Morton and Potter

10421 MASTERS TERRACE
POTOMAC, MARYLAND 20854

HENRY W. MORTON
10421 MASTERS TERRACE
POTOMAC, MARYLAND 20854
301-983-0365

THOMAS E. POTTER
4231 JENIFER STREET, N.W.
WASHINGTON, D.C. 20015
202-363-4727

5/22/89

Mr. Jackson Ransohoff
Neutron Products, Inc.
Dickerson, MD 20842

Dear Mr. Ransohoff:

Enclosed is the initial progress report describing my evaluation of the NPI radiation protection program. This report is intended to respond to condition 13.C.1 to 13.C.6 of your license issued by the State of Maryland. Please call if you have any questions.

Sincerely,

Thomas E. Potter

Thomas E. Potter

A/12

RADIATION PROTECTION EVALUATION OF NEUTRON PRODUCTS, INC.

PROGRESS REPORT 1

5/22/89

by

Thomas E. Potter

Morton and Potter
10421 Masters Terrace
Potomac, MD 20854

301-983-0365

MEMORANDUM

May 26, 1989

To: J. A. Ransohoff

From: W. J. Coatley & F. Schwoerer

Subj: Amendment 33 to MD-31-025-01 as Proposed by MDE - Conditions to Resume Activities Authorized by Condition P.2

A. Gas Proportional Portal Monitor

Neutron Products has obtained and installed and is routinely using a Helgeson mini-HECM monitor that meets the specifications of this condition. The monitor is temporarily located at the top of a staircase from the portal of the Limited Access Area (LAA) and doors have been sealed and other arrangements made to extend the boundary of the LAA to encompass the monitor. Background radiation in the area of the monitor is about 0.04 mR/hr. Construction of the permanent location of the monitor is nearly complete; background radiation there is less than 0.05 mR/hr; and the monitor will be installed in its permanent location prior to June 12, 1989.

Condition A is complete except for the following submittals to the Center for Radiological Health (CRH).

1. Inspection by Manufacturer/Service Record

Transmitted herewith (Attachment 1) are copies of the Service Contract and the Service Record from the last inspection by a representative of Helgeson. The Service Contract calls for routine service calls at approximately six month intervals and for nonroutine service as needed. The Service Record documents that the monitor was correctly set up and operating in accordance with the manufacturer's specifications.

2. Contingency Plan for Monitor Downtime

We have ordered a 100 cm^2 hand-held gas proportional counter (GPC) from Ludlum for frisking personnel at the portal monitor location. Delivery is scheduled for June 2 to 6, 1989. We estimate that the background count rate of this instrument will be about 3 cps or 180 cpm, and its lower detection limit will be 150 to 200 cpm. At an estimated counting efficiency at contact of 12.5%, the instrument will detect from 1200 to 1600 dpm, which if uniformly distributed is 1200 to 1600 dpm/100 cm^2.

Whenever the mini-HECM is not operable, the 100 cm^2 GPC frisker will be used to monitor for contamination on personnel and personal effects leaving the LAA.

Based on the highly reliable operating record of the mini-HECM to date, it is improbable that the mini-HECM will become inoperable during the short time before the 100 cm^2 GCP is delivered and put into operation. However, if the mini-HECM goes down before the 100 cm^2 GCP is on hand, the following steps will be taken.

- We will perform meticulous 2-man frisking of personnel as they leave the LAA, using a 15 cm^2 pancake GM detector. We estimate the lower detection limit to be about 100 cpm above background which, at an estimated 10% detection efficiency, corresponds to 1000 dpm or about 6700 dpm/cm^2, if uniformly distributed.

- We will notify the CRH by telephone within 2 hours.

C. Independent Evaluations by Health Physics Consultant

The initial independent evaluations specified by condition C.1.a.-j are contained in a letter transmitted to Neutron Products on May 22, 1989, a copy of which is appended to this memorandum (Attachment 2). Mr. Potter has ensured that the portal monitor is properly installed and maintained (condition C.2) and is being used correctly (condition C.4). He has overseen construction of the portal monitor area where measured background radiation levels are less than 0.05 mR/hr (condition C.3). He has also conducted a thorough evaluation of the hot cell ventilation system, which was documented in his report dated May 17, 1989.

Mr. Potter's evaluations for conditions C.1.a-j contain several recommendations for actions to be taken by Neutron Products. Our plans for addressing his recommendations are detailed in an Attachment 3 to this memorandum. Subject to our completion of the actions detailed in Attachment 3, it is our belief that all actions required prior to resumption of those activities permitted by condition P.2 are complete.

D. Health Physics Technician(s)

Neutron Products has assigned personnel trained and experienced as health physics technicians and others trained and experienced in electronics to perform the functions specified in condition D. The day-to-day activities of these personnel will be documented in a bound, sequentially page numbered log book. These personnel are:

Joseph Weedon
Wayne Marsh
Yann LeGuellec
Donald Mitchell
Bernard Bozwell

1. Health Physics technicians and electronics technicians have been monitoring the use of the mini-HECM monitor and related hand-held frisking since the monitor was formally put into operation on April 18, 1989. Initial training in the operation and use of the monitor was provided by a representative of the manufacturer, Helgeson Scientific Services, and has been continued by the electronics technicians.

   Specific daily assignments will be made to ensure that trained personnel are always available for this function.

2. The personnel assigned in 1 above will also have the responsibility for ensuring that all persons log in and log out upon entering and exiting the LAA.

3. The personnel assigned in 1 and 2 above will also be responsible for the proper use of hand-held friskers to locate contamination detected on personnel.

4. Neutron Products procedure R 1011, Rev. 0, Procedure for the Limits for Decontamination and Release of People and Personal Effects from the Limited Access Area, incorporates the provisions of this section.

5. In conjunction with the RSO, the personnel assigned in items 1 through 4 above will be responsible for documenting sources of contamination for further evaluation.

6&7. These duties have been and remain an integral part of our radiation protection program and will continue to be assigned to trained and experienced health physics technicians.

8. The plan for radiation surveys of soil and water contamination in surface and ground water at the plant boundary and within one kilometer radius of the plant is under development (refer also to condition N). In the interim, these surveys will continue to be performed in accordance with our existing procedures.

9. Contamination of vehicles and equipment will be governed by U.S. Department of Transportation regulations. Release limits on fixed contamination will be as contained in our procedure R 1011, referenced in 1 above.

G. Clothing Worn Inside and Outside the LAA

We are in full compliance with this condition.

J. Compaction of Radwaste

We are in full compliance with the prohibition on compaction of radwaste. We are evaluating concepts and working on a plan for conducting this activity in the future, after CRH approval.

L. Monitoring Boundaries of the Facility

Eleven TLDs have been placed around the fenced boundary of the property at intervals of no more than 100 ft. At the recommendation of our Health Physics consultant, TLDs have not been mounted on the outer walls of buildings that constitute portions of the property boundary.

On the basis of the information documented above and the attachments to this memorandum, we believe that Neutron Products has met all of the conditions specified by CRH for resumption of "activities requiring the use, handling, shipment, and transfer of doubly encapsulated cobalt-60" (ref: condition P.2).

FS/WJC:mvc:9

Attachment 1

HELGESON SCIENTIFIC SERVICES
5587 SUNOL BOULEVARD • PLEASANTON, CALIFORNIA 94566
(415) 846-3453 • TWX: 910 482 6460 • Cable Address: HELGENUC

DATE: MAY 26, 1989

TO: FRANK SCHWOERR
NEUTRON PRODUCTS

FAX #: (301) 349-5007

FROM: DAVID POLLARD
EXECUTIVE VICE PRESIDENT
HELGESON SCIENTIFIC SERVICES
5587 SUNOL BLVD.
PLEASANTON, CALIFORNIA 94566
FAX #: (415) 462-1157

REFERENCE: SERVICE AGREEMENT

TOTAL PAGES: 7 (INCLUDING COVER PAGE)

MESSAGE:

Dear Frank:

This is a preliminary copy of the Service Agreement that may be used as an example. It does not include Appendix A.

Look it over and see if your need any additions or deletions.

Very truly yours,

David Pollard
Executive Vice President

HELGESON SCIENTIFIC SERVICES
5587 SUNOL BLVD.
PLEASANTON, CALIFORNIA 94566

SERVICE AGREEMENT

AGREEMENT NO.: SA/89/1

CUSTOMER: Neutron Products
Dickerson, Maryland

COMMENCEMENT DATE: September 15, 1989

EQUIPMENT LOCATION: Dickerson, Maryland

TELEPHONE:

PRIMARY CONTACT:

SECONDARY CONTACT:

1. GENERAL

This agreement is entered between Helgeson Scientific Services, hereinafter called the Contractor, and Neutron Products, hereinafter called the Customer, and covers the equipment as listed on the equipment list Appendix A.

2. TERM

This agreement shall be effective when signed by both parties. The initial term is twelve (12) months from commencement date, after which this agreement may be terminated by either party upon ninety (90) days following written notice.

3. ELIGIBILITY FOR SERVICE

Equipment is eligible for service under this agreement provided it meets the provisions of paragraph 11, REMOVAL OF EQUIPMENT, and paragraph 12, EXCLUSIONS.

4. PRICE

The price for the initial term shall be paid in full at the commencement of the agreement. The price for each one-year renewal shall be paid in full at the commencement of each new term. Prices will be at the then available rates for service. Prior to the commencement of any new term, the contractor shall provide copies of rates which are applicable to the new term. The price for the initial term is stated in Appendix A to this agreement.

5. SERVICE-SCHEDULED

The contractor will provide scheduled preventive maintenance visits on the equipment covered in this agreement once every six months during the initial term, and such scheduled visits during all subsequent one-year renewal terms. These scheduled preventive maintenance visits will be provided between 8:00 A.M. to 5:00 P.M. Monday through Friday (usual business hours) excluding holidays. The timing of such service visits will depend upon the customer's equipment and last service date. Dates of visits will be mutually agreed upon by the contractor and the customer.

6. SERVICE-UNSCHEDULED

The contractor shall provide emergency service visits during the term of the service agreement. These service visits will be made at times mutually agreed upon by the contractor and the customer. The contractor will schedule this emergency service within twenty-four (24) hours of any request for emergency service made during normal business hours. Charges for this emergency service will be at the then applicable rates.

The contractor will repair or replace said property on a return to the factory basis provided that the needed repairs are the results of normal use and are not the result of misuse, abuse, neglect, or alterations made to said property without the written consent of contractor. The charge for this service is included in the annual fee.

7. ACCESS

The contractor shall have unhindered access to the equipment when providing service as stipulated in this contract.

8. PAYMENT

The customer agrees to be responsible for payment of any taxes or duties levied by any federal, state, or local government as a result of work performed in execution of this agreement. Any taxes or duties, charged directly to the contractor, shall be paid by the customer upon receipt of invoice. Payment for initial term and for each subsequent renewal will be due upon the signing of this agreement, and the anniversary of each renewal.

9. SPARE PARTS

Spare parts are not included, unless so stipulated in the equipment list Appendix A.

10. SOFTWARE

Service contract does not include software modifications requested by customer, but does include the software furnished/supplied by the contractor at the signing of this agreement. A software contract is available as a separate entity.

11. REMOVAL OF EQUIPMENT

This agreement does not cover removal of equipment by the customer, to other locations. If equipment is removed from its original installation location, the customer assumes responsibility for charges resulting from inoperable equipment due to relocation, and time and materials involved in repairing the equipment.

12. EXCLUSIONS

Service is contingent upon the proper use of all equipment and does not cover equipment or software that has been modified without the contractor's written approval. Equipment that has been subjected to temperature, power, or other physical stress outside the specified operating range, as determined by the contractor-representative, shall be excluded from the terms of this agreement. Contractor shall be under no obligation to furnish service under the terms of this agreement if adjustments, repair, or parts replacement are required because of accident, neglect, or improper use. This also includes electrical power failure or fluctuations, air conditioning, or humidity control failure, and failure of material not furnished by the contractor. Furthermore, this includes causes from unusual use, or if equipment is not maintained. If equipment is repaired, or if attempts to repair or service equipment are made by other than the contractor's personnel, without prior approval of the contractor, the aforementioned will render this agreement null and void.

13. CONCLUSION

This agreement is the entire agreement between the parties and supercedes and cancels all prior agreements, oral or written, between the parties covering the subject matter of this agreement. No term or provision of this agreement will be modified except in writing and signed by both parties.

14. AGREEMENT

This agreement shall be governed by the laws of the State of California.

TERM: From September 15, 1989
To September 14, 1990

AGREEMENT NO: SA/89/1

CUSTOMER	CONTRACTOR
_____	David E. Pollard
NAME	Executive Vice President NAME
_____	5587 Sunol Blvd., Pleasanton, CA.
ADDRESS	ADDRESS
_____	_____
DATE	DATE

HELGESON SCIENTIFIC SERVICES

Field Service Report

E NAME: NEUTRON PRODUCTS, INC..

CATION: DICKERSON, MARYLAND 20842

SITE N ER: HEC 1003

DATE: 17 APR-89

PHONI:

JOB DESCRIPTION: HELGESON SCIENTIFIC SERVICES "MINI HECM SERIAL #HSS-8011 (INSTALLATION)

ITY	MATERIAL	ITEM PART NUMBER	UNIT PRICE	AMOUNT
			MATERIAL TOTAL	

DESCRIPTION OF WORK

Installed "Mini-HECM" (HELGESON EXTERNAL CONTAMINATION MONITOR) SERIAL # HSS 8011 in second floor room. Purged proportional counters with P-10 gas and checked for leaks. Connected CPU, Monitor and printer. Software checked OK.

Checked indvidual detectors with NBS traceable 100 sq. cm sources and verified that efficencies were as stated in Helgeson Scientific Services document "SENSITIVITY OF THE "HECM". Sources used were Cobalt-60, source no. 182-54-3 which was 5017 dpm on Feb. 1, 1987 and Cesium-137, source No.182-54-2 which was 4995 dpm on Feb. 1, 1987.

LABOR

WORKMAN	HOURS	RATE	AMOUNT
SIGNATURE		LABOR TOTAL	

MISC./TRAVEL EXPENSES

DESCRIPTION	AMOUNT
TOTAL	

TOTAL MATERIALS	
TOTAL LABOR	
MISC. EXPENSES	
TOTAL	

Attachment 2

RADIATION PROTECTION EVALUATION OF NEUTRON PRODUCTS, INC.

PROGRESS REPORT 1

Introduction

This evaluation was undertaken in response to conditions added to Condition 13 of MDCRH license 31-025-01. Section numbers and titles in this report are keyed to the above noted conditions. The evaluation has been underway for approximately 15 working days. This report is offered as a progress report.

Because of the need for detailed evaluation of a broad scope of activities, substantial additional time will be required to complete the evaluation and to develop and implement recommendations necessary for the resumption of the full scope of operations. NPI has recognized this in requesting permission for resumption of activities in a phased manner, starting with operations that present low potential for contamination spread relative to full-scope operations. Therefore, the work plan for this evaluation has been tailored to the present situation, no operation, and the proposed plan for phased startup of operations.

The evaluation is focused on reexamination of the readiness for processing encapsulated cobalt-60 sources, a candidate first step for resumption of operations. Although singly-encapsulated sources have significantly more radioactive contamination associated with them than doubly-encapsulated sources, the levels of contamination and potential for a release of this contamination are both low.

C.1.a Contamination Control Procedures and Methods

Introduction and summary

The objective of contamination control procedures is to keep radiation doses below regulatory limits and as low as reasonably achievable. Control procedures commonly focus on distributed contamination, but contamination in the form of discrete particles has gained increasing attention in the last few years. An evaluation of the dose consequences of exposure to a 100-nanoCurie cobalt-60 discrete particle was prepared to aid in establishing appropriate action levels for cobalt-60 contamination. The results of this evaluation have been reported separately.

Contamination levels throughout most of the hot cell area are low and contamination control in these areas is generally adequate. The contamination control zone is the only exception and recommendations for improvements to the contamination control zone are given below. Operations with encapsulated cobalt should not increase contamination levels. Control of contamination from the hot cell interior surfaces and from equipment and tools removed from the pool appear to be the major requirements for operations involving encapsulated cobalt. No access to the hot equipment room will be required for these operations.

Potential Sources of Contamination

The potential contamination source of greatest significance is certainly the hot cell operations involving the handling and melting of unencapsulated cobalt. Contamination from these operations is unavoidably spread to equipment used in the operations, and is possibly spread during removal of equipment from the hot cell to the hot cell access room, and to the hot equipment room where the equipment is stored.

A second source of contamination is pool water. Pool water concentrations may not be high enough to constitute a major source directly, less than 0.001 microcurie per cubic centimeter, but cobalt can concentrate on some materials to create contamination sources of somewhat greater concern than the pool water. This source is relatively easy controlled by monitoring and control of equipment and materials during and after removal from the pool. Handling techniques should be critically evaluated during operations with encapsulated cobalt.

A contamination control zone is established in an area which includes the main pool and the floor area surrounding it, the decon room, the hot equipment room, and the hot cell access room. A shoe cover change is required at the line. However, there are no step-off areas, so that the line between clean and dirty is a little fuzzy. Contamination surveys on the clean side of the line show that high levels of contamination are not crossing the line, but low levels probably are. The procedure for the contamination control zone should be improved to provide a clear delineation of the line of demarcation, with appropriate step-off areas. Monitoring of tools and equipment moved from the contamination control zone to the cleaner side should also be improved.

Status of LAA Areas Outside the Contamination Control Area

A representative smear survey of the operating area surrounding the hot cell was made to characterize contamination levels. Of 40 smears taken from the floor on the manipulator side of the hot cell outside the contamination control zone, about 70 percent were below the limit of 990 dpm per 100 square centimeters. Most of the smears exceeding the limit exceeded it by a factor of two or less. Three floor smears exceeded the limit by more than a factor of two with levels of 2,600, 4,000, and 21,000 dpm per 100 square centimeters, respectively. Of 17 smears taken from equipment and surfaces above floor level in the same area, nine exceeded the limit, with four in the range of 3,000 to 8,000 dpm per 100 square centimeters, one at 16,000, and one at 81,000 dpm per 100 square centimeters.

The smear survey results show that floor contamination outside the contamination control zone is, for the most part, no more than a factor of two above limits, but that there is a fair chance of encountering floor contamination in isolated areas substantially greater than the limit. The results for surfaces above the floor show that contamination levels on those surfaces are significantly greater than contamination levels on the floor.

Status of the Contamination Control Zone

Smearable contamination levels on the floors and other surfaces in the contamination control zone are consistently substantially above the limit of 990 cpm per 100 square centimeters. Earlier surveys show that these levels of contamination have existed for some time, and there has been no recent decontamination. The area should be decontaminated. A limit of 990 dpm per 100 square centimeters may be lower than achievable and lower than necessary for a hot cell access area that is operated as a contamination control area. It may be advisable to establish a higher limit for routine operations, depending on the outcome of the decontamination effort. Any higher limit should be low enough to minimize the likelihood of contamination in the form of discrete particles in the activity range of tens of nanoCuries. (Higher levels should be expected on a temporary basis during special operations, such as a cell cleanup after a melt.)

Decontamination

Wet mopping is used for floor decontamination and mop water is dumped to the liquid waste tank if concentrations are sufficiently low. Mops and buckets are used in a progressive way from the less contaminated zones to the more contaminated so

that contaminated mops do not spread contamination. Because mop water is the major source of cobalt-60 in liquid waste, it is reasonable to assume that the annual liquid waste discharge of 10 to 40 millicuries per year is derived from contamination on surfaces.

Control of Contamination Transport to the Courtyard

The limited access area extends out into the yard from the hot cell area. Removable contamination levels in the yard are typically lower than 990 dpm per 100 square centimeters. There is no monitoring or shoe cover change at the entrances to the yard. If the floor contamination levels in the machine shop and in the area near the north canal are typical, as they appear to be, it is not likely that tracking of contamination on shoe covers is a significant mechanism for continuous contamination transport to the yard through these doors. Radiation levels limit the sensitivity of friskers in the LAA, but a frisking station, even with a relatively high background, could improve assurance that tracking contamination into the yard in the event of an unusual contamination release inside the building, and should be evaluated further. Sensitivity would be improved by the use of lead-shielded pancake G-M detectors. I've recommended purchase of several of these probes. Procedures should be modified to clarify that materials and equipment transferred out of the building be surveyed to assure contamination levels do not exceed levels for the LAA areas outside of contamination control zones.

Large-area doors to the building are required to move equipment in and out. Contamination control should be provided by controlling potential contamination sources including airborne contamination and contamination on surfaces. The procedure for using large area doors should be that these doors are opened only when necessary, that surface smear samples and an air sample should be collected and analyzed prior to opening the door, and that results should be compared to action levels set to assure adequate contamination containment. Contamination levels in the machine shop and in the area near the north canal are low, so the potential for spread of substantial contamination to the courtyard through those paths is small.

Contamination levels in the hot cell access room and the adjacent decon room are typically higher than in other areas. Therefore, the doors from the courtyard to the hot cell access room and the decon room should not be used until the areas are decontaminated. The doors to the courtyard should be considered boundaries to the contamination control zone. The procedures for exiting the contamination control zone and for removing equipment and material from the zone should apply to materials

5/31/89 RK
courtyard contamination low due to time of ventilation and exposure for rain in the month.

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Work area

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minute per ... her
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Measured a ... n the
MPC of 9 x ... ling
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conclusion
measuremen ... [illegible] radiation, discussed below indicate that long-term air concentrations are below MPC by a significant margin. I recommend increasing the frequency and duration of air sampling to improve the radiation protection program significantly. High-volume air samples should be collected at least every two hours in the LAA areas where work is being done. Installation of one or more fixed, low-volume continuous samplers should be considered.

Work area contamination surveys

Work area smear surveys are taken daily inside the LAA and monthly outside the LAA. Smear surveys are currently focused on the need to decontaminate, and areas that show contamination levels higher than action levels are decontaminated and surveyed again. Contamination control would be improved if the occurrence of contamination levels higher than limits were seen as an indication that other such areas may exist and that additional monitoring and evaluation of the effectiveness of contamination control measures would be appropriate. The procedure for smear surveys should be improved to provide for interpretation of results in the manner described.

Work area smear surveys are currently confined to floor surfaces. Floor surfaces are the most likely to be contaminated, and it is appropriate to focus primary attention on them. However, representative sampling of other surfaces is also required. About 25 percent of smear samples collected should be from surfaces above the floor, and should include equipment and materials.

Clean areas within the LAA and just outside the LAA at LAA access points should be smeared at a daily frequency for timely detection of any breakdown in the effectiveness of contamination control.

C.1.b Respiratory Protection Program

Procedures have been reviewed and are adequate. They are modeled on the specific requirements of 10 CFR Part 20.103. Respiratory protection is not routinely required for any operation except hot cell decontamination after handling unencapsulated cobalt. Respiratory protection is sometimes used for precautionary reasons for operations in which air concentrations are expected to be higher-than-normal, but lower than maximum permissible concentrations. These occasions appear to be determined on an appropriately conservative basis. Internal radiation measurements of workers (see Section C.1.c) provide evidence that the respiratory protection program has been effective in limiting concentrations inhaled to levels below MPC on an annual average basis.

10 CFR Part 20.103(b)(2) requires analysis of inhalation exposure over 7-day averaging periods for workers using respiratory protection equipment. Exposures over 40 MPC-hours (after taking account of the effectiveness of the respiratory protective equipment) in any 7-day period require evaluation of causes and actions to prevent recurrence. The NPI procedure, which properly includes provision for assessing actual exposure, should be improved to establish action levels and actions that incorporate the requirements of 10 CFR Part 20.103(b)(2).

Although respiratory protection equipment will be used in the hot cell wipedown and in decontamination of the controlled contamination area as a precaution, air concentrations associated with those activities are expected to be lower than the maximum permissible concentration. Therefore, reliance on respiratory protection for substantial protection factors is not likely to be necessary for operations with encapsulated cobalt.

C.1.c Personnel Monitoring for Internal and External Radiation Exposure

Worker external radiation dosimetry

Procedures and vendor-provided 1988-89 data for worker external dosimetry (Eberline LiF TLD, NVLAP Certified) have been evaluated and found to be adequate for operation with encapsulated cobalt. An evaluation of broad area skin dose from external sources indicates that the high attenuation of the relatively soft (0.314 Mev max) cobalt-60 beta radiation in air and in protective clothing makes this source of exposure negligible and makes monitoring unnecessary. Beta dose rates above an infinite planar source of cobalt-60 are reduced by a factor of 70 by 5 centimeters of air (7 milligrams per square centimeter), and are reduced by a factor of 700 by 15

centimeters of air (20 milligrams per square centimeter) (Meteorology and Atomic Energy, 1968, TID-24190).

The need for extremity gamma dosimetry is usually dictated by the extent to which small, relatively high-intensity sources (such as contaminated tools and equipment) are handled manually. Extremity gamma dosimetry should be used for the hot cell wipedown. Extremity gamma dosimetry should not be necessary for operations involving unencapsulated cobalt because there will be no manual handling of significant sources of radiation.

Worker internal radiation measurements

Cobalt-60 body burdens are routinely measured for each radiation worker and a number of other workers approximately annually. Measurements and burden calculations are made by Helgeson Scientific Services, a commercial vendor commonly used at nuclear power stations. Procedures and practices are sound.

Results of internal radiation measurements for the last two years were reviewed. Measured burdens are small fractions of ICRP 2 maximum permissible burdens corresponding to limits for workers in 10 CFR Part 20, 10 microCuries for the total body, and 1 microCurie for the lung, the organ of most concern. Most people counted have lung burdens of a fraction of a percent of the maximum permissible. The two people who work regularly in the LAA have lung burdens about 3 to 10 percent of the maximum permissible that have stayed fairly constant over a 16-month period.

Of 19 people counted on March 27, 1987, 11 (most of whom had little work in the LAA) had burdens of less than 4 nanoCuries, 6 had burdens ranging from 10 to 31 nanoCuries, one had a burden of 44 nanoCuries, and one had a burden of approximately 100 nanoCuries (91 and 114 nanoCuries in two counts). During this measurement cycle, there was no effort to determine whether the burden was truly internal, or whether the apparent burden, or some significant part of it was actually external skin contamination, so it is possible that some of the activity was external.

Of 26 people counted on June 1, 1988, 22 (most of whom had little work in the LAA) had burdens of less than 7 nanoCuries, and 4 had burdens ranging from 33 to 107 nanoCuries. During this measurement cycle, techniques designed to idsntify external contamination were employed, and the vendor concluded that one individual with an apparent burden of 56 nanoCuries actually had skin contamination. The other three individuals with elevated burdens had worked regularly in the LAA, and had also had elevated burdens in the 1987 count.

Two of these LAA workers were recounted on 7/28/88, together with an individual who has occasional LAA work, usually associated with hot cell cleanup. This count followed an incident in which higher-than-normal exposures were suspected. The measured burdens ranged from 57 to 73 nanoCuries. Counts on 2/8/89 and 2/14/89 of another individual, exposed to higher-than-normal air concentrations in an incident involving improper use of a vacuum cleaner in the LAA, resulted in an an estimated burden of from 30 to 135 nanoCuries. (The uncertainty range in this count stems from interference from surface contamination.)

The counting results for three counts over the period of 16 months show that the two individuals who work most of the time in the LAA carried reasonably constant lung burdens ranging from 30 to 100 nanoCuries for the first individual and ranging from 33 to 57 nanoCuries for the second individual.

These results are consistent with either a single exposure to material with a long residence time in the lung, or a roughly constant, continuous, lower-level exposure over time leading to an approximate steady state lung burden. The data available do not provide much basis for choice, but if the latter condition is close to reality, the counting results can be used to approximate the long-term average air concentration in the operators' breathing zones. The maximum permissible lung burden corresponds to the 10 CFR Part 20 MPC in air for workers. Because the two most exposed workers have lung burdens in the range of 3 to 10 percent of the maximum permissible, it follows that the long-term average air concentration in the workers' breathing zones must be about 3 to 10 percent of MPC. If the acute exposure scenario is closer to reality, the lung burden is associated with one or more discrete incidents and long-term average air concentrations in the workers' breathing zones must be appreciably less than 3 to 10 percent of MPC.

C.1.d Radiological Effluent Monitoring and Control for Liquid and Gaseous Releases

Evaluations of control measures for gaseous effluents and procedures for effluent air monitoring are discussed in a separate report, dated 5/17/89, on the hot cell ventilation system.

Evaluation of liquid effluent sampling and control indicates that releases are low and controls are adequate. Liquid effluent is collected in hold tanks, pumped to a tank truck, and shipped to the Washington Sanitary Sewer Commission. Periodic reports are filed with the Commission identifying shipments, volumes, and isotope inventories.

The major source of cobalt-60 in liquid effluent is floor scrub water, which is dumped to hold tanks if analysis shows concentrations are sufficiently low. Most of the volume of water collected is sanitary water not associated in any way with radioactive materials processing.

Hold tank contents cannot be mixed, but the sampling procedure requires that multiple samples be drawn from the material in transfer (samples are actually drawn from the truck) at the beginning, middle, and end of the transfer. Comparison of results for individual samples shows that concentrations are reasonably uniform through the truck.

Isotope quantities released over the last several years have been small, with annual quantities ranging from 10 to 40 milliCuries. Usually four to nine 3500-gallon shipments are made each month, for an annual average volume shipped of about 300,000 gallons. The annual average concentration is approximately 4×10^{-5} microCuries per cubic centimeter, lower than the 10 CFR Part 20 Appendix B Table 1 limit of 1×10^{-3} microCuries per cubic centimeter, and substantially below the more conservative license limit of 2×10^{-4} microCuries per cubic centimeter.

Operations involving encapsulated cobalt-60 will not result in significant increases in levels of cobalt-60 in liquid effluents.

C.1.e Adequacy of Air Handling Systems in the Production Areas

The hot cell ventilation system, evaluated in a separate report, draws approximately 800 SCFM. Virtually all air in LAA areas adjacent to the hot cell are ventilated by this system. This area has a volume of about 70,000 cubic feet. The air change rate is approximately one volume every two hours. Available measurements indicate that airborne contamination levels in the areas adjacent to the hot cell are routinely low, which indicates that ventilation is either adequate or not very important, relative to other factors, in the control of routine airborne contamination in the areas outside the hot cell.

The hot cell ventilation system maintains airflow direction from outside the building into the LAA. Differential pressures between interior areas of the LAA and other interior portions of the plant outside the LAA could permit airflow from the LAA to clean areas, but efforts have been made to seal the openings. Assurance of adequate airborne contamination control would be improved by balancing ventilation systems to provide flow into the LAA.

The hot cell area contains three heat pumps and associated ducting with dampers that can be arranged to direct air from inside the building to the outside. They are currently set to recirculate air inside. Changing the settings would create untreated and unmonitored exhaust flow paths. Procedures should be established to assure that inside air stays inside and outside air stays outside.

C.1.1 Control and Identification of Radiation and High Radiation Areas, and Contaminated Equipment and Facilities

High radiation areas, major gamma radiation sources and control measures

On an inspection tour of the LAA with hot cell operators and the NPI President, I performed a radiation survey which confirmed results of NPI radiation protection surveys. The major sources of radiation are the hot cell ventilation system, the hot equipment room, and the waste storage rooms. Except for these areas, exposure rates were typically less than 5 mr/hr.

Access to high radiation areas (hot cell, waste storage rooms, hot equipment room, and the fan room (which contains the ventilation system filters)) was controlled appropriately and the main pool alarmed gamma detector was in place and operational. Radiation areas and high radiation areas were appropriately posted.

Radiation exposure control procedures currently in place are adequate for operations involving encapsulated cobalt. Proposed operations involving encapsulated sources will create no new major source, nor will they add significantly to existing sources. Over the past few years, some procedures have been modified to reduce worker doses. An example is the reduction in the amount of manual handling of contaminated equipment following a melt. Evaluation of the potential for additional exposure reduction is not considered necessary for operations with encapsulated cobalt.

Work area direct radiation surveys

Procedures for monitoring work area radiation levels are adequate and effective. Although results are not posted on a status board, as is done at most facilities, key personnel all seemed to know quite accurately what the exposure rates were in various areas of the LAA. The main hot cell operators are capable of monitoring radiation levels on their own, and, based on my observations, do so regularly and capably. The results of my radiation survey generally agreed with results of recent surveys by NPI staff.

Control and identification of contaminated equipment and facilities

These topics are discussed in Section C.1.a.

C.1.g Radiological Waste Handling, Processing, and Disposition (Storage and Shipment)

Inspection of the waste storage rooms indicates that the storage capacity for additional radioactive waste is limited. This is not a problem for operation with encapsulated cobalt because the quantities of waste generated are expected to be small and the isotope inventories low.

C.1.h Hot Cell Decontamination Methods and Procedures

Exposure rates and contamination levels in the cell are anticipated to be relatively low, since no operations with unencapsulated cobalt and no melting have been performed since the last cleanup. Exposure rates at last measurement were approximately 200 mr/hr at the center of the cell.

Because the cell is designed to operate with high levels of contamination, removable contamination levels in the cell are not measured routinely. The radiation measurement at the center of the cell can be used to make a rough estimate of upper limits to contamination levels in the cell surfaces. If, as is likely, most contamination sources (cell walls and floor surfaces) are about one meter from the point of measurement, the total cobalt-60 inventory in the cell, both fixed-in-place and removable, must be about 200 milliCuries. Experience has shown that additional decontamination does not reduce exposure rates noticeably. Therefore, it is likely that the inventory of removable contamination is, at most, a few percent of the total, or about 10 milliCuries. If this contamination is assumed to be spread uniformly over the floor and walls of a 2-meter cube, the total area contaminated is roughly 20 square meters, or 200,000 square centimeters. In this case, the average removable contamination level would be about 5 microCuries per 100 square centimeters.

Prior experience indicates that these levels are low enough to prevent transport of significant quantities of cobalt-60 contamination on people or objects removed from the cell. For example, contamination limits on the doubly-encapsulated cobalt sources to be manipulated inside the cell are quite low, but are routinely met at expected cell contamination levels.

Operation with encapsulated cobalt-60 would not be expected to add significantly to contamination levels inside or outside

the cell. A wipe down of the cell is planned prior to operations with double-encapsulated cobalt, but the radiation and contamination levels should be sufficiently low to consider the operation no more than routine. Radiation monitoring must be performed prior to cleanup to check this. Additional evaluation will be performed if the radiation monitoring data indicate a need. The plan for radiation monitoring data to be collected during the wipedown must be designed to provide, to the extent practicable, data useful in evaluations for operations involving unencapsulated cobalt.

C.1.i Personnel Training and Qualification

I have concluded from discussions with key professional and non-professional personnel that they have an adequate understanding of the basic principles of radiation protection. In my judgment, this level of understanding is sufficient to help develop and to carry out procedures appropriate for use with encapsulated cobalt.

The capabilities of key personnel, including professional personnel, should be developed further in the following areas:

- interpretation and analysis of radiation protection measurement information,
- critical evaluation of radiation protection aspects of operating procedures and radiation protection procedures, and
- selection, calibration, and use of radiation monitoring instrumentation.

Present limitations in these areas appear to be primarily limitations in experience rather than limitations in technical capability. One of the key roles of the radiation protection consultant should be to help develop these capabilities in the NPI staff.

Informal training sessions will be required to make sure that key personnel are familiar with procedural changes to be implemented prior to operations. Sessions have been held on LAA access and exit procedures and on the PCM monitoring procedure.

C.1.j Management Oversight and Control of Radiological Activities

Observations made thusfar indicate that improved management control is desirable in the following areas:

- Clear assignment of responsibilities
- Specification in key procedures of action levels and corresponding actions, including documentation, evaluation, and management notification, sufficient to bring events to closure
- Management oversight of radiation protection procedures and operations and radiation protection aspects of production and maintenance procedures and operations
- Procedures for approval of changes to work methods and procedures, including radiation protection review of proposed changes where appropriate
- Summarization and communication of radiation protection information

The MDCRH requirement that a change to a procedure requires a license amendment makes timely modification of procedures very difficult. This situation can lead to procedures that are less specific than they might be, so that changes will not be necessary. This can decrease the effectiveness of the procedure. The delay can also act as a disincentive for improving procedures.

The license should be amended to allow NPI some operating room to change procedures on their own. NRC solves this problem with its materials licensees by requiring that license applications contain specification and demonstration sections. The licensee must have an amendment to change the specifications, but can change the demonstration section in any that does not conflict with the specifications. The licensee informs NRC of changes to the demonstration section on an annual basis.

C.2 Portal Monitor Installation and Maintenance

The personnel contamination monitor (PCM) has been installed on the second floor in an area just outside the cafeteria. The area and the access hallway and staircase are being considered a clean extension of the LAA until the PCM can be moved to its permanent location. LAA work clothes are not worn beyond the change room. Workers leave the area through the

door to the lunch room or through the door to the outside. Other doors from the monitoring area and access hall to interior portions of the plant have been sealed. A procedure for operation of the PCM has been prepared. Procedures for maintenance of the equipment are in development. The instrument has operated continuously (during working hours) and stably since installation. No maintenance, or repair has been required. No detector decontamination has been required.

C.3 Background at Portal Monitor

The background radiation level in the personnel contamination monitor area is approximately 50 microRoentgen per hour, as estimated from background on a pancake G-M counter. Backgrounds on the PCM detectors range from about 30 to 50 cps, depending on detector size and location. At these levels lower limits of detection below 2,500 dpm on hands and 5,000 dpm on other unshielded surfaces reasonably close to the detector are achieved with count times of approximately 40 seconds, a false alarm probability (Type I error) less than 10 percent, and a failure-to-detect probability (Type II error) of 1 percent.

C.4 Portal Monitor Performance Report

The personnel contamination monitor has performed well to date. Personnel assigned to operation of the PCM have received OJT instruction in the monitoring procedure, including reporting requirements. Personnel who work in the LAA have received OJT instruction in LAA access and exit procedures the use of the PCM, and interpretation of results. The training is on-going. Since the advent of new LAA access and exit procedures and high-sensitivity monitoring procedures, no reportable (>22,000 dpm) personnel contamination events have occurred. Incidents of contamination slightly above detection limits have been infrequent.

Work is underway to apply a correction factor to account for reduction in background due to body shielding. In the present orientation, the body is between the detectors and the probable sources of background radiation, which maximizes the body shielding. In the new LAA access area, the orientation will be reversed so that the body will not provide direct shielding. This should minimize the shielding effect.

C.5 Courtyard Roof Design and Construction

No action on this item.

C.6 Hot Cell Ventilation System

The hot cell ventilation system evaluation was submitted as a separate report dated May 17, 1989.

Attachment 3

PLANS FOR ADDRESSING RECOMMENDATIONS OF HEALTH PHYSICS CONSULTANT

p.2, para.3

Handling techniques involving removal of sources and equipment from water pools will be evaluated during activities authorized by P.2 and completed before initiating activities authorized by P.3.

p.2, para.4

The procedure for the contamination control zone and monitoring of tools and equipment will be improved as recommended; and step-off areas will be established prior to initiating activities authorized by P.2.

p.3, para.4

Portions of the Contamination Control Zone that will be utilized for the activities authorized by P.2, which comprise rooms behind the hot cell and the machine shop, will be decontaminated, as recommended, prior to initiating those activities.

p.4, para.2

Instead of establishing a frisking station between interior portions of the LAA and the courtyard, we propose to require changing of shoe covers at those locations during operations authorized by P.2. That will control the most probable mechanism for transfer of contamination between inside and outside areas. The background radiation at the portal locations is too high for frisking to be reliable. We will give further consideration to this recommendation in the course of developing a design for enclosing a portion of the courtyard (condition M).

p.4, para.3

We will limit the opening of large-area doors to times when it is absolutely necessary and take smears, as recommended, during the course of operations authorized by P.2.

p.4, para.4

During the course of activities authorized by P.2, we will decontaminate equipment and materials before moving them out of the Contamination Control Zone. This will include, for example, teletherapy casks, overpacks, and

Attachment 3

dollies. If the fork-lift truck is brought into the main enclosed area of the LAA, it will be wiped and smeared prior to exiting to the courtyard. We will give further consideration to controlling the possible spread of contamination through such operations as we develop the design for enclosing a portion of the courtyard.

p.5, para.2

Although we do not think it necessary, we will take high volume air samples at two-hour intervals, as recommended, during the course of activities authorized by P.2.

p.5, paras.3&4

Prior to initiating activities authorized by P.2, we will modify our procedure for smear surveys, as recommended, to take additional smears where higher levels of contamination are detected and to collect about 25% of the samples from surfaces above the floor.

p.6, para.2

Our procedure will be in compliance with the requirements of 10 CFR 20.103 (b) (2) before initiating activities authorized by P.2.

p.10, para.1

The dampers of the heat pumps in the LAA will be maintained in the current positions, so that air continues to be recirculated inside the LAA. This will be checked periodically by the RSO or designated alternate.

p.12, para.1

A radiation survey of the interior of the hot cell will be performed prior to initiating activities authorized by P.2. The Health Physics Consultant will participate in preparing the plan for collecting radiation monitoring data during the hot cell wipedown.

p.12, paras.3&4

A concentrated training program, as recommended and involving the HP Consultant, will be provided to professional and non-professional personnel who will be involved in activities authorized by P.2, prior to inititaion of those activities.

WJC/MMT/FS:mvc:9

Morton and Potter

10421 MASTERS TERRACE
POTOMAC, MARYLAND 20854

HENRY W. MORTON
10421 MASTERS TERRACE
POTOMAC, MARYLAND 20854
301-983-0365

THOMAS E. POTTER
4231 JENIFER STREET, N.W.
WASHINGTON, D.C. 20015
202-363-4727

5/17/89

Mr. Jackson Ransohoff
Neutron Products, Inc.
Dickerson, MD 20842

Dear Mr. Ransohoff:

Enclosed is a report describing my evaluation of the NPI hot cell ventilations system. This report is intended to respond to condition 13.C.6 of your license issued by the State of Maryland. Please call if you have any questions.

Sincerely,

Thomas E. Potter

Thomas E. Potter

EVALUATION OF THE NPI HOT CELL VENTILATION SYSTEM

Thomas E. Potter

Morton and Potter
10421 Masters Terrace
Potomac, MD 20854

5/17/89

INTRODUCTION

This report is in response to condition 13.C.6 of the NPI license issued by the State of Maryland for cobalt operations. That condition requires a comprehensive evaluation of the hot cell ventilation system. This evaluation focuses on three aspects of the system--general design, effluent monitoring, and impacts from accidents.

In summary, the general design is considered to be adequate. The effluent monitoring has been sufficient to show that releases have been low and is being improved to permit quantification with greater confidence. Finally, the impacts from accidents are shown to be small.

GENERAL DESIGN

The NPI hot cell ventilation system discharges all of the air drawn into the hot cell and essentially all of the air drawn into the pool area. The system is equipped with two primary HEPA filters in parallel (one normally in use, the other used during change of the first) followed by a secondary HEPA filter. A roughing filter located in the hot cell minimizes the rate of particle loading on the primary HEPA filter. The primary HEPA filter presently in use has been in service for approximately 17 months. The current pressure difference across the primary filter, about 0.5 inches of water, is within the range of expected values for existing flow conditions.

The hot cell ventilation system draws approximately 800 SCFM, as determined by recent NPI engineering measurements on May 3 (memo from F. Schwoerer dated 5/16/89, copy attached). This provides a linear flow rate of approximately 40 lfpm across the open cell door. This flow rate should be adequate to prevent significant releases of airborne materials from the cell during operations with encapsulated cobalt, since contamination levels in the cell are low in the relative sense and operations with encapsulated cobalt are not likely to add contamination to the cell. The flow rate may be adequate for operation with unencapsulated cobalt as well, but data obtained during

operations with encapsulated cobalt should be used in making that determination.

The large-area door from the courtyard to the hot cell access room is required to move equipment in and out. If this door is open when the cell door is open, it is possible (however unlikely) that transient pressure drops caused by wind flow patterns could cause a backdraft of contaminated air from the cell. This can and should be prevented by keeping the cell door closed when the large area door is open.

EFFLUENT MONITORING

Procedures and practices for effluent air monitoring have been reviewed. The previous practice of using a low-efficiency full cross-section filter to collect contamination in effluent air is unusual and may or may not be adequate. But the low contamination levels on the filter are reasonable indication that release quantities through this pathway have been small. The fact that contamination levels are low on the roof and on walls near the downward directed discharge point is strong evidence that releases have been low.

I have recommended and NPI has purchased a continuous sampler that will draw secondary HEPA effluent air from the exhaust duct through a high-efficiency (glass fiber or equivalent) filter paper at an appropriate velocity for representative sampling (ie., isokinetic flow) and at an appropriate flow rate for detecting a few percent of MPC for a 24-hour sampling period. All components are on hand except for the sampling tube, which will be fabricated by NPI. NPI engineering has completed a velocity profile measurement across the cross-section of the duct at the most appropriate sampling location (memo from F. Schwoerer dated 5/16/89). Although the system installation is nearly complete, the system may not be operational prior to operations with encapsulated cobalt. If not, an interim alternate method using a Staplex high-volume sampler for continuous sampling at the duct discharge point would be acceptable. Samples from the permanent system should be collected approximately daily when hot cell operations are being performed, and weekly otherwise.

ACCIDENT ANALYSIS

The inventory of cobalt-60 on the filters can be estimated from radiation measurements in the fan room. If one assumes that the increase in radiation levels at the fan room door since the last filter change, about 18 mr per hour at a point about ten feet from the primary filter, represents material deposited on the new filter, the primary filter inventory is about 0.2 Curies. Radiation measurements at contact on the primary and secondary filters are about 2 R/hr and 0.2 R/hr respectively, but the secondary filter is only about one meter from the primary filter. This means that virtually all of the radiation

measured at the secondary filter could be from material on or near the primary filter. Therefore, the inventory on the secondary filter is no more than, and certainly much less than, 0.02 Curies.

The most plausible mechanism for release of a part of the inventory would be mechanical damage or fire damage. Neither is likely because the filters are isolated in a separate room. But the consequence of the hypothetical release of a substantial part of the inventory held in the filters can be readily estimated. In a real accident involving the filters, it is likely that only a small fraction of the inventory would be released. Furthermore, it is likely that a release would occur during average atmospheric dispersion conditions. For purposes of a bounding analysis, however, it is assumed that the entire estimated filter inventory of 0.2 Curies is released. It is further assumed that release occurs in poor dispersion conditions, stable atmospheric conditions and a wind speed of 2 meters per second. Given these conditions, and given initial dilution in the wake of the building, the risk-weighted committed inhalation lung dose (ICRP 30) at the receptor point, would be 42 millirem. Inhalation doses to other organs would be lower. For comparison, the annual dose limit in the proposed revision to 10 CFR Part 20 is 100 millirem for a member of the public. Radiation levels one meter above a smooth, flat plane at the receptor location would be about 0.2 mR/hour, low enough to preclude the need for immediate emergency response. The details of these calculations are shown in Table 1.

Results from the effluent air sampling program will give information useful in determining the effectiveness of the treatment system as a whole. A technique for periodic determination of filter inventory by radiation survey of the filters may be workable and useful in providing sensitive indication of the performance of the primary filter and the isotope inventories of both filters. This will be examined in the future.

TABLE 1

CALCULATION OF DOSE FROM RELEASE OF COBALT-60

1.0 INPUT VARIABLES

Pasquill stability class	F
Q, quantity assumed to be released, Ci	0.2
x, downwind distance to receptor, meters	100
vdep, deposition velocity, meters per second (Ref. 1)	0.01
u, wind speed, meters/sec	2
sigz, vertical dispersion parameter, meters (Ref. 2, p. 103)	2.4
sigy, horizontal dispersion parameter, meters (Ref. 2, p. 104)	4
A, cross-sectional area of building, square meters	200
c, area constant, (Ref. 3, p. 302)	0.5
IDF, ICRP 30 risk-weighted inhalation dose factor for lung, mrem per pCi (Ref. 4)	1.5E-04
GDF, ground dose factor, mrem/hr per pCi/square meter (Ref. 5, Table E-6)	1.7E-08
BR, breathing rate, cubic meters per year (Ref. 5, Table E-5)	8000

2.0 CALCULATED VARIABLES

X/Q, dispersion parameter value, sec/cubic meters
DIN, 50-year committed inhalation dose, millirem
DGR, penetrating radiation dose rate one meter above material deposited on smooth plane, millirem/hour

3.0 Calculation of X/Q

From Ref. 3, equation 7.30:

X/Q = MAXIMUM OF 1/((pi*sigz*sigy+c*A)*u) OR 1/(3*pi*sigz*sigy*u)

X/Q = 5.5E-03 sec/cubic meter

TABLE 1 (CONT'D)

CALCULATION OF DOSE FROM RELEASE OF COBALT-60

4.0 Calculation of DIN

DIN = Q * X/Q * BR * IDF * 3.17E-08 * 1.0E12

yr/sec pCi/Ci

DIN = 42 millirem

5.0 Calculation of DGR

DGR = Q * X/Q * vdep * GDF * 1.0E12

pCi/Ci

DGR = 0.19 millirem/hour

REFERENCES

1. NCRP, Radiological Assessment: Predicting the Transport, Bioaccumulation, and Uptake by Man of Radionuclides Released to the Environment, NCRP 76, 1984.

2. Slade, D. (ed.), Meteorology and Atomic Energy, TID-24190, 1968.

3. Randerson, D. (ed.), Atmospheric Science and Power Production, DOE/TIC-27601, 1984.

4. ICRP, Limits for Intakes of Radionuclides by Workers, ICRP Publication 30, Supplement to Part 1, 1978.

5. USNRC, Regulatory Guide 1.109, Rev. 1

MEMORANDUM

DATE: May 16, 1989

TO: J. W. Corun
W. J. Costley
T. E. Potter
J. A. Ransohoff

FROM: F. Schwoerer

SUBJ: HOT CELL EXHAUST SYSTEM - MEASURED FLOWRATE

This is a report of measurements made on May 3, 1989 of the air flow velocity distribution in the discharge duct of the Hot Cell Exhaust System.

The measurement location was outside the wall between the fan room and the roof of the hot cell, as shown in Attachment #1.

The equipment used consisted of:

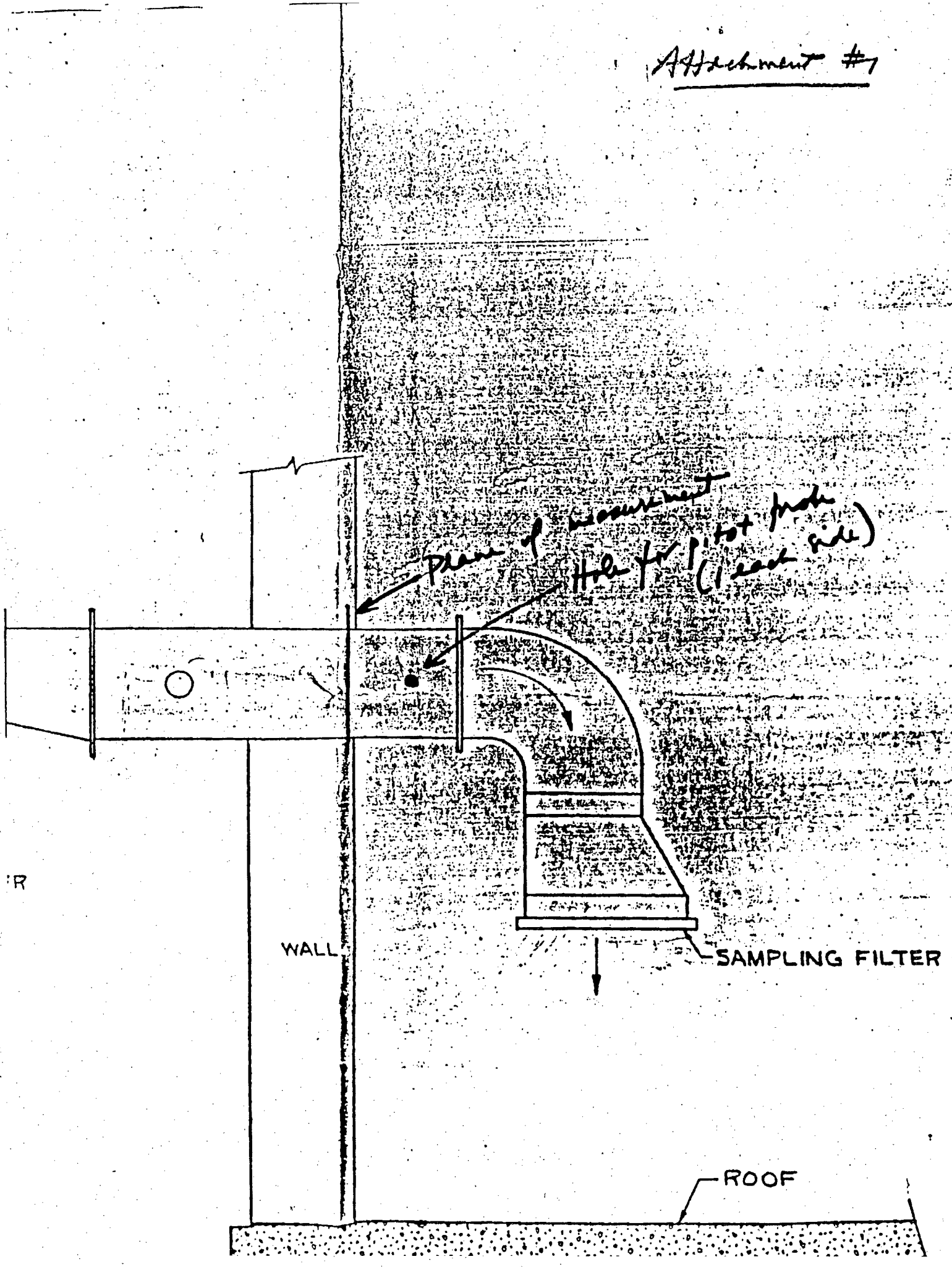
- A Dwyer dual-range dial manometer, which reads directly 500-2800 ft per minute air velocity,
- A Dwyer pitot probe (160-18), of 18" length and 5/16" diameter,
- Portable accessory kit, and
- Simple protractor and simple 12" scale.

The air velocity was measured at 25 points in the plane measurement. The locations of the 25 points are shown in Attachment #2. For each point, the necessary depth and angle of probe insertion, to place the active end of the probe at the point location, were precalculated. Holes were drilled into each side of the duct, as shown in Attachment #1. The probe was then positioned, using the protractor and scale, supplemented by a scale marked on the probe, to conform to the positions shown in Attachment #2.

Air velocities, which were relatively stable with time, were read directly off the manometer and tabulated in Attachment #3.

The velocity data were then plotted and averaged, as shown in Attachment #4.

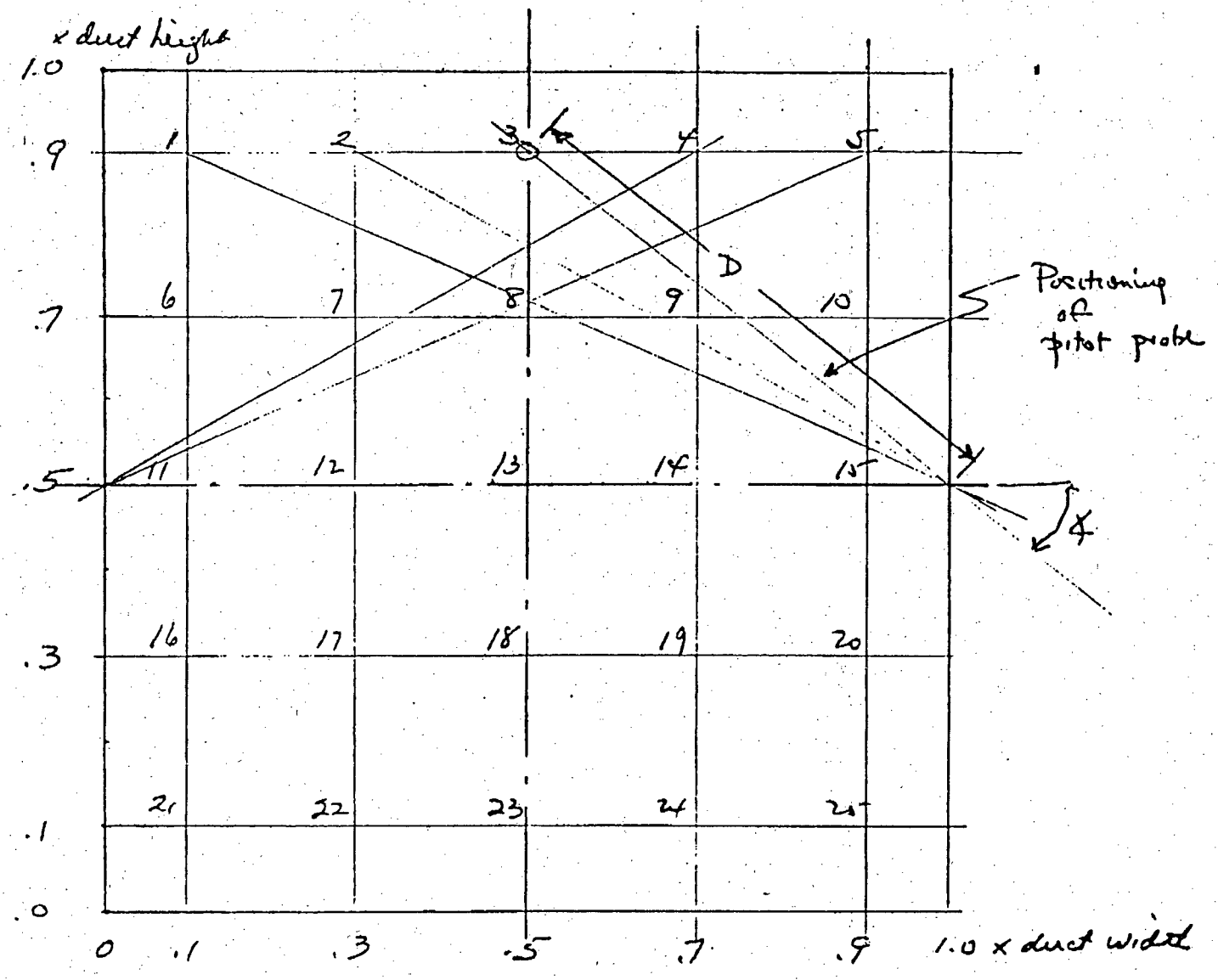
Attachment #7



Attachment #2

Measurement Points in Plane of Measurement

Duct dimensions: 11" x 11"

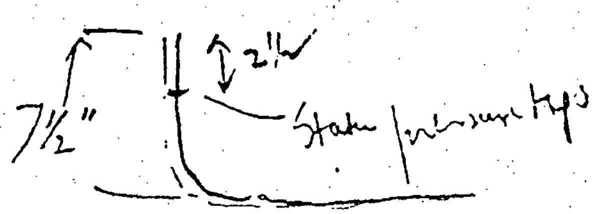


Looking towards blower

i.e., flow direction is out of the paper

Attachment #3

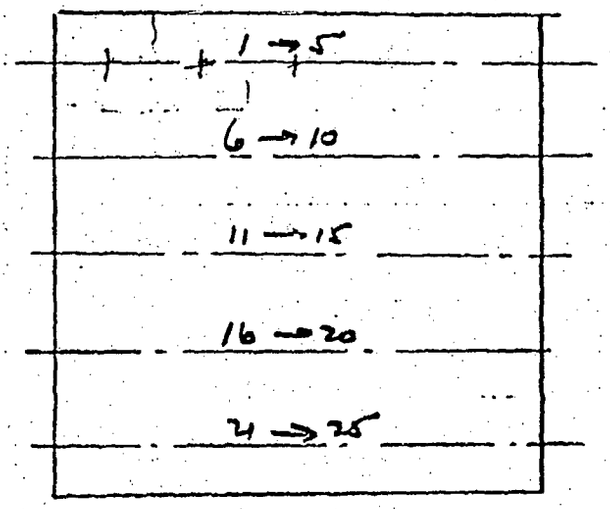
Pt #	X	D (11x11)	V / Vel
3	51	7.04	0 fpm
8	22	5.93	400
13	0	5.5	1100
18	-22	5.93	1500
23	-51	7.04	1300
2	30	8.87	0
7	16	8.0	0
12	0	7.7	800
17	-16	8.0	1100
22	-30	8.87	1300
1	24	10.8	0
6	12.5	10.1	0
11	0	9.9	600
16	-12.5	10.1	1400
21	-24	10.8	1000
4	30	-8.9	600
9	16	-8	800
14	0	-7.7	1300
19	-16	-8	1700
24	-30	-8.9	1800
5	24	-10.8	500
10	12.5	-10.1	800
15	0	-9.9	1600
20	-12.5	-10.1	1900
25	-24	-10.8	1850

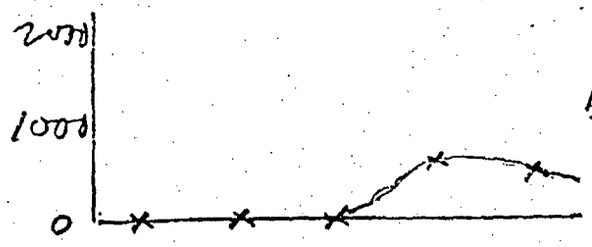


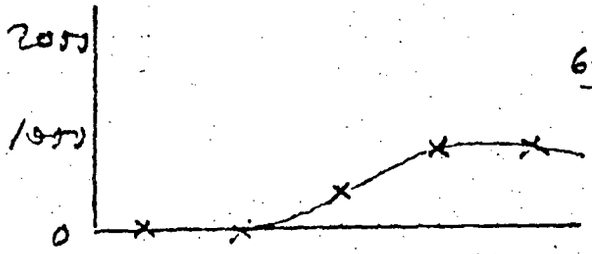
5/3/89

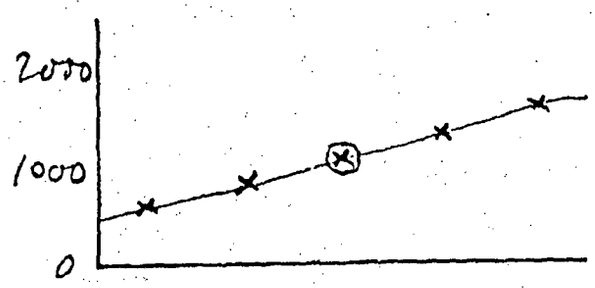
Attachment #4

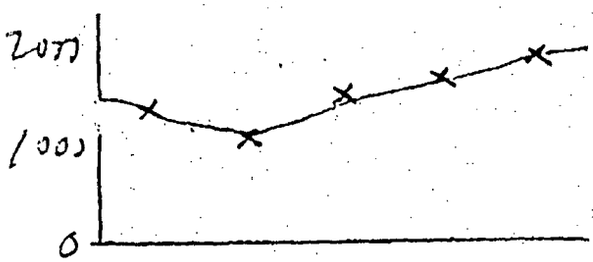
Flow direction - out of page

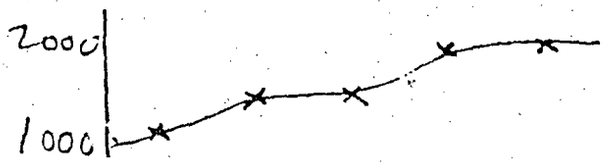












overall avg

= 932 fpm

Area = $\left(\frac{11}{12}\right)^2$ = .84 ft

∴ flow ≈ 800 cfm