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Results of the Radiological Survey at the New Betatron Building, Granite City Steel Facility, Granite City, Illinois (GSG002)

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MANAGED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
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ACKNOWLEDGMENTS

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ABSTRACT

At the request of the U.S. Department of Energy (DOE), a team from Oak Ridge National Laboratory conducted a radiological survey at the New Betatron Building, located in the South Plant facility of Granite City Steel Division, 1417 State Street, Granite City, Illinois. The survey was performed in August 1991. The purpose of the survey was to determine whether the property was contaminated with radioactive residues, principally ^{238}U, as a result of work done for the Atomic Energy Commission (AEC) from 1958 to 1966. The survey included a surface gamma scan of the ground surface outdoors near the building, the floor and walls in all accessible areas inside the building, and the roof; measurement of beta-gamma dose rates, alpha radiation levels, and removable alpha and beta-gamma activity levels at selected locations inside the building and on the roof; and radionuclide analysis of outdoor soil samples and indoor samples of shield-wall fill material and debris.

Analysis of soil, shield-wall fill material, debris, and smear samples showed no residual ^{238}U attributable to former AEC-supported operations at this site. None of the indoor or outdoor gamma exposure rate measurements were elevated above DOE guidelines. The slight elevations in gamma levels found outdoors and on the roof over the shield wall are typical of naturally occurring radioactive substances present in coal ash and cinders in the fill material surrounding the building and in concrete and cinders used in construction of the shield wall. The slightly elevated gamma levels measured at soil sampling locations can be attributed to the presence of naturally occurring radionuclides. In all samples, ^{226}Ra and ^{238}U appeared to be in equilibrium, indicating that these radionuclides were of natural origin and not derived from former AEC activities at this site.

Results of the Radiological Survey at the New Betatron Building, Granite City Steel Facility, Granite City, Illinois (GSG002)*

INTRODUCTION

During the late 1950s and early 1960s, the General Steel Castings Corporation was the custodian of a government-owned betatron used to X-ray uranium ingots for the Atomic Energy Commission (AEC) under purchase orders issued by Mallinckrodt Chemical Works. The facility used for this purpose is located at 1417 State Street in southwest Granite City, Illinois, northeast of St. Louis, Missouri, east of the Mississippi River (Fig. 1). The site is now part of the South Plant facility (Fig. 2) of Granite City Steel Division, a subsidiary of National Steel Corporation.

Purchase orders were issued by the Uranium Division, Mallinckrodt Chemical Works, from February 1958 through June 1966, first to General Steel Castings Corporation and later (July 14, 1961 and after) to General Steel Industries, Inc., at the same address. The purchase orders indicate that General Steel Castings furnished the film and film developing services and suggest that Mallinckrodt personnel may have handled the uranium metal and operated the betatron equipment used to X-ray the metal. The purchase orders do not specify actual periods of operation or the quantity and configuration of the metal X-rayed. There are indications, however, that the facility was used on an "as required" basis, and the metal was in the form of ingots 18 to 20 in. in diameter, approximately 18 in. long, and weighing up to 3000 lb.[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 DOE guidelines.[2] If they are found to deviate to any significant degree from those guidelines, remedial action may be implemented to correct the unacceptable condition. Furthermore, guidelines for using such sites without radiological restrictions have become more stringent as research on the effects of low-level radiation has progressed.

In March 1989, the Oak Ridge National Laboratory (ORNL) conducted a preliminary survey at the request of DOE to determine if this site should be included for further assessment in the Formerly Utilized Sites Remedial Action Program (FUSRAP). At that time the Betatron Building was examined. The building, its roof, and the area surrounding it were found to be generally free of residual radiological material originating from former AEC-sponsored activities. Some residual radioactive material was found in and around a vacuum cleaner and in scattered spots inside the building, but these were very localized and

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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 DOE contract DE-AC05-84OR21400.

limited in extent, rendering it highly unlikely that an individual working in or frequenting the area would receive a significant radiation exposure.[3]

Recent information has indicated that another building at this site, the New Betatron Building, may have been used for X-ray studies on uranium produced for DOE's predecessor, the AEC. At the request of DOE, the Measurement Applications and Development Group, ORNL, conducted a radiological survey of the New Betatron Building (Fig. 3) in August 1991. Results of that survey are presented in this report. The building was empty and idle at the time of the survey, but future plans include leasing the building for storage purposes.

SCOPE OF THE SURVEY

The radiological survey included: (1) a surface gamma scan of the ground surface outdoors near the building, the floor and walls in all accessible areas inside the building, and the roof; (2) measurement of beta-gamma dose rates and alpha radiation levels in selected locations inside the building and on the roof; (3) measurement of removable alpha and beta-gamma activity levels at 7 locations inside the building and 13 locations on the roof; (4) collection and radionuclide analysis of 3 outdoor soil samples, 2 samples of shield-wall fill material, and 2 indoor debris samples.

SURVEY METHODS

A comprehensive description of the survey methods and instrumentation used in this survey is given in *Procedures Manual for the ORNL Radiological Survey Activities (RASA) Program*, ORNL/TM-8600 (April 1987).[4]

Using a NaI scintillation probe connected to a Victoreen ratemeter, surface gamma levels were recorded for accessible areas of the floor and walls inside the building and outdoor areas near the building and on the roof. The detector was held approximately 2 in. above the floor/ground/roof surface, and measurements were recorded and then converted to μR/h. Using a Geiger-Mueller pancake detector, beta-gamma levels were recorded and then converted to mrad/h. Alpha levels were measured at selected locations with an ORNL alpha meter connected to a ZnS scintillation probe, and then converted to dpm/100 cm^2.

Smears were obtained from selected surfaces inside the building and on the roof to establish removable alpha and beta-gamma activity levels. Soil samples collected outdoors to depths of 15 cm and shield-wall* fill material and debris collected inside the building were analyzed for ^{210}Pb, ^{226}Ra, ^{232}Th, ^{238}U, and ^{235}U.

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*The ~10-ft-thick shield wall consisted of outer layers of concrete filled with a granular cinder-like material.

SURVEY RESULTS

DOE guidelines are summarized in Table 1. Typical background radiation levels for the Granite City, Illinois, area are presented in Table 2. These data are provided for comparison with survey results presented in this section. All direct measurement results presented in this report are gross readings; background radiation levels have not been subtracted. Similarly, background concentrations have not been subtracted from radionuclide concentrations measured in soil and debris samples. Removable radioactivity levels (smears) are reported as net disintegrations per minute (dpm) with background subtracted.

Current photographs of the site are shown in Figs. 4–15.

GAMMA EXPOSURE RATE MEASUREMENTS

Results of gamma exposure rate measurements at the New Betatron Building are shown in Figs. 16 and 17. Outdoor gamma exposure rates near the building generally ranged from 8 to 17 μR/h. Surface gamma levels at soil sampling locations measured 17, 19, and 21 μR/h. Indoor rates ranged from 6 to 11 μR/h except in the area on top of the filled shield wall where gamma levels reached 22 μR/h (Fig. 16). Gamma exposure rates on the roof were generally around 6 μR/h, but roof areas directly over the filled shield wall ranged from 8 to 13 μR/h (Fig. 17). Most gamma levels were near typical background levels of 7 to 11 μR/h in the Granite City area (Table 2). The slight elevations in outdoor gamma levels are probably due to naturally occurring radioactive substances present in coal ash and cinders present in the fill material surrounding the building. The slight elevations in gamma levels on the roof and on the shield wall can be attributed to naturally occurring radioactive substances present in concrete, cinders, and other such materials used in construction of the shield wall. All exposure rates were below the DOE indoor guideline of 20 μR/h above background (Table 1).

DIRECT AND REMOVABLE ALPHA RADIOACTIVITY LEVELS

Direct alpha activity was measured at 13 locations on the roof and 9 locations inside the building. Locations of the roof measurements are shown on Fig. 17 and results are given in Table 3 (T2–T8 and T16–T21). Directly measured alpha activity on the roof ranged from <25* to 320 dpm/100 cm^2, well below the applicable guideline for uranium (Table 1). Locations of indoor alpha activity measurements are shown on Fig. 18. Results of seven measurements are given in Table 3 (T9–T15) and two additional measurements are shown on Fig. 18. Directly measured alpha activity levels indoors ranged from <25 (Table 3) to 49 dpm/100 cm^2 (Fig. 18), well below the applicable guideline for uranium (Table 1).

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*The instrument-specific minimum detectable activities (MDAs) for directly measured and removable alpha radiation levels are 25 and 10 dpm/100 cm^2, respectively. For directly measured and removable beta-gamma radiation levels the MDAs are 0.01 mrad/h and 200 dpm/100 cm^2, respectively.

After recording the direct alpha activity levels, 13 locations on the roof and 7 locations inside the building were smeared to determine if removable activity was present. Results from all smear analysis (Table 3, Removable alpha activity) were below the instrument-specific MDA*.

DIRECT AND REMOVABLE BETA-GAMMA RADIOACTIVITY LEVELS

Beta-gamma dose rates were measured at 13 locations on the roof and 11 locations inside the building. Locations of the roof measurements and interior measurements are shown in Figs. 17 and 18, respectively. Results are given in Table 3 with four additional measurements shown on Fig. 18. Beta-gamma dose rates ranged from 0.01 (Fig. 18) to 0.07 mrad/h (Table 3), well below the guideline value of 0.2 mrad/h (Table 1). Smear analysis showed that removable beta-gamma activity at 13 locations on the roof and 7 locations inside the building was below the instrument-specific MDA* (Table 3, Removable beta-gamma activity).

SOIL AND SHIELD-WALL FILL MATERIAL SAMPLES

Radionuclide analysis was performed on soil and shield-wall samples collected at locations indicated in Fig. 18 (B). Results of analysis are listed in Table 4 (B). Concentrations of ^{226}Ra, ^{232}Th, and ^{238}U in soil and shield material ranged from 3.6 to 8.1 pCi/g, from 0.82 to 1.4 pCi/g, and from 6.1 to 13 pCi/g, respectively. All ^{232}Th levels were near typical background concentrations found in the Granite City area (Table 2) and below DOE guidelines of 5 pCi/g (Table 1). Concentrations of ^{238}U and ^{226}Ra were above typical background concentrations found in the Granite City area (Table 2), but, in all cases, these two radionuclides were in equilibrium, indicating that the sample material was of natural origin and not related to former AEC-sponsored activities at this site. Although no ^{238}U guidelines have been derived for this site, ^{238}U levels were below guidelines of 35 to 40 pCi/g applied at other FUSRAP sites (Table 1).

DEBRIS SAMPLES

Radionuclide analysis was performed on two debris samples collected at locations indicated in Fig. 18 (M). Results of analysis are listed in Table 4 (M). Concentrations of ^{226}Ra, ^{232}Th, and ^{238}U in sample M2 collected from a crack along the railroad track were 2.2, 0.56, and 3.0 pCi/g, respectively, well within the expected range. Sample M1, collected at a small (~8-in.^{2}) elevated spot (0.1 mrad/h) on a horizontal beam along the southeast wall of the building (Figs. 10 and 18), contained 33 pCi/g ^{226}Ra, 5.6 pCi/g ^{232}Th, and 27 pCi/g ^{238}U. When the counting error (±5) of the uranium analysis is included, ^{226}Ra and ^{238}U appear to be in equilibrium, indicating that the debris is of natural origin and not related to former AEC-sponsored activities at this site.

SIGNIFICANCE OF FINDINGS

Radionuclide analysis of soil, shield-wall fill material, debris, and analysis of smear samples collected at the New Betatron Building, Granite City Steel facility, Granite City, Illinois, showed no residual ^{238}U attributable to former AEC-supported operations at this site. None of the indoor or outdoor gamma exposure rate measurements were elevated above DOE guidelines. The slight elevations in gamma levels found outdoors and on the roof over the shield wall are typical of naturally occurring radioactive substances present in coal ash, cinders, concrete, and other such materials found in these areas. The slight elevations of gamma levels found in soil samples can be attributed to the presence of naturally occurring radionuclides. In all samples, ^{226}Ra and ^{238}U appeared to be in equilibrium, indicating that these radionuclides were of natural origin and not derived from former AEC-sponsored activities at this site.

REFERENCES

1. J. J. Fiore, U.S. Department of Energy, Washington, DC, letter (with attachments) to C. Cannon, Granite City Steel Company, Granite City, Illinois, June 1988.

2. DOE Order 5400.5, Radiation Protection of the Public and the Environment, April 1990.

3. W. D. Cottrell and R. F. Carrier, *Results of the Radiological Survey at the Granite City Steel Facility, Granite City, Illinois*, ORNL/RASA-89/10, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., July 1990.

4. T. E. Myrick, B. A. Berven, W. D. Cottrell, W. A. Goldsmith, and F. F. Haywood, *Procedures Manual for the ORNL Radiological Survey Activities (RASA) Program*, ORNL/TM-8600, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., April 1987.

Fig. 1. General location of Granite City, Illinois.

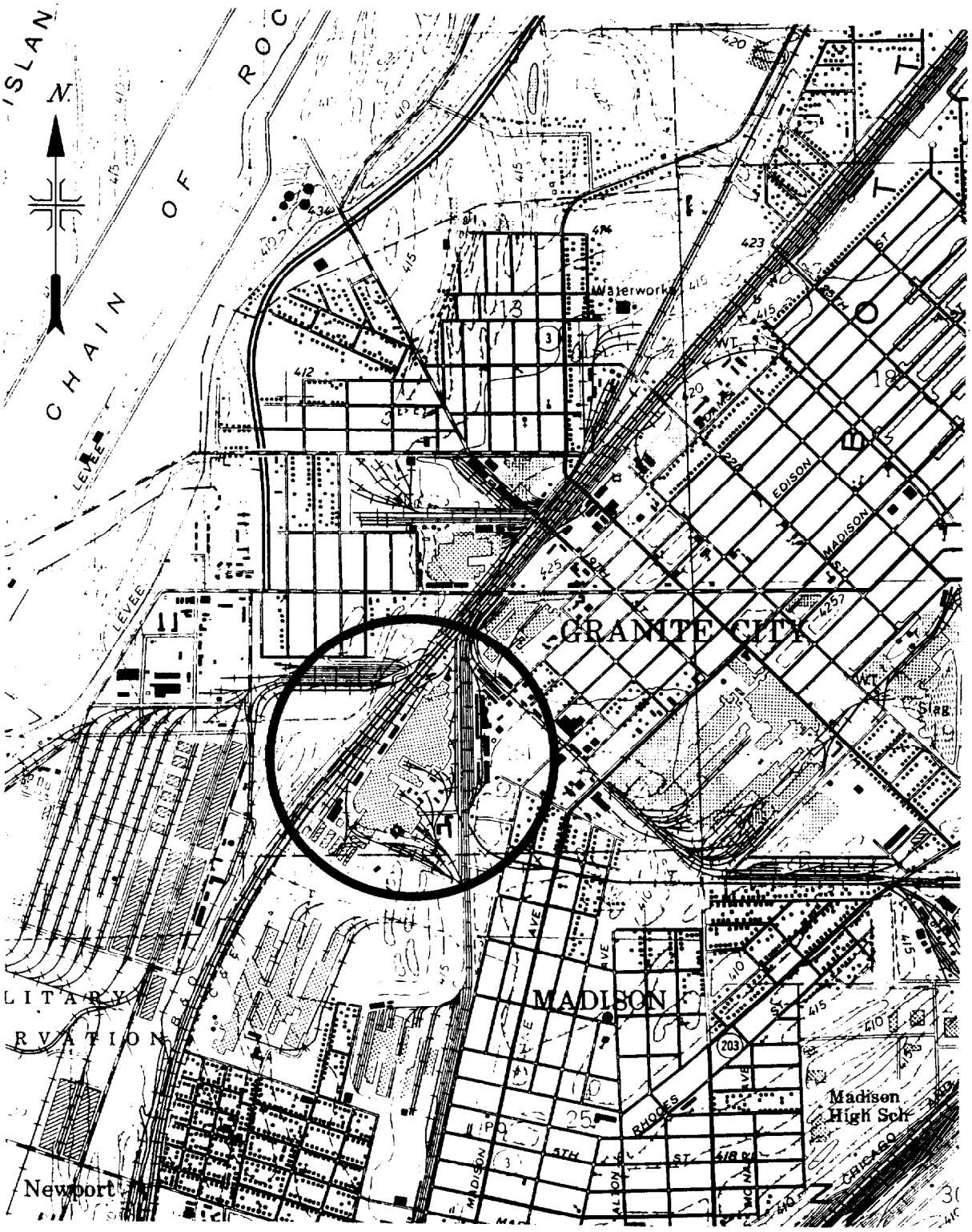

Fig. 2. General location of the South Plant facility, Granite City Steel Division, Granite City, Illinois. *Source*: "Granite City, Ill.- Mo." (topographic), N3837.5–W9007.5/7.5, AMS 2961 II NW–Series V863, U.S. Geological Survey, Reston, VA, 1974.

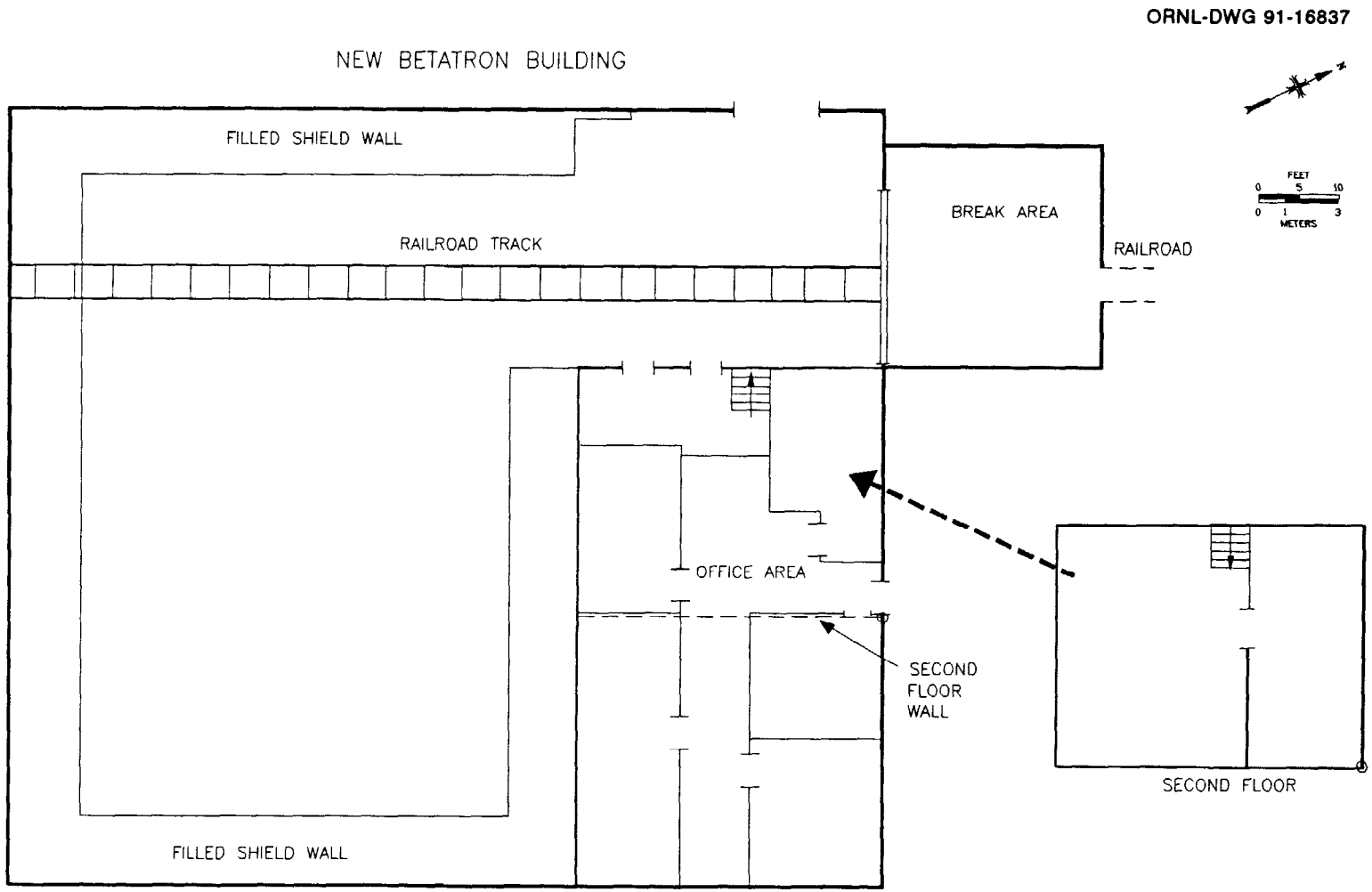

Fig. 3. Diagram of the New Betatron Building, Granite City Steel facility, Granite City, Illinois.

ORNL-PHOTO 11551-91

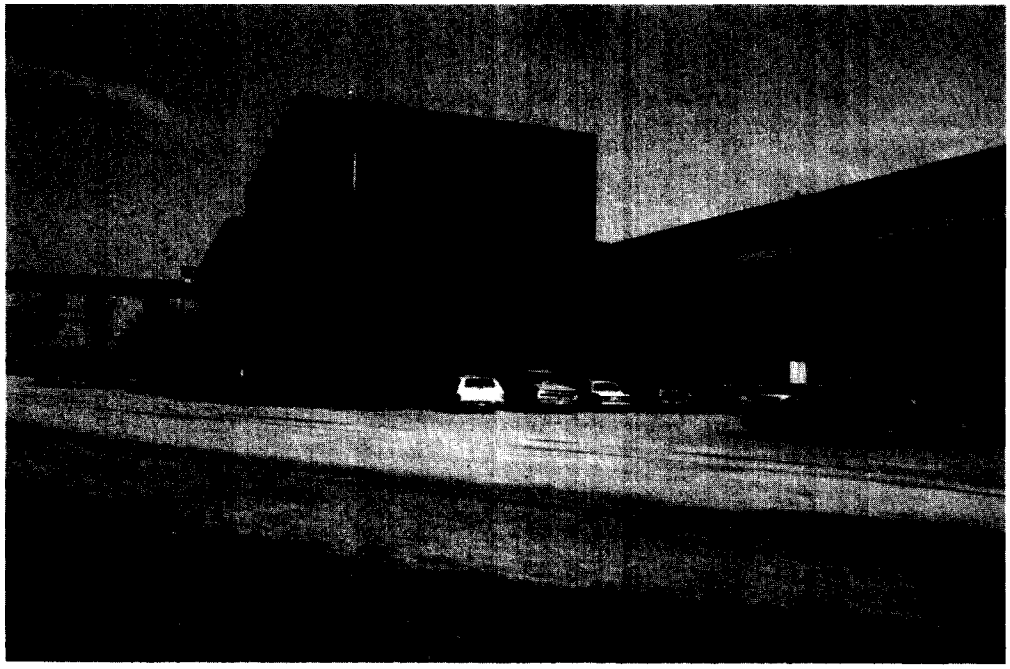

Fig. 4. View looking north northwest at the New Betatron Building, Granite City Steel facility, Granite City, Illinois. Second floor rooms are shown at the far right of the photograph.

ORNL-PHOTO 11552-91

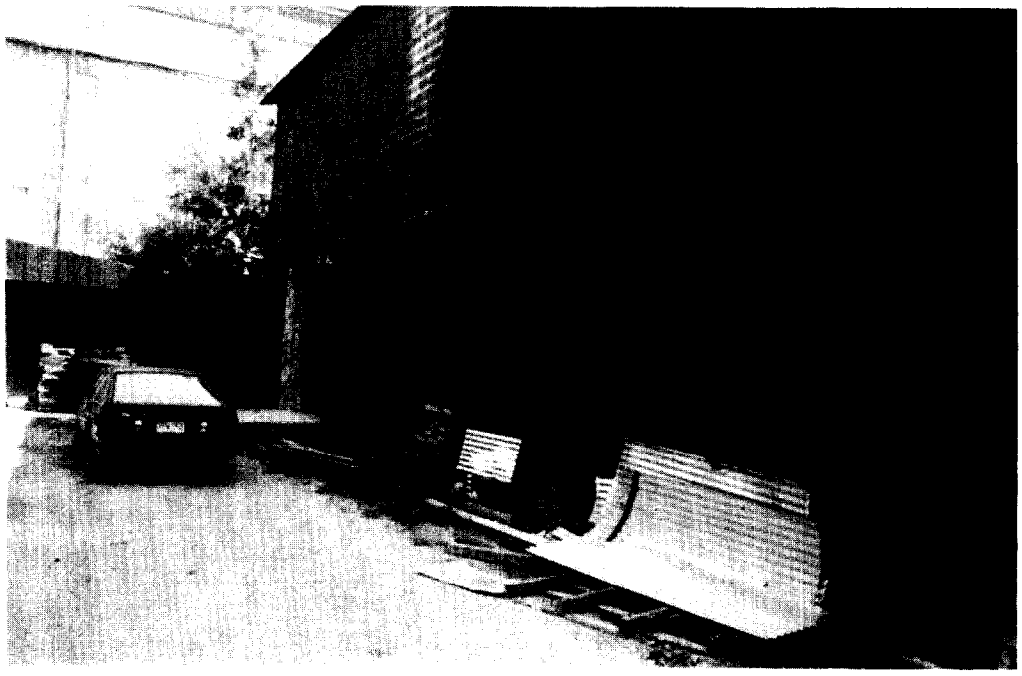

Fig. 5. View looking east at entrance to the New Betatron Building, Granite City Steel facility, Granite City, Illinois.

ORNL-PHOTO 11553-91

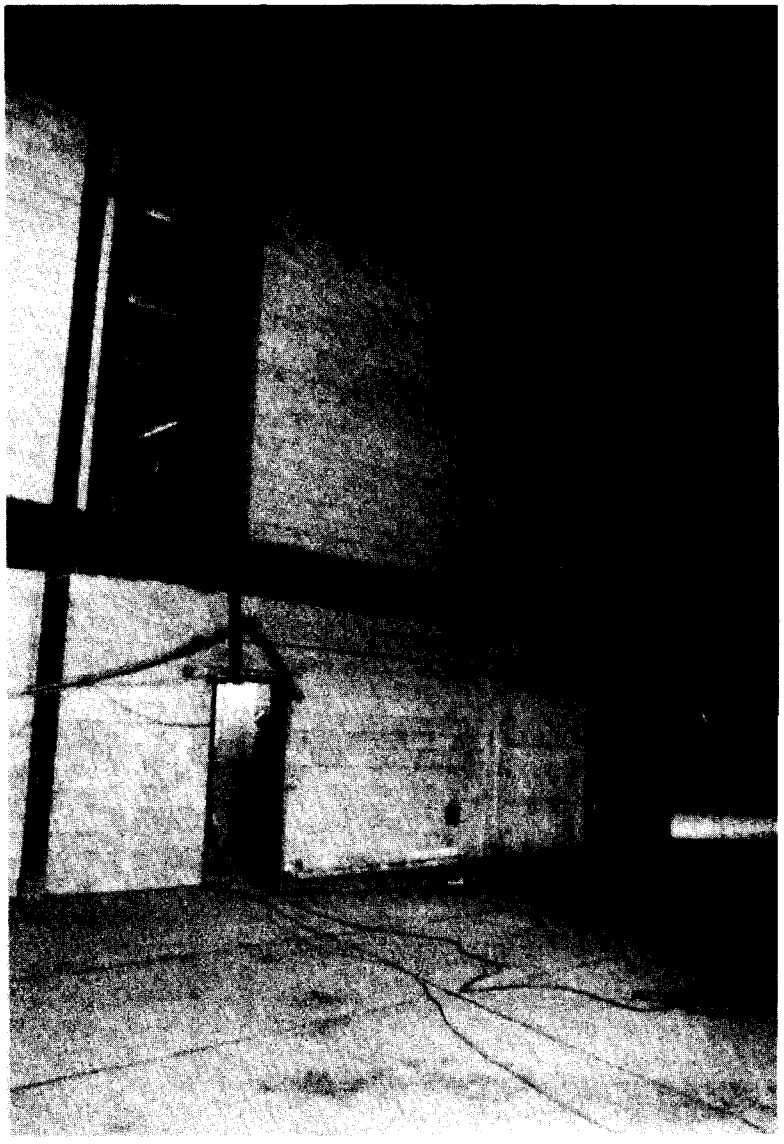

Fig. 6. View looking south at entrance to interior rooms.

ORNL-PHOTO 11554-91

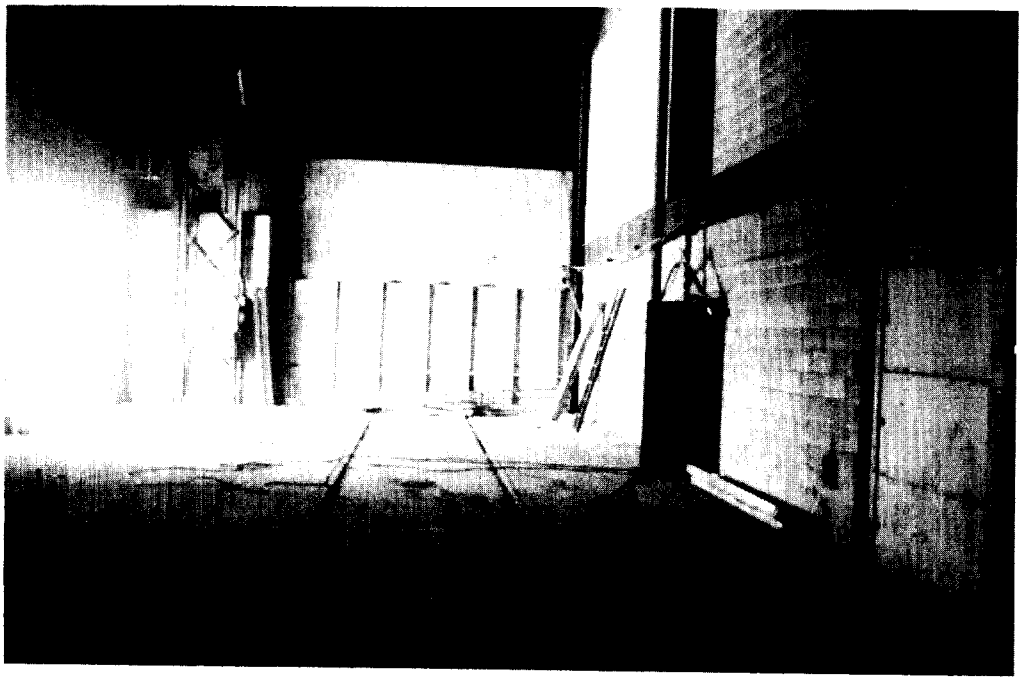

Fig. 7. View looking northeast inside New Betatron Building with main entrance at left of photograph.

ORNL-PHOTO 11555-91

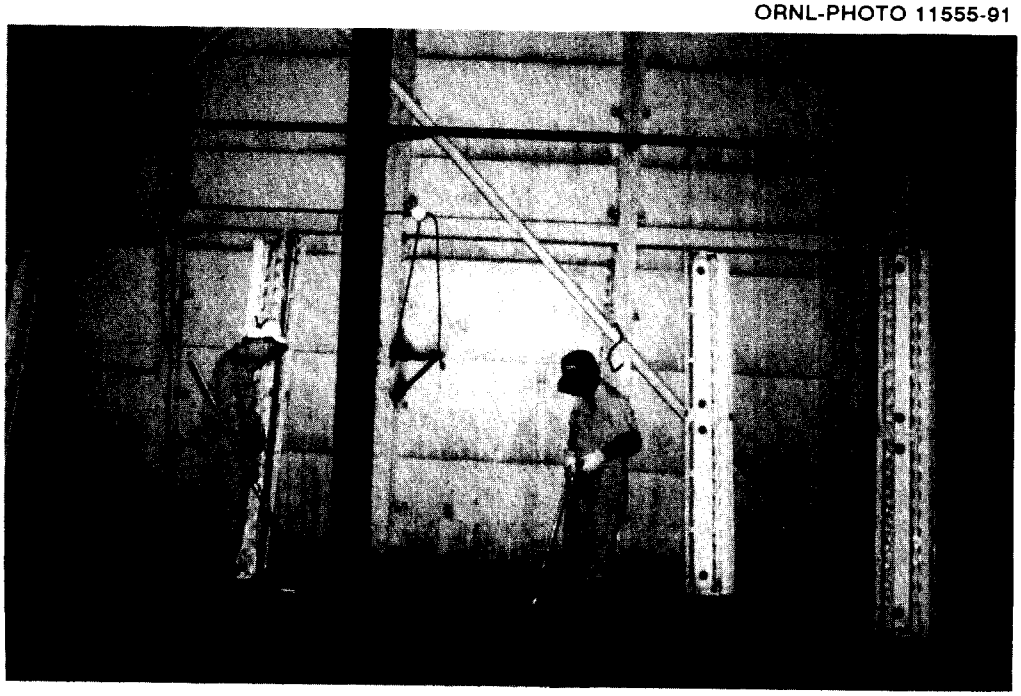

Fig. 8. View of northwest wall in the New Betatron Building, Granite City Steel facility.

ORNL-PHOTO 11556-91

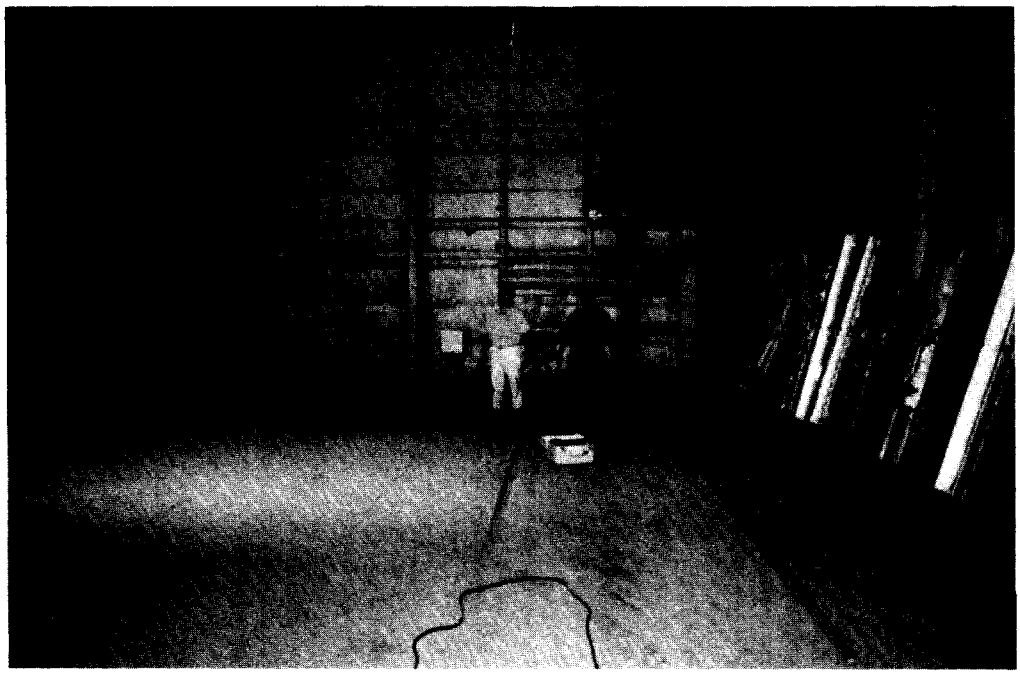

Fig. 9. View looking southwest inside the New Betatron Building, Granite City Steel facility.

ORNL-PHOTO 11557-91

Fig. 10. View looking at southeast wall from the railroad track. Arrow denotes sample location M1.

ORNL-PHOTO 11558-91

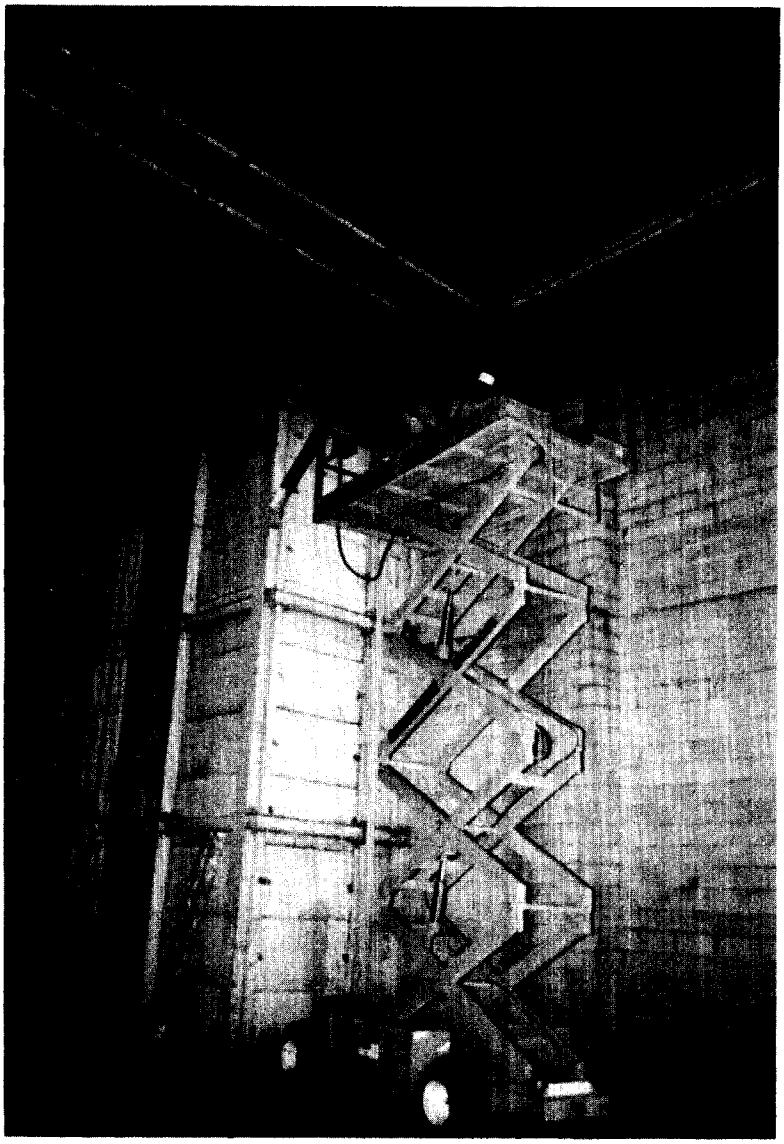

Fig. 11. View looking west at scissors lift used to access top of shield wall and upper-level horizontal beams.

ORNL-PHOTO 11559-91

Fig. 12. View of top of shield wall from scissors lift.

ORNL-PHOTO 11560-91

Fig. 13. View on top of shield wall looking southeast.

ORNL-PHOTO 11561-91

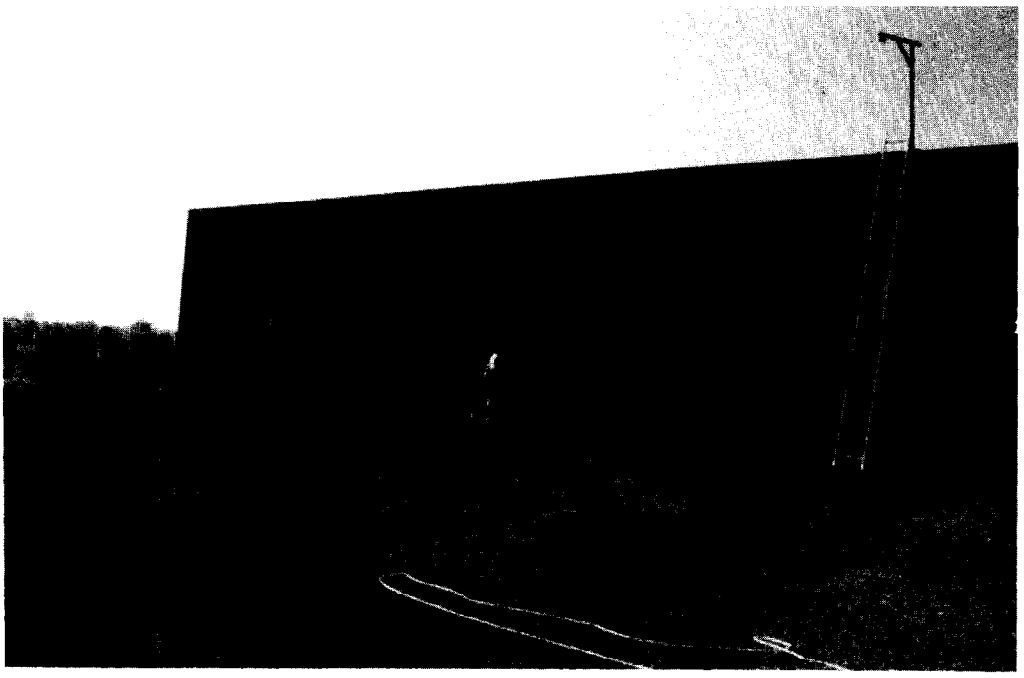

Fig. 14. View looking south at vent 4 on flat roof above second floor rooms. Ladder at right was used to access top of building.

ORNL-PHOTO 11562-91

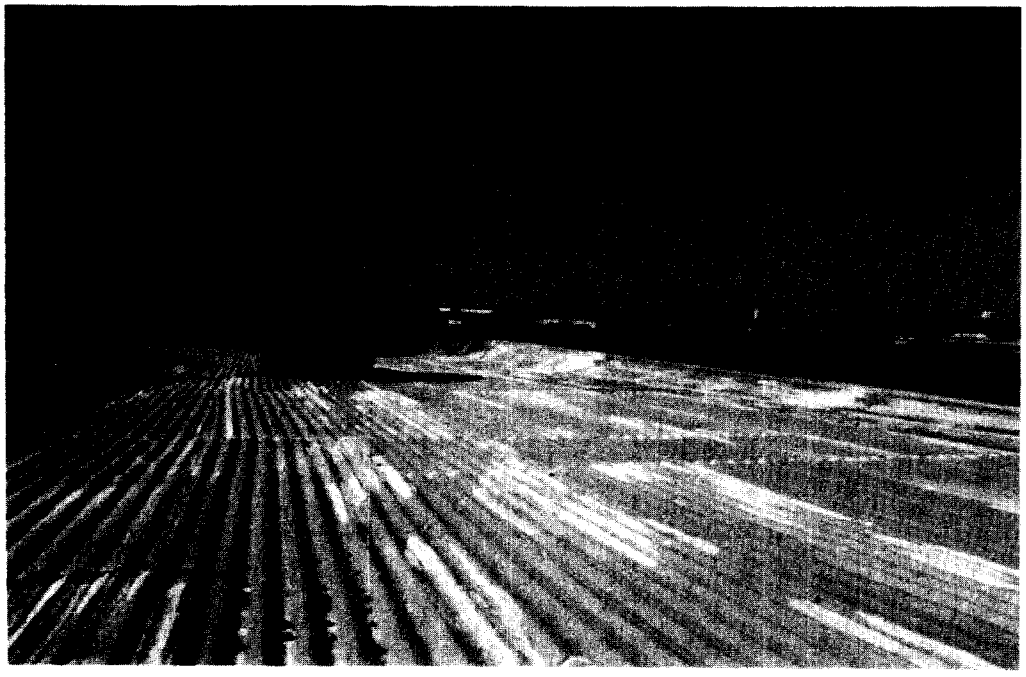

Fig. 15. View on top of New Betatron Building looking west at air vent 1.

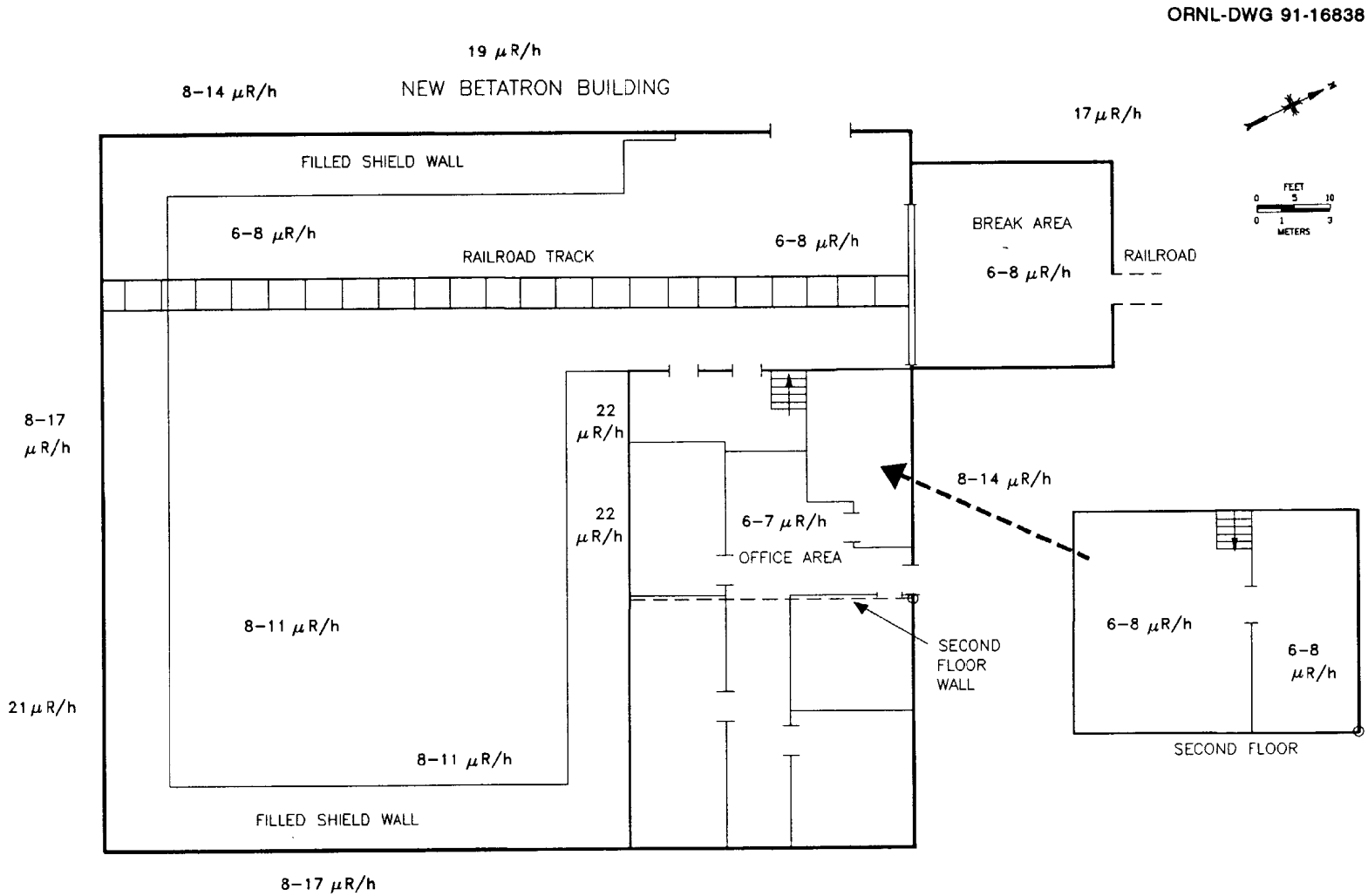

Fig. 16. Gamma exposure rates at the New Betatron Building, Granite City Steel facility, Granite City, Illinois.

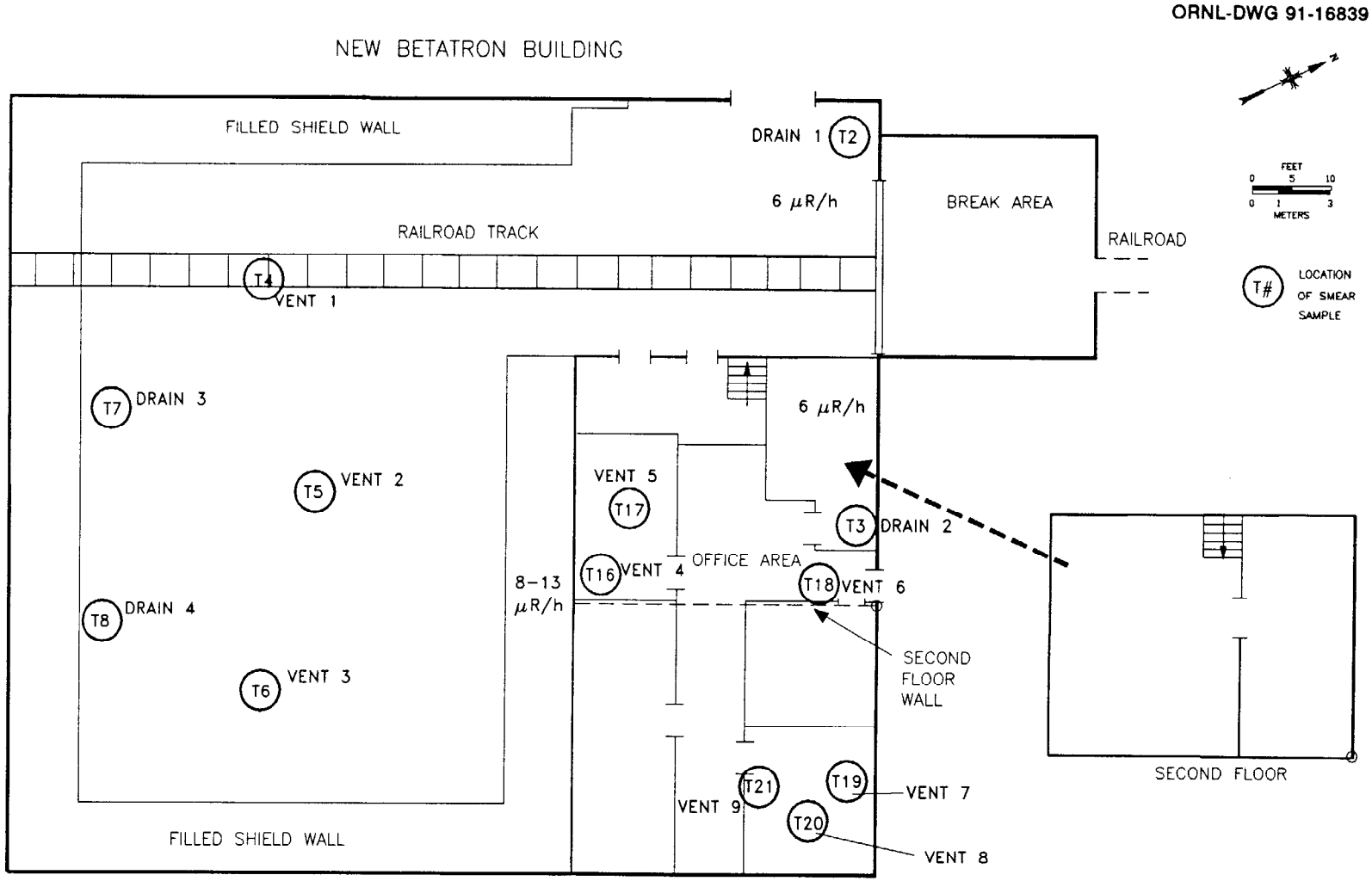

Fig. 17. Sample locations and results of the surface gamma scan on the roof at the New Betatron Building.

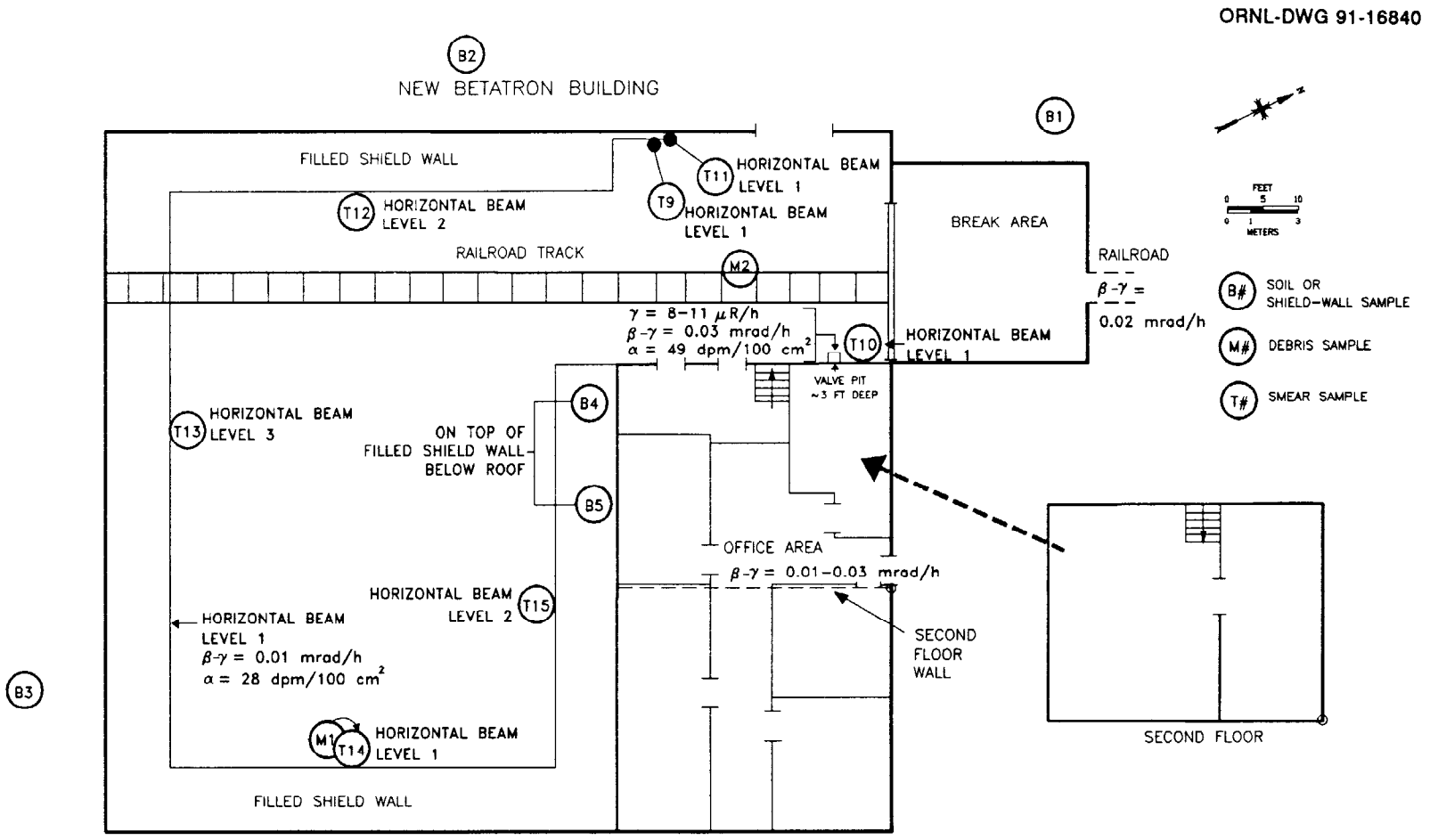

Fig. 18. Sample locations and results of alpha (α), beta-gamma (β-γ), and gamma (γ) measurements at selected locations inside the New Betatron Building.

Table 1. Applicable guidelines for protection against radiation
(Limits for uncontrolled areas)

Mode of exposure	Exposure conditions	Guideline value
Gamma radiation	Indoor gamma radiation level (above background)	20 μR/h[a]
Total residual surface contamination[b]	^{238}U, ^{235}U, U-natural (alpha emitters)	
	or	
	Beta-gamma emitters[c]	
	Maximum	15,000 dpm/100 cm^2
	Average	5,000 dpm/100 cm^2
	Removable	1,000 dpm/100 cm^2
	^{232}Th, Th-natural (alpha emitters)	
	or	
	^{90}Sr (beta-gamma emitter)	
	Maximum	3,000 dpm/100 cm^2
	Average	1,000 dpm/100 cm^2
	Removable	200 dpm/100 cm^2
	^{226}Ra, ^{230}Th, transuranics	
	Maximum	300 dpm/100 cm^2
	Average	100 dpm/100 cm^2
	Removable	20 dpm/100 cm^2
Beta-gamma dose rates	Surface dose rate averaged over not more than 1 m^2	0.20 mrad/h
	Maximum dose rate in any 100-cm^2 area	1.0 mrad/h
Radionuclide concentrations in soil (generic)	Maximum permissible concentration of the following radionuclides in soil above background levels, averaged over a 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
	^{226}Ra	
	^{232}Th	
	^{230}Th	

Table 1 (continued)

Mode of Exposure	Exposure conditions	Guideline value
Derived concentrations	^{238}U	Site specific[d]

[a]The 20 μR/h shall comply with the basic dose limit (100 mrem/year) when an appropriate-use scenario is considered.

[b]DOE surface contamination guidelines are consistent with *NRC Guidelines for Decontamination at Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for By-Product, Source, or Special Nuclear Material*, May 1987.

[c]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, ^{129}I, ^{126}I, ^{125}I.

[d]DOE guidelines for uranium are derived on a site-specific basis. Guidelines of 35–40 pCi/g have been applied at other FUSRAP sites. *Source:* J. L. Marley and R. F. Carrier, *Results of the Radiological Survey at 4 Elmhurst Avenue, Colonie, New York (AL219)*, ORNL/RASA-87/117, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., February 1988; B. A. Berven et al., *Radiological Survey of the Former Kellex Research Facility, Jersey City, New Jersey*, DOE/EV-0005/29, ORNL-5734, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., February 1982.

Sources: Adapted from U.S. Department of Energy, DOE Order 5400.5, April 1990, and U.S. Department of Energy, *Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites*, Rev. 2, March 1987.

Table 2. Background radiation levels for the Granite City, Illinois, area

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

[a]Exposure rate determined from 3 to 4 measurements at each of 3 locations.

[b]Data collected from 3 sampling locations.

[c]Data collected from 2 sampling locations.

Source: T. E. Myrick, B. A. Berven, and F. F. Haywood, *State Background Radiation Levels: Results of Measurements Taken During 1975–1979*, ORNL/TM-7343, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., November 1981.

Table 3. Alpha and beta-gamma measurements at the New Betatron Building, Granite City Steel facility, 1417 State Street, Granite City, Illinois

Sample[a]	Directly measured radioactivity		Removable radioactivity[d]		Location
	Alpha[b] (dpm/100 cm^2)	Beta-gamma[c] (mrad/h)	Alpha[e] (dpm/100 cm^2)	Beta-gamma[f] (dpm/100 cm^2)	
T2	49	0.03	<10	<200	Roof drain 1
T3	91	0.03	<10	<200	Roof drain 2
T4	<25	0.02	<10	<200	Roof vent 1
T5	42	0.02	<10	<200	Roof vent 2
T6	<25	0.02	<10	<200	Roof vent 3
T7	56	0.02	<10	<200	Roof drain 3
T8	77	0.02	<10	<200	Roof drain 4
T9	<25	0.02	<10	<200	Horizontal beam, level 1
T10	<25	0.02	<10	<200	Horizontal beam, level 1
T11	35	0.02	<10	<200	Horizontal beam, level 1
T12	<25	0.02	<10	<200	Horizontal beam, level 2
T13	28	0.02	<10	<200	Horizontal beam, level 3
T14	<25	0.07	<10	<200	Horizontal beam, level 1
T15	<25	0.03	<10	<200	Horizontal beam, level 2
T16	121	0.02	<10	<200	Roof vent 4

Table 3 (continued)

Sample[a]	Directly measured radioactivity		Removable radioactivity[d]		Location
	Alpha[b] (dpm/100 cm^2)	Beta-gamma[c] (mrad/h)	Alpha[e] (dpm/100 cm^2)	Beta-gamma[f] (dpm/100 cm^2)	
T17	77	0.03	<10	<200	Roof vent 5
T18	154	0.03	<10	<200	Roof vent 6
T19	<25	0.03	<10	<200	Roof vent 7
T20	320	0.03	<10	<200	Roof vent 8
T21	<25	0.02	<10	<200	Roof vent 9

[a]Sample locations on the roof (T2–T8 and T16–T21) are shown on Fig. 17; indoor sample locations (T9–T15) are shown on Fig. 18.

[b]Instrument-specific minimum detectable activity (MDA) level = 25 dpm/100 cm^2.

[c]MDA = 0.01 mrad/h.

[d]Removable radioactivity reported as net disintegration rates. Background radiation levels have been subtracted.

[e]MDA = 10 dpm/100 cm^2.

[f]MDA = 200 dpm/100 cm^2.

Table 4. Concentrations of radionuclides in soil and debris samples collected at the New Betatron Building, Granite City Steel facility, 1417 State Street, Granite City, Illinois

Sample[a]	Depth (cm)	Gamma exposure rate (μR/h)		Radionuclide concentration (pCi/g dry wt)[c]					Comments
		Surface	15 cm[b]	^{210}Pb	^{226}Ra	^{232}Th	^{238}U	^{235}U	
B1	0–15	17	34	9.7 ± 1	6.7 ± 0.1	1.3 ± 0.2	9.0 ± 1	<1.2	Soil[d] sample, north
B2	0–15	19	42	4.6 ± 1	3.6 ± 0.08	0.82 ± 0.08	6.1 ± 1	<0.35	Soil[d] sample, west
B3	0–15	21	42	6.4 ± 0.8	7.1 ± 0.2	1.1 ± 0.2	7.6 ± 0.9	<2.0	Soil[d] sample, south
B4	0–15	22	*e*	10 ± 2	8.1 ± 0.1	1.4 ± 0.1	13 ± 3	<0.26	Shield-wall material from top of shield wall
B5	0–15	22	*e*	7.3 ± 1	7.2 ± 0.1	1.3 ± 0.1	8.4 ± 1	0.19 ± 0.2	Shield-wall material from top of shield wall, beta-gamma=0.06 mrad/h
M1	*f*	*g*	*f*	17 ± 3	33 ± 0.6	5.6 ± 0.3	27 ± 5	1.7 ± 0.6	Debris on beam, beta-gamma=0.1 mrad/h
M2	0–6	7	4[h]	2.6 ± 0.6	2.2 ± 0.08	0.56 ± 0.1	3.0 ± 0.6	<0.16	Debris in crack along railroad track

[a]Sample locations are shown on Fig. 18.
[b]Depth of 15 cm.
[c]Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).
[d]Soil appeared to be fill material containing coal ash and/or cinders.
[e]Not measured.
[f]Not applicable.
[g]None above background.
[h]Depth of 6 cm.

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