

PHOTON MEASUREMENTS PLUS
P.O. BOX 63, SPICELAND, IN 47385
765/987-0365

facsimile transmittal

To: Mr. James Mullauer **Fax:** 623-214-5213
From: Edward E. Wroblewski, M.A. **Date:** 4/2/10
Re: Imaging Center of N.C. Indiana **Pages:** Total of 3 including Cover Sheet
CC: N/A

Urgent For Review Please Comment Please Reply As Requested

Notes:

Dear Jim. Attached are two signed signature pages as requested. Please realize, that as the USNRC now has regulatory authority over the licensing (registration) of Radioactive Materials (NARM), the State of Indiana no longer requires that an application is submitted to their office in order to receive a RAM license and/or registration of same. I am in the process of trying to obtain a letter from the State of Indianan, IN State Department of Health to confirm same for your future reference (with specific regard to licensing and/or registration of RAM's). If a registration application is submitted to the ISDH, it is merely out of courtesy these days. Moreover, the ISDH application requests a copy of the USNRC license to accompany their application. Now isn't that a pickle? Thanks Jim! Pager 317904-3607.

-ed

<u>PET/CT ROOM</u>	<u>POINTS</u>	<u>EXPOSURE RATE</u> <u>(mR/hr)</u>
[Patient injected with 16 mCi F-18]	A-B	0.13
	B-C	0.10
	C-D	0.15
	D-E	0.15
	E-F	0.40
	F-G	0.05
	H-I	0.30
	A-I	0.11
	J	0.15
	K	0.10
	UPTAKE ROOM 1	L-M
[Patient injected with 16 mCi F-18]	M-N	1.05
	N-P	0.35
UPTAKE ROOM 2	P-Q	0.08
[Patient injected with 16 mCi F-18]	Q-L	0.6
	N-R	0.5
	R-T	0.1-0.5
UPTAKE ROOM 3	T-X	0.08
[18 mCi F-18 in syringe as point source.]	X-P	0.6
	R-U	1.5
	U-V	0.4
	V-W	0.18
	W-T	1.1

Imaging Center of North Central Indiana, Kokomo, IN

A calibrated Victoreen Ion Chamber (M/N: 451P) was used to assess radiation exposure rates as noted above.

Edward E. Wroblewski, MA, DABSNM
Survey performed by William K. Breeden, MS, DABR
on February 19, 2010.



4-2-10

Edward E. Wroblewski
Medical Physicist



K & S Associates, Inc.

1926 Elm Tree Drive • Nashville, Tennessee 37210-3718
Voice 615-883-9760 • Fax 615-871-0856 • Schedule 800-522-2325

DIAGNOSTIC X-RAY FACILITY SHIELDING SPECIFICATIONS

FACILITY: IMAGING CENTER OF NORTH CENTRAL INDIANA
KOKOMO, INDIANA

REPORT DATE: 11/11/2003
VERSION: 1A
TEST NO.: 031808

ROOMS: R&F ROOM 150; CT SCAN ROOM 139; PET UPTAKE ROOMS 146, 148, 147

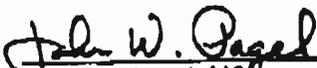
Design Criteria

The following shielding calculations and specifications are derived on the basis of the recommendations of the National Council on Radiation Protection and Measurements as contained in NCRP Report Number 49, "Medical X-Ray and Gamma-Ray Protection for Energies up to 10 MeV - Structural Shielding Design and Evaluation," and the enclosed stated workloads and conditions. The design limits, however, have been modified to reflect changes in Federal and State radiation protection regulations (NRC Part 20 compliance) and NCRP Report No. 116, "Limitation of Exposure to Ionizing Radiation." Also, where appropriate, alternative methods of calculation that reflect the continuing evolution of equipment, techniques, and available data were used as a supplement to NCRP 49. A list of references for these methods is provided in the report. Where specific information regarding the workload for the proposed facility was unavailable, the typical workloads for busy installations as provided in NCRP 49, supplemented and updated by the listed references, were used as a guide.

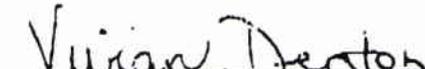
No responsibility is assumed or implied for the adequacy of the enclosed specifications for workloads and/or conditions other than those stated herein.

This report was prepared for:

BRIAN KOETTER
H&H SYSTEMS AND DESIGN INC.
NEW ALBANY, INDIANA


John W. Pagel, MS
Medical Health Physicist


Thomas W. Slowey, PE
Radiation Physicist


Vivian Denton, RT(R)(T)
Design Consultant

K & S Associates, Inc. • 1926 Elm Tree Drive • Nashville, Tennessee 37210
615-883-9760 • 1-800-522-2325 • Fax 615-871-0856 • E-mail: ksh@aol.com

PHOTON MEASUREMENTS PLUS

P.O. BOX 63, SPICELAND, IN 47385

765/987-0365

facsimile transmittal

To: Mr. James Mullauer	Fax: 623-214-5213
From: Edward E. Wroblewski, M.A.	Date: 4/1/2010
Re: Imaging Center of N.C. Indiana	Pages: Total of 4 including Cover Sheet
CC: N/A	
<input type="checkbox"/> Urgent <input type="checkbox"/> For Review <input type="checkbox"/> Please Comment <input type="checkbox"/> Please Reply <input checked="" type="checkbox"/> As Requested	

Notes:

Dear Jim. Attached are the results of the radiation integrity survey completed on February 19, 2010. Please call or page me if you have any questions. Pager 317904-3607. It is always my pleasure to work with you on USNRC licensing actions. Have a good rest of the day (& don't hurt yourself).

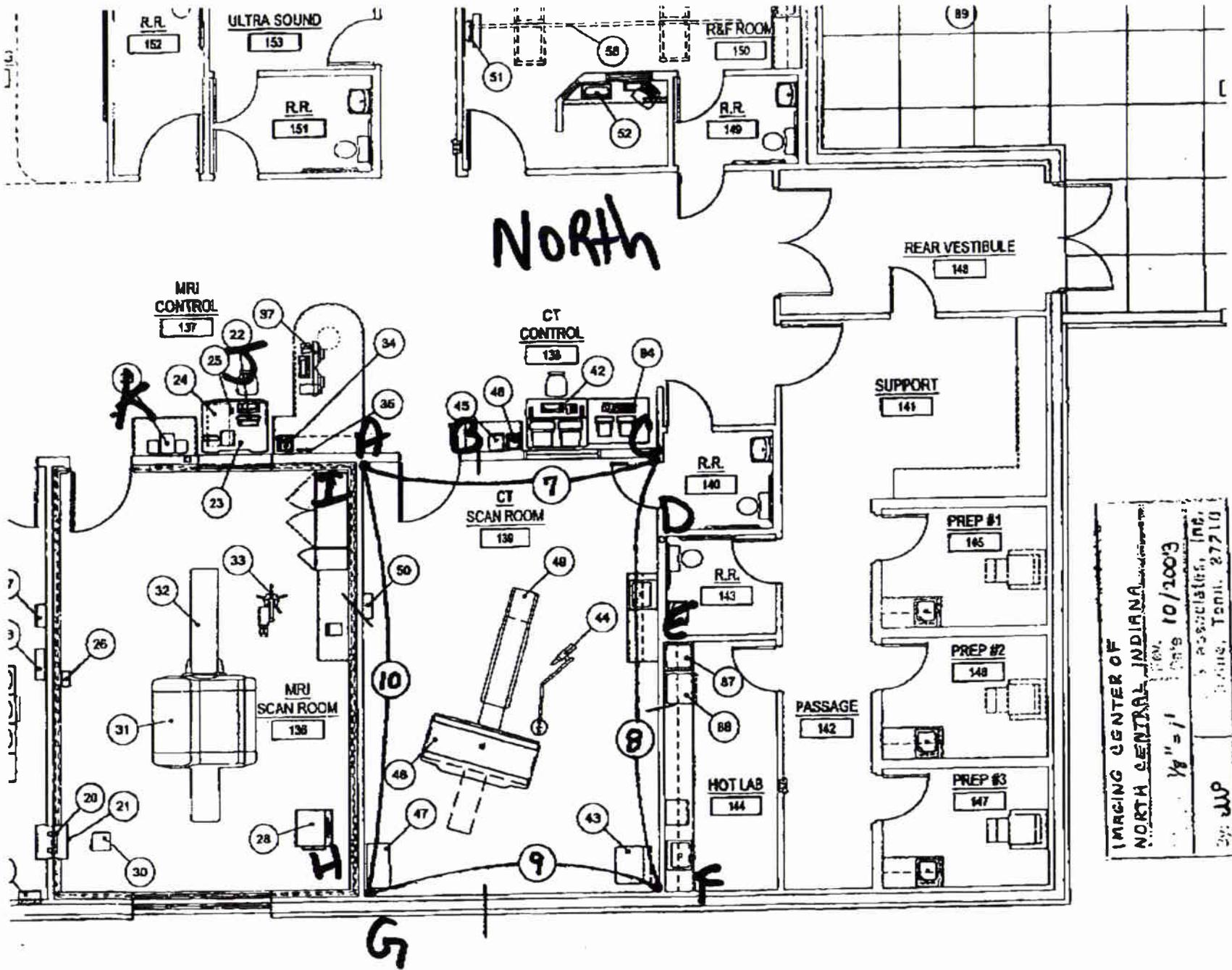
-ed

<u>PET/CT ROOM</u>	<u>POINTS</u>	<u>EXPOSURE RATE</u> <u>(mR/hr)</u>
<i>[Patient injected with 16 mCi F-18]</i>	A-B	0.13
	B-C	0.10
	C-D	0.15
	D-E	0.15
	E-F	0.40
	F-G	0.05
	H-I	0.30
	A-I	0.11
	J	0.15
	K	0.10
	UPTAKE ROOM 1	L-M
<i>[Patient injected with 16 mCi F-18]</i>	M-N	1.05
	N-P	0.35
UPTAKE ROOM 2	P-Q	0.08
<i>[Patient injected with 16 mCi F-18]</i>	Q-L	0.6
	N-R	0.5
	R-T	0.1-0.5
UPTAKE ROOM 3	T-X	0.08
<i>[18 mCi F-18 in syringe as point source.]</i>	X-P	0.6
	R-U	1.5
	U-V	0.4
	V-W	0.18
	W-T	1.1

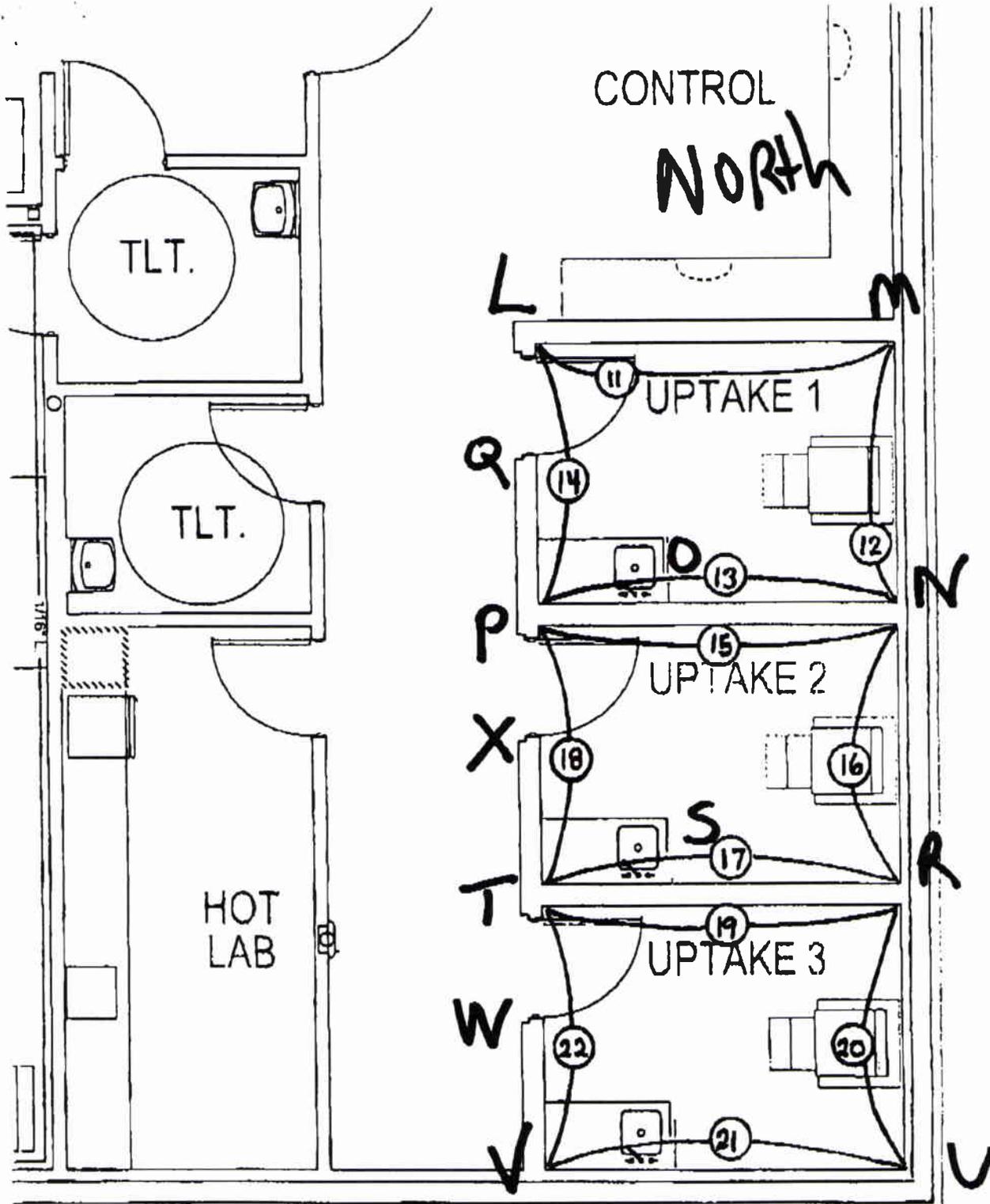
Imaging Center of North Central Indiana, Kokomo, IN

*A calibrated Victoreen Ion Chamber (M/N: 451P) was used
to assess radiation exposure rates as noted above.*

*Edward E. Wroblewski, MA, DABSNM
Survey performed by William K. Breeden, MS, DABR
on February 19, 2010.*



01728
 6002/01
 1 = "A"
 077



IMAGING CENTER OF NORTH
 CENTRAL INDIANA - KOKOMO, IN

SCALE: 1/4" = 1' | 11/2009

By: JP | H & S Associates, Inc.
 Nashville, Tenn. 37210

Mullauer, James

From: Wroblewski, Edward [EEWroble@stvincent.org]
Sent: Thursday, April 01, 2010 9:57 AM
To: Mullauer, James
Subject: Imaging Center of North Central Indiana-Shielding
Attachments: Original Physics Report.pdf

Dear James,

Please find the original Shielding Calculations that were done for the Imaging Center of N. Central Indiana (Kokomo, IN) completed by K & S Associates. Please note, I will be faxing a copy a radiation safety survey (shielding integrity test) that was completed on February 19, 2010 either this afternoon or tomorrow (4/2/10). Thank you for your assistance. Have a good day! -ed

Edward E. Wroblewski, MA
Diplomate, ABSNM
Medical Physicist/Radiation Safety Officer
St. Vincent Hospital
2001 W. 86th Street
Indianapolis, IN 46260
T: 317/338-2381
F: 317/338-2496
Pgr: 317/338-3550 ID 8836
E: ewroble@stvincent.org

*"Learn from yesterday, live for today, hope for tomorrow. The important thing is not to stop questioning." --**Albert Einstein***

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DIAGNOSTIC X-RAY FACILITY SHIELDING SPECIFICATIONS

FACILITY: IMAGING CENTER OF NORTH CENTRAL INDIANA
KOKOMO, INDIANA

REPORT DATE: 11/11/2003
VERSION: 1A
TEST NO.: 031908

ROOMS:
R&F ROOM 150; CT SCAN ROOM 139; PET UPTAKE ROOMS 145, 146, 147

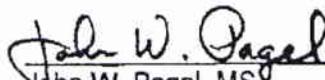
Design Criteria

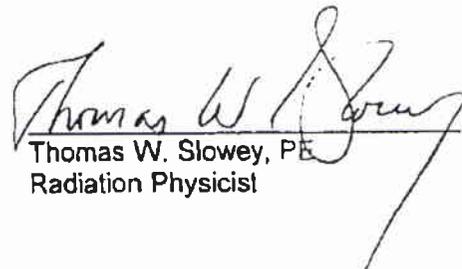
The following shielding calculations and specifications are derived on the basis of the recommendations of the National Council on Radiation Protection and Measurements as contained in NCRP Report Number 49, "Medical X-Ray and Gamma-Ray Protection for Energies up to 10 MeV - Structural Shielding Design and Evaluation," and the enclosed stated workloads and conditions. The design limits, however, have been modified to reflect changes in Federal and State radiation protection regulations (NRC Part 20 compliance) and NCRP Report No. 116, "Limitation of Exposure to Ionizing Radiation." Also, where appropriate, alternative methods of calculation that reflect the continuing evolution of equipment, techniques, and available data were used as a supplement to NCRP 49. A list of references for these methods is provided in the report. Where specific information regarding the workload for the proposed facility was unavailable, the typical workloads for busy installations as provided in NCRP 49, supplemented and updated by the listed references, were used as a guide.

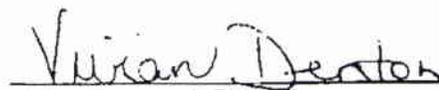
No responsibility is assumed or implied for the adequacy of the enclosed specifications for workloads and/or conditions other than those stated herein.

This report was prepared for :

BRIAN KOETTER
H&H SYSTEMS AND DESIGN INC.
NEW ALBANY, INDIANA


John W. Pagel, MS
Medical Health Physicist


Thomas W. Slowey, PE
Radiation Physicist


Vivian Denton, RT(R)(T)
Design Consultant

SHIELDING SPECIFICATION SUMMARY

Facility: IMAGING CENTER OF NORTH CENTRAL INDIANA
KOKOMO, INDIANA

Date: 11/11/2003

Version: 1A

Reviewed: 

The shielding recommendations listed below supersede all individual barrier specifications shown in the Calculation Details

NOTES:

1. Specifications in the **REQUIRED SHIELDING** column are the thicknesses required for the barrier without regard for any existing or proposed construction.
2. Specifications in the **RECOMMENDED ADDITIONAL SHIELDING** columns are the recommended thicknesses after consideration of any existing or proposed construction. These specifications are required *in addition to the existing or proposed construction*. Specifications for lead or gypsum have been rounded up to the next available standard size.
3. Any area of a barrier that deviates from the stated **EXISTING CONSTRUCTION** must be shielded with at least the amount of material shown in the **REQUIRED SHIELDING** column. Holes in barriers must be covered so that the overall protection provided is not impaired. Convenience outlets, switch boxes, utility recesses, etc. must be backed with lead of the thickness shown in the **REQUIRED SHIELDING** column.
4. These recommendations are accurate only under the stated conditions of this report. Any changes in equipment, construction, workload, or any other parameter of the project should be communicated to K & S so that its impact on the required shielding can be evaluated.

R&F ROOM 150

BARRIER NUMBER	REQUIRED SHIELDING Calculated Thickness	EXISTING or PROPOSED CONSTRUCTION	RECOMMENDED ADDITIONAL SHIELDING			COMMENTS
			BASIC Specification	DOOR Specification	VIEW WINDOW	
1	1.5 mm lead	2 x 5/8" gyp	1/16" lead		1.5 mm lead equivalent	
2	0.10 mm lead	2 x 5/8" gyp (= 0.11 mm Pb)	None	1/64" lead or 18 ga steel		
3	0.53 mm lead	2 x 5/8" gyp	1/32" lead			
3A (area behind chest stand)	1.06 mm lead	Barrier 3	1/32" lead			See Design Recommendation 11 for placement of lead in back of chest stand. Note: If 1/16" lead is used for Barrier 3, then no extra lead is required for Barrier 3A.
4	0.62 mm lead	2 x 5/8" gyp	1/32" lead			
5	0.24 mm lead	Exterior wall	1/16" lead*			* Lead also helps to shield x-ray room from PET scanner in courtyard.
6	0.12 mm lead	2 x 5/8" gyp	1/32" lead	1/32" lead		
Ceiling	0.00 mm lead	22 ga steel	None			
Floor	None	Slab on grade	None			

CT SCAN ROOM 139

BARRIER NUMBER	REQUIRED SHIELDING Calculated Thickness	EXISTING or PROPOSED CONSTRUCTION	RECOMMENDED ADDITIONAL SHIELDING			COMMENTS
			BASIC Specification	DOOR Specification	VIEW WINDOW	
7	1.20 mm lead	2 x 5/8" gyp	1/16" lead	1/16" lead	1.5 mm lead	
8	1.43 mm lead	2 x 5/8" gyp	1/16" lead	1/16" lead		
9	0.71 mm lead	6" CMU (= 2.14" concrete)	1/32" lead			
10	1.42 mm lead	2 x 5/8" gyp	1/16" lead			
Ceiling	1.58 mm steel	0.85 mm steel equivalent	22 ga steel, or None (if conditions listed under "Comments" are satisfied)			No extra shielding is required for roof if: 1 - No x-rays are produced while roof is occupied 2 - Access requires a key, which is kept by the Radiology Dept 3 - A sign is posted by any entry hatchway Ref: Indiana State Department of Health Radiologic Health Division
Floor	None	Slab on grade	None			

PET UPTAKE ROOM #1 (Room 145)

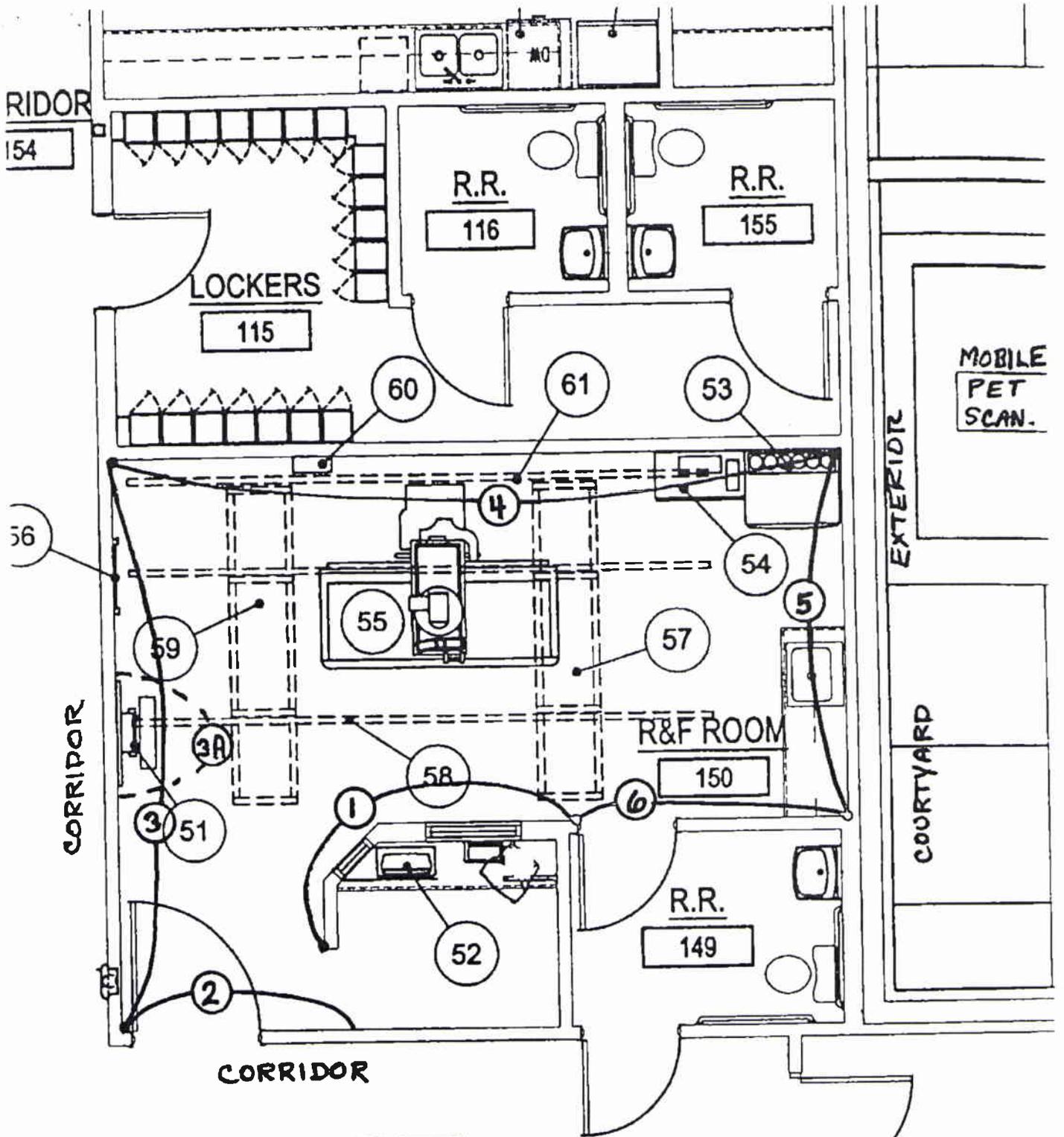
BARRIER NUMBER	REQUIRED SHIELDING Calculated Thickness	EXISTING or PROPOSED CONSTRUCTION	RECOMMENDED ADDITIONAL SHIELDING			COMMENTS
			BASIC Specification	DOOR Specification		
11	7.1" filled concrete block	8" filled concrete block	None			
12	2.2" filled block	8" filled block	None			
13	4.6" filled block	8" filled block	None			
14	None	8" filled block	None	1/32" lead (or steel, any gauge)		
Ceiling	None	22 ga steel	None			
Floor	None	Slab on grade	None			

PET UPTAKE ROOM #2 (Room 146)

BARRIER NUMBER	REQUIRED SHIELDING Calculated Thickness	EXISTING or PROPOSED CONSTRUCTION	RECOMMENDED ADDITIONAL SHIELDING			COMMENTS
			BASIC Specification	DOOR Specification		
15	3.7' filled concrete block	8" filled concrete block	None			
16	2.2' filled block	8" filled block	None			
17	3.7' filled block	8" filled block	None			
18	None	8" filled block	None	1/32' lead (or steel, any gauge)		
Ceiling	None	22 ga steel	None			
Floor	None	Slab on grade	None			

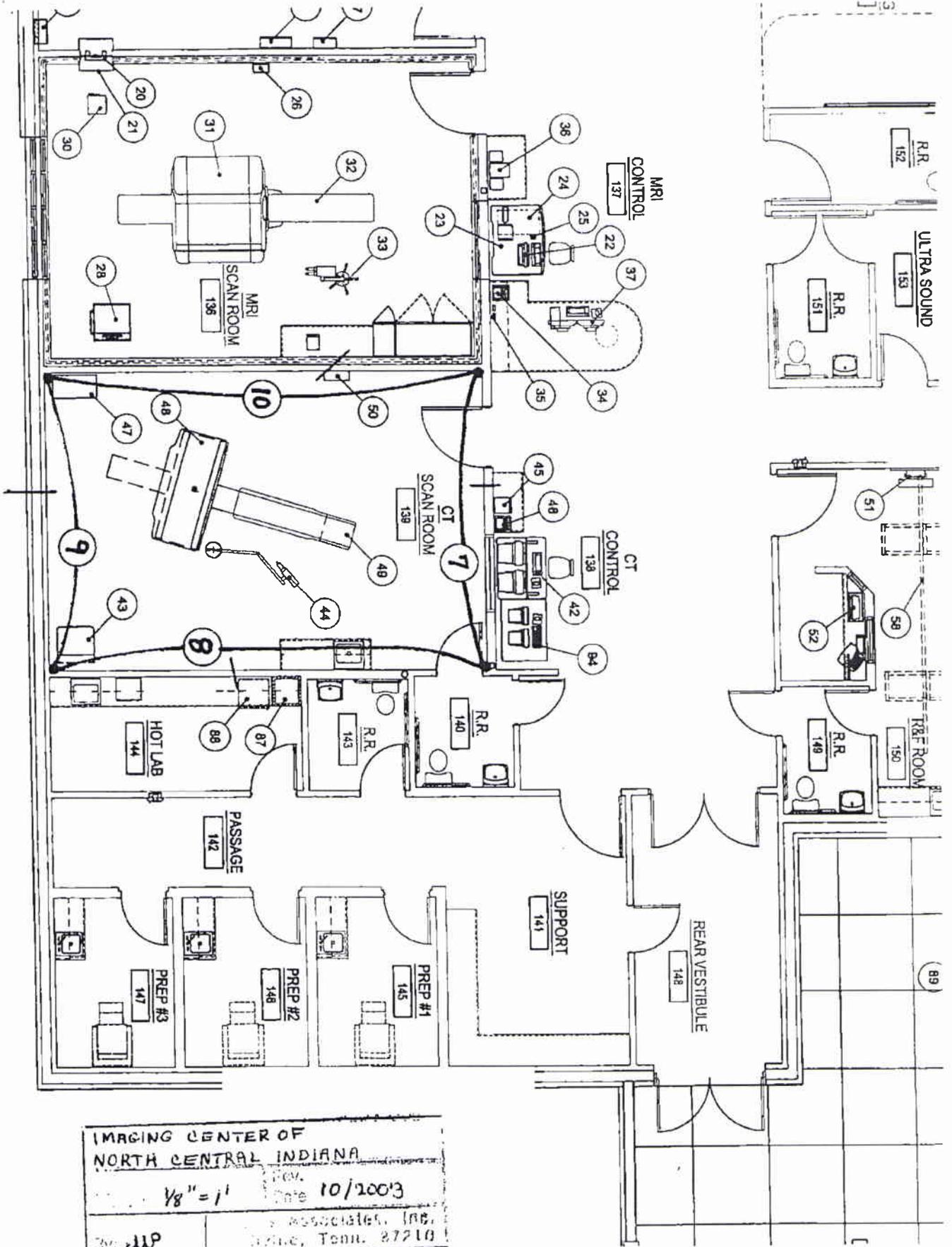
PET UPTAKE ROOM #3 (Room 147)

BARRIER NUMBER	REQUIRED SHIELDING Calculated Thickness	EXISTING or PROPOSED CONSTRUCTION	RECOMMENDED ADDITIONAL SHIELDING			COMMENTS
			BASIC Specification	DOOR Specification		
19	7.1' filled concrete block	8" filled concrete block	None			
20	2.2' filled block	8" filled block	None			
21	None	8" filled block	None			
22	None	8" filled block	None	1/32' lead (or steel, any gauge)		
Ceiling	None	22 ga steel	None			
Floor	None	Slab on grade	None			

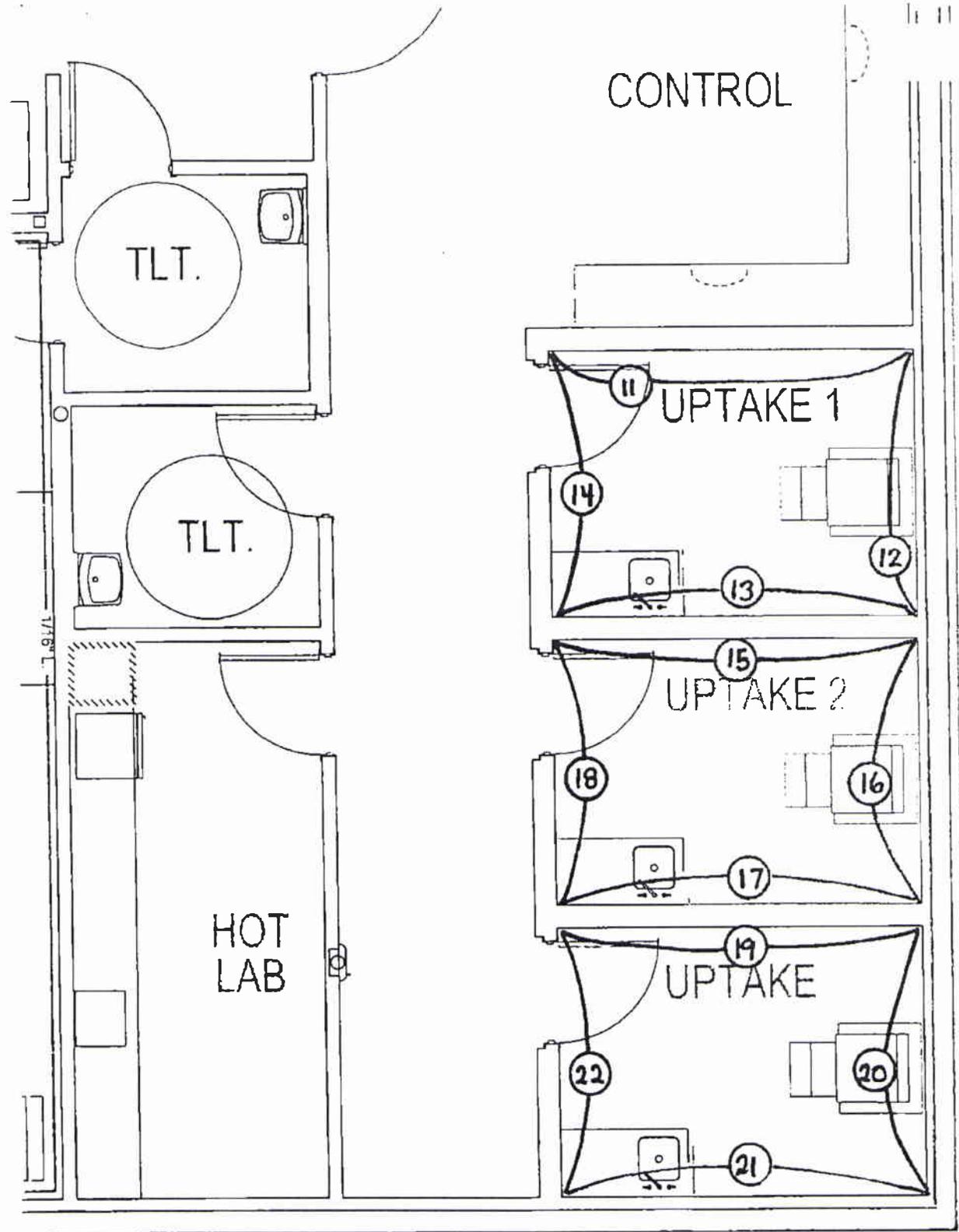


IMAGING CENTER OF NORTH CENTRAL INDIANA	
Scale: 1/4" = 1'	Rev. Date: 10/2009
WJP	M & S Associates, Inc.
	Chicago, IL 60611

CT CONTROL



IMAGING CENTER OF
 NORTH CENTRAL INDIANA
 1/8" = 1'
 Date 10/2003
 Associates, Inc.
 Knoxville, Tenn. 37210
 By: *MP*



IMAGING CENTER OF NORTH
 CENTRAL INDIANA - KOKOMO, IN
 SCALE: 1/4" = 1' | 11/2009
 By: JP | K & S Associates, Inc.
 Nashville, Tenn. 37210

INFORMATION FOR EVALUATING X-RAY INSTALLATIONS
R&F Room 150

- A. MILLIAMPERAGE - 1000
B. KILOVOLTAGE - 100
C. WORKLOAD (RADIOGRAPHIC) - 100 mA-minutes/week*
1. Percent of workload with beam directed toward wall cassette holder - 25%
2. Percent of workload with beam directed toward other walls - 10%
2. Percent of workload with beam directed toward floor - 100%
D. WORKLOAD (FLUOROSCOPIC) - 400 mA-minutes/week*
E. WALL, FLOOR AND CEILING MATERIALS AND THICKNESSES PROPOSED OR EXISTING
Barrier - 1 2 x 5/8" gyp plus 1/16 lead
Barrier - 2 2 x 5/8" gyp plus None (except door)
Barrier - 3 2 x 5/8" gyp plus 1/32" lead
Barrier - 3A Barrier 3 plus 1/32 lead
Barrier - 4 2 x 5/8" gyp plus 1/32 lead
Barrier - 5 exterior wall plus 1/16" lead
Barrier - 6 2 x 5/8" gyp plus 1/32" lead
Barrier - Ceiling 22ga stl
Barrier - Floor slab on grade plus NONE
F. DOES ROOM HAVE WINDOWS? No
G. OCCUPANCY OF AREAS ADJOINING WALLS, FLOOR CEILING
Barrier - 1 Control booth
Barrier - 2 Corridor
Barrier - 3 Corridor
Barrier - 3A Corridor
Barrier - 4 Lockers, Tlts
Barrier - 5 Exterior Court.
Barrier - 6 Toilet
Barrier - Ceiling roof
Barrier - Floor none
H. HEIGHT OF X-RAY ROOM AND ROOM BELOW (Floor to Floor)
X-Ray Room - 14.0 ft.
Room Below - 0.0 ft.
I. DESCRIBE PROPOSED SHIELDING FOR OPERATOR OF X-RAY UNIT
Barrier: 1 - 1/16 lead
View Window: 1.50 mm lead equivalence
I. DESCRIBE METHOD OF REPLACING SHIELDING IF ITS EFFECTIVENESS IS
REDUCED THROUGH SUCH INSTALLATIONS AS ELECTRICAL SWITCHES,
OUTLETS AND CONTROL BOXES AND PIPES OR DUCTS
Lead
K. SCALED DRAWING OF ROOM IS ATTACHED.

FACILITY: Imaging Center of North Central Indiana

PREPARED BY: K & S Associates, Inc. Date:10/23/2003

*NOTES

Avg workload for RF room in US (AAPM TG9 survey):
230 mA-min/wk(F), 35(R)
Increased to provide safety margin to: 350 mA-min/wk (F)
100 (rad)

SHIELDING SPECIFICATION TABLE
R&F Room 150

```

*****
*BARRIER | TYPE | DIST. U | T | WUT |   REQUIRED   | STD. | EXIST. | RECOMMENDED *
*          |      | (FT.)   |   |     | LEAD CON.# | SIZE | SHIELD | ADDITIONAL  *
*          |      |         |   |     | (mm.) (in.) |     |       |             *
*****
*1        | SN   | 8.0|1.00|1.00| 500| 1.50| 5.58|1/16 | 2 x 5/8" | 1/16 lead *
*          |      |     |     |     |     |     |     | gyp     |           *
*-----*
*2        | SN   | 14.0|1.00|0.13| 63| 0.10| 0.55|1/64 | 2 x 5/8" | None      *
*          |      |     |     |     |     |     |     | gyp     | (except door) *
*-----*
*3        | PN   | 11.5|0.10|0.13| 1| 0.53| 2.59|1/32 | 2 x 5/8" | 1/32" lead *
*          |      |     |     |     |     |     |     | gyp     |           *
*-----*
*3A       | PN   | 8.0|0.25|0.13| 3| 1.06| 4.05|1/16 | Barrier  | 1/32 lead *
*          |      |     |     |     |     |     |     | 3       |           *
*-----*
*4        | PN   | 6.5|0.10|0.08| 1| 0.62| 2.57|1/32 | 2 x 5/8" | 1/32 lead *
*          |      |     |     |     |     |     |     | gyp     |           *
*-----*
*5        | PN   | 15.0|0.10|0.13| 1| 0.24| 1.26|1/64 | exterior | 1/16" lead *
*          |      |     |     |     |     |     |     | wall    |           *
*-----*
*6        | SN   | 8.0|1.00|0.05| 25| 0.12| 0.67|1/64 | 2 x 5/8" | 1/32" lead *
*          |      |     |     |     |     |     |     | gyp     |           *
*-----*
*Ceiling  | SN   | 14.0|1.00|0.02| 8| 0.00| 0.00|     | 22ga stl | NONE      *
*          |      |     |     |     |     |     |     |         |           *
*-----*
*Floor    | ----| ----| ----| ----| ----| ----| ----| ----| slab on  | NONE      *
*          |     |     |     |     |     |     |     |     | grade   |           *
*****
# Concrete specifications are in 147 lb./cubic foot unless otherwise noted.

```

kVp: 100
mA: 1000

DOOR(S):

BARRIER 2: 1/64" lead or 18 ga. steel door
BARRIER 6: 1/32" lead

VIEW WINDOW(S):

BARRIER 1: 1.50 mm lead equivalent.

NOTES:

Equipment: GE Precision 500D, 65 kW, chest stand

SHIELDING SPECIFICATION TABLE - CT SCANNER

FACILITY: Imaging Center of North Central Indiana
Kokomo, Indiana

DATE: 11/4/03

ROOM: CT SCAN ROOM 139

BARRIER	P (R/wk)	A	T	Reference Scans (Note 1) mR/scan @ d _{ref} (ft)				D ₁ R/wk @1 ft	d (ft)	B(x)	CALCULATED SHIELDING		
				Body @ d _{ref}	Head @ d _{ref}	mm Lead	in Conc				mm Steel		
7 (SC) CT Controls	0.1	0.02	1	1.07	9.50	0.27	10.56	80.31	20.0	9.96E-03	1.20	4.8	14.7
Existing Shielding: 2 x 5/8" gyp (= 0.11 mm Pb)				RECOMMENDED ADDITIONAL SHIELDING:				View window: 1.5 mm Pb equiv Wall, Door: 1/16" lead					
8 (SN) Rest Room, Hot Lab	0.002	1	1/2	1.07	12.46	0.27	13.12	134.78	13.0	5.02E-03	1.43	5.6	18.1
Existing Shielding: 2 x 5/8" gyp (= 0.11 mm Pb)				RECOMMENDED ADDITIONAL SHIELDING:				Door: 1/16" lead 1/48" lead					
9 (SN) Exterior	0.002	1	1/16	0.53	13.49	0.53	10.79	100.27	12.0	4.60E-02	0.71	3.1	7.6
Existing Shielding: 8" CMU = 2.14" 147 pcf concrete				RECOMMENDED ADDITIONAL SHIELDING:				1/32" lead					
10 (SN) MRI Scan Room	0.002	1	1/2	1.07	13.40	0.27	13.18	151.54	14.0	5.17E-03	1.42	5.5	17.9
Existing Shielding: 2 x 5/8" gyp (= 0.11 mm Pb)				RECOMMENDED ADDITIONAL SHIELDING:				1/16" lead					
CEILING (SN) Roof	0.002	1	1/64	0.53	15.15	0.27	14.46	112.91	(Note 2) 16.75	3.18E-01	0.20	1.1	1.58
Existing Shielding: See Note 3: Equivalent to 0.85 mm steel + membrane roof + ...				RECOMMENDED ADDITIONAL SHIELDING:				22 ga steel or None (restricted access req'd)					
FLOOR (not calculated) None	0.002	1	0	-	-	-	-	-	-	-	0.00	0.0	0.0
Existing Shielding: Slab on grade				RECOMMENDED ADDITIONAL SHIELDING:				None					

N = Non-controlled area, C = Controlled area All barriers are Secondary barriers. Calculated shielding specification for concrete is for 147 pcf
P = weekly radiation limit for area to be shielded, A = ALARA reduction factor, T = occupancy factor, PAT = net weekly exposure limit

SUMMARY OF DOOR AND WINDOW SHIELDING REQUIREMENTS

DOORS: Barrier 7 - 1/16" lead VIEW WINDOW: Barrier 7 - 1.5 mm lead equivalent
Barrier 8 - 1/16" lead

* NOTE An additional 22 ga steel will provide sufficient shielding. Alternatively, no extra shielding is required if:
CEILING: Roof has restricted access, with signs by any entry points warning maintenance personnel or others who might be going on the roof of the hazard (requirement of Indiana State Department of Health). Any entry hatches or doors must be kept locked, with the key being kept in the Radiology Department. No x-rays can be produced by the x-ray machine in the CT room if anyone is on the roof.
Ref: John Ruyak, Director, Indoor and Radiologic Health Division, Indiana State Department of Health

EQUIPMENT: GE Lightspeed Pro 16 multislice scanner

WORKLOAD:

Realistic busy workload for a highspeed multislice scanner is W= 30,000 mA-min/wk @ 120 kVp (ref: G. Barnes)
 This is based on calculations which take into account the maximum x-ray housing cooling rate.
 Since a typical workload in practice ranges from 10-20,000 mA-min/wk, this workload should provide a safety margin.
 The radiation scatter diagrams are for 140 kVp, for which the equivalent workload is W = 15,000 mA-min/wk @ 140 kVp.
 Reference: see Table 2, p. 64, NCRP Report 49
 Assume half of workload is for body scans: **Body scans: 7,500 mA-min/wk**
 and half is for head scans: **Head scans: 7,500 mA-min/wk**
Total workload: 15,000 mA-min/wk

SCATTER SURVEY REFERENCE SCANS:

kV = 140

Average scatter radiation level at 1 foot is based on an equal workload for Head scans and Body scans
 Scatter diagram data is for 710 mAs per scan (11.83 mA-min/scan)
 Number of Reference Scans per weekly workload:

Note 1	Head scans:	7,500 mA-min/week /	11.83 mA-min/scan =	634	reference scans/wk
	Body scans:	7,500 mA-min/week /	11.83 mA-min/scan =	634	reference scans/wk

CEILING:

Due to gantry shielding, little radiation is emitted directly overhead. Calculation for ceiling is for 30 deg angle from vertical.

Floor-ceiling distance : $d_{FC}(ft) = 14.5$

Note 2 Angular distance: $d(ft) = 14.5 / \cos 30 = 16.75$ ft

Ceiling has 22 ga steel deck

22 ga steel = 0.79 mm steel

Effective floor thickness for incidence at an angle through a barrier θ is given by:

Note 3 $x_{eff} = s(1 + 1/\cos\theta)/2 = 0.79 \text{ mm steel} \times (1 + 1/\cos 30) / 2 = 0.86 \text{ mm steel}$

Ceiling also contains single-ply membrane roof, R-19 roof insulation, steel bar jst., and acoustic lay-in ceiling.

FORMULAS:

Ref: Simpkins, Health Physics, March 1990

$D_1 (R/wk @ 1 \text{ ft}) = (mR/scan @ d_{ref}) \times (scans/wk) \times d_{ref}^2 \times 0.001 \text{ R/mR}$

$B(x) = (PA/T) x d^2 / D_1 = [(1 + \beta/\alpha) e^{\beta x} - \beta/\alpha]^{-1/\gamma}$ $x = 1/\alpha \gamma \ln[(B(x)^\gamma + \beta/\alpha) / (1 + \beta/\alpha)]$

For B = 6.80E-01		kVp	α	β	γ	x(mm)	x(in)
Lead	120	2.70214	6.2227	0.7721	0.05	0.00	
	140	2.86862	4.659	0.7821	0.06	0.00	
Concrete	120	0.03829	0.0142	0.6582	7.59	0.30	
	140	0.03359	0.0122	0.5185	8.64	0.34	
Steel	120	0.27957	1.5191	1.2357	0.26	0.01	
	140	0.19215	0.9519	0.9649	0.39	0.02	
Gypsum	120	0.0010	0.0268	0.4125	14.99	0.59	
	140	0.0118	0.0167	1.3910	15.72	0.62	
Glass	120	0.03213	0.01460	0.2280	8.37	0.33	
	140	0.03544	0.00975	0.9450	8.85	0.35	

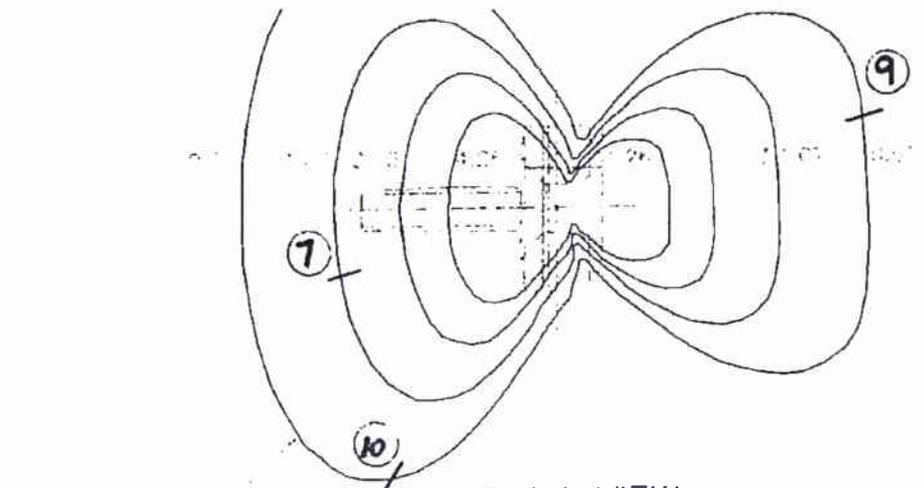
REFERENCES:

- Simpkin, Douglas, Health Physics 58: 363-7, 1990
- Barnes, Gary, Multislice CT Radiation Shielding Design: Implications of Increased Workload and Scatter, SE Chapter AAPM, 3/2000

EQUIPMENT TAIL
CT TYPICAL SCATTER SURVEY

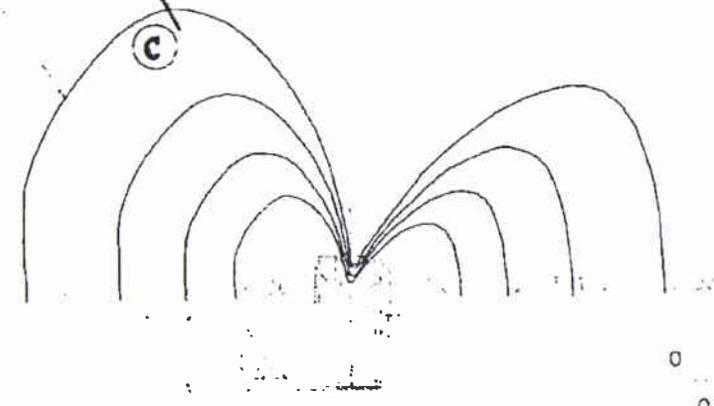
B78-16D

REV. DATE: 09/25/02



PLAN VIEW

mR PER SCAN



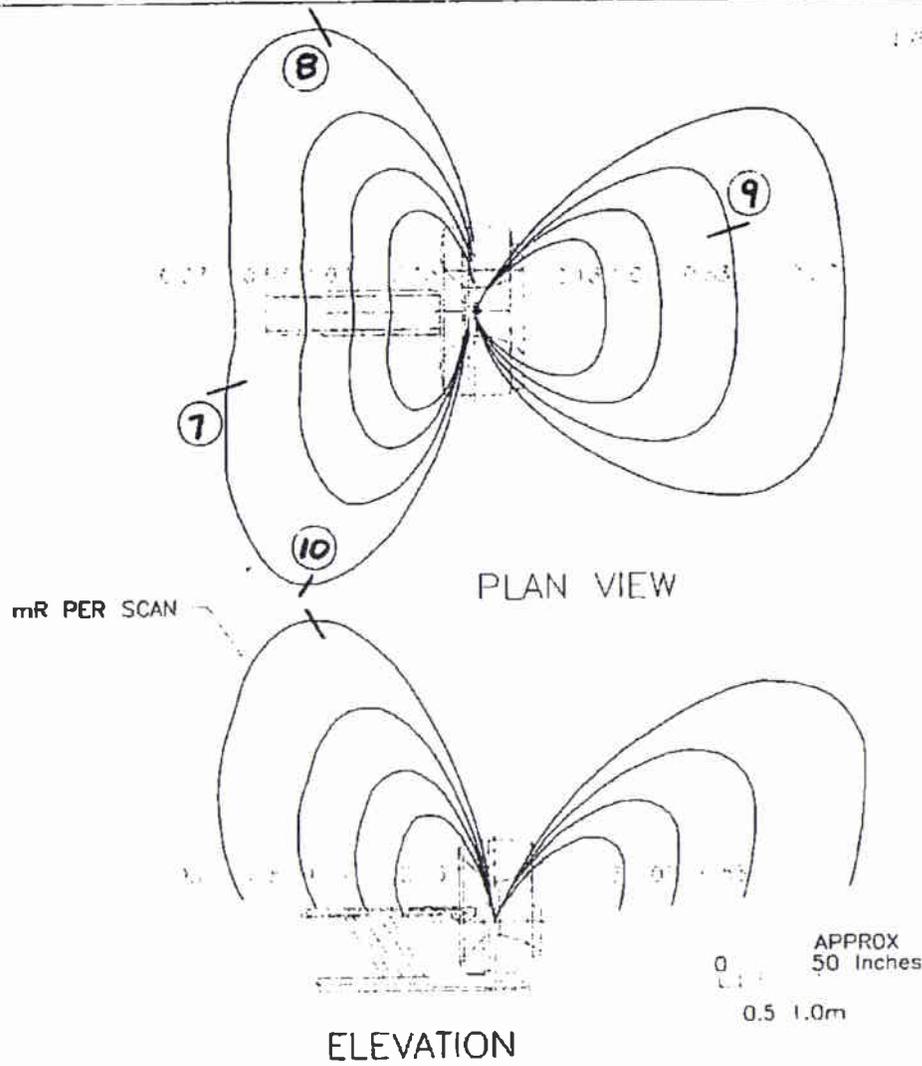
ELEVATION

0
APPROX.
50 inches
0.5 1.0m

EQUIPMENT ETAIL
CT TYPICAL SCATTER S RVEY

B78-16E

REV. DATE 09/25/02



is based on Drawing No.: 03113300

**PET INJECTION / UPTAKE ROOM
RADIATION SHIELDING REQUIREMENTS**

Facility: **Imaging Center of North Central Indiana
Kokomo, Indiana**

Date: **11/11/2003**

Room: **UPTAKE #1, Room 145**

Version: **1A**

RADIATION DOSE FROM PATIENTS

Administered dose of F-18:	Avg 12 mCi, max 15 mCi	15	mCi/pat
Half-life of F-18		1.83	hr
Uptake period (time spent waiting in room)		1	hr/pat
Dose rate from F-18 @ 1 foot		7.48	mR/(h-mCi)
Absorbed energy fraction for 500 KeV photons in whole body		0.34	
Max initial unshielded dose rate/patient from F-18 @ 1 ft	15 mCi x (1-0.34) x 7.48 =	74.1	mR/h @ 1'
Integrated dose from F-18 in patient t=0 hr to t=1 hr (maximum) taking into account the radioactive decay of the radionuclide during this period (see calc table below)		61.7	mrem @ 1'
Radioactive patients/wk:	3/week initially 15/week (max in future)	15	pat/wk
Total mrem/week @ 1 ft =	61.7 mrem/pat @ 1 ft x 15 patients/week =	926	mrem/wk @ 1'

SHIELDING CALCULATIONS

Adjacent Area	P (limit)	A	Occup.	d	mrem/wk @ d	Req'd Attenu. B(x)	REQUIRED SHIELDING		
							" Lead	" Concrete	Filled Block
11 (NC)	mrem/wk		T	(ft)			" Lead	" Concrete	Filled Block
	2	1	1/2	5.5	30.6	1.31E-01	0.49	5.8	7.1
Existing: 8" grout-filled CMU block	RECOMMENDED SHIELDING:						None		
12 (NC)	P	A	T	d	mrem/wk @ d	B(x)	REQUIRED SHIELDING		
	mrem/wk			(ft)			" Lead	" Concrete	Filled Block
	2	1	1/20	3.5	75.6	5.29E-01	0.15	1.81	2.2
Existing: 8" grout-filled CMU block	RECOMMENDED SHIELDING:						None		
13 (C)	P	A	T	d	mrem/wk @ d	B(x)	REQUIRED SHIELDING		
	mrem/wk			(ft)			" Lead	" Concrete	Filled Block
	10	1	1	5.0	37.0	2.70E-01	0.31	3.7	4.6
Existing: 8" grout-filled CMU block	RECOMMENDED SHIELDING:						None		
14 (NC)	P	A	T	d	mrem/wk @ d	B(x)	REQUIRED SHIELDING		
	mrem/wk			(ft)			" Lead	" Concrete	Filled Block
	2	1	1/8	9.5	10.3	1.56E+00	-0.11	-1.25	-1.5
Existing: 8" grout-filled CMU block	RECOMMENDED SHIELDING:						None		
Corridor	Existing: 8" grout-filled CMU block						None		
Ceiling (NC)	P	A	T	d	mrem/wk @ d	B(x)	REQUIRED SHIELDING		
	mrem/wk			(ft)			" Lead	" Concrete	
	2	1	1/40	14.0	4.7	1.69E+01	-0.68	-8.0	
Existing: 22 ga steel	RECOMMENDED SHIELDING:						None		
Floor (not occupiable)	P	A	T	d	mrem/wk @ d	B(x)	REQUIRED SHIELDING		
	mrem/wk			(ft)			" Lead	" Concrete	
	-	-	0	-	-	-	0.00	0.0	
Existing: SOG	RECOMMENDED SHIELDING:						None		

P=weekly limit, T=occupancy factor, d=distance from source to area to be protected, A = ALARA factor by which allowed dose is reduced
B(x) = transmission factor required to reduce radiation level to PA/T per week
C = Controlled area, NC = Non-controlled area

Revision to Version 1: Roof has 22 ga steel (not 22 ga steel + 4" concrete)

11/11/2003

RADIOACTIVE SOURCE DATA	Nuclide	Half-life	γ Energy	Dose Rate mR/h/mCi @ 1'	HVL mm Lead	HVL " Lead	HVL " Concrete
	F-18	1.83 h	511 KeV	7.48	4.2	0.17	1.97

EXPOSURE FROM PATIENT WITH INJECTED ACTIVITY

Exposure E(mR) @ 1 foot from patient injected with "A" mCi of a positron-emitting nuclide with half-life $T_{1/2}$ hours, beginning at time t_1 (hrs) after injection of the radionuclide, and ending at time t_2 (hrs) after injection, where the patient absorbs a fraction F of the energy emitted.

Positron-emitter	I^1 (mR/(h.mCi)) @ 1'	F	$T_{1/2}$ (hr)	A (mCi)	t_1	t_2	E(mR) @ 1'
¹⁸ F	7.48	0.34	1.83	15	0.0	1.0	81.7
¹⁸ F	7.48	0.34	1.83	15	1.0	1.5	23.1

CEILING

Floor-ceiling distance = 14 feet

Composition: 22 ga steel

REFERENCES:

C-PET Site Planning Guide
 GE PETTrace Site Planning Guide
 Handbook of Health Physics and Radiological Health, 3rd Ed, 1998
 Discovery LS Site Preparation Manual (10/17/01)

PETSh.xls

WEEKLY DOSE LIMITS

10 mrem/wk - Controlled areas

2 mrem/wk - Uncontrolled areas

PET INJECTION / UPTAKE ROOM RADIATION SHIELDING REQUIREMENTS

Facility: **Imaging Center of North Central Indiana**
Kokomo, Indiana

Date: 11/13/2003

Room: **UPTAKE #2, Room 146**

Version: 1A

RADIATION DOSE FROM PATIENTS

Administered dose of F-18: Avg 12 mCi, max 15 mCi	15 mCi/pat
Half-life of F-18	1.83 hr
Uptake period (time spent waiting in room)	1 hr/pat
Dose rate from F-18 @ 1 foot	7.48 mR/(h-mCi)
Absorbed energy fraction for 500 KeV photons in whole body	0.34
Max initial unshielded dose rate/patient from F-18 @ 1 ft $15 \text{ mCi} \times (1-0.34) \times 7.48 =$	74.1 mR/h @ 1'
Integrated dose from F-18 in patient, t=0 hr to t=1 hr (maximum) taking into account the radioactive decay of the radionuclide during this period (see table on next page)	61.7 mrem @ 1'
Radioactive patients/wk: 3/week Initially 15/week (max in future)	15 pat/wk
Total mrem/week @ 1 ft = $61.7 \text{ mrem/pat} @ 1 \text{ ft} \times 15 \text{ patients/week} =$	926 mrem/wk @ 1'

SHIELDING CALCULATIONS

Adjacent Area	P (limit) mrem/wk	A	Occup. T	d (ft)	mrem/wk @ d	Req'd Attenu. B(x)	REQUIRED SHIELDING		
							" Lead	" Concrete	Filled Block
15 (C) Uptake Room #2	10	1	1	5.0	37.0	2.70E-01	0.31	3.7	4.6
Existing: Barrier 13							RECOMMENDED SHIELDING: None		
16 (NC) Exterior	2	1	1/20	3.5	75.8	5.26E-01	0.15	1.81	2.2
Existing: 8" grout-filled CMU							RECOMMENDED SHIELDING: None		
17 (C) Uptake Room #3	10	1	1	5.0	37.0	2.70E-01	0.31	3.7	4.6
Existing: Barrier 18							RECOMMENDED SHIELDING: None		
18 (NC) Corridor	2	1	1/8	9.5	10.3	1.56E+00	-0.11	-1.26	-1.5
Existing: 8" grout-filled CMU							RECOMMENDED SHIELDING: Wall: none, Door: any steel or 1/32" Pb		
19 (NC) Ceiling	2	1	1/40	14.0	4.7	1.89E+01	0.68	8.0	
Existing: 22 ga steel							RECOMMENDED SHIELDING: None		
20 (NC) Floor	-	-	0	-	-	-	0.00	0.0	
Existing: SOG							RECOMMENDED SHIELDING: None		

P = weekly limit, T = occupancy factor, d = distance from source to area to be protected, A = ALARA factor by which allowed dose is reduced
 B(x) = transmission factor required to reduce radiation level to PAT per week
 C = Controlled area, NC = Non-controlled area
 Concrete thickness specified is for 147 pcf

Revision to Version 1: Roof has 22 ga steel (not: 22 ga steel + 4" concrete)

11/11/2003

RADIOACTIVE SOURCE DATA	Nuclide	Half-life	γ Energy	Dose Rate mR/h/mCi @1'	HVL mm Lead	HVL " Lead	HVL " Concrete
	F-18	1.83 h	511 KeV	7.48	4.2	0.17	1.97

EXPOSURE FROM PATIENT WITH INJECTED ACTIVITY

Exposure E (mR) @ 1 foot from patient injected with "A" mCi of a positron-emitting nuclide with half-life $T_{1/2}$ hours, beginning at time t_1 (hrs) after injection of the radionuclide, and ending at time t_2 (hrs) after injection, where the patient absorbs a fraction F of the energy emitted.

Positron-emitter	Γ [mR/(h.mCi)] @ 1'	F	$T_{1/2}$ (hr)	A (mCi)	t_1	t_2	E (mR) @ 1'
¹⁸ F	7.48	0.34	1.83	15	0.0	1.0	61.7
¹⁸ F	7.48	0.34	1.83	15	1.0	1.5	23.1

CEILING

Floor-ceiling distance = 14 ft

Composition: 22 ga steel

REFERENCES:

C-PET Site Planning Guide

GE PETtrace Site Planning Guide

Handbook of Health Physics and Radiological Health, 3rd Ed, 1998

Discovery LS Site Preparation Manual (10/17/01)

PETSb.xls

WEEKLY DOSE LIMITS

10 mrem/wk - Controlled areas

2 mrem/wk - Uncontrolled areas

PET INJECTION / UPTAKE ROOM RADIATION SHIELDING REQUIREMENTS

Facility: **Imaging Center of North Central Indiana**
Kokomo, Indiana

Date: 11/11/2003

Room: **UPTAKE #3, Room 147**

Version: 1A

RADIATION DOSE FROM PATIENTS

Administered dose of F-18: Avg 12 mCi, max 15 mCi	15 mCi/pat
Half-life of F-18	1.83 hr
Uptake period (time spent waiting in room)	1 hr/pat
Dose rate from F-18 @ 1 foot	7.48 mR/(h·mCi)
Absorbed energy fraction for 500 KeV photons in whole body	0.34
Max Initial unshielded dose rate/patient from F-18 @ 1 ft 15 mCi x (1-0.34) x 7.48 =	74.1 mR/h @1'
Integrated dose from F-18 in patient, t=0 hr to t=1 hr (maximum) taking into account the radioactive decay of the radionuclide during this period (see calc table below)	61.7 mrem @1'
Radioactive patients/wk: 3/week initially 15/week (max in future)	15 pat/wk
Total mrem/week @ 1 ft = 61.7 mrem/pat @ 1 ft x 15 patients/week =	926 mrem/wk @1'

SHIELDING CALCULATIONS

Adjacent Area	P (limit)	A	Occup.	d (ft)	mrem/wk @ d	Req'd Attenu. B(x)	REQUIRED SHIELDING		
							" Lead	" Concrete	Filled Block
18 (NC)	2	1	1/2	5.5	30.8	1.31E-01	0.49	5.8	7.1
Uptake #2 Room	Existing: 8" grout-filled CMU block					RECOMMENDED SHIELDING: None			
20 (NC)	2	1	1/20	3.5	75.6	5.29E-01	0.15	1.81	2.2
Exterior	Existing: 8" grout-filled CMU block					RECOMMENDED SHIELDING: None			
21 (C)	2	1	1/20	6.0	25.7	1.56E+00	-0.11	-1.3	-1.5
Exterior	Existing: 8" grout-filled CMU block					RECOMMENDED SHIELDING: None			
22 (NC)	2	1	1/8	8.5	10.3	1.56E+00	-0.11	-1.26	-1.5
Corridor	Existing: 8" grout-filled CMU block					RECOMMENDED SHIELDING: Wall: none; Door: any steel or 1/32 Pb			
Corridor (NC)	2	1	1/40	14.0	4.7	1.69E+01	-0.68	-8.0	
Roof	Existing: 22ga steel					RECOMMENDED SHIELDING: None			
Floor (not occupied)	-	-	0	-	-	-	0.00	0.0	
	Existing: SOG					RECOMMENDED SHIELDING: None			

P=weekly limit, T=occupancy factor, d=distance from source to area to be protected, A = ALARA factor by which allowed dose is reduced

B(x) = transmission factor required to reduce radiation level to PAT per week.

Concrete thickness specified is for 147 pcf

C = Controlled area, NC = Non-controlled area

Revision to Version 1: Roof has 22 ga steel (not 22 ga steel + 4" concrete)

11/11/2003

RADIOACTIVE SOURCE DATA	Nuclide	Half-life	γ Energy	Dose Rate mR/h/mCi @ 1'	HVL mm Lead	HVL " Lead	HVL " Concrete
	F-18	1.83 h	511 KeV	7.48	4.2	0.17	1.97

EXPOSURE FROM PATIENT WITH INJECTED ACTIVITY

Exposure E(mR) @ 1 foot from patient injected with "A" mCi of a positron-emitting nuclide with half-life $T_{1/2}$ hours, beginning at time t_1 (hrs) after injection of the radionuclide, and ending at time t_2 (hrs) after injection, where the patient absorbs a fraction F of the energy emitted.

Positron-emitter	I (mR/(h.mCi)) @ 1'	F	$T_{1/2}$ (hr)	A (mCi)	t_1	t_2	E(mR) @ 1'
¹⁸ F	7.48	0.34	1.83	15	0.0	1.0	61.7
¹⁸ F	7.48	0.34	1.83	15	1.0	1.5	23.1

CEILING

Floor-ceiling distance = 14 feet

Composition 22 ga steel

REFERENCES:

C-PET Site Planning Guide
 GE PETtrace Site Planning Guide
 Handbook of Health Physics and Radiological Health, 3rd Ed, 1998
 Discovery LS Site Preparation Manual (10/17/01)

PETSh.xls

UNCONTROLLED AREAS

10 mrem/wk - Controlled areas
 2 mrem/wk - Uncontrolled areas