HEALTH PHYSICS MANUAL

W. R. GRACE & CO.

POMPTON PLAINS

NEW JERSEY

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PREPARED BY

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INTRODUCTION

It is important for any organization using radioactive materials to establish a program that will insure the safety of its personnel and the inhabitants of the surrounding area, and compliance with local, state and federal regulations. The Pompton Plains Plant of the Davison Chemical Company has established the radiological safety program described below. Its success depends upon the cooperation of each individual.

The Health-Physics Department has three areas of prime responsibility. They are: the day-to-day evaluation of radiation exposure; the reduction of exposure by any applicable control measures; and, the monitoring of all materials and effluents discharged from the plant site. The fact that all exposure levels are maintained below maximum permissible levels is an indication that the control procedures are working, but since any unwarranted exposure is foolish, the efforts to maintain radiation levels as low as possible in these three areas of responsibility should be paramount.

A prime factor in the control of radiation exposure is the proper training of operating personnel. It is a part of the Health-Physics Department's responsibility to see that every individual knows what he is working with, what the hazards are, and what measures are being taken to insure his safety. The employee must be trained in safe techniques and know what to do in case of accident. Finally he must be made to realize that observance of safety rules and personnel monitoring requirements are just as much a part of the job as the actual operation performed.

Thorium, small amounts of uranium and their compounds occur naturally in monazite or thorite. Chemical separation produces a mixture of thorium ^{232} and thorium ^{288} plus the uranium disintegration products in radioactive equilibrium, and may drive off the active daughter creating an airborne hazard. Thorium decays slowly to form thoron gas which then decays to form stable lead, with the emission of alpha and beta activity.

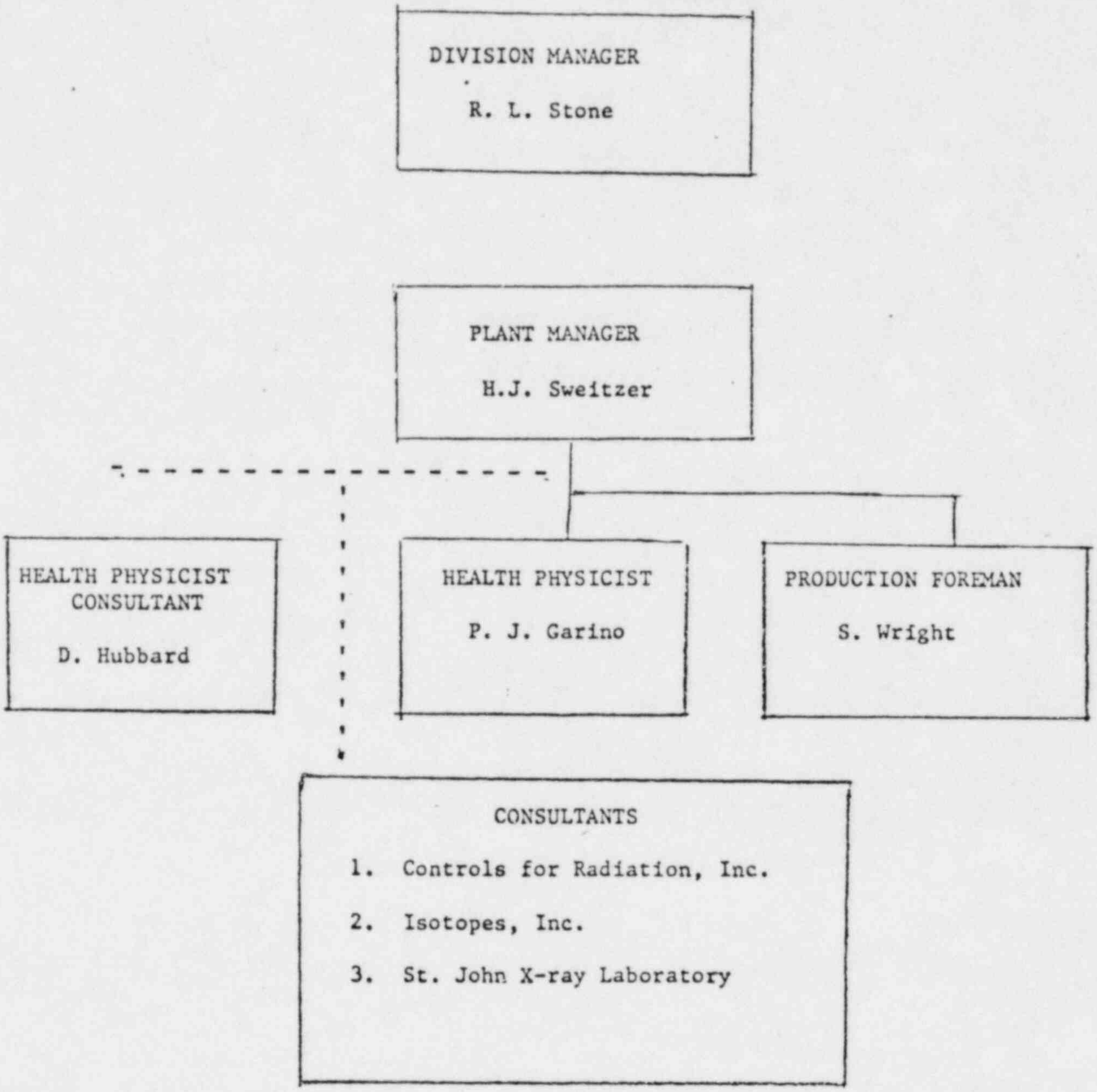
Fifty to seventy-five years of experience in refining thoria from monazite has produced no noticeable evidence of radiation injury or chemical toxicity. Industrial exposure averaged 10^{-10} uc/cc during this period.

Certain recent animal toxicity data indicates radiation dosage from thorium might better be compared to that of plutonium than to uranium. Calculations based on these and other animal data suggest that permissible occupational exposure to thorium should be reduced to 2×10^{-12} uc/cc for 40 hours per week. However, the most recent review on the subject strongly supports the uranium comparison and retention of the present limits. The National Committee on Radiation Protection has recognized this disparity and has proposed 3×10^{-11} uc/cc as a temporary permissible level with the recommendation that exposure levels be kept as low as operationally possible.

This manual contains general safety procedures and rules which must be followed by all employees, methods of analysis, administrative forms, and diagrams of the plant and surrounding area.

The basic purpose of these safety procedures is to prevent entry of radioactive material into the body by ingestion, inhalation, or other modes, to minimize exposure of personnel to external radiation, and to limit the cross contamination of areas and equipment.

RADIOLOGICAL SAFETY ORGANIZATION



DEFINITION OF TERMS

Controlled area — Any area, access to which is controlled by the licensee.

Spreadable activity — Airborne activity or activity on any object which may be transferred to a piece of filter paper which is lightly rubbed on the surface.

Non-spreadable activity — Fixed contamination which cannot be transferred to the smear paper.

Maximum permissable dose (MPD) — That amount of ionizing radiation, which in the light of present knowledge, is not expected to cause appreciable bodily injury to a person at any time during his lifetime.

Maximum permissable concentration(MPC) — In restricted areas this is limited to 3×10^{-11} microcuries per milliliter of air. This is equivalent to 110 130 alpha disintegrations per minute per cubic meter of air.

Roentgen — The quantity of X or gamma-radiation such that the associated corpuscular emmission per 0.001293 gram of air (1cc of dry air at standard conditions) produce, in air, ions, carrying one electro-static unit or quantity of electricity of either sign.

Roentgen Equivalent Man (REM) — The amount of ionizing radiation that will produce the same biological effect as that produced by one roentgen of high voltage X radiation.

Radioactivity — Process whereby certain nuclides undergo spontaneous disintegration, liberating energy through alpha or beta particles or gamma Photons or a combination of these.

Radiological Safety Officer (RSO) — A person trained in that branch of radiological science dealing with the protection of personnel from the harmful effects of ionizing radiation.

Definition of Terms

Radioactive Units	-	Measured in disintegrations per unit time or in curies. A commonly used submultiple of the currie is the micro curie (One uc = .000001c = 3.7×10^4 dpr = 2.2×10^6 dpm)
Restricted area	-	An area, access to which is controlled by the licensee
Radiation	-	Any or all of the following: alpha rays, beta rays, gamma rays, X-rays, neutrons, high speed electrons, high speed protons and other atomic particles.

MAXIMUM PERMISSIBLE LEVELS AND CONCENTRATIONS (cont.)

PERMISSIBLE CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND

MATERIAL	TABLE I[a]		TABLE II[a]	
	Column 1 Air	Column 2 Water	Column 1 Air	Column 2 Water
Th-natural (soluble)- - - - - - - - - - - - - - - - -	$3x10^{-11}$	$3x10^{-5}$	$1.0x10^{-12}$	$1.0x10^{-6}$
Th-natural (unsoluble)- - - - - - - - - - - - - - -	$3x10^{-11}$	$3x10^{-4}$	$1.0x10^{-12}$	$1.0x10^{-5}$
U-natural (soluble)- - - - - - - - - - - - - - - - - -	$7x10^{-11}$	$5x10^{-4}$	$3x10^{-12}$	$2x10^{-5}$
U-natural (unsoluble)- - - - - - - - - - - - - - - -	$6x10^{-11}$	$5x10^{-4}$	$2x10^{-12}$	$2x10^{-5}$

a Table I applies to restricted areas, Table II to unrestricted areas.

CONTAMINATION CONTROL

The processing of monazite ores results in potential health hazards to both the employees and to the plant community. The control of in-plant hazards require the evaluation of employees' exposures. The sources of the exposures are external radiation from thorium and its daughter products and small amounts of uranium, taken into the body by inhalation or ingestion of airborne activity or surface contamination. To control the potential hazards to the plant community it is necessary to determine and control the quantity of uranium and thorium with its daughter products released from the plant. This includes liquid and gaseous effluents, solid waste material and contamination on material or personnel leaving the plant area.

In the interest of general personal protection, all personnel working in the vicinity of operations in which a potential dust hazard exists are required to wear respirators.

All personnel working in the plant processing areas are required to undergo a clothing change prior to reporting to their work areas. On arrival at the plant, operators enter the clean area (west side of the locker room), undress and place their street clothes in their assigned lockers. They then pass into the process area (east side of the locker room) and put on their process clothing and safety shoes. At the end of their shift, operators return their process clothing to their lockers in the east locker room and pass into the west locker room.

Supervisory personnel and those individuals who have occasion to visit the processing areas are issued smocks and overshoes. These are worn at all times while the individual is in the processing area. They are maintained on hangers immediately adjacent to the chemical control laboratory. Plant visitors follow the same procedure described for supervisory personnel.

Controls have been established to insure that equipment and materials leaving the plant are not significantly contaminated. Prior to the release of any material, written approval must be obtained from the Health Physics office. All radioactive material brought onto the plant site will be monitored by the Health Physics department to insure that maximum permissable concentrations of radioactivity are not exceeded. Records of incoming and outgoing materials are maintained in the office.

RADIATION SURVEYS

1. Air Samples

The extent of airborne contamination in the Rare Earth Processing Plant site is monitored by sampling the air in different parts of the plant with a Staplex Hi-Volume Air Sampler, equipped with a T.F.A. #41 filter, and determining the radioactive content of the dust accumulated on the filter. The procedure employed consists of sampling the air in a particular locality at the rate of 20 cu. ft. per minute for a period of 5 minutes, allowing the collected dust to age 48 hours to permit the decay of radon and thoron, counting the sample in a proportional counter-scaler arrangement and converting the resulting reading to uc/ml.

Air samples are taken by each of two different schemes. In the first instance, each of the positions designated as air sampling stations in exhibit #1 are monitored at least once quarterly while other areas are monitored once every six months. In the second scheme, each operator station is monitored during a period of production. In the latter case a complete survey is conducted in event of a process change. In addition to these two systematic sampling methods, the Health Physicist makes a number of spot checks of the air count when he, during the course of his daily routine health inspection, feels that a particular operation or area requires such attention.

In the event that it is found that the air count in a particular area exceeds the following tolerance limits, the Health Physicist has the authority to cause a cessation of the applicable operation (s) until correctional measures have been taken.

TOLERANCE LIMITS FOR RESTRICTED AREAS

Thorium	3×10^{-11} uc/ml.
Uranium	7×10^{-11} uc/ml

Reports of the surveys of airborne contamination are prepared by the Health Physicist and distributed to the plant manager and department heads.

LOCATIONS OF AIR SAMPLING STATIONS

1. Restricted Areas

   a) Shipping Room - in the center of the room, five feet from the east wall.

   b) Pulverizing Room - in the center of the room

   c) Calcining Furnace - midway between press number 4 and the furnace.

   d) Thorium Refining - in the hallway near the rear south side entrance.

   e) Thorium Crystallization Unit - in the center of the room.

   f) Process storage - in the center of the room.

   g) Ball Mill - in the center of the room.

   h) Monazite Storage Area - three feet from the center of the south wall.

   i) Lunch Room - in the center of the room.

   j) Thorium Hydroxide Storage - on the south side of barrels.

   k) Development Laboratory - in the center of the room.

   l) Sulfonation Kettle Area - midway along the south wall of the room.

2. Unrestricted Areas

   a) North west corner of property line.

   b) Midway along south property line.

   c) Southwest corner of property line.

2. Liquid Waste - Plant Effluent

The waste treatment plant treats all liquid wastes issuing from the plant. The waste involved consists of wash water, floor washings and surface run-off from the adjacent plant property.

The process involves the use of an average of 18,000 gallons of water per day. All of the washes are discharged into a common 1,000 gallon sump equipped with two automatically controlled force pumps which pump the waste to a retention tank. Each pump has capacity to handle the peak load and is installed so that the second pump starts in case of extreme demand or failure of the first. Signals are installed in a control house to indicate the proper function of the pumps.

The retention tank has a capacity of 50,000 gallons which provides a minimum of 48 hours average retention of the wastes. In addition to the purpose of acting as a reservoir, or constant head installation, the tank provides means of blending effluents of widely varying pH so that the automatic pH controlling equipment may function more efficiently. The incoming wastes flow through a distributing channel in the tank and effluent, after initial settling, is removed from the midpoint of the tank and flows by gravity to a mixing tank. A draw-off is provided at the bottom of the tank to pump accumulated solids to the sludge filter press.

An 8,000 gallon mixing tank, equipped with a gate agitator receives effluent from the retention tank at its midpoint. A pH electrode assembly is in circuit with the mixing tank and electrically connected to a mechanically operated diaphragm valve. Two storage tanks are provided to feed either 50% sulphuric acid or 50% caustic soda solution through the automatic diaphragm valve to the mixing tank as called for by the pH controller. Again signals are provided to indicate proper functioning of the valve and chemical supply tanks as well as a recording chart which indicates the pH of the mixing tank. The mixing tank effluent is piped to a 2,000 gallcn Hardinge thickener at pH 5.8 - 6.2.

The Hardinge thickener provides a clear overflow to a final clarification tank and adjusted to give a 20% solids underflow which is pumped to a sludge filter press in the control house.

The final clarification tank of 50,000 gallon capacity provides an average 48 hours of retention time for the effluent before discharge from the system. The main function of this tank is to provide sufficient time for post precipitation of solids after pH adjustment. A draw off is provided at the bottom of the tank to pump accumulated solids to the sludge filter press.

The sludge filter is of the plate and frame type with a capacity of 6 cubic ft. of cake. Approximately 60 cubic feet of sludges, or 3,500 lbs. are removed weekly. These sludges are hauled to a dump on the property.

The system was designed to operate automatically. Twelve man hours per day are devoted to the maintenance, cleaning and control of the operation. The entire operation is under the supervision of the plant chemist who checks the performance of the equipment, and samples prepared by the shift operator.

A log is maintained which indicates satisfactory operation of the system for pH and turbidity control. The pH of the effluent is maintained between 5.0 and 8.0 according to the permit granted by the New Jersey State Department of Health who have approved the design and mode of operation of the system. We have found through experience that the system operates more satisfactorily at lower pH values since the precipitate formed by neutralization settles more rapidly assuring a clearer effluent.

The effluent is sampled daily at the overflow of the Hardinge thickener and at the Weir in the control house. Sampling at the Hardinge thickener in the system provides an average 48 hour retention time before discharge and will indicate the quality of the effluent entering the final clarification tank. Sampling at the Weir provides a check on the amount of contamination which has settled out of the effluent in the final clarification tank or if there is any additional contamination being added to the effluent through the accumulation of sludges in the clarification tank.

The samples are immediately taken to the laboratory together with the completed "plant effluent form". Upon completion of analysis of the sample the Health Physicist reviews the analytical results and compares them with the maximum permissable concentration. The effluent is then graded according to the following standards:

PLANT EFFLUENT STANDARDS

Grade of Effluent	Sample Position and % Hardinge Overflow		M. P. C. Weir	Disposition
A	33	=	33	Excellent effluent
B	33-66	=	33-66	Satisfactory effluent
C	0-66	=	33-66	Possible contamination from final effluent tank
D	33-66	=	33-66	Indicates buildup of contamination. Notify Plant Manager.
E	66-100	=	66-100	Continued contamination. Notify Plant Manager
E	66-100	=	66-100	Further build up from final effluent tank.
F	66-100	=	66-100	Increasing contamination from plant process. Alert Plant Manager. Additional analysis.

(continued)

Grade of Effluent	Sample Position and % Hardinge Overflow		M. P. C. Weir	Disposition
F	/ 100	=	66-100	Shut down departments discharging effluents.
F	/ 100	=	/ 100	Shut down departments discharging effluents and hold up effluent.

Copies of analysis of effluent grade D or lower must be immediately presented to the Plant Manager

On the final day of each month the Health Physicist prepares a "Monthly Report of Material Discharged into the Pompton River" in which he presents the high, low and average amounts of process effluent discharged during the preceding month and the high, low and average concentrates expressed as a percentage of the maximum permissible concentration. The original and two copies of the report will be sent to the Plant Manager and one copy retained by the originator.

All effluent and river samples are monitored with a Proportional counter, decade scaler circuit by methods outlined in Appendix B.

RADIATION SURVEYS

3. Personnel Monitoring

All employees who have reason to enter the processing areas are required to wear film badges. These badges, supplied by the St. John X-Ray Laboratory, are read every month and a report of the readings by name and badge number if furnished the health physicist. The health physicist prepares a report of the exposure readings which is sent to the plant manager.

New film badges are issued by the health physics office each week. Film badges are not carried home or left in process areas but are hung in their assigned spaces on film badge racks.

Individual work activities are so scheduled that an operator is not subject to radiation in excess of 1.25 rem/qr. In the event of a reading exceeding 1.25 rem/qr. as shown by a film badge report, the area supervisor is notified, the individual's work program reviewed and the results of the review filed with the weekly film badge report.

4. External Radiation Surveys

A radiological survey of the entire Rare Earths Processing Plant is made by the health physicist quarterly. To facilitate such surveys, the plant has been subdivided into a series of monitoring areas. A diagram of these areas is shown in Exhibit #2 (Appendix). Each area is surveyed carefully and the highest radiation level in the area is recorded. In the event that the radiation level in any part of a given area exceeds 5 mr/hr the portion of the area indicating such a level is posted with a radiation sign. Any area with a radiation level in excess of 10/mr/hr is so enclosed that only limited access to authorized personnel is available.

A report describing the results of each radiological survey is prepared by the health physicist and is forwarded to the plant manager. Such surveys are conducted using a Geiger counter manufactured by the Anton Electronic Laboratories, Inc., Brooklyn, New York, Model #5.

DECONTAMINATION PROCEDURES

Personal decontamination methods to be used are dependent upon the contaminating material and the area of the person contaminated. Generally the following procedure is to be used immediately.

First notify Health Physics; specific measures will then be carried out by this office. Thorough washing with soap and water and then rinsing off with large quantities of water is the best general decontamination method for the hands and other parts of the body. For well localized contamination, however, it is recommended that the area be washed off and cleansed with swabs and later, if necessary, by using a general washing. This avoids the dangerous procedure of spreading the contamination needlessly.

The following specific measures should be followed with the guidance of Health Physics:

(a) For general hand washing: the hands should be washed two to three minutes in tepid water using mild soap. Rinse thoroughly and repeat a maximum of four times. If the required degree of decontamination is not then reached, proceed with (b).

(b) Using a soft brush, wash and rinse three times in 8 minutes of which no less than 6 minutes should be spent in scrubbing. Use only light pressure so as not to abrade the skin. Rinse thoroughly and monitor.

Generally, persons with any wounds or cuts will not be permitted to work in a radioactive area, unless specific approval is obtained from Health Physics. Any wounds, cuts or bruises received while working with, in or near radioactive materials should be flushed with water immediately and must be referred to the Health Physics Department immediately so that more specific measures can be taken.

Equipmer nay be decontaminated by was g with detergent and water until the desired permissible level of activity is obtained. Other chemicals which may be used include ammonium citrate, trisodium phosphate and ammonium bi-fluoride. Equipment once contaminated, must be treated in the exact same method as other primary radioactive materials. Health Physics will supervise the decontamination of this material and equipment.

Health Physics will also monitor contaminated areas and determine the most practical method decontamination. The method used will include those mentioned under equipment and personal decontamination in addition to washing, surface stripping and repainting.

WASTE DISPOSAL

Waste materials are a natural result of the manufacturing process at the Rare Earth Processing Plant. Procedures have been established to collect, handle and dispose of the material. The general methods of waste disposal are:

(a) Transfer - This must be to an authorized recipient, whether he be a licensee, a commercial disposal facility or the Atomic Energy Commission.

(b) Burial - Is at a minimum depth of four feet, successive burials are separated by distance of at least six feet and not more than twelve burials are made in any year. Finally the total quantity of licensed material buried at any one location and times does not exceed, at the time of burial, 50,000 microcurai of natural thorium or uranium. The contractor or licensee must own the land used for these burials and must limit access to this property to prevent hazard to casual personnel.

(c) Discharge - Concentrations of licensed or other radioactive material released as an effluent into an unrestricted area must not exceed specifications set forth in AEC Regulations Title 10, Part 20. The amendment of a license will be issued if the applicant demonstrates that it is not likely that any individual will be exposed to concentrations in excess of those set forth in the regulation. Concentrations in effluents may be averaged over periods not greater than one year. The established procedure for effluent retention and disposal is outlined under Radiation Surveys, Plant Effluent.

MEDICAL EXAMINATIONS

The Rare Earth Processing Plant has a medical protection program and maintains medical records and radiation exposure records of each employee. This medical program in itself can only be an added precaution for radiation control and will be most valuable in maintaining the general health of the workers. The clinical systems of radiation damage occur only with a considerable over-exposure therefore the responsibility for prevention of radiation damage rests entirely on the personnel monitoring and control systems.

At the present time there are only a limited number of medical tests available for radiation protection. Most exposure information is still obtained from personnel and area monitoring. Any radiation program is a failure if clinical evidence of radiation damage appears. Thus medical tests are not as much a part of a protection program as they are a confirmation that some acute over-exposure has occurred.

Semi-annually each employee of the Rare Earth Processing Plant receives a complete blood count. Annually each employee receives a full chest x-ray. Additional examinations are performed at the termination of any employment or where candidates for employment exhibit or make known symptoms of normal disease which may also be attributed later to radiation exposure.

ADMINISTRATIVE FORMS

RARE EARTH DIVISION

DAVISON CHEMICAL COMPANY

POMPTON PLAINS, NEW JERSEY

HEALTH PHYSICS DEPARTMENT

AREA MONITORING SURVEY DATA SHEET

R.E.P.P WAYNE TWP., NEW JERSEY

DATE____________________

BUILDING OR AREA ______________________________

NATURE OF SUSPECTED ACTIVITY____

MONITORED BY____________________

INSTRUMENT USED______________________________

LOCATION	Distance From Source	Radiation Level	REMARKS

SURVEY OF RADIOLOGICAL AIR-BORNE CONTAMINATION

Location	Date	Time	Type of Survey	Results

Date ____________________

____________ ______________

INCINERATION PER T

Date ____________________

THIS FORM UPON COMPLETION, SURVEY AND SIGNATURE OF THE HEALTH-PHYSICS OFFICER AUTHORIZES THE FOLLOWING ITEM (S) TO BE BURNED IN THE TRASH BURNING AREA:

ITEMS

(1) ____________________

(2) ____________________

(3) ____________________

(4) ____________________

DATE TO BE INCINERATED ____________________

APPROVED BY ____________________
Department Manager

MONITORED BY ____________________
Health-Physics Department

RARE EARTH DIVISI

PROPERTY PASS

Date ____________________

THIS AUTHORIZES (Name)____ TO REMOVE THE FOLLOWING ITEM (S) OF COMPANY PROPERTY FROM THE PLANT:

ITEMS AND NUMBER OF EACH

(1)____

(2)____

(3)____

( ) PERMANENT REMOVAL

( ) TEMPORARY REMOVAL

DATE TO BE RETURNED ______________

DATE RETURNED ____________________

APPROVED BY_________________

MONITORED BY________________
Health Physics Dept.

HEALTH PHYSICS DEPARTMENT
RARE EARTH DIVISION

DUST RESPIRATOR INSPECTION REPORT

DATE OF INSPECTION ____________________

		CONDITION OF RESPIRATOR		
OPERATOR	CLASS	GOOD	FAIR	UNSATISFACTORY

By ______________________________
Health Physics Department

R.E.P.P WAYNE TWP., NEW JERSEY

RECORD OF DISCHARGE OF PROCESS EFFLUENTS TO THE POMPTON RIVER

Date	Volume	Plant Sample No.	Lab. Sample No.	Percent MPC	pH	Remarks

HEALTH AND SAFETY DEP

R.E.P.P., WAYNE TWP., N.J.

Operator ______________________________ ____________Shift

Job Description ________________________

TIME	OPERATION OR OPERATING AREA	$d/m/m^3$ CONCENTRATION (L)	(H)	(AVG)
8:00				
:10				
:20				
:30				
:40				
:50				
9:00				
:10				
:20				
:30				
:40				
:50				
10:00				
:10				
:20				
:30				
:40				
:50				
11:00				
:10				
:20				
:30				
:40				
:50				
12:00				
	LUNCH			
1:00				
1:00				
:10				
:20				
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2:00				
:10				
:20				
:30				
:40				
:50				
3:00				
:10				
:20				
:30				
:40				
:50				
4:00				
:10				
:20				
:30				
:40				
:50				
5:00				

JOB ANALYSIS SHEET

OPERATOR ____________________ ______MEN/SHIFT ______SHIFTS/DAY

Operation or Operating Area	Time per Oper.	Oper. per Shift	Time per Shift (min)	No. of slps.	CONCENTRATION M^3	AVGE CONC X TOTAL TIME

(TXC) / (T) ____________________ $d/m/M^3$ ____________________ times max. per. conc.

CONTACTS FOR EMERGENCY USE

OPERATIONS SUPERVISOR

H. J. Sweitzer

Home Phone 835-5119

OPERATIONS ASSISTANT

Spencer Wright

Home Phone 786-1375

HEALTH PHYSICS

P. J. Garino

Home Phone 694-0877

MEDICAL OFFICER

Dr. S. T. Bernson

Office Phone 835-2400

PLANT AREA FIRE

(1) Report fire alarm.
(2) Use fire extinguisher.
(3) Notify Operations Supervisors and Health Physicist.

PROCEDURES FOR THE MEASUREMENT OF RADIOACTIVITY

Health-Physics Department

Davison Chemical Company
Pompton Plains, N. J.

ALPHA COUNTING

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ALPHA COUNTING

ANALYSIS: Counting Procedure

The operations noted below are performed daily before any samples are counted.

1. Thoroughly clean the sample chamber with ethyl alcohol (C_2H_5OH).

2. To determine the background, place a blank filter paper (Whatman #41, 1-1/8 inch diameter) on the pedestal. In scintillation counters, fasten the blank in place with a plastic ring. In the proportional counter, place the blank on the middle of the pedestal. Whenever possible, allow the blank to count overnight. Record the time at which the counting was started. To determine the counts per minute, divide the total count by the count time (in minutes). This figure is recorded on the card provided.

   Example: Background (bkgd) count was 235 counts in 18-1/2 hours.

   18 x 60 = 1080 / 30 = 1110 = count time in minutes.

   235 / 1110 = .21 c/m bkgd.

   When it is impossible to count the background overnight, if may be counted in the morning. The background is then counted for 10 minutes.

   Example: Counter registered 4 counts in 15 minutes. Time in minutes was 15.

   4 /-15 = 27 c/m background.

3. The geometry is calculated after the background is counted. This is done by placing the alpha standard (496 d/m) in the chamber.

   A. In scintillation counters, the standard is counted for 640 counts and the time recorded. The standard is counted three times and the geometry is calculated from the average of the three.

B. In the proportional counter, the standard is counted for two minutes and the count recorded. This operation is repeated three times and the average count is used to calculate the geometry.

The geometry is calculated as follows: The counts per minute of the standard is divided by the known disintegrations of the standard.

<u>Example:</u> The counts per minute of the standard was 239. The d/m of the standard is 496.

<u>Therefore:</u> 239 ÷ 496 = .48 or 48% geometry.

Record this figure on the card with the background.

If the geometry drops to 35% or lower in scintillation counters or below 45% in the proportional counter, the counter should be checked by the instrument repair man.

ALPHA COUNTING

ANALYSIS: Plateaus

1. Place the alpha standard (496 d/m) in the sample chamber of the counter.
2. Find the lowest operating voltage of the counter.
3. At this voltage make three counts
   - A. In scintillation counters, make three 640 counts.
   - B. In the proportional counter, make three-minute counts.

   Record these figures.
4. Make three counts every 25 volts in scintillation counters and every 20 volts in the proportional counter.
5. Continue in this manner until the count becomes too fast. That is, until the scintillation counters record 640 counts in less than 1.50 minutes or the proportional counter records more than 1200 counts per three minutes.
6. Ascertain the average counts per minute by the following methods:
   - A. In scintillation counters, add the three count times and divide by 3 to find the average count time. Then divide 640 by the average count time to determine average c/m.

     Example: At 950 volts the count times were 3.28, 3.50 and 2.98.

     3.28 + 3.50 + 2.98 = 9.76

     9.76 ÷ 3 = 3.25

     640 ÷ 3.25 = 197, the average counts/minute
   - B. In the proportional counter, add the three counts and divide by 9 to find average counts/minute. 9 is used because there were 3 counts and each count was for 3 minutes.

     Example: At 840 volts the counts were 608, 626 and 599.

     608 + 626 + 599 = 1833

     1833 / 9 = 204, the average count/min.

7. The average counts are then plotted on graph paper against the voltage. By using French curves, a curve is drawn.

8. The operating voltage is chosen from the plateau or straight line on the graph. The operating voltage is usually 1/3 to 2/3 of the way across the plateau.

9. Plateaus should be run once every three months. If major repairs are made on the counter, or if the geometry is too low, spot checks should be made on the plateau. If the spot checks show much variance, an entire new plateau should be run.

ALPHA COUNTING

ANALYSIS: Alpha Air Dust

Procedure

1. The background and geometry should be taken daily before counting any samples. Directions for taking background and geometry appear in preparations for alpha counting.

2. The sample is placed on the pedestal and fastened with a plastic ring. Samples are counted either for 32 counts or for 15 minutes, whichever comes first. If a 32 count is reached in less than 0.05 minutes, it is advisable to recount it for a 64 count.

3. Types of Samples Counted:

   A. Uranium air dust samples - 4 to 5 hours should elapse from the time of sampling to the time of counting. This is to allow for the decay of radon gas.

   B. Thorium alpha samples - at least 24 hours should elapse between time of sampling and time of counting. This allows for the decay of thoron and other daughter products.

ALPHA COUNTING

ANALYSIS: Alpha Air Dust

Calculations

A. To determine counts per minute, divide the total count by the count time in minutes, then subtract the background of the counter. When referring to c/m, it is assumed that the background has been subtracted.

This formula is $\frac{\text{count}}{\text{time}} - \text{bkgd.} = \text{c/m}$

Count = total count Time = time in minutes.

Example: Sample 7B counted 32 counts in 7.38 minutes.

The counter background was .12 c/m.

$32 \div 7.38 = 4.35$

$4.35 - .12 = 4.23$ c/m

B. To determine d/m, this formula is used:

$$\text{d/m} = \frac{\text{c/m}}{\text{geom.}}$$

Example: Sample 7B c/m = 4.23 Geom. is 48%

$$\frac{4.23}{.48} = 8.81$$

C. To determine d/m/M^3. Air dust samples are usually reported in this way. This formula is used:

$$\text{d/m/M} = \frac{\text{d/m}}{(.7)^{*} \quad (Q)^{**}}$$

*.7 is the absorption factor for the filter paper in air dust samples.

**Q is the amount of air sampled in cubic meters.

Example: Sample 7B: d/m = 8.81

Q is .6 Absorption factor is .7

$$\text{d/m/M} = \frac{8.81}{.7 \times .6} = 20.98$$

ALPHA COUNTING

ANALYSIS: Counting Planchets

1. Before a planchet is used, it is counted for five minutes to determine the background of the planchet.

2. Planchets are always counted in the proportional counter. The planchet is placed in the middle of the pedestal. The sample is counted for 15 min. unless the count is very fast. Then the counter may be shut off at any time. (It is better to turn off the proportional counter on an even minute rather than a fraction of a minute, since calculating is easier with even minutes).

3. Planchets should be counted as soon as possible after they are dried, except for Radium at equilibrium, i. e. 40 days.

ALPHA COUNTING

ANALYSIS: Plant Effluent

Procedure

1. Sample

   A. Plate 5 ml. of the sample directly.

   B. Calculate d/m/ml in the usual way. (See Calculations)

2. Liquid Phase

   A. Place a 10 ml. aliquot of the sample in a centrifuge tube.

   B. Centrifuge for 15 minutes.

   C. Carefully plate the liquid on a stainless steel planchet 2" in diameter.

   D. Allow it to dry thoroughly and count in the proportional counter for 30 minutes.

   E. Calculate d/m/ml in the usual manner. (See Calculations)

3. Solid Phase

   A. The solid which remains in the bottom of the centrifuge tube is plated on a stainless steel planchet 2" in diameter.

   B. The centrifuge tube is rinsed with water and the rinsing is plated on the planchet.

   C. Allow the planchet to dry thoroughly and count it for 30 minutes in the proportional counter.

   D. Calculate d/m/ml in the usual manner. (See Calculations)

ALPHA COUNTING

ANALYSIS: Alpha Activity in Murky Water

Procedure

(Clear water samples are plated directly onto stainless steel planchets. A 5 ml. aliquot is generally used.)

Method for Murky Water Samples

1. Place an aliquot of the sample (20-100 ml.) in a beaker.
2. Add an approximately equal amount (20-100 ml.) of Nitric Acid (HNO_3) to the aliquot.
3. Place the beaker on a medium heat hot plate and evaporate until about 5-10 ml. of aliquot remains.
4. Remove from the hot plate and allow the beaker to cool.
5. Add about 25 ml. of Nitric Acid (HNO_3) to the aliquot.
6. Return to the hot plate, and allow the aliquot to evaporate until about 5-10 ml. remain.
7. Repeat steps 4-6 until the aliquot is clear.
8. Plate a small amount of the aliquot on a low background stainless steel planchet by means of a dropper. Dry on a low heat hot plate. Add another small amount of aliquot and allow it to dry. Continue in this manner until all of the aliquot is plated.
9. Rinse the beaker with a small amount of water (6-25 drops) and plate the rinsing on the planchet.
10. Allow the planchet to dry thoroughly.
11. Count in a low background proportional counter for 15 minutes.

ALPHA COUNTING

Calculations

1. To determine counts per minute, divide the total count by the count time in minutes and subtract the background of the planchet.

$$c/m = \frac{\text{total count}}{\text{count time}} - \text{bkgd.}$$

Example: 20 ml. of a sample was plated on a planchet. The background of the planchet was one count in five minutes or .20 counts per minute. The aliquot counted 7 counts in 15 minutes.

$$c/min = \frac{7}{15} - .20 = 0.27$$

2. To determine disintegrations per minute, divide the counts per minute by the geometry.

$$d/m = \frac{c/m}{\text{geom.}}$$

Example: The c/m of a sample was 0.27. The geometry of the counter was 50%.

$$d/m = \frac{0.27}{.50} = 0.54$$

3. To determine d/m/ml the d/m is divided by the sample aliquot.

$$d/m/ml = \frac{d/m}{\text{aliquot}}$$

Example: 20 ml. of a sample had a d/m of 0.54

$$d/m/ml = \frac{0.54}{20} = 0.027$$

BETA COUNTING

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BETA COUNTING

ANALYSIS: Counting Procedure

I. Background

A. The background of the beta counter is taken daily. It is always taken on the same shelf of the counting chamber on which the samples are counted.

1. The inside of the chamber and the counting shelf are thoroughly cleaned with ethyl alcohol (C_2H_5OH).
2. The shelf is placed in the second slot (or on whichever shelf the samples are to be counted.)
3. A thin aluminum absorber .001" thick is placed on the first shelf (or the shelf above the one on which the samples are to be counted). (This is done to remove the low energy RaD beta rays and the RaF alpha rays).
4. The empty shelf is then counted for fifteen minutes.
5. The total count is then divided by the count time to determine background in c/min.

$$\text{c/m bkgd} = \frac{C}{T} = \text{c/m bkgd.}$$

Example: The total count of a fifteen minute background was 125.

$$\text{c/m bkgd} = 125 \div 15 = 7.3 \text{ c/m bkgd.}$$

II. Geometry

A. The geometry is taken twice a week on the same shelf of the counting chamber on which the samples are to be counted. If another shelf is to be used, the geometry is taken on that shelf, before the sample is counted.

1. The Radium D and E source is placed on the counting shelf in the second slot of the counting chamber.

2. A thin aluminum absorber (.001" thick) is placed on the first shelf or the shelf above the one on which the samples are to be counted.

3. The source is counted for three, three minute counts.

4. The three counts are then added and the result is divided by nine and the background of the counter subtracted to determine the average c/m.

   Example: Radium D and E source counted 5300, 5282, and 5199 in three, three minute counts. The background of the counter was 7.3 c/m.

   Average c/m = 5300 + 5282 + 5199 = 15781 ÷ 9 = 1753.4 - 7.3 = 1746.1 c/m.

5. The d/s of the source at the time of counting is determined by use of the graph prepared for each source. This number is multiplied by 60 to determine d/m of the source. The average c/m of the source is divided by the known d/m of the source and the result is the geometry of the counter.

   Example: The source had a known d/s of 488 at the time of counting. 488 x 60 = 29280 d/m. The average c/m of the standard was 1746.1. Geo. = 1746.1 + 29280 = 6.0% geometry.

BETA COUNTING

ANALYSIS: Plateaus

Procedure

1. Place the Radium D + E standard on the second shelf of the counting chamber of the beta counter.
2. Find the lowest operating voltage of the counter.
3. Three, three minute counts are taken at this voltage.
4. Record the total count and the voltage.
5. Make three counts every twenty-five volts until the count becomes too fast. (That is, until the count is so fast that not all of the counts are registered.)
6. Ascertain the average counts per minute by adding the three counts and dividing by nine. Nine is used because there were three counts and each count was for three minutes.

   Example: At 700 volts the counts were 5200, 5169, and 5310.

   5200 + 5169 + 5310 = 15,679

   Average c/m = 15,679 ÷ 9 = 1742 c/m (average)
7. The average c/m's are then plotted on graph paper (20 x 20 sqs./in) against the voltage. By using French curves, a curve is drawn.
8. The operating voltage is chosen from the plateau or straight line on the graph. The operating voltage is 1/3 to 2/3 of the way across the plateau.
9. Plateaus should be run once every three months. If major repairs are made on the counter, or if the geometry is too low, spot checks should be made on the plateau. If the spot checks show much variance from the plateau, an entire new plateau should be run.

BETA COUNTING

ANALYSIS: Beta Activity in Gumpaper

Procedure

1. The entire gumpaper sample is placed in a clean 150 ml. porcelain crucible (Reference: Cleaning porcelain crucibles)
2. The crucible is placed in the muffle furnace (800-900 °F) until the gumpaper is completely ashed (approximately 20-30 minutes).
3. The crucible is removed from the furnace and allowed to cool.
4. The sides of the crucible are scraped with a spatula to remove the ash. The ash is then transferred to a plastic planchet, 1-1/4 in. diameter.
5. The crucible is rinsed with a small amount of distilled water (10-30 m.). Two to five drops of Nitric Acid (HNO_3) is added.
6. The crucible is returned to the muffle furnace until the rinsing has evaporated.
7. The crucible is removed from the furnace and allowed to cool.
8. The residue of the rinsing is added to the sample in the planchet. (Repeat steps 5-8 until the crucible is clean)
9. Record the time and date on which the sample was counted and report it along with the results.
10. Report as d/m sample.

ANALYSIS: Beta Activity in Gumpaper

Calculations

1. To determine counts per minute (c/m): divide the total count by the count time and subtract the background of the counter.

   Example: Gumpaper 330-1 counted 1029 counts in 15 minutes.

   The background of the counter was 8/1 c/m.

   c/m = 1029 ÷ 15 = 68.6 - 8.1 = 60.5 c/m

2. To determine disintegrations per minute per sample (d/m/sample), divide the c/m by the geometry of the counter.

   Example: Gumpaper #330-1 had a c/m of 60.5. The geometry of the counter was 7.1%.

   d/m/sample = 60.5 / .071 = 852 d/m/sample.

BETA COUNTING

ANALYSIS: Beta Activity in Liquids

Procedure

1. The background of a stainless steel planchet 2" diameter cupped planchet) is determined by counting it for five minutes in the counting chamber of the beta counter on the same shelf as the sample is to be counted.
2. The planchet is placed on a transite board on a medium heat hot plate.
3. The sample is plated, a milliliter at a time on the planchet. An aliquot of 1-5 ml. is usually used.
4. When the sample is completely dried, count it for 30 minutes on the second shelf of the counting chamber of the beta counter.
5. Record the time and date on which the sample was counted and report this along with the results.
6. Report the results as d/m/ml.

BETA COUNTING

ANALYSIS: Beta Activity in Liquids

Calculations

1. To determine the counts per minute (c/m): divide the total count by the time counted and subtract the background of the planchet.

   $c/m = \frac{C}{T} - \text{background} = c/m$

   Example: 3 ml. of water sample #PR 421-1 had a total count of 768 in 30 minutes. The planchet had a background of 37 counts in 5 minutes.

   Bkgd. = 37 ÷ 5 = 7.4 c/m.

   c/m = 768 ÷ 30 = 25.6 - 7.4 (bkgd.) = 18.2 c/m.

2. To find disintegrations per minute (d/m): divide the c/m by the geometry of the counter.

   $d/m = \frac{c/m}{\text{geo.}} = d/m$

   Example: 3 ml. of water sample #PR 421-1 had a c/m of 18.2

   The geometry of the counter was 6.3%.

   d/m = 18.2 ÷ .063 = 289 d/m.

3. To determine disintegrations per minute per milliliter (d/m/ml): divide the d/m by the aliquot of sample used.

   $d/m/ml = \frac{d/m}{\text{aliquot}} = d/m/ml$

   Example: 3 ml. of water sample #PR 421-1 had a d/m of 289.

   d/m/ml = 289 ÷ 3 = 96.3 d/m/ml.

BETA COUNTING

ANALYSIS: Beta Pleated Filters

Procedure

1. The filter is cut in half and one half is used as an aliquot. (Reference: Cleaning porcelain crucibles).

   The aliquot is placed in a 150 ml. clean porcelain crucible.

2. The crucible is placed in a muffle furnace (approximately 1000^{o}F) until the pleated filter is ashed. (Approximately 1-1/2 hours)

3. The crucible is removed from the furnace and allowed to cool.

4. By means of a stirring rod crumble the ash to a fine powder. If a fine enough powder is not obtained, a mortar and pestle may be used to break up the ash. The ash is then placed in a plastic planchet 1-1/4 in. diameter.

5. The sample is then counted on the second shelf of the beta counting chamber for fifteen minutes. (See beta counting procedure).

6. Record the time and date on which the sample was counted and report it along with the result.

7. Report the results as beta d/m/sample.

BETA COUNTING

ANALYSIS: Beta Pleated Filters

Calculations

1. To determine counts per minute (c/m): divide the total count by the count time and subtract the background of the counter.

   Example: 1/2 of pleated filter #412-1 had a total count of 562 counts in 15 minutes. The background of the counter was 8.5 c/m.

   c/m = 562 ÷ 15 = 37.5 - 8.5 c/m (bkgd.) = 29.0 c/m

2. To calculate disintegrations per minute (d/m): divide the c/m by the geometry of the counter.

   $d/m = \frac{c/m}{geo.} = d/m$

   Example: 1/2 of pleated filter #412-1 had a c/m of 29.0.

   The geometry of the counter was 6.4%.

   d/m = 29.0 ÷ .064 = 453.1 d/m

3. To determine beta disintegrations per minute per sample (d/m/sample): multiply the d/m by 2 since 1/2 of the entire sample was used.

   d/m/sample = d/m x 2 = d/m/sample.

   Example: 1/2 of pleated filter #412-1 had a d/m of 453.1.

   d/m/sample = 453.1 x 2 = 706.2 d/m/sample.

BETA COUNTING

ANALYSIS: Beta Activity in Solids

Procedure

1. On the analytical balance, weigh a plastic planchet 1-1/4 in. diameter. Record the weight.
2. Carefully place an aliquot of the sample (enough to cover the bottom of the planchet) into the planchet.
3. Reweigh the planchet and the sample and record the second weight.
4. Count the sample in the beta counter on the second shelf of the counting chamber for fifteen minutes.
5. Record the time and the date on which the sample was counted and report this along with the results.
6. Report the results in d/m/gram.

BETA COUNTING

ANALYSIS: Beta Activity in Solids

Calculations

1. To determine counts per minute (c/m): divide the total count by the count time and subtract the background of the counter.

   Example: An aliquot of mud sample #712 counted 27198 counts in 15 minutes. The background of the counter was 8.1 c/m.

   c/m = 27198 ÷ 15 = 1813.2 - 8.1 = 1805.1 c/m

2. To determine disintegrations per minute (d/m): divide the c/m by the geometry of the counter.

   $d/m = \frac{c/m}{geo.} = d/m$

   Example: An aliquot of mud sample #712 had a c/m of 1805.1.

   The geometry of the counter was 6.2%.

   d/m = 1805.1 ÷ .062 = 29115 d/m.

3. To determine disintegrations per minute per gram (d/m/gram): Subtract the first weight of the plastic planchet from the second weight (planchet / sample) to find the weight of the sample. Divide 1 by the weight of the sample (this is the factor for converting to grams). Multiply the d/m by the factor to obtain d/m/gram.

   d/m/gram = d/m x factor = d/m/gram.

   Example: The first weight of a plastic planchet was 0.3561 grams.

   The second weight, (sample / planchet) was 0.7678 grams.

   The d/m of the sample was 29115.

   0.7678g. - 0.3561g. = 0.4117g. (weight of sample)

   1 ÷ 0.4117g. = 2.43 (factor)

   d/m/gram = 29115 x 2.43 = 70749 d/m/gram.