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COMPLETION REPORT FOR THE EXTERIOR FOAM APPLICATION/RADON TREATMENT SYSTEM OPERATION OF THE K-65 INTERIM STABILIZATION PROJECT - FEED MATERIALS PRODUCTION CENTER

05/23/88

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DOE/USEPA
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REPORT
OU4

Department of Energy
Oak Ridge Operations
P. O. Box E
Oak Ridge, Tennessee 37831

May 23, 1988
DOE-871-88

Mr. William D. Franz, Chief
Environmental Review Branch
Planning & Management Division
U. S. Environmental Protection Agency
Region V - 5ME-12
230 S. Dearborn Street
Chicago, Illinois 60604

Dear Mr. Franz:

COMPLETION REPORT FOR THE EXTERIOR FOAM APPLICATION/RADON TREATMENT SYSTEM OPERATION OF THE K-65 INTERIM STABILIZATION PROJECT - FEED MATERIALS PRODUCTION CENTER (FMPC)

Reference is made to the letter from W. H. Muno to me, dated August 14, 1987, subject "RI/FS For K-65 Silos". A copy is provided as Enclosure 1.

Pursuant to Item B of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Section of the Federal Facilities Compliance Agreement (FFCA) between the Department of Energy (DOE) and the United States Environmental Protection Agency (USEPA), the exterior foam weatherproof coating of the silo domes has been completed as part of the K-65 Interim Stabilization Project at the Feed Materials Production Center (FMPC). Enclosure 2 is the subject Completion Report.

The Completion Report describes the work involved in the construction and operation of a radon treatment system and in the application of foam to the exterior of each K-65 silo dome. The remainder of the K-65 Interim Stabilization Project involves the application of foam inside each of the K-65 Silos. This activity is currently under design review to address design concerns in the areas of foam application, together with exothermic characteristics and expansive natures of the foam materials.

In addition to completion of the external foaming, activities are underway to safely complete internal stabilization of the silos and fulfill the interim remedial measures identified in CERCLA Part B, FFCA. DOE will continue to provide an ongoing status of the remaining interim remedial measures for the K-65 Silos at the monthly Technical Information Exchange (TIE)

meetings. We feel it is prudent to complete the current course of activities to fulfill the requirements of CERCLA Part B of the FFCA rather than integrate interim remedial measures with the Remedial Investigation/Feasibility Study (RI/FS) for the K-65 Silos as described in the referenced letter. We have revised our original request and feel it is more appropriate to conduct the alternatives study for remediation of the K-65 Silos via the RI/FS schedule outlined in Revision 3 of the workplan. Acceleration of K-65 Silo activities in a manner other than what is outlined under the proposed interim remedial measures could potentially compromise the health and safety concerns already raised for your attention in monthly TIE meetings.

Please contact Margaret Wilson of our Environmental Protection Division at FTS 626-8528, if you have any questions.

Sincerely,

James A. Reafsnyder
Site Manager

DP-84:Reafsnyder

Enclosures: As stated

cc w/encl.:
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Original File Copy

4374

Westinghouse
Materials Company
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WMCO:SR(WR)88:134
April 18, 1988

James A. Reafsnyder
Site Manager
U. S. Department of Energy
P. O. Box 398705
Cincinnati, Ohio 45239

Dear Mr. Reafsnyder:

SUBJECT: REVISED COMPLETION REPORT FOR THE EXTERIOR FOAM APPLICATION/RADON TREATMENT SYSTEM OPERATION OF THE K-65 INTERIM STABILIZATION PROJECT

References: 1) Letter, W. A. Weinreich to J. A. Reafsnyder, "Completion Report for the Exterior Foam Application/Radon Treatment System Operation of the K-65 Interim Stabilization Project," dated February 4, 1988. B-816

2) Letter, J. A. Reafsnyder to M. B. Boswell, "Completion Report for the Exterior Foam Application/Radon Treatment System Operation of the K-65 Interim Stabilization Project," dated March 9, 1988.

The purpose of this letter is to transmit the revised Completion Report for the K-65 Interim Stabilization Project: Exterior Foam Application/Radon Treatment System Operation. Revisions have been made to the original Completion Report (Reference 1) in response to the specific DOE review comments for the document (Reference 2).

The Completion Report describes the work that was completed as a part of the K-65 Interim Stabilization Project. This work involved the construction and operation of a radon treatment system and the application of foam to the exterior of each K-65 silo dome. The remaining portion of the K-65 Interim Stabilization Project involves the application of foam inside each of the K-65 Silos, and is currently undergoing design review by WMCO to address design concerns in the areas of foam application and the exothermic and expansive nature of the foam materials.

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Specific DOE review comments (Reference 2 - Attachment) have been reviewed by WMCO and have been incorporated into the revised Completion Report as noted. The Completion Report has been revised to reflect DOE review Comments #1, #2, #4, #6, #8, #9, #10, #12, #13 and #15 as noted by the DOE.

In response to DOE review Comment #3, the Completion Report has been revised to read "working level grab sample" in place of "breathing zone sample." Working levels cannot be converted to pCi/Liter radon unless each daughter concentration is known. The Kusnetz method used does not measure individual daughter concentrations.

In response to DOE review Comment #5, the dose rate at the dome surface dropped from approximately 200 mrem/hr to less than 70 mrem/hr after the radon treatment system was shutdown. Even though the radon and daughter products began increasing the dose rate immediately following the system shutdown, the dose rate was kept below 100 mrem/hr by restarting the system, as required.

Continuing with DOE review Comment #5, the charcoal adsorption efficiency was not measured during the exterior foaming of the K-65 Silo domes. WMCO is planning to measure the charcoal adsorption efficiency during the internal foaming of the K-65 Silos. An Eberline Sam assay meter with a Tl doped 3" X 3" sodium iodide gamma scintillation crystal will be used to qualitatively estimate the radon concentration before and after the charcoal adsorption system. This system will qualitatively measure reductions but, since it is not calibrated, it will not measure concentrations of radon. Calibration of this system is not practical without a major research project. Radon daughter plate out within the PVC pipe, static charging of the pipe, filter efficiency and constantly changing radon concentration make calibration very difficult. Also, industry does not have the equipment to measure radon at these levels. WMCO feels it is not practical or advisable to procure gas bag grab samples since the dose rate at the pipe surface are too high and would result in unacceptable personnel exposures. When WMCO was studying the feasibility of continuous radon monitoring during system development, WMCO considered developing either a small volume flow through ionization chamber or a system to provide measured gas dilution to a mixing box and then run the gas through an RGM-II or RGA-40 continuous radon monitor. The flow through ionization chamber would take months of development and calibration work and would probably cost in excess of $10,000. The latter system will cost $18,000 just for the RGM-II continuous radon monitor. Temperature, humidity, and velocity instrumentation would further increase the cost.

Finally, for DOE review Comment #5, "poisoned" charcoal will be removed from the adsorption system and treated as low level waste prior to the start of the internal foaming operations.

In response to DOE review Comment #7, it is WMCO's position that the increase in radon concentration outside the containment bag did not result from leakage from an imperfect seal around the containment bag against the manway flange. If radon did escape due to an imperfect seal around the containment bag, the volume would be insignificant compared to the volume of radon that would have escaped due to diffusion through the containment bag. This is due to the containment bag having more surface area through which radon can diffuse compared to an imperfect seal.

In response to DOE review Comment #11, measurements at locations #20 were not taken while the radon treatment system was operating on each silo because the dose rates within this area were excessive due to radon daughters plating out on the inner pipe elbow walls. A measurement at location #21 could have been taken during the operation for Silo 1 since this location is positioned on the side where the circulating air would have already filtered through the radon treatment system. Measurements at this location during the operation for Silo 2 indicated the radiation levels did not increase significantly during the operation of the radon treatment system.

In response to DOE review Comment #14, the wind direction at the time the NW monitor was reading increased radon concentrations was directly from the south (182°). Consequently, the monitors located north of the K-65 Silos were detecting the increased radon concentrations.

Your approval and submittal of the Completion Report to the U. S. and Ohio EPA is requested.

Very truly yours,

R. C. Kispert for

L. C. Bogar
Vice President &
Manager, Site Remediation

PAS/ksv

Attachment

cc w/ attach:

S. L. Bradley
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H. D. Christiansen
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Central Files

cc w/o attach:

C. J. Brown
M. A. Gibson (MK65s05)
A. L. Hannum (K65-86008)

ENCLOSURE 1

4374

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
230 SOUTH DEARBORN ST.
CHICAGO, ILLINOIS 60604

REPLY TO THE ATTENTION OF:
5HE-12

14 AUG 1987

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

James A. Reafsnyder
U.S. Department of Energy
P.O. Box ~~3798705~~ 398705
Cincinnati, Ohio 45325-8705
9

Re: RI/FS For K-65 Silos
U.S. DOE FMPC - Fernald, Ohio
OH6 890 008 976

Dear Mr. Reafsnyder:

The purpose of this letter is to confirm discussions between the United States Environmental Protection Agency (U.S. EPA) and the United States Department of Energy (U.S. DOE) regarding U.S. DOE's Remedial Investigation/Feasibility Study (RI/FS) at the Fernald, Ohio facility. On July 21, 1987, U.S. DOE requested approval from U.S. EPA to accelerate the RI/FS for the K-65 silos. This change could lead to a separate Record of Decision (ROD), approximately one year earlier than the ROD for the entire site.

U.S. EPA feels the acceleration of the K-65 silo RI/FS is environmentally beneficial and this proposal is acceptable upon the following conditions:

1. It is understood that the ROD for the overall site may influence decisions and activities under the previously issued K-65 silos ROD;

2. Interim remedial measures for securing the K-65 silos proceed without delay;

3. The pipeline leading to the K-65 silos and surrounding areas be included in the K-65 silos accelerated RI/FS;

4. All environmental monitoring and sampling surrounding the K-65 silos also be accelerated; and

5. The accelerated K-65 silo RI/FS program should in no way impinge on funds or activities for the full-site RI/FS.

A technical proposal outlining interim remedial measures and a schedule for the K-65 silos should be submitted to U.S. EPA and the Ohio Environmental Protection Agency (OEPA) within thirty (30) days.

Please contact Catherine McCord at (312) 886-1478 if you have any questions.

Sincerely yours,

William H. Miner, Chief
Hazardous Waste Enforcement Branch

cc: Rick Collier, U.S. DOE

Graham Mitchell, OEPA-SWDO

Rich Bendula, OEPA-SWDO

Michael Savage, OEPA-CO

ENCLOSURE 2

COMPLETION REPORT

K-65 INTERIM STABILIZATION PROJECT

EXTERIOR FOAM APPLICATION/RADON

TREATMENT SYSTEM OPERATION

REVISION 1

April, 1988

Prepared by

J. T. Grumski and P. A. Shanks

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ACKNOWLEDGMENT

The authors would like to acknowledge the extensive efforts and diligence of Steven M. Ferguson in performing radiation monitoring during the project and L. Scott Walker for his in-depth review of this report. The entire K-65 Interim Stabilization Project has been a team effort by WMCO, DOE, The RUST Engineering Company, USEPA, and OEPA.

EXECUTIVE SUMMARY

The Feed Materials Production Center (FMPC) has implemented actions involving interim stabilization of the two K-65 waste storage silos. The primary purpose of the project is to provide additional structural support to the K-65 Silo domes and reduce radon emissions from the silos. Specifically, the project involved construction and operation of a radon treatment system and an external foam application (weatherproofing) in the Fall of 1987 to be followed by internal silo foaming operations in the Spring, 1988.

The radon treatment system was operated nine times between November 23 and December 6, 1987, for the purpose of adsorbing radon contained within the silos onto activated carbon. The radon system operation reduced penetrating radiation levels on the K-65 Silo domes by an average of 60 to 70% without increasing ambient radon levels at the K-65 Silo fenceline. The exterior foam application was conducted between November 25 and December 6, 1987. The foaming consisted of applying a three-inch layer of rigid polyurethane foam to the outer dome surface and a 1.5-inch layer to the dome cap. This was followed by a 45 dry mil (0.045 inches thick when dry), waterproof, ultra-violet resistant, urethane finish coating.

The following benefits are derived from the external foam application:

- Weather protection of the K-65 Silo domes
- Insulation of the silo domes
- Improvement to the structural integrity of the silo dome due to the rigid foam application
- Reduction of radon emissions.

The insulation of the silo domes will reduce stresses in the concrete caused by expansion and contraction and radon emissions caused by heating and expansion of the silo gases. Radon emissions will also be reduced due to the attenuating ability of the rigid foam application.

The total whole body, penetrating radiation dose for all construction and operation activities related to the K-65 Interim Stabilization Project to date was recorded as approximately 6110 mrem. The estimated project dose was calculated to be 29.6% higher or 7920 mrem.

The total project cost to date is approximately $665,000, comprising of $443,000 for the treatment system and $222,000 for the external foam application. Internal foaming operations for both silos next Spring is estimated to require an additional $1.5 million. All project funding is provided by Program GF-01.

1.0 INTRODUCTION

Westinghouse Materials Company of Ohio (WMCO) operating under its prime contract with the Department of Energy (DOE), is responsible for waste remediation and management of low-level radioactive materials at the Feed Materials Production Center (FMPC) located in Fernald, Ohio.

As part of the comprehensive waste remediation and management program for the FMPC, specific interim actions have been implemented to maintain the K-65 waste storage silos in the most environmentally safe containment mode possible until final remedial alternatives can be evaluated and implemented. Details relating to the structure, history, and waste content of the K-65 Silos can be found in Reference 1.

The K-65 Interim Stabilization project was developed in response to Item B of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Section of the Federal Facilities Compliance Agreement between the Department of Energy (DOE) and the United States Environmental Protection Agency (USEPA). Included in Item B are the requirements that the DOE do the following: 1) implement interim control of radioactive emissions, including radon and radon decay product emissions from the K-65 Silos and 2) provide interim controls to ensure the structural integrity of the two K-65 Silos. WMCO prepared a Feasibility Investigation (FI) that evaluated alternatives for the control of radon emissions from the K-65 Silos (Reference 1). Based upon this evaluation, the FMPC recommended the alternative to fill the void space in the K-65 Silos with polymeric foam, including a temporary solid media adsorption system to treat the initial displaced gas.

The recommended alternative was further developed by WMCO in the Conceptual Design Report (CDR, Reference 2). The final detailed project design was prepared by Advanced Sciences Incorporated (ASI) in conjunction with International Technology Corporation (IT) (Reference 3) based on the FI and CDR.

This completion report describes the work that was undertaken as part of the K-65 Interim Stabilization Project that involves internal and external applications of polyurethane foam while providing for safe treatment of the accumulated and continually generated radon contained within the K-65 Silos. The operation of the radon treatment system and the exterior foam application was completed on December 6, 1987. The internal foam application, designed to fill the air space above the waste residues inside each K-65 Silo, has been postponed until the Spring of 1988, due to cold temperature conditions in the Fall of 1987.

The radon treatment system was designed and constructed using the best available practical technology to safely remove continuously generated radon within the K-65 Silos. The primary purpose of operating the radon treatment system prior to the external foam application was to reduce as low as reasonably achievable (ALARA) the whole body radiation dose to personnel involved in the project. Another very important purpose was to demonstrate the success of the radon treatment system prior to filling the silo inner space with polyurethane foams in the Spring of 1988. The radon, however, is continually generated from the Ra-226 contained in the K-65 Silo residues and the reduction in radiation dose levels is temporary. Primary system components include carbon beds, dehumidification beds, a fan for circulation and specially designed flange assemblies to replace the four manway covers on each silo. The basic operation of the system allows for removal of the

contaminated air from the K-65 Silos, transport to the treatment building, removal of moisture, adsorption of the radon, and return of the clean, dry air to the K-65 Silos.

The foam coating (weatherproofing) was applied to the exterior dome surface of both the K-65 Silos. The foaming process involved the application of a two-component, black, urethane primer that is used to help bond the polyurethane foam to the application surface. The second step involved the application of approximately 3 inches of two component rigid, closed cell, polyurethane foam to the outer concrete dome surface and approximately 1.5 inches to the dome covers. The final step involved applying an approximate 45 dry mil thickness (0.045 inches thick when dry) of waterproof, ultra-violet resistant, silver grey urethane material over the entire silo dome surfaces.

The remaining sections of this report deal with the radon treatment system operation, external foam application, radiation monitoring data, air monitoring data and funding/cost summary for the construction and operation activities including personnel radiation dose.

2.0 RADON TREATMENT SYSTEM

2.1 Overview

Figure 2.1-1 illustrates the basic components of the radon treatment system. The radon treatment system was originally designed for a one-time use for each K-65 Silo. This design assumed a system airflow of 1,000 ft^3/min., an initial radon curie content in the air space above the residues of 37 Ci and a one-time, 10-volume turnover for each silo. It is estimated that at least 0.4 Ci of radon remained in the silos after treatment because of continual generation of radon. For the external foam application, a target reduction in the radon curie content was not defined. The controlling criterion for the radon system operation was based on the gamma radiation exposure rates at the silo dome surfaces rather than the radon concentration within the silos. Although the dome surface exposure rate is proportional to the radon concentration within the silo, accurate results can be obtained in less time by measuring the dome surface exposure rates.

The specific objective for the operation of the radon treatment system was the reduction of the silo dome surface radiation dose rate to less than 100 mrem/hr. Specific data concerning the efficiency of the radon treatment in reducing silo radiation levels is detailed in Section 5.0, Radiation Monitoring Data.

2.2 Construction

The construction of the radon treatment system was initiated October 5, 1987 and was completed on November 17, 1987. The major phases of construction involved the following: construction of the treatment building and installation of the 2 calcium sulfate drier canisters, 8 charcoal adsorption canisters, and 2 fan units; erection of the 32-inch-thick concrete block radiation shielding wall around the treatment building; connection of the system transfer piping; and changeout of the flanges on the silo domes.

The most crucial phase of the construction involved the flange changeout on the existing four manways of each K-65 Silo. Specifically, the flange changeout involved the removal of the existing flange covers on the silo manways and replacing them with specially designed flanges using a containment bag procedure. The new flanges were designed to facilitate the connection of the silos to the treatment system piping and allow greater air flow through the manways during radon treatment. Air monitoring data and personnel dose for the flange changeout operation are reported in Sections 6.2 and 7.2, respectively.

2.3 Operation

An operation summary of the radon treatment system for the K-65 Silos (Silo 1 and Silo 2) is outlined in Table 2.3. The radon treatment system was operated five times (10.6 hours total) for K-65 Silo 1 and four times (9.6 hours total) for K-65 Silo 2. The operation time and duration of the radon treatment system was determined by the predicted weather conditions, the radiation levels at the dome surface, and the readiness of the foaming subcontractor. If the weather conditions were predicted to be acceptable for a four hour period and the foaming subcontractor could be ready to work for the majority of the four hour period, the radon treatment system was operated to reduce the radiation dose rate at the silo dome surface to less than 100 mrem/hr.

Prior to operation of the radon treatment system, baseline radiation surveys and baseline air monitoring were conducted. Radiation dose rates on the dome surfaces of Silos No. 1 and 2 were approximately 195 and 230 mrem/hr., respectively. During operation of the radon treatment system and immediately after, radiation surveys and air monitoring were conducted continuously. The survey and monitoring data are presented in Sections 5.0 and 6.0 respectively.

To operate the radon treatment system, a designated set of valves were opened to provide a flow path for the air from a K-65 Silo, through the two calcium sulfate beds, through two of the charcoal beds and then return the air to the silo. After the flow path was verified and baseline monitoring conducted, the blower unit was turned on and the pressure drop across the fan immediately verified. The pressure drop measurement across the blower unit was used as a continuous check to ensure that flow conditions were stable. The treatment system operates as a closed, recirculating system so that the radon component of the silo air volume is continuously adsorbed onto the charcoal beds. It is estimated that an air volume changeout took 38 minutes for K-65 Silo 1 and 48 minutes for K-65 Silo 2, based on a system flowrate of 1000 ft^3/min and air volumes of 38,000 ft^3 and 48,000 ft^3 respectively.

After the radiation levels on the dome surface did not decrease with continuing radon treatments, the blower unit was shut-off and all of the system valves closed. Radiation and air monitoring was then conducted and if the dose rates were less than 100 mrem/hr, the foaming subcontractor personnel were allowed access to the K-65 Silos.

3.0 EXTERIOR FOAM APPLICATION

3.1 Overview

Weather conditions played a major role as to whether the exterior foam application could begin each day. The two component, black, urethane primer could be applied at temperatures above 35°F, minimal wind conditions, and a dry dome surface. The primer material would not adhere to the dome surface if these weather conditions were not met. The two component, rigid, closed cell, polyurethane foam and the waterproof, ultra-violet resistant, silver-grey urethane material are ideally applied at temperatures above 40°F, minimal wind conditions, dry surface, and a relative humidity below 70%. The temperature criterion became less critical once the first layer of rigid foam material was applied due to the insulating properties of the first foam layer. In addition, the final coating is less temperature restrictive than the rigid foam layer and can be applied down to temperatures as low as 20°F. The foam applicators and WMCO personnel were on stand-by each day until weather criteria were met to start the foam application.

3.2 Foam Loading

Table 3.1-1 presents information relating the density, application thickness, and loading of the polyurethane rigid foam material and final urethane coating material. The weight of the primer material is negligible. Two thicknesses are computed in Table 3.1-1 for the rigid foam material: the 3 inch thickness applied on the outer dome area and the 1.5 inch thickness applied on the dome cap. The same final coating thickness was applied to the outer dome area and dome cap.

Table 3.1-2 presents material loading information relating to the two surface areas of the dome, the cap and outer dome area. The surface area of a dome cap is 707 ft^2. The foam materials increased the loading on the cap by 0.72 lb/ft^2 which is approximately 1% of the allowable limit (70 lb/ft^2). The surface area of the outer dome area is 4320 ft^2. The foam materials increased the loading on the outer dome area by 1.08 lb/ft^2 which is approximately 1.5% of the allowable limit (70 lb/ft^2). The total weight added to the silo dome is calculated to be 5,175 pounds.

Based upon the information in Tables 3.1-1 and 3.1-2 and the Camargo Report (Reference 4), the additional weight added to the K-65 Silo domes due to the foam application is well within allowable load limits listed in the above tables. In addition, the rigid foam material adds to the structural integrity of the K-65 Silo dome.

4.0 PROJECT BENEFITS

4.1 Radon Treatment Systems

The most significant benefit of the radon treatment system operation in conjunction with the Phase 6 foam application was a 60 - 70% average reduction in whole body radiation dose to the personnel performing the work. In addition, a method of reducing radon concentration within the K-65 Silos has been successfully demonstrated. The treatment system operation will be necessary to support the internal foaming and residue sampling scheduled for the Spring, 1988.

4.2 External Foam Application

The benefits derived from the external foam application are significant. First, the foam coating will protect the concrete silo domes from further exterior deterioration caused by weather elements. Secondly, the foam will insulate the K-65 Silos and reduce temperature fluctuations in the silo head space. The moderation of temperature fluctuations reduces expansion and contraction stress to the dome concrete and radon emission caused by displacement of the expanded gases within the dome. Thirdly, the rigid foam material coupled with the urethane coating provides additional structural integrity to the K-65 Silos. Thus, the probability of a center dome collapse with the release of radon, radon daughters, and particulates is lessened. Lastly, the polyurethane foam materials have been verified by independent testing as an excellent barrier for attenuating the diffusion of radon (Reference 5). The bulk diffusion coefficient for the rigid polyurethane foam material was determined to be approximately 4.0×10^{-6} cm^2/sec. In comparison, most clay cover materials have bulk diffusion coefficients in the range of 10^{-2} to 10^{-4}, depending on moisture content and density. The exterior foam coating should therefore reduce the flux rate of radon emanating from the silo dome surfaces.

5.0 RADIATION MONITORING DATA

5.1 Monitoring Techniques

Whole body penetrating radiation dose was measured using either a handheld ionization chamber or a GM type teletector device. Radiation dose surveys conducted on a routine basis during the K-65 flange changeout operation remained consistent because no radon treatment occurred. The most critical monitoring of penetrating (gamma) radiation occurred during the radon treatment system operation. Figure 5.1-1 illustrates the radiation survey locations that were monitored during radon treatment of the K-65 Silos.

5.2 Radon Treatment System Radiation Monitoring

Table 5.2-1 contains the radiation monitoring data from the initial radon treatment system operation of K-65 Silos No. 1 and 2. The data, listed in mrem/hr, represents the baseline readings taken prior to operation of the treatment system and readings taken during operation of the radon treatment system. The numbered locations can be referenced to Figure 5.1-1 which show the locations of the monitoring. The radiation monitoring data are representative of the nine times the treatment system was operated. Note that the readings taken on the unshielded roof of the radon treatment system (11, 12 & 13) are significantly higher for the Silo 2 baseline than the Silo 1 baseline measurement. The reason for the higher baseline readings is that the radon that was adsorbed onto the activated carbon from the Silo 1 treatment was radioactively decaying during the Silo 2 treatment. Recall that radon has an approximate half-life of 3.8 days.

The highest radiation dose rate measured, however, was observed at the pipe inlet to the radon treatment system (Figure 2.1-1). The dose rate which was measured as high as 13,500 mrem/hr was a result of radon daughter plateout in the calcium sulfate dehumidifier canisters and decayed off with an approximate 30 minute half-life. Because the piping on the outlet side of the radon treatment system (Figure 2.1-1) did not show a significant radiation dose rate increase, the dehumidifier canisters were extremely effective at trapping the radon daughters.

5.3 K-65 Silo Radiation Monitoring

The radiation, dose rate increase occurring after radon treatment is represented in Figures 5.3-1 and 5.3-2 for K-65 Silo 1 and K-65 Silo 2 respectively. The horizontal baseline across the top of each of the Figures indicates the average dome surface gamma radiation levels prior to radon treatment. The after treatment, gamma radiation levels on the dome surface are plotted following the last radon treatment for each silo. At the time of this completion report, the K-65 Silos dome surface radiation levels remained below the levels prior to radon treatment.

During the design phase of the radon treatment system, the regeneration rate of radon from the residues in the K-65 Silos, after radon treatment, was calculated by using diffusion equations to be approximately 0.28 Ci/hr. Based upon the dose rate data presented in Figures 5.3-1 and 5.3-2, the calculated regeneration rates for K-65 Silos No. 1 and 2 are approximately 0.26 Ci/hr and 0.42 Ci/hr, respectively. The higher regeneration rate of radon in K-65 Silo 2 indicates that radon diffuses faster through the residues or the radium concentration is higher near the surface of the residues as compared to Silo 1. The radium concentration in the K-65 Silos is expected to be equal or slightly higher in Silo 1.

6.0 AIR MONITORING DATA

6.1 Monitoring Techniques

6.1.1 Working Level Grab Sampling

Working Level (WL) grab samples were used to obtain a short-term interpretation of the radon daughter activity present in various monitoring locations. Radon daughter activity is measured in units of Working Levels (WL). A Working Level is a unit of measure defined as any combination of short-lived radon daughters per liter of air (without regard to equilibrium) which, in decaying completely through Po-214, will result in the emission of 1.3×10^5 million electron volts (MeV) of alpha energy. The samples were collected using a portable, battery-powered air pump that draws a set volume of air through a small filter where particulates are collected. The WL grab samples were normally taken over a five minute period at a flowrate of 2 liters/min. which yielded a 10 liter sample volume. After the sampling period, the filter paper was then counted for gross alpha activity using one of two techniques. The first method, commonly referred to as the Kusnetz procedure (Reference 6), involves a five minute sampling period followed by a two minute count for total alpha activity any time between 40 and 90 minutes after the end of sampling.

The WL calculation for the Kusnetz technique is determined as follows:

$$WL = \frac{C}{K_{(t)}\ V\ E}$$

where

C = Sample counts/min. - Background counts/min.

$K_{(t)}$ = Kusnetz factor (from tables)

V = Total sample air volume in liters

E = Counter efficiency in $\frac{\text{Counts/min}}{\text{dis/min}}$

The second method, commonly referred to as the Rolle method (Reference 7), involves a five minute sampling period followed by a two minute count for total alpha activity exactly 8.5 minutes after the end of sampling. The WL calculation is the same as the Kusnetz technique, however, the Kusnetz factor is replaced by a conversion factor (Reference 7).

Both the Kusnetz technique and Rolle method are accepted methods for determining the WL concentration of radon daughters and are normally accurate to within 30%. The Rolle method, due to the fast WL determination, was used more frequently during the operational stages of Phase 6 of the K-65 Interim Stabilization Project.

6.1.2 Radon Monitors (RGM-2)

Continuous radon monitoring is conducted at the K-65 fenceline using alpha scintillation devices (RGM-2) made by Eberline. The RGM-2 unit first draws filtered air through a ZnS(Ag) scintillation cell. As the radon contained in the air decays by alpha emission, the ionized daughters plate out on the interior surface of the cell. The daughters decay further, emitting alpha particles that cause scintillations to be detected. The signals produced by the scintillation detection are electrically processed and the results printed out every hour in pCi/liter of radon. The data from the RGM-2 units is used directly in determining radon concentrations in the area of the K-65 Silos. The pCi/liter unit can be converted into the Working Level (WL) unit by assuming an equilibrium concentration of the radon daughters. For instance, assuming that the radon daughters are in 100% equilibrium with the parent radon, then one WL of radon daughters is equal to 100 pCi/liter of radon. At 50% equilibrium of radon daughters, one WL is equal to 200 pCi/liter of radon. For converting pCi/liter measurements from the RGM-2 in WL, the most conservative approach is to assume 100% equilibrium of radon with its daughter products.

6.1.3 Interior Silo Gas Sampling

Gas samples were taken from the interior of K-65 Silos No. 1 and 2 on November 4, 1987. Samples were taken in multi-layer gas bags and glass flasks. WMCO analyzed the samples taken in the glass flasks by evacuating a one liter Lucas cell and then adding 10 milliliters of gas sample from a gas-tight syringe. Four samples were also taken to Mound Laboratories for analysis. The sampling bags taken to Mound Laboratories were diluted by WMCO to 100 parts of air to 1 part gas sample. The results of the K-65 Silo gas sample analyses are reported in Table 6.1.3-1. The glass flask sample activities analyzed by both WMCO and Mound Laboratories were approximately 2.6×10^7 pCi/liter for K-65 Silo 1 and 3.0×10^7 pCi/liter for K-65 Silo 2. The Mound Laboratories analysis for the glass flask samples were within 4% of the WMCO analysis. The sampling bag gas analyses performed by Mound Laboratories were approximately 8% (2.3×10^7 pCi/liter) and 55% (1.3×10^7 pCi/liter) lower than the glass flask analyses for the K-65 Silos No. 1 and 2 respectively. The reason for the difference between the sampling bag and the glass flask analyses is most likely the result of dilution error associated with the sample bag procedure. Subsequent counting of the gas sampling by WMCO allowed calculations that indicated a 3.8 day half-life which confirms that the gas sample was radon. The results of Mound Laboratories analyses and the data interpretation by WMCO are presented in the Appendix. In comparison, FMPC radon monitoring results between September 20, 1984 and December 5, 1985 ranged from 5.1 pCi/liter near the K-65 Silos to 0.24 pCi/liter at locations farthest downwind along the eastern FMPC site perimeter (approximately 0.75 miles). Note, the average background radon concentration for other locations in the northeastern United States ranged from 0.2 to 0.3 pCi/liter (Reference 1).

6.2 Flange Changeout

6.2.1 Silo 1

Four specially designed flange assemblies were installed to replace the four manway covers on the K-65 Silo 1 (South Silo) on Wednesday, November 4, 1987 between the hours of 10:00 a.m. and 12:00 noon. The flange changeout was necessary to facilitate the hookup between the radon treatment system and K-65 Silo 1.

Three WL grab samples were collected during the K-65 Silo 1 flange installation. The WL grab sample was collected in the immediate vicinity of the containment bags for three of the four flange installations. No sample was obtained on the southeast flange installation due to time constraints. WL grab samples were also taken 24 hours prior to the flange installation and at 2, 24, and 36 hours respectively after the flange installation. All of the WL grab sample results are found in Table 6.2.1-1.

The results in Table 6.2.1-1 indicate that there was an increase in the concentration of radon immediately surrounding the containment bag during each of the flange installations. The radon concentrations were essentially the same 24 hours and 36 hours after the flange installation as they were 24 hours prior to the installation. The increase in radon concentrations surrounding the containment bag was the result of diffusion of the radon through the containment bag. The concentration of radon inside of the containment bag has been estimated to be approximately 30 million pCi/liter or 300,000 Working Levels (assuming 100% equilibrium). Therefore, the use of the containment bag was estimated to be more than 99.96% effective in controlling leakage and/or diffusion of radon during the flange installation even when the highest WL grab sample data from Table 6.2.1-1 (130 working levels) is used.

The RGM-2 data, plotted for 24 hour periods prior to, during and after the K-65 Silo 1 flange changeout, are shown in Figures 6.2.1-1 through 6.2.1-3, respectively. The actual flange changeout operation occurred on November 4, 1987 between the hours of 1000-1200. The data is plotted for the K-65 fenceline perimeter RGM-2 units located at the compass positions noted in the legend. No data was available from the southeast RGM-2 unit due to instrumentation problems. Note that the northeast or northwest RGM-2 unit normally showed a higher radon concentration during the afternoon hours. The reason for this measured increase is that the predominant wind direction at the FMPC is from the south-southwest and as the K-65 Silos heat up with raising ambient temperatures during the day, the air containing radon inside the silos expands and leaks through the domes. During the flange changeout operation on November 4, 1987, however, no increase above normal day to day radon emissions were measured at the K-65 Silo fenceline.

During installation of one of the flanges, a subcontractor individual incurred a minor injury that involved a laceration of his hand which required five stitches. The subcontractor personnel received immediate medical attention and no further medical attention has been deemed necessary. The injury was properly reported and documented.

6.2.2 Silo 2

Four more specially designed flange assemblies were installed on the K-65 Silo 2 (North Silo) on Thursday, November 12, 1987. The operation began at approximately 11:00 a.m. with the flange changeout of the southwest flange on Silo 2. Upon removal of the first flange, the containment bag was pressurized. The flange was immediately replaced; a second containment bag was placed over the first bag; and the flange clamps were placed back onto the manway. Air sampling results conducted during and after the containment bag pressurization verified that an increase in radon levels at the K-65 Silo fenceline did not occur.

The flange changeout operation was completed the evening of November 12, 1987 after a manometer reading of zero inches of water indicated that the silo had come to pressure equilibrium with the environment. The flange changeout of the four Silo 2 manways was subsequently completed between the hours of 5:00 p.m. and 7:00 p.m.

Four WL grab samples were collected during the Silo 2 flange installation. The WL grab samples were collected in the immediate vicinity of the containment bags for each flange installation. WL grab samples were also taken the day before the flange installation, during the morning flange installation attempt, and during the actual flange installation downwind (north) of Silo 2. All of the WL grab sample results are found in Table 6.2.2-1.

The results in Table 6.2.2-1 indicate that no increase in the concentration of radon immediately surrounding the containment bag occurred during each of the installations and downwind from the silo. The radon concentrations were essentially the same during installation as they were the day before the installation. The levels of radon concentration did not increase during the flange installation due to proper containment and the fact that the silo had either a pressure equilibrium with the environment or was in a slight vacuum. The WL grab samples taken downwind during the morning flange installation attempt did increase as shown in Table 6.2.2-1. The increased radon concentration immediately outside the containment bag was the result of diffusion of radon through the bag as was the case during the Silo 1 flange installation.

The RGM-2 data, plotted for 24 hour periods prior to, during and after the K-65 Silo 2 flange changeout, are shown in Figures 6.2.2-1 through 6.2.2-3, respectively, Slight increases in ambient radon levels are shown during the afternoon hours for the period of November 11-13, 1987. No increase above normal day to day radon concentrations were measured at the K-65 Silo fenceline during the attempted flange changeout at 1100 hours or the actual flange changeout between 1700 and 1900 hours on November 12, 1987.

6.3 Radon Treatment

6.3.1 Silo 1

The radon treatment system was operated five times during the external foaming application to reduce radiation levels on the Silo 1 dome. The WL grab sample results for the five treatments are illustrated in Tables 6.3.1-1 through 6.3.1-5. The RGM-2 data are plotted for each day of

radon treatment in Figures 6.3.1-1 through 6.3.1-5. Neither the WL grab sample data or RGM-2 data shows any significant increase in radon levels during the treatment of K-65 Silo 1.

6.3.2 Silo 2

The radon treatment system was operated four times during the external foaming application to reduce radiation levels on the Silo 2 dome. The WL grab sample results for the four treatments are illustrated in Tables 6.3.2-1 through 6.3.2-4. The RGM-2 data are plotted for each day of radon treatment in Figures 6.3.2-1 through 6.3.2-4. Neither the WL grab sample data or RGM-2 data shows any significant increase in radon levels during the treatment of K-65 Silo 2.

7.0 HEALTH PHYSICS CONTROLS

7.1 Control Criteria

Before construction began, the Environmental Radiation Monitoring Technician (ERMT) handling the K-65 Interim Stabilization Project met with Health Physics personnel to establish parameters for radiological control. As a result of that meeting, TLD's, Self-Reading Pencil Dosimeters, an Ion Chamber, and a Teletector were used to compare dose rates at one and three feet above the K-65 Silo 2 dome. These measurements yielded the following results:

Measuring Device	1' Above Dome mrem/hr	3' Above Dome mrem/hr
TLD	139	139
Pencil Dosimeter	158	157
Ion Chamber	135	130
Teletector (GM tube)	175	168

As can be seen from the results, both the self reading pencil dosimeter and the Teletector devices are conservative when detecting gamma radiation and were the primary controlling instruments used during the project.

Further radiological controls established as a result of the meeting were as follows:

1. Two self-reading pencil dosimeters and one TLD were worn by personnel working on the K-65 silo domes.

2. Radon samples were routinely taken at the work locations during the construction phase.

3. Radiation work permits were re-issued daily.

4. Self-contained breathing apparatuses (SCBA's) were required during the flange changeout operation.

5. The Health Physics program was evaluated routinely and improved during the course of the operation.

6. Radiation controls zones were established around the perimeter of the K-65 Silo fence.

7.2 Personnel Radiation Dose

The whole body, penetrating radiation dose to personnel during all stages of Phase 6 of the K-65 Interim Stabilization Project was monitored by both self-reading pencil dosimeters and personnel whole body dosimeters (TLDs). A summary of the predicted and actual doses for the flange changeout operation, radon treatment system construction/operation, and external foam application is provided in Table 7.0-1.

As shown in Table 7.0-1 the predicted personnel dose is 29.6% higher than the actual personnel dose received. The largest difference between the predicted and actual doses occurred during the flange changeout operation. The reason for the lower actual dose during the flange changeout operation is that it was conducted in an extremely expeditious manner due to extensive pre-job training on the empty, nonradioactive Silo 4.

Table 7.0-1 also shows that the actual dose is higher than predicted for the radon treatment system construction/operation activity. The predicted dose, however, is based on a one time treatment for both K-65 Silos. Recall that the radon treatment system was operated five times for K-65 Silo 1 and four times for K-65 Silo 2, and therefore, the actual dose is higher due to the repetitive operation.

The last activity shown in Table 7.0-1 is the external foaming where the predicted dose is lower than the actual dose. The predicted dose was calculated based on the internal foam application being performed prior to the external foam application. The internal foam materials would have sealed the radon at the surface of K-65 residues thereby reducing the radiation exposure on top of the silo domes. As a point of interest, a personnel dose reduction of 1030 mrem was estimated for the external foaming application as a result of operating the radon treatment system based upon the radiation dose rates on the silo domes prior to and after the radon treatment. An estimated personnel dose of 7140 mrem was predicted for the external foaming application if the radon treatment system was not constructed. Moreover, an additional personnel dose reduction will take place during the internal foaming and sampling operations due to the utilization of the radon treatment system, especially since the flange changeout and the construction of the radon treatment system will not take place.

8.0 FUNDING/COST SUMMARY

A funding/cost summary is provided in Table 8.0-1 and illustrates the budget information for the total K-65 Storage Silo Radon Mitigation and Dome Reinforcement Project (external and internal foaming). Table 8.0-2 shows the authorized construction funds to date which includes only the radon treatment system and external foam (Phase 6) application.

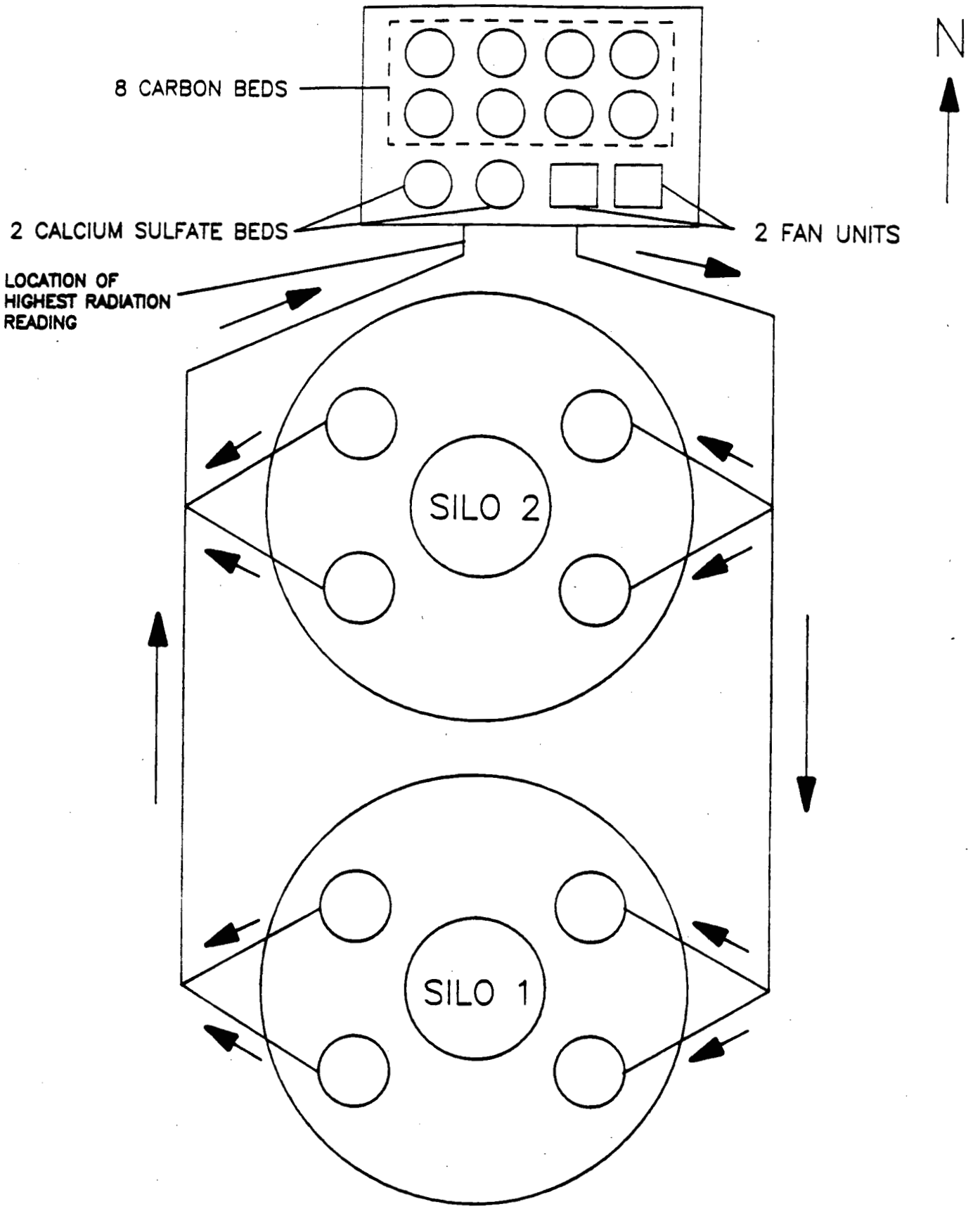


FIGURE 2.1-1
K-65 RADON TREATMENT SYSTEM

TABLE 2.3

SUMMARY OF K-65 SILO RADON TREATMENT SYSTEM OPERATION

K-65 Silo 1

Date Operated	Time Operated	Hours Operated
11/23 - 11/24/87	2025 - 0114	4.8
11/28/87	0915 - 1045	1.5
11/29/87	0900 - 1015	1.3
12/5/87	0850 - 1050	2.0
12/6/87	0900 - 1000	1.0
	Total =	10.6 hours

K-65 Silo 2

Date Operated	Time Operated	Hours Operated
11/30/87	0930 - 1415	4.8
12/2/87	0900 - 1100	2.0
12/4/87	1200 - 1255	0.9
12/5/87	1105 - 1300	1.9
	Total =	9.6 hours

FOAM LOADING ON DOME SURFACE OF K-65 SILOS 1 AND 2

TABLE 3.1-1
MATERIAL SPECIFICATIONS

Material	Density lb/ft^3	Thickness ft (in)	Loading lb/ft^2
Rigid	3.0	0.25 (3)	0.75
Rigid	3.0	0.13 (1.5)	0.39
Coating	88	0.0038 (0.045)	0.33

TABLE 3.1-2
FOAM LOADING ON K-65 SILO DOME SURFACE

Dome Section	Area Loading lb/ft^2	Surface Area ft^2	Dead Weight lb
Dome Cap	0.72	707	509
Outer Dome	1.08	4320	4666

Total Weight = 5175 lbs.
on dome

(1) Maximum allowable load on dome cap = 2,425 lbs (Reference 4)

(2) Control load limits on dome cap and outer dome = 70 lb/ft^2 (Reference 4)

(3) Calculated buckling limit on outer dome area = 284 lb/ft^2 (Reference 4)

FIGURE 5.1-1
RADIATION SURVEY LOCATIONS

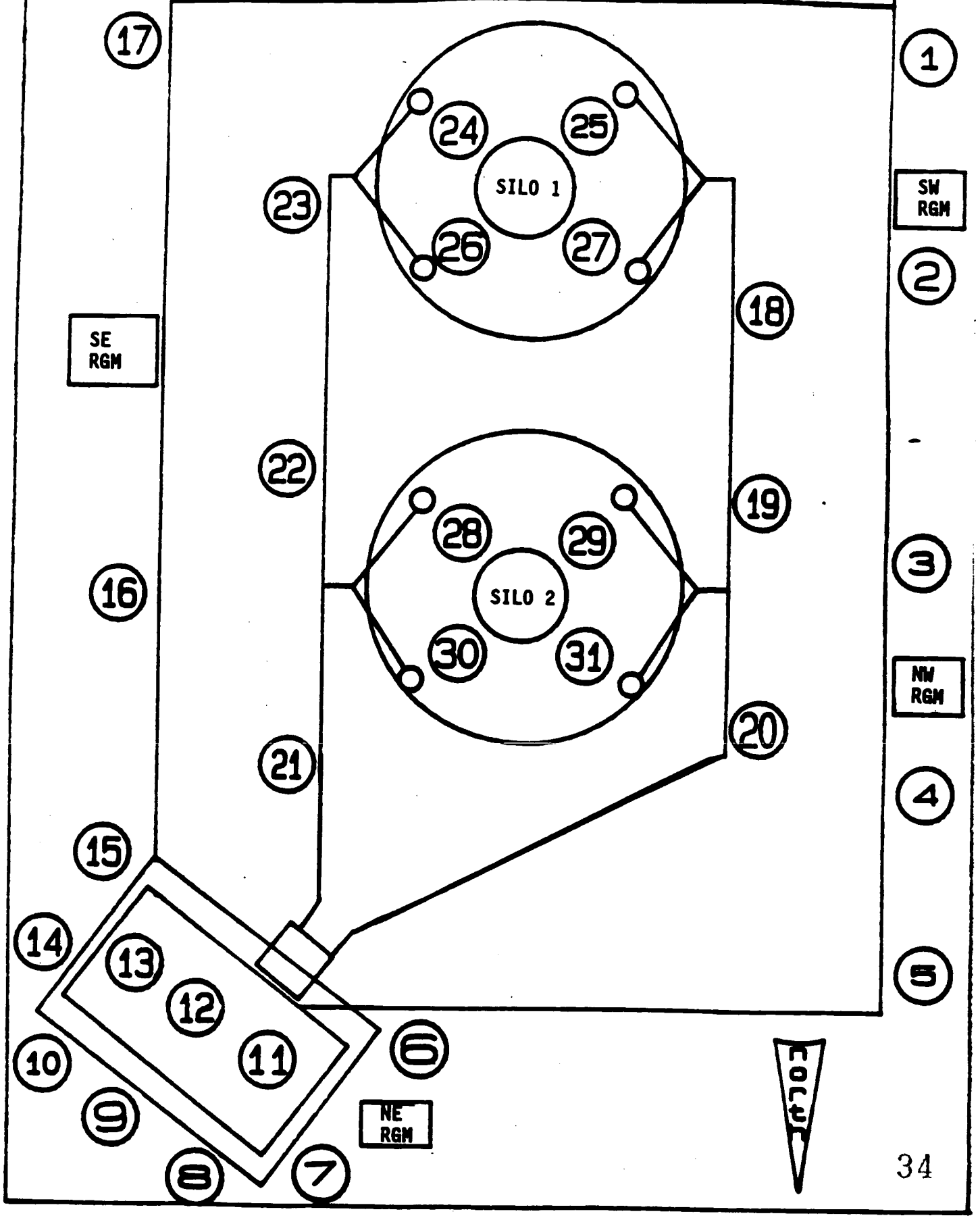


TABLE 5.2-1

RADIATION SURVEY RESULTS (mrem/hr)

NUMBER	LOCATION	SILO 1 BASELINE	SILO 1 DURING	SILO 2 BASELINE	SILO 2 DURING
		TIME	TIME	TIME	TIME
		1800 11/23/87	0100 11/24/87	0830 11/30/87	1300 11/30/87
		GAMMA READING			
1	Tape Mark, West K-65 Fence	0.3	0.2	0.3	0.3
2	Tape Mark, West K-65 Fence	0.4	0.3	0.4	0.4
3	Tape Mark, West K-65 Fence	0.4	0.4	0.4	0.3
4	Tape Mark, West K-65 Fence	0.5	0.4	0.5	0.4
5	Tape Mark, West K-65 Fence	0.4	0.4	0.4	0.4
6	Tape Mark, West Fence, Treatment System	0.3	1.4	1.0	2.0
7	Tape Mark, West Fence, Treatment System	0.3	1.3	1.0	1.9
8	Tape Mark, North Fence, Treatment System	0.3	1.4	1.1	2.3
9	Tape Mark, North Fence, Treatment System	0.3	1.7	1.0	2.8
10	Tape Mark, North Fence, Treatment System	0.3	1.5	1.1	2.5
11	Roof of Treatment System	0.4	370	431	455
12	Roof of Treatment System	0.5	450	458	1100
13	Roof of Treatment System	0.3	75	89	1000

TABLE 5.2-1
(continued)

RADIATION SURVEY RESULTS (mrem/hr)

NUMBER	LOCATION	SILO 1 BASELINE	SILO 1 DURING	SILO 2 BASELINE	SILO 2 DURING
		TIME	TIME	TIME	TIME
		1800 11/23/87	0100 11/24/87	0830 11/30/87	1300 11/30/87
		GAMMA READING			
14	Tape Mark, East Fence, Treatment System	0.3	1.3	1.0	1.9
15	Tape Mark, East Fence, Treatment System	0.3	1.2	0.9	1.9
16	Tape Mark, East K-65 Fence	0.4	0.7	0.4	0.5
17	Tape Mark, East K-65 Fence	0.5	0.4	0.3	0.3
18	12" Diameter Pipe, West Side, Top of Berm	5.0	7.0	N/A	N/A
19	12" Diameter Pipe, West Side, Top of Berm	4.0	6.5	N/A	N/A
20	12" Diameter Pipe, West Side, Top of Berm	8.0	N/A	10.0	N/A
21	12" Diameter Pipe, East Side, Top of Berm	10.0	---	8.0	9.0
22	12" Diameter Pipe, East Side, Top of Berm	3.5	3.0	N/A	N/A

TABLE 5.2-1
(continued)

RADIATION SURVEY RESULTS (mrem/hr)

NUMBER	LOCATION	SILO 1 BASELINE	SILO 1 DURING	SILO 2 BASELINE	SILO 2 DURING
		TIME	TIME	TIME	TIME
		1800 11/23/87	0100 11/24/87	0830 11/30/87	1300 11/30/87
		GAMMA READING			
23	12" Diameter Pipe, East Side, Top of Berm	5.0	2.5	N/A	N/A
24	Contact, Silo #1 Dome Surface	168	35.5	N/A	N/A
25	Contact, Silo #1 Dome Surface	191	57.0	N/A	N/A
26	Contact, Silo #1 Dome Surface	208	60.0	N/A	N/A
27	Contact, Silo #1 Dome Surface	205	68.0	N/A	N/A
28	Contact, Silo #2 Dome Surface	N/A	N/A	226	68.0
29	Contact, Silo #2 Dome Surface	N/A	N/A	250	76.0
30	Contact, Silo #2 Dome Surface	N/A	N/A	221	60.0
31	Contact, Silo #2 Dome Surface	N/A	N/A	230	70.0

FIGURE 5.3-1

AVG. SILO 1 DOSE RATE VS. TIME

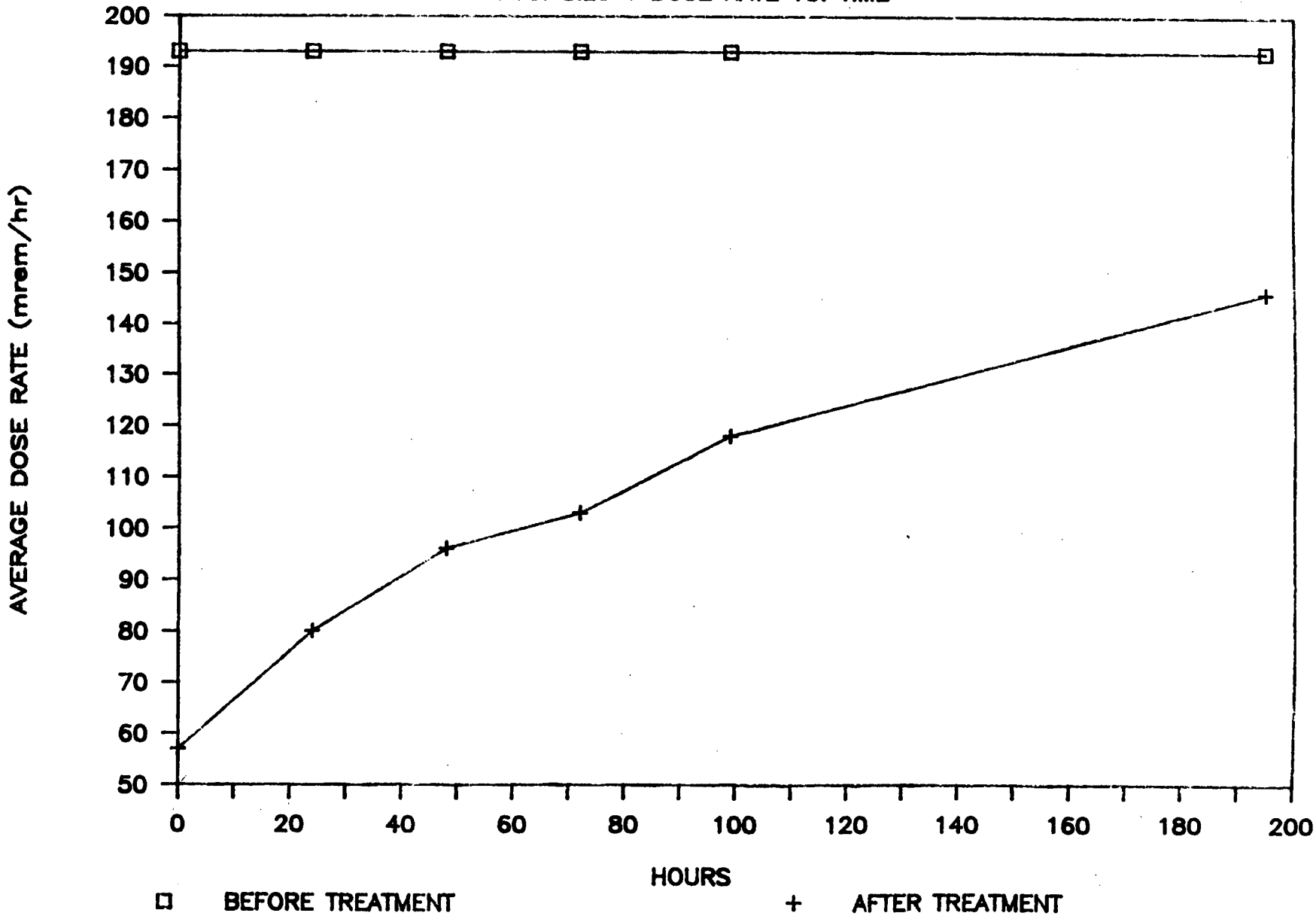


FIGURE 5.3-2

AVG. SILO 2 DOSE RATE VS. TIME

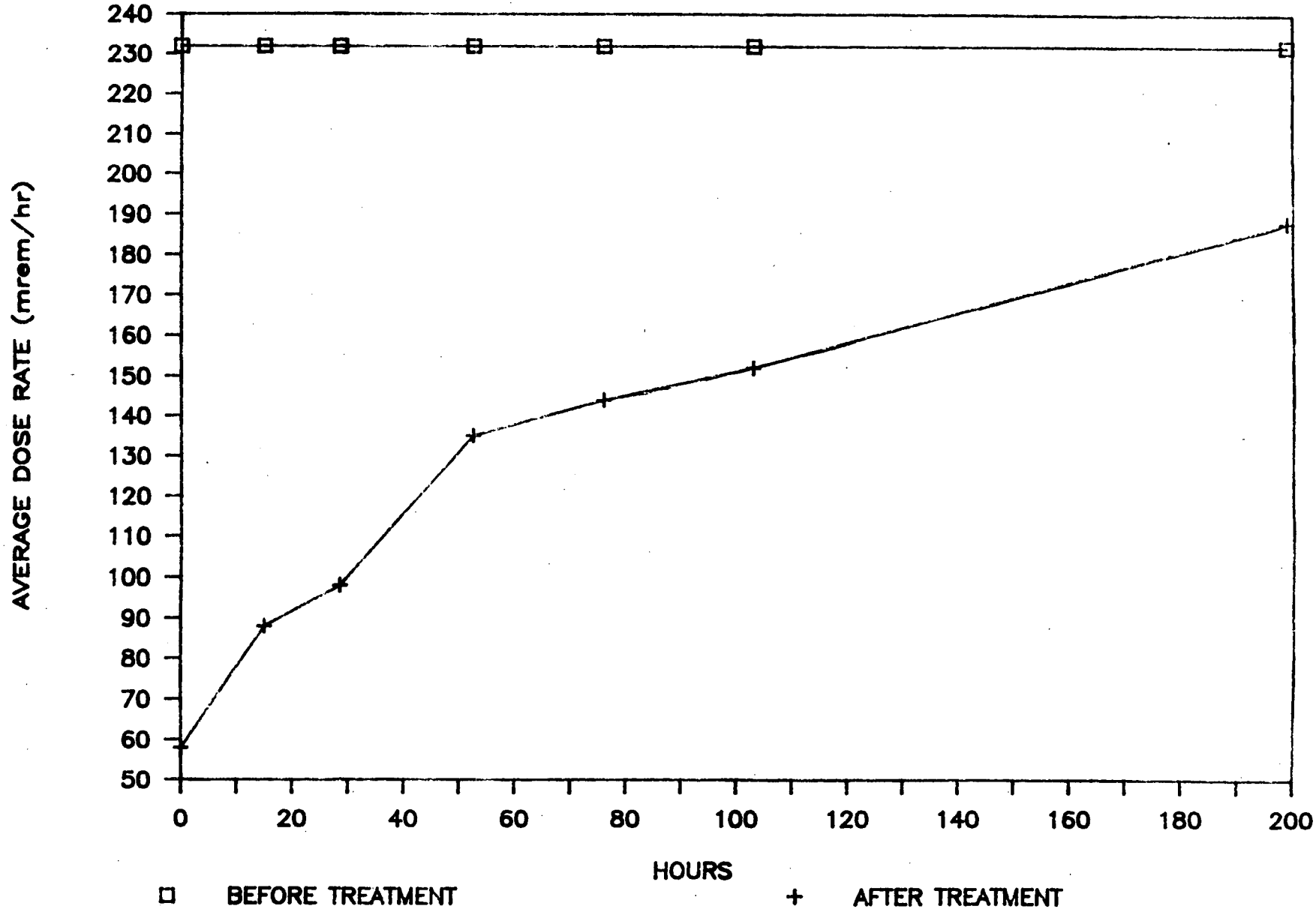


TABLE 6.1.3-1

K-65 SILO GAS SAMPLING RESULTS

SAMPLE TYPE AND SILO	WMCO ANALYSIS (pCi/liter)	MOUND ANALYSIS (pCi/liter)
SAMPLING BAG, SILO 1	---------	2.3×10^7
SAMPLING BAG, SILO 2	---------	1.3×10^7
GLASS FLASK, SILO 1	2.6×10^7	2.5×10^7
GLASS FLASK, SILO 2	3.0×10^7	2.9×10^7

TABLE 6.2.1-1

WL GRAB SAMPLE RESULTS FROM NEW FLANGE ASSEMBLY INSTALLATION ON SILO 1

DATE	TIME	WORKING LEVELS W. L.	COMMENTS
11/3/87	1000	0.19	Northeast manway 24 hours prior to flange changeout
11/3/87	1000	0.05	Northwest manway 24 hours prior to flange changeout
11/3/87	1000	1.8	Southeast manway 24 hours prior to flange changeout
11/3/87	1000	3.2	Southwest manway 24 hours prior to flange changeout
11/4/87	1000-1200	61.8	Northeast manway During flange changeout
11/4/87	1000-1200	29.7	Northwest manway During flange changeout
11/4/87	1000-1200	NO MEASUREMENT	Southeast manway During flange changeout
11/4/87	1000-1200	130	Southwest manway During flange changeout
11/4/87	1400	3.2	Northeast manway 2 hours after flange changeout
11/4/87	1400	20.1	Northwest manway 2 hours after flange changeout
11/4/87	1400	22	Southeast manway 2 hours after flange changeout
11/4/87	1400	47.9	Southwest manway 2 hours after flange changeout
11/5/87	1200	0.01	Northeast manway 24 hours after flange changeout
11/5/87	1200	0.01	Northwest manway 24 hours after flange changeout
11/5/87	1200	0.36	Southeast manway 24 hours after flange changeout

TABLE 6.2.1-1 (CONTINUED)

WL GRAB SAMPLE RESULTS FROM NEW FLANGE ASSEMBLY INSTALLATION ON SILO 1

DATE	TIME	WORKING LEVELS W. L.	COMMENTS
11/5/87	1200	1.9	Southwest manway 24 hours after flange changeout
11/6/87	0000	N.D.	Northeast manway 36 hours after flange changeout
11/6/87	0000	0.03	Northwest manway 36 hours after flange changeout
11/6/87	0000	0.1	Southeast manway 36 hours after flange changeout
11/6/87	0000	0.5	Southwest manway 36 hours after flange changeout

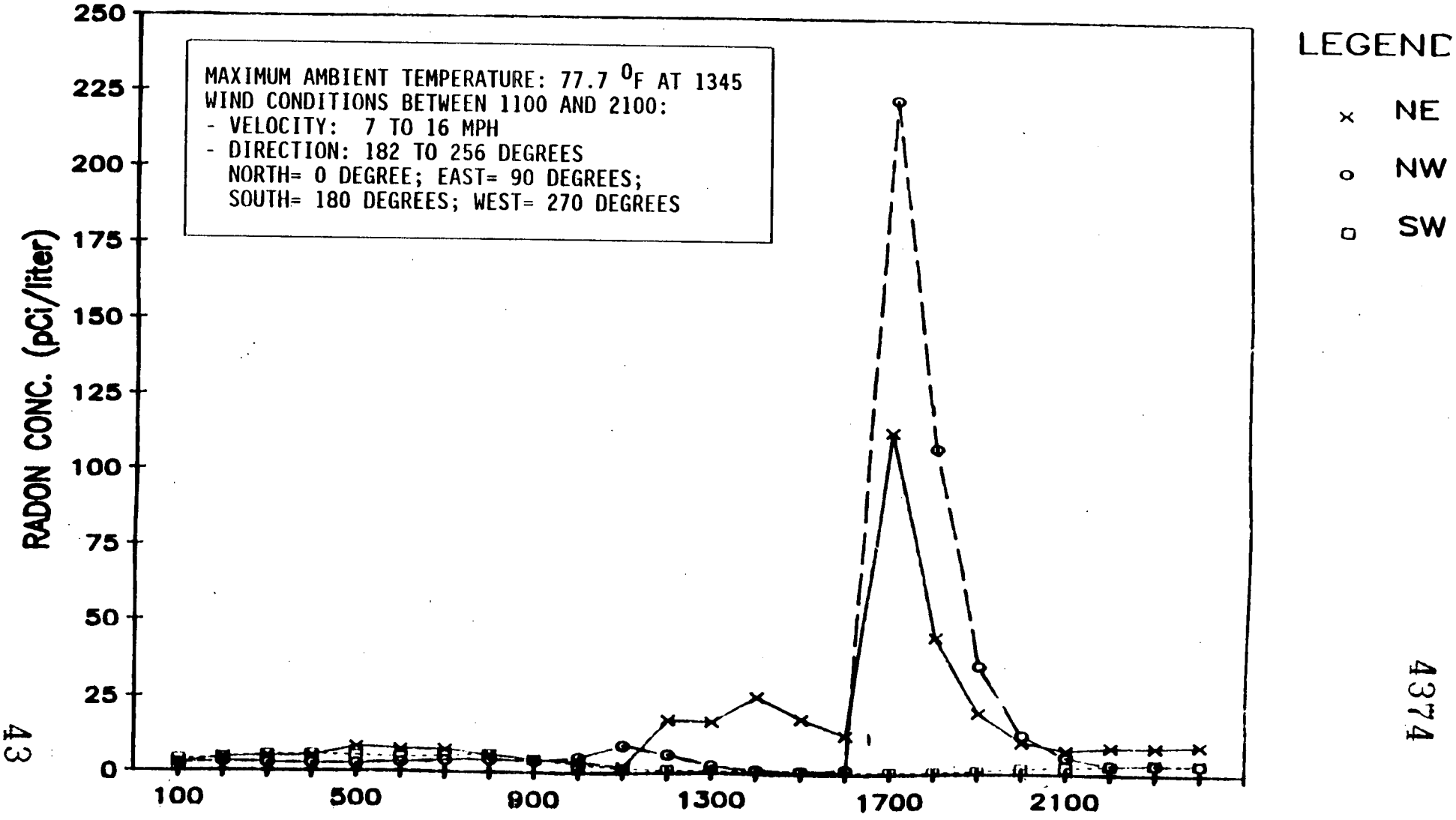
NOTES:

1) WL grab samples taken for 5 minutes at 2 liters/min. and counted 40 to 90 minutes after sampling for Alpha activity.

2) W. L. = Working Level. A Working Level is defined as any combination of short-lived radon daughters per liter of air which, in decaying completely through Po-214, will result in the emission of 1.3 x 10E5 million electron volts (MeV) of alpha energy.

3) The new flange assembly installation on Silo 1 occurred on 11/4/87 from 1000 to 1200.

FIGURE 6.2.1-1
K-65 RGM PERIMETER DATA
DAY BEFORE FLANGE CHANGEOUT SILO 1
NOVEMBER 3, 1987



4374

FIGURE 6.2.1-2
K-65 RGM PERIMETER DATA
FLANGE CHANGEOUT SILO 1
NOVEMBER 4, 1987

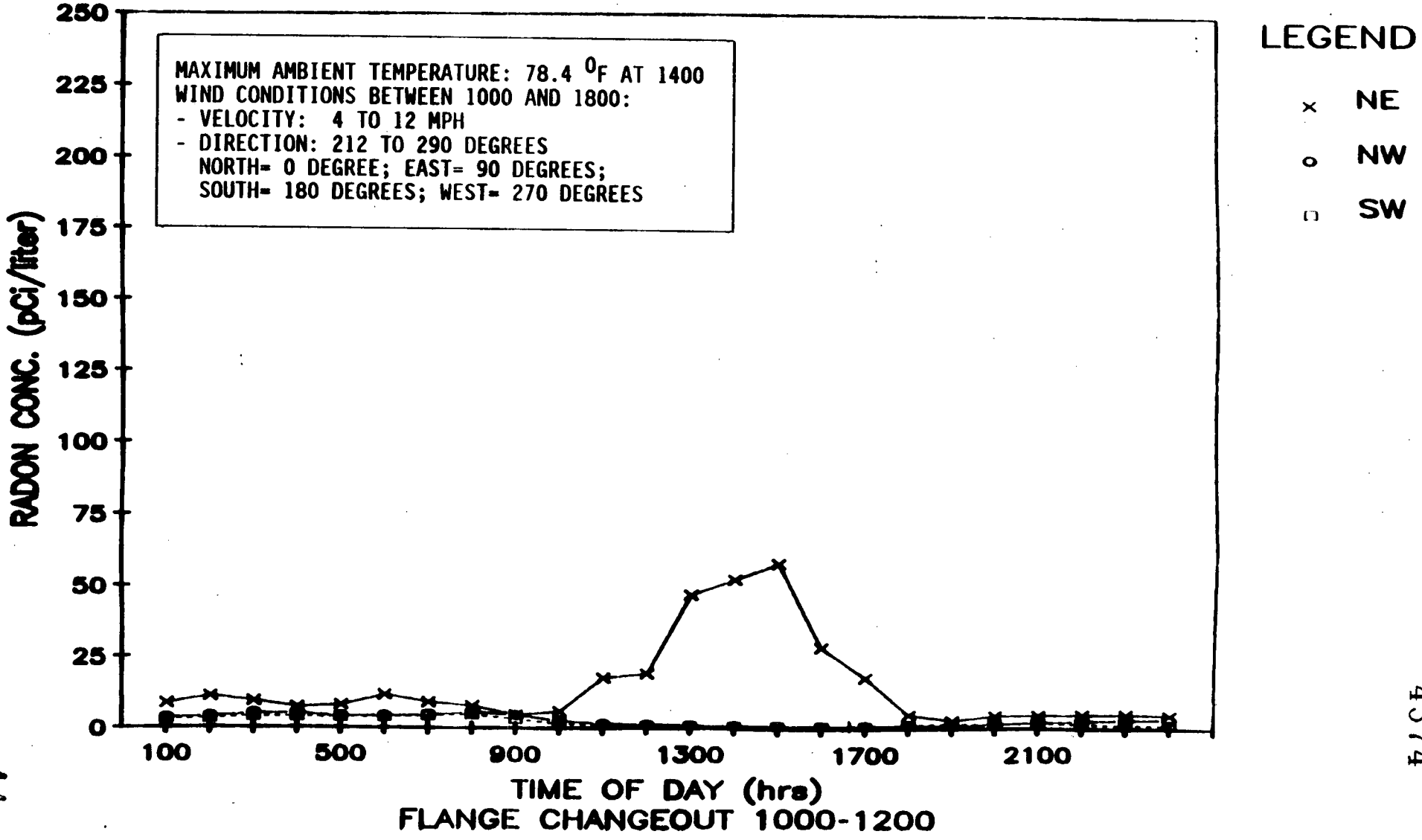


FIGURE 6.2.1-3
K-65 RGM PERIMETER DATA
DAY AFTER FLANGE CHANGEOUT SILO 1
NOVEMBER 5, 1987

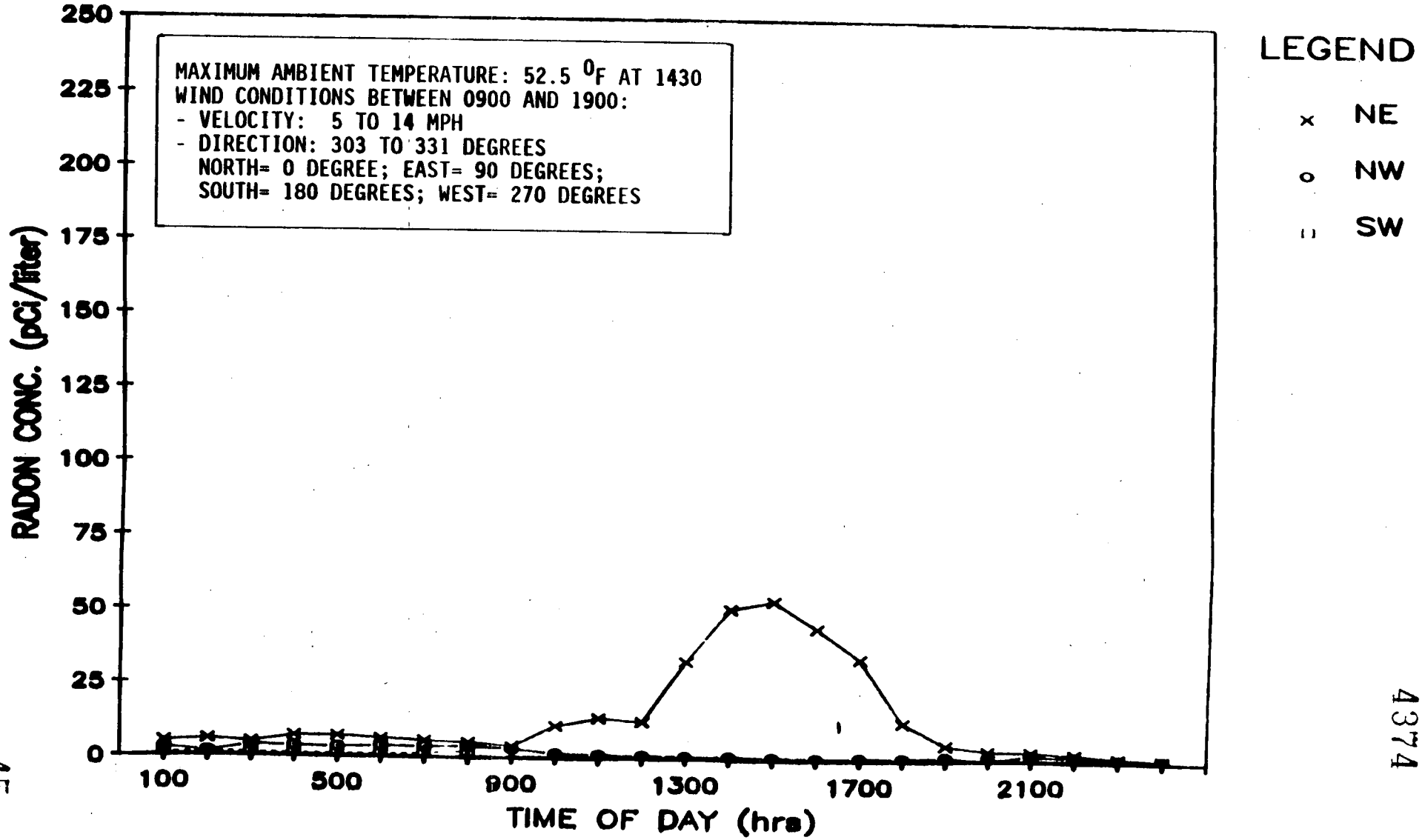


TABLE 6.2.2-1

WL GRAB SAMPLE RESULTS FROM NEW FLANGE ASSEMBLY INSTALLATION ON SILO 2

DATE	TIME	WORKING LEVELS W. L.	COMMENTS
11/11/87	0952	0.801	Northeast manway Day before flange changeout
11/11/87	0951	0.013	Northwest manway Day before flange changeout
11/11/87	0944	0.101	Southeast manway Day before flange changeout
11/11/87	0940	0.227	Southwest manway Day before flange changeout
11/12/87	1916	0.69	Northeast manway During flange changeout
11/12/87	1850	0.013	Northwest manway During flange changeout
11/12/87	1825	0.15	Southeast manway During flange changeout
11/12/87	1803	0.732	Southwest manway During flange changeout
11/12/87	1808	0.047	Downwind (North) of silos During flange changeout
11/12/87	1825	0.019	Downwind (North) of silos During flange changeout
11/12/87	1853	0.016	Downwind (North) of silos During flange changeout
11/12/87	1919	0.034	Downwind (North) of silos During flange changeout
11/12/87	Before	0.01	Southwest manway Previous flange changeout attempt
11/12/87	During	59	Southwest manway Previous flange changeout attempt
11/12/87	After	0.08	Southwest manway Previous flange changeout attempt

TABLE 6.2.2-1 (CONTINUED)

WL GRAB SAMPLE RESULTS FROM NEW FLANGE ASSEMBLY INSTALLATION ON SILO 2

NOTES:

1) WL grab samples taken for 5 minutes at 2 liters/min. and counted 40 to 90 minutes after sampling for Alpha activity.

2) W. L. = Working Level. A Working Level is defined as any combination of short-lived radon daughters per liter of air which, in decaying completely through Po-214, will result in the emission of 1.3 x 10E5 million electron volts (MeV) of alpha energy.

3) The new flange assembly installation on Silo 2 occurred on 11/12/87 from 1500 to 1900. The first attempt of the installation occurred at 1100 on 11/12/87 but was immediately halted due to complications.

FIGURE 6.2.2-1
K-65 RGM PERIMETER DATA
DAY BEFORE FLANGE CHANGEOUT SILO 2
NOVEMBER 11, 1987

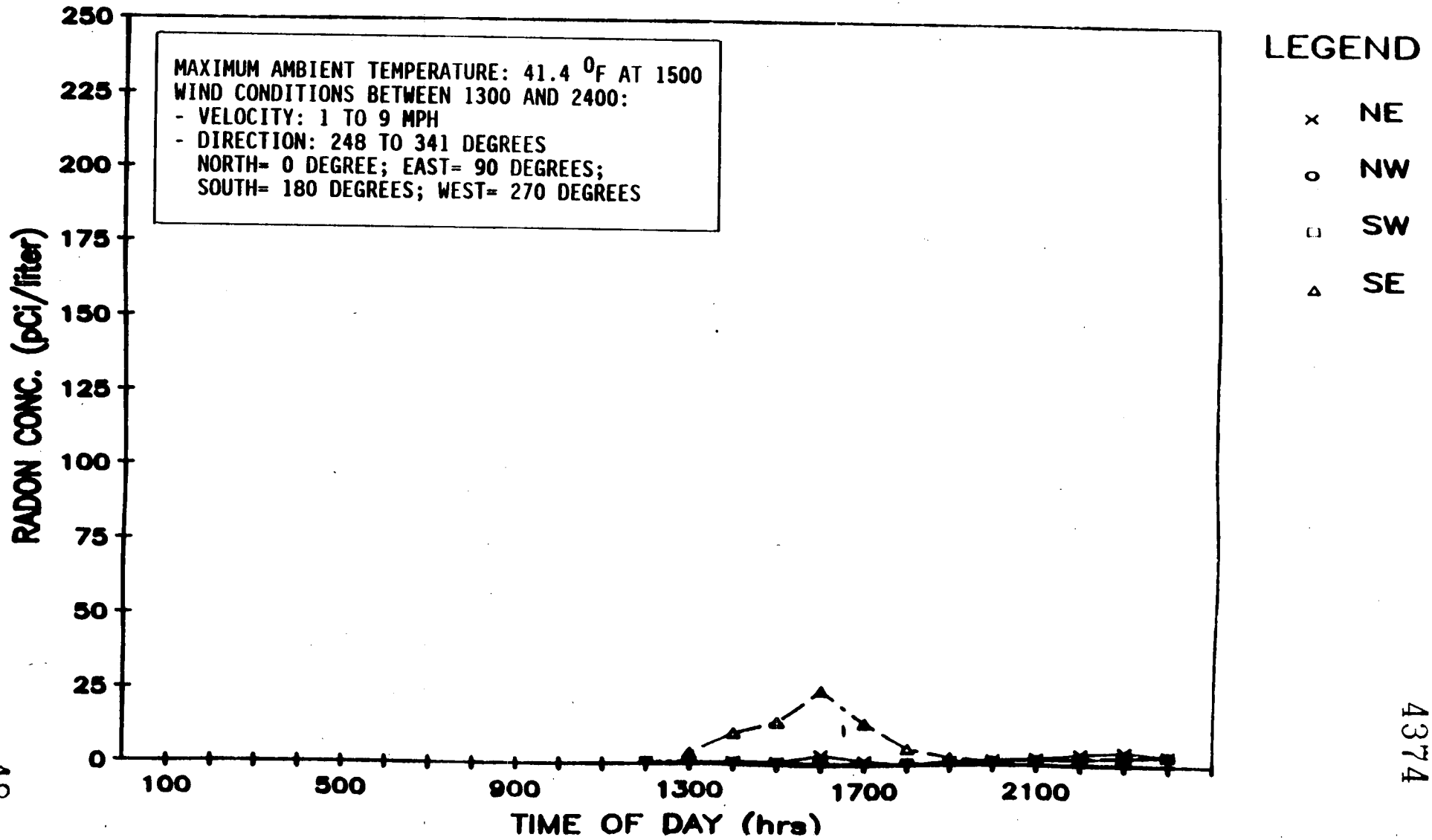


FIGURE 6.2.2-2
K-65 RGM PERIMETER DATA
FLANGE CHANGEOUT SILO 2
NOVEMBER 12, 1987

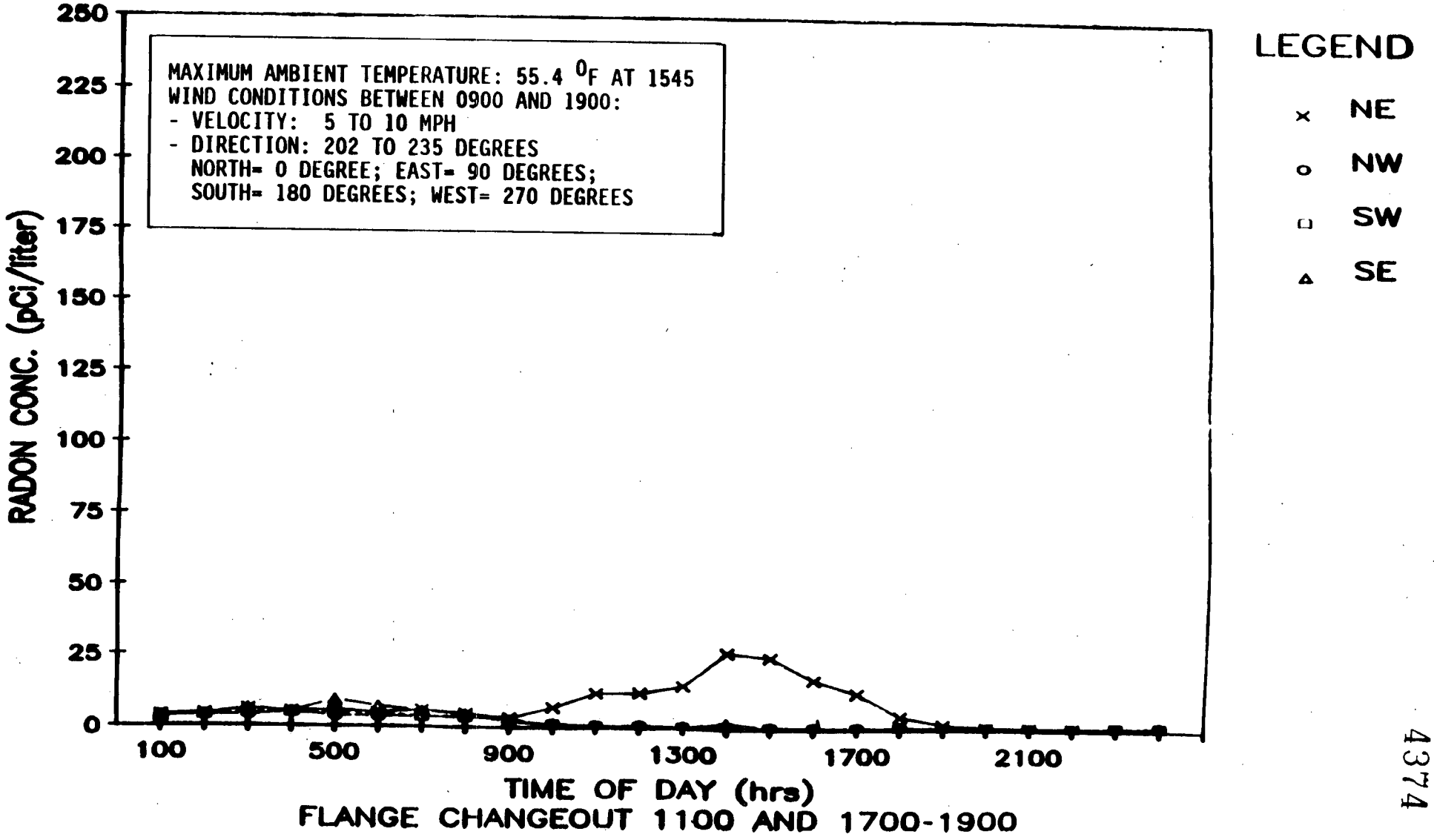


FIGURE 6.2.2-3
K-65 RGM PERIMETER DATA
DAY AFTER FLANGE CHANGEOUT SILO 2
NOVEMBER 13, 1987

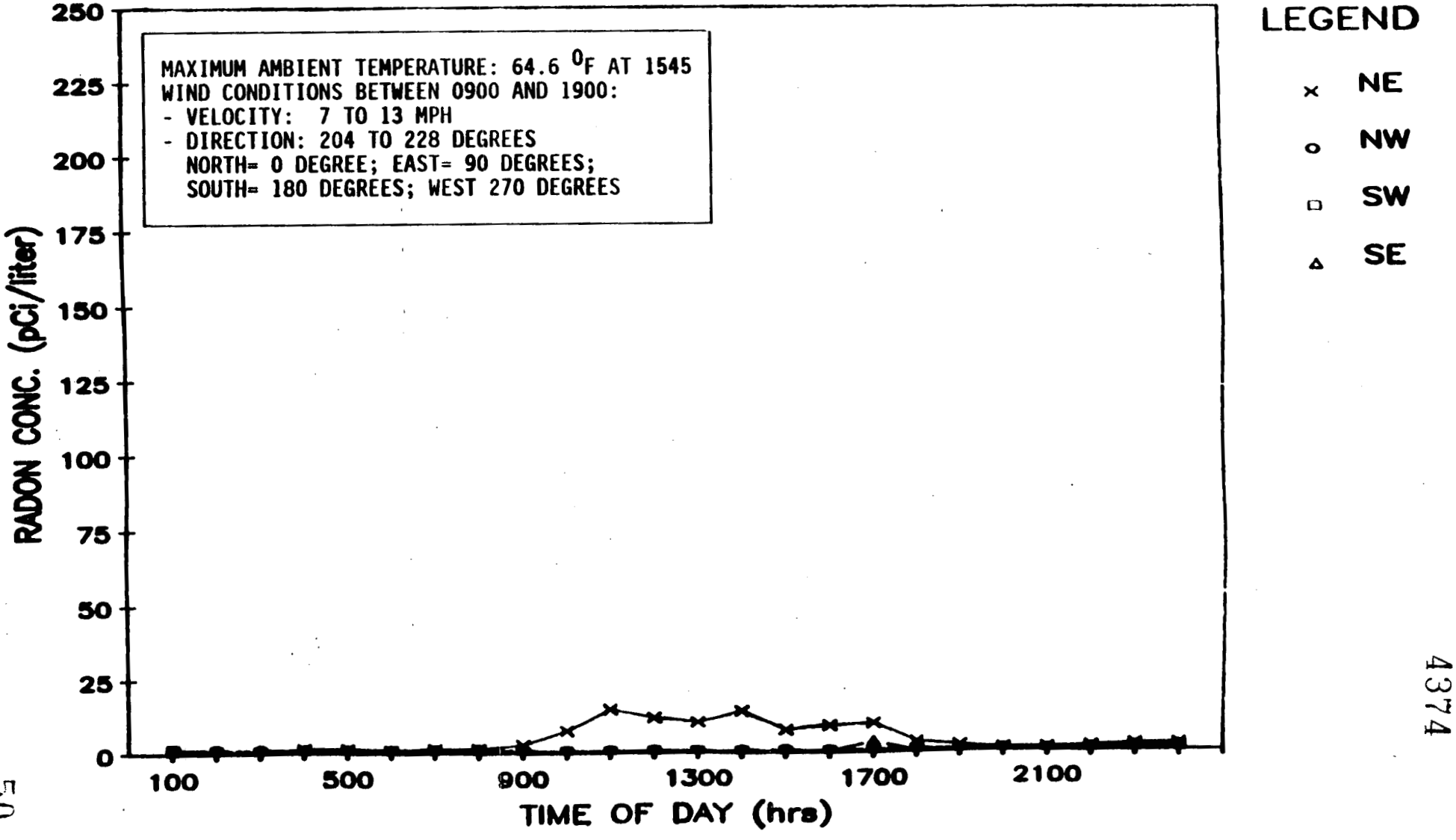


TABLE 6.3.1-1

WL GRAB SAMPLE RESULTS FROM INITIAL RADON TREATMENT OF K-65 SILO 1

DATE	TIME	WORKING LEVELS	COMMENTS
11/23/87	1716	0.004	Outside Treatment Bldg., prior to operation
11/23/87	1717	0.01	Outside Treatment Bldg., prior to operation
11/23/87	2025	0.6	Outside Treatment Bldg., during operation (downwind)
11/23/87	2028	0.29	Outside Treatment Bldg., during operation (downwind)
11/23/87	2044	0.44	Outside Treatment Bldg., during operation (downwind)
11/23/87	2049	0.31	Outside Treatment Bldg., during operation (downwind)
11/23/87	2130	0.203	Outside Treatment Bldg., during operation (downwind)
11/23/87	2133	0.39	Outside Treatment Bldg., during operation (downwind)
11/23/87	2200	0.025	Top of berm, between K-65 Silos
11/23/87	2200	0.252	Outside Treatment Bldg., during operation (downwind)
11/23/87	2203	0.0687	Outside Treatment Bldg., during operation (downwind)
11/23/87	2229	0.007	Outside Treatment Bldg., during operation (downwind)
11/23/87	2257	0.33	Top of berm, between K-65 Silos
11/23/87	2339	0.016	Outside Treatment Bldg., during operation (downwind)
11/24/87	0008	0.12	Top of berm, between K-65 Silos
11/24/87	0117	0.004	Outside Treatment Bldg., after system shutdown (downwind)

TABLE 6.3.1-1
(continued)

WL GRAB SAMPLE RESULTS FROM INITIAL RADON TREATMENT OF K-65 SILO 1

NOTES:

1) WL grab samples taken for five minutes at 2 liters/min. and counted for total alpha activity (2 minute count) exactly 13.5 minutes after initiation of sample.

2) Working levels is a unit of measure defined as any combination of short-lived radon daughters per liter of air which, in decaying completely through Po-214, will result in the emission of 1.3×10^5 million electron volts (MeV) of alpha energy.

3) Radon Treatment System operation began at 2025 hours on November 23, 1987 and was concluded at 0114 hours on November 24, 1987.

TABLE 6.3.1-2

WL GRAB SAMPLE RESULTS FROM SECOND RADON TREATMENT OF K-65 SILO 1

DATE	TIME	WORKING LEVELS	COMMENTS
11/28/87	0845	0.031	Outside Treatment Bldg., prior to operation
11/28/87	0913	N. D.	Outside Treatment Bldg., during operation (downwind)
11/28/87	0930	0.007	Outside Treatment Bldg., during operation (downwind)
11/28/87	1005	0.027	Outside Treatment Bldg., during operation (downwind)

NOTES:

1) WL grab samples taken for five minutes at 2 liters/min. and counted for total alpha activity (2 minute count) exactly 13.5 minutes after initiation of sample.

2) Working levels is a unit of measure defined as any combination of short-lived radon daughters per liter of air which, in decaying completely through Po-214, will result in the emission of 1.3 x 10^5 million electron volts (MeV) of alpha energy.

3) Radon Treatment System operation began at 0913 hours and was concluded at 1045 hours on November 28, 1987.

TABLE 6.3.1-3

WL GRAB SAMPLE RESULTS FROM THIRD RADON TREATMENT OF K-65 SILO 1

DATE	TIME	WORKING LEVELS	COMMENTS
11/29/87	0817	0.003	Outside Treatment Bldg., prior to operation
11/29/87	0904	0.106	Outside Treatment Bldg., during operation (downwind)
11/29/87	0955	2.0	Top of berm on Silo 1 handrail, during operation (downwind)
11/29/87	1005	0.064	Outside Treatment Bldg., during operation (downwind)

NOTES:

1) WL grab samples taken for five minutes at 2 liters/min. and counted for total alpha activity (2 minute count) exactly 13.5 minutes after initiation of sample.

2) Working levels is a unit of measure defined as any combination of short-lived radon daughters per liter of air which, in decaying completely through Po-214, will result in the emission of 1.3 x 10^5 million electron volts (MeV) of alpha energy.

3) Radon Treatment System operation began at 0900 hours and was concluded at 1015 hours on November 29, 1987.

TABLE 6.3.1-4

WL GRAB SAMPLE RESULTS FROM FOURTH RADON TREATMENT OF K-65 SILO 1

DATE	TIME	WORKING LEVELS W. L.	COMMENTS
12/5	0854	N.D.	Outside treatment building During operation
12/5	0940	N.D.	Top of berm west of Silo 1 During operation
12/5	0959	0.016	East K-65 fenceline During operation
12/5	1035	0.384	Top of berm east of Silo 1 During operation
12/5	1215	N.D.	Top of berm east of Silo 1 Prior to foaming operation

NOTES:

1) WL grab samples taken for 5 minutes at 2 liters/min. were counted for 2 minutes 13.5 minutes after sampling.

2) W. L. = Working Level. A Working Level is defined as any combination of short-lived radon daughters per liter of air which, in decaying completely through Po-214, will result in the emission of 1.3 x 10E5 million electron volts (MeV) of alpha energy.

3) The fourth radon treatment on Silo 1 occurred on 12/5/87 from 0850 to 1050.

TABLE 6.3.1-5

WL GRAB SAMPLE RESULTS FROM FIFTH RADON TREATMENT OF K-65 SILO 1

DATE	TIME	WORKING LEVELS W. L.	COMMENTS
12/6	0915	0.033	Top of berm east of Silo 1 During operation
12/6	0925	0.007	Outside treatment building During operation
12/6	0945	N.D.	Outside treatment building During operation

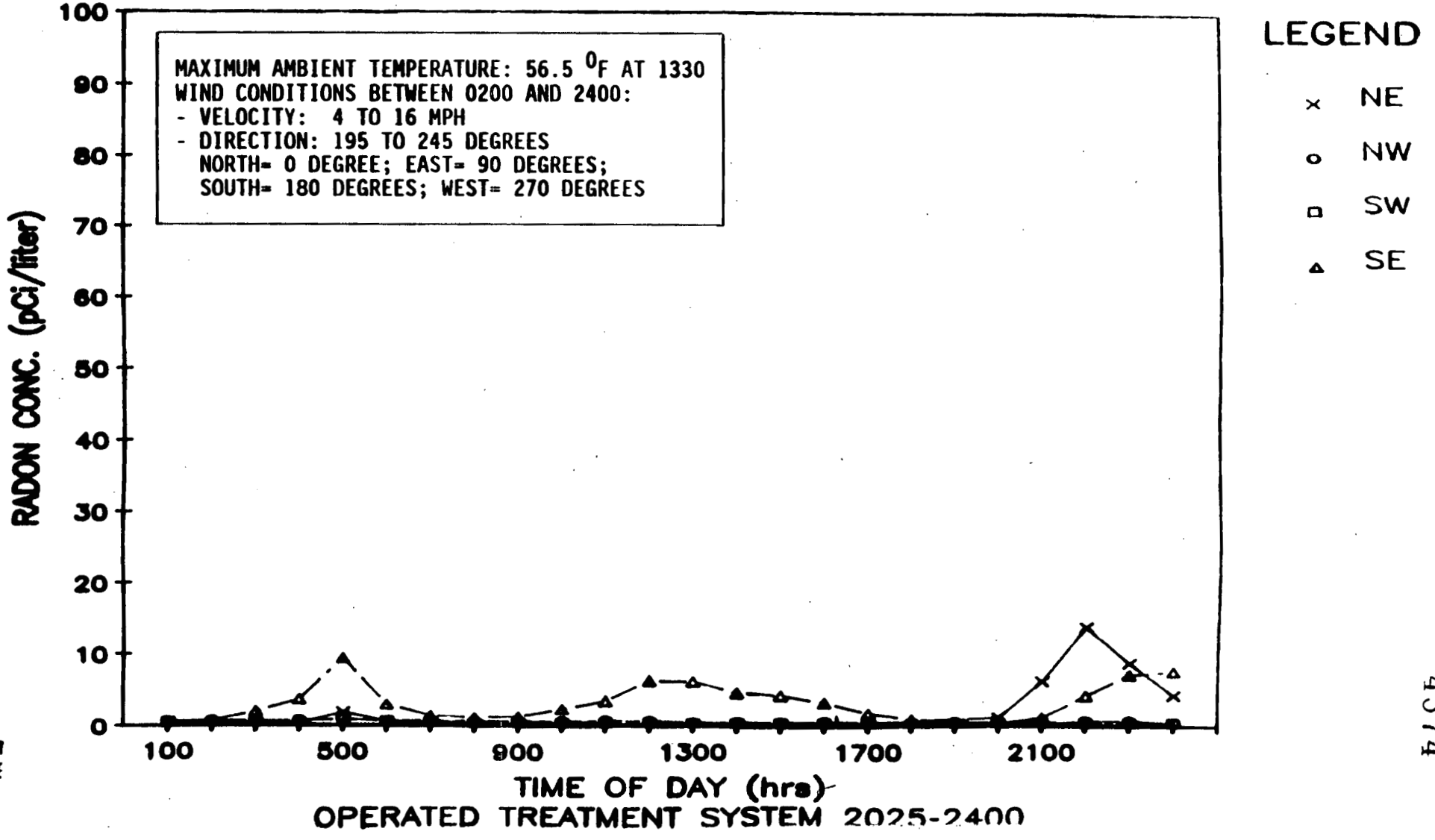
NOTES:

1) WL grab samples taken for 5 minutes at 2 liters/min. were counted for 2 minutes 13.5 minutes after sampling.

2) W. L. = Working Level. A Working Level is defined as any combination of short-lived radon daughters per liter of air which, in decaying completely through Po-214, will result in the emission of 1.3 x 10E5 million electron volts (MeV) of alpha energy.

3) The fifth radon treatment on Silo 1 occurred on 12/6/87 from 0900 to 1000.

FIGURE 6.3.1-1
K-65 RGM PERIMETER DATA
INITIAL RADON TREATMENT OF SILO 1
NOVEMBER 23, 1987



OPERATED TREATMENT SYSTEM 2025-2400

FIGURE 6.3.1-1 CONT.
K-65 RGM PERIMETER DATA
INITIAL RADON TREATMENT OF SILO 1
NOVEMBER 24, 1987

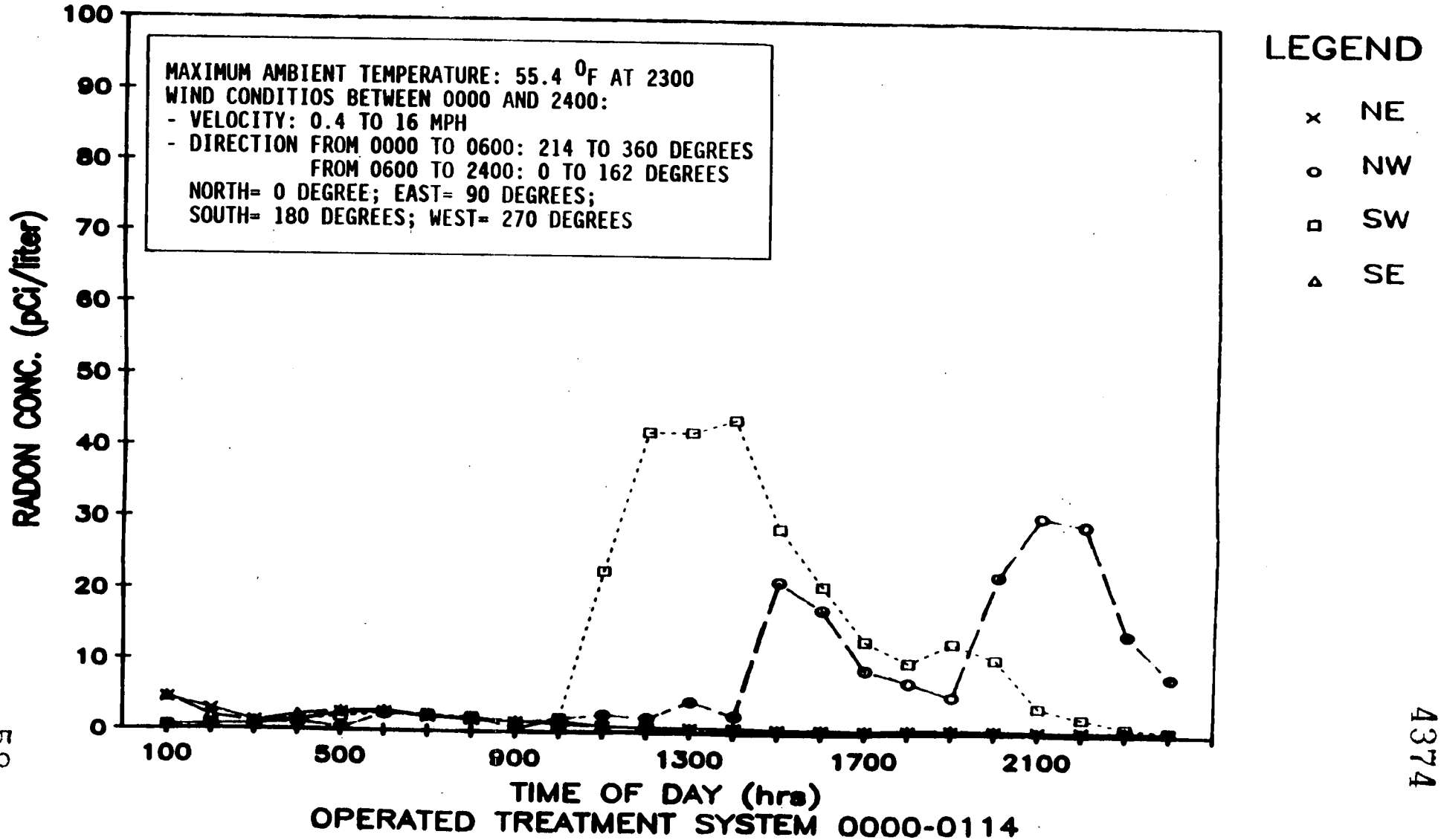


FIGURE 6.3.1-2
K-65 RGM PERIMETER DATA
SECOND RADON TREATMENT OF SILO 1
NOVEMBER 28, 1987

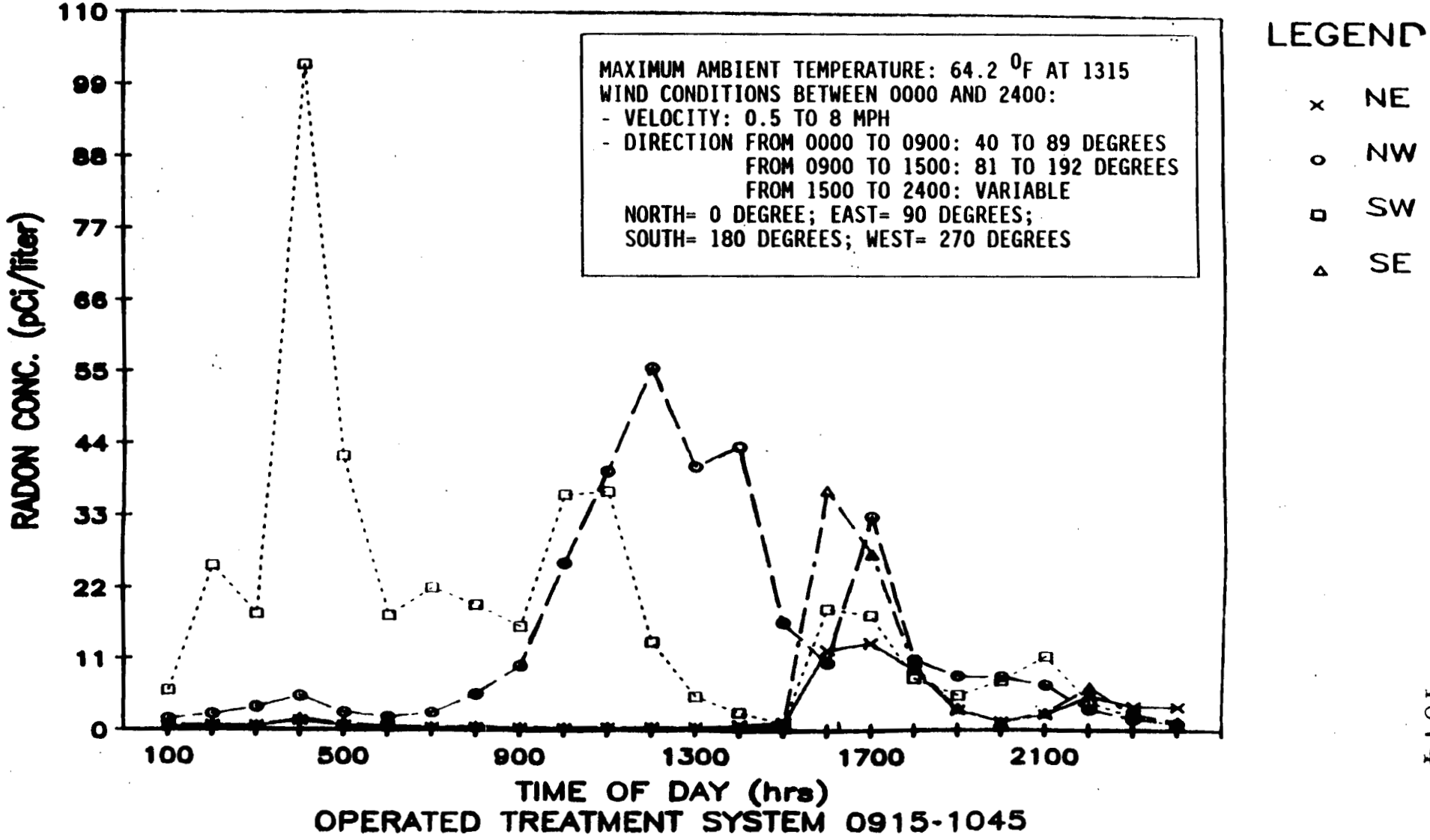


FIGURE 6.3.1-3
K-65 RGM PERIMETER DATA
THIRD RADON TREATMENT OF SILO 1
NOVEMBER 29, 1987

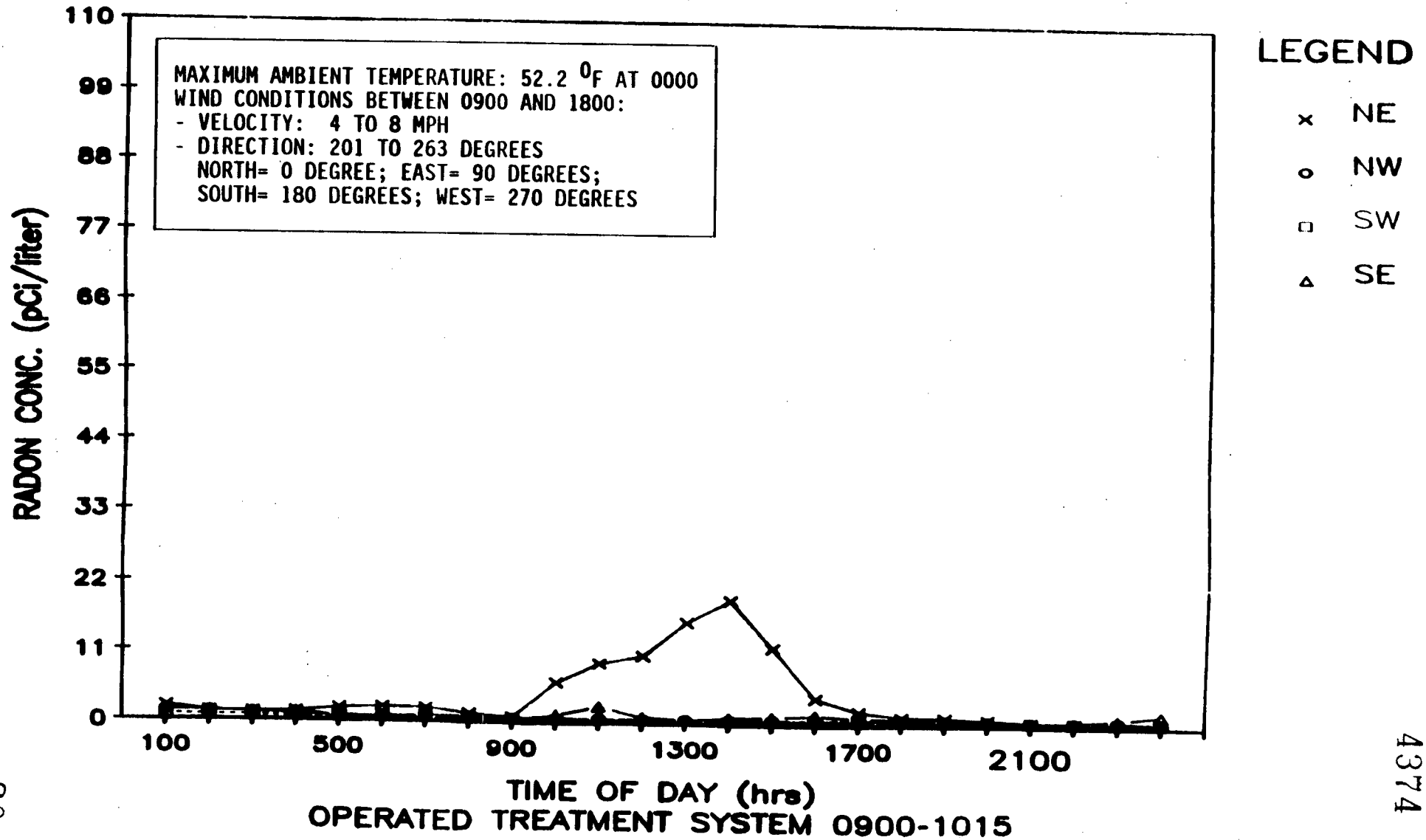


FIGURE 6.3.1-4
K-65 RGM PERIMETER DATA
FOURTH RADON TREATMENT OF SILO 1
DECEMBER 5, 1987

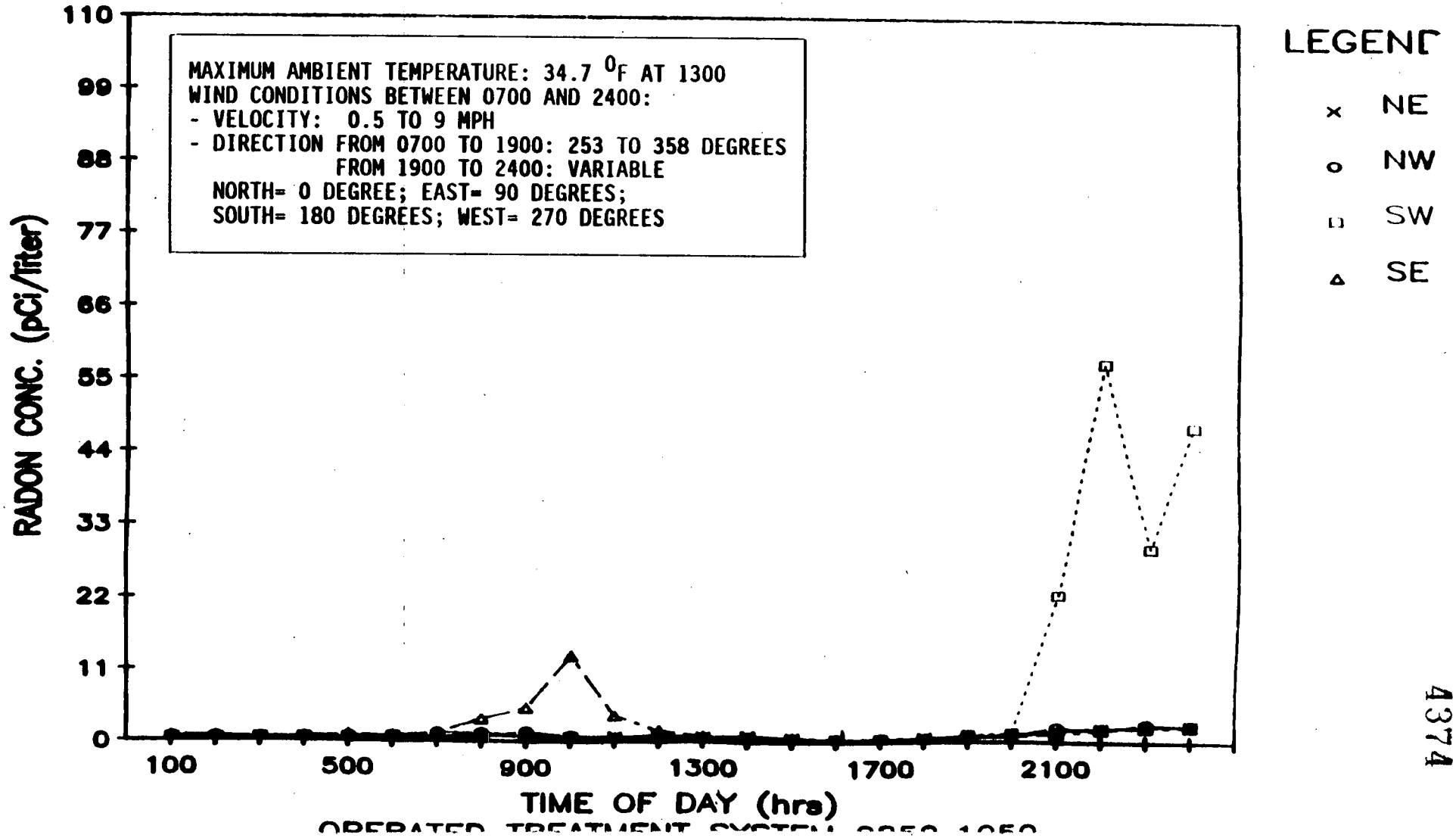


FIGURE 6.3.1-5
K-65 RGM PERIMETER DATA
FIFTH RADON TREATMENT OF SILO 1
DECEMBER 6, 1987

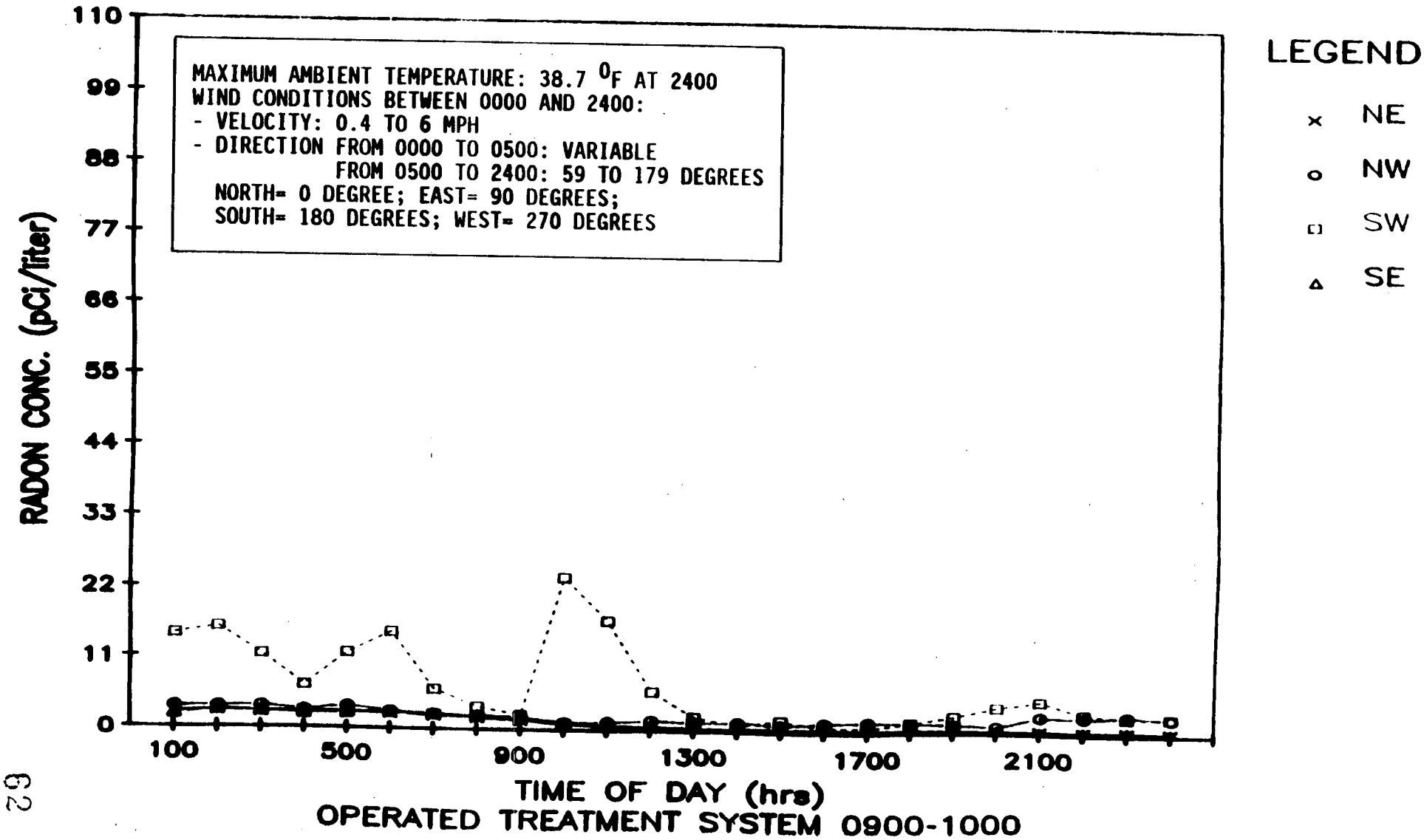


TABLE 6.3.2-1

WL GRAB SAMPLE RESULTS FROM INITIAL RADON TREATMENT OF K-65 SILO 2

DATE	TIME	WORKING LEVELS	COMMENTS
11/30/87	0845	.001	Outside Treatment Bldg., prior to operation
11/30/87	0936	0.064	Outside Treatment Bldg., during operation (downwind)
11/30/87	1031	1.85	Top of berm on Silo 2 handrail, during operation (downwind)
11/30/87	1039	N. D.	Top of berm, downwind of Silo 2.
11/30/87	1334	0.051	Outside Treatment Bldg., during operation (downwind)

NOTES:

1) WL grab samples taken for five minutes at 2 liters/min. and counted for total alpha activity (2 minute count) exactly 13.5 minutes after initiation of sample.

2) Working levels is a unit of measure defined as any combination of short-lived radon daughters per liter of air which, in decaying completely through Po-214, will result in the emission of 1.3 x 10^5 million electron volts (MeV) of alpha energy.

3) Radon Treatment System operation began at 0935 hours and was concluded at 1415 hours on November 30, 1987.

TABLE 6.3.2-2

WL GRAB SAMPLE RESULTS FROM SECOND RADON TREATMENT OF K-65 SILO 2

DATE	TIME	WORKING LEVELS W. L.	COMMENTS
12/2	0802	N.D.	Outside treatment building Prior to operation (downwind)
12/2	0901	0.007	Outside treatment building During operation (downwind)
12/2	0928	0.003	Outside treatment building During operation (downwind)
12/2	1004	0.510	Outside treatment building During operation (downwind)

NOTES:

1) WL grab samples taken for 5 minutes at 2 liters/min. were counted for 2 minutes 13.5 minutes after sampling.

2) W. L. = Working Level. A Working Level is defined as any combination of short-lived radon daughters per liter of air which, in decaying completely through Po-214, will result in the emission of 1.3 x 10E5 million electron volts (MeV) of alpha energy.

3) The second radon treatment on Silo 2 occurred on 12/2/87 from 0900 to 1100.

TABLE 6.3.2-3

WL GRAB SAMPLE RESULTS FROM THIRD RADON TREATMENT OF K-65 SILO 2

DATE	TIME	WORKING LEVELS W. L.	COMMENTS
12/4	1144	N.D.	Outside treatment building Prior to operation (downwind)
12/4	1203	N.D.	Outside treatment building During operation (downwind)
12/4	1212	0.002	East K-65 fenceline During operation (downwind)
12/4	1223	0.526	Top of berm between silos During operation (downwind)

NOTES:

1) WL grab samples taken for 5 minutes at 2 liters/min. were counted for 2 minutes 13.5 minutes after sampling.

2) W. L. = Working Level. A Working Level is defined as any combination of short-lived radon daughters per liter of air which, in decaying completely through Po-214, will result in the emission of 1.3 x 10E5 million electron volts (MeV) of alpha energy.

3) The third radon treatment on Silo 2 occurred on 12/4/87 from 1200 to 1255.

TABLE 6.3.2-4

WL GRAB SAMPLE RESULTS FROM FOURTH RADON TREATMENT OF K-65 SILO 2

DATE	TIME	WORKING LEVELS W. L.	COMMENTS
12/5	1109	7.02	Top of berm east of Silo 2 During operation
12/5	1112	N.D.	Top of berm north of Silo 2 During operation
12/5	1130	0.167	Top of berm east of Silo 2 During operation
12/5	1133	0.002	Top of berm between silos During operation
12/5	1211	0.436	Top of berm east of Silo 2 During operation

NOTES:

1) WL grab samples taken for 5 minutes at 2 liters/min. were counted for 2 minutes 13.5 minutes after sampling.

2) W. L. = Working Level. A Working Level is defined as any combination of short-lived radon daughters per liter of air which, in decaying completely through Po-214, will result in the emission of 1.3 x 10E5 million electron volts (MeV) of alpha energy.

3) The fourth radon treatment on Silo 1 occurred on 12/5/87 from 1105 to 1300.

FIGURE 6.3.2-1
K-65 RGM PERIMETER DATA
INITIAL RADON TREATMENT OF SILO 2
NOVEMBER 30, 1987

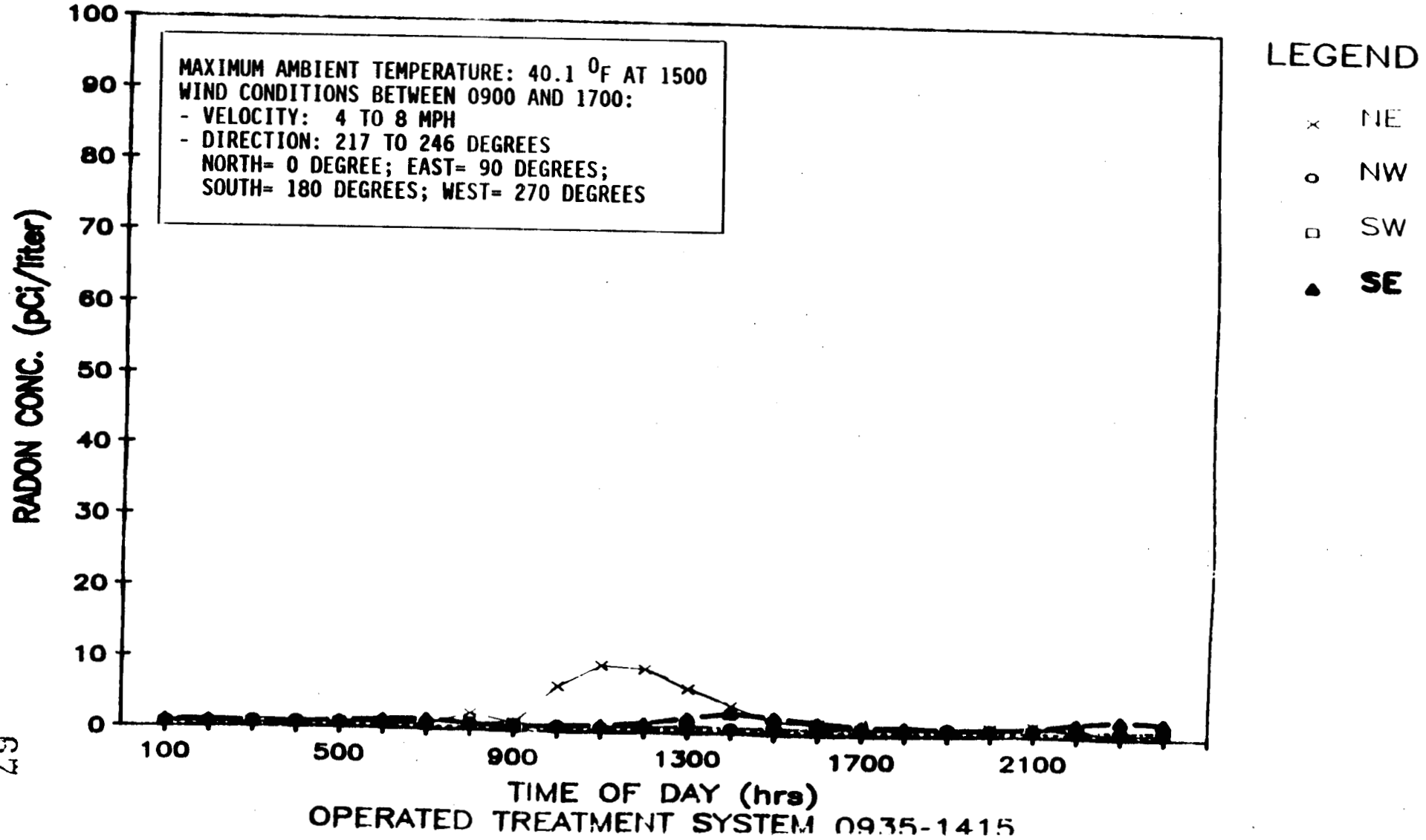


FIGURE 6.3.2-2
K-65 RGM PERIMETER DATA
SECOND RADON TREATMENT OF SILO 2
DECEMBER 2, 1987

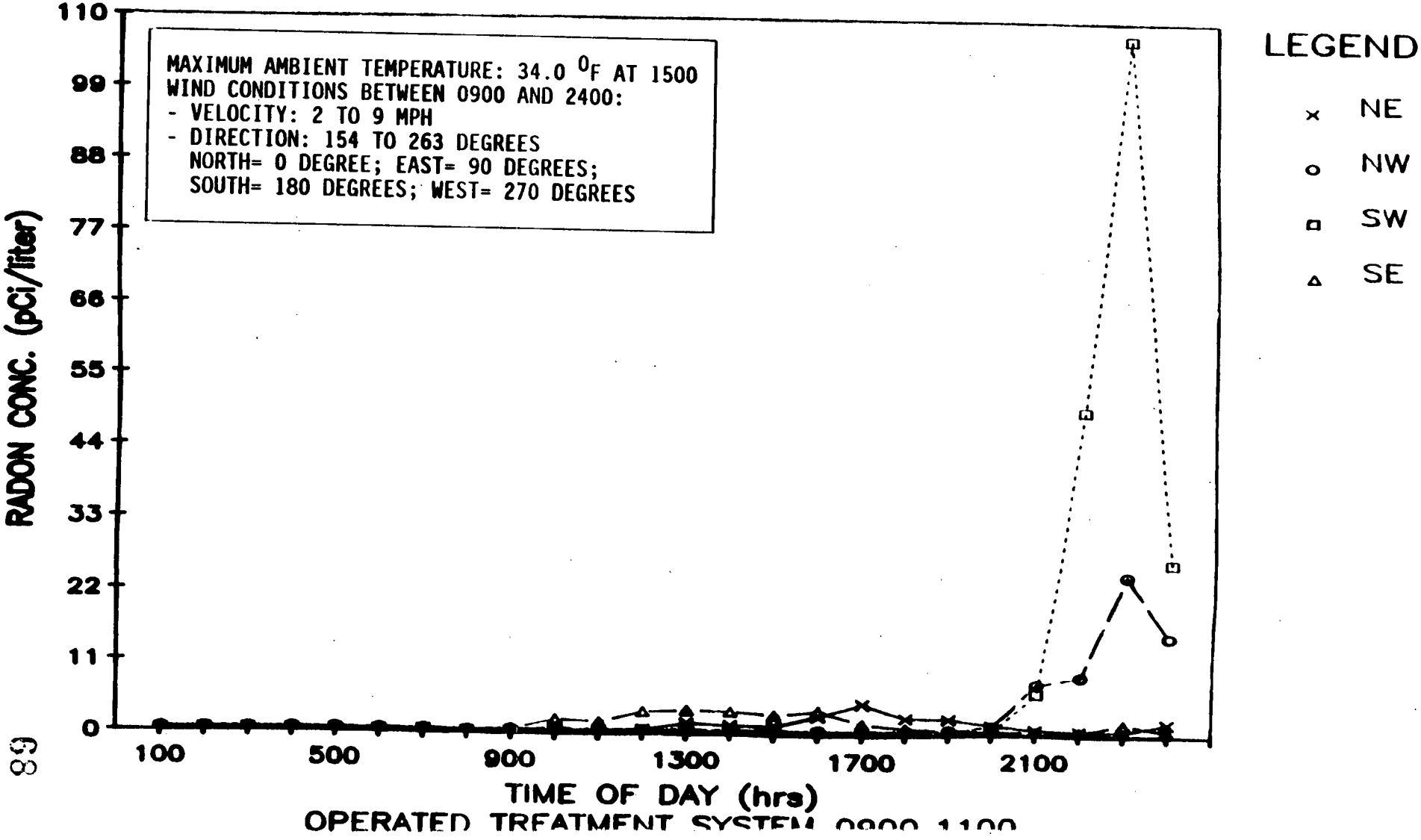


FIGURE 6.3.2-3
K-65 RGM PERIMETER DATA
THIRD RADON TREATMENT OF SILO 2
DECEMBER 4, 1987

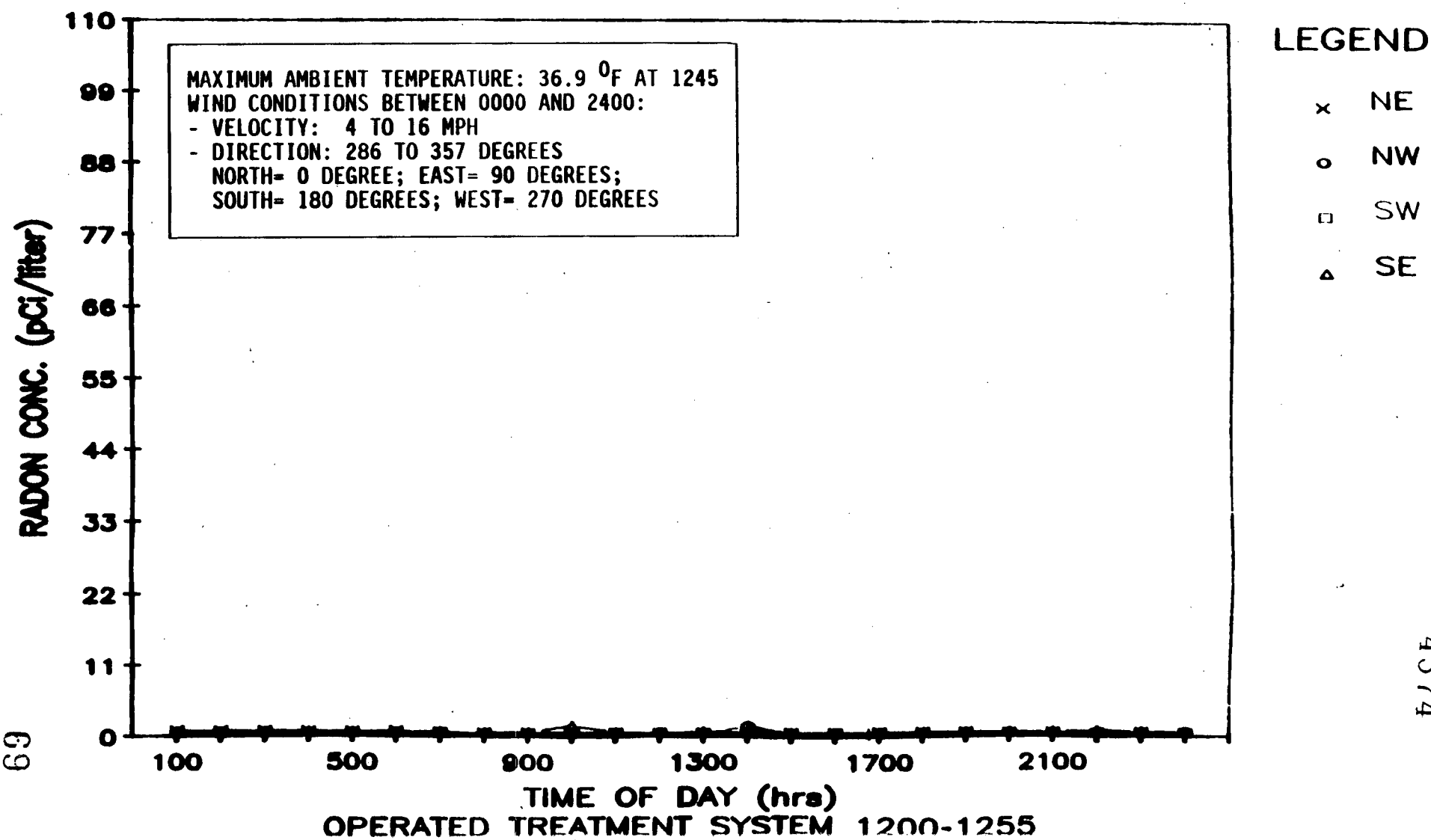


FIGURE 6.3.2-4
K-65 RGM PERIMETER DATA
FOURTH RADON TREATMENT OF SILO 2
DECEMBER 5, 1987

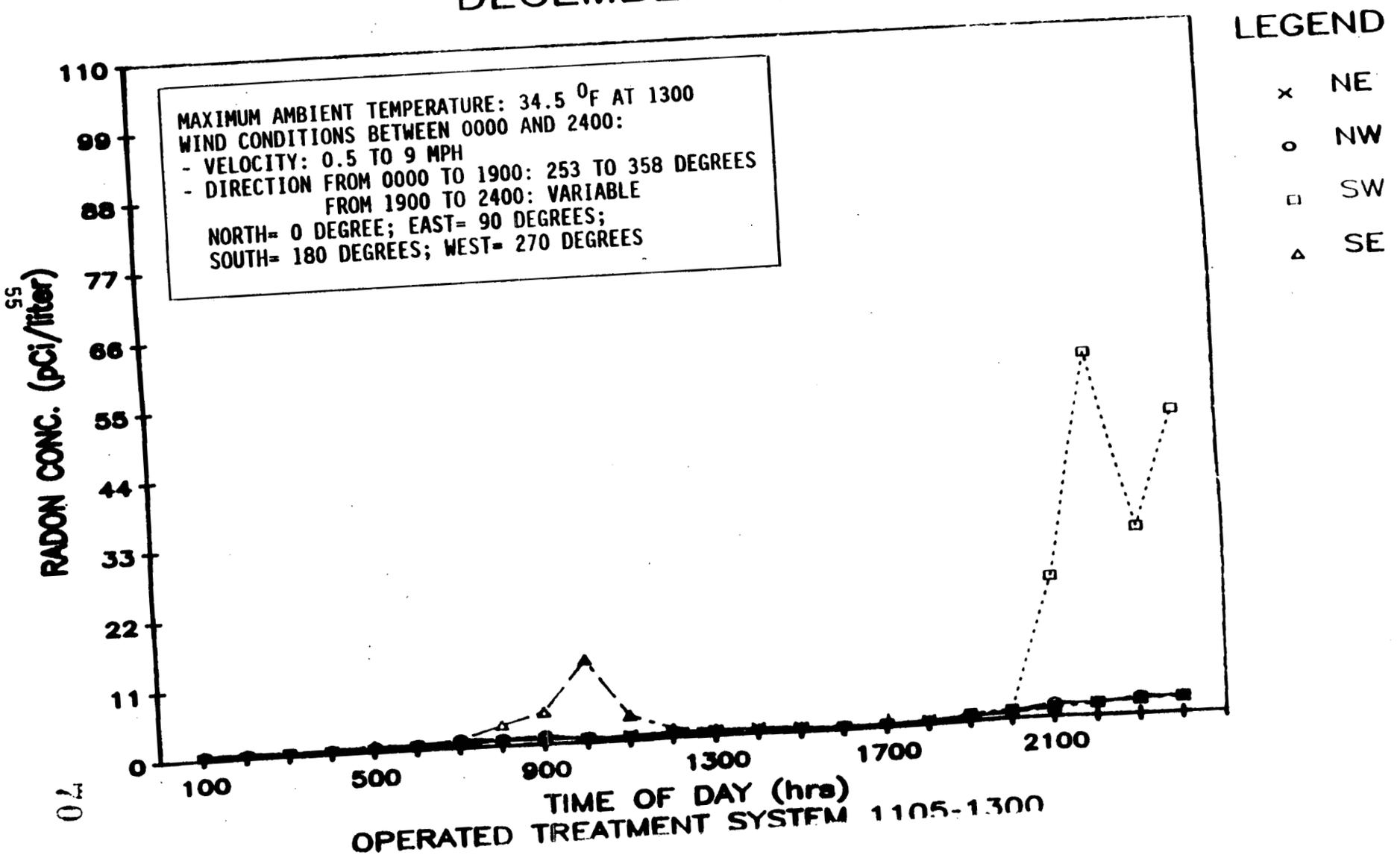


TABLE 7.0-1

SUMMARY OF PREDICTED AND ACTUAL WHOLE BODY PENETRATING RADIATION DOSES(1)

ACTIVITY (2)	PREDICTED (mrem)	ACTUAL (mrem)
Flange Changeout	5600	1575
Treatment System Construction/ Operation	1620	2305
External Foaming	700	2230
Totals:	**7920**	**6110**

(1) Doses are based on self-reading pencil dosimeters.
(2) All activities include both K-65 Silos.

TABLE 8.0-1

FUNDING/COST SUMMARY

K-65 STORAGE SILO RADON MITIGATION AND DOME REINFORCEMENT PROJECT

PROJECT TITLE.....K-65 STORAGE SILO RADON MITIGATION AND DOME REINFORCEMENT PROJECT
PA NUMBER.....34-87601
TOTAL.....$2,200,000
FUNDING SOURCE.....FY 88 GF01

BUDGET INFORMATION

SUBJECT	ORIGINAL PA BUDGET	BUDGET AFTER ECP	COMMITTED FUNDS	EXPENDED TO DATE	ESTIMATE TO COMPLETE	TOTAL ESTIMATED COST
A-E DESIGN (TITLE I & II)	$135,000	$135,000	$135,000	$112,835	$22,165	$135,000
TITLE III INSPECTION	$35,000	$35,000	$3,169	$3,169	$31,831	$35,000
WMCO DESIGN	$10,000	$20,000	$20,000	$13,741	$6,259	$20,000
	$0	$0	$0	$0	$0	$0
SUBTOTAL TITLE I, II, & III	$180,000	$190,000	$158,169	$129,745	$60,255	$190,000
ES&H SERVICES	$20,000	$20,000	$0	$0	$20,000	$20,000
	$0	$0	$0	$0	$0	$0
SUBTOTAL ADMINISTRATION	$20,000	$20,000	$0	$0	$20,000	$20,000
CONSTRUCTION MANAGEMENT	$154,500	$302,816	$124,054	$16,591	$286,225	$302,816
CONSTRUCTION SUBCONTRACT	$618,000	$1,357,021	$540,842	$334,961	$1,022,060	$1,357,021
	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0
SUBTOTAL CONSTRUCTION	$772,500	$1,659,837	$664,896	$351,552	$1,308,285	$1,659,837
PROJECT SUBTOTAL	$972,500	$1,869,837	$823,065	$481,297	$1,388,540	$1,869,837
CONTINGENCY/ESCALATION	$187,500	$330,163	N/A	N/A	$330,163	$330,163
PROJECT TOTAL	$1,160,000	$2,200,000	$823,065	$481,297	$1,718,703	$2,200,000

TABLE 8.0-2

AUTHORIZED CONSTRUCTION FUNDS TO DATE

DESCRIPTION	DOCUMENT	DATE	WORK	MANAGEMENT	TOTAL
PURCHASE RADON FILTERING EQUIPMENT	RCA	8/27	$182,400	$45,600	$228,000
RADON FILTER HOUSE INSTALLATION	CWO	9/28	$132,053	$28,920	$160,973
CONSTRUCTION MODIFICATIONS	CCP	N/A	$64,614	$14,085	$78,700
UNUSED CONSTRUCTION FUNDS FROM EXISTING WORK	CCP	N/A	($20,525)	($4,475)	($25,000)
FOAM ROOF OF DOMES (PHASE 6)	CWO	11/05	$182,300	$39,924	$222,224
CAMERA MONITORING	CWO	N/A	$0	$0	$0
INTERNAL FOAMING (PHASE 1-5)	CWO	N/A	$0	$0	$0
TOTAL PROPOSED CONSTRUCTION			$540,842	$124,054	$664,896

9.0 REFERENCES

1) Grumski, J. T., Feasibility Investigation for Control of Radon Emission from the K-65 Silos, Revision 1, July 30, 1987.

2) Grumski, J. T., Conceptual Design Report - K-65 Silo Radon Mitigation and Dome Reinforcement Study, Revision 1, May 13, 1987.

3) IT Corporation, Engineering Study of the K-65 Storage Silo Radon Mitigation and Dome Reinforcement Project at the Feed Materials Production Center, August 20, 1987.

4) Camargo Associates, Limited, K-65 Silos Study and Evaluation for the Feed Materials Production Center Volume I, Sections I through IX, February 25, 1986.

5) Nielson, K. K. and Rogers, V. C., Technical Information Memorandum (TIM-8700/18), Radon Diffusion Coefficient Measurements of Polyurethane Materials and Radon Attenuation Calculation for K-65 Silos, October 13, 1987.

6) Nuclear Energy Agency, Metrology and Monitoring of Radon, Thoron and Their Daughter Products, OECD, January, 1985.

7) Rolle, R., "Rapid Working Level Monitoring," Health Physics Journal, Vol. 22, pp. 233-238.

APPENDIX

ESTIMATES OF THE RADIUM SOURCE

TERM FROM K-65 INTERIOR RADON GAS SAMPLES

The radium-226 source term has been re-evaluated using the measured concentrations of radon inside the K-65 domes. It is initially assumed that 1650 curies of radium-226 are present in the K-65 material. Since the measured concentrations of radon-222 inside the south (Silo 1) and north (Silo 2) silos are 3×10^7 pCi/liter and 2.5×10^7 pCi/liter respectively, curie content within the silo is calculated as follows:

The volume of the north silo: $V = \pi r^2 h$

where h = effective height of silo head space
r = radius of silo

and $h = 7.5$ feet $r = 40$ feet

$$V = \pi (40^2)(7.5) \simeq 38{,}000 \text{ ft.}^3$$

The volume of the south silo:

where $h = 9.5$ feet $r = 40$ feet

$$V = \pi (40^2)(9.5) \simeq 48{,}000 \text{ ft}^3$$

The radon-222 content of the north silo is then:

$$38{,}000 \text{ ft}^3 \times 28.3 \frac{1}{\text{ft}^3} \times 3\text{x}10^7 \frac{\text{pCi}}{1} \times \frac{1 \text{ Ci}}{1\text{x}10^{12} \text{ pCi}} = 32.3 \text{ Ci}$$

The radon-222 curie content of the south silo is:

$$48{,}000 \text{ ft}^3 \times 28.3 \frac{1}{\text{ft}^3} \times 2.5\text{x}10^7 \frac{\text{pCi}}{1} \times \frac{1 \text{ Ci}}{1\text{x}10^{12} \text{ pCi}} = 34.0 \text{ Ci}$$

Since the curie content of each dome head space is essentially the same, i.e. 33.1 curies, radon must be generated at the same rate inside each dome. The radon generation rate is calculated as follows:

$$A = \frac{A_0}{\lambda} (1 - e^{-\lambda t})$$

where A = the curie content of a K-65 silo
A_0 = radon production rate in Ci/second
λ = the radon decay constant in seconds^{-1}
t = time interval long compared to the half life of radon (this allows secular equilibrium to be established).

therefore since

$$\lambda = 2.1 \times 10^{-6}/\text{second}$$
$$t = 100 \text{ days or } 8.64 \times 10^{6} \text{ second}$$
$$A = 33.1 \text{ Ci}$$

$$33.1 \text{ Ci} = \frac{A_0}{2.1\times10^{-6}/\text{sec}}(1 - e)^{-2.1 \times 10^{-6}/\text{second } (8.64 \times 10^{6}\text{second})}$$

$$A_0 = 6.95 \times 10^{-5} \text{ Ci/second}$$

The surface area inside the silo is:

$$A = \pi r^2 \text{ and since } r = 40 \text{ ft}$$

$$A = \pi (40 \text{ ft} \times 12 \frac{\text{in}}{\text{ft}} \times 2.54 \frac{\text{cm}}{\text{in}})^2 = 4.67 \times 10^{6} \text{ cm}^2$$

The radon-222 flux is then:

$$\phi = \frac{6.95 \times 10^{-5} \text{ Ci/sec}}{4.67 \times 10^{6} \text{ cm}^2}$$

$$= 1.49 \times 10^{-11} \frac{\text{Ci}}{\text{cm}^2 \text{ sec}} \times 1\times10^{12} \frac{\text{pCi}}{\text{Ci}}$$

$$= 15 \text{ pCi/cm}^2 \text{ sec}$$

This number is essentially the same flux as that calculated by T. A. Borak (Reference 1). The fact that the radon flux is the same for each dome implies that the radium-226 concentration in the K-65 residues is nearly uniform in each silo.

K-65 Gas Sample Data

Sample count data was acquired at both Mound Laboratory and WMCO. The radioactive gas decays with a 3.8 day half life and has a pure radon daughter gamma scintillation spectrum. Therefore, the radioactive gas is proven to be radon.

MIC-MOUND

Operated for the United States
Department of Energy

January 6, 1988

Mr. Scott Walker
Westinghouse Materials Co. of Ohio
P. O. Box 398704
Cincinnati, Ohio 45239

Dear Mr. Walker:

Please find enclosed tables of data summarizing the counting of the gas sampling tubes that were brought to Mound on November 5, 1987. Each tube was counted three times on four days ranging from November 6 to November 30. The counting was performed by placing a tube horizontally approximately two inches above the surface of a 3 x 3-in. sodium iodide detector. A Tracor-Northern multichannel analyzer was used to obtain the gamma-ray spectrum from the sample. Data were obtained from two energy regions. Region 1 included the peaks from the three gamma rays from lead-214 and the gamma ray from bismuth-214. Region 2 included only the peak from bismuth-214. An approximate calibration was established for these two regions by counting an NBS radium standard. The standard was placed in the same location as the gas sampling tubes; however, the standard was not in precisely the same geometry as the sampling tubes. This procedure was performed with two standards and the results were averaged to obtain the counting efficiency factors used. These factors appear in the enclosed tables in units of (cpm/uCi).

The column labeled "Act." contains the calculated activity of radon in the tube corrected for decay back to the time the sample was collected. The column labeled "Conc." contains the calculated concentration at the time of sampling; in this case, the concentration was calculated by dividing the activity value by the assumed volume of the sample, 0.125 liter. The last column is not labeled but contains the averages of the six concentration values obtained each day.

There was no indication from the gamma-ray spectra of the presence of any gamma-emitting nuclides other than radon decay products. Note that the calculated activity for each tube was essentially the same each time it was counted. Thus, the sample was disappearing at a rate consistent with the half-life of radon.

If there are any questions , please call me at FTS 774-4216.

Very truly yours,

Phillip H. Jenkins

Phillip H. Jenkins, PhD
Radon Program Manager

MONSANTO RESEARCH CORPORATION P.O. BOX 32 Miamisburg, Ohio 45342 (513) 865-4020
a subsidiary of Monsanto Company

Date	Location	Cell #	Time	Date	Instr.	Str. Time	t1 (hr)	Cnt (sec)	Bkg (CPS)	Gr. Cnts	Net Cnts	RCT (sec)	Eff	Act. (uCi)	Conc. (uCi/l)	
11/04/87	PWPC-S	#18	11:00 EST	11/06/87	T-N Reg1	16:02	53.03333	100	8.554	298236	297381	66.985	1422	3.12201	24.97604886	25.00930
				11/06/87	T-N Reg2	16:02	53.03333	100	1.7759	72620	72442	66.985	344.6	3.13833	25.10662380	
				11/06/87	T-N Reg1	16:04	53.06666	100	8.554	297041	296186	66.968	1422	3.11024	24.88194877	
				11/06/87	T-N Reg2	16:04	53.06666	100	1.7759	72507	72329	66.968	344.6	3.13422	25.07377343	
				11/06/87	T-N Reg1	16:08	53.13333	100	8.554	296737	295882	66.935	1422	3.10862	24.86893053	
				11/06/87	T-N Reg2	16:08	53.13333	100	1.7759	72686	72508	66.935	344.6	3.14356	25.14848664	
				11/09/87	T-N Reg1	08:35	117.5833	100	8.554	183147	182292	41.136	1422	3.11633	24.93062588	25.08793
				11/09/87	T-N Reg2	08:35	117.5833	100	1.7759	44798	44620	41.136	344.6	3.14771	25.18166283	
				11/09/87	T-N Reg1	08:43	117.7166	100	8.554	183186	182331	41.095	1422	3.12014	24.96108643	
				11/09/87	T-N Reg2	08:43	117.7166	100	1.7759	44686	44508	41.095	344.6	3.14297	25.14376600	
				11/09/87	T-N Reg1	08:46	117.7666	100	8.554	183724	182869	41.079	1422	3.13052	25.04419562	
				11/09/87	T-N Reg2	08:46	117.7666	100	1.7759	44886	44708	41.079	344.6	3.15829	25.26629111	
				11/11/87	T-N Reg1	10:52	167.8666	100	8.554	125366	124511	28.136	1422	3.11198	24.89583299	25.15741
				11/11/87	T-N Reg2	10:52	167.8666	100	1.7759	30614	30436	28.136	344.6	3.13912	25.11297041	
				11/11/87	T-N Reg1	10:55	167.9166	100	8.554	126275	125420	28.126	1422	3.13588	25.08706018	
				11/11/87	T-N Reg2	10:55	167.9166	100	1.7759	30785	30607	28.126	344.6	3.15795	25.26360164	
				11/11/87	T-N Reg1	10:58	167.9666	100	8.554	126592	125737	28.115	1422	3.14500	25.15996874	
				11/11/87	T-N Reg2	10:58	167.9666	100	1.7759	30969	30791	28.115	344.6	3.17813	25.42507745	
				11/30/87	T-N Reg1	14:26	627.4333	600	8.554	28658	23526	5.243	1422	3.15537	25.24294150	25.11690
				11/30/87	T-N Reg2	14:26	627.4333	600	1.7759	6708	5642	5.243	344.6	3.12293	24.98343010	
				11/30/87	T-N Reg1	14:50	627.8333	600	8.554	28364	23232	5.227	1422	3.12536	25.00291062	
				11/30/87	T-N Reg2	14:50	627.8333	600	1.7759	6715	5649	5.227	344.6	3.13626	25.09011826	
				11/30/87	T-N Reg1	15:40	628.6666	600	8.554	28314	23182	5.195	1422	3.13833	25.10663991	
				11/30/87	T-N Reg2	15:40	628.6666	600	1.7759	6721	5655	5.195	344.6	3.15942	25.27536549	

Date	Location	Cell #	Time	Date	Instr.	Str. Time	ti (hr)	Cnt (sec)	Bkg (CPS)	Gr. Cnts	Net Cnts	BCT (sec)	Eff	Act. (uCi)	Conc. (uCi/l)	
11/04/87	FHPC-S	#28	11:00 EST	11/06/87	T-N Reg1	15:33	52.55	100	8.554	292074	291219	67.230	1422	3.04617	24.36938914	24.27329
				11/06/87	T-N Reg2	15:33	52.55	100	1.7759	70727	70549	67.230	344.6	3.04518	24.3614561	
				11/06/87	T-N Reg1	15:38	52.63333	100	8.554	289188	288333	67.188	1422	3.01788	24.143079	
				11/06/87	T-N Reg2	15:38	52.63333	100	1.7759	70496	70318	67.188	344.6	3.03712	24.29697868	
				11/06/87	T-N Reg1	15:42	52.7	100	8.554	289971	289116	67.154	1422	3.02760	24.22083617	
				11/06/87	T-N Reg2	15:42	52.7	100	1.7759	70319	70141	67.154	344.6	3.03100	24.24802781	
				11/09/87	T-N Reg1	08:51	117.85	100	8.554	179190	178335	41.053	1422	3.05483	24.43863433	24.56256
				11/09/87	T-N Reg2	08:51	117.85	100	1.7759	43727	43549	41.053	344.6	3.07835	24.62679641	
				11/09/87	T-N Reg1	08:54	117.9	100	8.554	179829	178974	41.038	1422	3.06693	24.53546648	
				11/09/87	T-N Reg2	08:54	117.9	100	1.7759	43543	43365	41.038	344.6	3.06650	24.53200958	
				11/09/87	T-N Reg1	08:58	117.9666	100	8.554	179658	178803	41.017	1422	3.06555	24.52437083	
				11/09/87	T-N Reg2	08:58	117.9666	100	1.7759	43850	43672	41.017	344.6	3.08977	24.71812513	
				11/11/87	T-N Reg1	10:32	167.5333	100	8.554	123904	123049	28.207	1422	3.06770	24.54163638	24.59177
				11/11/87	T-N Reg2	10:32	167.5333	100	1.7759	29906	29728	28.207	344.6	3.05839	24.46711964	
				11/11/87	T-N Reg1	10:35	167.5833	100	8.554	124419	123564	28.197	1422	3.08171	24.65366087	
				11/11/87	T-N Reg2	10:35	167.5833	100	1.7759	30289	30111	28.197	344.6	3.09896	24.79169842	
				11/11/87	T-N Reg1	10:38	167.6333	100	8.554	123659	122804	28.186	1422	3.06391	24.51127979	
				11/11/87	T-N Reg2	10:38	167.6333	100	1.7759	30027	29849	28.186	344.6	3.07316	24.58526895	
				11/30/87	T-N Reg1	15:56	628.9333	600	8.554	27832	22700	5.184	1422	3.07927	24.63418433	24.63750
				11/30/87	T-N Reg2	15:56	628.9333	600	1.7759	6721	5655	5.184	344.6	3.16579	25.32632880	
				11/30/87	T-N Reg1	16:13	629.2166	600	8.554	27687	22555	5.173	1422	3.06616	24.52926771	
				11/30/87	T-N Reg2	16:13	629.2166	600	1.7759	6558	5492	5.173	344.6	3.08113	24.64907804	
				11/30/87	T-N Reg1	16:25	629.4166	600	8.554	27563	22431	5.165	1422	3.05391	24.43129242	
				11/30/87	T-N Reg2	16:25	629.4166	600	1.7759	6462	5396	5.165	344.6	3.03186	24.25486360	

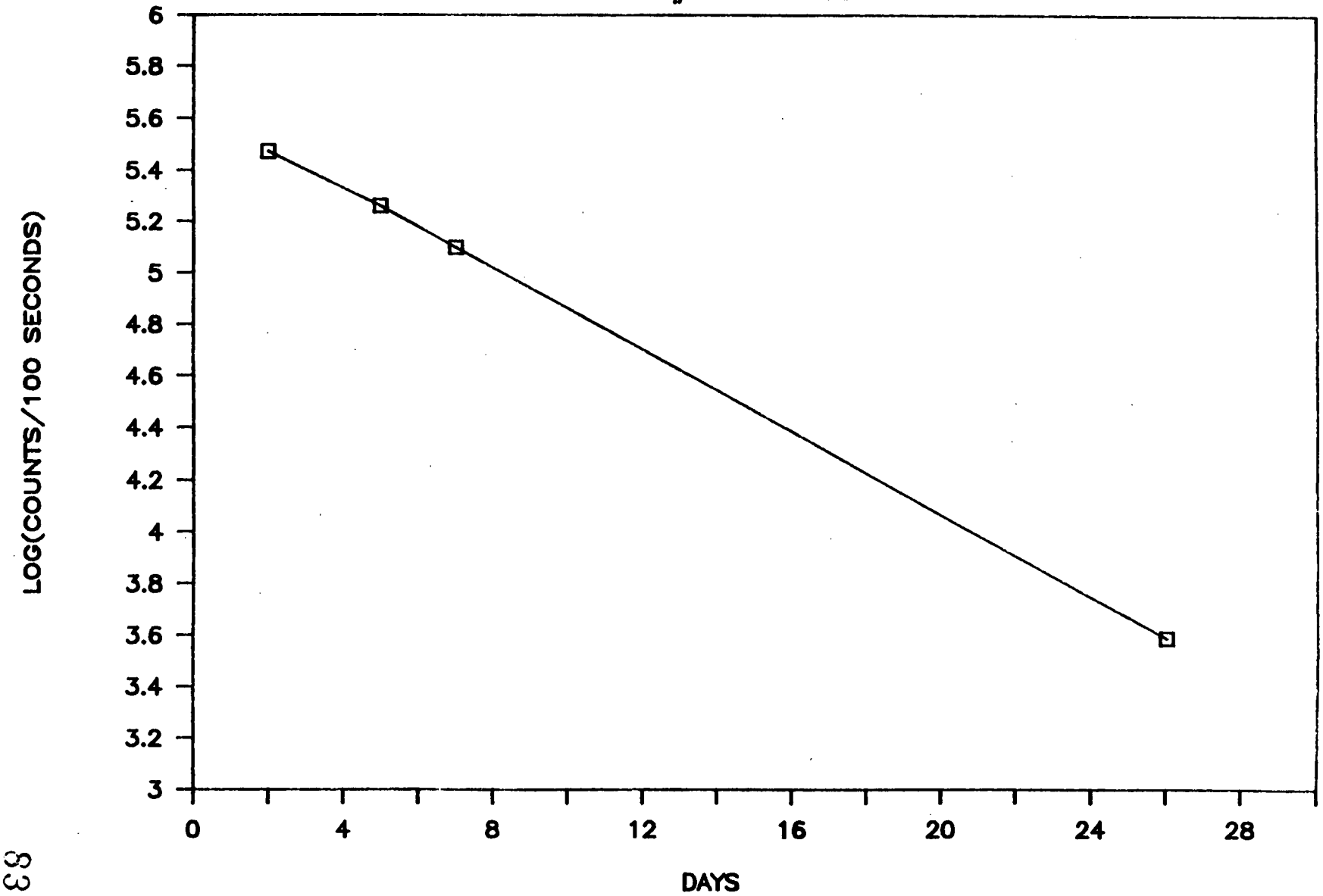
Date	Location	Cell #	Time	Date	Instr.	Str. Time	t1 (hr)	Cat (sec)	Bkg (CPS)	Gr. Cats	Net Cats	ECT (sec)	Eff	Act. (uCi)	Conc. (uCi/l)	
11/04/87	FHPC-N	#3N	11:00 EST	11/06/87	T-N Reg1	15:52	52.86666	100	8.554	354740	353885	67.070	1422	3.71053	29.68424572	29.89822
				11/06/87	T-N Reg2	15:52	52.86666	100	1.7759	86913	86735	67.070	344.6	3.75280	30.02237969	
				11/06/87	T-N Reg1	15:55	52.91666	100	8.554	355004	354149	67.044	1422	3.71470	29.71761197	
				11/06/87	T-N Reg2	15:55	52.91666	100	1.7759	86843	86665	67.044	344.6	3.75119	30.00948191	
				11/06/87	T-N Reg1	15:58	52.96666	100	8.554	355535	354680	67.019	1422	3.72168	29.77341239	
				11/06/87	T-N Reg2	15:58	52.96666	100	1.7759	87309	87131	67.019	344.6	3.77278	30.18224000	
				11/09/87	T-N Reg1	09:03	118.05	100	8.554	218633	217778	40.991	1422	3.73612	29.88894776	30.02825
				11/09/87	T-N Reg2	09:03	118.05	100	1.7759	53377	53199	40.991	344.6	3.76616	30.12926642	
				11/09/87	T-N Reg1	09:14	118.2333	100	8.554	218878	218023	40.935	1422	3.74550	29.96403914	
				11/09/87	T-N Reg2	09:14	118.2333	100	1.7759	53377	53199	40.935	344.6	3.77138	30.17101914	
				11/09/87	T-N Reg1	09:32	118.5333	100	8.554	217508	216653	40.842	1422	3.73041	29.84330329	
				11/09/87	T-N Reg2	09:32	118.5333	100	1.7759	53260	53082	40.842	344.6	3.77162	30.17296178	
				11/11/87	T-N Reg1	10:18	167.3	100	8.554	150512	149657	28.257	1422	3.72449	29.79595213	29.99377
				11/11/87	T-N Reg2	10:18	167.3	100	1.7759	36651	36473	28.257	344.6	3.74569	29.96553841	
				11/11/87	T-N Reg1	10:23	167.3833	100	8.554	150854	149999	28.239	1422	3.73536	29.88284712	
				11/11/87	T-N Reg2	10:23	167.3833	100	1.7759	37039	36861	28.239	344.6	3.78792	30.30337737	
				11/11/87	T-N Reg1	10:28	167.4666	100	8.554	150824	149969	28.222	1422	3.73696	29.89568291	
				11/11/87	T-N Reg2	10:28	167.4666	100	1.7759	36792	36614	28.222	344.6	3.76491	30.11927438	
				11/30/87	T-N Reg1	11:03	624.05	600	8.554	33802	28670	5.379	1422	3.74828	29.98623261	29.76413
				11/30/87	T-N Reg2	11:03	624.05	600	1.7759	7874	6808	5.379	344.6	3.67319	29.38552712	
				11/30/87	T-N Reg1	11:16	624.2666	600	8.554	33602	28470	5.370	1422	3.72823	29.82582116	
				11/30/87	T-N Reg2	11:16	624.2666	600	1.7759	7934	6868	5.370	344.6	3.71163	29.6930453	
				11/30/87	T-N Reg1	11:29	624.4833	600	8.554	33573	28441	5.361	1422	3.73053	29.84424321	
				11/30/87	T-N Reg2	11:29	624.4833	600	1.7759	7959	6893	5.361	344.6	3.73124	29.84993566	

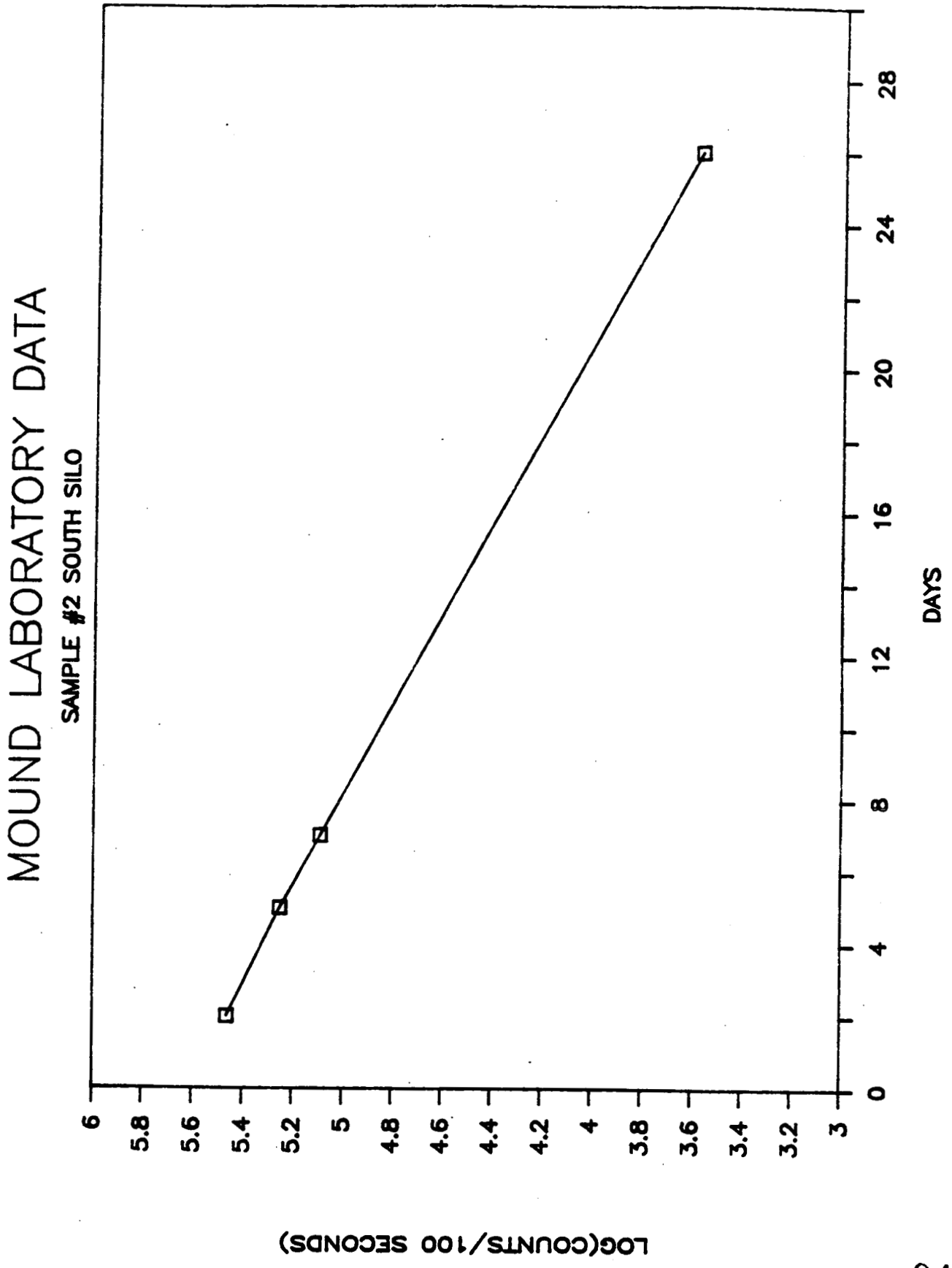
Date	Location	Cell #	Time
11/04/87	FMPC-N	#4N	11:00 EST

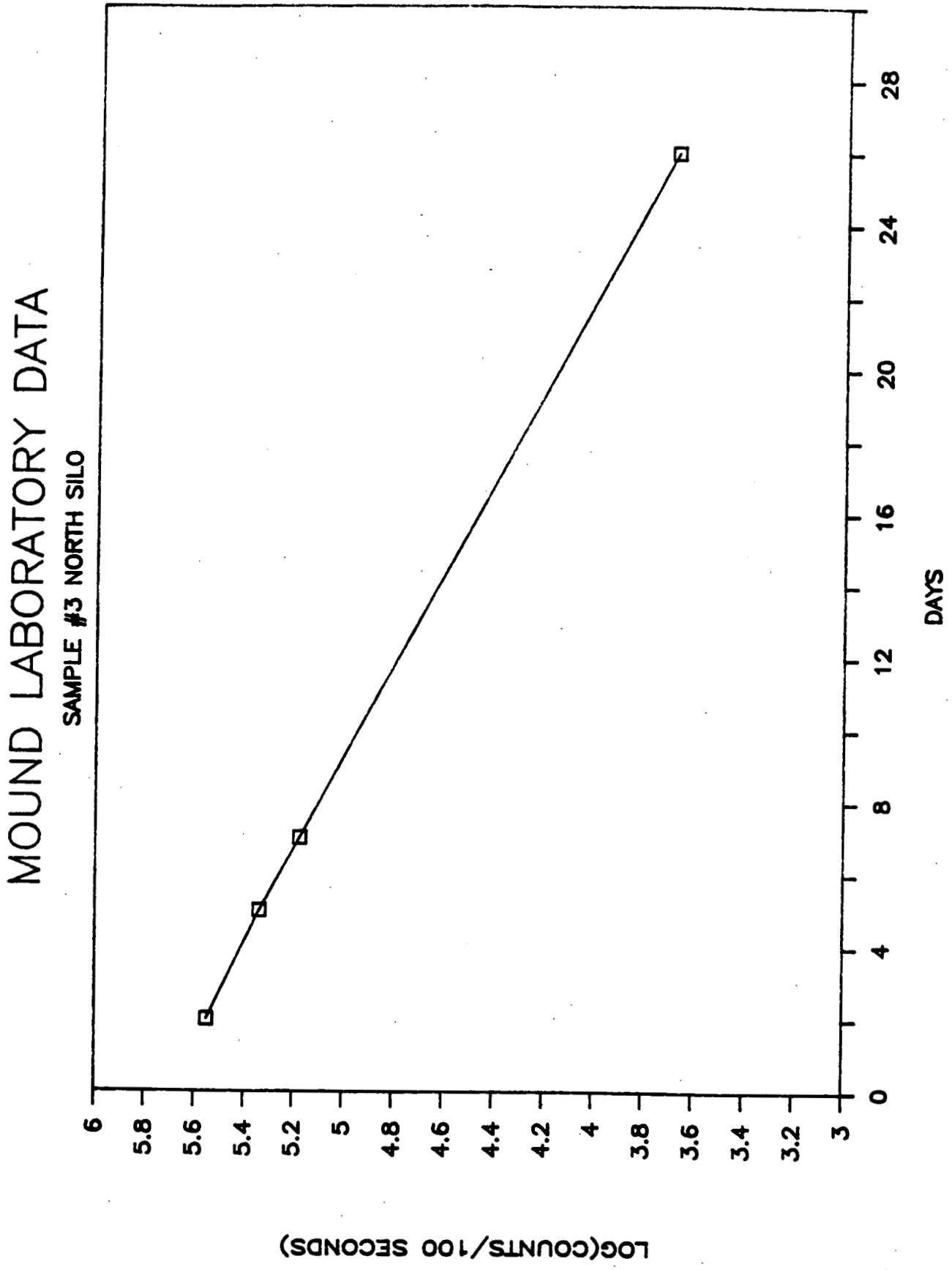
Date	Instr.	Str. Time	t1 (hr)	Cnt (sec)	Bkg (CPS)	Gr. Cnts	Net Cnts	RCT (sec)	Eff	Act. (uCi)	Conc. (uCi/l)	
11/06/87	T-N Reg1	16:12	53.2	100	8.554	339300	338445	66.901	1422	3.55759	28.46069092	28.52577
11/06/87	T-N Reg2	16:12	53.2	100	1.7759	83101	82923	66.901	344.6	3.59691	28.77526461	
11/06/87	T-N Reg1	16:15	53.25	100	8.554	336964	336109	66.876	1422	3.53437	28.27492743	
11/06/87	T-N Reg2	16:15	53.25	100	1.7759	82864	82686	66.876	344.6	3.58798	28.70386203	
11/06/87	T-N Reg1	16:18	53.3	100	8.554	337113	336258	66.850	1422	3.53727	28.29814759	
11/06/87	T-N Reg2	16:18	53.3	100	1.7759	82654	82476	66.850	344.6	3.58022	28.64177776	
11/09/87	T-N Reg1	08:25	117.4166	100	8.554	209152	208297	41.188	1422	3.55641	28.45128972	28.54456
11/09/87	T-N Reg2	08:25	117.4166	100	1.7759	50989	50811	41.188	344.6	3.57994	28.63949441	
11/09/87	T-N Reg1	08:29	117.4833	100	8.554	209677	208822	41.167	1422	3.56717	28.53736665	
11/09/87	T-N Reg2	08:29	117.4833	100	1.7759	51048	50870	41.167	344.6	3.58590	28.68719181	
11/09/87	T-N Reg1	08:32	117.5333	100	8.554	208908	208053	41.152	1422	3.55538	28.44301615	
11/09/87	T-N Reg2	08:32	117.5333	100	1.7759	50713	50535	41.152	344.6	3.56363	28.50904157	
11/11/87	T-N Reg1	10:42	167.7	100	8.554	144322	143467	28.172	1422	3.58125	28.64998469	28.60786
11/11/87	T-N Reg2	10:42	167.7	100	1.7759	35160	34982	28.172	344.6	3.60344	28.82754355	
11/11/87	T-N Reg1	10:45	167.75	100	8.554	143200	142345	28.161	1422	3.55458	28.43666153	
11/11/87	T-N Reg2	10:45	167.75	100	1.7759	34805	34627	28.161	344.6	3.56822	28.54578201	
11/11/87	T-N Reg1	10:48	167.8	100	8.554	143465	142610	28.151	1422	3.56255	28.50036346	
11/11/87	T-N Reg2	10:48	167.8	100	1.7759	34963	34785	28.151	344.6	3.58586	28.68686480	
11/30/87	T-N Reg1	11:46	624.7666	600	8.554	32027	26895	5.350	1422	3.53530	28.28240760	28.29707
11/30/87	T-N Reg2	11:46	624.7666	600	1.7759	7696	6630	5.350	344.6	3.59658	28.77261074	
11/30/87	T-N Reg1	13:59	626.9833	600	8.554	31629	26497	5.261	1422	3.54179	28.33434534	
11/30/87	T-N Reg2	13:59	626.9833	600	1.7759	7344	6278	5.261	344.6	3.46314	27.70514888	
11/30/87	T-N Reg1	14:12	627.2	600	8.554	31604	26472	5.252	1422	3.54425	28.35397794	
11/30/87	T-N Reg2	14:12	627.2	600	1.7759	7476	6410	5.252	344.6	3.54175	28.33396306	

MOUND LABORATORY DATA

SAMPLE #1 SOUTH SILO

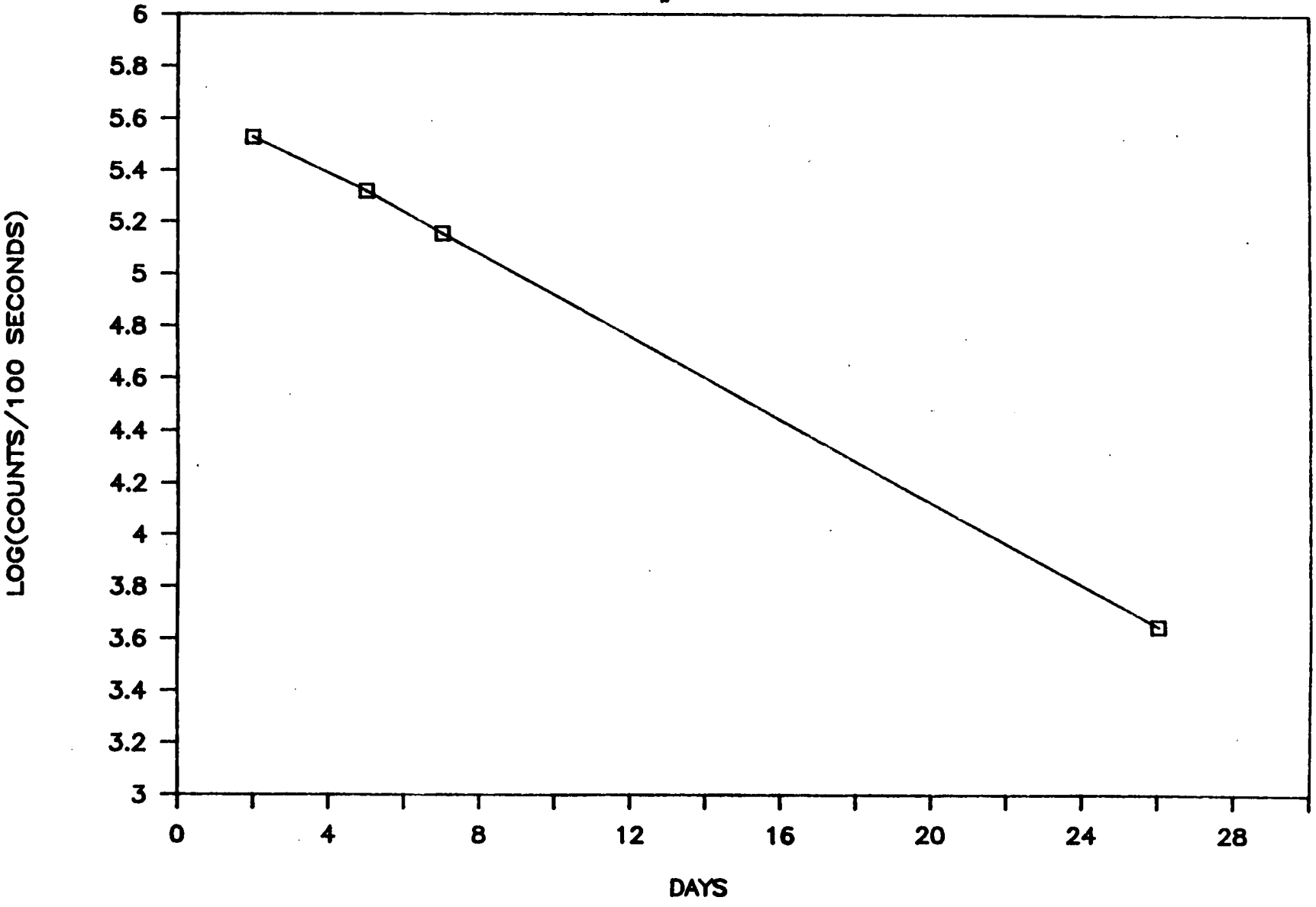



MOUND LABORATORY DATA
SAMPLE #2 SOUTH SILO
LOG(COUNTS/100 SECONDS)
6
5.8
5.6
5.4
5.2
5
4.8
4.6
4.4
4.2
4
3.8
3.6
3.4
3.2
3
0
4
8
12
16
20
24
28
DAYS


MOUND LABORATORY DATA
SAMPLE #3 NORTH SILO
LOG(COUNTS/100 SECONDS)
6
5.8
5.6
5.4
5.2
5
4.8
4.6
4.4
4.2
4
3.8
3.6
3.4
3.2
3
0
4
8
12
16
20
24
28
DAYS

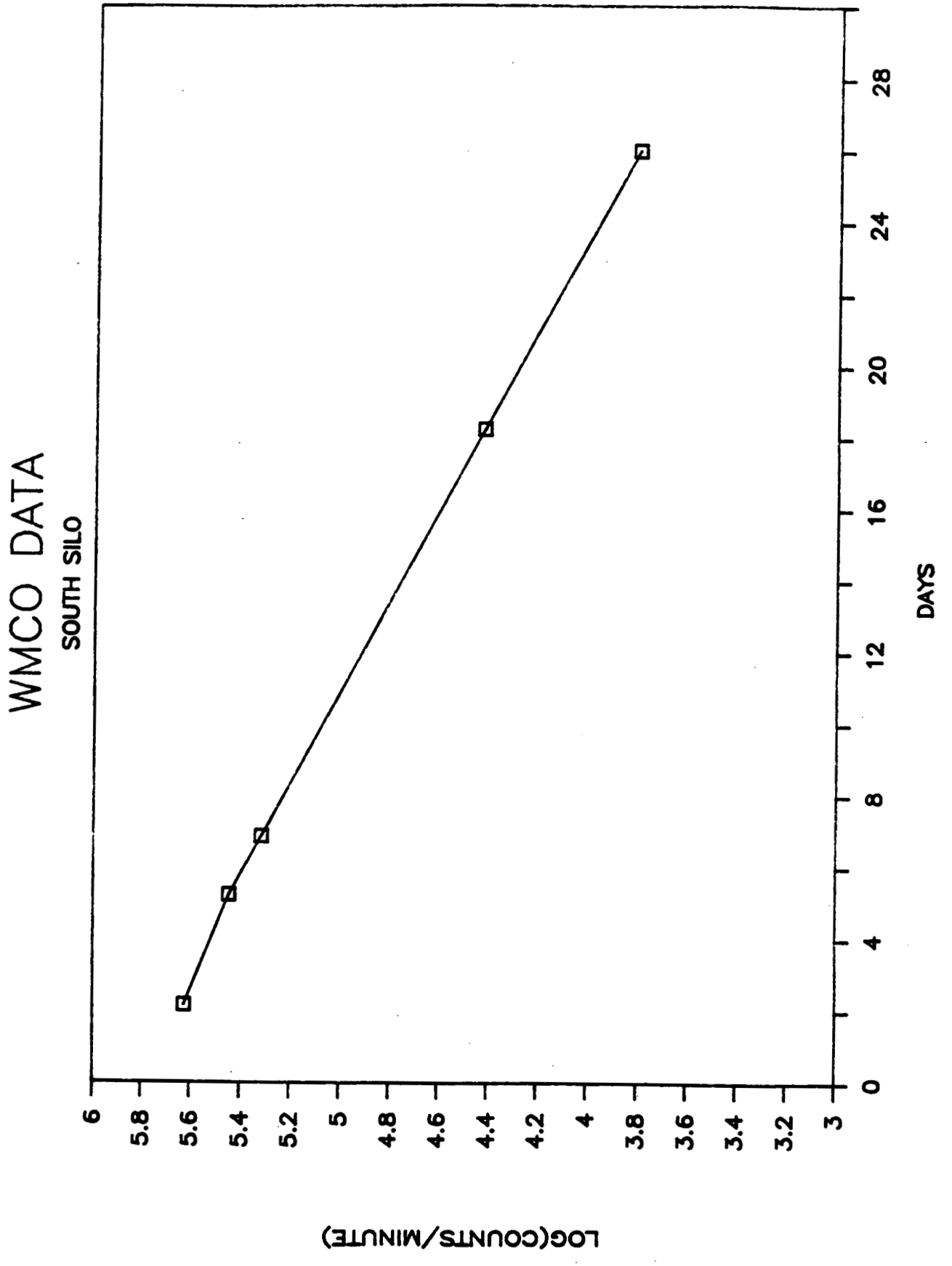
MOUND LABORATORY DATA

SAMPLE #4 NORTH SILO



Silo No.1 Counting Data

Date	Event	Time	CPM	Days From Sampling	Concentration pCi/L
11/4/87	Sample Taken	11:00	N/A	N/A	N/A
11/6/87	First Count	13:15	424,347	2.09	1.9E+7
11/6/87	Second Count	14:30	423,455	2.15	2.0E+7
11/6/87	Third Count	15:05	419,631	2.17	1.9E+7
11/6/87	Fourth Count	16:23	417,534	2.23	1.9E+7
11/9/87	Fifth Count	16:30	278,465	5.23	2.2E+7
11/11/87	Sixth Count	07:40	207,528	6.85	2.2E+7
11/22/87	Seventh Count	16:30	26,444	19.23	2.7E+7
12/1/87	Eighth Count	11:15	6,432	26.00	2.2E+7


WMCO DATA
SOUTH SILO
LOG(COUNTS/MINUTE)
6
5.8
5.6
5.4
5.2
5
4.8
4.6
4.4
4.2
4
3.8
3.6
3.4
3.2
3
0
4
8
12
16
20
24
28
DAYS

REFERENCES

1) Borak, T. B., Calculation of Radon Emission, Dispersion and Dosimetry from K-65 Storage Tanks at the Feed Materials Production Center, October, 1985.