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Results of the Radiological Survey at the Former McKinney Tool and Manufacturing Company, 1688 Arabella Road, Cleveland, Ohio (MTC001 and MTC002)

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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 site of the former McKinney Tool and Manufacturing Company, 1688 Arabella Road, Cleveland, Ohio. The survey was performed on November 17 and 18, 1990. 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 Manhattan Engineer District in 1944. The survey included a gamma scan, a beta-gamma scan, and measurement of alpha levels; measurement of direct and removable alpha and beta-gamma levels; and the collection of soil and sediment, dust, and air samples for radionuclide analyses. The survey and sampling covered accessible areas of buildings currently occupied by Parker Rust-Proof and Meistermatic, Inc., and exterior areas immediately adjacent to these buildings.

Results of the survey demonstrated no radionuclide concentrations or radiation measurements in excess of the DOE Formerly Utilized Sites Remedial Action Program guidelines for uranium. The radionuclide distributions were not significantly different from typical background levels in the Cleveland, Ohio, area.

Results of the Radiological Survey at the Former McKinney Tool and Manufacturing Company, 1688 Arabella Road, Cleveland, Ohio (MTC001 and MTC002)*

INTRODUCTION

In the early 1940s, the Manhattan Engineer District (MED) was established as the lead agency in the development of nuclear energy for defense-related projects. Raw materials containing uranium ores were procured, stored, and processed into various uranium oxides, salts, and metals. Fabricators were contracted as needed to form (roll and machine) the metal into various shapes. At contract termination, sites used by contractors were decontaminated according to the criteria and health guidelines in use at that time. In some instances, however, documentation was limited and insufficient to establish the current radiological conditions at a site. Therefore, it was necessary to reevaluate the current radiological conditions at these sites under the U.S. Department of Energy (DOE) Formerly Utilized Sites Remedial Action Program (FUSRAP).

McKinney Tool and Manufacturing Company was one of four commercial metal fabricators engaged by DuPont, a MED prime contractor, to fabricate a special order of 48,000 unbonded uranium slugs required for use in the Hanford Reactor. Work performed by McKinney, which began in May or June 1944 under Purchase Order RPG-4021 1/2, included machining and finishing slugs from uranium metal rod supplied by DuPont. The slugs were machined and rough-turned, then finished to specifications on a centerless grinder provided by DuPont. Upon completion of the order, this grinder was apparently shipped to Hanford for use in the Hanford Engineer Works production facility.

The quantity of uranium metal handled and the specific period of performance under the purchase order are unknown. However, a design and procurement history[1] prepared by DuPont indicates that these orders were all performed on a 24-hour-per-day basis in less than 3 months. A comparison of the costs associated with the four purchase orders indicates that approximately half the total 48,000-slug requirement was probably produced at the McKinney facility. No record of the radiological status of the building at the completion of the uranium metal fabrication work for DuPont has been found.

The building where the work for DuPont was conducted, is located at 1688 Arabella Road, Cleveland, Ohio. The McKinney estate sold the equipment at auction and the building to KCF Properties. The south section of the building was subsequently sold to the president of Parker Rust-Proof. The north section of the building was sold to Meistermatic, Inc. Parker Rust-Proof uses its space for applying a protective phosphate coating to metal fittings, such as bolts and nuts. Meistermatic runs a metal-machining operation.

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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.

On April 9, 1981, a preliminary radiological survey, sponsored by the Department of Energy (DOE), was conducted in the building. At this time, extensive renovation and remodeling had been accomplished in the area where the uranium metal machining and grinding work was done. The walls of the ~25- by 30-ft room where the uranium work was performed had been removed. Most of the original machinery had been sold at auction, and only a small heat-treating oven remained on the premises.

The Parker Rust-Proof building was constructed of brick and concrete-block walls, concrete flooring, and steel beams for roof support. In the upper areas of the building were windowed clerestories constructed of wood. The roof sheathing appeared to be 2- × 6-in. tongue and groove covered with weatherproof material. The Meistermatic area was identical, including a concrete floor, a combination of brick and concrete-block walls, and the same type roof.

The Parker Rust-Proof area had undergone extensive renovations in one section. The installation of a line of degreasing and rust-proofing process tanks required digging out a large area of the concrete floor, restructuring drain areas, and adding a sewer system to collect run-off from the operation. Also, the northeast corner of the building was restructured to contain the boiler room that produced hot water and steam necessary for operation. In the Meistermatic section, it appeared that very little remodeling had been done other than adding a concrete-block wall to separate the Meistermatic and the Parker Rust-Proof area.

During the 1981 survey, approximately 10 to 15% of the floor area of the building occupied by the two tenants was surveyed. The remainder of the floor area, occupied by equipment lines and storage areas, was not accessible. Interior building wall surfaces and structural support members, particularly those that were part of the original construction, were surveyed.

General gamma radiation levels in all areas were identical to natural background, 3 to 4 μR/h. Some old brick in the load-bearing wall construction measured 6 to 7 μR/h, and glazed wall and floor tile in toilet areas measured 6 to 10 μR/h. These readings were due to natural radioactivity contained in the brick and tile.

Although this preliminary survey indicated no residual radioactive material above current guidelines, there was insufficient information to recommend eliminating this site from FUSRAP. Therefore, a radiological survey of the property was scheduled.

On November 17 and 18, 1990, a radiological survey was conducted at the former McKinney Tool and Manufacturing Company by members of the Measurement Applications and Development Group of the Oak Ridge National Laboratory (ORNL) at the request of DOE. The survey and sampling at this site (Fig. 1) covered selected areas outdoors and accessible areas inside the buildings currently occupied by Parker Rust-Proof (Fig. 2) and Meistermatic, Inc. (Fig. 3). Survey emphasis was on the interior floors, walls, overhead beams, and ambient air. Machinery and offices were not surveyed.

SCOPE OF THE SURVEY

The radiological survey included: (1) a surface gamma scan of the floor and walls in all accessible areas inside the building, and a gamma scan of the ground surface in selected areas outdoors; (2) measurement of surface and 1-m gamma exposure rates at the center of each survey block; (3) a beta-gamma scan of dose rates in accessible areas of the floor inside the building; (4) measurement of alpha activity levels in each survey block; (5) collection of 3 air samples in the Parker area and 2 in the Meistermatic area; (6) collection of 15 dust samples from overhead beams that were part of the original building construction and 1 sample of phosphate/oxide from the chem baths; (7) measurement of direct and removable alpha and beta-gamma levels at 20 locations inside the building; (8) collection of 3 soil samples outside the building and 1 sediment sample inside.

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).[2]

To facilitate reporting of results, the support columns or beam intersections in each building were numbered 1 to 8 (Figs. 2 and 3). In addition, the Parker Rust-Proof area was further subdivided into Bay A, B, C, and D, dividing the building into a series of survey blocks. At the Parker Rust-Proof site (Fig. 2), Bay A contains 8 survey blocks: areas between beams 1 and 2, between beams 2 and 3, etc. At the Meistermatic site, the entire horizontal area between two beams is a survey block (Fig. 3).

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 in selected areas outdoors. The detector was held approximately 2 in. above the floor/ground/wall surface, and measurements were recorded and then converted to μR/h. Gamma levels were also measured at the surface and at 1 m above the floor/ground surface in the center of each survey block. 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.

Air samples were collected during time periods of 136 to 200 min and analyzed for alpha and beta activity. Dust samples were collected inside the building from overhead beams in areas where residuals may have been deposited; these samples were analyzed for ^{40}K, ^{137}Cs, ^{210}Pb, ^{226}Ra, ^{232}Th, ^{238}U, and ^{235}U. Smears were obtained from selected surfaces to establish transferable alpha and beta-gamma activity levels. Soil samples collected outdoors to depths of 15 cm and one sediment sample collected from an inside drain were analyzed for ^{40}K, ^{137}Cs, ^{210}Pb, ^{226}Ra, ^{232}Th, ^{238}U, and ^{235}U. Samples locations are shown on Figs. 4 and 5.

SURVEY RESULTS

DOE guidelines are summarized in Table 1. Typical background radiation levels for the Cleveland, Ohio, 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/sediment and dust samples. Removable radioactivity levels (smears) and activity levels in air samples are reported as net disintegrations with background subtracted.

Current photographs of the site are shown in Figs. 6–17.

GAMMA EXPOSURE RATE MEASUREMENTS

Results of gamma exposure rate measurements indoors at the Parker Rust-Proof and Meistermatic facilities are shown in Figs. 18 and 19 and in Tables 3 and 4. At the center of each survey block, gamma levels at 1 m ranged from 2 to 6 μR/h; surface exposure rates at the same points ranged from 3 to 8 μR/h. A gamma scan of accessible floor area showed extremes of 2 and 11 μR/h and an average of 5 to 6 μR/h. Scans of the walls indicated extremes of 5 and 17 μR/h. Most gamma levels were near typical background levels for the Cleveland, Ohio, area (Table 2). The slight elevations in gamma levels can be attributed to naturally occurring radioactive substances present in bricks, concrete, granite, and other such materials used in paving and building construction. All exposure rates were below the DOE indoor guideline of 20 μR/h above background (Table 1).

Gamma exposure rate measurements outdoors ranged from 9 to 11 μR/h on the lawn near the entrance to the Parker facility and along Arabella Road (Figs. 18 and 19). These levels are near typical background levels for the Cleveland, Ohio, area (Table 2). Gamma levels at soil sample locations (Table 5) ranged from 11 to 14 μR/h at the surface, from 10 to 12 μR/h at 1 m, and from 13 to 18 μR/h at a depth of 15 cm. These slight elevations in gamma levels can be attributed to the presence of ^{40}K, a naturally occurring radionuclide (see soil and sediment sample analysis results).

BETA-GAMMA AND ALPHA RADIATION MEASUREMENTS ON FLOORS

Beta-gamma dose rates measured indoors above accessible areas of the floor ranged from 0.01 to 0.03 mrad/h (Tables 3 and 4). This is well below the DOE surface dose-rate limit of 0.20 mrad/h averaged over not more than 1 m^2. Surface alpha measurements ranged from <25 to 32 dpm/100 cm^2 (Tables 3 and 4). All alpha measurements were near or below the minimum detectable activity (MDA) of 25 dpm/100 cm^2 and well below the DOE average surface contamination guideline value of 5000 dpm/100 cm^2 (Table 1).

AIR SAMPLES

The five air sample locations are denoted Z1–Z3 at Parker Rust-Proof (Fig. 4) and Z1–Z2 at Meistermatic (Fig. 5). Volume of air sampled ranged from 2.7 to 4.8 m^3. Radiological analysis of air samples for ^{238}U revealed disintegration rates below the counting equipment MDA*.

DUST SAMPLES

Fifteen dust samples from overhead beams and one sample of phosphate/oxide deposit from the chem baths were collected for radionuclide analyses. Sample locations are shown on Figs. 4 (M1–M8) and 5 (M1–M8), and anlytical results are provided in Table 6 [M1–M8 (Parker) and M1–M8 (Meistermatic)]. Concentrations of ^{40}K, ^{137}Cs, ^{210}Pb, ^{226}Ra, ^{232}Th, and ^{235}U were within expected background ranges. Concentrations of ^{238}U at the Meistermatic facility were also within the background range. Slightly elevated levels of ^{40}K and ^{238}U would normally be found in the phosphate/oxide deposit from the chem baths [M1 (Meistermatic)]. At the Parker facility, some dust samples contained slightly elevated concentrations of ^{238}U (Table 6). In order to compare results with DOE guidelines, ^{238}U concentrations ranging from 2.0 to 10 pCi/g at the Parker facility were converted to dpm/100 cm^2 (38 to 130 dpm/100 cm^2). These calculations showed that ^{238}U concentrations at the Parker facility were between 4% and 13% of the guideline of 1000 dpm/100 cm^2 for residual removable ^{238}U contamination (Table 1). All samples were well below DOE guidelines.

RADIATION MEASUREMENTS ON BEAMS

Eighteen direct alpha and beta-gamma measurements were taken on overhead beams after dust samples had been collected. Sample locations are indicated on Figs. 4 (D1–D11) and 5 (D12–D20), and results are listed in Table 7. In all cases, directly measured alpha radiation levels were near or below the MDA† of 25 dpm/100 cm^2, and directly measured beta-gamma dose rates were well below the DOE guideline of 0.20 mrad/h (Table 1). After recording the direct measurement, the area was smeared to determine if removable radioactivity was present. Results from all smear analysis (Table 7), including those collected from the chem baths and chem bath heater assembly, were below MDAs†.

SOIL AND SEDIMENT SAMPLES

Radionuclide analysis was performed on soil and sediment samples collected at locations indicated in Figs. 4 (B1, S1, and E1) and 5 (B1). Results of analysis are listed in Table 6. Concentrations of ^{226}Ra, ^{232}Th, and ^{238}U ranged from 0.43 to 1.5 pCi/g, from 0.37 to 1.4 pCi/g, and from 0.71 to 3.0 pCi/g, respectively. All samples were below DOE guidelines

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*The minimum detectable activity (MDA) corresponds to an air concentration of <4.5% of the ^{238}U guideline value in U.S. DOE Order 5400.5, February 8, 1990, via inhaled air, Y-Class.

†The instrument-specific 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.

(Table 1) and near typical background concentrations found in the Cleveland, Ohio, area (Table 2).

SIGNIFICANCE OF FINDINGS

Radionuclide analysis of soil, sediment, dust, and smear samples collected at the site of the former McKinney Tool and Manufacturing Company, 1688 Arabella Road, Cleveland, Ohio, showed no radionuclide concentrations above DOE guidelines (Table 1). None of the indoor or outdoor radiation measurements were elevated above DOE guidelines. Air samples collected in the buildings were <4.5% of applicable DOE guidelines for ^{238}U. Radionuclide concentrations in the surveyed areas (Table 3 and 4) were similar to typical background values in the Cleveland, Ohio, area (Table 2). The slight elevations in gamma levels found in some parts of the building are typical of naturally occurring radioactive substances present in bricks, concrete, granite, and other such materials used in paving and building construction. Slightly elevated concentrations of ^{238}U in dust samples from the Parker facility (Table 6) were well below the DOE guideline for residual removable ^{238}U contamination. The slight elevations of gamma levels found in soil samples can be attributed to the presence of ^{40}K (Table 6, B1), a naturally occurring radionuclide.

REFERENCES

1. E. I. DuPont DeNemours and Company, Inc., *Design and Procurement History of Hanford Engineer Works and Clinton Semi-Work*, Volume II, E. I. DuPont DeNemours and Company, Engineering Department, December 1945.

2. 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.

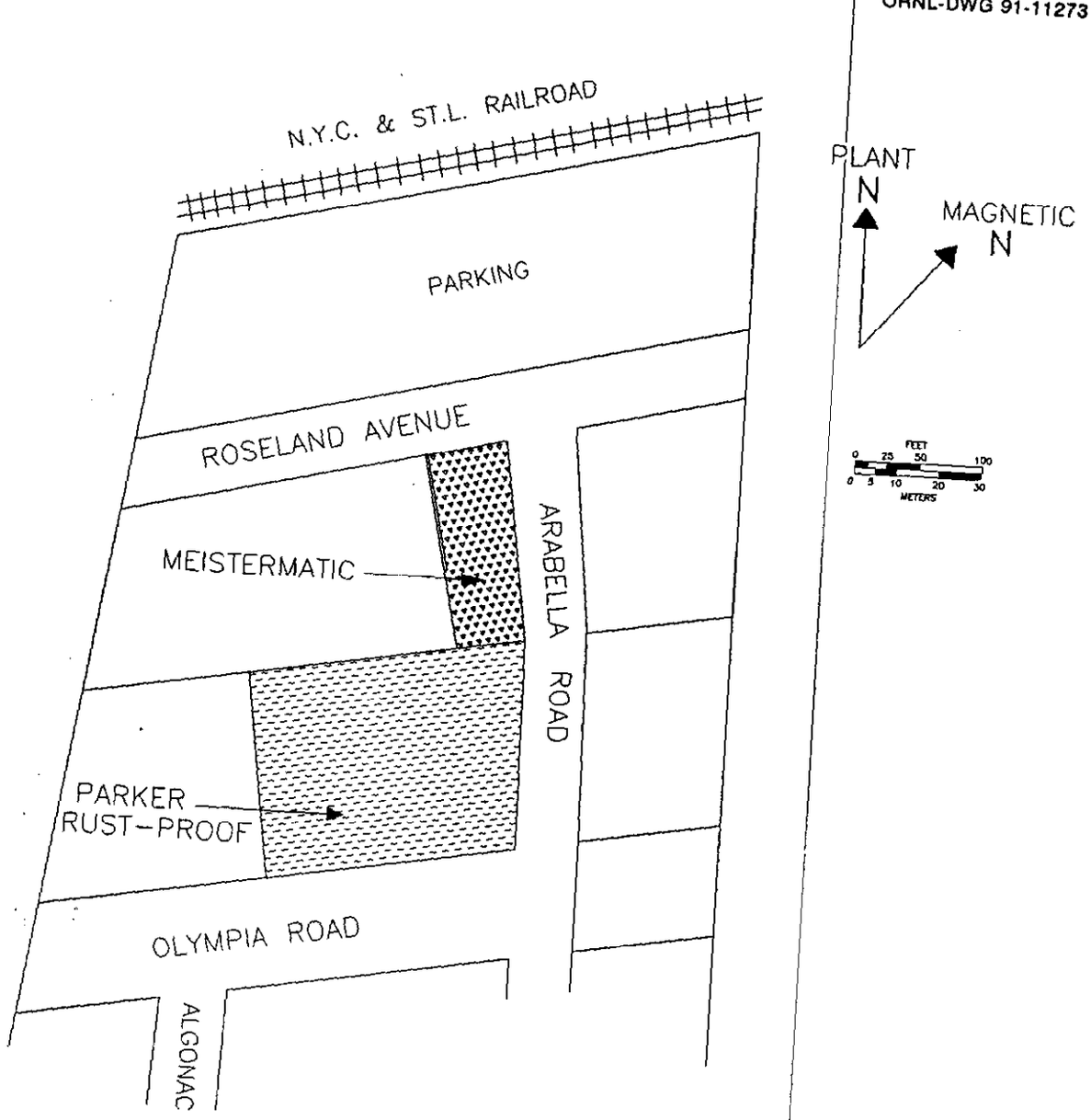

Fig. 1. Location of the former McKinney Tool and Manufacturing Company, 1688 Arabella Road, Cleveland, Ohio. Hatching indicates surveyed areas of the property currently occupied by Parker Rust-Proof and Meistermatic, Inc.

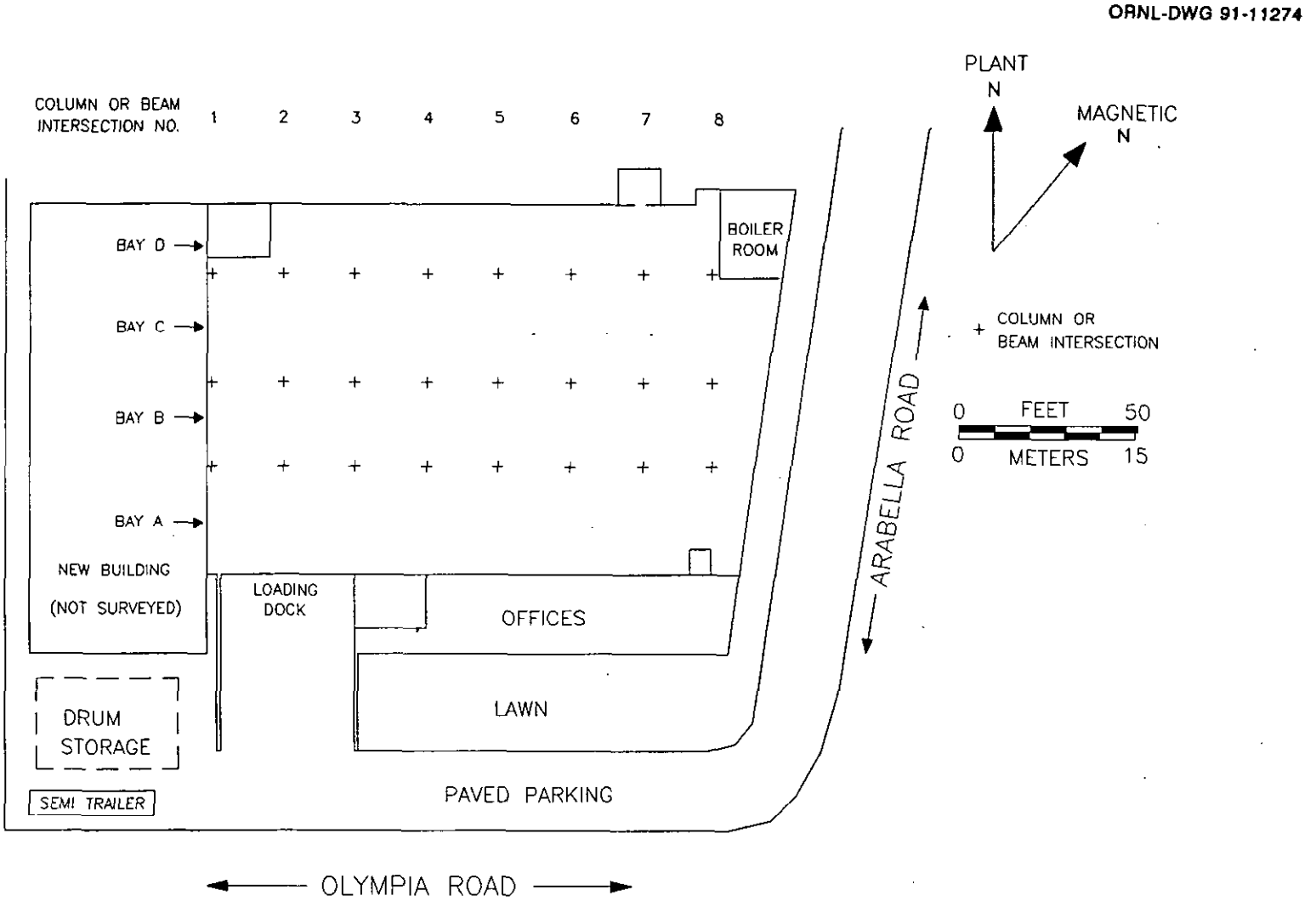

Fig. 2. Building currently occupied by Parker Rust-Proof at the site of the former McKinney Tool and Manufacturing Company. To facilitate reporting of results, the building was divided into Bays A, B, C, and D; and the columns or beam intersections were numbered 1 to 8.

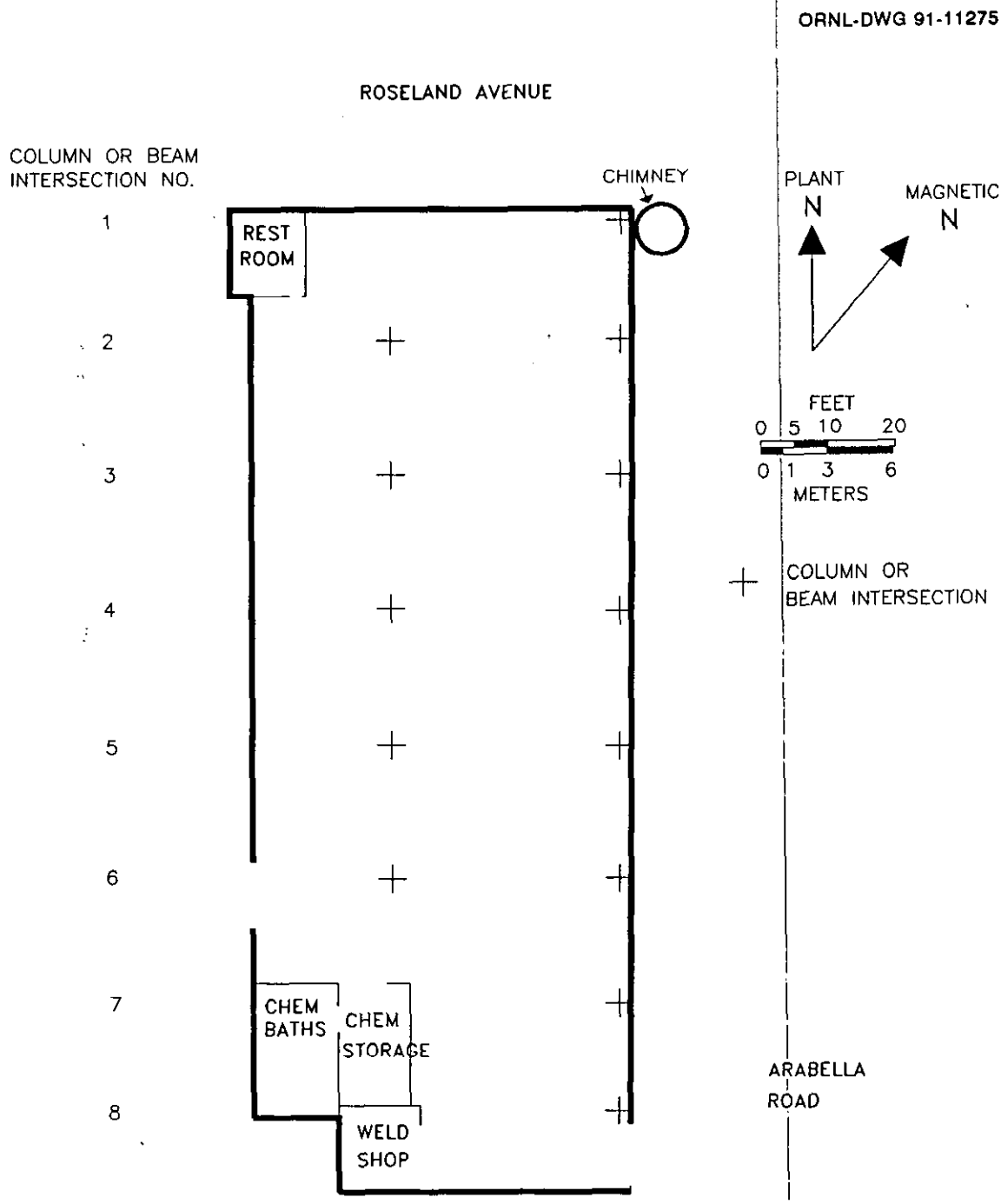

Fig. 3. Building currently occupied by Meistermatic, Inc., at the site of the former McKinney Tool and Manufacturing Company. To facilitate reporting of results, the support columns or beam intersections were numbered 1 to 8.

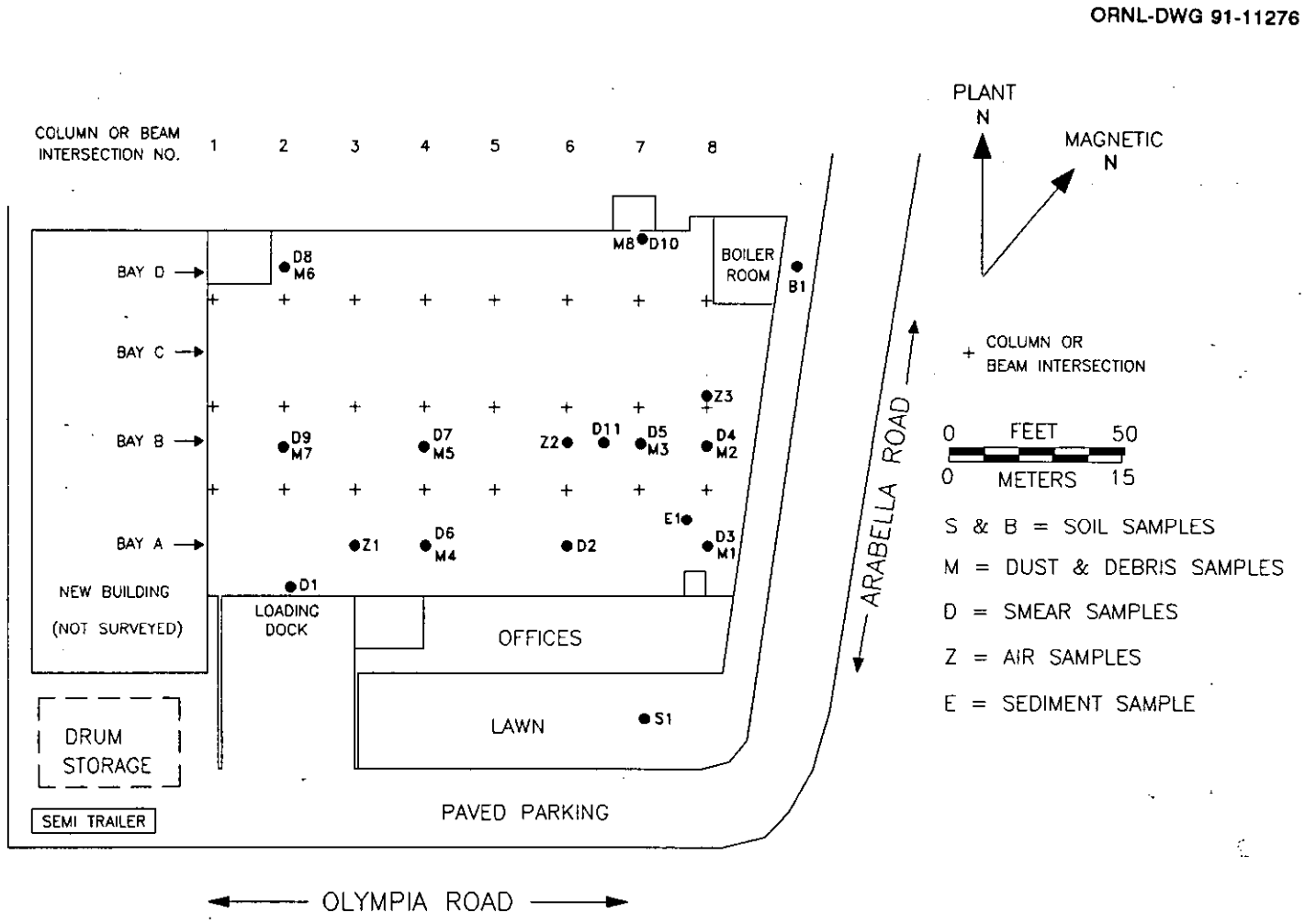

Fig. 4. Sampling locations for soil (S and B), dust (M), smears (D), air (Z), and sediment (E) at Parker Rust-Proof.

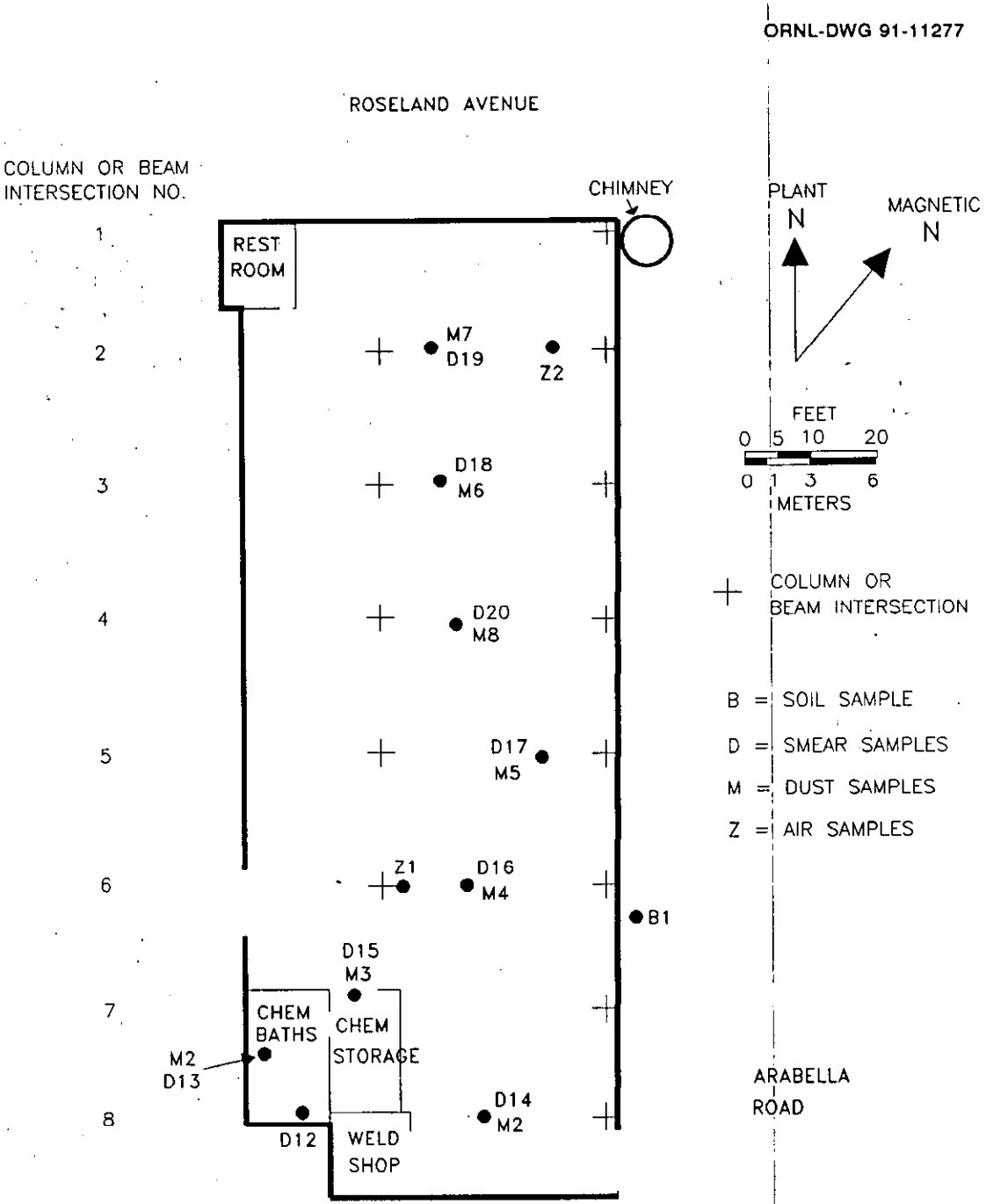

Fig. 5. Sampling locations for soil (B), smears (D), dust (M), and air (A) at Meistermatic, Inc.

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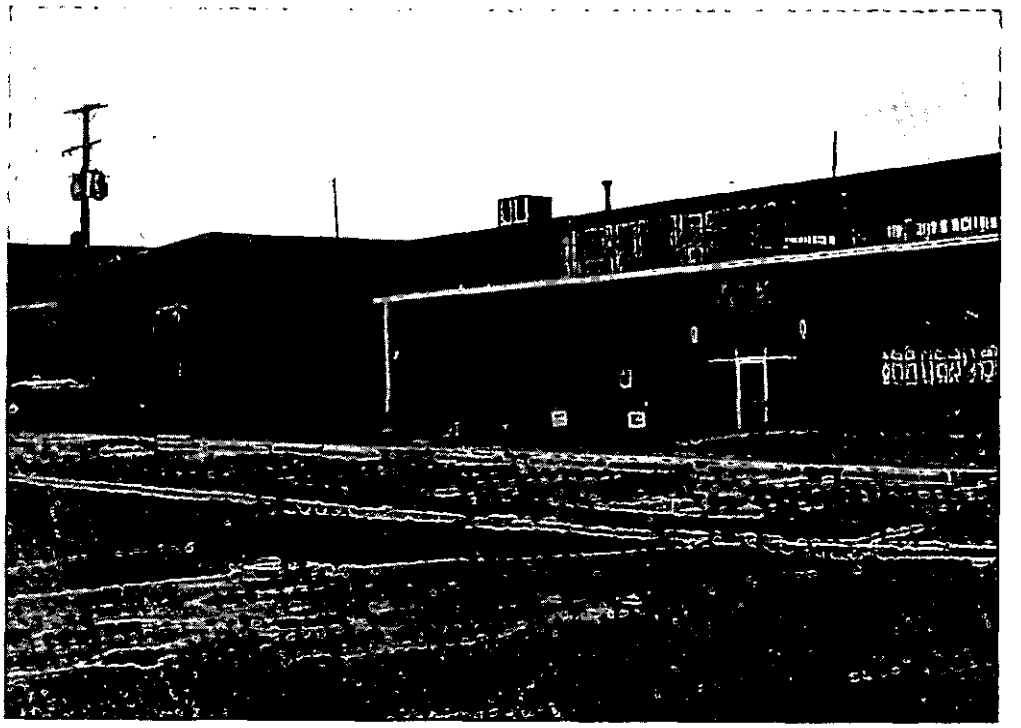

Fig. 6. View looking northwest at Parker Rust-Proof. The new building to the left beyond the loading dock was not surveyed. Offices are located to the right of the entrance.

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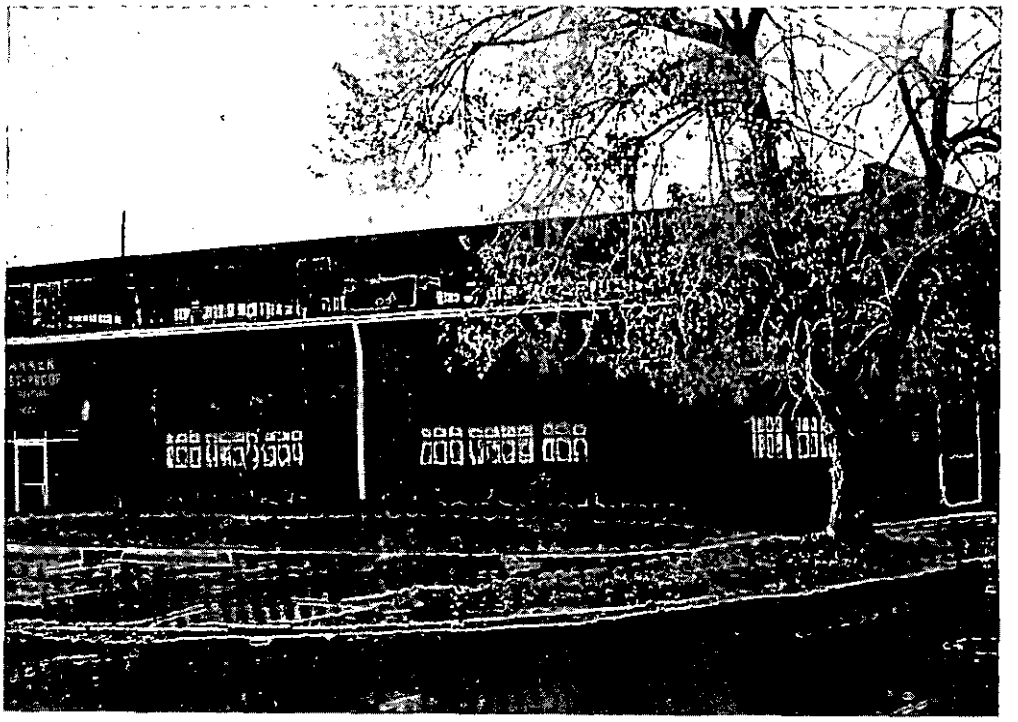

Fig. 7. View looking northwest at Parker Rust-Proof office area.

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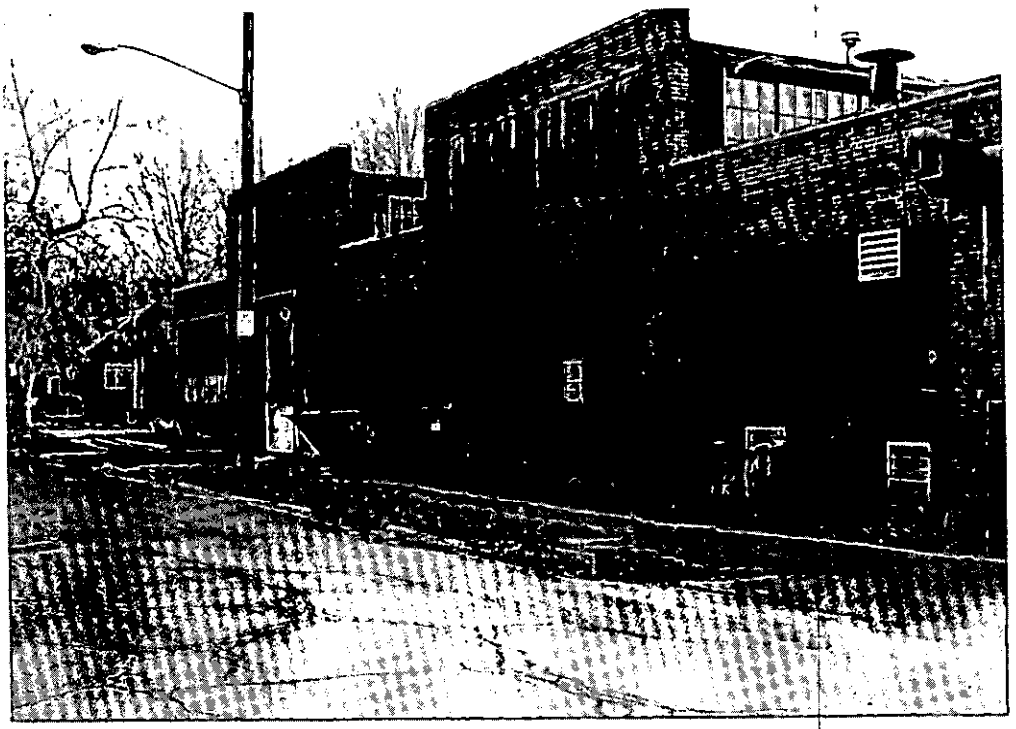

Fig. 8. View looking southwest at the section of Parker Rust-Proof that borders Arabella Road.

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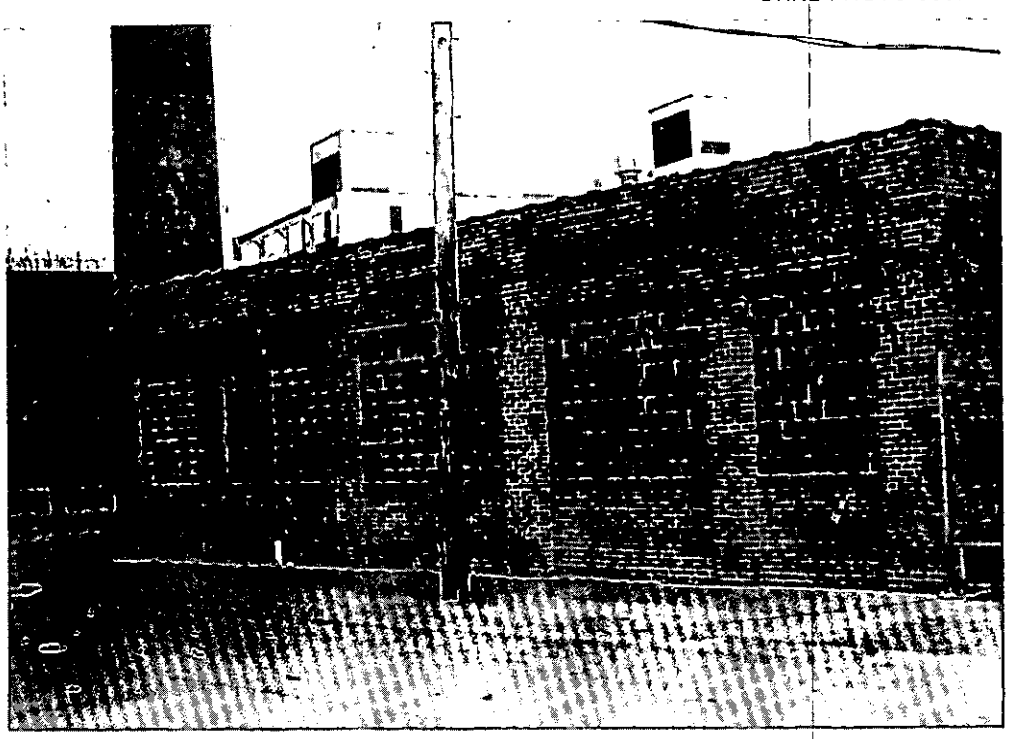

Fig. 9. View looking southeast at the section of Meistermatic, Inc., that borders Rosedand Avenue.

ORNL-PHOTO 5338-91

Fig. 10. View of chimney formerly used for incinerator at the northeast corner of Meistermatic, Inc. The small basement room formerly located at this corner has been filled with dirt with a covering of concrete poured to floor level. The steel manhole covers shown in the photo have been welded closed.

ORNL-PHOTO 5339-91

Fig. 11. View looking east in Bay A at Parker Rust-Proof.

ORNL-PHOTO 5340-91

Fig. 12. View looking west in Bay A at Parker Rust-Proof.

ORNL-PHOTO 5341-91

Fig. 13. View of inaccessible area in Bay B at Parker Rust-Proof.

ORNL-PHOTO 5342-91

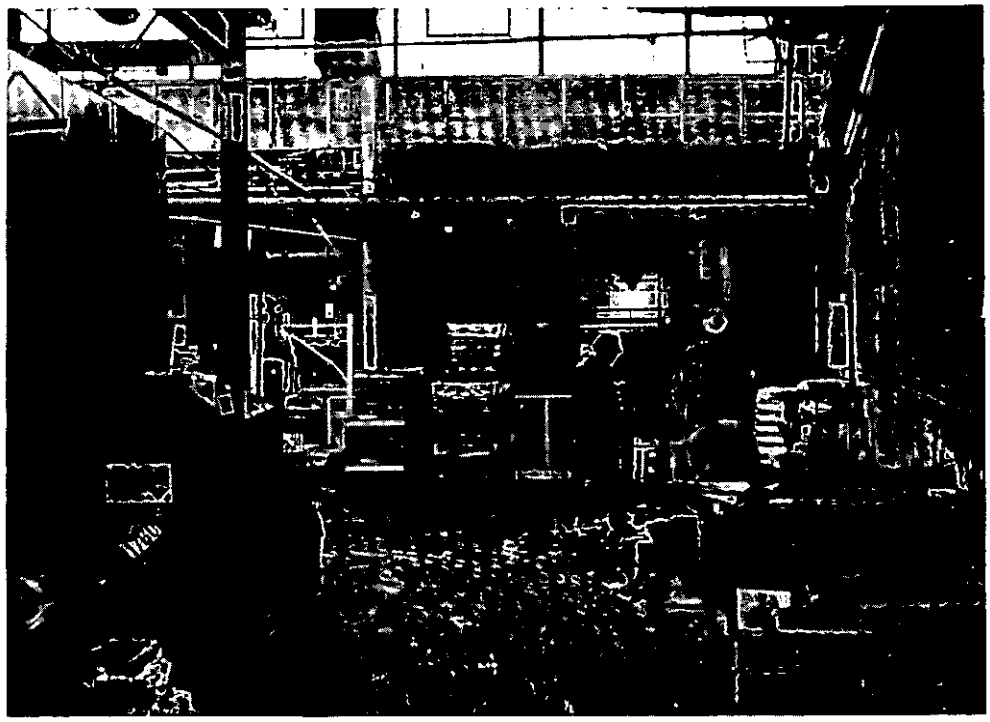

Fig. 14. View looking north at the boiler room at Parker Rust-Proof.

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Fig. 15. View looking north at machinery at Meistermatic, Inc.

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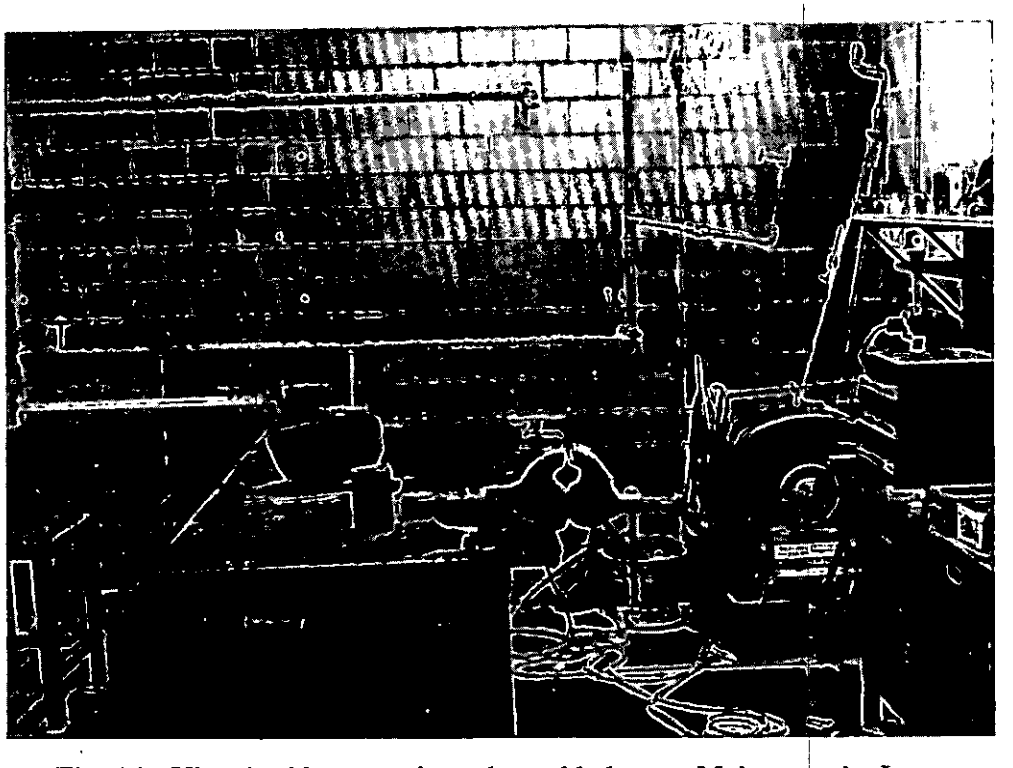

Fig. 16. View looking west into the weld shop at Meistermatic, Inc.

ORNL-PHOTO 5443-91

Fig. 17. View looking southwest into the chem storage room (left) and chem baths (right) at Meistermatic, Inc.

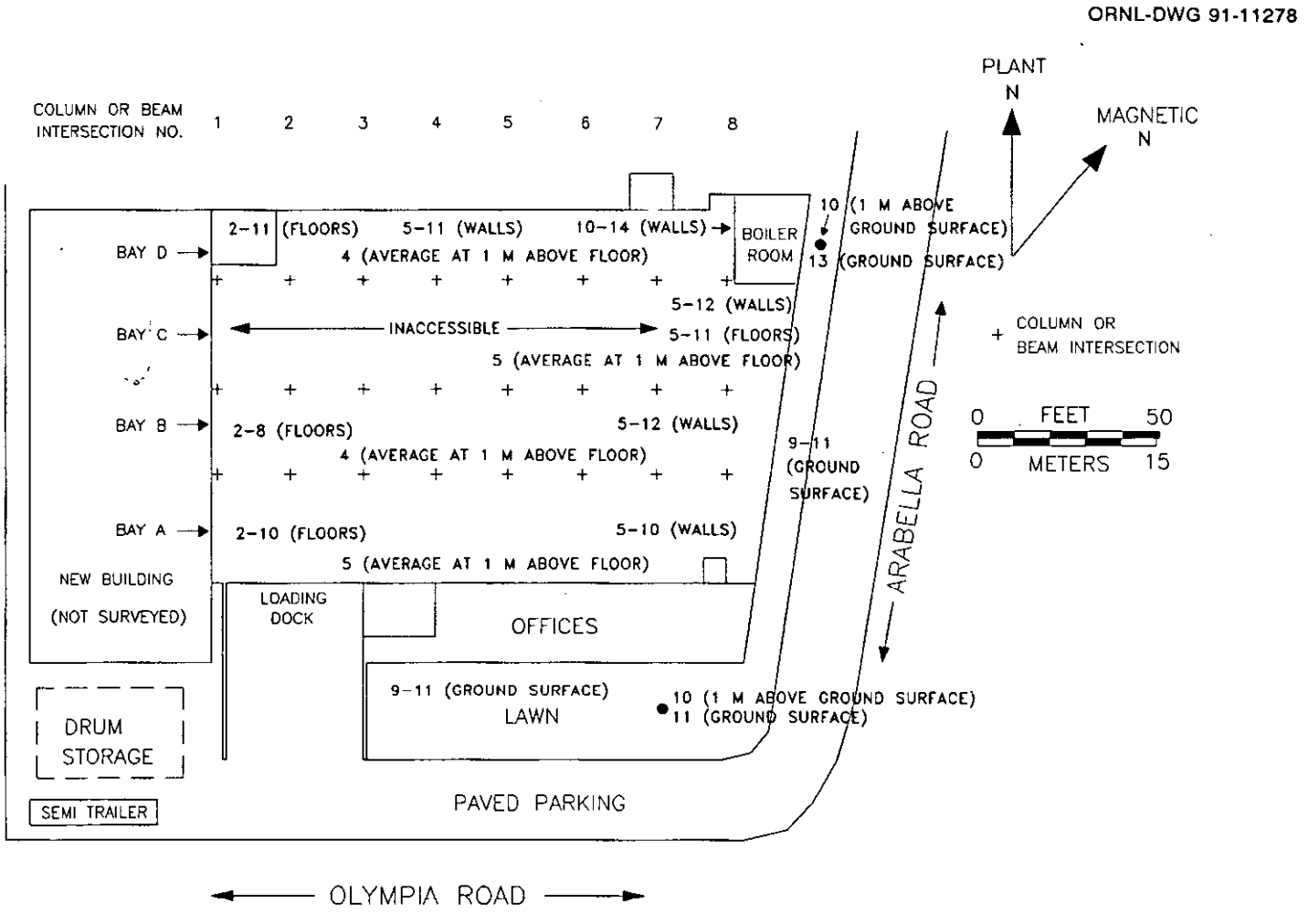

Fig. 18. Gamma exposure rates (μR/h) at Parker Rust-Proof. Walls were inaccessible in Bay A between beams 6 and 7, Bay B between beams 6 and 8, and Bay D between beams 2 and 5. Floor and walls were inaccessible in Bay C between beams 1 and 7.

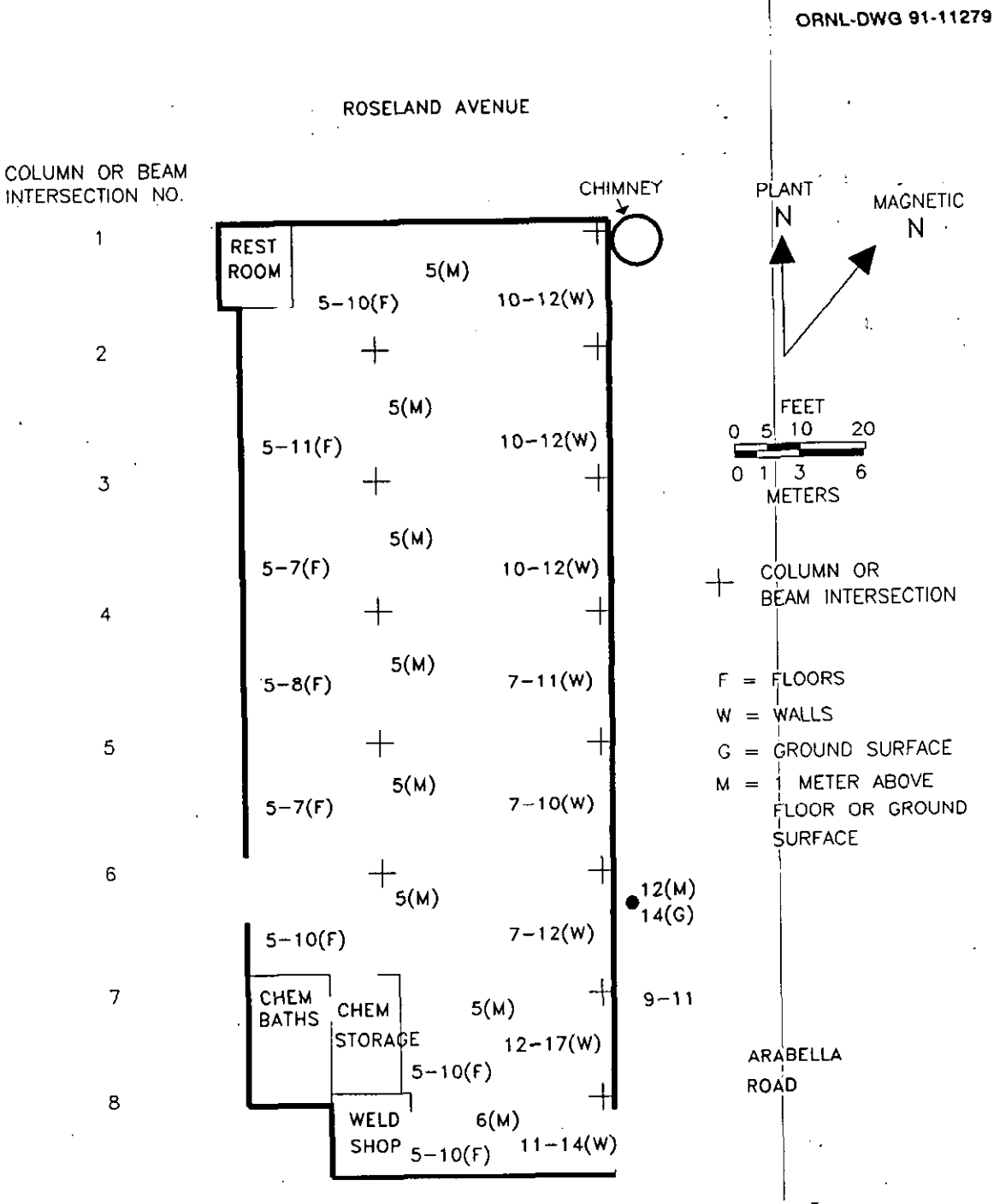

Fig. 19. Gamma exposure rates (μR/h) at Meistermatic, Inc.

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]
	Concentration limit in surface soil above background levels based on dose estimates from major exposure pathways	
	^{137}Cs	80 pCi/g over a 100-m^2 area of contamination[e]

[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.

[e]J. W. Healy, J. C. Rodgers, and C. L. Wienke, *Interim Soil Limits for D&D Projects*, LA-UR-79-1865-Rev., Los Alamos Scientific Laboratory, Los Alamos, NM, 1979. Cited in U.S. Department of Energy, *Radiological Guidelines for Application to DOE's Formerly Utilized Sites Remedial Action Program*, ORO-831, March 1983.

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 Cleveland, Ohio, area

Type of radiation measurement or sample	Radiation level or radionuclide concentration
Average external gamma exposure rate at 1 m above ground surface	9.2 μR/h[a]
Concentration of radionuclides in surface soil	
^{226}Ra	1.1 ± 0.04 pCi/g[b]
^{232}Th	1.1 ± 0.10 pCi/g[b]
^{238}U	1.2 pCi/g[c]

[a]Average of 3 to 4 measurements.
[b]Standard deviation is the 2σ value.
[c]Error in measurement is ±5% (2σ).

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. Summary of radiation measurements in building currently occupied by Parker Rust-Proof at the site of the former McKinney Tool and Manufacturing Company, 1688 Arabella Road, Cleveland, Ohio

Location	Gamma exposure rate, center survey block (μR/h)		Gamma exposure rates, range (average) (μR/h)		Beta-gamma dose rates, floor range (average)	Maximum alpha[b]	Remarks
bay, beam[a]	1 m	Surface	Floor	Walls	(mrad/h)	(dpm/100 cm^2)	
A, 1–2	5	7	4–10 (5)	5–10 (7)	0.01–0.02 (0.01)	<25	50% of area accessible
A, 2–3	5	7	4–7 (5)	5–10 (7)	0.01–0.02 (0.01)	<25	80% of area accessible
A, 3–4	6	7	4–10 (7)	6–8 (7)	0.01–0.02 (0.01)	<25	95% of area accessible
A, 4–5	6	6	4–8 (6)	6–8	0.01–0.02 (0.01)	<25	80% of area accessible
A, 5–6	4	6	4–7 (5)	6–8	0.01–0.02 (0.01)	<25	60% of area accessible
A, 6–7	4	5	5–7 (6)	*c*	0.01–0.02 (0.01)	<25	50% of area accessible
A, 7–8	6	5	5–8 (6)	5–7	0.01–0.02 (0.01)	<25	50% floor area, 5% wall area accessible
A, 8–wall	*d*	*d*	5–7 (6)	10–12 (brick)	0.01–0.02 (0.01)	<25	
B, 1–2	4	5	4–8 (6)	10–12 (brick)	0.01–0.02	<25	60% of area accessible
B, 2–3	4	4	4–7 (5)	5–10	0.01–0.02	<25	80% of area accessible

Table 3 (continued)

Location	Gamma exposure rate, center survey block (μR/h)		Gamma exposure rates, range (average) (μR/h)		Beta-gamma dose rates, floor range (average)	Maximum alpha[b]	Remarks
bay, beam[a]	1 m	Surface	Floor	Walls	(mrad/h)	(dpm/100 cm^2)	
B, 3–4	4	5	4–6 (5)	5–7	0.01–0.02	<25	80% of area accessible
B, 4–5	5	8	4–7 (5)	5–7	0.01–0.02	<25	70% of area accessible
B, 5–6	4	5	5–7	5–7	0.01–0.02	<25	40% of area accessible
B, 6–7	2	4	2–5 (4)	*c*	0.01–0.02	<25	30% of area accessible
B, 7–8	2	3	2–5 (4)	*c*	0.01–0.02	<25	
B, 8–wall	*d*	*d*	5–7 (6)	10–12 (brick)	0.01–0.02	<25	
C, 1–2	*c*	*c*	*c*	*c*	*c*	*c*	
C, 2–3	*c*	*c*	*c*	*c*	*c*	*c*	
C, 3–4	*c*	*c*	*c*	*c*	*c*	*c*	
C, 4–5	*c*	*c*	*c*	*c*	*c*	*c*	
C, 5–6	*c*	*c*	*c*	*c*	*c*	*c*	
C, 6–7	*c*	*c*	*c*	*c*	*c*	*c*	
C, 7–8	5	6	5–7	*e*	*d*	<25	95% of area accessible

Table 3 (continued)

Location bay, beam[a]	Gamma exposure rate, center survey block (μR/h) 1 m	Surface	Gamma exposure rates, range (average) (μR/h) Floor	Walls	Beta-gamma dose rates, floor range (average) (mrad/h)	Maximum alpha[b] (dpm/100 cm^2)	Remarks
C, 8–wall	5	6	5–11	5–12	*d*	<25	60% of floor accessible
D, 1–2	6	7	5–11 (7)	5–11 (7)	*d*	<25	30% of area accessible
D, 2–3	4	5	4–6	*c*	*d*	<25	40% of area accessible
D, 3–4	2	3	4–6	*c*	*d*	<25	50% of area accessible
D, 4–5	2	3	2–5	*c*	*d*	<25	20% of area accessible
D, 5–6	5	5	2–6	7–11 (brick)	*d*	<25	50% of area accessible
D, 6–7	6	7	4–10 (6)	10–14 (brick)	*d*	<25	80% of area accessible
D, 7–8	5	6	4–7 (5)	10–14	*d*	<25	30% or area accessible

[a]Location of bays and beams shown in Fig. 2.
[b]Highest of four alpha measurements. Instrument-specific minimum detectable activity (MAD) level = 25 dpm/100 cm^2.
[c]Inaccessible.
[d]Not measured.
[e]No walls.

Table 4. Summary of radiation measurements in building currently occupied by Meistermatic, Inc., at the site of the former McKinney Tool and Manufacturing Company, 1688 Arabella Road, Cleveland, Ohio

Beam[a]	Gamma exposure rate, center survey block (μR/h)		Gamma exposure rates, range (average) (μR/h)		Beta-gamma dose rates, floor (mrad/h)			Alpha[b] (dpm/100 cm^2)		Remarks
	1 m	Surface	Floor	Walls	East	West	Range	East	West	
1–2	5	5	5–10 (7)	10–12	0.02	0.02	0.01–0.03	<25	<25	50% of area accessible
2–3	5	5	5–11 (7)	10–12	0.02	0.02	0.01–0.03	32	<25	50% of area accessible
3–4	5	5	5–7 (6)	10–12	0.02	0.02	0.01–0.03	<25	28	50% of area accessible
4–5	5	5	5–8 (6)	7–11	0.02	0.02	0.01–0.03	<25	<25	60% of area accessible
5–6	5	5	5–7 (6)	7–10	0.02	0.02	0.01–0.03	<25	<25	70% of area accessible
6–7	5	5	5–7 (6)	7–12	0.02	0.02	0.01–0.03	<25	<25	70% of area accessible
7–8	5	5	5–10 (7)	12–17	0.02	0.02	0.01–0.03	<25	<25	80% of area accessible
8–wall	6	6	5–10	11–14	0.01	0.02	0.01–0.02	<25	<25	70% of area accessible

[a]Location of beams shown in Fig. 3.
[b]Instrument-specific minimum detectable activity (MDA) level = 25 dpm/100 cm^2.

Table 5. Gamma exposure rate measurements at soil and sediment sample locations at the site of the former McKinney Tool and Manufacturing Company, 1688 Arabella Road, Cleveland, Ohio

Location	Sample[a]	Depth (cm)	Gamma exposure rate (μR/h)			Comments
			1 m	Surface	15 cm[b]	
Parker Rust-Proof	B1	0–15	10	13	16	Biased[c] soil sample collected N of building in grass
Parker Rust-Proof	S1	0–15	10	11	13	Systematic[d] soil sample collected outside near offices
Parker Rust-Proof	E1	*e*	*f*	24[g]	*f*	Water and sediment collected from floor drain inside building
Meister-matic	B1	0–15	12	14	18	Biased soil sample collect near road next to fire hydrant

[a]Sample locations at Parker Rust-Proof are shown on Fig. 4 and Meistermatic on Fig. 5.
[b]Depth of 15 cm.
[c]Biased samples are taken from areas with elevated gamma exposure rates.
[d]Systematic samples are taken at locations irrespective of gamma exposure rates.
[e]Not applicable.
[f]Not measured.
[g]Measured at surface of water. The slight elevation in gamma level is typical of naturally occurring radioactive substances present in ceramic tile, which lined the floor drain.

Table 6. Concentrations of radionuclides in soil, sediment, and dust samples collected at the site of the former McKinney Tool and Manufacturing Company, 1688 Arabella Road, Cleveland, Ohio

Sample No.	Radionuclide concentration (pCi/g)[a]						
	^{40}K	^{137}Cs	^{210}Pb	^{226}Ra	^{232}Th	^{238}U	^{235}U
			Parker Rust-Proof[b] *Soil and sediment samples*				
B1[c]	15 ± 0.4	0.45 ± 0.02	2.4 ± 0.7	1.5 ± 0.03	1.1 ± 0.04	1.8 ± 0.5	0.05 ± 0.04
E1[d]	4.5 ± 0.2	0.02 ± 0.01	<2.0	0.43 ± 0.02	0.37 ± 0.03	0.71 ± 0.7	<0.05
			Parker Rust-Proof[b] *Dust samples*				
M1	9.0 ± 1	0.42 ± 0.07	1.4 ± 0.5	0.57 ± 0.08	0.67 ± 0.1	8.7 ± 0.8	<0.50
M2	7.4 ± 0.9	0.30 ± 0.07	0.91 ± 0.5	0.37 ± 0.05	0.39 ± 0.09	8.7 ± 0.6	0.58 ± 0.2
M3	5.2 ± 1	0.22 ± 0.07	1.2 ± 0.5	0.37 ± 0.06	0.31 ± 0.09	7.7 ± 0.5	0.33 ± 0.2
M4	8.2 ± 1	0.27 ± 0.09	1.7 ± 0.7	0.39 ± 0.1	0.39 ± 0.2	5.3 ± 0.6	<0.28
M5	5.2 ± 1	0.22 ± 0.07	1.2 ± 0.5	0.35 ± 0.08	0.31 ± 0.1	10 ± 0.7	0.63 ± 0.2
M6	4.2 ± 1	0.18 ± 0.06	0.60 ± 0.3	0.24 ± 0.06	0.36 ± 0.1	2.0 ± 0.5	0.16 ± 0.2
M7	5.2 ± 0.8	0.07 ± 0.03	0.63 ± 0.3	0.27 ± 0.05	0.23 ± 0.07	2.1 ± 0.3	<0.13
M8	5.0 ± 0.8	0.20 ± 0.06	1.3 ± 0.4	0.36 ± 0.08	0.44 ± 0.1	4.0 ± 0.5	<0.18
			Meistermatic, Inc.[e] *Soil samples*				
S1[f]	16 ± 0.3	0.60 ± 0.3	3.0 ± 0.5	1.1 ± 0.03	1.0 ± 0.03	2.1 ± 0.5	0.10 ± 0.04
B1[c]	25 ± 0.7	0.13 ± 0.02	2.0 ± 0.6	1.2 ± 0.04	1.4 ± 0.08	3.0 ± 0.8	0.14 ± 0.07

Table 6 (continued)

Sample No.	Radionuclide concentration (pCi/g)						
	^{40}K	^{137}Cs	^{210}Pb	^{226}Ra	^{232}Th	^{238}U	^{235}U
	Meistermatic, Inc.[e] *Dust samples*						
M1[g]	27 ± 8	0.13 ± 0.2	<8.0	0.62 ± 0.2	0.60 ± 0.4	9.4 ± 2	<2.0
M2	2.2 ± 0.7	0.04 ± 0.03	0.52 ± 0.3	0.33 ± 0.05	0.19 ± 0.07	1.1 ± 0.3	0.14 ± 0.1
M3	5.1 ± 0.7	0.33 ± 0.05	0.71 ± 0.5	0.39 ± 0.05	0.54 ± 0.07	1.5 ± 0.4	<0.08
M4	4.4 ± 0.7	0.14 ± 0.03	0.95 ± 0.4	0.56 ± 0.06	0.72 ± 0.08	2.3 ± 0.5	0.13 ± 0.1
M5	7.5 ± 1	0.33 ± 0.06	0.82 ± 0.4	0.57 ± 0.08	0.61 ± 0.1	2.7 ± 0.4	<0.24
M6	5.0 ± 0.8	0.18 ± 0.04	0.80 ± 0.3	0.51 ± 0.06	0.53 ± 0.08	1.2 ± 0.4	<0.22
M7	4.5 ± 1	0.19 ± 0.06	1.2 ± 0.4	0.45 ± 0.07	0.38 ± 0.1	1.5 ± 0.4	0.17 ± 0.2
M8	3.5 ± 1	0.12 ± 0.05	1.5 ± 0.4	0.43 ± 0.07	0.53 ± 0.1	1.5 ± 0.5	0.08 ± 0.09

[a]Indicated counting error is at the 95% confidence level (±2σ).
[b]Sample locations are shown on Fig. 4.
[c]Biased soil samples (B) are taken from areas with elevated gamma exposure rates.
[d]Water and sediment sample collected from floor drain inside building.
[e]Sample locations are shown on Fig. 5.
[f]Systematic soil samples (S) are taken at locations irrespective of gamma exposure rates.
[g]Phosphate/oxide deposit from chem baths.

Table 7. Direct and removable radiation measurements at the site of the former McKinney Tool and Manufacturing Company, 1688 Arabella Road, Cleveland, Ohio

Sample[a]	Directly measured radioactivity		Removable radioactivity[d]	
	Alpha[b] (dpm/100 cm^2)	Beta-gamma[c] (mrad/h)	Alpha[e] (dpm/100 cm^2)	Beta-gamma[f] (dpm/100 cm^2)
D1	<25	0.02	<10	<200
D2	<25	0.02	<10	<200
D3	<25	0.02	<10	<200
D4	28	0.02	<10	<200
D5	<25	0.02	<10	<200
D6	<25	0.02	<10	<200
D7	<25	0.02	<10	<200
D8	<25	0.01	<10	<200
D9	<25	0.01	<10	<200
D10	<25	0.02	<10	<200
D11	<25	0.02	<10	<200
D12	*g*	*g*	<10	<200
D13	*h*	*h*	<10	<200
D14	<25	0.02	<10	<200
D15	<25	0.02	<10	<200
D16	<25	0.02	<10	<200
D17	<25	0.02	<10	<200
D18	<25	0.02	<10	<200
D19	<25	0.01	<10	<200
D20	<25	0.01	<10	<200

[a]Locations of samples D1–D11 are shown on Fig. 4 and samples D12–D20 are shown on Fig. 5.

[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.

[g]Smear taken inside chem bath. No direct measurements taken.

[h]Smear from chem bath heater assembly. No direct measurements taken.

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