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RADIOLOGICAL ASSESSMENT OF THE

FORMER REDUCTION PILOT PLANT
Huntington Alloys, Inc.
Huntington, West Virginia

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Manpower Education, Research, and Training Division
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RADIOLOGICAL ASSESSMENT OF THE FORMER REDUCTION PILOT PLANT AT HUNTINGTON ALLOYS, INC. HUNTINGTON, WEST VIRGINIA

J.D. Berger, C.W. Kuechle, C.F. Riemke, C.F. Weaver

INTRODUCTION

The Reduction Pilot Plant (RPP), located in Huntington, West Virginia, on the site of Huntington Alloys, Inc., (formerly known as the International Nickel Company) was constructed in 1951 by the Atomic Energy Commission (AEC). The initial purpose of the facility was to supply nickel powder for use in the gaseous diffusion plants at Paducah, Kentucky and Portsmouth, Ohio. One source of material for this process was scrap nickel, contaminated with uranium (maximum enrichment 4%), returned from the gaseous diffusion operations. The plant was shut down in 1963 and maintained in a standby condition. In January 1975, the first survey to determine the radiological status of the facility was conducted by the Oak Ridge Operations Office of the AEC.[1] A plan view of the site in 1975 is shown in Figure 1. Demolition from November 1978-May 1979 removed classified and contaminated equipment, and a second survey of the site was conducted in May 1979 by the Oak Ridge office of the Department of Energy (DOE).[1] Although residual contamination was not noted on this survey, and unrestricted release of the site was recommended by DOE, a review of the survey results by the Health and Safety Research Division of Oak Ridge National Laboratory (ORNL) identified certain areas requiring further evaluation.[2,3] A follow-up survey of these questionable areas was conducted by ORNL in August 1980. Results of that survey indicated several locations of residual uranium in surface soil and elevated gamma radiation levels in the remains of an elevator shaft and inside the compressor building.[4] High concentrations of nickel were also noted in some surface soil samples.

ORNL recommended a detailed formal survey to determine the following:

1. The source of elevated gamma readings in the compressor building and elevator shaft,
2. External gamma-radiation levels throughout the site,
3. Radionuclide concentrations in subsurface soil,

4. Contamination levels on surfaces inside the compressor building, and
5. Nickel concentrations in surface and subsurface soil.

A team from the Oak Ridge Associated Universities' Radiological Site Assessment Program performed the recommended surveys of this facility on November 17-19, and December 3, 1980.

SITE DESCRIPTION

The Reduction Pilot Plant is located on approximately 1.6 hectares of land, presently owned by Huntington Alloys, Inc. A general plan of the site as it appears today is shown in Figure 2. The only original structure remaining on the site is the compressor building. This building is of concrete block construction and consists of a large open storage area, change room facility, office area above the change room, and a small electrical craft training room (see Figure 3). Approximate floor areas of these building sections are 9000 ft^2 (81.8 m^2), 875 ft^2 (79.5 m^2) 875 ft^2 (79.5 m^2), and 300 ft^2 (37.3 m^2) respectively.* Items of large mechanical equipment are stored on racks in the open area and training classes are being conducted in the small room at the northwest corner of the building; other areas of the building are not in use. A concrete pad, which was the floor of the former process building, remains on the north side of the compressor building and, at the time of this survey, a large pile of chromate ore occupied approximately 31.8 m^2 of this pad. Large pieces of scrap metal and construction equipment are stored at the north edge of the property.

SURVEY PROCEDURES

Compressor Building Interior

Gamma radiation levels were measured over accessible areas of the compressor building floor. These measurements were performed by traversing the floor at about 1 meter intervals and noting the count rate levels at contact with the floor and at approximately 1 meter above the floor. The ranges of levels, measured in the major building sections, were recorded. Locations and levels of elevated count rates, which might indicate the presence of residual contamination, were also recorded. Contact measurements were performed at random on walls (to approximately 2 meters above the floor), other building surfaces, and items of equipment - again in search of elevated gamma-radiation levels.

Transferable surface contamination was determined by rubbing 5 cm diameter Whatman 51 filter paper over approximately 100 cm^2

English units are used here to correspond with scales indicated on figures and to facilitate comparisons with previous survey reports of this site, which were presented mainly in English units.

and then analyzing these swipes (smears) for long-lived gross alpha and gross beta activity. Walls, floors, pipes, benches and other surfaces were monitored in this manner. At approximately one-third of the locations where swipes were taken, total alpha and beta-gamma surface contamination was measured, using portable scalers with alpha scintillation and "pancake" Geiger-Mueller detectors. Direct pancake G-M probe measurements were performed at 17 other locations. The locations of survey points are indicated on Figure 4.

Samples for laboratory analysis were collected from a shower drain in the change room and paint from a wall where elevated gamma levels were noted. A small portion of the concrete block wall from this area of elevated gamma levels was also obtained for analysis.

Outdoor Property

Gamma-Radiation Survey

The outdoor property was gridded into 50 ft (15.25 m)* spacings over the northern section, where previous site surveys had indicated the presence of elevated surface gamma levels and radionuclide concentrations in the soil (see Figure 5). Over the southern portion of the property 100 ft (30.5 m)* grid spacings were established. Gamma radiation levels were measured at contact with the ground surface by traversing the property at about 3 meter intervals, using gamma-scintillation ratemeters. The range of measured levels and the locations of areas having elevated count rates were recorded for each grid block region. Systematic measurements of exposure rates at 1 meter above the surface were not performed, since a previous survey had shown these levels to range between 6 and 11 μR/hr - not significantly different from the normally expected background levels.[1] Several random measurements confirmed these previous findings.

Soil Sampling

Surface (0-15 cm) soil samples of approximately 10 kg were systematically collected at the center of the grid blocks established on the southern portion of the property. Sampling points, over the remainder of the site, were selected to provide information on other soil areas and to concentrate attention on the vicinity of the loading pad, where previous surveys had identified elevated radionuclide concentrations in surface soil. Subsurface samples at depths of 15-30 cm and 45-60 cm were collected at four of the surface soil sampling locations by first drilling a hole of approximately 1 meter deep using a power auger,

Only survey tapes marked in English units (feet) were available for use at the time the grid was being established.

then scraping soil from the hole walls at desired depth. Attempts to auger additional holes on the northern portion of the property were unsuccessful due to the presence of coarse gravel fill and subsurface concrete pads in this area. Surface samples were collected at locations of elevated gamma radiation levels determined by the property walkover scan. These samples are identified as "biased" samples. Locations of soil samples are indicated on Figure 6.

Surface and subsurface soil samples were also obtained from two locations on adjacent property (Figure 6) and from a river flood plain approximately 1.5 km southeast of the site. It was assumed that the radioactivity in these samples would be typical of the area and had not been contaminated by RPP operations. They served as "baseline" samples.

Other Sampling

Debris was removed from portions of the conveyor trench and from the elevator shaft using a backhoe. These areas were surveyed using gamma-scintillation instruments and samples of debris and standing water were collected from each location (see Figure 6).

Sample Analysis and Interpretation of Data

Soil, debris, and water samples were analyzed for ^{238}U, ^{235}U, and ^{226}Ra by gamma spectrometry. Nickel levels in soil were determined by x-ray fluorescence. Instrumentation and techniques for collection and analysis of samples and data are described in Appendix A.

RESULTS

Compressor Building Interior

The results of the compressor building survey are presented in Table 1 and Figure 7. Gamma radiation measurements indicated general levels from 9-12 μR/hr at 1 meter above the floor in the larger open area; higher levels (up to 35 μR/hr) were noted in small rooms and enclosed spaces of the change room, stairway, and second floor office area. No isolated locations of elevated levels, which would indicate possible residues or contamination, were identified. Analysis of a sample of concrete block, obtained from the stairwell wall, indicated that the block has a ^{226}Ra concentration of 3.7 pCi/gm. This is assumed to be due to naturally occurring radium in the construction materials, since there was no evidence of radionuclides other than the radium and its decay products in the block sample. This level of naturally-occurring radium in the block walls could account for

the elevated general radiation levels in the small enclosed spaces, where there is more concrete surface in close proximity to the survey instrument.

Transferrable alpha surface-contamination ranged from 3 d/m per 100 cm^2, the minimum detectable level (MDL)*, to 9 d/m per 100 cm^2 with an average of <3 d/m per 100 cm^2. Direct alpha surface measurements indicated a range of 40 d/m per 100 cm^2 (MDL) to 140 d/m per 100 cm^2. The average direct alpha measurement was also less than the MDL of 40 d/m per 100 cm^2.

Transferrable beta surface-contamination levels ranged from 56 d/m per 100 cm^2 (MDL) to 71 d/m per 100 cm^2. The average was equal to or less than the minimum detectable level. Direct beta-gamma surface measurements ranged from <320 d/m per 100 cm^2 (MDL) to 2600 d/m per 100 cm^2. The average was 770 d/m per 100 cm^2. These direct beta-gamma measurements are equivalent to dose rates at 1 cm from the surface of <0.004, 0.031, and 0.009 millirads/hr respectively.

Levels of radionuclides in the drain residues and paint scraping were below the minimum detectable level.

Outdoor Property

Gamma Radiation Levels

Figure 8 indicates the results of the outdoor gamma scintillation measurements. With the exception of three locations, no elevated radiation levels were noted. These three locations were the elevator shaft, small isolated spots near the edge of the loading pad, and a small area on the outside east wall of the compressor building. Maximum radiation levels noted in these locations were 33 µR/hr, 45 µR/hr, and 18 µR/hr respectively. Debris (mostly scraps of concrete block) and soil were removed from the elevator shaft using a backhoe, and additional monitoring was performed to identify residual sources of activity. Measurements in the shaft and of the debris removed from the shaft indicated a maximum of 22 µR/hr with no specific elevated areas in the shaft or on pieces of debris noted. A sample of the debris had concentrations of ^{238}U, ^{235}U, and ^{226}Ra slightly above the baseline ranges.

The area of elevated ground surface radiation near the concrete pad is believed to be contamination, originating from equipment stored in this location during the 1978-79 demolition activities. A section of earth approximately 60 cm wide x 60 cm deep x 2.5 meters long was removed; however, a generalized elevated region up to 25 µR/hr remained in the excavated area. The soil removal exposed a layer of coarse gravel, which had been used as fill under the concrete pad. Analysis of this gravel

* *The MDL as used in this report is based on the 2σ confidence limit of the instrument background.*

verified that it contained elevated levels (2.5 pCi/gm) of radium 226. This is assumed to be naturally-occurring since there was no evidence of radionuclides other than radium and its decay products in the gravel. Soil removed from the area near the pad was placed in metal drums for shipment to Portsmouth, Ohio for disposal.

The elevated portion of the east compressor building wall is believed to be due to the naturally occurring radium in construction materials (refer to the earlier section on the survey results of the compressor building interior).

Soil Samples

Most soil sample analysis (see Table 2) indicates radionuclide concentrations generally comparable to the ranges noted in baseline soil samples from off-site locations, i.e. ^{238}U, <3 to 4.6 pCi/gm; ^{235}U, 0.3 to 0.5 pCi/gm, and ^{226}Ra, 0.7 to 1.5 pCi/gm. Several biased samples obtained near locations of elevated surface gamma radiation levels, contained elevated levels of these radionuclides. The maximum ^{238}U concentration measured was 300 pCi/gm in surface soil near the concrete loading pad (Sample B-1). Following removal of the surface soil in this area the concentration of ^{238}U was reduced to 14 pCi/gm. Additional samples from the immediate area near the pad ranged from 4.6 to 22 pCi/gm of ^{238}U. Samples from the conveyor trench were also in the range of the baseline samples. Maximum radium-226 and uranium-235 soil concentrations following cleanup of elevated areas are 2.0 pCi/gm and 0.70 pCi/gm respectively.

Nickel concentrations in soil samples are also listed in Table 2. Concentrations ranged from approximately 400 ppm to 1.4×10^5 ppm (at the site of highest ^{238}U soil concentration). There does not appear to be a correlation between radionuclide contamination levels and nickel concentrations. It is interesting to note that off-site samples also contained significant nickel levels. In particular, sample 0-3 of surface soil, obtained from a river flood plain approximately 1.5 km from the plant site, contained 1.3×10^4 ppm - substantially higher than many of the on-site samples. This suggests that general nickel contamination of surface soil may exist throughout this area as a result of past International Nickel Company operations.

Water Samples

Water from the conveyor trench and elevator pit had concentrations of uranium-238, uranium-235, or radium-226 below the detectable limits (see Table 3).

COMPARISON OF SURVEY RESULTS WITH RELEASE GUIDELINES

Two guidelines regarding surface contamination limits are provided in Appendix B. They are "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material" prepared by the U.S. Nuclear Regulatory Commission (NRC), November 1976, and the proposed American National Standard ANSI N328-197, "Control of Radioactive Surface Contamination on Materials, Equipment, and Facilities to be Released for Uncontrolled Use". Comparison of the compressor building survey results with the guidelines for natural uranium and its decay products, indicates that the measured levels are below those guidelines for transferrable and total alpha and beta-gamma contamination. The external beta-gamma radiation dose rates at 1 cm from the building surfaces are also below the NRC guidelines.

These documents provide no guidance regarding gamma-ray exposure levels; however, the National Council on Radiation Protection and Measurements recommends a maximum dose equivalent of 500 millirem for an individual in the general population.[5] Assuming continual exposure, i.e. 168 hr/week, an individual exposed to the highest levels measured inside the compressor building would receive an annual dose equivalent of less than 305 millirem. Using the same exposure time criteria, gamma-radiation levels in outdoor areas of the site would result in individual dose equivalent of less than 200 millirem annually.

Guidelines for permissible soil concentrations of uranium-238 and uranium-235 have not yet been adopted. Values for maximum concentrations which have been applied by the NRC for specific sites are 35 pCi/gm for ^{238}U and 32.5 pCi/gm for ^{235}U.[6] The remaining soil levels, following removal of contaminated spots and debris, were within these values. The Environmental Protection Agency has proposed a limit of <5 pCi/gm for ^{226}Ra in surface soil.[7] The measured soil concentrations at this site are below this limit.

Concentrations of uranium-238, uranium-235 and radium-226 in water for unrestricted release are listed in Appendix B, Table II, Column 2 of Title 10, Part 20 of the Code of Federal Regulations. These concentrations are 3×10^{-5}, 4×10^{-5}, and 3×10^{-8} μCi/ml respectively. The measured concentrations in the water from the conveyor trench and elevator shaft were below these levels for ^{238}U and ^{235}U. Concentrations of ^{226}Ra in these samples were below the MDL of 5×10^{-8} and comparisons with the 3×10^{-8} μCi/ml permissible concentrations are therefore inconclusive. However, other analyses provides evidence that AEC operations in this facility did not result in increases of radium 226 concentrations above baseline values, and it is considered doubtful that more sensitive analytical procedures would indicate to the contrary for the water samples.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the assistance of P.R. Cotten in the preparation and analysis of samples. The recommendations and comments of the ORNL Health & Safety Research Division's Off-Site Pollutant Measurement Group, regarding our survey and analytical procedures and the initial draft of this report, are also appreciated.

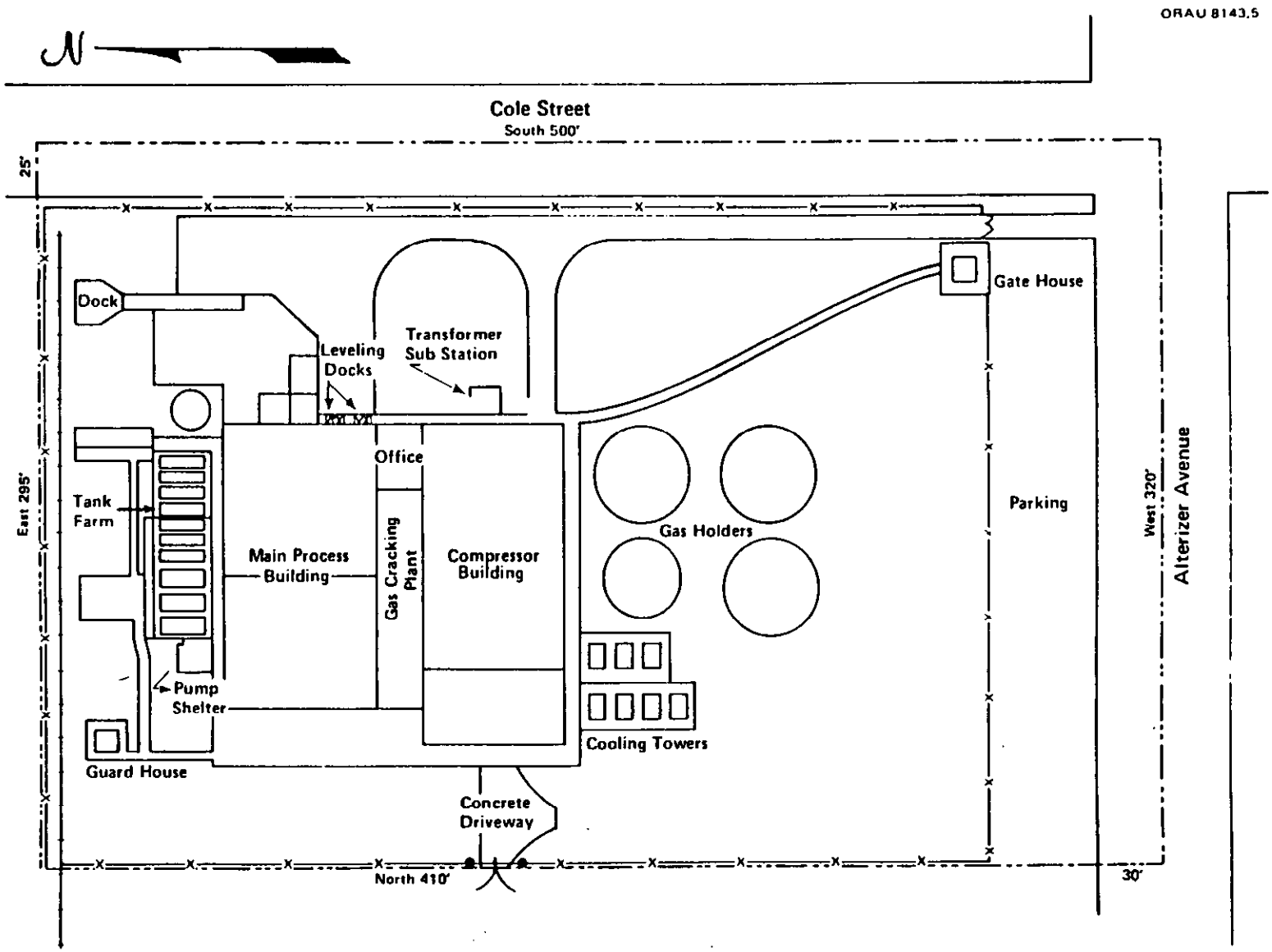


FIGURE 1. Plan View of the Reduction Pilot Plant Site at the Time of Shutdown (approx. 1963).

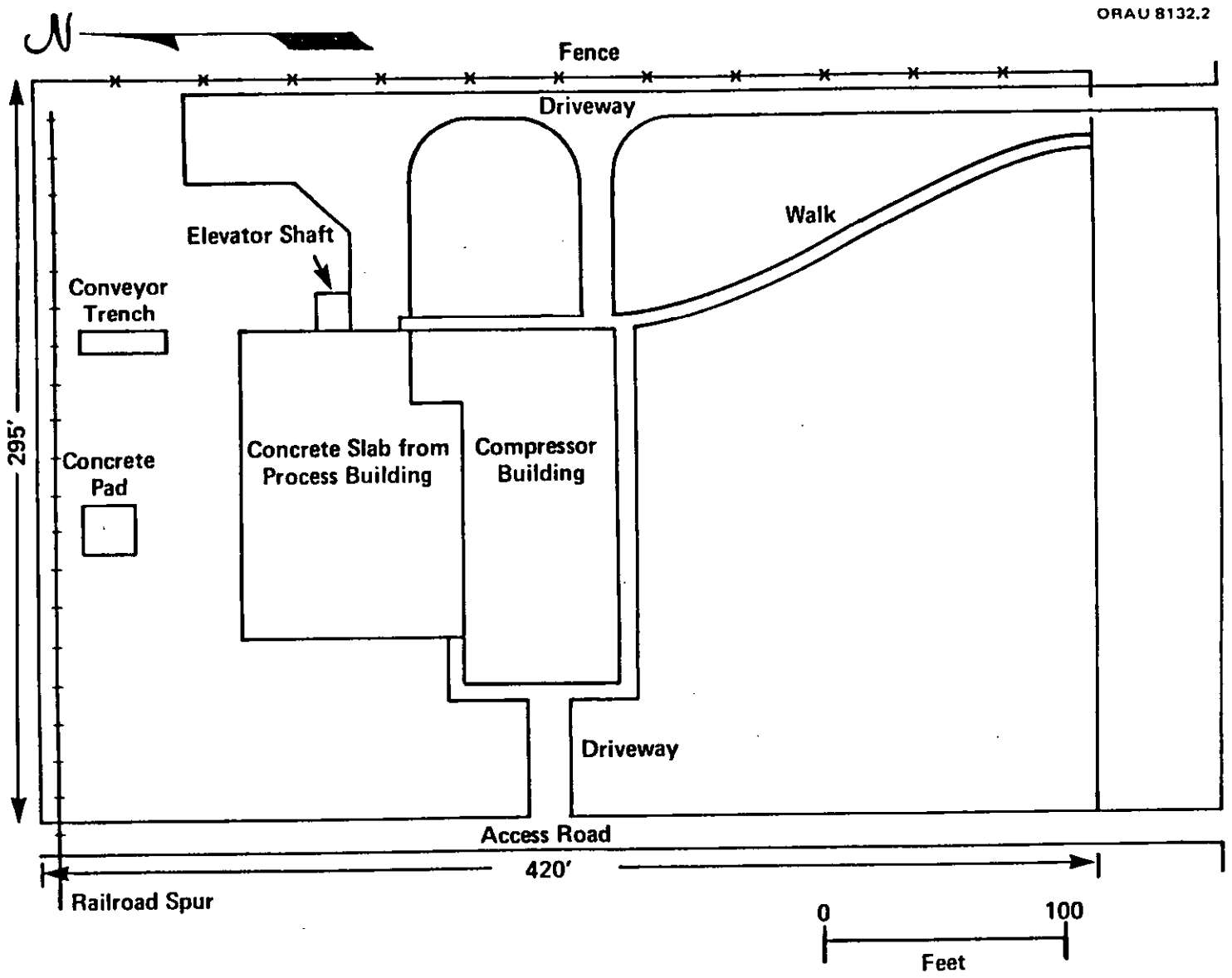


FIGURE 2. Plan View of the Former Reduction Pilot Plant at the Time of this Survey.

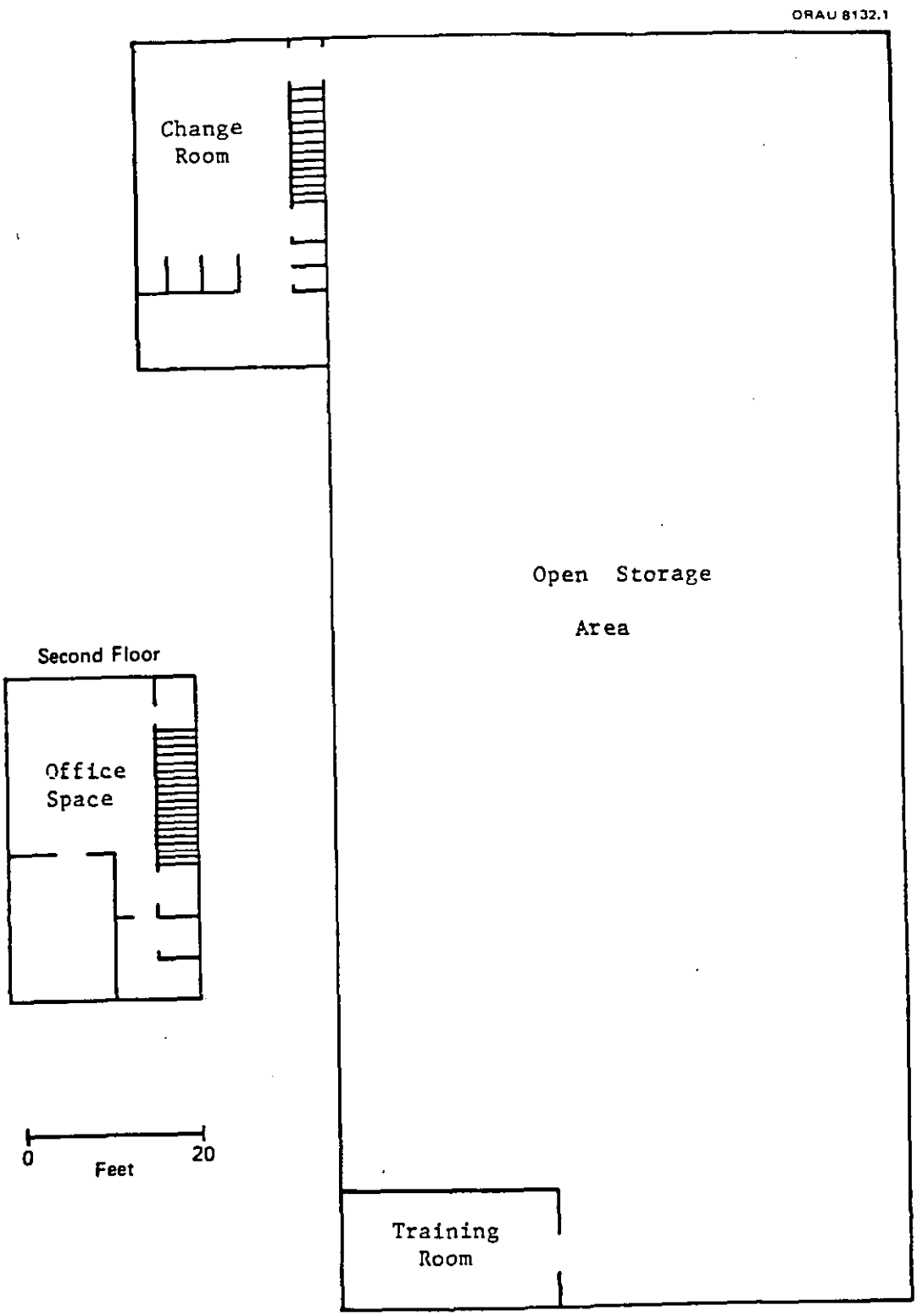
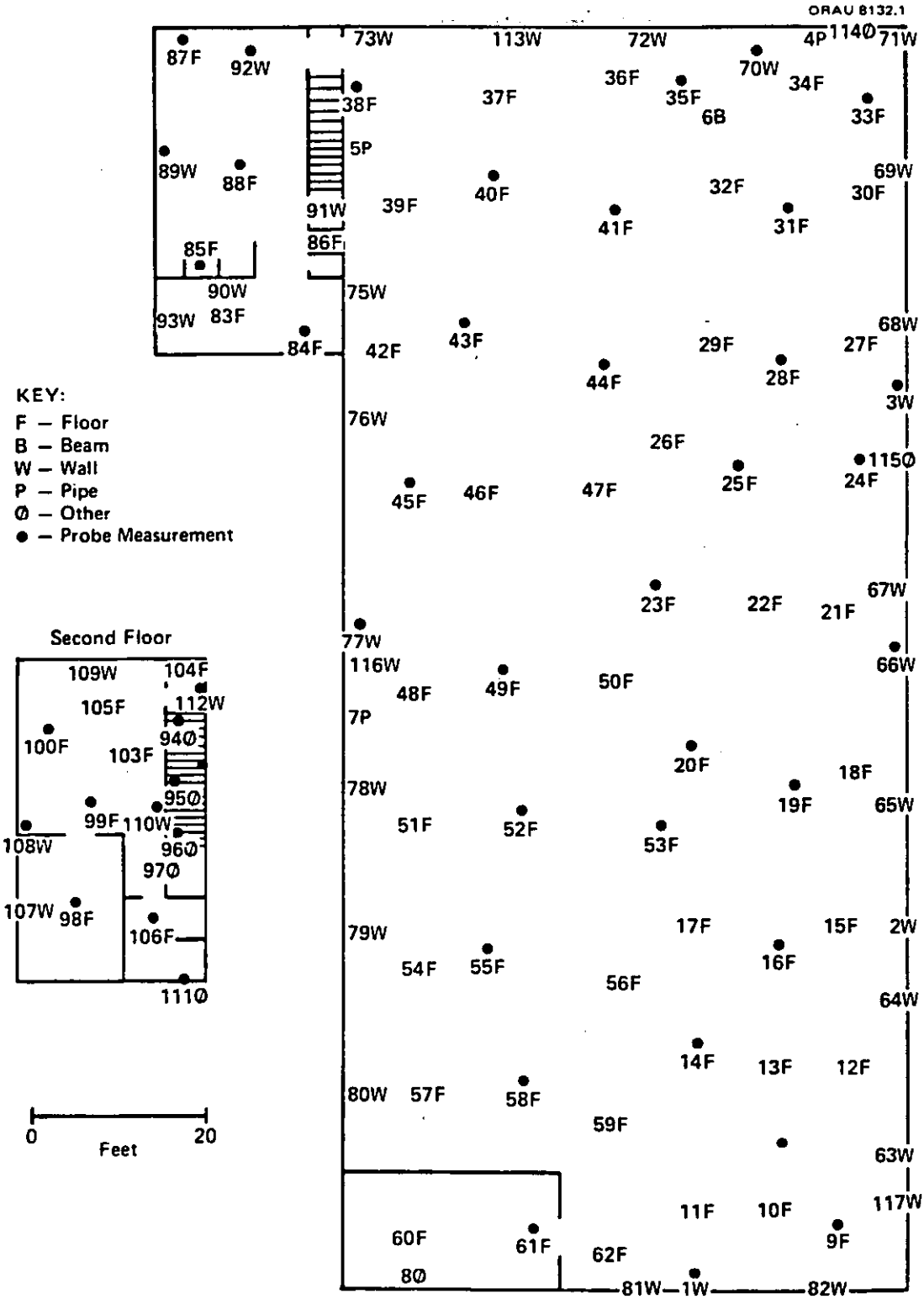


FIGURE 3. Layout of Compressor Building



Number is swipe sample identification; letter (see key) indicates type of surface surveyed; identifies locations of direct probe measurements.

FIGURE 4. Layout of Compressor Building Indicating Contamination Survey Points.

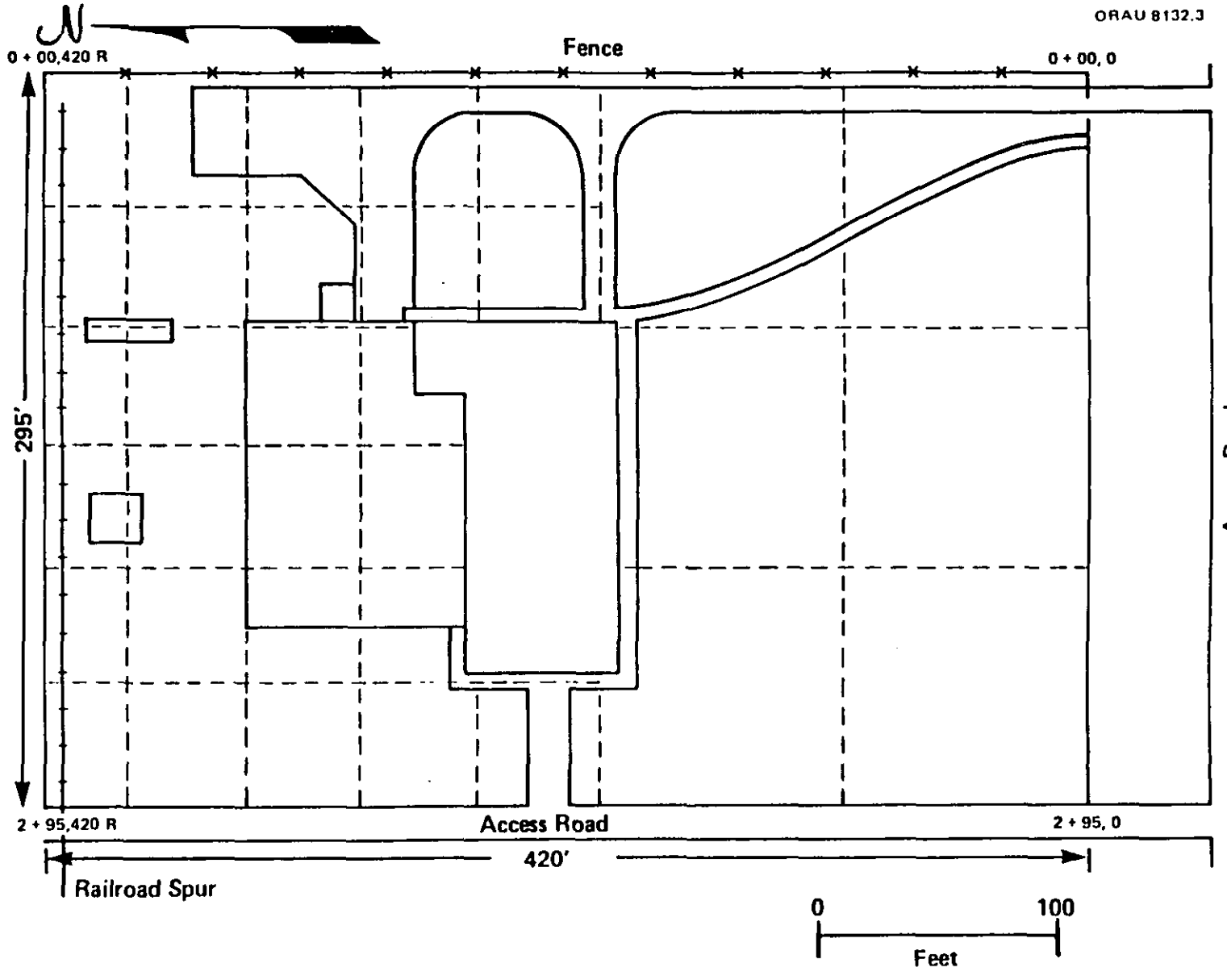
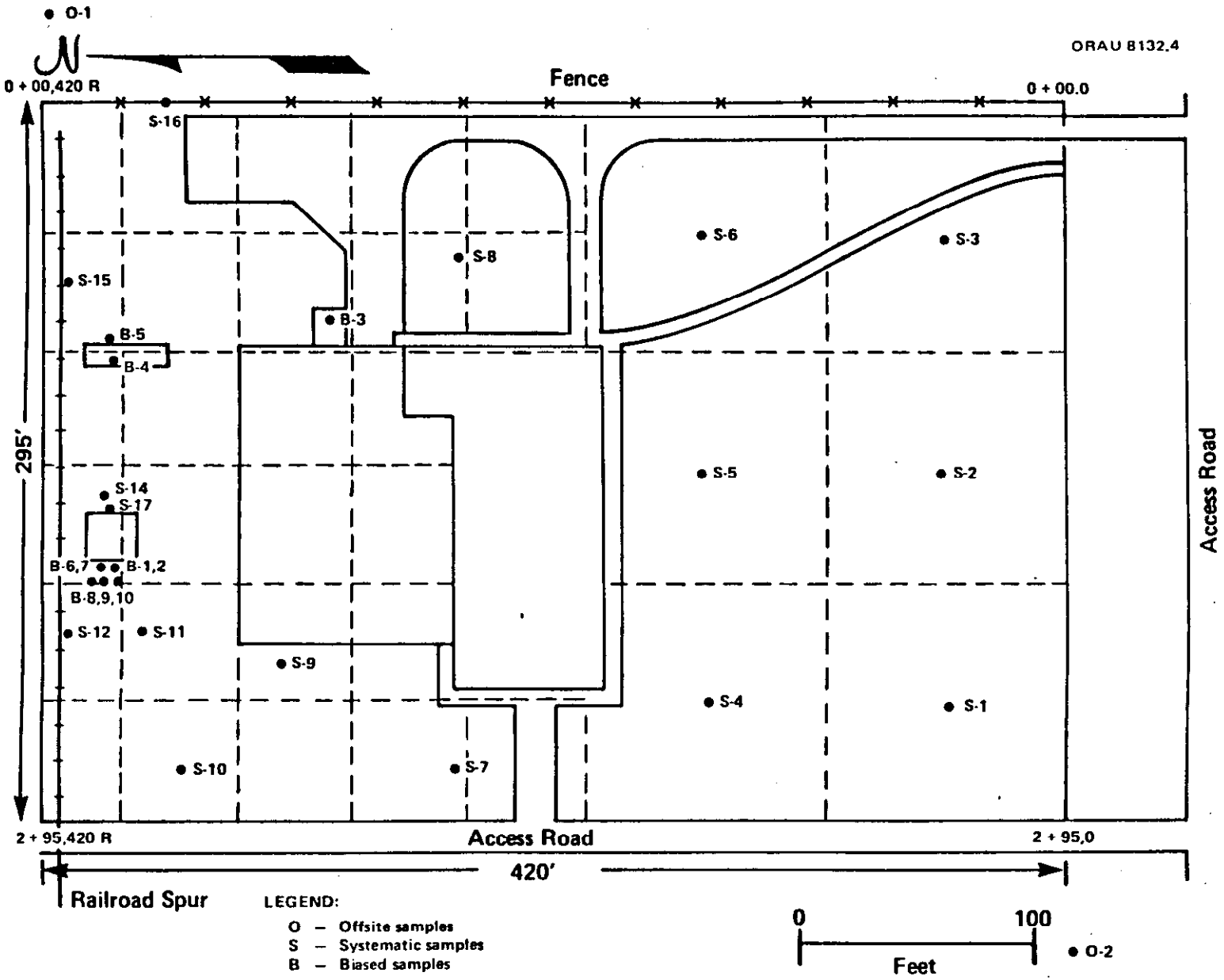


FIGURE 5. Plan View Showing Grid Spacings for Outdoor Gamma-Scintillation Survey.



Subsurface samples were taken at

O-1, O-2, S-2, S-4, S-6, S-10, B-2, B-4, B-6, and B-7; surface samples only were obtained at the remaining locations.

FIGURE 6. Locations of surface and subsurface soil samples.

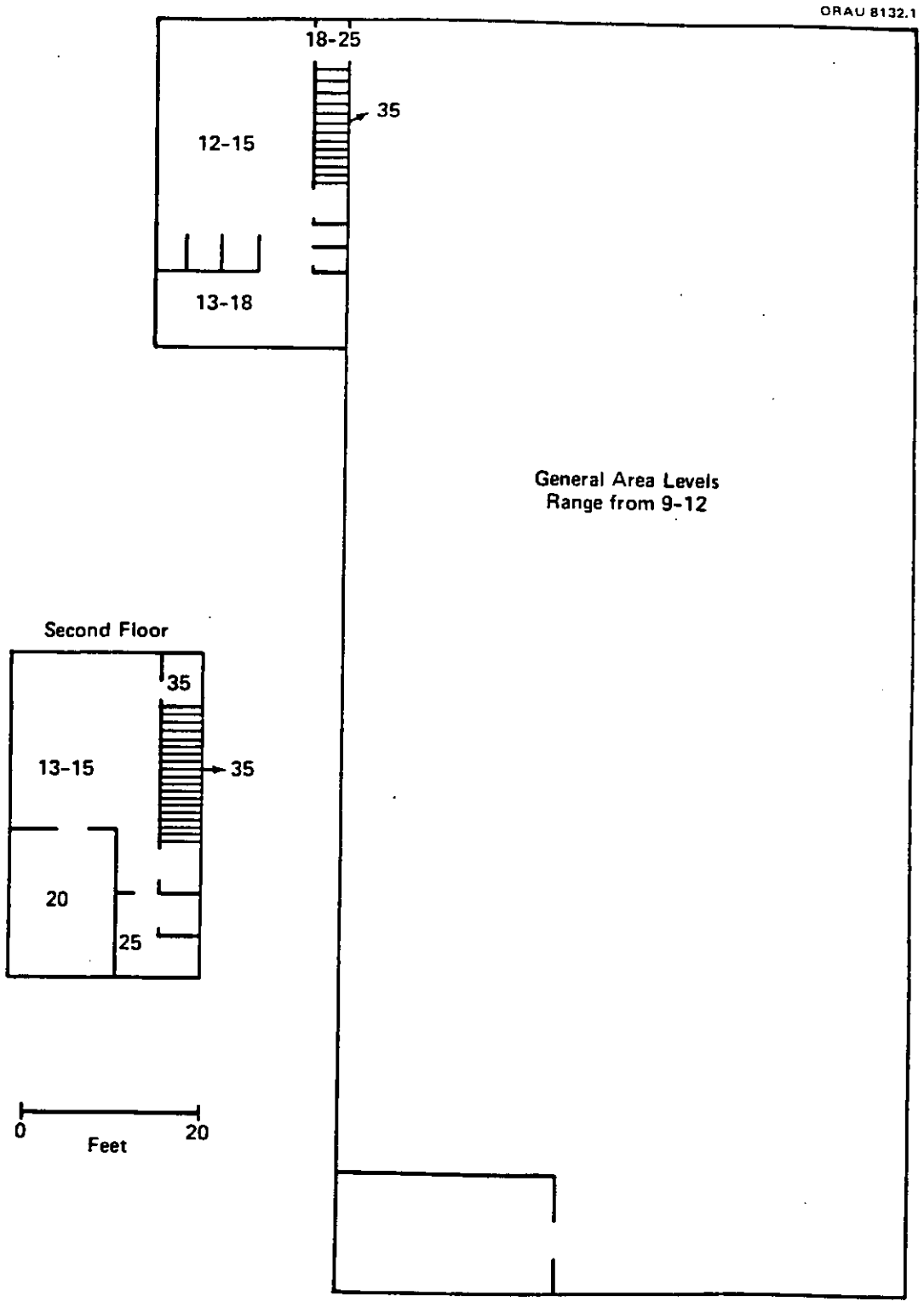


FIGURE 7. Compressor Building Plan Indicating Gamma Radiation Levels (μR/hr) at 1 meter above the floor.

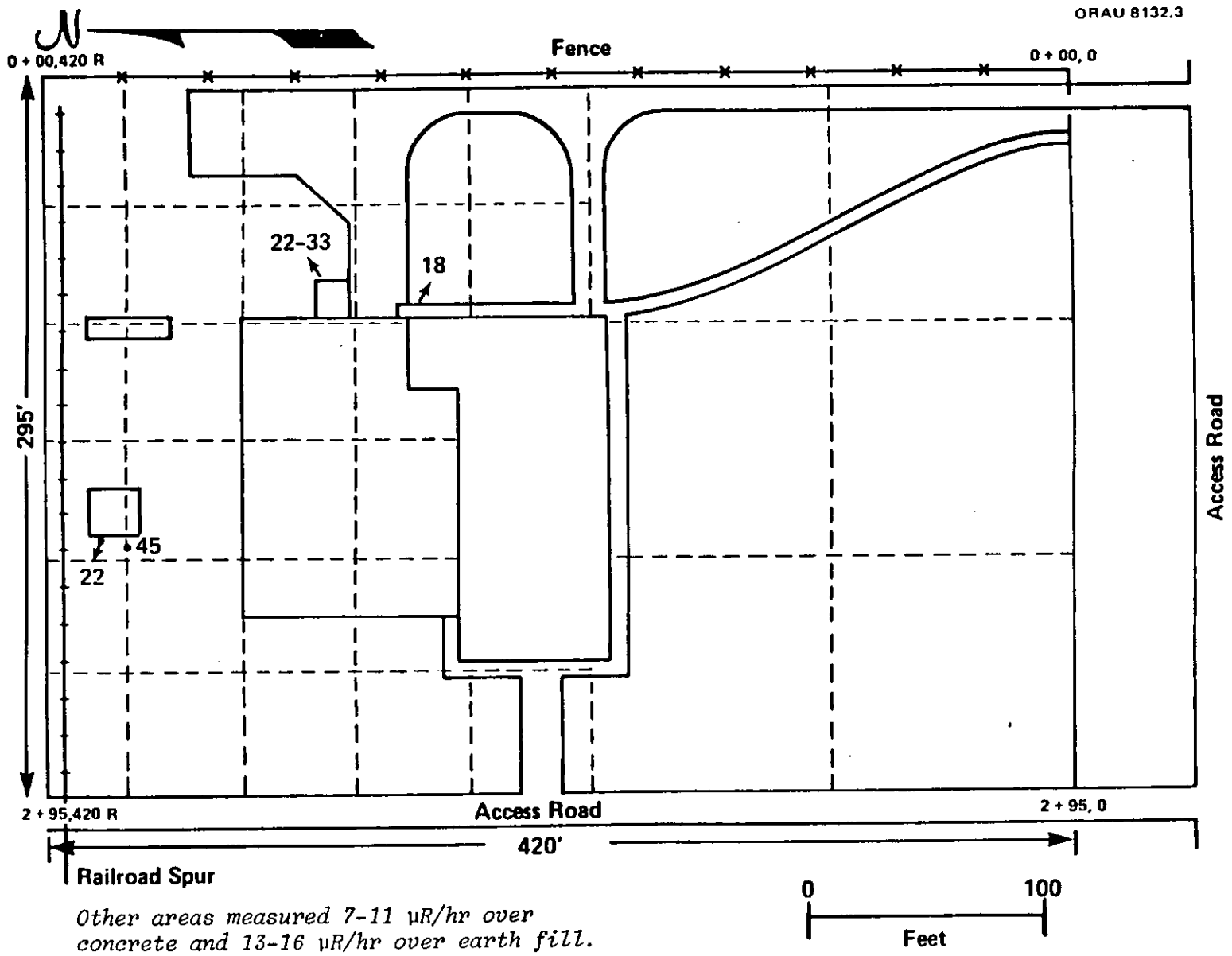


FIGURE 8. Plan view indicating locations of elevated surface gamma radiation levels (μR/hr).

TABLE 1. SUMMARY OF COMPRESSOR BUILDING SURVEY RESULTS

Location	Direct Probe Measurements [a]									Transferable Contamination [a]				
	Number of Measurements			Alpha(d/m/100cm^2)		Beta-gamma(d/m/100cm^2) [mrad/hr.] [b]		Gamma(μR/hr.)		Number of Swipes	Alpha(d/m/100cm^2)		Beta(d/m/100cm^2)	
	α	β-γ	γ	Maximum	Average[c]	Maximum	Average	Maximum	Average		Maximum	Average	Maximum	Average
Floors	21	33		80	<40	1600 [0.019]	610±740 [0.007± 0.009]	-	-	66	6	<3	<56	<56
Walls	7	10		140	<40	2600 [0.031]	1200±1300 [0.014± 0.015]	-	-	36	9	<3	71	<56
Other Surfaces	5	11		80	<40	1800 [0.021]	880±840 [0.010± 0.010]	-	-	12	<3	<3	<56	<56
1 meter above floor and contact with floor, wall, and equipment surfaces[e]	-	-	NA[d]	-	-	-	-	35	9-12	-	-	-	-	-

(a) Minimum Detectable Levels

Direct: alpha; 40 d/m/100cm^2
beta-gamma; 320d/m/100cm^2

Transferable: alpha; 3 d/m/100cm^2
beta; 56 d/m/100cm^2

(b) 8.4×10^5 d/m/100cm^2 is equivalent to approx. 1 mrad/hr.

(c) Deviation noted is 2σ; no standard deviation was determined where more than 50% of the measurements were below the Minimum Detectable Level.

(d) NA - not applicable: continuous scanning was performed during gamma scintillation measurements.

(e) Refer to Figure 7 and the text for additional information.

TABLE 2. Concentration of ^{238}U, ^{235}U, and ^{226}Ra and nickel in Soil Samples.

Location[a]	Depth (cm)	^{238}U (pCi/gm)	^{235}U (pCi/gm)	^{226}Ra (pCi/gm)	Nickel (ppm x 10^3)
0-1	0-15	4.6 ± 3.0[b]	0.08 ± 0.02[b]	1.01 ± 0.04[b]	5.3[c]
0-1	15-30	<3.0	0.07 ± 0.02	1.16 ± 0.04	2.4
0-1	45-60	<3.0	0.08 ± 0.02	1.49 ± 0.05	5.7
0-2	0-15	<3.0	0.05 ± 0.01	0.70 ± 0.03	1.2
0-2	15-30	<3.0	0.07 ± 0.02	1.42 ± 0.04	1.2
0-2	45-60	<3.0	0.06 ± 0.01	1.06 ± 0.04	0.89
0-3	0-15	4.3 ± 2.5	0.07 ± 0.02	1.04 ± 0.04	13
0-3	15-30	<3.0	0.05 ± 0.02	1.54 ± 0.05	0.90
0-3	45-60	<3.0	0.05 ± 0.01	1.00 ± 0.04	0.84
S-1	0-15	<3.0	0.06 ± 0.01	1.09 ± 0.04	1.0
S-2	0-15	<3.0	0.08 ± 0.02	1.16 ± 0.04	1.7
S-2	15-30	3.7 ± 2.4	0.08 ± 0.02	1.21 ± 0.04	1.3
S-2	45-60	3.0 ± 1.8	0.05 ± 0.01	1.09 ± 0.04	0.95
S-3	0-15	<3.0	0.20 ± 0.02	1.36 ± 0.05	0.83 ± 0.11
S-4	0-15	<3.0	0.05 ± 0.02	1.12 ± 0.04	0.88
S-4	15-30	3.2 ± 1.8	0.05 ± 0.01	0.98 ± 0.04	0.95
S-4	45-60	3.3 ± 1.8	0.06 ± 0.01	1.12 ± 0.03	0.77
S-5	0-15	<3.0	0.06 ± 0.02	1.06 ± 0.04	1.3
S-6	0-15	5.3 ± 2.8	0.08 ± 0.02	1.01 ± 0.05	1.9
S-6	15-30	3.0 ± 1.8	0.07 ± 0.01	1.17 ± 0.04	0.82
S-6	45-60	<3.0	0.06 ± 0.01	1.10 ± 0.04	1.0
S-7	0-15	<3.0	0.06 ± 0.02	1.28 ± 0.05	1.1 ± 0.1
S-8	0-15	<3.0	0.70 ± 0.20	1.15 ± 0.05	0.40 ± 0.11
S-9	0-15	7.8 ± 5.5	0.86 ± 0.03	1.87 ± 0.08	0.92 ± 0.11
S-10	0-15	3.0 ± 2.4	0.06 ± 0.02	0.92 ± 0.04	5.6
S-10	15-30	3.7 ± 1.6	0.06 ± 0.01	1.18 ± 0.04	0.88
S-10	45-60	<3.0	0.08 ± 0.02	1.01 ± 0.03	0.85
S-11	0-15	<3.0	0.04 ± 0.01	1.06 ± 0.04	5.1
S-12	0-15	4.1 ± 2.5	0.10 ± 0.02	0.94 ± 0.04	10
S-13		no sample collected.			

Table 2, cont.

Location[a]	Depth (cm)	^{238}U (pCi/gm)	^{235}U (pCi/gm)	^{226}Ra (pCi/gm)	Nickel (ppm x 10^3)
S-14	0-15	4.6 ± 2.4[b]	0.09 ± 0.02[b]	1.26 ± 0.05[b]	1.3[c]
S-15	0-15	3.3 ± 1.8	0.07 ± 0.02	1.30 ± 0.04	3.8
S-16	0-15	<3.0	0.05 ± 0.02	1.16 ± 0.04	5.5
S-17	0-15	9.0 ± 2.4	0.24 ± 0.03	1.05 ± 0.04	13
B-1	0-15	300 ± 6	9.0 ± 0.1	0.64 ± 0.03	140
B-2[d]	45-60	14 ± 2	0.46 ± 0.02	2.08 ± 0.05	not determined
B-3	0-15	5.0 ± 2.2	0.15 ± 0.02	1.54 ± 0.04	15
B-4	0-15	<3.0	0.07 ± 0.02	1.34 ± 0.04	2.4
B-4	45-60	<3.0	0.06 ± 0.01	1.36 ± 0.04	3.3
B-5		3.3 ± 2.2	0.07 ± 0.02	1.23 ± 0.04	5.1
B-6[e]	45-60	4.6 ± 2.2	0.10 ± 0.02	1.99 ± 0.04	0.61
B-7[f]	45-60	6.9 ± 1.9	0.15 ± 0.02	2.47 ± 0.05	not determined
B-8	0-15	5.3 ± 1.7	0.13 ± 0.01	0.78 ± 0.03	3.4
B-9	0-15	9.2 ± 1.9	0.07 ± 0.02	1.16 ± 0.04	1.0
B-10	0-15	22 ± 2	0.63 ± 0.02	1.73 ± 0.02	29
Minimum Detectable Concentration		3.0	0.03	0.05	0.01

[a] Refer to Figure 6 for locations of samples.

[b] Errors given are 2σ due to counting statistics only.

[c] Except as noted 2σ statistical errors are less than ±10%.

[d] After removal of surface soil at B-1.

[e] Clay beneath loading pad.

[f] Gravel fill beneath pad.

TABLE 3. Concentrations of ^{238}U, ^{235}U, and ^{226}Ra in other samples.

Sample	Location	^{238}U	^{235}U	^{226}Ra
Paint Chips	Window sill - Compressor Bldg.	<13 (pCi/gm)	<0.12 (pCi/gm)	2.25 ± 0.46 (pCi/gm) (a)
Shower Drain Residue	Change room	<12 (pCi/gm)	<0.12 (pCi/gm)	<0.12 (pCi/gm)
Cement block	Stairway - Compressor Bldg.	<12 (pCi/gm)	<0.12 (pCi/gm)	< 3.74 ± 0.61 (pCi/gm)
Water	Elevator shaft	$< 3 \times 10^{-6}$ (μCi/ml)	$< 3 \times 10^{-8}$ (μCi/ml)	$< 5 \times 10^{-8}$ (μCi/ml)
Water	Conveyor trench	$< 3 \times 10^{-6}$ (μCi/ml)	$< 3 \times 10^{-8}$ (μCi/ml)	$< 5 \times 10^{-8}$ (μCi/ml)

(a) Errors are 2σ due to counting statistics only; where errors are not given, the value represents the minimum detectable concentration.

APPENDIX A

Instrumentation and Analytical Procedures

Gamma Scintillation Measurements

Measurements of gamma radiation levels were performed using a Victoreen Thyac III Model 490 portable ratemeter with a Victoreen Model 489-5 gamma scintillation probe containing a 3.2 cm x 3.8 cm NaI(Tl) scintillation crystal. Count rates (c/m) were converted to exposure levels (μR/hr) using a factor of 450 c/m = 1 μR/hr. This factor was determined by comparing the response of the scintillation detector with that of a Victoreen Model 440 ionization chamber survey meter to gamma photons from natural uranium.

Surface Contamination Surveys

Swipes of building surfaces for removable contamination were assayed for alpha count rates using an internal gas-flow proportional counter, Nuclear Measurements Company model PCC-11T, and for beta count rates using an automatic sample counter, Baird-Atomic Model SSC-4 with a thin-window gas-flow proportional detector. Count rates were converted to disintegration rates by subtracting instrument background and applying appropriate detector calibration factors.

Measurements for total surface contamination were performed using Eberline "Rascal," Model PRS-1, portable ratemeters with Model AC3-7 ZnS(Ag) alpha scintillation probes and Model HP-260 thin-window, pancake G-M, beta probes. Count rates were converted to d/m per 100 cm^2 for comparison to removable contamination levels obtained by the swipe technique. Conversion included subtraction of background rates and applying appropriate factors for detector calibration and effective probe areas. Dose rates (mrad/hr) at 1 cm from the surface were determined by comparison of the response of a Victoreen Model 440 ionization chamber survey meter to that of the G-M probes for natural uranium. A conversion factor of 8.4×10^4 d/m per 100 cm^2 = 1 mrad/hr was determined.

Soil Samples

Soil samples were dried at 120°C, finely ground, mixed, and a portion placed in a one-liter Marinelli beaker. The quantity placed in each beaker was chosen to reproduce the calibrated counting geometry and ranged from 400 to 600 grams of soil. The beakers were capped but not sealed. Net soil weights were determined and the samples counted for 30,000 seconds using a 23% Ge(Li) detector (Princeton Gamma Tech) coupled to a Tracor Northern Model 1705 pulse height analyzer. The following energy peaks were used for determination of the radionuclides of concern:

^{238}U - 1.001 MeV from $^{234}Pa^{m}$ (secular equilibrium assumed)
^{226}Ra - 0.609 MeV from ^{214}Bi
^{235}U - 0.185 MeV

The background plus compton continuum was "stripped" by hand calculations from each of the photopeaks of interest, prior to applying appropriate calibration and correction factors.

To evaluate the effect of possible radon losses on the equilibrium of ^{214}Bi with ^{226}Ra, several soil samples were sealed in counting beakers. The relative photopeak intensities of various ^{226}Ra decay products were noted and compared to the relative intensities of capped, but unsealed, samples over a time period necessary for the ^{214}Bi peak intensity to stabilize. From this comparison it was determined that radon losses resulted in a 20% decrease in the ^{214}Bi concentration and that this condition reached an equilibrium state in the unsealed sample within approximately three days after sample preparation (drying, grinding, and placing into the beakers). Sufficient time to reach this equilibrium state was therefore allowed between sample preparation and analysis and, a correction for the 20% decrease due to radon loss was applied to all ^{226}Ra calculations based on the ^{214}Bi photopeak intensity.

For ^{235}U analysis, contributions in the 0.185 MeV photopeak area from the 0.186 MeV ^{226}Ra gamma ray were subtracted. The ratio of the 0.186 MeV to 0.609 MeV peak intensities in a soil sample containing ^{226}Ra, but no ^{235}U, was determined and this ratio was multiplied by the intensity of the 0.609 MeV photopeak in each of the samples to determine the magnitude of this contribution.

Approximately 10 grams of each soil sample was pulverized using a mortar and pestle. About 1 milligram was placed in a Spectro cup and the exact weight determined. This sample was then analyzed for 3000 seconds using an ORTEC x-ray fluorescence system with a Cd 109 source and Si(Li) detector. Nickel concentration was determined by two different methods. The first utilized the Ni Kβ emission peak to calculate the concentration in ppm directly. When this peak was obscured due to other materials in the sample, it was necessary to use the Ni Kα peak, which also contains interferences from the Fe Kβ emission peak. The ratio of Fe Kα to Fe Kβ was established using a known iron standard. The expected Fe Kβ contribution in a sample was then determined using this ratio multiplied by the Fe Kα peak intensity. Subtraction of this interference left the Ni Kα peak which was then used to calculate the nickel concentration.

Other Samples

Analysis of debris, paint scrapings, and concrete block, were performed in the same general manner as the soil samples. However, limited quantities of these materials required the use of small cups rather than Marinelli beakers, and different geometry

and gamma efficiency factors were utilized for calculations of concentrations. Water samples were filtered to remove suspended solids and analyzed in Marinelli beakers.

Calibration and Quality Assurance

With the exception of the exposure- and dose-rate conversion factors for portable survey gamma and beta-gamma meter; all survey and laboratory instruments were calibrated with NBS-traceable standards. The response of these survey meters was determined by comparison with a portable ionization survey meter, calibrated (15%) with a sealed radium-226 needle, certified by Atomic Energy of Canada, Ltd. Quality control procedures on all instruments included daily background and check-source measurements to confirm lack of malfunctions and nonstatistical deviations in equipment.

Two soil samples, obtained from the ORNL Health and Safety Research Division, were analyzed for radium-226. ORAU analysis indicated 1.55 and 4.54 pCi/gm for these samples as compared to the ORNL values of 2.10 and 4.78 pCi/gm respectively.

Portions of six RPP soil samples were analyzed by the ORNL Analytical Chemistry Group for ^{238}U and ^{235}U. The ^{238}U analysis was performed by neutron capture. Delayed neutrons from ^{235}U fission were used to determine the ^{235}U concentration. Results of these analyses are compared below with ORAU results.

Sample	^{238}U Concentration(pCi/gm)		^{235}U Concentration(pCi/gm)	
	ORAU	ORNL	ORAU	ORNL
1	14 ± 2	26	0.46 ± 0.02	1.4
2	<3	2.3	0.06 ± 0.02	0.077
3	300 ± 6	257	9.0 ± 0.1	11.8
4	3.0 ± 1.8	1.8	0.86 ± 0.02	1.0
5	5.3 ± 2.8	1.2	0.08 ± 0.02	0.066
6	<3	1.3	0.05 ± 0.02	0.066

Concentrations determined by ORNL and ORAU are in agreement within the 2 error bounds for 50% of the analyses. The remainder of the analyses differ from a low of 14% to a high of 440%. The reason for the differences is not known but investigation is continuing.

APPENDIX B

Guidelines for Decommissioning of Facilities

GUIDELINES FOR DECONTAMINATION OF FACILITIES AND EQUIPMENT PRIOR TO RELEASE FOR UNRESTRICTED USE OR TERMINATION OF LICENSES FOR BY-PRODUCT, SOURCE, OR SPECIAL NUCLEAR MATERIAL

U.S. Nuclear Regulatory Commission
Division of Fuel Cycle and Material Safety
Washington, D.C. 20555

November 1976

The instructions in this guide in conjunction with Table III-1 specify the radioactivity and radiation exposure rate limits which should be used in accomplishing the decontamination and survey of surfaces or premises and equipment prior to abandonment or release for unrestricted use. The limits in Table III-1 do not apply to premises, equipment, or scrap containing induced radioactivity for which the radiological considerations pertinent to their use may be different. The release of such facilities or items from regulatory control will be considered on a case-by-case basis.

1. The licensee shall make a reasonable effort to eliminate residual contamination.
2. Radioactivity on equipment or surfaces shall not be covered by paint, plating, or other covering material unless contamination levels, as determined by a survey and documented, are below the limits specified in Table III-1 prior to applying the covering. A reasonable effort must be made to minimize the contamination prior to use of any covering.
3. The radioactivity on the interior surfaces of pipes, drain lines, or ductwork shall be determined by making measurements at all traps, and other appropriate access points, provided that contamination at these locations is likely to be representative of contamination on the interior of the pipes, drain lines, or ductwork. Surfaces of premises, equipment, or scrap which are likely to be contaminated but are of such size, construction, or location as to make the surface inaccessible for purposes of measurement shall be presumed to be contaminated in excess of the limits.
4. Upon request, the Commission may authorize a licensee to relinquish possession or control of premises, equipment, or scrap having surfaces contaminated with material in excess of the limits specified. This may include, but would not be limited to, special circumstances such as razing of buildings, transfer or premises to another organization continuing work with radioactive materials, or conversion of facilities to a long-term storage or standby status. Such request must:

a. Provide detailed, specific information describing the premises, equipment or scrap, radioactive contaminants, and the nature, extent, and degree of residual surface contamination.

b. Provide a detailed health and safety analysis which reflects that the residual amounts of material on surface areas, together with other considerations such as prospective use of the premises, equipment or scrap, are unlikely to result in an unreasonable risk to the health and safety of the public.

5. Prior to release of premises for unrestricted use, the licensee shall make a comprehensive radiation survey which establishes that contamination is within the limits specified in Table III-1. A copy of the survey report shall be filed with the Division of Fuel Cycle and Material Safety, USNRC, Washington, D.C. 20555, and also with the Director of the Regional Office of the Office of Inspection and Enforcement, USNRC, having jurisdiction. The report should be filed at least 30 days prior to the planned date of abandonment. The survey report shall:

   a. Identify the premises.

   b. Show that reasonable effort has been made to eliminate residual contamination.

   c. Describe the scope of the survey and general procedures followed.

   d. State the findings of the survey in units specified in the instruction.

Following review of the report, the NRC will consider visiting the facilities to confirm the survey.

Table III-1. Acceptable surface contamination levels

Nuclides[a]	Average[b,c,f]	Maximum[b,d,f]	Removable[b,e,f]
U-nat, U-235, U-238, and associated decay products	5,000 dpm α/100 cm^2	15,000 dpm α/100 cm^2	1,000 dpm α/100 cm^2
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100 dpm/100 cm^2	300 dpm/100 cm^2	20 dpm/100 cm^2
Th-nat, Th-232, Sr-90 Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000 dpm/100 cm^2	3,000 dpm/100 cm^2	200 dpm/100 cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and other noted above.	5,000 dpm βγ/100 cm^2	15,000 dpm βγ/100 cm^2	1,000 dpm βγ/100 cm^2

[a] Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

[b] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[c] Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

[d] The maximum contamination level applies to an area of not more than 100 cm^2.

[e] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

[f] The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/hr at 1 cm and 1.0 mrad/hr at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.

Proposed American National Standard

ANSI N328-197

Control of Radioactive Surface Contamination on Materials, Equipment, and Facilities to be Released for Uncontrolled Use

Property shall not be released for uncontrolled use unless documented measurements show the total and removable contamination levels to be no greater than the values in Table III-2 or Table III-3. (Table III-3 is easier to apply when the contaminants cannot be individually identified.)

Where potentially contaminated surfaces are not accessible for measurement (as in some pipes, drains, and ductwork), such property shall not be released pursuant to this standard, but made the subject of case-by-case evaluation. Credit shall not be taken for coatings over contamination.

Table III-2. Surface contamination limits

The levels may be averaged[a] over the 1 m^2 provided the maximum activity in any area of 100 cm^2 is less than 3 times the limit value.

Nuclide	Limit (activity) dpm/100 cm^2	
	Total	Removable
Group 1: Nuclides for which the nonoccupational MPC_a[b] is 2×10^{-13} Ci/m^3 or less or for which the nonoccupational MPC_w[c] is 2×10^{-7} Ci/m^3 or less; includes Ac-227; Am-241; -242m, -243; Cf-249; -250, -251, -252; Cm-243, -244, -245, -246, -247, -248; I-125, -129; Np-237; Pa-231; Pb-210; Pu-238, -239, -240, -242, -244; Ra-226, -228; Th-228, -238.[d]	100	20
Group 2: Those nuclides not in Group 1 for which the nonoccupational MPC_a[b] is 1×10^{-12} Ci/m^3 or less or for which the nonoccupational MPC_w[c] is 1×10^{-6} Ci/m^3 or less; includes Es-254; Fm-256; I-126, -131, -133; Po-210; Ra-223; Sr-90; Th-232; U-232.[d]	1000	200
Group 3: Those nuclides not in Group 1 or Group 2.	5000	1000

[a] See note following table on applications of limits.

[b] MPC_a: Maximum Permissible Concentration in Air applicable to continuous exposure of members of the public as published by or derived from an authoritative source such as NCRP, ICRP, or NRC (10 CFR 20, Appendix B, Table 2, Column 1).

[c] MPC_w: Maximum Permissible Concentration in Water applicable to members of the public.

[d] Values presented here are obtained from 10 CFR Part 20. The most limiting of all given MPC values (e.g., soluble vs. insoluble) are to be used. In the event of the occurrence of a mixture of radionuclides, the fraction contributed by each constituent of its own limit shall be determined and the sum of the fractions must be less than one.

Table III-3. Alternate surface contamination limits

(All alpha emitters, except U-nat and Th-nat are considered as a group.) The levels may be averaged over 1 m^2[a] provided the maximum activity in any area of 100 cm^2 is less than 3 times the limit value.

Nuclide	Limit (activity) dpm/100 cm^2	
	Total	Removable
If the contaminant cannot be identified; or if alpha emitters other than U-nat and Th-nat are present; or if the beta emitters comprise Ac-227, Ra-226, Ra-228, I-125, and I-129.	100	20
If it is known that all alpha emitters are generated from U-nat and Th-nat; and beta emitters are present which, while not identified, do not include Ac-227, I-125, I-129, Ra-226, and Ra-228.	1000	200
If it is known that alpha emitters are generated only from U-nat and Th-nat; and the beta emitters, while not identified, do not include Ac-227, I-125, I-129, Sr-90, Ra-223, Ra-228, I-126, I-131, and I-133.	5000	1000

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[a]Note on application of Tables III-2 and III-3 to isolated spots or activity:

For purposes of averaging, any m^2 of surface shall be considered to be contaminated above the limit, L, applicable to 100 cm^2 if:

a. From measurements of a representative number, n, of sections, it is determined that $1/n \sum_{1}^{n} Si \geq L$, where Si is the dpm/100 cm^2 determined from measurement of section i; or

b. On surfaces less than 1 m^2, it is determined that $1/n \sum_{1}^{n} Si \geq AL$, where A is the area of the surface in units of m^2; or

c. It is determined that the activity of all isolated spots or particles in any area less than 100 cm^2 exceeds $3L$.

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