DAKOTA MIDLAND HOSPITAL

DIVISION OF THE HEALTH CENTRAL SYSTEM

HIGHWAY 281 NORTH AND FIFTEENTH AVENUE NORTHWEST • ABERDEEN, SOUTH DAKOTA 57401 • (605) 622-3300

Applicant Nov. 1 IV
Check No. 32433
Amount/Fee Category $230 (7A)
Type of Fee AMD
Date Check Rec'd 11/14/85
Received By SR

November 4, 1985

Mr. R.E. Hall, Chief
Technical Program Branch, Region IV
U.S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 1000
Arlington, TX 76011

Dear Mr. Hall,

Dakota Midland Hospital, 15th Avenue and Highway 281 North, Aberdeen, SD, 57401, is asking that the NRC license #40-13245-01, be amended. We are replacing our existing Picker V4 therapy unit with a Theratron 80 Cobalt 60 therapy unit. Enclosed please find our license amendment fee of $230 and also the necessary drawings and calibrations by our physicist, Joseph Giganti, Ph.D.

We ask that you give this amendment, your earliest possible attention, as we cannot receive our reconditioned Theratron 80 Cobalt 60 teletherapy unit until our amendment has been processed.

If you have any questions regarding the amendment to our teletherapy license, please notify Mr. Kim Erb, RT, in Dakota Midland Hospital's Radiology Department.

We will anxiously await your reply. Thank you very much for your prompt attention to this matter.

Sincerely,

Philo D. Hall,
Executive Vice President
Dakota Midland Hospital

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Enclosure

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APPLICATION FOR MATERIALS LICENSE AMMENDMENT, TELETHERAPY

I. Applicant:

NRC license Number: 40-13245-01

Dakota Midland Hospital
1400 15th Ave. N.W.
Aberdeen, SD 57401
Tel: (605) 622-3346

II. Address of use:

Same

III. Responsibility for this report:

Joseph R. Giganti, Ph.D.
Radimetrix, inc.
1785 Taconite Point
St. Paul, MN 55122
(612) 452-4982

IV. Qualifications:

JRG is certified by the American Board of Radiology in Therapeutic Radiological Physics since June 1984.

V. Byproduct Materials and activity limit requested:

12,000 Ci.Cobalt-60 (maximum) as two teletherapy sources (of 6000 Ci. maximum each) to cover the operation of source exchange.

VI. Proposed replacement teletherapy device:

manufacturer:	A.E.C.L.
model:	Theratron 80 Cobalt teletheapy unit with beamstop.
source model:	NPI-15-5400W
nominal exposure rate:	5400 RHM
maximum activity:	6000 Ci.

VII. Installation:

equipment will be installed, tested and guaranteed by:

Neutron Products, Inc.
2230 Mt.Ephraim Road
P.O.Box 68
Dickerson, MD 20842

under Maryland License MD-31-025-03.

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VIII. Conditions of use:

A. The device has an isocentrically mounted source head with integral beamstop and treatment couch. The head may be "swiveled" off the beamstop subject to mechanical and electrical interlock. The installation requirement will be to allow off-beamstop operation only over an angular range from vertically downward to 90 degree (horizontal) to the right. This will insure that the existing primary barrier is the only one which can be directly struck by the beam.

With the beam directed through isocenter (and, therefore at the beamstop) no constraint on beam angle is to be made.

B. Plan and elevation drawings are attached. These are scaled and marked with distance, thickness of barrier and construction materials. The location points for exposure calculation are keyed with mathematical formulations below. In all cases, compliance with the provisions of 10 CFR 20.105 are demonstrated.

C. Patient viewing will be done with closed cuicuit TV and backed up by a mirror system viewable through a window in the treatment room door.

D. The room is of maze design to reduce scatter to the entry door. All conduits and heating pipes enter the room through 90 degree bends or follow the entryway maze. Power and control service to the gantry is through electrical conduit from below floor level (unexcavated) into the "pit". The barrier protecting the operator may not be struck by the beam.

E. Door interlocks are inplace which will prevent the beam from being turned on with an open room door or will initiate source retraction if opened during an exposure. Source reexposure will not be allowed after door opening except at the console.

F. A source position monitor "Primalert -10" with battery backup accessory will be positioned on a wall in the maze area which will provide independent verification of beam condition. This unit will also be provided by Neutron Products at the time of installation.

IX. Radiological Protection Criteria

The installation of this teletherapy unit must not, under any possible configuration of use, produce radiation levels in surrounding areas in excess of the provisions found in 10CFR20.105. These are quoted as follows:

(1) Radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of two millirems in any one hour, or

(2) Radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of 100 millirems in any seven consecutive days.

The ability of this installation to meet these criteria will be demonstrated below through calculations, drawings and the use of interlocks. Where assumptions must be made, they are fully stated and conservative in that they tend to overestimate the radiation levels to be encountered. Barriers to the radiation in this installation are of both "primary" and "secondary" types depending on whether the beam may directly strike them or not. Separate calculations are provided for each type.

Assumptions:

* 32 patients per day
* 8 hr. per day of operation, 4 hours on Saturday
* 4 patients per hour
* Average treatment: 200 Rads @5 cm. depth.(80% DD)
  30 x 30 cm field size
  2 fields per patient
* Workload : 66,000 R/week @ 1 meter (see below)
* Source maximum activity: 6000 Ci
* source maximum exposure rate: 5400 RHM
* T (occupancy): 1 for all areas
* U (use factor): 1 for scatter, leakage
* Maximum Activity in head: 6000 Ci. cobalt-60
* Head exposure modifying factor: 0.8 (the exposure from the encapsulated source in its head, relative to a bare exposed Co-60 in free space)
* Beam stopper present for all secondary barrier calculations
* Isocentric gantry with 360 degree rotation and 80 cm SAD.
* Head swivel (off beamstop) allowing beam angle range from vertically downward to horizontal to the right.

[Note on mathematical notation: Because of printer constraints the representation of numbers taken to a power is: n^m where the value (n) is multiplied times itself (m) times. Thus 5^2 = 5 x 5 = 25]

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A. Calculation average hourly workload.

a) Number of fields given per hour:

$$\frac{32\ \text{pts}}{\text{day}} \times \frac{1\ \text{day}}{8\ \text{hrs}} \times \frac{2\ \text{fields}}{\text{patient}} = \frac{8\ \text{fields}}{\text{hour}}$$

c) Average exposure at 1 meter required for an average hour of treatments (at 80 cm):

$$\frac{200\ \text{R}}{\text{field}} \times \frac{1}{80\%} \times \left[\frac{.8}{1}\right]^2 = 160\ \text{R/field @ 1 meter}$$

and from step (a):

$$\frac{8\ \text{fields}}{\text{hour}} \times \frac{160\ \text{R}}{\text{field}} = 1280\ \text{R/hour @ 1 meter}$$

d) The "duty cycle" (% time beam is exposed) is therefore calculated:

from step (c): 1280 R/hour needed

from assumptions: 5400 R/hour possible

$$\frac{1280\ \text{R/hour needed}}{5400\ \text{R/hour possible}} \times 100\% = 24\%$$

Thus to be conservative we may assume the source will be exposed 27.8% of the time and the hourly "workload" will be:

$$5400 \times 27.8\% = 1500\ \text{RHM}$$

B. Total facility operating time per week:

$$5\ \frac{\text{day}}{\text{week}} \times 8\ \frac{\text{hrs}}{\text{day}} + 4\ \text{hrs(Sat.)} = 44\ \text{hrs./week}$$

X. Calculated exposures at specified locations beyond radiation barriers.

A. Primary Barriers.

Barriers against teletherapy radiations are considered "primary" if they may be directly struck by the beam, or "secondary" if they may only be hit by scattered radiation. Primary barriers must significantly more efficient and are, for conservativism, assumed to be protecting against the worst use configuration of the teletherapy head for the entire period under consideration.

The formulation for estimating exposure (P) through a primary barrier during an average hour of operation in a cobalt teletherapy installation is taken from N.C.R.P. handbook #49 (pg. 52, eq.4) with modification:

$$P = \frac{Bug \times W \times U \times T \times 10^3}{d^2pri} \quad \text{(milliRem/avg.hr)}$$

where:

$$Bug = \exp\left[\frac{-.693 \times t}{2.45}\right]$$

where: t = inches of concrete

W = 1500 RHM (avg.hourly workload)
U = 1 (barrier "use" factor)
T = 1 (full occupancy assumed outside barrier)
dpri = distance to location of intereat beyond the barrier.

1. Location #1: (see figs. 1,2)

The barrier protecting location "A" is the only primary barrier in this installation.

t = 48 inches concrete
dpri = 12 feet (3.6 meters) minimum distance possible, by using head swivel off beamstop directly horizontal toward barrier.

from equations I, II:

$$bug = \exp\left[\frac{-.693 \times 48"}{2.45"}\right]$$

$$p = \frac{1.27 \times 10^{-6} \times 1500 \times 1 \times 1 \times 10^{3}}{(3.6 \text{ meter})^{2}} =$$

= 0.146 millirem per Avg. hour of operation

****** This exposure is below the 2 mRem/1 hour limit imposed by 10CFR20.105.

The seven consecutive day exposure at this location would be (from IV B):

44 hrs/week X 0.147 mRem/hour = 6.5 mRem/7 days

****** This exposure is below the 100 mRem per seven consecutive days limit imposed by 10CFR20.105.

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B. Secondary Barriers.

Secondary barriers are incapable of being struck by the radiation beam, but will receive scatter radiation from the patient and leakage radiation from the source head. Radiation exposure beyond each secondary barrier due to scatter and leakage are calculated separately. They are combined to verify that the provisions of 10CFR20.105 are not being exceeded.

The relation between workload and scatter exposure (Ps) in milliRem, is modified from NCRP report #49 (pg.60, 6g) to allow calculation of the exposure due to scatter from one average hour of operations:

$$P_s = B_{sg} \times a \times W \times T \times \frac{F}{400} \times \frac{1}{dsec^2} \times \frac{10^3}{dsca^2} \qquad III$$

where:

$$B_{sg} = \exp\left[\frac{-.693 \times t}{HVT}\right] \qquad IV$$

where: t= concrete thickness (inches)
HVT= 1.79 inches, calculated from NCRP Rept#49 Fig.15, Appendix "D" for 90 degree scatter.

a = 1 x 10^3 (fraction of 90 degree scatter)

W = 1500 RHM (average horuly workload)

T = 1 (occupancy)

F = 900 (30 x 30 cm^2, largest possible field size likely to hit secondary scatterer at treatment distance usually employed)

dsca = 0.8 meter (distance from source to scatterer)

dsec: distance from scattering material to point of interest.

To calculate exposure due to sourcehead leakage (Plg) in milliRem during an average hour of facility operation, the NCRP Report #49 equation (pg.54,5c) is used with modification:

$$Plg = \frac{(.001) \times Blg \times W}{dlkg^2} \times 10^3 \qquad V$$

where:

$$Blg = \exp\left[\frac{-.693 \times t}{2.45}\right] \quad \text{i.e. same as for primary} \qquad VI$$

Plg: exposure during average hour of operation due to sourcehead leakage (mRem)

W = 1500 RHM (hourly workload, as above)

dlkg: distance from source location to point of interest.

[note that sourcehead leakage with beam 'off' is limited to 10 mRHM maximum and, hence, is insignificant outside the barrier]

1. Location #1: (beyond primary barrier)

[this primary barrier is grossly in excess of that needed to attenuate secondary radiation, but is included here for completeness]

dsec= 7ft.(2.1m)
t= 48" concrete

a. scatter exposure,from eq. III,IV:

$$Bsg = \exp\left[\frac{-.693 \times 48"}{1.79"}\right]$$

$$Ps = 8.50\text{x}10^{-9} \times 1500 \times \frac{900}{400} \times \frac{1}{2.1^2}$$

= .0000065 mRem/ avg. hr.

b. leakage exposure, from eq. V, VI:

$$Blg = \exp\left[\frac{-.693 \times 48"}{2.45}\right]$$

$$Plg = \frac{1.27\text{x}10^{-6} \times 1500}{2.1^2} = .00043 \text{ mRem/hr}$$

c. total exposure due to scatter and leakage:

Psec= 0.0000065+ 0.00043 = 0.00043 mRem/Avg. hour.

****** This exposure is below the 2 mRem/1 hour limit imposed by 10 CFR 20.105.

d. total seven-consecutive-day exposure:

P7day=0.00043 x 44 hrs/week = 0.02 mRem

****** This exposure is below the 100 mRem per seven consecutive days limit imposed by 10 CFR 20.105.

2. Location #2: (mechanical closet)

dsec= 17ft.(5.2m)
t= 30" concrete

a. scatter exposure,from eq. III,IV:

$$B_{sg} = \exp\left[\frac{-.693 \times 30"}{1.79"}\right]$$

$$P_s = 9.03\text{x}10^{-6} \times 1500 \times \frac{900}{400} \times \frac{1}{5.2^2}$$

= 0.0011 mRem/ avg. hr.

b. leakage exposure, from eq. V, VI:

$$B_{lg} = \exp\left[\frac{-.693 \times 30"}{2.45}\right]$$

$$P_{lg} = \frac{2.06\text{x}10^{-4} \times 1500}{5.2^2} = 0.011 \text{ mRem/hr}$$

c. total exposure due to scatter and leakage:

Psec= 0.0011 + 0.011 = 0.012 mRem/Avg. hour.

****** This exposure is below the 2 mRem/1 hour limit imposed by 10 CFR 20.105.

d. total seven-consecutive-day exposure:

P7day= .012 x 44 hrs/week = 0.53 mRem

****** This exposure is below the 100 mRem per seven consecutive days limit imposed by 10 CFR 20.105

3. Location #3: (Hallway)

dsec= 18.5ft.(5.6m)
t= 21" concrete

a. scatter exposure,from eq. III,IV:

$$Bsg = \exp\left[\frac{-.693 \times 21"}{1.79"}\right]$$

$$Ps = 2.9510\text{^-4} \times 1500 \times \frac{900}{400} \times \frac{1}{5.6\text{^2}}$$

= 0.032 mRem/ avg. hr.

b. leakage exposure, from eq. V, VI:

$$Blg = \exp\left[\frac{-.693 \times 21"}{2.45}\right]$$

$$Plg = \frac{2.60\text{x}10\text{^-3} \times 1500}{5.6\text{^2}} = 0.12 \text{ mRem/hr}$$

c. total exposure due to scatter and leakage:

Psec= 0.032 + 0.12 = 0.15 mRem/Avg. hour.

****** This exposure is below the 2 mRem/1 hour limit imposed by 10 CFR 20.105

d. total seven-consecutive-day exposure:

P7day= .15 x 44 hrs/week = 6.6 mRem

****** This exposure is below the 100 mRem per seven consecutive days limit imposed by 10 CFR 20.105.

4. Location #4: (Entryway)

dsec= 11ft.(3.4m)
t= 17" concrete

a. scatter exposure,from eq. III,IV:

$$B_{sg} = \exp\left[\frac{-.693 \times 17"}{1.79"}\right]$$

$$P_s = 1.4\text{x}10^{-3} \times 1500 \times \frac{900}{400} \times \frac{1}{3.4^2}$$

= 0.41 mRem/ avg. hr.

b. leakage exposure, from eq. V, VI:

$$B_{lg} = \exp\left[\frac{-.693 \times 17"}{2.45}\right]$$

$$P_{lg} = \frac{8.16\text{x}10^{-3} \times 1500}{3.4^2} = 1.06 \text{ mRem/hr}$$

c. total exposure due to scatter and leakage:

Psec = 0.41 + 1.06 = 1.47 mRem/Avg. hour.

****** This exposure is below the 2 mRem/1 hour limit imposed by 10 CFR 20.105.

d. total seven-consecutive-day exposure:

P7day= 1.47 x 44 hrs/week = 65 mRem

****** This exposure is below the 100 mRem per seven consecutive days limit imposed by 10 CFR 20.105.

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5. Location #5: (Control console)

dsec= 13ft.(4m)
t= 16" concrete

a. scatter exposure,from eq. III,IV:

$$B_{sg} = \exp\left[\frac{-.693 \times 16"}{1.79"}\right]$$

$$P_s = 2.0\times10^{-3} \times 1500 \times \frac{900}{400} \times \frac{1}{4.0^2}$$

= 0.42 mRem/ avg. hr.

b. leakage exposure, from eq. V, VI:

$$b_{lg} = \exp\left[\frac{-.693 \times 16"}{2.45}\right]$$

$$P_{lg} = \frac{1.08\times10^{-2} \times 1500}{4.0^2} = 1.01 \text{ mRem/hr}$$

c. total exposure due to scatter and leakage:

Psec= 0.42 + 1.01 = 1.43 mRem/Avg. hour.

****** This exposure is below the 2 mRem/1 hour limit imposed by 10 CFR 20.105.

d. total seven-consecutive-day exposure:

P7day = 1.43 x 44 hrs/week = 63 mRem

****** This exposure is below the 100 mRem per seven consecutive days limit imposed by 10 CFR 20.105

6. Location 6: (dressing carrel)

dsec= 10.5ft.(3.2m)
t= 21" concrete

a. scatter exposure,from eq. III,IV:

$$Bsg = \exp\left[\frac{-.693 \times 21"}{1.79"}\right]$$

$$Ps = 3.0x10^{-4} \times 1500 \times \frac{900}{400} \times \frac{1}{3.2^2}$$

= 0.10 mRem/ avg. hr.

b. leakage exposure, from eq. V, VI:

$$Blg = \exp\left[\frac{-.693 \times 21"}{2.45}\right]$$

$$Plg = \frac{2.63x10^{-3} \times 1500}{3.2^2} = 0.40 \text{ mRem/hr}$$

c. total exposure due to scatter and leakage:

Psec= 0.10 + 0.40 = 0.50 mRem/Avg. hour.

****** This exposure is below the 2 mRem/1 hour limit imposed by 10 CFR 20.105.

d. total seven-consecutive-day exposure:

P7day= .50 x 44 hrs/week = 22.0 mRem

****** This exposure is below the 100 mRem per seven consecutive days limit imposed by 10 CFR 20.105.

7. Location #7: (Physical therapy area)

dsec= 11.5ft.(3.5m)
t= 21" concrete

a. scatter exposure,from eq. III,IV:

$$Bsg = \exp\left[\frac{-.693 \times 21"}{1.79"}\right]$$

$$Ps = 2.95\text{x}10^{-4} \times 1500 \times \frac{900}{400} \times \frac{1}{3.5^2}$$

= 0.081 mRem/ avg. hr.

b. leakage exposure, from eq. V, VI:

$$Blg = \exp\left[\frac{-.693 \times 21"}{2.45}\right]$$

$$Plg = \frac{2.63\text{x}10^{-3} \times 1500}{3.5^2} = 0.32 \text{ mRem/hr}$$

c. total exposure due to scatter and leakage:

Psec= 0.081 + 0.32 = 0.40 mRem/Avg. hour.

****** This exposure is below the 2 mRem/1 hour limit imposed by 10 CFR 20.105

d. total seven-consecutive-day exposure:

P7day= .40 x 44 hrs/week = 18.0 mRem

****** This exposure is below the 100 mRem per seven consecutive days limit imposed by 10 CFR 20.105.

8. Location #8: (Roof above)

dsec= 9.5ft.(2.9m)
t= 18" concrete

a. scatter exposure,from eq. III,IV:

$$Bsg = \exp\left[\frac{-.693 \times 18"}{1.79"}\right]$$

$$Ps = 9.1x10^{-4} \times 1500 \times \frac{900}{400} \times \frac{1}{2.9^2}$$

= 0.37 mRem/ avg. hr.

b. leakage exposure, from eq. V, VI:

$$Blg = \exp\left[\frac{-.693 \times 18"}{2.45}\right]$$

$$Plg = \frac{6.2x10^{-3} \times 1500}{2.9^2} = 1.11 \text{ mRem/hr}$$

c. total exposure due to scatter and leakage:

Psec= 0.37 + 1.11 = 1.48 mRem/Avg. hour.

****** This exposure is below the 2 mRem/1 hour limit imposed by 10 CFR 20.105.

d. total seven-consecutive-day exposure:

P7day= 1.48 x 44 hrs/week = 65 mRem

****** This exposure is below the 100 mRem per seven consecutive days limit imposed by 10 CFR 20.105.

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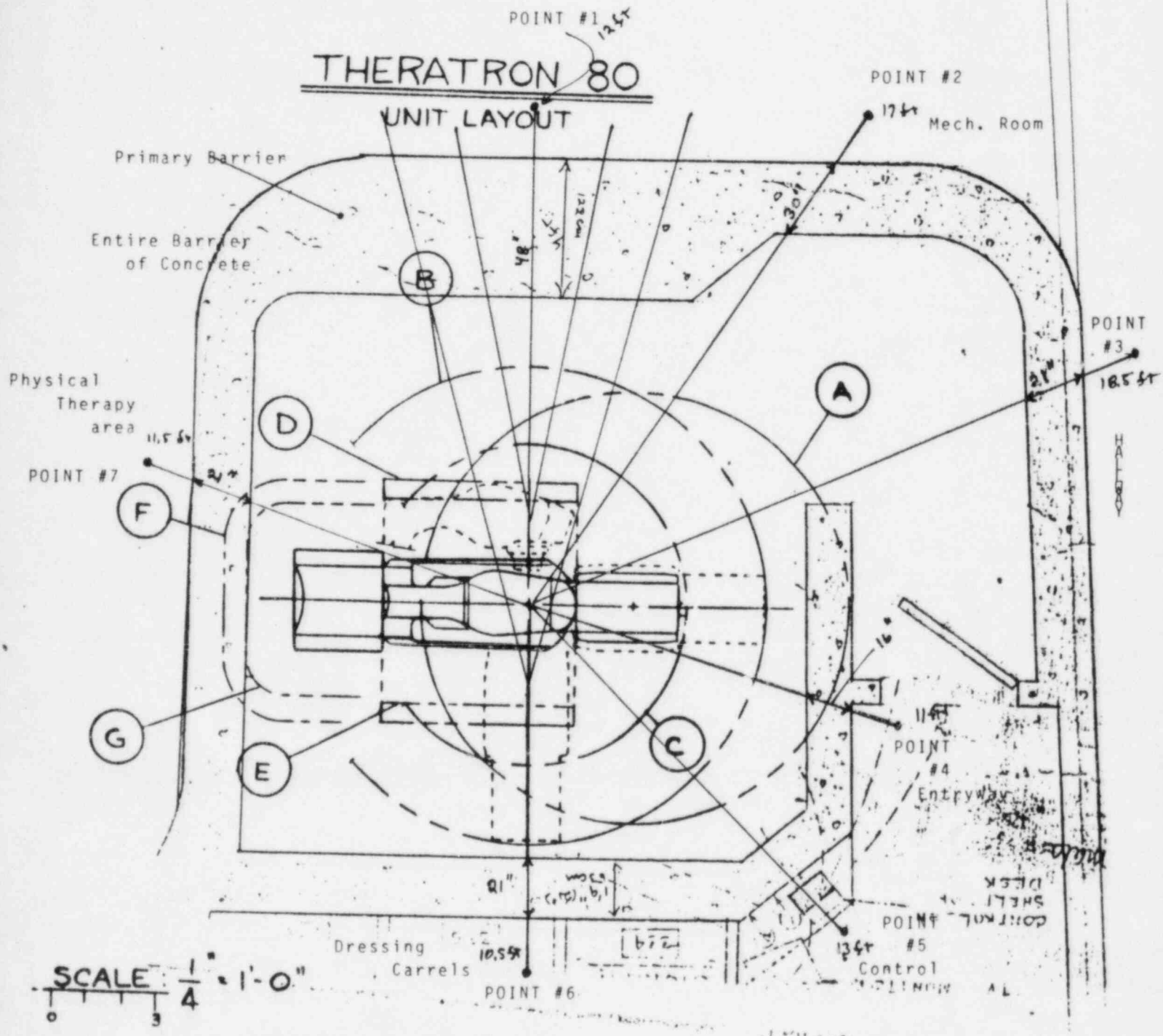
XI. Statement:

The above estimates, assumptions and calculations are believed to conservatively estimate the exposure levels which will be encountered during normal operation of this facility. It is further understood that a complete radiation hazard survey will be performed after installation and before treatment of any patients and the results will be forwarded to the N.R.C.

Submitted,

Joseph R. Giganti, Ph.D.
A.B.R. certified radiological physicist.

Dakota Midland Hospital, Aberdeen, SD 57401



A - TABLE TOP ROTATION
B - PEDESTAL ROTATION W/TABLE EXTENDED
C - PEDESTAL ROTATION W/ TABLE FORWARD
D - HEAD ROTATION
E - BEAM STOP ROTATION
F - PREFERRED SPACE FOR MAINTENANCE
G - MINIMUM SPACE FOR MAINTENANCE

Drawing prepared by: J.R. Giganti, Ph.D.

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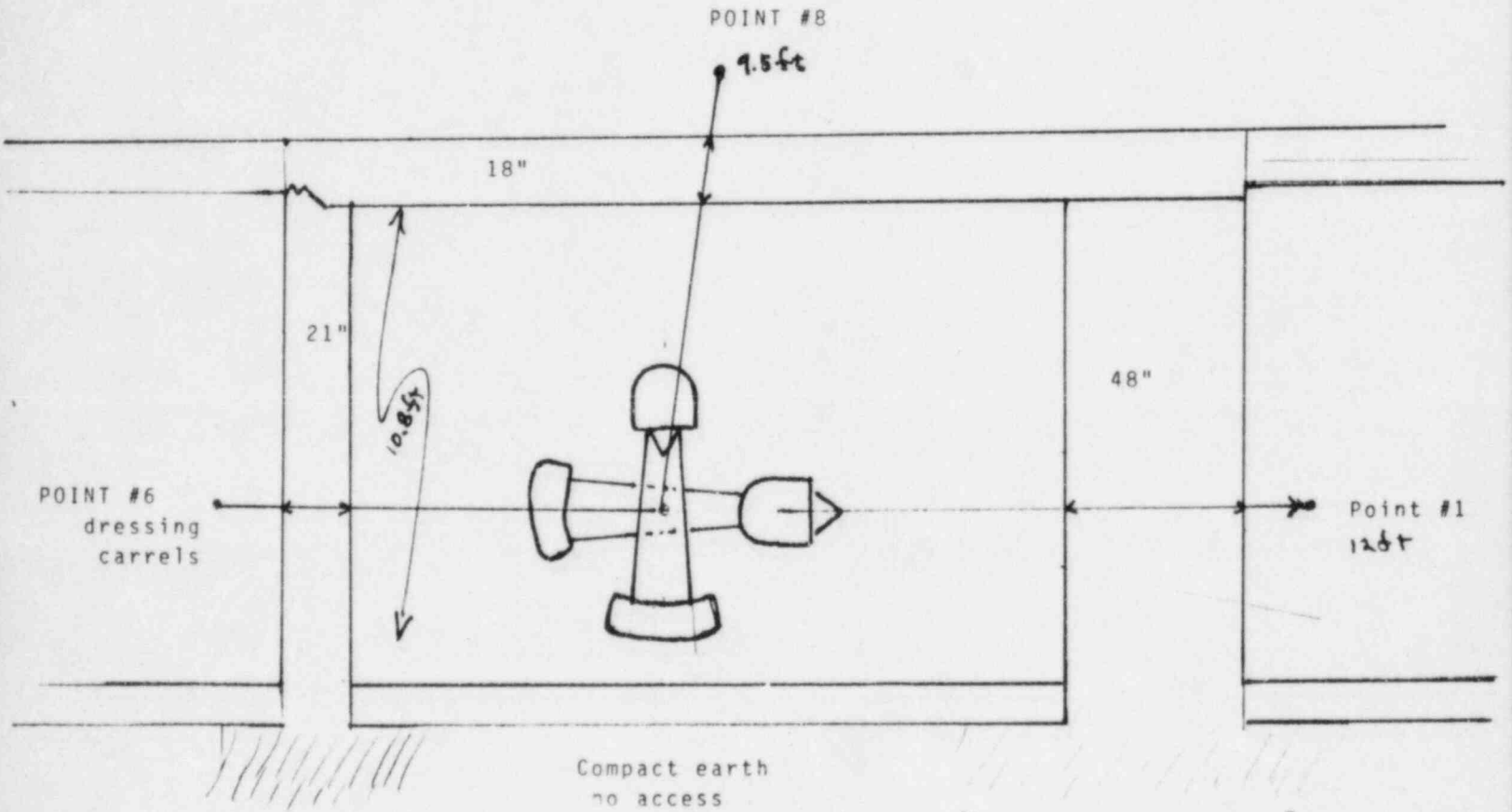
DWG. BY:

Dakota Midland Hospital
Cobalt Teletherapy Room

ELEVATION THROUGH PLANE OF
RADIATION BEAM AXIS



Prepared after inspection by:

Joseph R. Giganti, Ph.D.
Radimetrix, inc.
Oct. 29, 1985

RADIMETRIX, INC.
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