Yale University School of Medicine

DEPARTMENT OF THERAPEUTIC RADIOLOGY
Division of Radiological Physics

333 Cedar Street
New Haven, Connecticut 06510

February 14, 1984

License Management Branch
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Gentlemen:

I am writing in support of Alfred G. Agostinelli's request to be recognized as a qualified expert by the NRC.

Mr. Agostinelli has been employed in the Department of Therapeutic Radiology of the Yale-New Haven Hospital since 1962. He has been a member of my staff and a close colleague since I assumed the directorship of the Physics Division in 1970. As a result of his many years of experience, the in-service training that I provide to all of my staff, and his participation in a wide variety of clinical research projects that are constantly underway in this department, he has developed into an extremely competent, reliable and knowledgable radiological physicist. I regard him as superior to the majority of board-certified radiological physicists that I encounter in the field and at scientific meetings.

In discussions with Mr. Agostinelli on the various aspects of calibrating and surveying teletherapy units, I have come to the conclusion that he is thoroughly conversant with NRC regulations as well as with all of the practical aspects of performing these types of measurements.

In summary, I strongly recommend Mr. Agostinelli as a competent and experienced radiological physicist, and that he be designated a qualified expert by the NRC.

Sincerely yours,

R.J. Schulz, Ph.D.
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The Stamford Hospital

Cobalt-60

Safety, Alignment and Output Check

A. Beam on/off indicators.

1) Check "beam off" light indicators: in room on wall; over door to room; "operation indicator" on Primalert room monitor; and green light on console.

2) Turn beam on and check all flashing "beam on" indicators; on machine; on wall in room; above door to room; on the console; and on the Primalert.

B. Door Interlocks.

1) With the beam on, open the door slightly to check if the door interlock shuts off the beam.

2) With the beam off, time set on the timer and the door ajar, try to turn the beam on to check that the beam will not go on.

3) Close the door and check that the beam may only go on after resetting at console.

C. Timer Check.

1) Let the beam turn off normally to check that the timer shuts the beam off when zero time is reached.

2) With zero time set, attempt to turn the beam on to check that it will not come on.

D. Emergency off switches.

1) With the beam on, see that the emergency off bar on the console shuts off the beam.

E. Alignment of distance measuring device.

-- Set a 10 x 10 cm field at 80 cm.
-- Raise the table until it stops automatically.
-- Place the spacer on the table with mattress removed.
-- Place the alignment jig on the spacer.
-- Center the 10 x 10 cm field.
-- Set the Optical Distance indicator to 80 cm.
-- The arrow should intersect the cross hairs (within 2mm).

F. Light vs. Radiation Field - Congruence.

1. Place a ready pack of RP/V film between the alignment jig and the spacer; align the 10 x 10 cm light field on the 10 x 10 wires on the jig.

2. Irradiate to approximately 80 rads.

3. When developed, the radiation beam should be within 3mm of the light beam (i.e., the wires).

G. Output Check.

1. Set a 10 x 10 cm field at 80 cm.

2. Place the output jig in the center of the field on the spacer (with the couch fully raised).

3. Place the blue diode in the center of the field. Read the diode on the Nuclear Associates Diode Dosemeter.

4. Irradiate for 1 minute.

5. The reading multiplied by ~~0.75~~ 0.72 should be within 5% of the posted output for the month, for a 10 x 10 cm field.

To calculate this value:

$$\frac{100\ [\ (\text{Reading})\ (\cancel{0.75}\ 0.72)\ -\ \text{Posted}\ ]}{\text{Posted}} = \pm\ \_\_\_\_\_\_\ \%\ \text{deviation}$$

For example, on July 5, 1983, the reading was 111, and the posted output was 83.5. Therefore:

$$\frac{100\ [\ (111)\ (\cancel{0.75}\ 0.73)\ -\ 83.5\ ]}{83.5} = -\ 0.3\%\ \text{deviation}$$

H. Timer Accuracy.

1. Irradiate the diode as in the output check. This is Reading A (Rd_a).

2. Repeat the irradiation, turning the beam off 4 times during the 1 minute irradiation. When the beam shuts off it will have had 5 on-off cycles. This is Reading B (Rd_b).

Timer Accuracy (TA) is determined by the following:

$$TA = \frac{Rd_b - Rd_a}{5\ Rd_a - Rd_b}$$

For example:

A 1-minute irradiation with one on-off cycle readings 153 (Rd_a).

A 1-minute irradiation with 5 on-off cycles reads 159 (Rd_b).

$$TA = \frac{159 - 153}{5\ (153) - 159} = 0.01 \text{ min}$$

$$0.01 \text{ min} \times 60 \frac{\text{sec}}{\text{min}} = 0.59 \text{ sec}$$

A G Agostinelli Sr

Alfred G. Agostinelli
Radiological Physicist
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		Indicato	Interlock	Timer	Emergency	Alignmen	Light /				Timer Accuracy	
								G - Output Check				
Date	Initial	A	B	C	D	E	F	Meter Reading	Chart Dose Rate	% Dev.	H	Physicist Review

The following is a description of methods used in complying with 10 CFR 35.21 regarding full calibration measurements of a teletherapy unit:

A. The Stamford Hospital Cobalt unit is calibrated in accordance with the recommendations of the Scientific Committee on Radiation Dosimetry (SCRAD) of the American Association of Physicists in Medicine (Phys. in Med. & Bio. 1971 vol. 16).

An example of this method as used on May 18, 1984 at the time of the most recent source replacement on the Picker-C-10 cobalt unit at Stamford Hospital, follows.

The equipment used was a PTW Lucite wall Farmer chamber (model 30-351, SN. A197). The cobalt exposure factor, N_c, for this chamber was obtained from NBS on November 4, 1982, its value is 5.636×10^9 R/c at 22°C and 1 Atm. The electrometer was a Keithley 616 with a 6169 ion chamber interface.

The center of the chamber with cobalt build-up cap was placed in air at 80 cm from the source. This distance was determined using the mechanical distance indicator provided by the manufacturer. Using a 10 cm x 10 cm field at 80 cm, several exposures of 2 min and 1 min were made. The 1 minute readings were subtracted from the 2 minute readings in order to eliminate any effects of timer/shutter error. The reading was multilpied by the appropriate factors to obtain the dose in rads to tissue (water) in a full phantom, at d_{max} (0.5 cm) for a 10 cm x 10 cm field at 80 cm was determined to be 153.5 rads/min.

From: $(\overline{Rd}_{2min} - \overline{Rd}_{1min})(TPC)(N_c)(f)(T)(A)(IS)$

where TPC = 0.996 = Temperature/pressure correction (21.5°C, 762.0 mmhg)

$N_c = 5.636 \times 10^9$ R/c = NBS supplied Cobalt exposure factor

f = 0.965 = exposure-to-dose conversion factor for water

T = 1.036 = tissue - air ratio (BSF)

A = 0.985 = "Attenuation factor"

I = 0.988 = Inverse square from 80.0 to 80.5 cm

$\overline{Rd} = 28.1 \times 10^{-9}$ C

The variation of output with field size was determined by placing a Farmer chamber at 5 mm depth in a 30 cm x 30 cm x 30 cm polystyrene phantom. Readings were taken as a function of field size from 4 cm x 4 cm to 20 cm x 20 cm which is the full range if the Johns-McKay collimator on the Picker C-10.

The data was plotted and normalized to a 10 cm x 10 cm field. These output factors were used to determine the dose rate at d_{max} as a function of field size and are incorporated in the monthly calibration report which is used for therapy calculations. A decay factor of 0.93905 per month is used and the output is checked monthly with a diode dosimeter.

This effect was also checked taking "in air" measurements with a Farmer chamber including build-up cap as a function of field size. These in turn were multiplied by the standard BJR Supplement 11 cobalt backscatter factors. The results, normalized to a 10 cm x 10 cm field compare favorable with the directly measured output factors. These factors are checked yearly.

B. The congruence between radiation field and light field was checked using RP/v film, and an alignment jig containing lead wires which describe a 10 cm x 10 cm square. The light beam was set to the wires and the film exposed. The resulting film shows the congruence to be within 3 mm. This technique is used during the monthly spot checks. An example of a recent film is enclosed.

C. The uniformity of the beam as a function of beam direction was done using film. A series of films of a 20 cm x 20 cm field was taken at 0°, 90°, 180° and 270° gantry angles. Each film was perpendicular to the central axis of the beam at approximately 5 mm depth with sufficient scatter. The four resulting films were then scanned in the front-to-back and left-to-right directions. The optical density (OD) of the central 16 cm x 16 cm area was noted. The OD was then converted to dose using a dose response curve determined with the same batch of film developed at the same time as the field uniformity films.

The resulting data shows that the cobalt unit has essentially the same uniformity regardless of gantry angle (i.e. beam direction).

Gantry Angle	Front OD / CAX OD	Back OD / CAX OD	Left OD / CAX OD	Rig t OD / CAX OD
0°	0.95	0.97	0.95	0.98
90°	0.94	0.96	0.95	0.97
180°	0.95	0.97	0.96	0.98
270°	0.94	0.95	0.94	0.97

The above ratio of off-axis to central axis optical densities are all within a few percent of each other at any gantry angle demonstrating that the uniformity does not change with beam direction.

This is to be expected with the newer solid sources as opposed to the older style "loose" pellets. This parameter is checked yearly.

D. The timer accuracy was determined by both acquiring readings as a function of time and plotting this data and also the multiple shut-off method, i.e.

$$\text{Timer accuracy} = \frac{B - A}{5A - B}$$

where A = a one minute reading with 1 shut-off

B = a one minute reading with 5 shut-offs

On 5/18/84 the results were as follows:

$A = 28.0 \times 10^{-9}C$ and $B = 29.28 \times 10^{-9}C$

Then TA = 0.012 mm = 0.69 sec.

This value has been consistent with this machine for years and is checked monthly. The error is very small and incorporated into clinical use when appropriate.

E. The distance measuring devices supplied with the machine include a mechanical distance indicator as well as an optical distance indicator. These two methods of determining SSD are compared daily and verified monthly with an independent method. (see monthly spot check program section E.)

THE STAMFORD HOSPITAL

PICKER COBALT-60 RADIATION THERAPY UNIT

CALIBRATION REPORT FOR JULY, AUGUST AND SEPTEMBER 1985

A. 80.0 CM SSD

FIELD SIZE	RADS/MIN @ MAX (0.5 CM) (1)		
	JULY	AUGUST	SEPTEMBER
4^2 = 16 cm^2	119.4	118.1	116.8
5^2 = 25 cm^2	120.9	119.5	118.2
6^2 = 36 cm^2	122.7	121.4	120.1
7^2 = 49 cm^2	124.4	123.1	121.7
8^2 = 64 cm^2	125.8	124.4	123.1
9^2 = 81 cm^2	127.9	126.5	125.1
10^2 = 100 cm^2	129.2	127.8	126.4
11^2 = 121 cm^2	130.3	128.8	127.4
12^2 = 144 cm^2	131.4	130.0	128.6
13^2 = 164 cm^2	132.6	131.2	129.7
14^2 = 196 cm^2	133.9	132.5	131.0
15^2 = 225 cm^2	134.2	132.7	131.3
16^2 = 256 cm^2	135.1	133.6	132.2
17^2 = 289 cm^2	136.2	134.7	133.2
18^2 = 324 cm^2	136.6	135.1	133.6
19^2 = 361 cm^2	137.2	135.7	134.2
20^2 = 400 cm^2	138.1	136.6	135.1

(1) THE OUTPUT IS STATED IN RADS TO TISSUE AND INCLUDES FULL BACKSCATTER. BASED ON CALIBRATION OF 5/18/85

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