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RESULTS OF THE RADIOLOGICAL SURVEY AT THE GRANITE CITY STEEL FACILITY, GRANITE CITY, ILLINOIS

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OPERATED BY
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W. D. Cottrell and R. F. Carrier

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ABSTRACT

In the late 1950s and early 1960s, uranium ingots were x-rayed for the Atomic Energy Commission at the South Plant facility of the Granite City Steel Company, Granite City, Illinois. The x-ray equipment is still housed in a building on the southern end of the property. At the time of the survey, neither the equipment nor the building had been used for some time. It is the policy of the U. S. Department of Energy (DOE) to verify that such sites are in compliance with current federal guidelines. Because documentation establishing the current radiological condition of the property is unavailable, a radiological survey was conducted by members of the Measurement Applications and Development Group of the Oak Ridge National Laboratory in March 1989. The survey included: (1) measurement of gamma exposure rates both indoors and outdoors; (2) collection and radionuclide analysis of soil and debris samples; and (3) measurements to determine alpha and beta-gamma surface contamination.

The results of the survey demonstrate that the building, its roof, and the area surrounding it are generally free of residuals originating from former DOE-sponsored activities. Most radiological measurements in the building were within the range of background values for southwestern Illinois. The exceptions were a contaminated vacuum cleaner inside the building, its contents, some of the building surfaces in its immediate vicinity, and two additional localized spots on the surface of the ground level floor. Concentrations of residual radioactive material in and around the vacuum cleaner and in scattered spots inside the building are in excess of concentration guidelines established by DOE to determine the eligibility of a site for remedial action. However, the contamination is very localized and limited in extent, rendering it highly unlikely that an individual working in or frequenting the area would receive a significant radiation exposure.

RESULTS OF THE RADIOLOGICAL SURVEY AT THE GRANITE CITY STEEL FACILITY, GRANITE CITY, ILLINOIS*

INTRODUCTION

During the late 1950s and early 1960s, the General Steel Casting Corporation x-rayed uranium ingots for the Atomic Energy Commission (AEC) under purchase orders issued by Mallinckrodt Chemical Company. The facility used for this purpose is located at 1417 State Street in southwest Granite City, Illinois, northeast of St. Louis, Missouri, across the Mississippi River (Fig. 1). Although purchase orders dated July 14, 1961, and others subsequent to that time are available, actual periods of operation are unknown. Ostensibly, the facility was used on an "as required" basis. During operations, the film and film developing services were apparently provided by General Steel Casting with Mallinkdrodt personnel handling the uranium metal and using the x-ray apparatus. The two Allis-Chalmers betatrons (Magnetic Induction Electron Accelerators) still remain in a building on the southern section of the plant property. Granite City Steel Company representatives indicate that the building is no longer in use. The site is now called the South Plant facility of the Granite City Steel Division and is owned by the Granite City Steel Company.[1]

It is the policy of the U. S. Department of Energy (DOE) to verify that radiological conditions at such sites or facilities comply with current Federal guidelines. If they are found to deviate to any significant degree from those guidelines, remedial action may be implemented (where DOE has the authority to do so) to correct the unacceptable condition. Furthermore, guidelines for release and use of such sites have become more stringent as research has provided more information since previous cleanups. No records have been found to suggest that any residual radioactive contamination remained on the Granite City site as a result of past operations or of any cleanup activities conducted following use of the betatron equipment. Neither is it believed that activities conducted at this site represent a potential for significant radiological contamination. However, because no documentation has been discovered to establish the current radiological condition of the environment in and around the building in which the x-ray equipment is housed, Oak Ridge National Laboratory (ORNL) conducted a preliminary survey at the request of DOE to

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*The survey was performed by members of the Measurement Applications and Development group of the Health and Safety Research Division at Oak Ridge National Laboratory under U. S. DOE contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc.

determine if this site should be included for further assessment in the Formerly Utilized Sites Remedial Action Program (FUSRAP). The following radiological survey discussed in this report was conducted by ORNL in March 1989.

SITE DESCRIPTION

The building housing the betatrons is largely constructed of metal and concrete (Figs. 2 and 3). A railroad track extends from the north end of the building through a high bay area into a large, open room at the south end (Fig. 4). The walls around this room and high bay area are of 10-ft thick concrete. The remaining northeast quarter of the building is subdivided into offices and utility rooms over which is a second level. At the time of the survey, the betatrons, one of which is shown on Fig. 5, were located on the east side of the large room (Fig. 4). Against the north wall of this room is a concrete pad on which stand several transformers (Fig. 6). Much of the building contains abandoned equipment and rubbish. Floors in some indoor areas were wet at the time of the survey.

SURVEY PROCEDURES

The radiological survey included: (1) gamma scanning of the ground surface outdoors near the building; (2) gamma scanning at floor and wall surfaces throughout the building and on the roof; (3) collection and radionuclide analysis of outdoor soil samples and indoor dust and debris; (4) the determination of direct and transferable beta-gamma and alpha activity levels on indoor surfaces and on the roof. A comprehensive description of the survey methods and instrumentation has been presented in another report.[2]

Using a portable gamma scintillation (NaI) survey meter, ranges of exposure rates were recorded by scanning near the ground surface outdoors and near the building floor, wall, and roof surfaces. Beta-gamma dose rates and total alpha activity levels were determined by direct measurement on indoor surfaces and on the roof. Smears were also taken in selected locations indoors and on the roof to establish transferable alpha and beta-gamma activity levels. Samples of outdoor soil and indoor dust and debris were collected from locations selected without regard to gamma levels (systematic samples) and where gamma levels were elevated (biased samples). The samples were analyzed for radionuclide content.

SURVEY RESULTS

Applicable DOE guidelines for sites included within the FUSRAP are summarized in Table 1. Typical radiation background levels in the southwestern Illinois area are presented in Table 2. These data are provided for comparison with the survey results presented in this section. With the exception of measurements of transferable activity, which are reported as net disintegration rates, all direct measurements presented in this report are gross readings; background radiation levels have not been subtracted. Similarly, background concentrations have not been subtracted from radionuclide concentrations in soil and environmental samples.

BUILDING SURVEY

INDOOR SURVEY

Gamma Exposure Rate Measurements

Inside the building, scan measurements generally ranged from 3 to 16 μR/h with a range of 3 to 8 μR/h on the second level as shown on Figs. 7 and 8. Gamma levels were slightly higher on walls. The first-floor values are slightly above the range of background for the southwestern Illinois area (Table 2) but below the DOE indoor guideline of 20 μR/h above background (Table 1). However, gamma exposure rates in the northeast corner of the x-ray room were 90 μR/h on contact with an industrial vacuum cleaner and 40 μR/h beneath it. A photo of the vacuum cleaner is reproduced in Fig. 9; its location is shown on Fig. 4. These elevated gamma levels are above the guideline value.

Alpha and Beta-gamma Activity Levels

Ranges of directly measured alpha and beta-gamma activity levels on surfaces of the ground floor of the building are shown on Fig. 7. Results of alpha measurements for the second level are given on Fig. 8. Alpha measurements on surfaces of the ground floor of the building ranged from background (<25*) to 540 dpm/100 cm^2. Second floor alpha values ranged from 36 to 108 dpm/100 cm^2. These values are lower than the DOE guideline of 5,000 dpm/100 cm^2 for uranium alpha-emitters (Table 1). Beta-gamma dose rates on ground floor surfaces ranged from 0.02 to 0.06 mrad/h except on contact with the vacuum cleaner, and in one isolated spot nearby (Fig. 7). There, the dose rate was 0.2 mrad/h. All measurements except the latter are below the DOE guideline of 0.2 mrad/h for maximum dose rate over any 100 cm^2 area.

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*The instrument-specific minimum detectable activity is 25 dpm/100 cm^2.

The locations of smears obtained inside the building are shown on Fig. 10. The resulting alpha activity levels are shown in the table below.

Transferable alpha (α) activity levels (dpm/100 cm^2), first floor

	#24	#25	#27	#28	#29	#33	#34	#35	#38
α	<10	<10	<10	41	12	<10	<10	<10	<10

Analysis of smears disclosed transferable alpha levels ranging from less than the minimum detectable activity (10 dpm/100 cm^2) to 41 dpm/100 cm^2 with the maximum measurement, 41 dpm/100 cm^2, taken on the vacuum cleaner. All removable beta-gamma levels were less than the instrument-specific minimum detectable activity of 200 dpm/100 cm^2. The DOE guidelines for transferable alpha and beta-gamma activity levels are 1,000 dpm/100 cm^2 (from ^{238}U decay).

Debris Analyses

Six systematic (S1-S6) and two biased (B1–B2) samples of dust and debris were collected indoors at the locations shown on Fig. 10. Results of analyses are listed in Table 3. Concentrations of ^{226}Ra and ^{232}Th in samples from inside the building ranged from 0.85 to 2.4 pCi/g, and 0.40 to 0.53 pCi/g, respectively. Uranium-238 was present at concentrations of 0.70 to 75 pCi/g. In two biased samples, concentrations (pCi/g) of ^{226}Ra and ^{232}Th were <0.88 and 1.6 pCi/g and <1.3 and 0.75 pCi/g, respectively. Concentrations of ^{238}U were 3,300 and 4,000 pCi/g in samples from the floor beside the contaminated vacuum cleaner and from the cleaner itself, respectively. All concentrations of ^{226}Ra and ^{232}Th are below the applicable soil guideline (Table 1) and near background values (Table 2). In systematic samples collected from the floor near the railroad tracks (S4), from the damper in a vent above the vacuum cleaner (S5), and from the floor near the center of the high bay (S6), ^{238}U concentrations were at or above values of 35 to 40 pCi/g used as the criterion at other FUSRAP sites. Uranium-238 concentrations in the sample from the cleaner (B2) and in the sample from beneath it (B1) were also above these guidelines.

ROOF SURVEY

Gamma Exposure Rate Measurements

Exposure rates ranged from 5 to 10 μR/h on the roof surface with the highest measurement taken at two spots on the outside wall of the upper part of the structure (Fig. 11). These values are within the range of background for the southwestern Illinois area (7–11 μR/h, Table 2).

Alpha and Beta-gamma Activity Levels

Directly measured alpha activity levels on the roof (Fig. 11) were less than the guideline for uranium (Table 1), ranging from 20 to 500 dpm/100 cm^2. Beta-gamma dose rates were 0.02 to 0.03 mrad/h, values below the applicable guideline. Results of analysis of smears taken at the roof locations shown on Fig. 11 (smears 31 and 32) showed transferable alpha activity levels of 16 and 96 dpm/100 cm^2, respectively. These values are less than the DOE guideline for removable activity (Table 1).

Debris Analyses

Concentrations of ^{226}Ra, ^{232}Th, and ^{238}U in the sample of material from the roof (B4) were 1.7, 0.42, and 1.6 pCi/g, respectively. Values for ^{226}Ra and ^{232}Th are below the DOE guideline for surface soil (Table 1). The concentration of ^{238}U, 1.6 pCi/g, is below DOE quidelines used at other sites (35-40 pCi/g).

OUTDOOR SURVEY

Gamma Exposure Rate Measurements

Gamma levels ranged from 5 to 36 μR/h outdoors on the property (Fig. 12). The maximum measurement (36 μR/h) was taken ~75 ft from the northeast corner of the building. Exposure rates of 30 μR/h were measured on some mounds of dirt north and east of the property, and at the southeast corner of the building. Some exposure rates were above background for the southwestern Illinois area (7–11 μR/h, Table 2).

Soil Sample Analyses

Locations of soil samples are shown on Fig. 12 with results of analyses listed in Table 4. The radioisotopes ^{226}Ra and ^{238}U, found in the three systematic samples from the top 15-cm layer of soil, were in secular equilibrium. Their concentrations ranged from 5.7 to 13 pCi/g, and 5.4 to 13 pCi/g, respectively. Thorium-232 in those 15-cm surface samples ranged from 1.4 to 2.2 pCi/g. The concentrations of ^{226}Ra in samples S7A and S8A (8.4 and 13 pCi/g, respectively) exceed the DOE guideline (Table 1). However, this type of radionuclide distribution would not result from the DOE-related operations which had taken place at this site.

Systematic samples taken from subsurface soil at depths of 15 to 45 cm showed ^{226}Ra and ^{238}U in approximately equal amounts, ranging from 3.8 to 12 pCi/g and 4.2 to 12 pCi/g, respectively. Concentrations of ^{232}Th in subsurface soil were 0.75 to 1.9 pCi/g. Radionuclides in subsurface samples are below guidelines.

In the three biased soil samples from depths of 0 to 41 cm, concentrations of ^{226}Ra and ^{238}U were again approximately equal at 20 to 21 pCi/g, and 18 to 21 pCi/g, respectively. Concentrations (pCi/g) of ^{232}Th were 3.3 to 3.4. The values for ^{226}Ra exceed the DOE guideline in all three samples but are in equilibrium with ^{238}U in those samples.

The ratio and distribution of the radioisotopes ^{226}Ra and ^{238}U found here are consistent with those for other samples known to contain naturally occurring material such as coal ashes and/or cinders. In any case, DOE-related operations conducted at this site would not have resulted in the type of radionuclide distribution found outdoors on this property.

SIGNIFICANCE OF FINDINGS

Survey results show that a small amount of residual radioactivity from former operations remains in several discrete, localized spots in the x-ray building at the Granite City Steel Facility. Uranium-238 was found indoors in elevated concentrations in debris from an industrial vacuum cleaner, and in dust and debris in scattered locations throughout the building.

Gamma levels inside the building were generally acceptable in all areas of the building and on the roof, ranging from 3 to 16 μR/h. Background in the southwestern Illinois area averages 9 μR/h. However, exposure rates were 90 and 40 μR/h on and beneath the vacuum cleaner, respectively. These values are above the DOE guideline of 20 μR/h above background (Table 1). All directly measured alpha activity levels were below the guideline for uranium (Table 1). No beta-gamma dose rate measurements exceeded the criterion of 0.2 mrad/h over 100 cm^2 (two measurements on and near the contaminated cleaner were equal to the guideline). Evaluation of smear results indicated that all transferable alpha and beta-gamma activity levels were below the DOE guideline of 1,000 dpm/100 cm^2 for uranium. Nevertheless, sampling of indoor dust and debris confirmed the presence of ^{238}U residuals. Uranium-238 was found in concentrations as high as 4,000 pCi/g in and around the vacuum cleaner.

Concentrations of ^{226}Ra in excess of the DOE guidelines for surface and subsurface soil were found in apparent equilibrium with ^{238}U outdoors. However, because former DOE-supported operations at this site would not result in radionuclide distributions of this type, the outdoor contamination found at this facility is not the result of DOE-related operations.

In summary, concentrations of residual radioactive material found in and around an industrial vacuum cleaner on the site, and in scattered spots inside the building, are in excess of concentration guidelines established by DOE to determine the eligibility of a site

for remedial action. These conservative guidelines are based on possible exposure through inhalation, ingestion, or direct contact, and are typically derived to ensure that unrestricted use (including residential use) will not result in above-guideline doses to the general public. Furthermore, the contamination is very localized and limited in extent, and an examination of any credible use scenario for this site suggests that no significant radiation exposures would accrue to individuals frequenting the area.

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2. T. E. Myrick, B. A. Berven, W. D. Cottrell, W. A. Goldsmith, and F. F. Haywood, *Procedures Manual for the ORNL Remedial Survey Activities Program,* Oak Ridge National Laboratory, Oak Ridge, Tennessee, ORNL/TM–8600 (September 1982).

3. T. E. Myrick and B. A. Berven, *State Background Radiation Levels: Results of Measurements Taken During 1975-1979, Oak Ridge National Laboratory,* ORNL/TM-7343 (November 1981).

Fig. 1. General location of the Granite City Steel Facility, Granite City,

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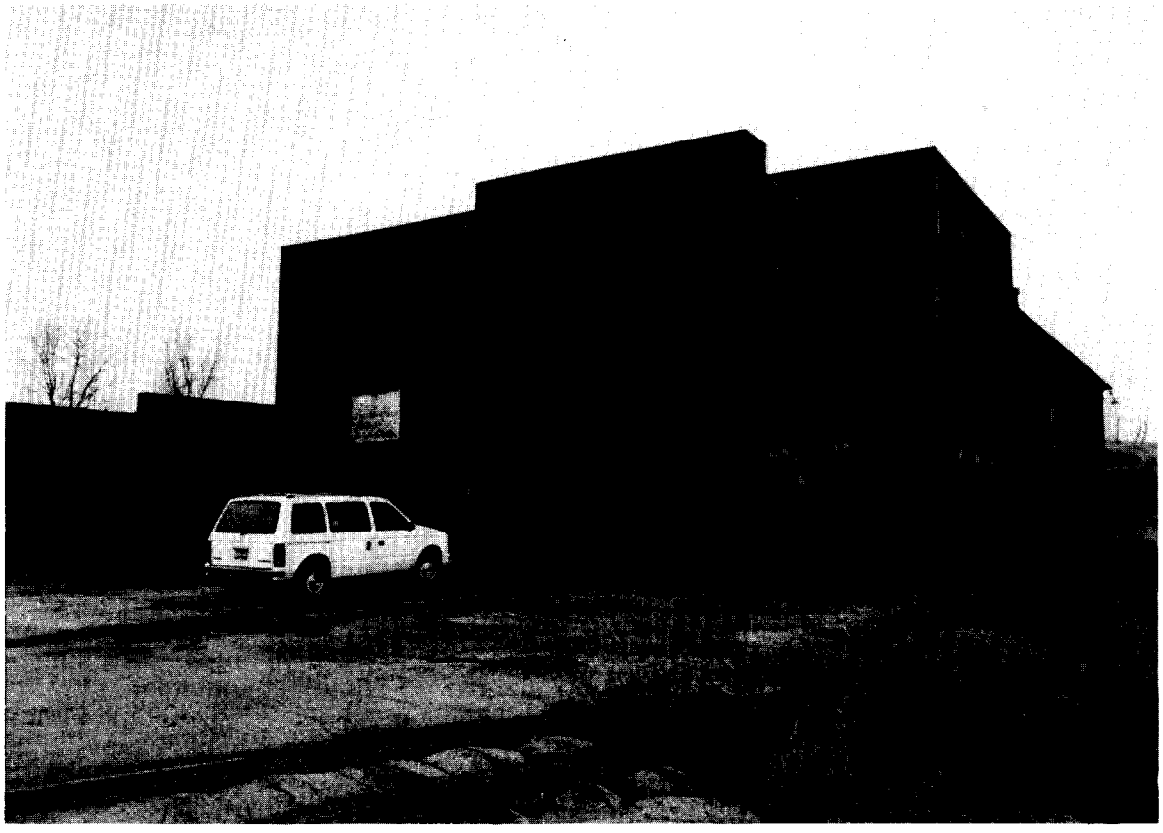

Fig. 2. View of the betatron building, looking south.

ORNL-PHOTO 9023-89

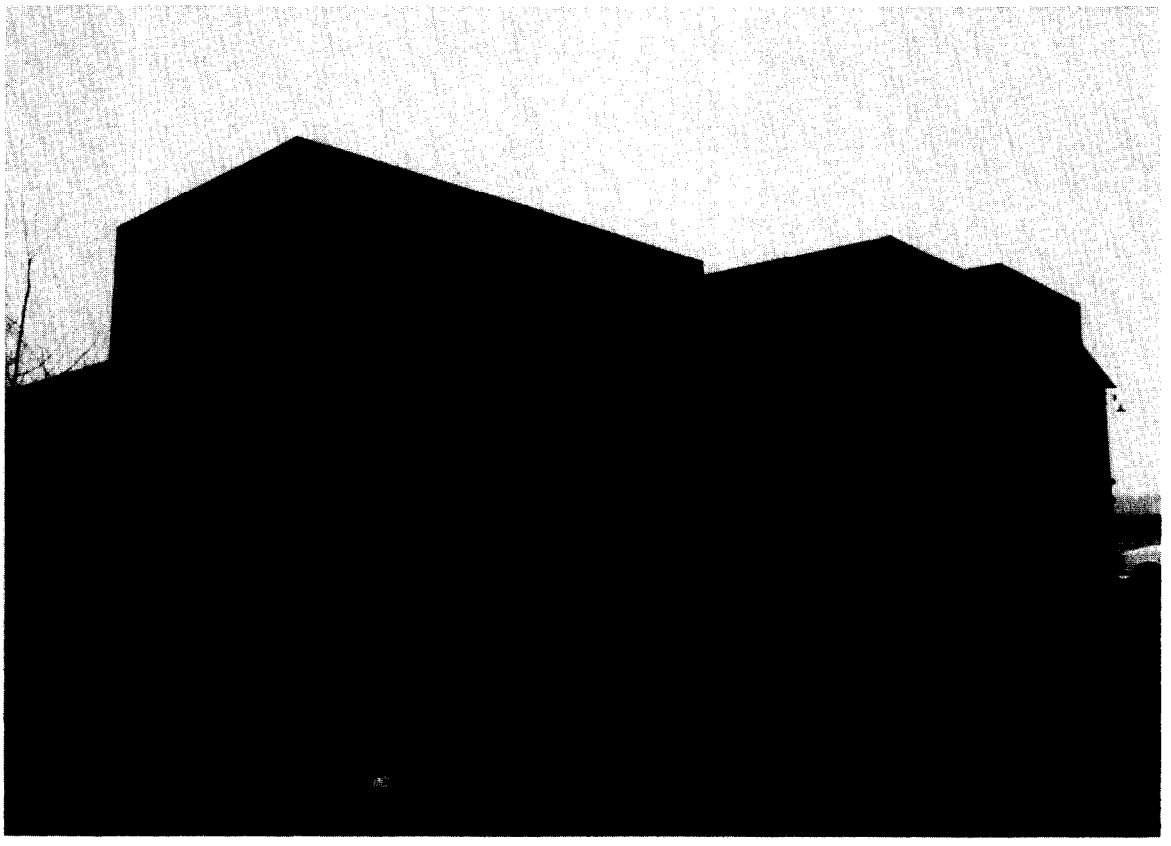

Fig. 3. View of the betatron building, looking west.

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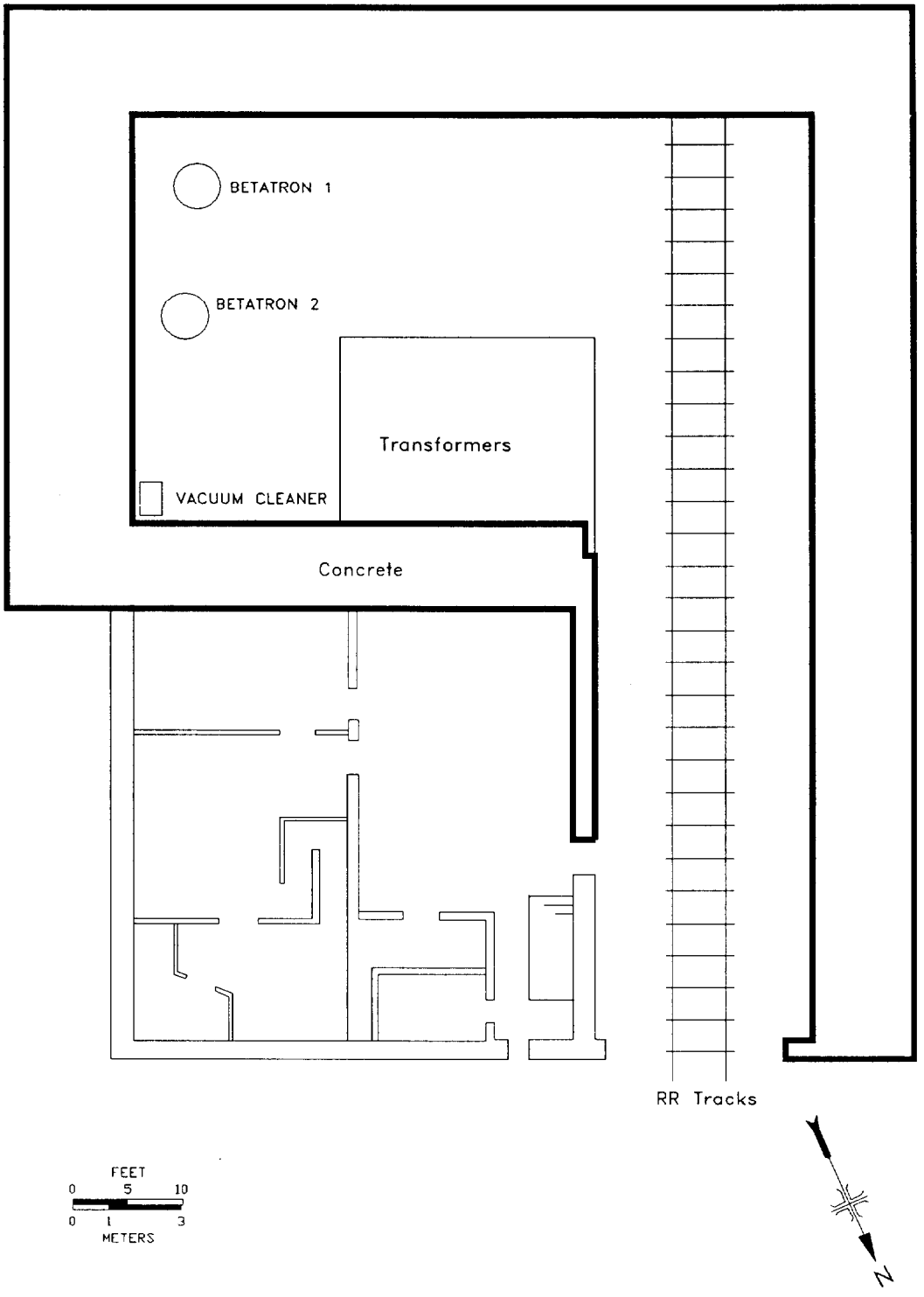

Fig. 4. Diagram of the ground floor of the betatron building.

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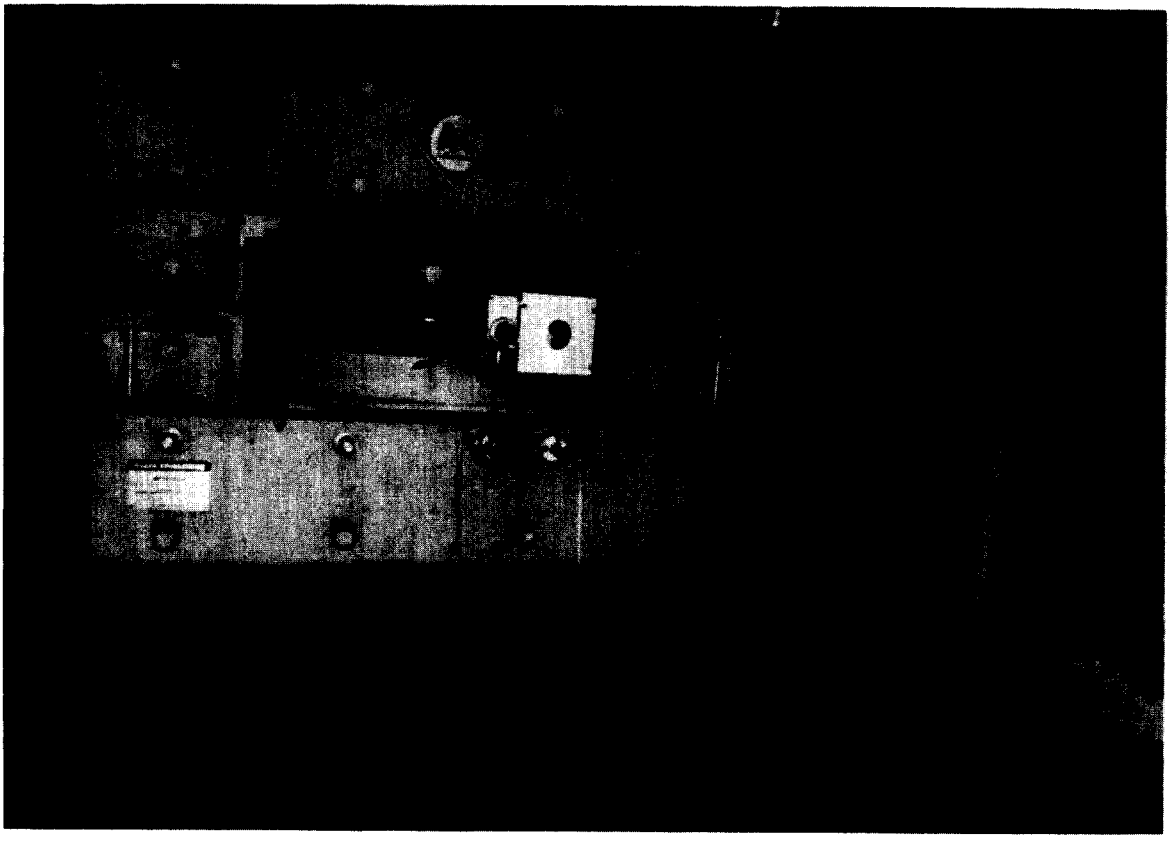

Fig. 5. Photo showing the larger of the two betatrons (no. 1, Fig. 4).

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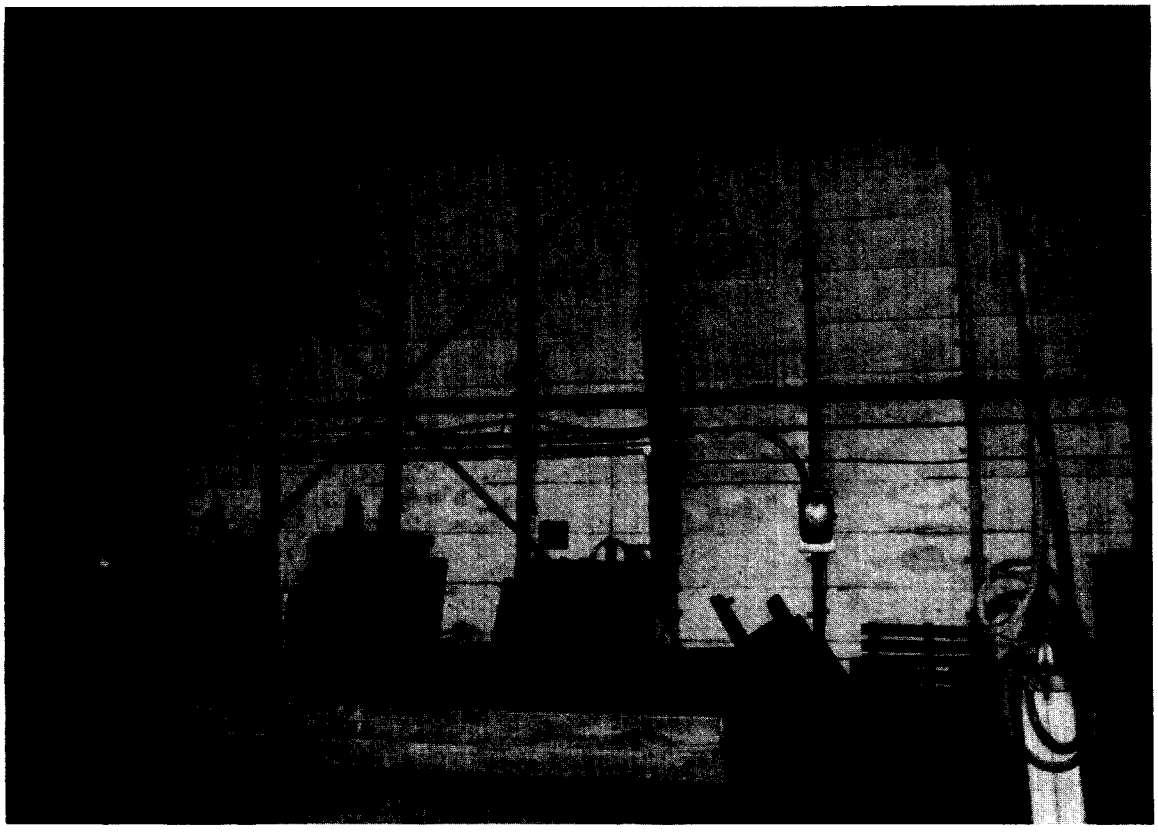

Fig. 6. View of transformer storage area inside the betatron building.

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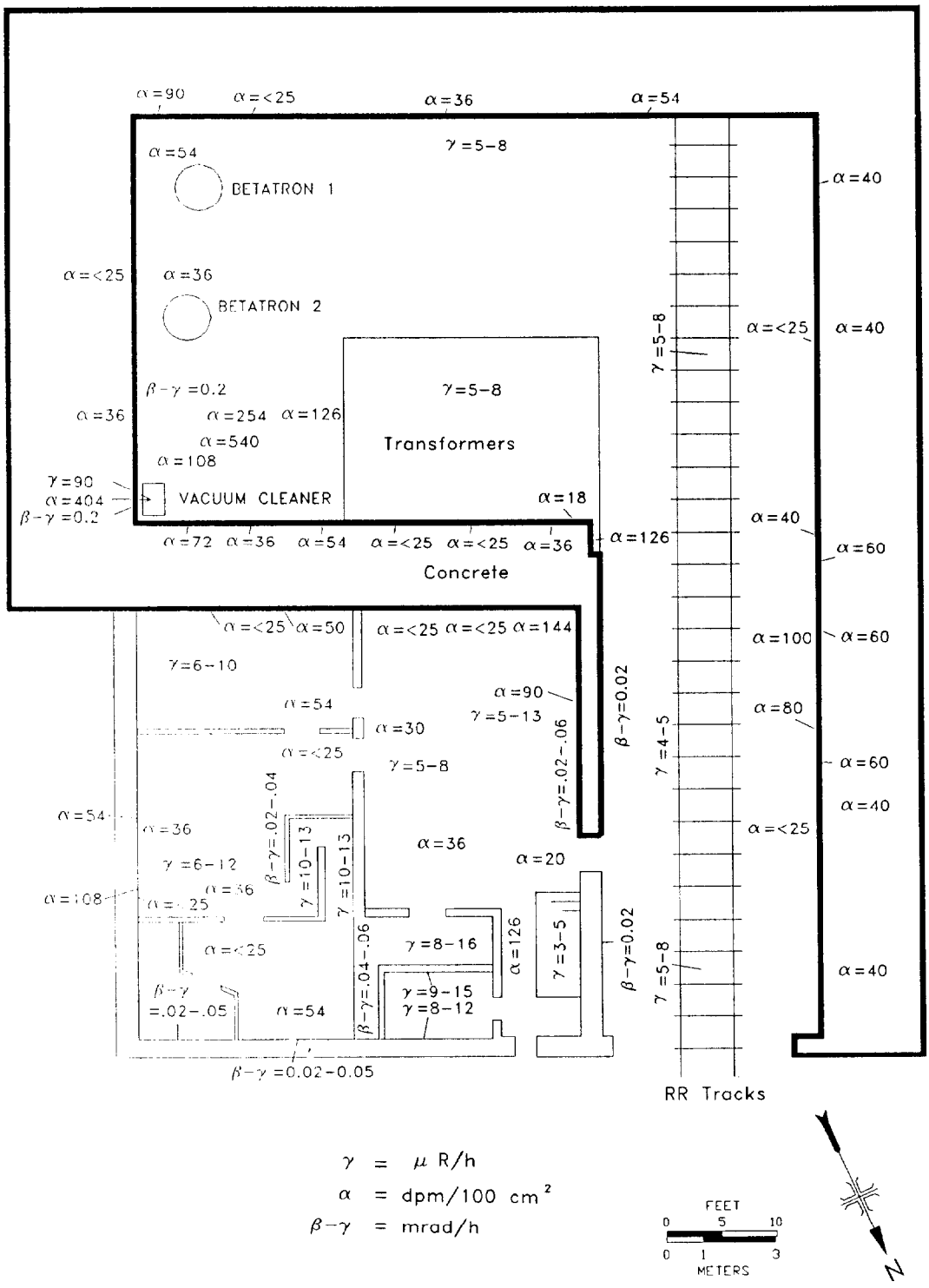

Fig. 7. Directly measured radiation levels inside the betatron building, first level.

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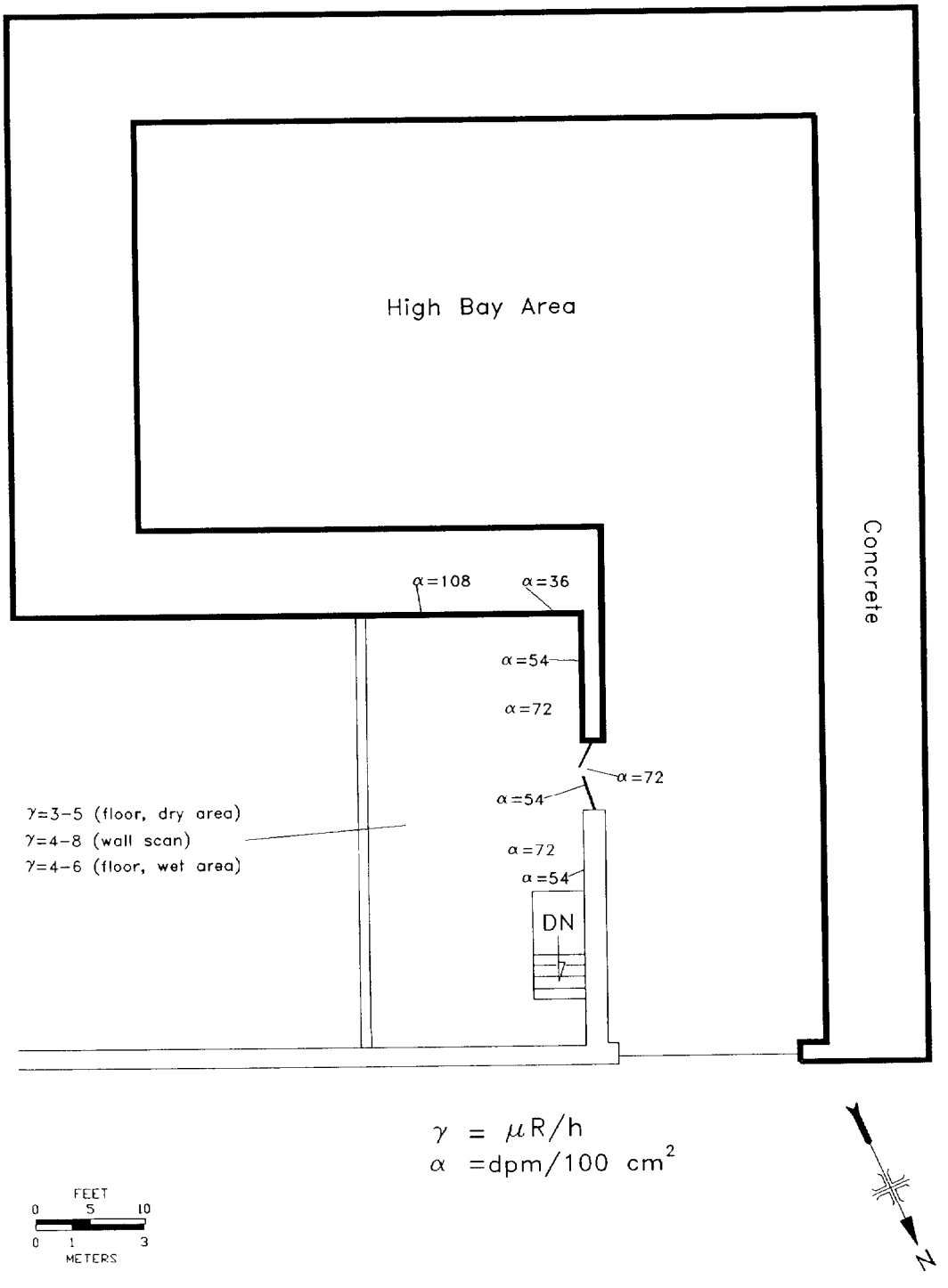

Fig. 8. Results of directly measured radiation levels taken in the betatron building, second level.

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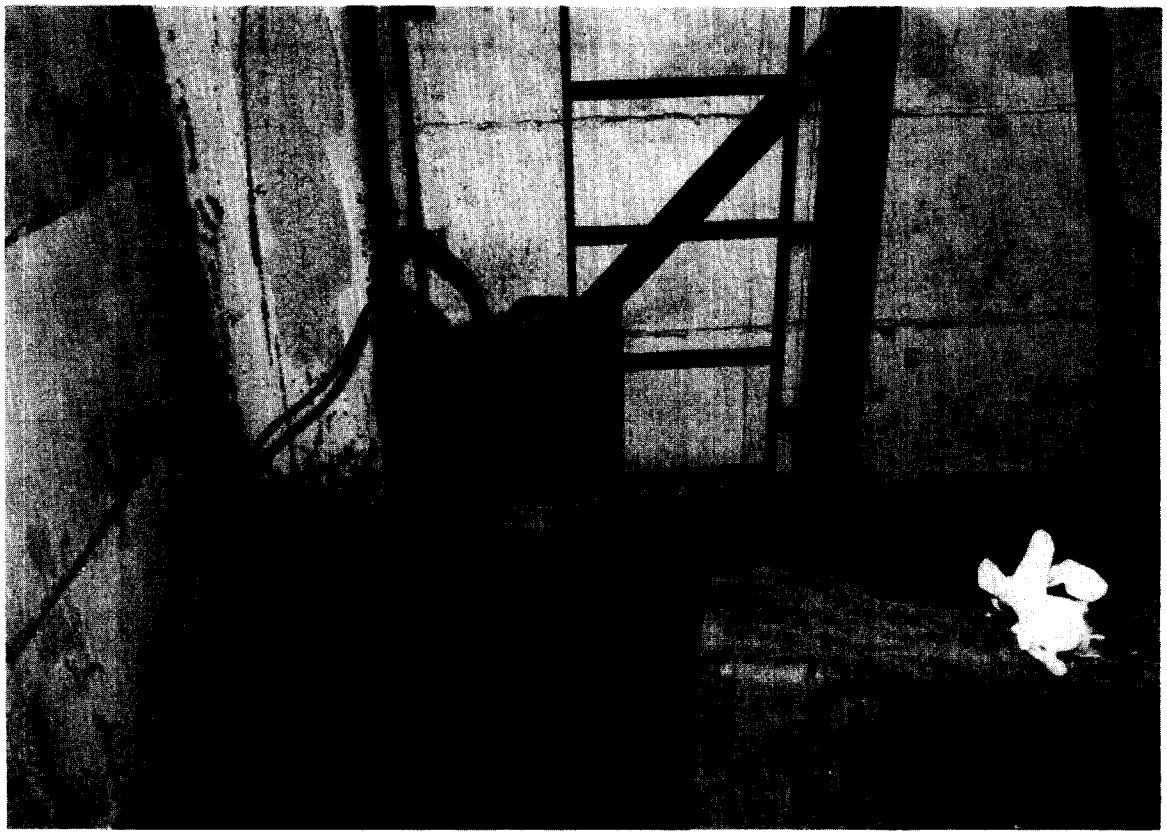

Fig. 9. Industrial vacuum cleaner having elevated radiation levels and radionuclide concentrations.

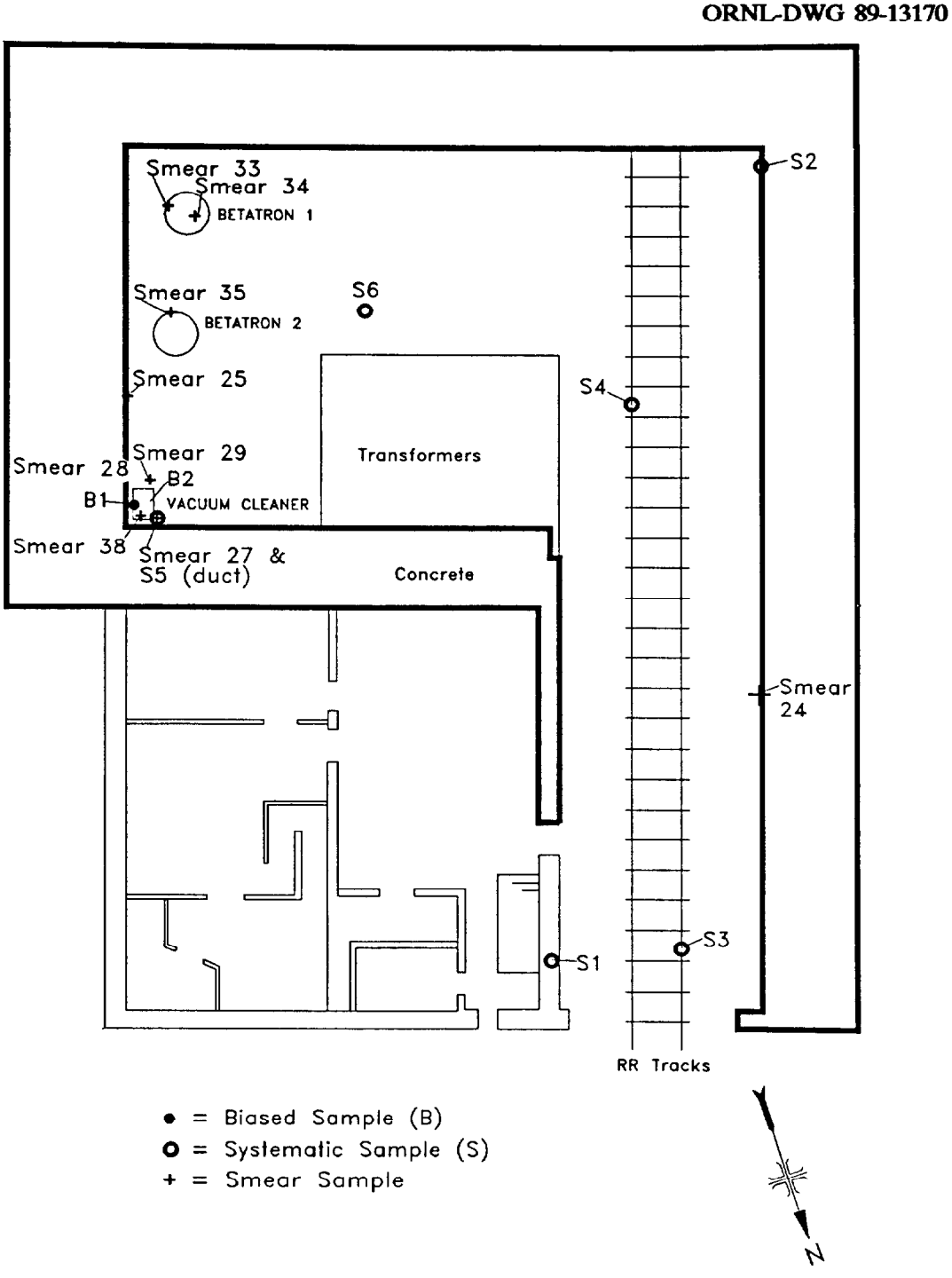

Fig. 10. Locations of smears, and indoor dust and debris samples.

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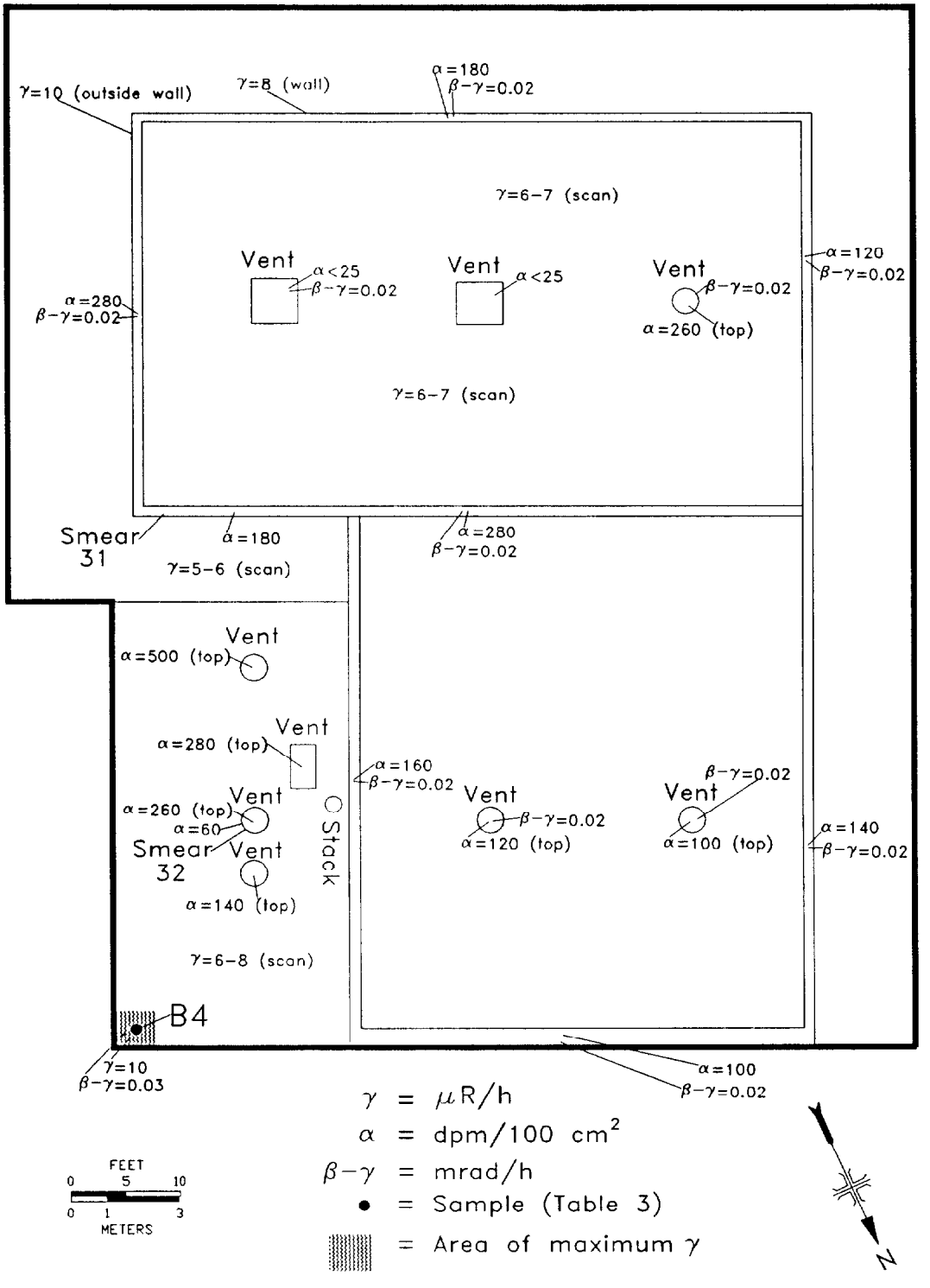

Fig. 11. Results of direct radiation measurements and locations of smear and debris samples taken from the building roof.

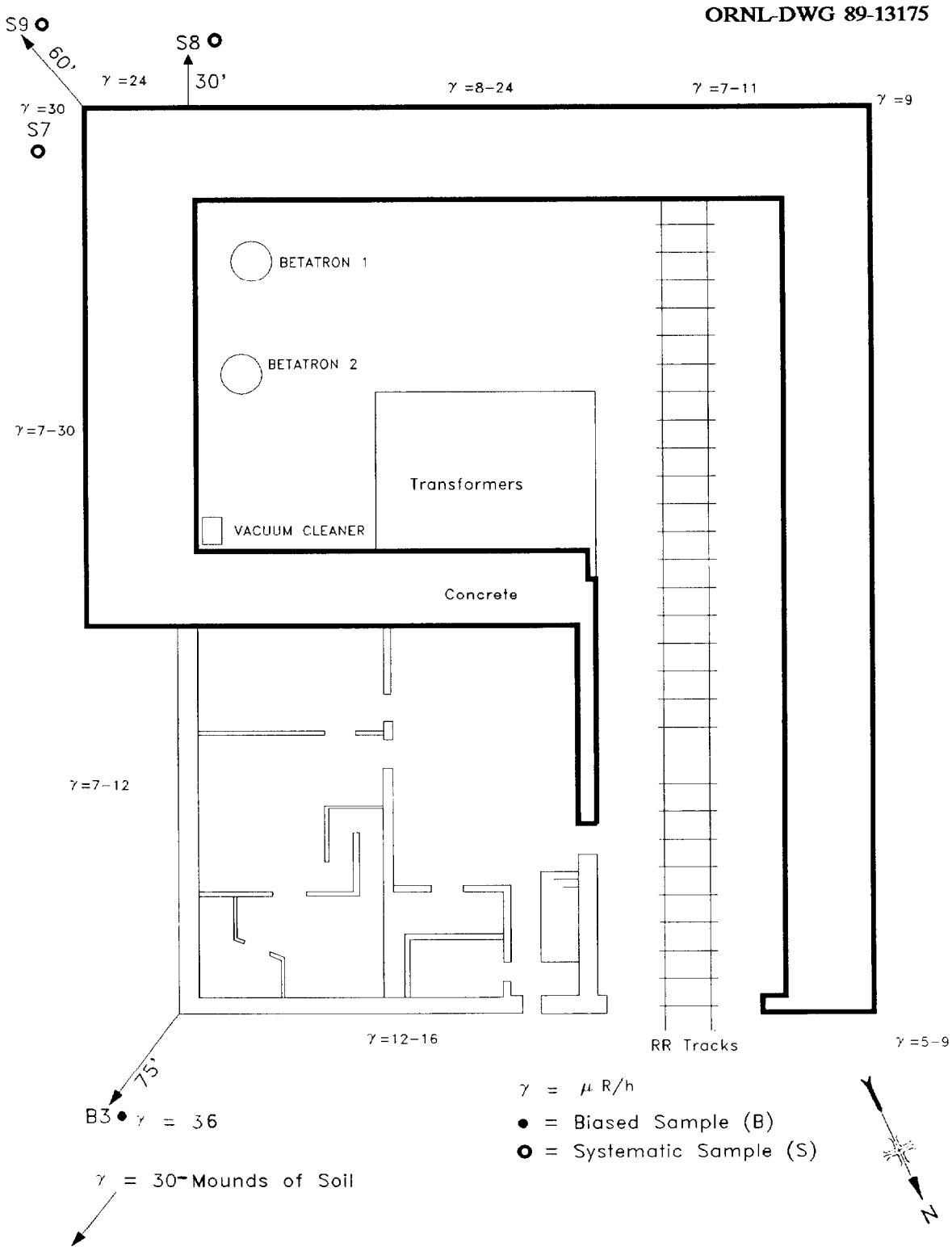

Fig. 12. Outdoor gamma exposure rates and locations of soil samples.

Table 1. Applicable guidelines for protection against radiation[a]

Mode of exposure	Exposure conditions	Guideline value
Gamma radiation	Indoor gamma radiation level (above background)	20 μR/h
Surface contamination	^{238}U, U-natural	
	Fixed on surfaces	5000 dpm/100 cm^2
	Removable	1000 dpm/100 cm^2
	^{232}Th, Th-natural	
	Fixed on surfaces	1000 dpm/100 cm^2
	Removable	200 dpm/100 cm^2
	^{226}Ra	
	Fixed on surfaces	100 dpm/100 cm^2
	Removable	20 dpm/100 cm^2
Beta-gamma dose rates[b]	Surface dose rate averaged over not more than 1 m^2	0.20 mrad/h
	Maximum dose rate in any 100 cm^2	1.0 mrad/h
Radionuclide concentrations in soil	Maximum permissible concentration of the following radionuclides in soil above background levels averaged over 100 m^2 area	5 pCi/g averaged over the first 15-cm of soil below the surface; 15 pCi/g when averaged over 15-cm thick soil layers more than 15 cm below the surface
	^{232}Th	
	^{230}Th	
	^{228}Ra	
	^{226}Ra	
	^{238}U	Derived (site specific)

[a]U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites (April 1987).

[b]Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except ^{90}Sr, ^{228}Ra, ^{223}Ra, ^{227}Ac, ^{133}I, ^{131}I, ^{129}I, ^{126}I, ^{125}I.

Table 2. Background radiation levels and concentrations of selected radionuclides in soil samples taken in southwestern Illinois

Type of radiation measurement or sample[a]	Radiation level or radionuclide concentration	
	Range	Average
Gamma exposure rate at 1 m above ground surface (μR/h)	7-11	9
Concentration of radionuclides in soil (pCi/g dry wt)		
^{232}Th	1.0-1.2	1.1
^{226}Ra	0.88-0.93	0.90
^{238}U	1.0-1.1	1.0

[a]With the exception of ^{226}Ra concentrations that were derived from two sampling locations, values were obtained from 3 locations in southwestern Illinois.[3]

Table 3. Concentrations of radionuclides in soil and debris samples at the General Steel Facility, Granite City, Illinois

Sample[a]	Depth (cm)	Radionuclide concentration (pCi/g)		
		^{226}Ra[b]	^{232}Th[b]	^{238}U[b]
		Systematic samples[c]		
S1	*d*	0.85 ± 0.02	0.40 ± 0.02	0.70 ± 0.36
S2	*d*	2.2 ± 0.04	0.53 ± 0.04	2.8 ± 0.74
S3	*d*	2.0 ± 0.06	0.46 ± 0.04	2.8 ± 0.44
S4	*d*	2.3 ± 0.12	*e*	35 ± 11
S5	*d*	1.5 ± 0.1	*e*	75 ± 25
S6	*d*	2.4 ± 0.1	*e*	60 ± 12
S7A	0–15	8.4 ± 0.12	1.5 ± 0.15	8.5 ± 0.42
S7B	15–30	3.8 ± 0.04	0.75 ± 0.04	4.2 ± 0.98
S8A	0–15	13 ± 1.3	2.2 ± 0.04	13 ± 1.3
S8B	15–30	12 ± 0.10	1.9 ± 0.08	12 ± 1.9
S9A	0–15	5.7 ± 0.04	1.4 ± 0.08	5.4 ± 0.56
S9B	15–30	6.7 ± 0.06	1.3 ± 0.06	5.7 ± 1.1
S9C	30–45	8.7 ± 0.10	1.6 ± 0.02	7.1 ± 2.9
		Biased samples[f]		
B1	*g*	<0.88	<1.3	3300 ± 58
B2	*g*	1.6 ± 0.89	0.75 ± 0.16	4000 ± 1000
B3A	0–15	20 ± 0.12	3.3 ± 0.04	21 ± 5.5
B3B	15–28	20 ± 0.14	3.3 ± 0.06	21 ± 6
B3C	28–41	21 ± 0.2	3.4 ± 0.2	18 ± 4
B4	*g*	1.7 ± 0.02	0.42 ± 0.02	1.6 ± 0.34

[a]Locations of samples are shown on Figs. 10, 11, and 12.

[b]Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).

[c]Systematic samples are taken at selected locations irrespective of gamma exposure rates.

[d]Samples of dust and debris from overhead beams (S1, S2), floor near R. R. tracks (S3, S4), from damper in vent above vacuum cleaner (S5), and floor near center of high bay (S6).

[e]No analysis performed.

[f]Biased samples are taken from areas shown to have elevated gamma exposure rates.

[g]Dust and debris from the floor beside the vacuum cleaner (B1), the cleaner itself (B2), and the roof above the photo lab (B4).

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