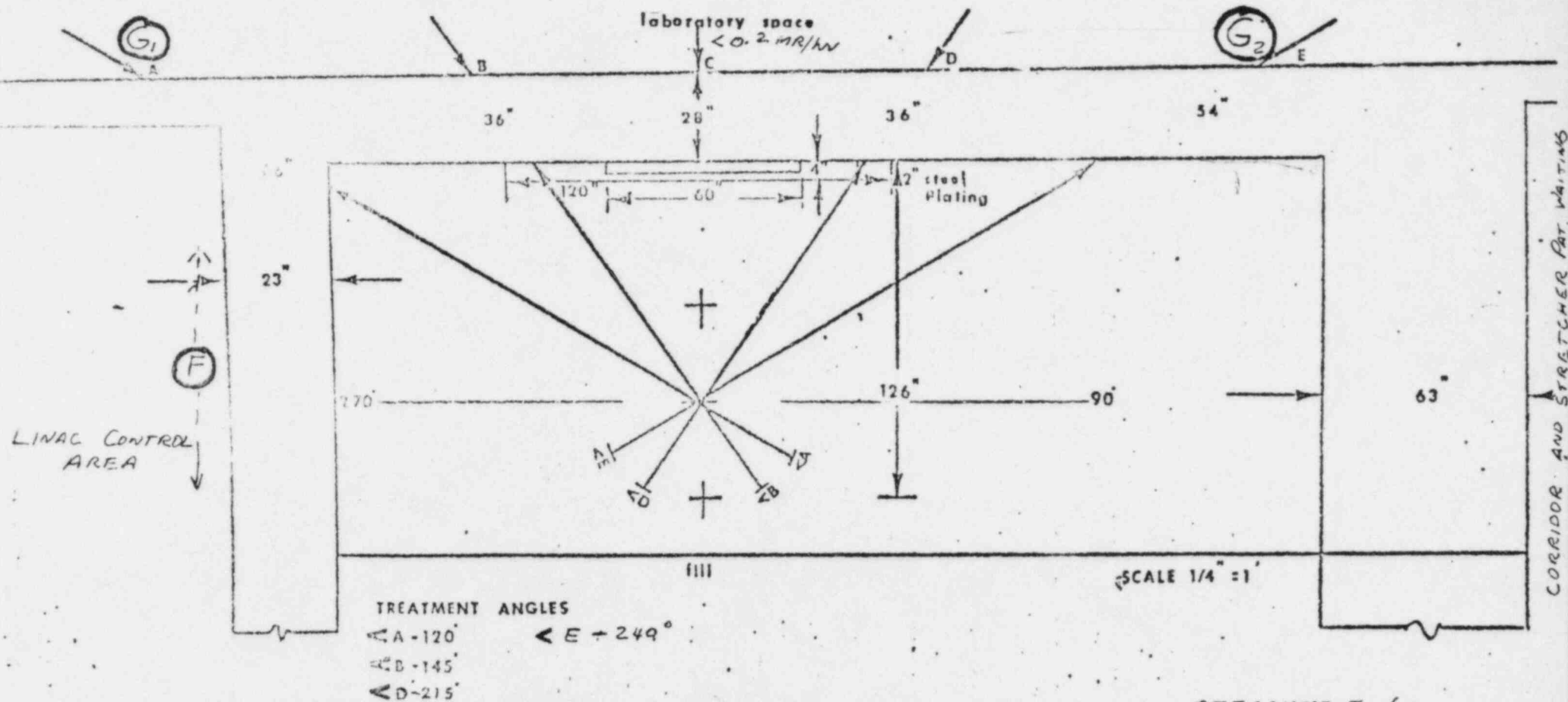
# PLAN OF THERAPY AREA



# SECTION B-B'

## ELEVATION OF THERAPY AREA SHOWING VIEW OF ANGULAR TREATMENT

ATTACHMENT 6



ATTACHMENT 6

REPORT OF ROUTINE WIPE TEST FOR CONTAMINATION

P&S 43408



IMPORTANT:

Sources shall be tested for leakage at intervals not to exceed six months. Records of test results shall be kept in units of microcuries and maintained for inspection by the appropriate Licensing Authority.

CUSTOMER LOCATION:

NAVAL MEDICAL COMMAND  
MID ATLANTIC REGION  
PORTSMOUTH VIRGINIA

MODEL & SERIAL NO. T-780 # 182

23708 DATE OF TEST(S): 6-6-85

DESCRIPTION OF SOURCE(S) TESTED:

Source in Rack ☐  
Drawer hole ☒  
Collimator ☐

for  $^{60}\text{Co}$  ☒ ,  $^{137}\text{Cs}$  ☐ ,  $^{238}\text{U}$  ☐

Survey Meter Used: Berthold RATO/F

Serial No. 056886

	A	B
Instrument Sensitivity:	400 c/min = 0.05 $\mu\text{Ci}$	$^{60}\text{Co}$ <input type="checkbox"/>
	1000 c/min = 0.05 $\mu\text{Ci}$	$^{137}\text{Cs}$ <input type="checkbox"/>
	350 c/min = 0.005 $\mu\text{Ci}$	$^{238}\text{U}$ <input type="checkbox"/>

Calibration Date: 85 05 02

Leak Test(s) Performed:

- ☒ 1. Routine wipe contamination test as detailed in the Facility Instruction and Maintenance Manual or Field Service Instructions.
- ☐ 2. Other test(s) as described on reverse side.

Gross Wipe Reading = 2.1 c/min

Background Reading = 0.1 c/min

Net Wipe Reading = 2.0 c/min x (B) 0.05  $\mu\text{Ci}$  = 0.1  $\mu\text{Ci}$   
(A) c/min

Test Evaluation:

- ☒ 1. NEGATIVE - Test showed less than reportable limit.
- ☐ 2. POSITIVE - Readings and initial corrective action to be detailed on reverse side.

It is hereby certified that the test(s) indicated above have been carried out under the supervision of the undersigned.

Conversion to S.I. Radiological Units  $0.05 \mu\text{Ci} = 1.85 \text{ kBq}$  and  $1 \text{ mrem} = 10 \mu\text{Sv}$ .

Date 6-6-85

Signed [Signature]

Title Senior Rep.

IMPORTANT:

Sources shall be tested for leakage at intervals not to exceed six months.  
Records of test results shall be kept in units of microcuries and maintained for inspection by the appropriate Licensing Authority.

CUSTOMER LOCATION:

NORTH AMERICAN CONTINENTAL  
 MID-ATLANTIC REGION  
 WASHINGTON VIRGINIA 22708

MODEL & SERIAL NO. T-780 "182

DATE OF TEST(S): 6 June 55

DESCRIPTION OF SOURCE(S) TESTED:

Source in Rack ☐  
 Drawer hole ☐  
 Collimator ☒

for  $^{60}\text{Co}$  ☐ ,  $^{137}\text{Cs}$  ☐ ,  $^{238}\text{U}$  ☒

Survey Meter Used: Berthold RATO/F

Serial No. 056996

Instrument Sensitivity:	A	B
	400 c/min = 0.05 $\mu\text{Ci}$ $^{60}\text{Co}$ <input type="checkbox"/>	
	1000 c/min = 0.05 $\mu\text{Ci}$ $^{137}\text{Cs}$ <input type="checkbox"/>	
	350 c/min = 0.005 $\mu\text{Ci}$ $^{238}\text{U}$ <input type="checkbox"/>	

Calibration Date: 85 05 02

Leak Test(s) Performed:

- ☒ 1. Routine wipe contamination test as detailed in the Facility Instruction and Maintenance Manual or Field Service Instructions.
- ☐ 2. Other test(s) as described on reverse side.

Gross Wipe Reading = 14.1 c/min  
 Background Reading = 1.1 c/min

Net Wipe Reading = 13.0 c/min x (B) \_\_\_\_\_  $\mu\text{Ci}$  = \_\_\_\_\_  $\mu\text{Ci}$   
 (A) \_\_\_\_\_ c/min

Test Evaluation:

- ☒ 1. NEGATIVE - Test showed less than reportable limit.
- ☐ 2. POSITIVE - Readings and initial corrective action to be detailed on reverse side.

It is hereby certified that the test(s) indicated above have been carried out under the supervision of the undersigned.

Conversion to S.I. Radiological Units 0.05  $\mu\text{Ci}$  = 1.85 kBq and 1 mrem = 10  $\mu\text{Sv}$ .

Signed . . . . .

Title . . . . .

Date . . . . .



# LEAK TEST CERTIFICATE ATTESTATION D'ÉTANCHÉITÉ

ORDER No.  
N° DE COMMANDE

43408

DATE 1985 May 6

## DESCRIPTION OF SOURCE TESTED DESCRIPTION DES SOURCES VÉRIFIÉES

One Cobalt-60 Teletherapy Source 2.0 CM. Active Diameter, AECL Type C 146  
Une source de téléthérapie au Cobalt-60, CM de diamètre actif, ÉACL, Type C

Serial No. S-3743 Other  
N° de série Autre

## LEAK TESTS PERFORMED ÉPREUVES D'ÉTANCHÉITÉ EFFECTUÉES

(See reverse for description of tests)  
(Description des épreuves au verso)

## RESULTS OF TESTS RÉSULTATS DES ÉPREUVES

- ☒ 1. THE DRY WIPE TEST, PROCEDURE DG-0065  
ÉPREUVE PAR FROTTEMENT À SEC, PROCÉDÉ DG-0065
- ☐ 2. OTHER TESTS (AS DESCRIBED BELOW)  
AUTRES ÉPREUVES (DÉCRITES CI-APRÈS)

NEGATIVE

DATE OF COMPLETION OF TESTS  
ÉPREUVES TERMINÉES LE

1985 May 6

FOR THE COMPANY  
POUR LA SOCIÉTÉ



Source Production Department  
Service de la production des sources



Atomic Energy  
of Canada Limited

Radiochemical Company

P.O. Box 13500  
Kanata, Ontario  
Canada  
K2K 1X8

L'Énergie Atomique  
du Canada, Limitée

Société Radiochimique

C.P. 13500  
Kanata, Ontario  
Canada  
K2K 1X8



A.E.C.L. Procedure DG-0065

**TITLE: DRY WIPE TEST — ABSTRACT**

The surface of the capsule is thoroughly wiped with a filter paper. The paper is monitored and the amount of radioactive material present is determined. If less than 0.0005 microcuries are present, the results are described as negative. The limit is raised to 0.005 microcuries on the inner capsule of a double encapsulated assembly.

The source assembly is retested after a minimum period of 7 days of storage and within 7 days of final packaging. The limit on the 7 days leak test is 0.005 microcuries.

Procédé DG-0065 ÉACL

**TITRE: ÉPREUVE PAR FROTTEMENT À SEC — APERÇU**

*On essuie soigneusement la surface de la capsule avec un papier filtre. On vérifie le papier pour déterminer la quantité de matières radioactives présentes. Lorsqu'on détecte moins de 0.0005 microcuries, on considère que les résultats sont négatifs. Cette limite est portée à 0.005 microcuries sur la capsule intérieure d'un ensemble doublement encapsulé.*

*On revérifie l'ensemble de la source après une période minimale de 7 jours de stockage et dans les 7 jours qui précèdent l'emballage définitif. La limite prévue pour l'épreuve détachéité de 7 jours est de 0.005 microcuries.*