IDO - 12037

ANNUAL PROGRESS REPORT 1963

HEALTH and SAFETY DIVISION

IDAHO OPERATIONS OFFICE
U. S. ATOMIC ENERGY COMMISSION

NATIONAL REACTOR TESTING STATION

PRICE $2.00

AVAILABLE FROM THE
OFFICE OF TECHNICAL SERVICES
U. S. DEPARTMENT OF COMMERCE
WASHINGTON 25, D. C.

PRINTED IN USA

122605

IDO-12037
AEC Research and Development Report
Health and Safety
TID-4500 (32nd Ed.)
Issued: August 1964

HEALTH AND SAFETY DIVISION ANNUAL PROGRESS REPORT, 1963

John R. Horan
DIRECTOR

Aubrey O. Dodd
EDITOR

Idaho Operations Office
U. S. Atomic Energy Commission

ABSTRACT

This Progress Report summarizes for 1963 the significant health and safety data characterizing the protection program for over 5000 persons at the National Reactor Testing Station in southeastern Idaho. Information presented here is briefed for the reader's convenience, and emphasizes the major innovations, concepts, and new trends. Repetitive information, essential for perspective in a continuing program, has been kept to a minimum, allowing space for reporting developments considered to be of special interest to persons working in the field of health and safety.

TABLE OF CONTENTS

FIGURES

TABLES

NATIONAL REACTOR TESTING STATION NOMENCLATURE

AEC	Atomic Energy Commission
ANL	Argonne National Laboratory
ARA	Army Reactor Area
ATR	Advanced Test Reactor
CERT	Controlled Environment Radioiodine Test
CFA	Central Facilities Area
EBR-I, -II	Experimental Breeder Reactor No. 1, No. 2
ETR	Engineering Test Reactor
GCRE	Gas Cooled Reactor Experiment
ICPP	Idaho Chemical Processing Plant
ID	Idaho Operations Office (USAEC)
IET	Initial Engineering Test Facility
MTR	Materials Testing Reactor
NRF	Naval Reactor Facility
NRTS	National Reactor Testing Station
PPCo.	Phillips Petroleum Company
S5G	Natural Circulation Reactor (NCR)
Spert I, II, III, IV	Special Power Excursion Reactor Test Nos. 1, 2, 3, and 4
TAN	Test Area North (Formerly ANP)
TRA	Test Reactors Area (MTR, ETR, ATR)
TSF	Technical Services Facility
WCF	Waste Calcination Facility

I. INTRODUCTION

(John R. Horan, Division Director)

At the National Reactor Testing Station, the major highlight for the year 1963, from the viewpoint of health and safety, was the fact that there was not a single injury to any operating personnel during the entire year. The safety experience for 1963 was one of the best in the history of the NRTS. There was a total of eight disabling injuries, one of which was a fatality, all occurring during construction activities. Property damage, fire loss, and vehicle accident damage were of a minor nature. Exposure to the off-site environs from toxic or radioactive materials was insignificant.

Radiation exposure to NRTS personnel was identical to those recorded the previous year; namely, 2156 rem whole body. There were no personnel exposures recorded during 1963 which exceeded the average guide level of 5 rem/yr established by the Federal Radiation Council. There were no cases involved where the internal deposition of radioactive material in the body was estimated to have exceeded 10 percent of the maximum permissible body burden averaged over a 12-month period.

As of December 31, 1963, no individual accumulated a total body dose of external radiation which exceeded the age pro-rated formula 5 x (N-18). The highest accumulated dose of total body radiation received by an employee while working at the NRTS was 38.6 rem. The ten highest accumulative doses ranged downward to 27.5 rem.

The Radiological Assistance Team responded to 11 off-site incidents involving radioactive materials. Six of the incidents involved radioactive shipments. None of the incidents resulted in exposure to personnel or to the environment.

A review of the year's activities indicates a number of solid accomplishments. The major highlights of the Health and Safety program for 1963 are the following:

(1) The preliminary experiment of the CERT series was successfully performed in May. This involved the study of the pasture-cow-milk-man chain following the release of radioiodine to a controlled environment.

(2) Locations were selected and contracts awarded for the field study of aerosol disposal through the use of gas injection wells in the lithosphere.

(3) A portable whole-body counter prototype was developed. This unit, which is relatively inexpensive and contains minimum shielding, is designed for use in the plant areas.

(4) The Radiological Assistance Plan for Region 6 was revised to incorporate improvements based on field experiences over the past four years (IDO-12013, Rev.1).

(5) Revision was completed on the Standard Health and Safety Requirements (ID Manual Appendix 0500-1; IDO-12028) which is a compilation of the codes and standards applicable to the National Reactor Testing Station in the fields of Industrial Safety, Fire Protection, Industrial Hygiene, Health Physics, and Industrial Medicine.

In addition, new facilities and equipment as well as a major reorganization of the Divisional structure provides the environment for more effective operations in the future. These new developments were:

(1) Construction on the new Health and Safety Building at the Technical Center of the Central Facility Area neared completion. Work also was started on an addition to the Dispensary. This will provide the Division with laboratory facilities and work areas designed for its unique needs.

(2) The table of organization of the Division was changed significantly delegating authority to three Assistant Directors who are now directly responsible for the field Branches. As a result of the expansion and contraction of various elements of the program, the waste management activities were transferred to a separate branch while all environmental activities were consolidated with the Health Physics Branch.

(3) The U. S. Weather Bureau group received delivery of an M-33 radar trailer, which provides greater versatility and more detailed wind trajectory and diffusion data.

II. MEDICAL

(George L. Voelz, M. D., Branch Chief)

1. SCOPE

All operating contractors and ID-AEC at the NRTS used the services and facilities of the ID Health and Safety Medical Services Branch for their in-plant medical program during 1963. This comprehensive occupational medical service emphasizes a preventive medical program founded on physical examinations, prompt medical evaluation and treatment of occupational injuries and illnesses, and consultant services on in-plant health problems. In addition, first-aid and emergency medical care are provided all construction contractor personnel working at the NRTS.

2. MEDICAL SERVICES BRANCH SPECIAL PROJECTS

During 1963, construction of a 2400 ft^2 addition to the Central Facilities Dispensary was begun with occupancy scheduled for early 1964. It will provide additional ward space for three beds, additional office space, examining rooms, and new clinical laboratory facilities. A change room was included which also will be incorporated as part of a future medical decontamination facility.

One physician was added to the medical staff in December 1963. The assistant branch chief took a year's leave of absence for post-graduate study on an AEC Fellowship in Industrial Medicine. Arrangements were made for the medical technologist to spend part time assisting the Hazards Control Branch in industrial hygiene studies. A second medical technologist was added to the staff during 1963.

2.1 Industrial Medicine Investigations

2.11 Lead Exposures in NRTS Construction. A significant lead exposure hazard existed in a construction area and was followed closely during 1963. The exposed group of lead burners varied in number from three to six persons. This problem was a continuation of the exposure condition detected in the last three months of 1962 [a]. Urine lead values were frequently found to exceed 0.20 mg/l and ranged as high as 0.53 mg/l. Excretion values exceeding 0.20 mg/l in a spot urine sample are considered evidence of hazardous exposure conditions. No acute or chronic clinical symptoms of lead intoxication were observed. Lead work is expected to resume in early 1964 with better housekeeping, work habits and ventilation.

2.12 Dioxane Exposures. Two chemists developed acute toxic symptoms and mild, reversible liver damage as a probable result of skin and inhalation exposures to an organic solvent dioxane. The use of fume hoods and rubber gloves for handling this material did not completely control exposure due to failure of the operators to follow the prescribed procedures. The two chemists were finally removed from all work with dioxane. A third chemist, assigned to this job, is being observed for possible effects suggestive of excessive exposure.

---

[a] IDO-12033, Health and Safety Division Annual Report, 1961, pages 5 and 6.

2.13 Acute Minor Radiation Exposures. Two radiographers in a construction area were exposed to ionizing radiation from an Ir-192 source as a result of failure to heed safety regulations on the part of the licensee. The source was loose in the radiography cable carried in the hand of one individual for a few seconds before the error was discovered. Film badges on the radiographers registered 1.6 and 1.7 r gamma exposures. The dose to the gonads were assigned as 1.6 and 3.75 rem, respectively. There was no evidence of skin changes in the radiographer carrying the source. There were no symptons of acute radiation injury, and blood counts remained normal.

In another minor incident, two hot-cell laboratory assistants were found to have radioactive contamination on limited skin areas and on their clothing when returning to work one morning. The length of exposure was indeterminate so medical consultation was sought. No indication of skin damage or blood count abnormality was observed.

2.14 Acute Solvent Exposure. Two men were directed to clean up grease and oil on the floor of a deep pit area. Trichloromethane was used as the cleaning solvent. Typical symptons of drowsiness, dizziness, and numbness developed, but the men were able to climb out of the pit only to return several times to complete the work. One individual developed nausea and vomiting for nine hours afterward. This exposure incident caused the contractor to review its procedures for controlling solvent exposures and to reeducate its employees in these procedures.

2.15 Sodium Burns. Several minor sodium burns were experienced in 1963 during the start-up procedures of a liquid sodium-cooled reactor. These burns have occurred principally to the hands, arms, and face. They have not resulted in lost-time and have been treated promptly and effectively with immediate mineral oil application, ice water soaks, and burn dressings by the nurse in the immediate plant area. No radiation exposures were involved in these incidents.

2.16 Radiological Assistance Team Medical Investigation. In 1963, one investigation was performed by the ID medical consultant on the Radiological Assistance Team. Three men were exposed to the smoke from a fire involving a large amount of magnesium-thorium-232. Urinary and fecal excretion rates were measured by the ID Analysis Branch. Low levels of thorium were noted but not in sufficient concentration to be hazardous or to warrant treatment with chelating agents.

2.17 Eye Study for Radiation Cataracts on Reactor Personnel. The continuing study on reactor personnel for potential effects of radiation on the eye lens was reviewed this past year. There are now 764 individuals in the study who have had 1233 eye examinations which were reviewed and coded on IBM cards. Fifty-five cataracts found in this study have been classified into the following types: 35 congenital, 16 developmental, and 4 degenerative cataracts. There were no cataracts noted which were attributable to occupational radiation exposures.

2.18 Plutonium Contamination Incident. A low level spread of plutonium-240 alpha contamination occurred at an NRTS reactor area during the period November 13 to November 18, 1963. The contamination was first detected on November 15, but discovery of the source and confirmation of the element involved was not accomplished until November 18. The source of the contamination was found to be a movable glove box which had previously been used for seal welding various capsules containing transuranic elements including one containing Pu-240. Personnel who were unaware of the contamination used the box for unrelated work, which subsequently resulted in the spread of contamination. After the contamination was detected, control measures were instituted, which included isolation of the area and contamination checks of persons, buses, and homes. Low level contamination was found in eight homes, one automobile, and three NRTS buses, all of which were easily cleaned. Evaluation of personnel exposures was started on November 16, with collection of urine and feces samples for analysis by the ID Analysis Branch.

As of March 11, 1964, a total of 99 urine samples from 78 individuals was analyzed for plutonium, with only one sample from each of six people being statistically positive. These values ranged from 0.18 ± 0.003 to 0.0014 ± 0.0005 d/m/ml. This highest reading was later proved to be false as a result of reagent contamination. The results of all subsequent samples were below the detection limit of 0.0004 d/m/ml based on a sample size of 1000 ml.

The excretion rate in urine was the primary method used for estimating the body burden of plutonium in the system. Since all urine values were below detection limits within a few days after exposure, the dose from absorbed "soluble" plutonium was completely negligible to all organ systems including the critical organ, bone.

A total of 68 fecal samples from 22 individuals was analyzed. Plutonium was found at least once in samples from 10 of the subjects. The initial samples from the four persons with the highest values contained 26, 10, 3.8, and 1.6 d/m/g of feces. Most of the other positive samples from all subjects ranged from 0.1 to 0.01 d/m/g. The fecal elimination curves were followed with periodic samples on individuals with detectable activity. As of March 11, 1964, the fecal excretion (on all but one individual) had dropped below the detection limit of 0.004 d/m/g of feces based on a 100-gram sample.

Five individuals were still being sampled as of March 1, 1964, primarily to determine the lung clearance half-time which is still an unknown value in man for insoluble plutonium. The plutonium in the feces can be taken as an indirect measure of the lung elimination rate of "insoluble" material which is being brought up out of the lung, transferred to the gastrointestinal tract, and eliminated. Calculations based on the fecal elimination curves indicate that the highest dose constitutes no medically significant lung burden. No work or radiation restrictions on any individual were recommended as a result of these exposures.

3. MEDICAL SERVICES BRANCH CONTINUING ACTIVITIES

3.1 CFA Dispensary Visits

In 1963, the 6273 personnel visits for treatment and consultation at the CFA AEC Dispensary represent a 13 percent decrease from 1962. A major factor in the decrease was the cancellation of the influenza immunization program by one contractor this year. Seventy-four percent of the treatments were for non-occupational injuries or illnesses. A review of the treatment visits indicates that 50 percent were administered to Phillips Petroleum employees, 18 percent to construction workers, 16 percent to AEC personnel, 5 percent for Argonne National Laboratory, 1 percent for Aerojet General, and 10 percent for all others.

The five-year trend of treatments and dispensary visits at the CF Dispensary is shown in Figure 1. A decrease of 12 percent was experienced in the total number of visits -- from 10,149 in 1962 to 8944 this year.

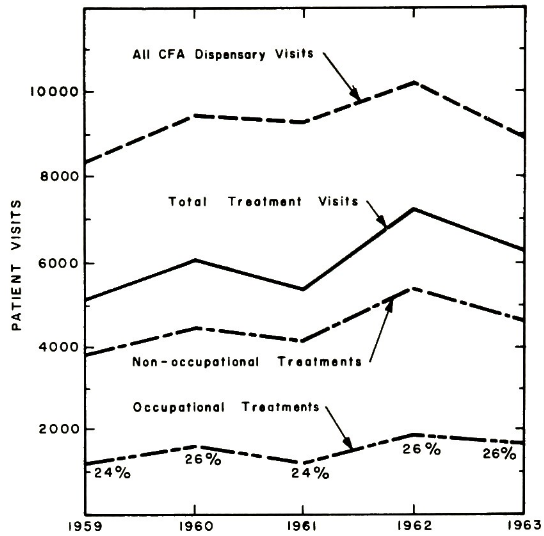

FIG. 1 CFA DISPENSARY VISITS, 1959—1963.

3.2 All NRTS Dispensaries

A summary of the visits to all NRTS dispensaries is tabulated in Table I. The 42,275 total visits represents a seven percent decline from 1962.

TABLE I

1963 NRTS DISPENSARY VISITS

Dispensary	Occupational Treatments	Other [a]	(%)	Nonoccupational Treatments	(%)	Total
CFA (AED-ID)	1627	2671	48	4646	52	8944
CPP (Phillips)	281	793	33	2154	67	3228
MTR-ETR (Phillips)	506	2541	46	3632	54	6679
EBR-II (Argonne)	384	--	16	1967	84	2351
NRF (Westinghouse)	2835	2012	30	11,072	70	15,919
TAN (Phillips)	145	400	22	1880	78	2425
ATR Constr. (Fluor)	363	--	50	365	50	728
First-Aid (Constr.)	759	--	38	1242	62	2001
TOTAL	6900	8417	36	26,958	64	42,275

[a] "Other" - Includes visits for laboratory samples, physical examinations and other nontreatment-type visits.

3.3 Physical Examination Program

A total of 1187 persons was given physical examinations in 1963. Although this is a 17 percent decrease from 1962, the number of periodic and preplacement examinations (777 and 294, respectively) remained about the same as the past three years. The major decrease occurred in the number of termination physical examinations -- 106 compared to 296 in 1962. The improved system for scheduling examinations set up three years ago has resulted in a more regulated and productive program. The trend of the physical examinations from 1959-1963 is shown in Figure 2.

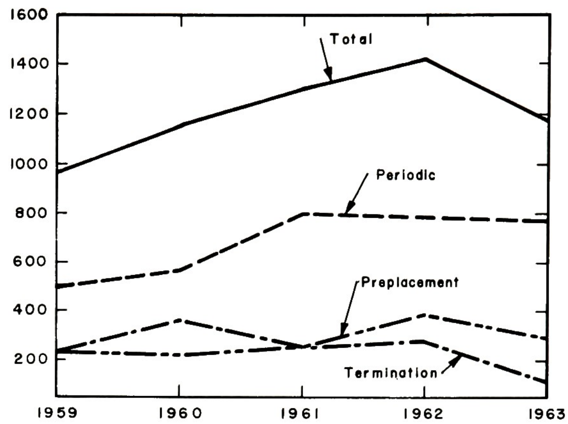

FIG. 2 PHYSICALS PERFORMED BY MEDICAL BRANCH, 1959 - 1963.

A limited study of findings on physical examinations performed for one operating contractor shows that a "significant" disease was recorded on 22 percent of persons examined. Approximately one out of four of these conditions was unknown prior to the examination. The more frequent conditions recorded were hernias, high blood pressure, heart conditions, peptic ulcers, and marked obesity.

Table II tabulates the work restrictions resulting from the physical examination program. It is interesting that some type of work restriction is recommended for about three persons out of every ten examined. A very large proportion of these restrictions results from vision defects sufficiently severe to require corrective lenses. Color vision deficiences, although of relatively high frequency in males, seldom justify work restrictions and are not included since determinations of shades of color are not a requirement for most jobs, and recognition of basic colors is usually adequate in the color blind individual. The recorded restrictions were imposed only when it was felt to have a direct bearing on the invididual's job performance and safety. Only four individuals were disqualified on preplacement examinations; two of these were later employed after corrective measures were taken.

3.4 X-Ray and Laboratory Studies

The X-ray examinations done at the CFA Dispensary have remained almost constant for the past five years, as shown in Figure 3. A total of 19 new or previously unsuspected diagnoses were established on 1550 routine chest X-rays -- a 1.2 percent rate of discovery. The most frequent new diagnoses were pneumonia, bronchitis or bronchiectasis, and cardiac enlargement. In addition, there also were 81 previously diagnosed conditions noted on these chest X-rays.

The total of 11,148 laboratory procedures performed in 1963 was a slight increase over the previous work (Figure 3). Several procedures were added to the laboratory capability including transaminase tests for diagnosis of certain liver and heart conditions, and bacteriological testing of water samples. The latter tests were previously done at the state public health laboratory. The increased convenience and speed of analysis justified the establishment of these laboratory procedures.

Of a total of 258 electrocardiograms performed in 1963, there were abnormalities on 51 tracings. The selection of patients age 40 or older, or those with contributory conditions, such as high blood pressure or marked over-

TABLE II

WORK RESTRICTIONS ON 1018 PHYSICAL EXAMINATIONS

		Preplacement	Periodic
Total Examinations Studied		257	761
Disqualified from Employment until treated		4	---
Work Restrictions (No. of Individuals)		73	233
Restriction	**Reason**		
1. Corrective lenses at all times	Vision 20/50 or worse	44	106
2. Corrective lenses for close work	Vision 14/20 or worse	7	62
3. Safety Glasses in work area	Industrial blindness in one eye	5	15
4. Lifting restrictions to 25 or 50 lbs.	a. inguinal hernia	1	7
	b. recurrent lumbosacral strain	3	12
	c. herniated intervertebral disc	2	14
	d. chronic backaches	0	1
5. No high noise level area work	Hearing loss more than 10%	2	17
6. No high radiation areas	a. history of deep X-ray therapy	0	1
	b. posterior subcapsular cataracts	0	1
7. Sedentary work only	a. coronary heart disease	0	5
	b. rheumatic heart disease	2	5
8. Avoid pulmonary irritants	a. asthma	1	1
	b. chronic bronchitis, emphysema, silicosis	0	3
9. Avoid skin irritants, solvents	a. eczema, contact dermatitis	3	6
10. Others (Limited walking, no work alone, no work around machinery, etc)		3	4

weight, may account for this high incidence of abnormality (20 percent). One-third of the abnormalities detected were due to coronary heart disease.

4. FUTURE PROGRAMS

4.1 Physical Examination Program

The construction workers at the NRTS are not presently included in the physical examination program. In 1963, several preliminary meetings with cost-type construction contractors explored the problems involved in setting up a

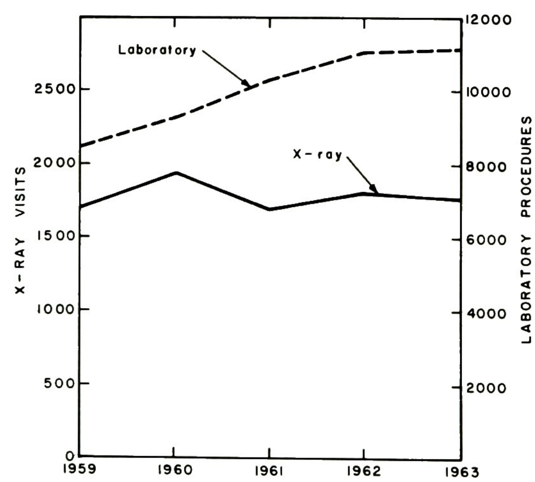

FIG. 3 CFA DISPENSARY X-RAY VISITS AND LAB PROCEDURES, 1959 – 1963.

physical examination program on personnel who work around hazardous materials, including radiation. This program will be instituted during 1964.

4.2 Medical Laboratory and X-Ray Trailer

During 1963, initial plans were made toward construction of a truck-van which would contain equipment for taking chest X-rays and gamma whole-body counts. The van would be used at the plant dispensaries on a regular schedule. In this program, each worker in a radiation area would be scheduled for an annual blood count, urinalysis, chest X-ray, and whole-body count at his work area. At the present time such examinations involve transportation of each worker from 5 to 70 miles for examination during productive work hours. The savings in time and transportation should reduce the cost of these health examinations substantially, in addition to increasing the scope of the chest X-ray and whole-body counting programs.

5. PUBLICATIONS

1. "The Psychological Effects of Disasters", G. L. Voelz, M. D. Presented to ID Radiological Assistance Team and ID Emergency Cadre, March 1963.

2. "Emergency Planning for Persons Contaminated with Radioactive Materials", G. L. Voelz, M. D. Presented at American Industrial Hygiene Assn., Cincinnati, Ohio, May 6-10, 1963.

3. "What an Industrial Nurse Should Know about Radiation", G. L. Voelz, M. D. Presented at NW Association of Occupational Medicine, Portland, Oregon, September 8, 1963.

4. "Reactor Accidents", G. L. Voelz, M. D. Presented to USPHS course on Medical Management in Radiation Emergencies, Las Vegas, Nevada, September 27, 1963.

5. "Special Slit Lamp Eye Examinations in the Atomic Energy Industry", G. L. Voelz, M. D. Presented at Annual AEC Health Personnel Meeting, Idaho Falls, Idaho, November 7, 1963.

6. "Medical Management of Contaminated Personnel with Wounds or Persons Internally Contaminated", G. L. Voelz, M. D. Presented at Symposium on Radiation Emergencies, Chicago, Illinois, December 19, 1963.

III. DOSIMETRY
(F. V. Cipperley, Branch Chief)

1. SCOPE

The major objectives of the Dosimetry Branch are to supply radiation dosimetry film badge service to the NRTS, keep complete records of exposure doses, provide consulting service to contractors on dosimetry problems, and perform research to improve the monitoring system. In 1963, these services were provided for 18 prime contractors in 22 different geographical locations. Coverage for more than 7000 regular employees was provided and more than 140,000 beta-gamma films were processed.

During 1963, the ID designed and constructed automatic film reader, discussed in the 1962 Annual Progress Report, was utilized in conjunction with 1620 computer programs for energy determinations and dose evaluation. The only significant operational difficulties experienced were a result of the malfunctioning of commercially acquired power supplies and digital voltmeter, and variations in the size of the film supplied in the duPont type 558 film packets.

A considerable amount of time and effort was expended in a study of the advantages and/or disadvantages of converting a strictly random access-type operation, such as the personnel metering program, to a form compatible with a sequential-type computer, such as the IBM 7040, in order to utilize a computer center. Also studied was the practicability of storage of radiation exposure histories and other records on magnetic disk files, suitable for 1620 computer analysis, to achieve more complete automation with increased efficiency and lower cost. These studies are continuing and some reportable results should be forthcoming during 1964.

2. SUMMARY RADIATION EXPOSURE STATISTICS

2.1 Dose Frequency Distribution -- 1963

The frequency distribution of total annual individual radiation exposures received at the NRTS during 1963 is presented in Table III. The data show that over 5800, or more than 81 percent of the total, received less than the recommended RPG of 0.5 rem for the general population, and none exceeded the recommended RPG of 5.0 rem per year for radiation workers.

2.2 Dose Frequency Distribution -- 1951-1963

The exposure histories of individuals regularly assigned to the NRTS have been analyzed on an integrated NRTS-to-date basis, and the frequency of occurrence of exposure in each of a number of ranges has been determined.

As shown by Table IV, 12,572 out of 19,355 individuals, or 65 percent of the total, accumulated 200 mrem or less during the entire 13 years of record, while for the same period only 4.8 percent received over 5 rem, the RPG value for

TABLE III

TOTAL DOSE FREQUENCY DISTRIBUTION -- 1963
PENETRATING RADIATION (GAMMA + NEUTRON)

Range (rem)		No. of Persons
0 - 0.200		5176
0.201 - 0.400		624
0.401 - 0.600		352
0.601 - 0.800		188
0.801 - 1.000		144
1.001 - 1.500		244
1.501 - 2.000		134
2.001 - 5.000		276
> 5.000		0
	Total	7138

one year. The tabular data present the actual numbers of people whose accumulated penetrating radiation exposures for the periods 1951-1962 and 1951-1963, respectively, fell in the indicated exposure ranges. To obtain uniformity of reporting, some consolidation of the 1962 data was necessary.

The range of the ten highest integrated NRTS exposures for the period ending 12-30-62 was from 25.3 to 38.5 rem, and for the period ending 12-31-63, was 27.5 to 38.6 rem. All reported data are penetrating radiation exposures (gamma plus neutron).

3. PROJECTS

3.1 Improvement of the Environmental Film Badge

Since 1958 a modified version of the NRTS personnel film badge (Figure 4 A) has been used to determine environmental radiation levels on and near the NRTS. The purpose of the system is to determine radiation levels due to releases and to record the cloud path. Meteorological measurements permit dose calculations and hazard estimates. This monitoring also is used for operational control at the NRTS radioactive waste burial grounds.

One of the problems in environmental monitoring is the extreme weather conditions that are experienced by the device. Questionable data from film due to moisture combined with extreme temperatures led to a program to improve the film badge design and the system of monitoring.

TABLE IV

TOTAL DOSE FREQUENCY DISTRIBUTION,
1951 - 1963 PENETRATING RADIATION (GAMMA + NEUTRON)

	Number of Persons		
Range (rem)	1951 - 1962	1951 - 1963	
0 - 0.200		12,572	
0.201 - 0.400		1975	
0.401 - 0.600		901	
0.601 - 0.800		556	
0.801 - 1.000	14,625	365	(16,369)
1.001 - 1.500		599	
1.501 - 2.000	871	396	(995)
2.001 - 5.000	939	1033	
5.001 - 7.500		319	
7.501 -10.000		215	
10.001 -12.000	633	125	(659)
12.001 -15.000		135	
15.001 -20.000	194	114	(249)
20.001 -30.000	39	45	
>30.000	5	5	
Total	17,306	19,355	

From past experience, the gamma contribution to the total exposure received by the film was known to be much greater than any beta contribution. Also, most of the effluents at the NRTS are principally short-lived gamma emitters.

A clear plastic badge (Figure 4 B) was designed and fabricated. The film chosen for inclusion was a prenumbered packet containing sensitive and insensitive film, with a 0.7-mil-thick lead strip wrapped over one end. The packet was wax-dipped to provide additional moisture-proofing. Laboratory and field tests of this badge indicated one particular fault. The paper wrap over the film had a tendency to loosen due to the combined effects of the wax on the wrapper seal and the mechanical action of wind whipping the badge against the supporting post. This caused light leaks along the lower edge of the film near the lead filter strip. To overcome this problem the lead strip was placed at the top of the film packet and the wax coating was eliminated. The color of the plastic material was changed to a dark red to absorb the visible spectrum from approximately 650 mμ into the ultraviolet region.

Again, laboratory and field tests indicated discrepancies in density-exposure information. These were found to be from moisture sealed within the badges during assembly. The badges were being fabricated by a commercial supplier in an environment which has an average year-round relative humidity of 76 $\pm$ 6 percent. Therefore, a small flat bag of dessicant silica gel was sealed within the badge during assembly. This final design (Figure 4 C) proved very satisfactory, providing an overall reliability of density-exposure results of approximately 99 percent.

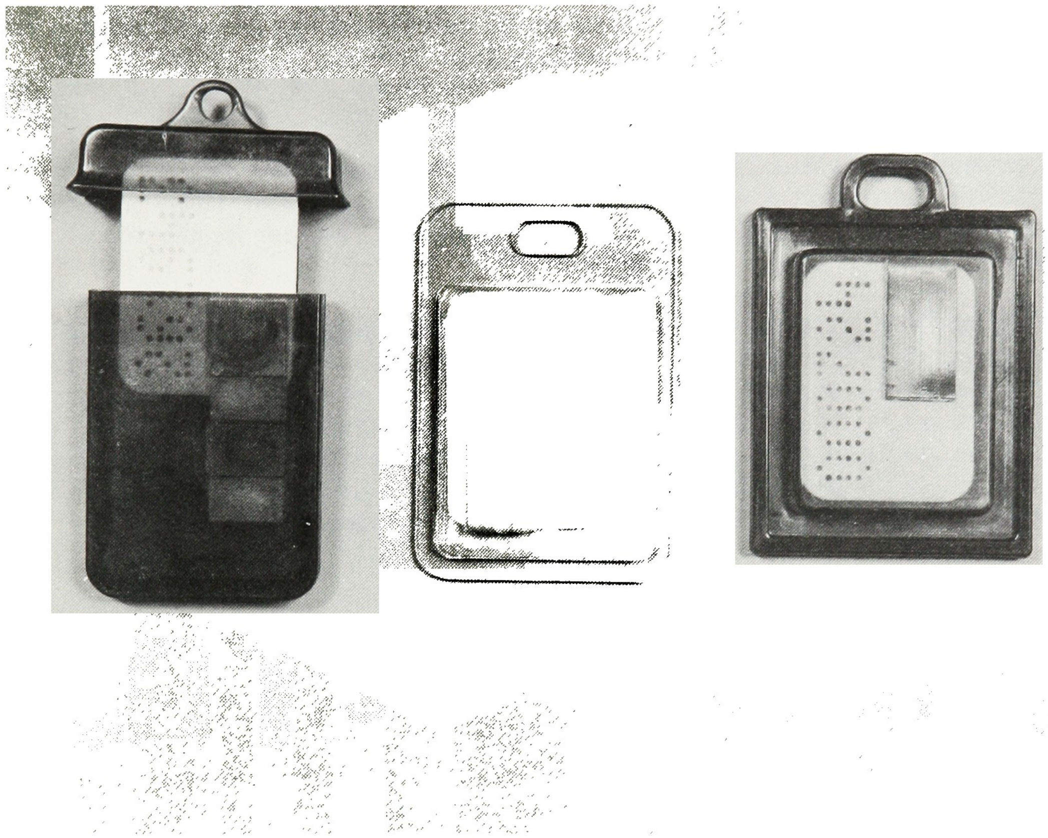

FIG. 4 NRTS ENVIRONMENTAL FILM BADGE, DEVELOPMENTAL STAGES.

3.2 The Personnel Metering Standard Man Phantom in the Spert I Destructive Test

A program similar to that of the previous year was carried out in connection with the second Spert I Destructive Test. Details of the test are presented in Appendix C of this report. Results of this study showed that previously determined dose ratios were substantiated and that reliable information could be obtained from a criticality source by using film dosimeters.

3.3 Latent Image Fading

Due to a completed study on latent image fading in personnel neutron monitoring film, most of the badge changes are now on a four week schedule. The limiting factor had been the possibility of fading, but the study results indicated that even over a period of more than four weeks this effect was still negligible.

3.4 Data Reduction

The computer program for data reduction of film badge information was improved through a reevaluation of calibration data. An average of five beta and gamma calibrations is used to derive the coefficients for dose calculation with each batch of film processed. Also, the beta evaluation was further improved through a comparison with a soft gamma spectrum to separate the components. This allows a value of exposure dose to be calculated for the soft gamma and added to the previous hard gamma determination.

3.5 Solid-State Systems for Radiation Dosimetry

An extensive literature search was accomplished during the year to determine the feasibility of using silver-activated metaphosphate glass, lithium fluoride, calcium fluoride, and calcium sulfate systems as personnel monitoring dosimeters.

While each of these radiophotoluminescent and thermoluminescent solid-state systems appears to have some operational and economic advantages over existing dosimeters for personnel monitoring, none meets the ideal dosimetry requirements nor the particular NRTS personnel monitoring criteria. Consequently, no dosimetry program change is contemplated at present. Developments in solid-state dosimetry technology in the near future may indicate a need for reevaluation of the NRTS personnel dosimetry program.

4. FUTURE PROGRAMS

4.1 Nonlinear Energy Density Effects on Film

An investigation will begin on the nonlinear energy density effects on personnel monitoring film to arrive at a more accurate and suitable method of radiation exposure determination. This will consist mainly of a study of various filter materials that might enhance the nonlinear characteristics.

4.2 Emulsion Track Counting

A revamping of the nuclear emulsion track counting procedures in the present system of neutron dosimetry is planned in conjunction with the development of a system using either tilt-table continuous scanning, microscope projection techniques, or a combination of both systems.

4.3 Mixed Radiation Dosimetry

During 1963 preliminary experiments were performed to study the density effect on duPont 508 film of thermal neutrons in the presence of gamma, beta, and fast neutrons. The problem of gamma fogging on neutron film has not been resolved. These studies will continue.

4.4 Backscatter Effects

Exploratory studies were begun in 1963, and are continuing, to determine "backscatter effect" using tissue-equivalent solution and other absorbing materials in a standard phantom and other geometrical shapes and orienting film badges at various angles with respect to source. These studies are aiding in the interpretation of data from reactor destructive tests now in progress at NRTS.

4.5 Long-Term Storage Effects

The study of long-term storage aging effects on processed dosimetry film at the NRTS was begun during the year. No conclusive results have been obtained to date. The study is continuing.

5. PUBLICATION

Latent Image Fading in Personal Neutron Monitoring Film at the NRTS, John P. Cusimano, IDO-12031, April 1963.

IV. ANALYTICAL CHEMISTRY
(Claude W. Sill, Branch Chief)

1. SCOPE

The Analytical Chemistry Branch maintains and operates a general purpose analytical laboratory from which all AEC and contractor personnel at the NRTS may obtain analyses of any chemical or radioactive material that may be required. The principal effort is directed toward determination of toxic or radioactive materials which could affect the health and safety of personnel working at the NRTS or of people who live in the surrounding communities.

2. RADIOCHEMICAL METHODS DEVELOPMENT

2.1 Precipitation of Submicrogram Quantities of Thorium by Barium Sulfate

Investigation of the use of barium sulfate for separation of submicrogram quantities of thorium prior to its fluorometric determination with morin has been completed. Bismuth and the rare earths are the only elements interfering seriously with the separation by barium sulfate. Surprisingly, the extent of interference by these elements is decreased markedly by having potassium ions present and by adding barium ions before the pyrosulfate fusion is made. Accordingly, the interference tests made last year on most of the elements of the periodic table had to be repeated with and without potassium and with the barium added both before and after the fusion to determine the extent of interference for each element under each set of conditions. In addition, optimum conditions were determined for decontamination from zirconium, for dissolution of the barium sulfate formed in the procedure, and to minimize error from a trace of platinum dissolved during the fusion of ores in a platinum dish. The final procedure also was applied to rare earth materials as well as to ores and biological samples and is probably the most sensitive, precise, and reliable procedure presently available for natural thorium. Standard samples from both the USGS and the New Brunswick Laboratory of the USAEC were analyzed to determine "best values" numbers for these standards. The procedure was accepted for publication in the March 1964 issue of Analytical Chemistry.

2.2 Precipitation of Submicrogram Quantities of Cerium by Barium Sulfate

During the above investigation of the precipitation of thorium by barium sulfate, cerium was found to be precipitated to better than 99.8 percent from either valence state up to about 1 mg of cerium. An investigation to determine the analytical utility of this reaction was completed. The results show that cerium reacts in a manner almost identical to thorium. Presence of potassium ions and addition of barium before the pyrosulfate fusion are of paramount importance in minimizing the effect of other elements on the recovery of cerium. As a separations method, precipitation of cerium by barium sulfate is very efficient, precise, and thoroughly reliable as well as being rapid and convenient. However, since the principal application of the method was intended to be the determination of radiocerium in fission products, the barium sulfate must be dissolved in an alkaline solution of diethylenetriaminepentaacetic acid. Cerium is then precipitated as the peroxide to separate it from other interfering fission products that also are carried efficiently in small quantities on barium sulfate, particularly, barium-140, lanthanum-140, and the rare earths. In the presence of cerium, lanthanum, and zirconium carriers, more than 99 percent of the cerium can be separated from all other fission products with a decontamination factor of at least 10^3 in the worst case. The procedure works very well on mixed fission products one day, one month, and one year old, is relatively rapid, and requires little personal attention or skill on the part of the analyst.

2.3 Preparation and Use of Carrier-Free Thorium-234 Tracer

The preparation of thorium-234 tracer from natural uranium on a fairly large scale has been achieved. One pound of reagent grade uranyl nitrate was converted to the chloride form and absorbed from 9.6 M hydrochloric acid on a Dowex-1 anion exchange resin column, 132 cm long and 5 cm in diameter. The thorium-234, daughter of the uranium-238, passed through the resin unabsorbed. The effluent is evaporated and thorium separated from the lead impurities in the uranyl nitrate. Otherwise, if the tracer were used in a sulfate system, the lead sulfate produced would precipitate most of the tracer and interfere seriously with the research being carried out. Most importantly, it was shown that thorium-234 can be gamma counted in a three-inch thallium-activated sodium iodide well crystal, rather than having to resort to the more tedious and exacting methods of counting either the very weak (0.19 MeV) beta emission of the thorium itself or the 2.3-MeV beta emission from the 1.18-minute protoactinium-234 (UX_2) daughter through an aluminum absorber. Approximately 2 x 10^7 gamma counts per minute can be obtained from one pound of uranyl nitrate hexahydrate containing an equilibrium quantity of thorium-234. Half this quantity can be obtained every 24 days. Thus, an inexhaustible supply of thorium tracer can be readily obtained from common laboratory materials. The procedure has been accepted for publication in the March 1964 issue of Analytical Chemistry.

2.4 Determination of Thorium-230

A tentative procedure for the determination of thorium-230 in solid samples has been developed. The method was devised to fit into an existing procedure for natural uranium and radium-226 and, thus, permit the simultaneous determination of all three nuclides in a single sample. Radium and thorium were precipitated with the insoluble sulfates of barium and lead, the uranium remaining in the aqueous solution. The sulfates were dissolved in an alkaline solution of DTPA-TEA, and radium and barium were reprecipitated by addition of acetic acid. Thorium and lead were not precipitated as sulfates from a weakly-acidic solution containing DTPA. However, on addition of excess sulfuric acid to the acetic acid filtrate, lead sulfate was precipitated quantitatively, carrying with it the thorium-230. The thorium was subsequently separated from the lead sulfate by carrying on lanthanum hydroxide. When rare earth elements were not present in appreciable quantities, the thorium was alpha counted in the presence of the small amount of lanthanum carrier. When necessary, the thorium was separated from rare earths by extraction into TTA and then alpha counted. The analysis of a single sample for thorium-230 required less than one man-day.

The procedure has been successfully applied to a variety of mill tailings, sludge, and soil samples. However, rigorous studies relating to sensitivity and interferences have yet to be made. Further work will be undertaken in an attempt to modify the procedure to include the determination of lead-210 and to make it applicable to liquid samples of widely varying composition.

2.5 Chemistry of the Actinides

2.51 Plutonium. The growing use of plutonium at the NRTS has increased the need for adequate personnel and environmental monitoring for this element. A study was made on the existing method for the analysis of plutonium in urine wherein the concentrations of hydrochloric acid and the liquid amine (LA-1) used as the extractant were varied. Plutonium was extracted quantitatively from 6 to 12 M hydrochloric acid and from 10 to 35 percent (v/v) LA-1 in AMSCO. The concentration of amine chosen for use was 15 percent, at which concentration the plutonium also can be back extracted quantitatively by reduction to the trivalent state. The percentage of certain nuclides not removed in the separation are as follows: Th-234, 0.1 percent; Pa-233, 0.1 percent; U-233, 0.3 percent; Np-237, 93 percent; Am-241, 0.7 percent; Cm-244, 0.2 percent; and Ra-226, 0.1 percent.

A method has been developed for the analysis of plutonium in feces by wet ashing the sample with nitric acid and hydrogen peroxide. After treating the residue with 2 N nitric acid, any remaining insoluble material was filtered off, fused with sodium pyrosulfate, and added to the main filtrate. The plutonium was reduced to the tri- or tetravalent state and separated from the bulk of the salts by precipitation as the fluoride with a rare earth carrier. The precipitate was dissolved and tetravalent plutonium extracted into a solution of thenoyltrifluoroacetone (TTA) in xylene. The plutonium was back extracted into 8 M nitric acid, dried on a planchet, and alpha counted.

2.52 Americium. A tentative method has been developed for the determination of Am-241. Americium was carried on a rare-earth fluoride precipitate and extracted as the thiocyanate complex with a quaternary amine. Any extracted carrier was scrubbed off with thiocyanate and the americium back extracted with concentrated hydrochloric acid and alpha counted.

3. WHOLE-BODY COUNTING

The counting program during 1963 has again emphasized the need for whole-body counting to detect certain internal contaminants in human beings. To date, 31 different nuclides have been identified in the program, with Mo-Tc-99, Te-I-132, I-133, and Hg-197 having been seen in humans for the first time. Experience to date indicates that a large part of the internal contaminants are due to inhalation of insoluble particulates. These materials are not metabolized and, therefore, urinalysis is inadequate as a body monitor.

3.1 Internal Emitter Identification

Considering convenience, sensitivity, time, and reliability, whole-body counting is the select personnel monitor for internal radioactivity from gamma-emitting nuclides. A summary of the nuclides identified (excluding K-40), the number of times seen, and the number of different individuals involved from January 1961 through March 17, 1964, is given in Table V.

TABLE V

SUMMARY STATISTICS FROM THE WHOLE-BODY COUNTING PROGRAM

Radionuclide	Times Reported	Number of Individuals	Maximum Activity (μc)
Cr-51	15	10	1.2
Co-60 and/or Fe-59	848	387	1.5
Mn-54	98	51	0.16
Co-58	62	50	0.03
Zn-65	505	171	1.20
Zr-Nb-95	427	232	1.66
Ru-103-106	93	75	0.22
Ag-110	583	186	0.93
Sb-122	2	2	0.08
I-131	110	82	5.0
Cs-134	361	168	0.14
Cs-137	2332	573	1.32
Ba-La-140	90	51	0.07
Ce-141-144	59	49	0.16
Ta-182	50	36	0.02
Hg-203	28	6	0.16
Pa-233	13	10	0.48
Np-239	1	1	1.68
Sb-125	3	3	0.1
Mo-Tc-99	8	5	0.72
I-132	8	7	< 0.1
I-133	3	3	< 0.1
Te-132	6	6	< 0.1
Hg-197	7	3	0.7

3.2 Effective Half-Lives of Radionuclides in Program

The effective half-lives of radionuclides found in the NRTS whole-body counting program have been markedly different in most cases from those recommended by the International Commission on Radiological Protection (ICRP). Undoubtedly, the difference is caused by the insoluble particulates present in this study rather than soluble materials. These values are tabulated below. The variability of the values found is most significant.

Nuclide	Effective Half-Life (days) Present	ICRP
Cs-137	90 - 281	70 (total body) 138 (muscle)
Ag-110m	8 - 69	4.9
Co-60	70 - 730	9.5
Zn-65	85 - 134	194
Mn-54	64	5.6
Hg-203	25	8.2
Hg-197	2	2.1
Mo-Tc-99	1	1.8

3.3 Portable Whole-Body Counter Development

To increase the utility of the whole-body counter concept for internal dosimetry, a portable system was developed by the ID Health and Safety Laboratory for field use at the NRTS. Details and photographs of this unit are presented in Appendix B of this report.

3.4 Internal Contaminant Case Histories

3.41 Ag-110. During the operation of the ML-1 reactor a number of individuals was inadvertently exposed to Ag-110. The highest body burden measured was 0.17 μc. Two individuals having the highest body burdens were used to determine the mode of elimination from the body. After each 24-hour period, a whole-body count was given and the excreta analyzed. Results showed that there was no activity present in the urine but activity was found in the feces, which indicated insoluble particulates.

3.42 Cs-137. Seven men who had worked in the uranium mining and milling operation at Grants, New Mexico, were employed at the NRTS. A whole-body count, given them at the time of employment, revealed that the body burden of Cs-137 was about 50 percent of that found in the resident of southeastern Idaho.

3.43 Mo-Tc-99. Two individuals were contaminated with fission products including Mo-Tc-99 while working in the Test Reactor Area. The largest body burden was 0.72 μc Mo-Tc-99, with some minor amounts of other isotopes. Mo-Tc-99 was eliminated in both urine and feces, while Cr-51 was found only in the feces.

3.44 Hg-197. Hg-197 was detected in an individual from a routine whole-body count. The person was exposed to Hg vapors released from an adjacent experiment while working in a laboratory. The mode of elimination was both by way of the urine and feces and followed the same excretion ratio (approximately 1:1) as a previous case involving Hg-203.

3.45 Co-60/Fe-59. Co-60 and/or Fe-59 are two of the isotopes which are seen routinely in the workers at the NRTS. An employee was exposed while working on a cask used for the shipment of spent fuel elements. The employee was wearing a respirator but admits having talked to several individuals, which necessitated its momentary removal. The initial body burden was calculated to be 1.5 μc. All excreta were collected covering the three-day period before the next whole-body count. Activity was identified in both the urine and feces, with that in the feces predominating. This was the first time Co-60 and/or Fe-59 had been detected in the urine. The body burden dropped from 1.5 to 0.21 μc in the three-day, flushing-out period, and has remained nearly constant since that time. About ten days after the initial exposure, a rectilinear scan of the body was made which showed the activity to be distributed deep in the lungs.

4. RADIOMETRIC DEVELOPMENTS

4.1 Alpha and Gamma Spectrometry

Analytical methods utilizing gamma and alpha spectrometry have been improved during the past year. A new analyzer system was put into operation including a resolver-integrator unit which is used for spectrum stripping. Complicated spectra can now be analyzed without resorting to the high speed computer techniques or manual methods previously used for spectrum stripping. The resolver unit is especially useful for obtaining the rapid analyses required for special samples which may involve only a single determination. Both qualitative and quantitative results may be obtained by use of standard spectra stored on punched tape.

Complete automation is now feasible for the analysis of radioactive samples by gamma spectrometry. Computer programs for processing gamma ray spectra have been greatly improved so that data reduction may be performed by the computer in a small fraction of the time previously required for multiple radionuclide determinations. The cost of computer time is no longer prohibitive. Successful trials have been carried out involving automatic output of spectra on punched tape from the analyzer system by use of an automatic sample changer. A proposal has been submitted to the Instrumentation Branch for design of an automatic changer to be used for automatic transfer of samples into and out of the conventional spectrometer vaults.

A thin-crystal scintillation detector has been used to determine relatively low gamma and X-ray energies. This type of detector is transparent to the higher gamma energy so that the lower region of the spectrum is more clearly defined. Energies have been determined for Tm-170, Pu-239, and Pu-240 by use of this thin-crystal detector.

Sb-125 and Mn-54 were identified in wheat products by gamma spectrometry. These radionuclides had not been identified previously in environmental samples. Gamma spectrometry also was used as the method of analysis for samples collected at the time of the second Spert Destruct Test. The specific gamma-emitting radionuclides released to the environment were determined by this method. Also included were samples of reactor water, neutron activation products, and dosimeter components.

With the addition of a low noise biased amplifier and new solid-state detectors, the Branch is now capable of resolving alpha spectra with only 20-keV separation between energies.

4.2 Activation Analysis

An activation program was established to irradiate samples in the VG and VH facilities at the MTR. Twenty-three samples were irradiated during the last quarter of the year. The majority of these irradiations were made for the Weather Bureau to determine the practicality of using irradiated particles for atmospheric dispersion studies. Stable salts of manganese and copper were disseminated, collected on air filters, and activated. Prompt and delayed gamma-ray analysis of the activated samples gave quantitative data about tracer materials on the filters. Also, radioactive tracers and fission products were prepared by activating stable isotopes and fissionable material.

5. MISCELLANEOUS ACTIVITIES

5.1 Collaborative Survey on Analytical Procedure for Beryllium

At the request of the American Conference of Governmental Industrial Hygienists (ACGIH), a procedure was selected for the fluorometric determination of beryllium to be checked out to determine its suitability to become the official procedure of the ACGIH. Five samples containing known quantities of beryllium were carefully prepared to demonstrate the sensitivity, linearity, precision, reliability, and freedom from interferences of the selected procedure and submitted to thirteen collaborating laboratories for analysis. The laboratories represent industrial, state, and federal organizations. Initial results indicate that existing commercially-available fluorophotometers are not adequate to check the ultimate precision and sensitivity of which the procedure is capable.

5.2 Radiation Dosimetry

A syllabus of procedures used in the calculations of internal dose for various organs and nuclides was prepared for use as a training aid. A considerable amount of time also was spent in furthering the Branch's capability in this field.

A brief survey of solid-state dosimeters indicated that radiophotoluminescence of silver-activated phosphate glass and thermoluminescence of calcium fluoride or lithium fluoride all show many of the characteristics desirable for dosimetry systems. Further evaluation will be necessary to determine their applicability to personnel monitoring and nuclear accident dosimetry.

5.3 Routine Analyses

A numerical summary of routine analyses performed during the year is given in Table VI.

TABLE VI

SUMMARY OF ROUTINE ANALYSES

Biological Samples (urine, feces)	9254
Water Samples (potable, effluents)	4021
Biological Samples (milk, animal, vegetation)	1628
Air Dusts (carbon cartridges, filters)	3853
Mill Samples (air dusts, effluents)	122
Miscellaneous (liquids, Spert samples)	337
Whole-Body Analyses:	
(a) Body counts	1035
(b) Scans	1859

6. FUTURE PROGRAMS

6.1 Flavones as Fluorometric Reagents

Very little headway was made during 1963 on the program outlined in a previous report for screening approximately 30 synthetic and naturally-occurring flavones as fluorometric and spectrophotometric methods for the determination of ultra-micro quantities of various elements. This work is now underway and a procedure has been established to allow rapid testing of each flavone against approximately 40 elements of the periodic table under a wide variety of conditions such as acidity, complexing agents, extractability, etc. Those reactions showing promise will then be investigated in detail.

6.2 Mobile Whole-Body Counter

As a further development of the portable whole-body counter concept (see Appendix B of this report), a mobile facility will be built in a small van so that it can be moved to the various reactor areas requiring whole-body counting service on a routine basis. By taking the counter to the areas, whole-body counting coverage can be increased significantly for the same cost by reducing the working time lost while the subjects are going to and from a counting facility located some distance from their work area. The van-mounted mobile counter will permit relatively more shielding to be used than with the portable counter and can still be handled by female technicians and nurses. The additional shielding is particularly desirable in an instrument designed to be taken to reactor areas where the increased backgrounds would otherwise cause an undesirable decrease in sensitivity.

6.3 Transuranium Elements

A recent plutonium contamination incident pointed out a significant deficiency in most available analytical procedures for this element. They are generally too time consuming to generate analytical data fast enough to permit early decision on the advisability of corrective medical action and/or administrative control. Considerable emphasis will be placed on attempts to shorten the analytical procedures without sacrifice of adequate sensitivity and precision.

6.4 Improved Tritium Sensitivity

To follow underground water flow for operational purposes, it will be necessary to seek for further sensitivity in the analytical procedures for tritium in water.

7. PUBLICATIONS

1. "Precipitation of Submicrogram Quantities of Thorium by Barium Sulfate and Application to Fluorometric Determination of Thorium in Mineralogical and Biological Samples", by Claude W. Sill and Conrad P. Willis, Analytical Chemistry, Vol. 36, No. 3, p 622, March 1964.

2. "Preparation of Carrier-Free, Thorium-234 Tracer", by Claude W. Sill, Analytical Chemistry, Vol. 36, No. 3, p 675, March 1964.

V. HAZARDS CONTROL
(Denver H. Dierks, Branch Chief)

1. SCOPE

The ID Hazards Control Branch employs the specialties of Safety Engineering, Fire Protection Engineering, Fire Protection Services, Industrial Hygiene Engineering, and Health Physics in its program of control of hazardous conditions at the NRTS. In addition to its safety functions in ID-AEC direct activities, the Branch conducts safety program appraisals of ID contractors. Also, the Branch maintains health and safety liaison service for NRTS-wide construction and operating activities through its working contacts with safety specialists of all AEC Field Offices at the NRTS. Through consultation and appraisal activities, the sponsoring of formal quarterly meetings of all NRTS safety engineers, and publishing Standard Health and Safety Requirements (ID Manual Appendix 0500-1), Safety and Fire Protection Design Criteria Manual (IDO-12008), and periodic Health and Safety information bulletins, the Hazards Control Branch provides leadership in meeting AEC standards and promulgating an effective program.

2. SAFETY ENGINEERING
(Neil C. Harker, Safety Engineer)

The primary functions of the ID Safety Engineers are: the appraisal of contractor safety activities through review, evaluation and recommendations; design-specification review of proposed new construction and modification of existing facilities; accident investigation; establishing and interpreting minimum acceptable codes and standards; collection, analysis, and evaluation of accident experience data; and consultation on special safety problems and activities.

2.1 Disabling Injury Experience

2.11 Frequency. Figure 5 presents the total NRTS disabling injury frequency history in comparison with all AEC activities and with the chemical industry, for the same period. The sharp drop in the NRTS disabling injury frequency from 1962 (1.78) to 1963 (0.68) represents a reduction of disabling injuries from 18 to 7, with about 10.2 million manhours worked in both years.

The 1963 disabling injury frequency for ID and ID contractor activities was 0.14. This reflects one disabling injury during 7.3 million manhours worked, for the lowest frequency rate in ID history.

2.12 Severity. Comparison of the total NRTS severity rate, as presented in Figure 6, with all AEC activities and the chemical industry, reveals that 1963 had the third highest severity rate in the history of the NRTS. The NRTS rate was 2.7 times that for all AEC activities. This high severity rate was due primarily to a fatal fall on a construction project, resulting in 6000 days charged. The severity rate for ID and ID contractor activities during 1963 was 5. This is the lowest severity rate in ID history.

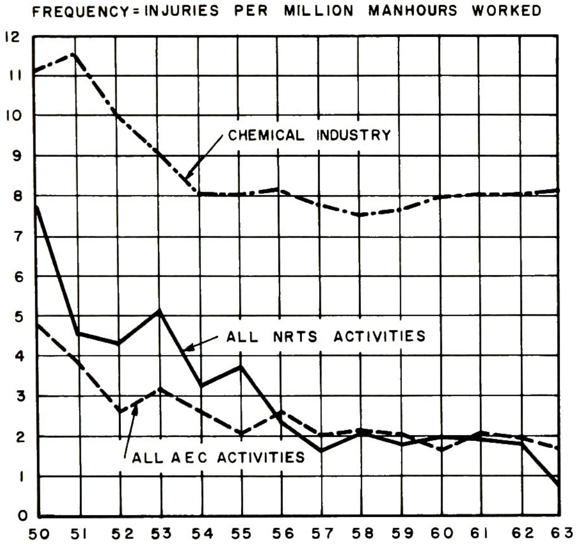

FIG. 5 NRTS DISABLING INJURY FREQUENCY RATE COMPARISONS.

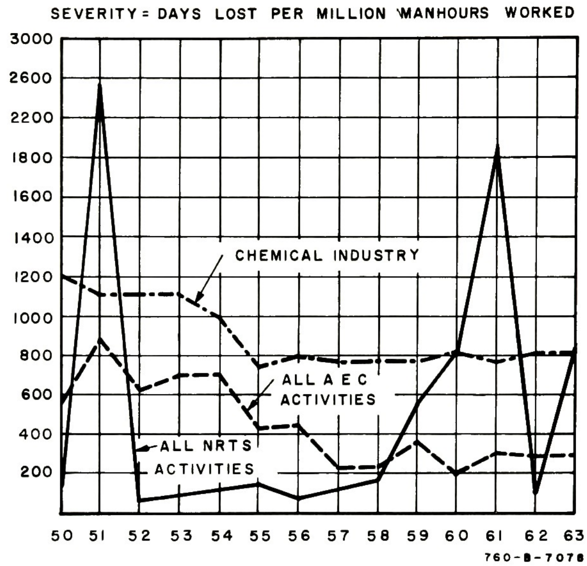

FIG. 6 NRTS INJURY SEVERITY COMPARISONS.

2.13 Summary NRTS Experience. During 1963, a milestone was passed at the NRTS. It is estimated that on October 8, 1963, the 100-millionth manhour was worked at the NRTS since its inception in 1949. During this period, there were 257 disabling injuries resulting in 60,439 man-days lost or charged. This results in an injury frequency of 2.57 per million manhours worked and a severity of 604 man-days per million manhours worked.

2.2 NRTS Motor Vehicle Accident Experience

Table VII shows that the government motor vehicle accident frequency (accident per million miles) and government loss per 1000 miles of travel are well below those for 1962 and below the 12-year average (1952-1963).

TABLE VII

NRTS GOVERNMENT MOTOR VEHICLE ACCIDENT EXPERIENCE

Period Covered	Miles Traveled	All Accidents	Frequency	Govt Loss	Govt Loss/ 1000 miles
1952-1963	83,314,371	696	8.35	$53,036	$0.64
1962	9,639,182	74	7.68	4,977	0.52
1963	9,425,983	62	6.58	4,147	0.44

There were no motor vehicle fatalities in 1963 and only one vehicle accident which necessitated hospitalization of vehicle occupants.

2.3 Property Damage Accidents

Five property damage accidents, exclusive of motor vehicle accidents and fires, occurred at the NRTS in 1963 resulting in $40,376 government loss. These statistics compare with those of property damage accidents in 1962 resulting in $23,135 government loss. Of the five property damage accidents occurring in 1963 one, an alpha contamination incident, contributed $26,076 (principally clean-up costs) of the total $40,376 government loss.

2.4 Awards

After appropriate record audit during 1963, safety awards for manhour accumulations without a disabling injury (shown in Table VIII) were authorized. In addition, the Phillips Petroleum Company, AED, was eligible to receive the AEC Award of Honor for exceeding 3.3 million manhours without a disabling injury as of the end of calendar year 1963.

TABLE VIII

SAFETY AWARDS FOR MANHOUR ACCUMULATIONS WITHOUT DISABLING INJURY

Company	Manhours	Period	Award Type
Fluor Corp., Ltd.	434,863	8/27/62 - 4/21/63	AEC Award of Merit
H. K. Ferguson	1,000,000	12/1/58 - 6/30/63	State Award
Phillips Petroleum Company, AED	2,500,000	12/5/62 - 7/10/63	AEC Award of Merit and State Award
Idaho Operations Office, USAEC	1,325,000	1/22/62 - 6/2/63	AEC Award of Merit and State Award
Fluor Corp., Ltd.	440,960	5/7/63 - 12/29/63	AEC Award of Merit
Argonne National Laboratory	2,000,000	5/3/56 - 12/31/62	State Award

2.5 Special Activities

2.51 Blasting Safety Study. The ID Hazards Control Branch specified the H. K. Ferguson blasting procedures on the ICPP Waste Storage Tank excavation, and coordinated a seismic study by an outside technical firm in connection with this blasting operation. The seismic study was undertaken because of the proximity of existing waste storage tanks, and it revealed that the shock waves produced by the blasting technique were well below levels necessary to produce plaster damage in ordinary structures.

2.52 Construction Safety Review. In conjunction with the ID Monthly Labor-Management meeting, a monthly safety review of one of the construction areas has been reestablished. These safety reviews are conducted by the ID Safety Engineer with representatives of labor and management. The results of these reviews are reported back to the Labor-Management group meeting for information and orientation.

2.53 Seat Belt Requirements. ID Announcement #162, restating seat belt use requirements for government vehicles, was issued. In addition, labels noting the mandatory use of seat belts were posted in all AEC vehicles equipped with seat belts.

2.54 Standard Health and Safety Requirements. The ID Standard Health and Safety Requirements manual was revised and updated. The new edition was published and issued as ID Manual Appendix 0500-1. All AEC operations offices having activities at the NRTS are using this issuance as a guide.

3. FIRE PROTECTION ENGINEERING
(Richard J. Beers, Fire Protection Engineer)

Fire protection engineering services were provided throughout the year without significant program changes. Fire protection engineering appraisals of all NRTS facilities were accomplished during the year, including assistance to other AEC facilities. Major fire protection improvements were made at several NRTS facilities. The newly acquired high expansion foam equipment was rigorously tested and information was obtained relative to improved operation of the equipment and to broader application of this unusual extinguishing agent. Fire protection design reviews and consulting services were provided at approximately the same rate as in previous years.

3.1 Fire Loss Experience

ID and NRTS fire loss experience in 1963 was lower than in 1962 and was less than half the preceding five-year average. The fire loss ratio was 0.039¢ per $100 property valuation. Had ID and NRTS fire losses occurred at the loss ratios experienced in all AEC Comparative (0.73 ¢/$100 valuation), in Improved Risk (2.8¢/$100 valuation), and in National Comparative (approximately 15 ¢/$100 valuation) areas, the property damage loss due to fire in 1963 would have been as indicated in Table IX.

3.2 Major Fire Protection Improvements

Fire protection recommendations contributed to the removal of the Library and Data Processing Sections from a combustible building at MTR to improved-risk-type quarters. A wooden office building at ICPP was vacated and surplused. Two gravity-feed oil tanks at MTR were removed from service. Two others were relocated outside ETR and placed underground. Fire doors and dampers were installed at indicated points at Spert II and at MTR facilities. A fire extinguishing system was installed at MTR Hot Cells. An addition, the MTR/ETR Maintenance Building was separated by a fire wall from the original building. Sprinkler systems were installed at the new CF-661 Storage Building and at CF-688. The new Phillips Petroleum Company Technical Services Center at CFA is predominantly noncombustible. Sprinkler systems and fire detection systems were installed at various buildings at NRF, and a water spray deluge system was installed at a cooling tower. At EBR-II a paint shop was relocated, a gravity feed oil system improved, floors of a power plant resurfaced with fire-resistive

TABLE IX

ID AND NRTS FIRE LOSS EXPERIENCE COMPARISONS

Year	NRTS Valuation	Actual ID & NRTS Loss [a]	AEC Comparative Loss	Improved Risk Comparative Loss	National Comparative Loss
1963	$458,320,000	$1,810 [b]	$33,457 [c]	$128,399 [c]	$687,480 [c]
5-yr ave 1958-62	341,180,000	4,600	28,400	94,000	512,000

[a] This includes only reportable losses in excess of $50 as per AEC Reporting Requirements.
[b] $85 of this loss occurred at an off-site ID facility, San Ramon.
[c] Computed on most recent 10-year average.

material, and a fire detection system extended to cover the Boiler Plant oil system and a new library addition.

3.3 Test Developments

3.31 High-Expansion Foam Test -- Injection Into High Bay Areas. In conjunction with reactor containment studies by Dr. Leslie Silverman of Harvard, a test was conducted in the EOCR Hydraulic Test Facility to determine the height to which high-expansion foam could be pumped and to evaluate the stability of the foam blanket. Using a standard 13,500 cfm foam truck and a mixture with double the normal stabilizer, foam was pumped into the above facility with a high bay area 72 feet in height. Due to improper formulation of the mixture resulting in wetter foam, a malfunction of the equipment occurred when the foam level reached a 51-foot height. Maximum settling of the foam blanket appeared to be about five feet per hour in the closed facility, with complete dissipation overnight. Other observations made during operation of the equipment led to minor modifications and to improvement of operating procedure. With proper mixture of formula, the foam column would have successfully filled the building. Insignificant quantities of liquid formed (in the discharge tube), indicating that foam will not impose a significant neutron moderating effect in criticality hazard areas. Cleanup was accomplished by dry-mopping the floor area.

3.32 New Portable Foam Generator. A 5000 cmf high-expansion foam generating unit was added to the NRTS fire-fighting equipment. The unit is light enough to be handled by two men and is readily transported in a pickup truck. Tests indicate superior control of foam proportioning and fan air speed with improved light foam discharge. This low-cost unit has greatly improved fire fighting capability at TAN.

3.33 High-Expansion Foam in Criticality Hazard Areas. Tests at NRTS and at other AEC facilities indicate there is no likely criticality hazard in the use of high-expansion foam due to its negligible hydrogen content and its inability to disturb arrangement of fuel units. Consequently, permission is being obtained for its use in many criticality hazard areas where water is prohibited.

4. FIRE PROTECTION SERVICES

(Austin M. Hess, Chief, Fire Department)

Professional fire protection services are provided at all areas at the NRTS by the Fire Department operated by ID-AEC. The Fire Department has four fire stations so located that response can be made to any area in less than ten minutes. Area plant fire brigades provide a manpower reserve to attack local fires quickly and to assist the Department in the event of major fires. Ambulance driver and first-aid services are provided by the Department. Fire brigade training, site-wide fire alarm system testing, inspection of built-in fire protection devices, and servicing all types of fire extinguishers round out the major services provided NRTS by the Fire Department.

4.1 Statistics

During calendar year 1963, the Fire Department responded to 72 fire alarms, 24 of which involved actual fires. Total fire losses at NRTS, including those of less than $50 property damage valuation, amounted to $1904. Causes of fire at the NRTS are shown in Table X.

TABLE X

FIRE CAUSES AT NRTS - 1963

Electrical Short	8
Liquid Sodium Spill	4
Trash	3
Cigarette	2
Overheated Stove	1
Overheated Head-bolt Heater	1
Lightning	1
Hot Exhaust Pipe (vehicle)	1
Tire Friction	1
Welding-Cutting	1
Undetermined	1
Total Fires	24

The following tabulation relates Fire Department recurring costs to property valuation at NRTS:

	1959	1960	1961	1962	1963
Property Valuation (millions of $)	321.8	337.6	363.8	423.1	458.3
Fire Dept. Costs (thousands of $)	314.9	308.6	349.7	374.3	386.3
Cost Ratio ($Cost/ million $ valuation)	979	914	961	885	843

The most comparable data for industrial property indicate that the average improved risk type firm currently spends $2470 per year for protection of each $1,000,000 of property valuation. Above figures show NRTS cost-to-valuation ratio at present to be only about one-third that amount.

4.2 New Fire Protection Equipment

During 1963, a 13,500 cfm high-expansion foam unit mounted on a one-ton truck chassis was integrated into the Department's mobile equipment. A 5000 cfm portable high-expansion foam unit was placed in service at TAN because of numerous water exclusion areas and for immediate first alarm response.

Considerable improvement in the utility of the Fire Department's drill field was accomplished by the addition of a six-inch water main extension with fire hydrant located near the fuel pits, by the addition of a standard type hose house for plant fire brigade training, by installation of a small metal storage building for housing pyrophoric metals, and by acquisition of a safety net complete with metal supporting stand for drill tower training activities.

4.3 Special Activities

Tactical exercises were conducted for the benefit of Fire Department officers. Fire-radiation problems at the NRTS facilities were posed under hypothetical conditions, with recommended action submitted individually in writing, followed by criticizing the exercise as a group.

All department personnel received procedural training by Health Physics Branch instructors for response to radioactive effluent alerts. This air-sampling, monitoring, and reporting instruction will increase the Department's capability for emergency support action if needed at the NRTS.

Under its mutual aid agreement with nearby communities, the Fire Department responded to and controlled a public school fire at Terreton, Idaho. The estimated loss was $45,000 and would have been considerably greater without this assistance.

4.4 Fire Protection Planning

Improvement of the ADT fire alarm system will be effected by moving McCullogh recorders from ICPP, MTR, NRF, Spert, and EBR-I to the CFA Fire Station. This will permit full-time supervision of all supervisory signals and assure prompt corrective action for any malfunction of alarm circuits, waterflow alarms, power failure, smoke detectors, fire detectors, supervised valves, and water pressure changes. Testing functions will be improved at less cost and better manpower efficiency.

5. INDUSTRIAL HYGIENE

(John T. Collins, Jr., Industrial Hygiene Engineer)

The ID Industrial Hygiene program during 1963 provided functional and consultative services to all NRTS contractors and to the AEC Health and Safety Laboratory group.

The Industrial Hygiene Engineer appraised ID contractors' hygiene programs, reviewed engineering drawings and project proposals, maintained the NRTS emergency respiratory equipment, clothing and food supplies, reviewed contractors' respiratory equipment programs, and served as chairman of the NRTS Filter Advisory Committee (FAC).

5.1 Routine Duties

5.11 Industrial Hygiene Services. Services provided to AEC and contractors at NRTS during 1963 included the following: information bulletins, specific toxicity data, consultations, surveys and design of ventilation systems for the control of toxic materials, analyses of noise and heat problems, and air pollution and contamination studies. Industrial hygiene service requests by NRTS organizations in 1963 increased by about 14 percent over the previous year.

5.12 Filter Advisory Committee Activities. The Filter Advisory Committee, composed of members of ID and AEC contractor organizations, advised NRTS organizations on filter problems, recommended filter standards, and conducted an in-line filter testing program. There were 16 requests for in-line filter tests in 1963. The committee, recognizing the need for uniform particulate filter specifications and for filter installation standards, prepared and issued the "Hazardous Material Filter Manual", IDO-12032, as a guide.

5.13 Potable Water Sampling and Laboratory Service. The Industrial Hygiene Engineer supervises the bacteriological water sampling and analysis program at the NRTS, the objective of which is to ensure adequate drinking water to all site personnel. Potable water samples are collected bi-monthly by the individual operating contractors and analyzed by the ID Medical Laboratory. During 1963, of a total of 676 water samples analyzed, there were six samples of unpotable water detected in this program, requiring investigation. Three of these were found contaminated from handling and three were unexplained but nonrecurring.

5.2 Special Investigations

5.21 Effect of Cigarette Smoke on Nonsmoking NRTS Bus Passengers. As a follow-up to complaints of annoyance to nonsmokers by cigarette smoke on NRTS buses, the Phillips Petroleum Company and ID Industrial Hygiene Engineers conducted an air analysis survey of representative buses to determine if there were any measurable health hazards present. Numerous air samples were taken at various points within buses where cigarette smoking occurred and in empty buses both before and after transporting passengers. No significant difference in concentrations of carbon monoxide, hydrogen cyanide, oxides of nitrogen, or aldehyde concentrations were found on the occupied buses versus the empty buses. Concentrations of the above gases were all near or below the levels of instrument detection, and certainly far below harmful concentrations. This was probably due to the efficient exhaust ventilation by overhead fans throughout the buses.

From this study, it was concluded that there was no measurable health hazard to nonsmoking passengers from the combustion-product gases due to cigarette smoking on the NRTS buses.

5.22 Lead Fume Exposure. There was a recurrence of lead fume exposure noted in the 1962 Annual Report. Considerable industrial hygiene and medical attention was given to this problem in order to prevent toxic effects to the workers. Poor work habits finally resulted in suspension of the operation pending improvement of lead fume control. Bioassay results are noted under Medical Branch Section 2.31 of this Report.

6. HEALTH PHYSICS
(William Lyle Slagle, Health Physicist)

The health physics function in the ID Hazards Control Branch is principally concerned with the ID contractors' in-plant health physics programs. This is in contrast to the function in the ID Health Physics Branch, which is concerned with radiation safety out-of-plant and off-site. The Hazards Control Branch health physicist maintains frequent contractor in-plant contacts, and performs an annual appraisal of the health physics programs. Appraisal reports are submitted to the ID Manager, indicating the contractor's effectiveness and efficiency in implementing required radiation safety controls according to the rating scale employed by the Branch.

6.1 Health Physics Program Appraisals

During 1963, health physics program appraisals were made of all ID contractor facilities at the NRTS. The Branch Health Physicist also assisted with reviews at NRTS facilities operated by General Electric Company and Argonne National Laboratory, under OR and CO, respectively.

6.2 ID Requirements for Health Physics Program

ID minimum requirements for a contractor's health physics program were published as Chapter XVII - Health Physics, in the 1963 revision of Standard Health and Safety Requirements, ID Manual Appendix 0500-1 (IDO-12028).

6.3 Health Physics Issuance Reviews

The Branch health physicist reviewed all AEC HQ issuances pertaining to radiation safety and initiated constructive comments and evaluations where appropriate. By reason of the health physicist's frequent contact with contractor personnel, he is able to provide efficient coordination and liaison between HQ personnel and the operating contractors in the field. In addition, the Branch Health Physicist reviewed all policy or procedural issuances by ID contractors affecting radiation safety and commented where appropriate.

6.4 Facility Design Reviews

All current design drawings and specifications for new or modified nuclear and allied facilities were reviewed for radiation safety. Of interest were radiation protection procedures, radiation detection-alarm instrumentation, contamination control systems and procedures, personnel traffic control, layout of hot and cold work areas and change rooms, ventilation, and radioactive waste disposal.

7. FUTURE PROJECTS

7.1 Design Criteria

Revision of IDO-12008, ID Safety and Fire Protection Design Criteria Manual, will be accomplished in 1964.

7.2 Fire Tests

The effectiveness of certain emulsifier additives to water, in concentrations as low as one-half to one percent will be determined by testing with flammable liquid fires. This is part of the continuing program of keeping informed of developments in fire-fighting and of assuring optimum fire-fighting capability at NRTS.

Different types of pyrophoric metals, which commonly react violently with wet extinguishants, will be tested for reaction with high-expansion foam. There is some indication that foam will react very slowly or not at all with such materials.

7.3 Particle Size Study

It is becoming increasingly apparent that mass or total concentration of toxic and/or radioactive airborne particles is a misleading measurement of inhalation exposure. In order to evaluate a potential hazard with any degree of reliability, the retention of the hazardous material in the various body organs must be determined.

Currently, the most common method of sample collection for airborne toxic and/or radioactive particulates is by use of the hi-volume sampler equipped with some type of filter medium. Unfortunately, this type of collection equipment can only determine the total quantity of material available for inhalation in the aerosol. This method does not indicate sites of deposition within the body, nor does it lead to any accurate determination of the number or sizes of the particles available.

A study will be initiated to evaluate all commercially available equipment which can be used for the collection of atmospheric samples, both in-plant and out-plant, for subsequent quantitative and qualitative determination of those particles in the respirable range; namely, particles five microns and less.

The second phase of this study will be to investigate and develop analytical methods for the determination of particle size, count, and solubility which are less tedious and time-consuming than previous methods.

7.4 Respiratory Equipment Testing

Mechanical leakage tests (exhaust valves, canister seals, eye pieces, communication systems connections) of various makes of respirators will be conducted in 1964.

8. PUBLICATIONS

1. Standard Health and Safety Requirements, ID Manual Appendix 0500-1, IDO-12028, 1963 revision.

2. Hazardous Material Filter Manual for the NRTS, prepared by the Filter Advisory Committee, August 1963, IDO-12032.

3. NRTS Health and Safety Information Bulletins:

   No. 35, "Report on Glove Boxes and Containment Enclosures"

No. 36, "Diffusion Parameters at the NRTS"

No. 37, "Respirators and Beards"

No. 38, "Diffusion Factors at the NRTS"

No. 39, "Valve Outlet Standards for Breathing Air"

No. 40, "Potable Water Sampling and Laboratory Services"

No. 41, "Advisory Center on Toxicology"

VI. HEALTH PHYSICS
(W. P. Gammill, Branch Chief)

1. SCOPE

The basic function of the Health Physics Branch is to assure that all NRTS operations are conducted in a manner which will minimize the radiation hazard to site personnel and to the off-site population in accordance with radiation protection guides established by the Federal Radiation Council. This is accomplished by pre-operational safety analyses of new installations, gaseous effluent controls, and an environmental monitoring program. The branch is also responsible for conducting field and laboratory experiments in radiobiology and applied health physics, and for maintaining a noxious weed and predatory animal control program.

2. ENVIRONMENTAL
(Clyde Hawley, Section Chief)

2.1 Environmental Monitoring

The Environmental Section has the responsibility for surveillance of radiation in the physical environment outside areas specifically assigned to the operating contractors at the NRTS and to prepare, semi-annually, a compilation of off-site monitoring data for release to the public. This is accomplished by continual radiological evaluation of air, water, and biological samples from the NRTS and environs. The 1963 summary appears as Appendix A to this report.

2.11 Atmospheric Monitoring. Continuous air sampling for radionuclides was conducted at 13 on-site stations and at 14 off-site stations located in populated areas surrounding the NRTS.

The highest concentration of airborne beta-gamma activity measured on-site for a one-week period in 1963 was 7.9×10^{-11} μc/cc, which is eight percent of the on-site Radioactivity Concentration Guide (RCG). The average for the year was 1.7×10^{-11} μc/cc (1.7 percent of RCG). The highest concentration measured off-site for a one-week period was 5.5×10^{-11} μc/cc (55 percent of the off-site RCG) with an average of 1.5×10^{-11} μc/cc (15 percent of RCG).

During 1963, two on-site and one off-site continuous air sampling stations were established to obtain background concentrations of plutonium-239 prior to start-up of plutonium-fueled reactors. The results of 69 samples showed concentrations ranging from 1.3×10^{-16} μc/cc to 2.0×10^{-15} μc/cc, with an average of 6×10^{-16} μc/cc (0.01 percent of MPC per NBS No. 69).

2.12 Water Monitoring. Twenty-two on-site production wells, which supply water for human consumption, were sampled bi-weekly, and 30 off-site potable water supplies were sampled and analyzed quarterly. Table XI presents the concentrations observed.

TABLE XI

POTABLE WATER ACTIVITY CONCENTRATIONS

On-Site	% of RCG, High Sample	% of RCG, Average
Alpha	10.0	4.0
Beta	0.27	0.07
Tritium	0.31	0.02
Off-Site		
Alpha	50.0	40.0 (natural contributors)
Beta	4.0	2.0
Tritium	0.17	0.02

These concentrations show no significant change from previously observed levels.

Tritium analyses of 43 precipitation samples collected at the NRTS showed an average concentration of 19 pc/ml.

2.13 Milk Monitoring. Iodine-131 activity in milk produced near the NRTS during 1963 was less than the detection limit of 20 pc/l set by Health Physics. Cs-137 activity increased from 60 pc/l in January to 230 pc/l in July and August with a drop to 170 pc/l in September. By the end of the year, it had returned to mid-year levels (Figure 7). An analysis of the data indicates that tnere was no significant variance in the Cs-137 activity in milk from the locations studied, and that feeding practices had no apparent effect on Cs-137 levels.

Sr-90 activity was unlike Cs-137 activity in that it stayed near 10 pc/l for the first three months of the year and then increased to 35 pc/l until August. It then dropped to 20 pc/l for the remainder of the year.

An analysis of the Sr-90 data indicates that there was no significant difference between the radio-strontium levels of milk from the various locations. Additional studies have shown that during 1963, Sr-90 activity was reduced by approximately a factor of two when the cows were maintained on dry feed only.

2.14 External Radiation Monitoring.

(1) Film Dosimetry - Film dosimeters are located at 280 stations throughout the NRTS and surrounding areas as a means of monitoring external radiation and to supply information in the event of a nuclear accident.

In the past, considerable data have been lost due to weather damage to the film packet. Early in February 1963, an investigation was initiated to ascertain the availability of a laminated film dosimeter. Correspondence with plastic

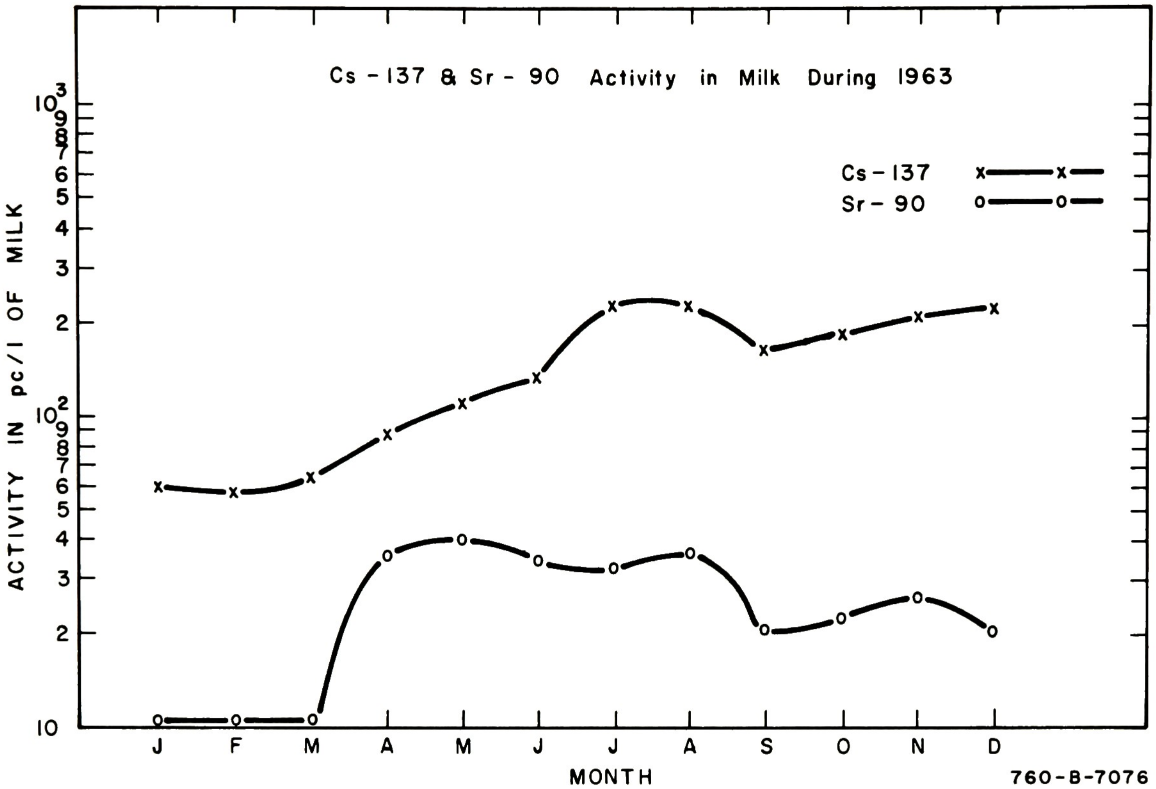

FIG. 7 CS—137 AND SR—90 ACTIVITY IN MILK DURING 1963.

fabricating and engineering firms indicated that a satisfactory badge could be supplied at a cost of 45¢ per unit. A description of the new badge will be found in Section III-3, pages 11-13.

The results of the first three film changes using the desiccant indicated that all film was readable and there was no loss due to heat and/or moisture in the dosimeter. The performance of the new dosimeter permits one-month exposures without a significant loss of data.

(2) Road Scanning - Summer employees utilized the road scanning equipment developed by the Health and Safety Division in surveying 16 miles of roads and all major parking lots on the southern portion of the NRTS. A total of 146 particles, ranging in activity from 1 mrad/hr to about 4 rad/hr at one inch, was detected and removed. The activity was primarily beta radiation. In addition, at the request of Phillips Petroleum Company health physics personnel, the roads and parking areas inside the ICPP area were scanned.

2.15 Radiation Monitoring Telemetry. During 1963, the radiation monitoring telemetry system became fully operational, although some minor items still remain to be perfected. Efforts during 1963 included the following: (a) check-out of desired monitoring locations for suitable signal reception and negotiating with landowners for location contracts; and (b) establishing calibration procedures for the various channels, developing standard sources, and making mechanical adjustments on air pumps, sequencing devices, and recording equipment for the purpose of standardizing the analytical efficiencies of all the stations.

The Division's automatic data-processing equipment is used to convert the telemetry system's punch tape data to meaningful dose rates, radioactivity concentrations, and weather information.

The following performance specifications have been established for the telemetry system's collection and counting equipment and can be maintained within plus or minus 10 percent throughout the 17 stations system: (a) flow rate of 1 cfm through the collection filters; (b) proper sequencing daily of particulate filters; (c) GM tube #1 counting efficiency of 4.2 percent (based on Sr-Y-90 source); (d) GM tube #2 counting efficiency of 43 percent (based on Sr-Y-90 source; (e) scintillator counting efficiency of 55 percent (Cs-137 - Ba-133 source simulating I-131; and (f) ion chambers are to read between zero and ten mr/hr as calibrated with 0.1 mg and 1.0 mg radium sources.

2.16 Special Monitoring Programs

(1) Wheat Monitoring - A comprehensive program for the measurement of radionuclides in wheat was initiated in 1963. At the end of the crop year, 16 samples of wheat had been grown under two types of irrigation systems (surface flooding and sprinkling from deep wells) and on dry farm land were collected from six of the milk sampling areas.

Sr-90 levels were determined by chemical analysis of a 25-g sample and counting for 30 minutes in a low-background beta counter. Of the 16 samples analyzed, 10 were less than the detection limit of 6.0×10^{-8} μc/g. The highest observed value was 1.7×10^{-7} μc/g.

Cs-137 activity levels were determined by gamma spectrum analysis of a three-liter sample (approximately 2200 g) in a Marinelli-type container. Cesium levels were found to range from $1.0 - 8.0 \times 10^{-7}$ μc/g with an average of 4.5×10^{-7} μc/g.

The gamma spectra revealed the presence of another gamma emitter with approximately the same peak height as that of Cs-137, which was identified as Mn-54. Since Mn-54 has a relatively long half-life (291 days) and a gamma energy of 0.84 MeV, and is not normally found with fission products, chemical separation was required to confirm the identification. Mn-54 values ranged from $1.0 - 5.6 \times 10^{-7}$ μc/g with an average of 4.1×10^{-7} μc/g.

The values in Table XII show no significant differences in the Mn-54 and Cs-137 content of wheat grain from the areas indicated. A significant difference is indicated, however, for Sr-90 activity. Monteview grain may be somewhat higher in Sr-90 than grain from the other areas.

(2) ICPP Waste Calciner. "Hot" operation at the ICPP Waste Calciner started in early December 1963. Prior to start-up, a 12-station air sampling grid was established around the ICPP. Stations were located at a distance of approximately one mile (estimated distance for maximum average concentration

TABLE XII

RADIOACTIVITY LEVELS IN WHEAT

	Idaho Falls			Blackfoot			American Falls		
	Sr-90 [a]	Cs-137 [b]	Mn-54 [c]	Sr-90	Cs-137	Mn-54	Sr-90	Cs-137	Mn-54
Flood	1.6	0.3	0.7	1.3	0.5	0.2	1.8[e]	0.5[e]	0.4[e]
Sprinkle	1.6	0.4	0.3	1.6	0.4	0.3	[d]	[d]	[d]
Dry Land	1.8	0.2	0.2	[c]	0.2	0.3	[c]	0.5	0.7
	Minidoka			Arco			Monteview		
	Sr-90	Cs-137	Mn-54	Sr-90	Cs-137	Mn-54	Sr-90	Cs-137	Mn-54
Flood	[c]	0.4	0.4	1.3	0.6	0.6	3.6	0.4	0.4
Sprinkle	2.1	0.6	0.5	1.6	0.4	0.6	[d]	[d]	[d]
Dry Land	[d]	[d]	[d]	1.3	0.1	0.1	[d]	[d]	[d]

[a] pc/25 g sample
[b] pc/g
[c] Lost in analysis
[d] Sample not available
[e] Mixed sample (Flood and sprinkled)

and deposition) from the ICPP stack. Emphasis was placed on sampling locations in the northeast and southwest sectors due to the prevailing wind directions. In addition, 70 fallout collection stations were set up encircling the stack at distances from 300 feet to one mile.

Air samples were collected and analyzed daily during the first three weeks of operation. Fallout plates were collected weekly. All samples were gross gamma counted. Gamma scans for isotopic identification were made on all samples with sufficient activity. Samples with the highest activity were then analyzed for Sr-90.

Radionuclides, collected on the filters, were identified as Zr-95, Nb-95, Ce-144 and/or -141, and Ru-106 and/or -103. The highest concentration of Sr-90 detected for a three-day period was 2.5 x 10^{-12} μc/cc, which is about one percent of the on-site RCG for a 40-hour week.

On the basis of the analytical results, the monitoring program was discontinued after two months of operation.

2.2 Special Activities

2.21 CERT Program. With the initiation of the Controlled Environmental Radioiodine Test (CERT) program in the spring of 1963, the Branch devoted more time to environmental research than in any previous year. This research program, which is being supported by the Division of Biology and Medicine, USAEC, is designed to study the behavior of radioiodine from its point of release to the atmosphere to its intake by human beings via the pasture-milk chain. The results of phase I of this study are summarized in Appendix D of this report. Phase II will begin in the fall of 1964 and will utilize an irrigated pasture established at the NRTS for this purpose.

2.22 Strontium Contamination Versus Metabolism in Wheat. Preliminary investigations carried out during the summer of 1962 at Mud Lake and at Idaho Falls seemed to indicate that there was a difference in Sr-90 content of wheat grain which was grown in the open compared to that which was grown under cover. This suggested that current fallout was contributing measurable amounts of Sr-90 to the wheat grain, and that only a small percentage was being removed from the soil.

An experiment was conducted on a farm west of Idaho Falls to test the above observations statistically and to determine (a) if certain nitrogen fertilizers applied to a wheat crop differed in effect upon the uptake of Sr-90 from the soil and (b) the mechanism of radiostrontium contamination of wheat grain, ie, what percentage of Sr-90 in the threshed grain was surface absorbed from current fallout and what percentage was absorbed from the soil.

A portion of a wheat field was divided into 18 plots measuring 6 x 6 meters each. Three nitrogen fertilizers [NH_3, $(NH_4)_2SO_4$, and NH_4NO_3] were applied to the plots prior to wheat seeding. Each type of fertilizer was applied to six randomly selected plots. When the wheat reached the boot stage, nine (three with each kind of fertilizer) of the 18 plots were randomly selected and covered with polyethylene covers. The covers measured 3 x 3 meters and were tacked to a wooden frame supported by four steel posts. The covers were centered over each plot to reduce edge effects. The covers were kept about six inches above the wheat heads by raising them periodically.

In the fall one square meter of wheat was harvested from the center of each plot, threshed by hand, and the grain analyzed for Sr-90. The covered grain contained as much Sr-90 as the grain which was grown in the open. Since the covers should have eliminated fallout debris and the plot treatments were equal, it is concluded that all of the Sr-90 in the wheat grain was absorbed through the roots and that none was absorbed from fallout. Statistical analysis of the data indicates that there was no significant difference in Sr-90 uptake between the nitrogen fertilizers applied in this study.

2.23 Dove Study. A study was conducted at two reactor facilities to determine if mourning doves utilizing low level effluent water from these facilities were becoming contaminated with radioactivity from these sources.

The reactor facilities of interest were MTR and GCRE, each of which has a small body of water associated with it. Each month during the summer, several mourning doves were collected at the two ponds. Background specimens were collected at Birch Creek northwest of the NRTS which is about 30 miles from the other investigated areas. The latter were certain to contain only natural radioactivity.

After each intact specimen was gross gamma counted, it was skinned and eviscerated and the carcass oven dried and pulverized. Each of these portions was also gross gamma counted. Several of the intact birds and some of the portions were analyzed by gamma spectrometry to identify the nuclides present. The nuclides identified in the intact birds were Ce-144, Ru-106, and Zr-Nb-95. These same nuclides were present in the skin and feathers as well. No radioactive nuclides were identified in any of the carcasses analyzed. Two of the specimens collected in July, one from the MTR and one from GCRE, showed I-131 on skin and feathers. Analysis of the data collected over the summer indicates no difference between the radioactivity of doves collected at Birch Creek and of doves collected at GCRE. It further indicates no difference between the radioactivity of the carcasses of doves collected from the MTR area and the carcasses of those collected off NRTS, although the other portions were somewhat more contaminated than similar portions of background specimens. Since the edible portion did not contain significantly more radioactive contamination than background specimens, these doves would not be expected to present any hazard to health.

2.24 Biology of Settling Ponds. As a part of the general investigation of radioactive waste disposal to the environment, the fate of radionuclides in the algae community of the settling ponds is being explored. A bench-scale laboratory model was used to test the uptake by pond algae of four radionuclides (Cs-137, Ag-110, Sr-85, and Co-60) at three pH levels (3.5, 7.0, and 9.0) and at two solution-total ionic strengths (the dilute being 1/100 that of the concentrate).

No different absorption at different pH's or ionic concentrations were found for Ag-110. Nearly 100 percent of the Ag-110 was removed by the algae in all cases. Removal of the other nuclides was enhanced 30 to 60 percent in the solutions of low ionic concentration. With the exception of Ag-110, increased removal was found in all cases with increase in pH, the greater gain being from 3.5 to 7.0, with less gain from 7.0 to 9.0. Co-60 removal in the low ionic concentrations changed from 25 to 95 percent when the pH was raised from 3.5 to 7.0. This nuclide was the most sensitive to change in pH. Uptake of Cs-137 was about 25 percent in the high ionic concentrations and 50 percent in the low. Changes in pH had less effect on removal of Cs-137 than on Sr-85 or Co-60.

2.25 MTR Canal Fungus. A slime mold, tentatively identified as belonging to the Class Myxomycetes, has been growing in the handling and storage canal. This slime mold has been prolific enough to cause problems of handling irradiated specimens, water turbidity, etc. Since the nature of the materials stored in the canal practically precludes the use of chemical fungicides, a study of other control methods has been started. To date, the use of ultrasonics as a destructive agent shows greater promise than ultraviolet or infrared light.

2.26 Biological Availibility of Calcined Waste Material. Calcined radioactive waste produced was used to determine experimentally the amount of Sr-90 metabolically available to a rabbit if a gram of the material were eaten. As a preliminary approach, a two-gram sample was encapsulated and fed to a laboratory "Dutch" rabbit. After 30 days retention time, the rabbit's bones were analyzed for Sr-90. The analysis showed a concentration of 189 pc of Sr-90 per gram of tissue. Using an average figure of 30 grams of calcium per skeleton, this amounts to 5670 pc of Sr-90 per rabbit at 30 days post dose. By using a biological decay curve for Sr-85 decay for 30 days, it was estimated that 0.65 microcurie of Sr-90 per gram of calcined radioactive material was metabolically available to the rabbit. This type of experiment is being repeated using six rabbits and product from the waste calcination facility now in operation at the NRTS.

2.27 Noxious Weed Control. Halogeton control for 1963 consisted of the reseeding of disturbed areas, mainly road sides, to crested wheatgrass. Seeding was performed by using a heavy-duty rangeland drill made especially to seed without seed-bed preparation in brushy, rough, or rocky terrain. Spring seeding on flood control ditch banks amounted to 124 acres. Fall seeding of 593 acres included the denuded area around SL-1, all roads to the SL-1 burial ground, the construction area around EBR-II and the CERT area, and several scattered road sites, making a grand total of over 700 acres this year.

2.28 Predatory Animal Control. During 1963, under contract with the Bureau of Sport Fisheries and Wildlife, a Government trapper maintained 40 poison bait (#1080) stations, 70 steel traps part of the year, and used 450 "coyote getters" (cyanide guns). A total of 100 coyotes and 3 bobcats was killed by the above methods. Records were kept on sex and location of each animal taken. In addition, Branch personnel recovered four coyotes which were either shot by Security Division personnel or killed by automobile traffic.

2.29 Sr-90 in Jack Rabbit Bones. Jack rabbit collections were made during the spring and fall seasons at five locations each, both off-site and on-site. The Sr-90 levels of the off-site rabbits continue to exceed those of on-site rabbits as noted in 1962. The average of all jack rabbit bones analyzed for the fall collections was 74 pc of strontium per gram of calcium. This indicates a 30 percent increase over the 1962 levels.

2.210 Spert I Destructive Test -- Health Physics. Health Physics Branch participation in the second Spert I Destructive Test is treated in Appendix C of this report.

3. TECHNICAL
(W. P. Gammill, Acting Section Chief)

3.1 Training

3.11 AEC Technical Internship in Health Physics. Two 1963-64 Technical Interns were assigned to the Branch in July for three months of preceptor training with the Health and Safety Division. At the completion of this first phase of their training program, they were assigned to the Health and Safety Branch, Atomic Energy Division, Phillips Petroleum Company for reactor health physics experience.

As a phase III assignment, one of the 1962-63 interns was provided three months of intensified study on reactor safety analysis techniques by the ID Health and Physics Branch, and the other was assigned to the Hazards Control Branch where he specialized in filter efficiency determinations.

An Oak Ridge Operations Office Intern received two months of specialized health physics training with ID and Phillips Petroleum Company.

3.12 AEC Health Physics Fellowship Program. Six fellows from the University of Kansas received 12 weeks of on-the-job specialized training with the ID and Phillips Petroleum Company Health and Safety organizations.

3.13 Special Training Programs

(1) Eight weeks of basic health physics and specialized technician training was given by ID and Phillips Petroleum Company to a member of the NS Savannah's crew.

(2) Inservice training in health physics practices and emergency procedures was given personnel of the ID -- Emergency Relocation Center Cadre, Fire Department, Health Physics Branch, and Health and Safety Division new employees.

(3) Sixty members of the Federal Aviation Agency and the U. S. Department of Agriculture were given instructions in weapons phenomena, fallout monitoring, and radioactive decontamination.

3.2 Technical Review -- Radiation

3.21 Safety Analysis. As a part of the program to assure that NRTS personnel and the general population do not receive unnecessary radiation exposures, an independent review is made of all studies that evaluate potential radiation hazards. These include feasibility studies, design criteria, and safety analysis reports for experiments, reactors, and facilities at the NRTS. Emphasis is placed on the review of hazards evaluation for radioactive material which might be released to the atmosphere intentionally or accidentally. Subsequent to review, restrictions on the intentional release of radioactive material to the atmosphere are established either by limiting the release rates of known quantities and/or by limiting the release to favorable meteorological conditions. During 1963, reviews were made of studies prepared on the Waste Calcination Facility, the Power Burst Facility, the 710 Reactor Facility, the Loss of Fluid Test Facility, the Nuclear Test Facility, the Experimental Beryllium Oxide Reactor Facility, and for the Spert I destructive test, the SNAPTRAN 2/10 A destructive tests, and the Spert II Afterheat Core Meltdown Experiment.

3.22 Reactor Siting. Reviews are made of proposals for siting of new facilities to be located at the NRTS. These reviews and subsequent recommendations are based on the potential hazards to the general public and on the potential hazards between the new facility and existing facilities. Siting reviews and recommendations were made in 1963 for the Loss of Fluid Test Facility, the Fast Reactor Test Facility, the 710 Reactor Facility, the 630-A Reactor Facility, the Zero Power Plutonium Reactor Facility, and for the Army Reactors experimental area. A study was initiated to review past siting practices and to establish criteria and guides for future facility siting at the NRTS.

3.23 Special Studies. Technical studies are made to obtain special information to assist in document review and to report new information obtained in the Health Physics Branch programs. During 1963, meteorological parameters found applicable to the NRTS were published in two information bulletins, a hazards evaluation was written for the preliminary CERT test, the monitoring program for the SNAPTRAN tests was evaluated, and preparation of the report of the radiation monitoring program for the Spert I destructive tests was started.

4. FUTURE PROJECTS

4.1 Calcined Waste Biological Availability

Final product from the Waste Calcination Facility at ICPP will be administered to experimental animals to determine the metabolizable fractions.

4.2 Off-Site Census Survey

A door-to-door canvas in agricultural areas surrounding the NRTS is to be conducted to obtain specific human population information on geographical and age distributions, milk consumption, and dairy practices. The information will be compiled and organized through use of the 1620 computer and automatic data processing machines.

4.3 Controlled Environmental Radioiodine Tests

Continuations of the preliminary experiments described on page 89 of this report will be conducted.

5. PUBLICATIONS

1. Radioiodine Uptake in Native Animals at the NRTS and Environs, R. McBride, HEALTH PHYSICS Vol. 9, pp 1227-1230, 1963, Pergamon Press.

2. Controlled Environmental Radioiodine Tests, C. Hawley, C. Sill, G. Voelz, N. Islitzer, IDO-12035, June 1964.

VII. RADIOACTIVE WASTE MANAGEMENT
(Bruce L. Schmalz, Branch Chief)

1. SCOPE

The Waste Management Branch was established in mid-1963 as a part of the reorganization of the Health and Safety Division. The waste management functions previously were accomplished by sections within the Health Physics and Analytical Chemistry Branches. The ID Waste Management Branch is charged with responsibility for the regulatory control of all radioactive waste disposal at the NRTS. The discharge of this responsibility involves a program of research and development in methods of treatment and disposal. The Branch functions also include the surveillance and evaluation of the various contractors' systems, techniques, and programs for the storage, treatment, and disposal of radioactive wastes generated at the NRTS or received from off-site.

2. RADIOACTIVE WASTE STORAGE

The temporary or long-term storage of the higher-level radioactive wastes, for subsequent release to seepage ponds or discharge wells or for further processing, is a programmatic responsibility of the operating contractor. Although such storage programs are a review and regulatory responsibility of this Branch, they are not discussed as an operational activity in this report.

3. OPERATIONAL WASTE DISPOSAL DATA

Radioactive wastes discharged at the NRTS during 1963 are categorized according to physical state in which released, and are summarized as follows (from "Radioactive Waste Disposal Data for NRTS Facilities", by J. H. Osloond, May 1963):

3.1 Liquid Radioactive Waste

The total amount of liquid waste discharged to the surface and subsurface environments during 1963 is summarized in Table XIII. Activity having a half-life of less than 30 days comprised approximately 68 percent of the total waste activity. Installations discharging the major proportion of waste are listed separately. Table XIV lists the isotopes, half-life, and activity which were identified in the liquid waste. Total activity of alpha-emitting isotopes in the liquid waste amounted to less than 0.5 curie.

A treatment system began operating in December 1963 at the ICPP fuel storage basin to reduce activity from such isotopes as Sr-90 and Cs-137 in liquid effluent discharged to the ground. The system consists of three sections, with two vertical tanks in each, all connected in series and filled with clinoptilolite (a naturally-occurring zeolite available locally). Prior to this time, the concentrations of Sr-90 and Cs-137 had been of the order of 10^{-3} $\mu c/ml$ in waste effluent at point of discharge. Early results indicate that virtually all cesium will

TABLE XIII

LIQUID WASTE DISCHARGED TO THE GROUND AT NRTS - 1963

NRTS Facilities		Volume of Waste (Million gallons)	Beta-Gamma Activity (kilocuries)
TRA (MTR-ETR)		202	5.918
ICPP		259	1.111
NRF (S1W-A1W-ECF)		27	0.057
CFA		48	0.005
ANL, GCRE, ML-1, OMRE, TAN, Spert		50	0.003
TOTAL	1963	587	7.1
Totals, Previous Years	1962	660	7.5
	1961	494	4.6
	1960	483	3.4
	1959	612	5.1
	1958	649	3.6
	1957	351	1.3
	1956	462	0.9
	1955	509	1.3

be removed by this system and that the concentration of strontium will be reduced by at least two orders of magnitude.

3.2 Gaseous Radioactive Waste

Table XV sets forth the amount of gross beta-gamma activity released to the atmosphere from NRTS operations during 1963. Three installations (MTR, ETR, and ICPP) contributed 99 percent of the total. Alpha activity discharged by all NRTS Areas was insignificant during 1963. Since the Waste Calcination Facility started processing radioactive waste on December 8, 1963, it did not add a significant amount of activity to the airborne discharges from the ICPP area for the year.

3.3 Solid Radioactive Waste

Solid waste generated at the NRTS during 1963 amounted to a bulk volume of 3278 m^3 with an estimated activity of 239,518 curies. A waste volume of 5477 m^3 with an activity of 14,047 curies, from off-site areas, also was disposed of at the NRTS burial ground. Burial of off-site waste was discontinued on August 11, 1963, with the exception of waste from the Dow Chemical Company's Rocky Flats facility. Table XVI presents a summary of solid waste burial (volume and activity) at NRTS since 1955.

TABLE XIV

IDENTIFIED ISOTOPES IN LIQUID WASTE DISPOSALS (CURIES) NRTS-1963

Isotope	Half-Life	Beta-Gamma Activity
Tritium	12 years	1492
Barium-Lanthanum-140	13 days, 40 hours	196
Iodine-131	8 days	136
Chromium-51	26 days	134
Ruthenium-Rhodium-106	1 year, 30 seconds	116
Cerium-141-144	32 days, 292 days	111
Strontium-89	50 days	49
Cesium-137	33 years	21
Cobalt-60	5 years	14
Strontium-90	28 years	12
Cesium-134	2 years	1
Zirconium-Niobium-95	65 days, 35 days	1
Cobalt-58	71 days	1
	Total curies	2284

4. FIELD RESEARCH

4.1 Gaseous Waste

Preparations are being made to investigate the feasibility of underground disposal of radioactive gaseous waste by using the lithosphere rather than the atmosphere. Natural gas is stored underground in many places where suitable geologic structures exist. There is reason to believe that under proper conditions radioactive off-gas also can be stored or disposed of in this manner. Completely impermeable conditions are sought for storage of natural gas. However, if radioactive gases can merely be held for a relatively short time, decay of the radioactivity can result in attenuation of the hazard and an impermeable trap would not be necessary.

Engineering studies to determine the feasibility of underground radioactive gas disposal were accomplished during 1963 under Contract No. AT(10-1)-1159 by Ball Associates, Denver, Colorado. Invitation bid specifications were prepared for Contract No. AT(10-1)-1191 to provide test wells for this purpose at the northern part of the NRTS. It is anticipated that this research will yield results useful in many localities where the nuclear industry is developing.

TABLE XV

ACTIVITY DISCHARGED TO THE ATMOSPHERE - NRTS - 1963

Installation		kilocuries	Identified Isotopes
TRA (MTR-ETR)		596.624	A-41, Xe-137-138, Kr-88-90
ICPP		294.102	Cs-137, Ru-106, Sr-90, Xe-133-135, I-131-132
ANL		0.206	A-41
Other (CFA-Laundry-GCRE, OMRE, ML-1, NRF, Spert, TAN)		< 0.001	Unidentified
TOTAL	1963	891	26% Xe-137
Totals, Previous Years	1962	960	25% Xe-133
	1961	659	10% Xe-135-138
	1960	900	20% Kr-89
	1959	735	17% A-41
	1958	883	
	1957	364	
	1956	213	
	1955	404	

TABLE XVI

SOLID RADIOACTIVE WASTE BURIAL AT NRTS

Year	Volume (m^3)	Activity (kCi)
1963	8760	255.0
1962	8180	118.0
1961	7690	156.0
1960	5410	9.2
1959	4480	23.6
1958	6880	10.5
1957	4970	15.0
1956	3820	10.0
1955	1910	1.5

4.2 Geophysics Exploration

The Petty Geophysical Engineering Co. of San Antonio, Texas, was awarded Contract No. (10-1)-1189 for preliminary seismic exploration studies of the basalt formations at the NRTS. Results of seismic studies will be integrated with gravity and aero-magnetic survey information from the U. S. Geological Survey.

4.3 Geohydrology Investigation

Reports were prepared by the U. S. Geological Survey through a cooperative program on delineating aqueous waste disposed to the lithosphere. A total of 27 auger holes was drilled to basalt in the ICPP storage basin area for determining migration of cesium and strontium in the alluvium. Investigation indicates that Cs-137 has been retained in the soil by cationic exchange, but Sr-90 has moved into the basalt.

A total of 25 holes was augered near the two seepage ponds at the NRF area for determining the geology, hydrology, and radioactive saturated zones above the water table. Information from these holes was used to show basalt surface configuration, perched water table, and direction of movement. (For details see "Subterranean Distribution of Radioactivity at the Naval Reactor Facility", by G. M. Hogenson and W. E. Teasdale, U. S. Department of Interior, Geological Survey, 1963.)

Existing auger holes (six) and observation wells (five) were used to study migration of liquid effluent discharged to the MTR-ETR pond following a fission break in the MTR reactor. Increase in gamma activity due to the fission break was observed in the regolith surrounding the pond only under saturated conditions. Activity was shortlived, and after 30-40 days, the regolith sampled returned to background radiation levels.

Water level measurements in the auger holes were used to appraise the effects of a pipeline break at the MTR-ETR area. Increased perched ground water levels were observed in the vicinity of the plant buildings in the reactor area. After repair of the disposal pipeline, water levels in the regolith receded. (See MTR-ETR Pipeline Break Study, by W. E. Teasdale, U. S. Department of Interior, Geological Survey, August 1963.)

4.4 Tritium Investigations

Tritium studies concerning ground water, regional watersheds, movement, and proposed work were prepared by D. B. Hawkins and B. L. Schmalz. (See Low-Level Tritium Studies at the National Reactor Testing Station: A Review and Proposed Study, by D. B. Hawkins, October 1963, and Résumé of Tritium Investigations at the NRTS, Idaho, by Bruce L. Schmalz, October 1963.) Summarized tritium data indicated a need for more reliable low level analysis and an accelerated sampling program. Distribution of tritium in the regional ground water is shown in Figure 8 for the ICPP-CFA area.

TABLE XV

ACTIVITY DISCHARGED TO THE ATMOSPHERE - NRTS - 1963

Installation		kilocuries	Identified Isotopes
TRA (MTR-ETR)		596.624	A-41, Xe-137-138, Kr-88-90
ICPP		294.102	Cs-137, Ru-106, Sr-90, Xe-133-135, I-131-132
ANL		0.206	A-41
Other (CFA-Laundry-GCRE, OMRE, ML-1, NRF, Spert, TAN)		< 0.001	Unidentified
TOTAL	1963	891	26% Xe-137
Totals, Previous Years	1962	960	25% Xe-133
	1961	659	10% Xe-135-138
	1960	900	20% Kr-89
	1959	735	17% A-41
	1958	883	
	1957	364	
	1956	213	
	1955	404	

TABLE XVI

SOLID RADIOACTIVE WASTE BURIAL AT NRTS

Year	Volume (m^3)	Activity (kCi)
1963	8760	255.0
1962	8180	118.0
1961	7690	156.0
1960	5410	9.2
1959	4480	23.6
1958	6880	10.5
1957	4970	15.0
1956	3820	10.0
1955	1910	1.5

4.2 Geophysics Exploration

The Petty Geophysical Engineering Co. of San Antonio, Texas, was awarded Contract No. (10-1)-1189 for preliminary seismic exploration studies of the basalt formations at the NRTS. Results of seismic studies will be integrated with gravity and aero-magnetic survey information from the U. S. Geological Survey.

4.3 Geohydrology Investigation

Reports were prepared by the U. S. Geological Survey through a cooperative program on delineating aqueous waste disposed to the lithosphere. A total of 27 auger holes was drilled to basalt in the ICPP storage basin area for determining migration of cesium and strontium in the alluvium. Investigation indicates that Cs-137 has been retained in the soil by cationic exchange, but Sr-90 has moved into the basalt.

A total of 25 holes was augered near the two seepage ponds at the NRF area for determining the geology, hydrology, and radioactive saturated zones above the water table. Information from these holes was used to show basalt surface configuration, perched water table, and direction of movement. (For details see "Subterranean Distribution of Radioactivity at the Naval Reactor Facility", by G. M. Hogenson and W. E. Teasdale, U. S. Department of Interior, Geological Survey, 1963.)

Existing auger holes (six) and observation wells (five) were used to study migration of liquid effluent discharged to the MTR-ETR pond following a fission break in the MTR reactor. Increase in gamma activity due to the fission break was observed in the regolith surrounding the pond only under saturated conditions. Activity was shortlived, and after 30-40 days, the regolith sampled returned to background radiation levels.

Water level measurements in the auger holes were used to appraise the effects of a pipeline break at the MTR-ETR area. Increased perched ground water levels were observed in the vicinity of the plant buildings in the reactor area. After repair of the disposal pipeline, water levels in the regolith receded. (See MTR-ETR Pipeline Break Study, by W. E. Teasdale, U. S. Department of Interior, Geological Survey, August 1963.)

4.4 Tritium Investigations

Tritium studies concerning ground water, regional watersheds, movement, and proposed work were prepared by D. B. Hawkins and B. L. Schmalz. (See Low-Level Tritium Studies at the National Reactor Testing Station: A Review and Proposed Study, by D. B. Hawkins, October 1963, and Résumé of Tritium Investigations at the NRTS, Idaho, by Bruce L. Schmalz, October 1963.) Summarized tritium data indicated a need for more reliable low level analysis and an accelerated sampling program. Distribution of tritium in the regional ground water is shown in Figure 8 for the ICPP-CFA area.

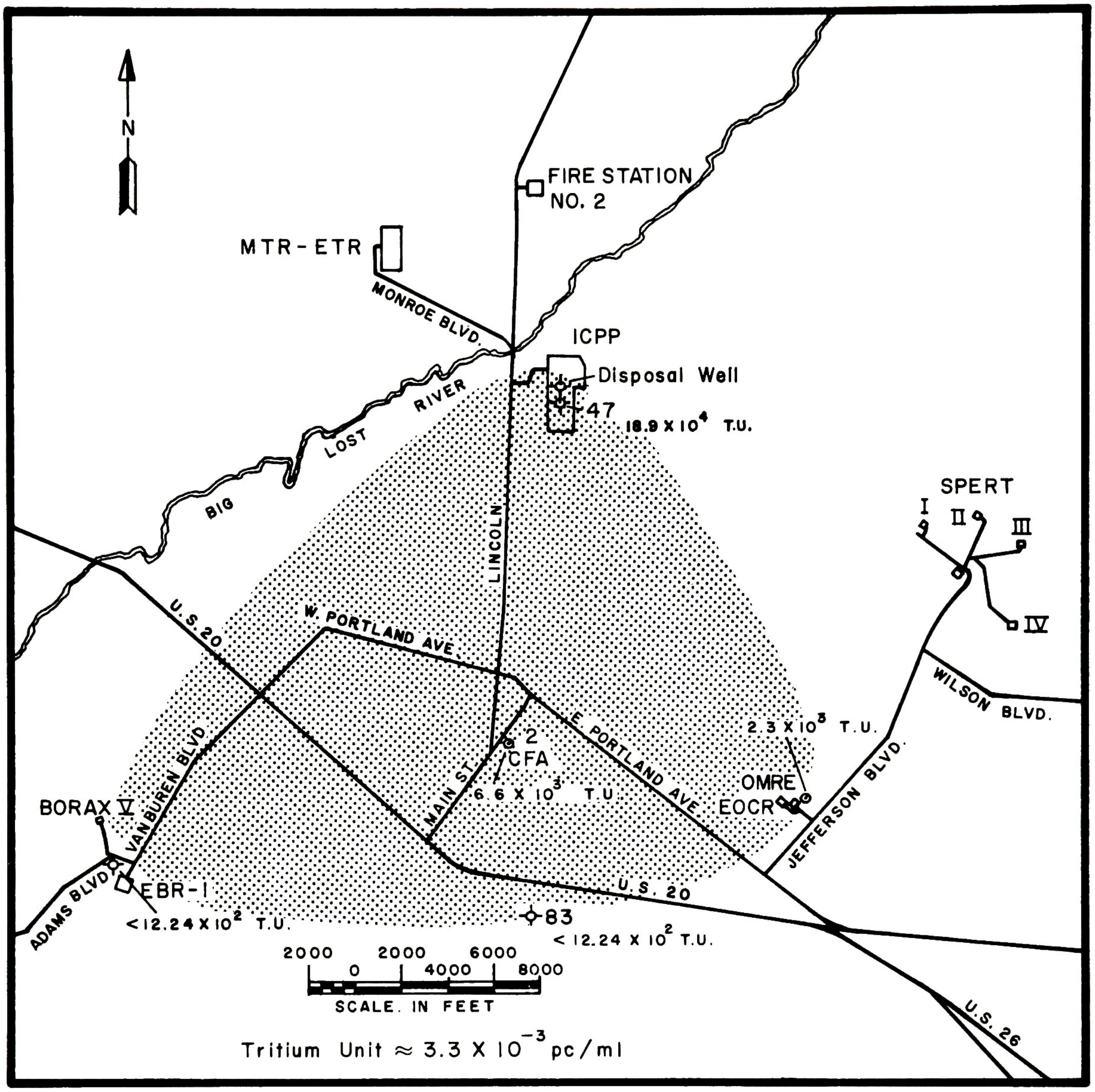

FIG. 8 TRITIUM IN GROUND WATER, ICPP – CFA

5. LABORATORY RESEARCH

5.1 Sorption of Strontium, Cesium, and Cobalt on Soil and Clinoptilolite

This work is a continuation of that described in the 1962 Annual Report, IDO-12033. The laboratory experiments on this study have been completed, the results of which are now being evaluated statistically. Preliminary results indicate that there are about nine significant chemical factors alone affecting the exchange of strontium by the soil. The results of the statistical evaluation of this data will be incorporated in an equation for predicting the exchange of cesium, strontium, and cobalt by soil and clinoptilolite for a variety of chemical conditions. The predictions will then be checked experimentally in the laboratory.

A smaller experiment will be designed using the significant variables determined above to refine the predictions.

5.2 Removal of Cobalt and Chromium from Reactor Waste Streams by Lignite, Clinoptilolite, and Soil

Alkaline permanganate and ammonium citrate solutions have been used to decontaminate certain reactors at the NRTS. The use of these solutions causes Co-60 and Cr-51 contaminants to appear as anions or anionic complexes in the waste streams. Upon discharge of the waste to the soil these radionuclides are not removed from solution by ion exchange since the soil has a negligible anion-exchange capacity.

Studies carried out using synthetic waste solutions indicate that it is possible to combine the two waste solutions, adjust the pH to 4.5-7.0, and remove 99.2-99.5 percent of the Co-60 and 75 percent of the Cr-51 on the MnO_2 precipitate formed. The remaining Co-60 and Cr-51, which are converted to cationic form by this treatment, are readily exchanged by the soil and other naturally-occurring cation exchangers. A locally-available lignite has proved to be the best exchanger for cobalt and chromium. Clinoptilolite is not significantly better than the soil for the removal of these elements. The results to date using lignite in conjunction with the precipitation process indicate that from 99.8-99.9 percent of the Co-60 and about 85 percent of the Cr-51 can be removed from the waste stream. Studies using the actual waste from the various reactors will be completed by May 1964.

6. GEOPHYSICAL LOGGING

Borehole geophysical logs were obtained from NRTS wells which were not included in 1962 work. These logs will aid in better waste management and research programs. All geophysical logs are being recorded by using a reduced photocopying method. This allows direct comparison of well logs due to the standardized scale used. The lithologger now is contained in a larger vehicle with modifications for logging to depths of approximately 500 meters. A tracejector tool (a device for releasing isotopes), used with the lithologger, is aiding in refining existing concepts of borehole water circulation.

7. FUTURE PROJECTS

7.1 Environmental Tritium Investigation

Previous data on the concentrations of tritium in precipitation and in surface and ground water were appraised and found to be inconclusive. An accelerated program of investigation has been proposed (Low-Level Tritium Studies at the National Reactor Testing Station: A Review and Proposed Study, by D. B. Hawkins, October 1963). The objective of this study is (a) to determine the contribution of NRTS operations to environmental tritium contamination and (b) to establish a basis for dating and ultimate tracing of water through the hydrologic cycle in the region. Information on the latter would greatly assist in planning waste disposal criteria.

7.2 Geophysical

The postulated rift zone that parallels or forms a boundary along the eastern part of the NRTS requires clarification. Seismic and magnetic techniques will be tried to obtain more specific sub-surface structure data of the NRTS areas.

Equipment was purchased during the latter part of 1963 for use in the gas injection tests, and initial start of gas injection into the lithosphere is planned for the third quarter of 1964.

7.3 Solid Waste Burial

ANL was given approval to establish a high level burial ground in the vicinity of EBR-II. This area will be used for the burial of wastes generated in a closed cycle fuel processing facility. Each sealed waste container (steel drum) will be limited to a radiation level of 10^4 r/hr unshielded. The waste will be transferred in a bottom-emptying cask and dropped into a lined auger-type hole or vault in the regolith. A proposal for testing the burial of spent fuel elements was submitted by the Phillips Petroleum Company. The test objectives would be heat dissipation characteristics, fission product migration, and handling techniques. It is hoped that this test can be completed within the next year. (See Report PTR-653-PPCo, A Proposal for a Burial Test of Spert Reactor Fuel Elements, ICPP Technical Branch, Phillips Petroleum Co., 1963.)

7.4 Geochemistry

The equations obtained in Section 5.1 above will be combined with the simple Kaufman equation [a], and the predicted rate of movement of the different radio-cations relative to that of tritiated water will be checked experimentally. The rate of movement of the different radio-cations, as a function of temperature, flowrate, and permeability of the exchange medium, will be determined directly from laboratory columns 3.5 to 4.0 meters in length using a collimated detector and a multichannel gamma spectrometer.

A program will be undertaken in 1964 to synthesize various clay minerals of the Montmorillonite group. The exchanger of cesium, cobalt, and strontium as functions of controlled differences in the composition and structure of these minerals will be studied, and thermodynamic parameters of the exchange reactions will be determined. In addition, an attempt will be made to synthesize zeolites exhibiting selective ion-exchange properties for strontium and other radionuclides.

[a] Ground Disposal of Radioactive Waste, Conference proceedings, Berkeley, California, August 1959, TID-7621, p 135.

VIII. INSTRUMENTATION BRANCH
(Mack Wilhelmsen, Chief)

1. SCOPE

The Instrumentation Branch provides a complete radiation instrumentation program for the ID Health and Safety Division and for other government agencies at the NRTS when needed. Calibrated portable radiation detection instruments also are supplied on a centralized loan basis to all government agencies and contractors at the NRTS. The Branch is divided into two sections, Laboratory Systems and Field Systems, with both development and maintenance of the respective instrumentation being performed by each section.

2. FIELD SYSTEMS SECTION
(Rex Purcell, Chief)

The responsibility of the Field Systems Section is to (a) provide, maintain, and calibrate portable radiation detection instruments; (b) maintain and operate a Radio Telemetry Network for remotely monitoring radiation and weather parameters in off-site areas adjacent to the NRTS; (c) develop instrumentation compatible with field usage where such is not commercially available; (d) adapt existing commercial equipment to fill specific needs of a particular program; and (e) provide programmatic support on instrumentation problems encountered by other Health and Safety Division Branches, affiliated government agencies, and associated contractors.

2.1 Portable Instrumentation

A total of 3758 repairs and/or calibrations of items designated as portable instruments was performed during the year. This represents an average of 313 servicings per month from a total inventory of 1513 instruments.

Rewriting and compilation of all portable instrument calibration procedures were accomplished to assure that these procedures reflect the practices now in use by the Instrumentation Branch.

2.2 Film Calibration

In a continuing effort to improve procedures and techniques, an automatic film calibration apparatus was designed, fabricated, and placed in operation for controlled exposure of dosimetry film to gamma radiation. This apparatus incorporates a circular film holder rotating about the radiation source. The exposure time is automatically controlled by a solid-state electronic timer (Figure 9).

Dosimetry film packets totaling 4135 pieces were exposed for calibration purposes to gamma and/or beta radiation.

2.3 Telemetering

The telemetering system was placed in operational status by the close of the year, providing radiation monitoring from 16 locations and weather monitoring from two locations. Each radiation monitor station provides data from:

(1) an ion chamber detector recording air activity;

(2) two GM tubes monitoring particulates deposited on a sequential filter paper tape sequenced each 24 hours. The first detector monitors the buildup of activity during the 24 hour sampling period, and the second monitors the decay of the previous 24 hour sample; and

(3) a scintillation detector recording the collection of gaseous activity, particularly I-131.

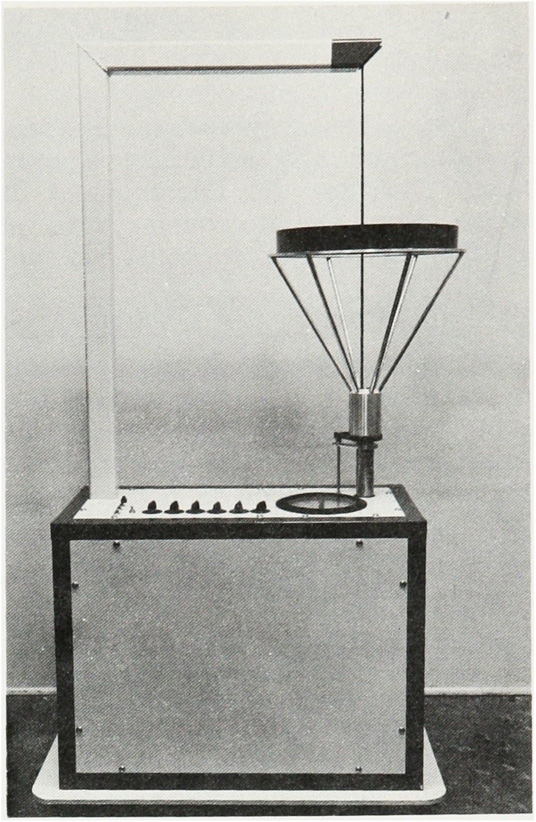

FIG. 9 AUTOMATIC FILM CALIBRATOR.

In addition to the continuous monitoring capability of each station, a supervisory control allows for the remote turn-on of high volume air samplers at each location. Each of the two weather stations records wind direction and speed.

During the Spert I destruct tests the complete system was utilized to provide radiation and weather monitoring. Both weather stations and two radiation monitoring stations were relocated to down-wind sites on the Spert grid to give a continuous record of conditions preceding and following the test excursion.

2.4 Aerial Monitoring

The Aerial Monitoring Team is composed of five members from the Health and Safety Division with the assigned responsibility to provide rapid tracking of effluent released to the atmosphere and delineation of ground deposition. Twelve flights were made during the year, monitoring scheduled and unscheduled releases of radioactive materials over the NRTS. Radio communications were improved by the acquisition of a light weight transceiver specifically designed for aircraft use and by the installation of antennas permanently mounted to the aircraft.

Flights were conducted for the USWB in support of their program of utilizing radar for the tracking of airborne weather observation equipment. The use of aircraft was made to check the calibration of the radar plotting board relative to azimuth and distance.

3. LABORATORY SYSTEMS SECTION
(DeRay Parker, Chief)

The Laboratory Systems Section has the responsibilities of (a) maintenance of electronic and scientific equipment used in laboratories of the Health and Safety Division; (b) development of instrumentation in specialized programs where commercial counterparts are not available; and (c) modification of existing equipment to meet the specific needs of an experiment or program.

3.1 Laboratory Systems Maintenance

About 60 laboratory instrumentation systems are maintained by the Section. These range in complexity from the multi-channel analyzer system used in the whole-body counting programs of the Analytical Chemistry Branch to a simple detector-scaler system used in sample scanning programs by the Health Physics Branch. Maintenance is not only required for established instrumentation, but also evolves in development projects. Here undefinable lines are crossed as corrective efforts finally give way to routine maintenance. The following topic will demonstrate this.

3.2 Automatic Film-Badge Reader

The Automatic Film-Badge Reader (Health and Safety Division Annual Report 1962 and IDO-12029) was used throughout the year by the Dosimetry Branch. An estimated 70,000 pieces of film were processed satisfactorily by the system. However, from a maintenance standpoint there were four areas that gave significant trouble:

(1) The lamp-voltage power supply ran too hot and frequently failed, even when operated at about three-fourths its rated level. This was a commercial unit and is to be replaced with another of more exacting specifications.

(2) The digital voltmeter gave trouble intermittently until a "cold" solder joint was discovered and corrected.

(3) The Talley tape punch failed occasionally. It is evident that the punch block will require factory service from time to time.

(4) The positioning of the film in the badges is a continuing problem which can be solved by using a redesigned badge or by loading the present badge carefully with only one packet of film. The choice depends upon the philosophy of the Dosimetry Branch. A mispositioned film does not present the X-ray coded number dots correctly to the reader and requires a manual insertion of the number. This is an inconvenience which may be tolerated for the time being.

After a year's operation and refinement, the Automatic Film Reader now is a successful system. It surveys film rapidly and reads out highly reproducible values. It is an object of interest throughout the industry. An article entitled "Automatic Film-Badge Reader Improved" by R. B. Purcell, H. McGary, D. Parker, P. Boren, and M. Wilhelmsen of the U. S. Atomic Energy Commission, Idaho Falls, Idaho, was published in the November 1963 issue of Nucleonics. Response with expression of further interest has come from agencies in the

United States, England, Australia, Germany, Switzerland, Austria, Czechoslovakia, and Canada. Several agencies from the United States have sent representatives to study the operation of the instrument. Some have expressed an interest in duplicating it. To these the U. S. Atomic Energy Commission has extended help in terms of technical information.

3.3 Personnel Dosimetry Vans

The X-ray units for the film badge reading system are being redesigned. These units -- one in each of two vans -- have given very little trouble. Electronic timer control to provide a higher degree of uniformity of exposure is being installed along with new mountings to give better performance and a more professional appearance.

3.4 Calibration Source Wells

Two calibration source wells were outfitted for instrument calibration at the new Health and Safety building. One, a low-level well, contains a one-curie radium source which may be positioned via a translator and stepping motor drive system. The high-level well contains a 225-curie Cs-137 source which is positioned through approximately 30 feet via a mechanical ball and disc integrator drive system. This drive system is positive and easily controlled.

This source, when fully recessed, is within a lead pig of two-inch wall thickness at the bottom of the well. This was found necessary to suppress the radiation level throughout the building when the source was not in use.

3.5 Portable Whole-Body Counter

The capabilities of the whole-body counter for detecting and identifying internal gamma emitters are well known. So that the advantages of this technique would not be limited to facilities having massive, high density shielding and sophisticated electronic counting equipment systems, a portable counter weighing only 650 pounds was developed. It is capable of detecting gamma emitting nuclides at body concentrations well below permissible levels. It should prove valuable for nuclide scanning in personnel protection programs. Description and discussion of the instrument appear as Appendix B in this report.

4. FUTURE PROJECTS

Projects to be initiated and/or completed in 1964 are:

(1) Equipment for the whole-body counters of the Analysis Branch is to be designed and installed with the intent to take full advantage of the high density shielding facilities of the new lab.

(2) A K X-ray unit for the Dosimetry Branch is to be set up for the purpose of making low energy studies of film, instruments, foils, etc.

(3) Design and fabrication of neutron calibration equipment are to be effected. This will provide a more precise and extensive calibration facility for the Instrumentation Branch.

(4) A Mobile Whole-Body Counter and X-ray facility is to be set up for the Medical Services Branch. This will allow scanning of personnel in the field.

(5) A sample changer for automatic spectrum analysis is to be constructed. This will allow long counting times during the absence of personnel.

(6) Development of a battery operated portable scaler for use in field experimentation, such as emergency milk monitoring programs, will facilitate getting to the job and obtaining more acceptable data.

(7) A radiation field simulator and detector is to be designed for the training of personnel in the use of portable detectors without the hazards associated with actual radiation sources.

5. PUBLICATIONS

1. "Automatic Film-Badge Reader Improved", R. B. Purcell, H. McGary, D. Parker, P. Boren, and M. Wilhelmsen, Nucleonics, November 1963.

2. Automatic Film Density Reading System, Rex B. Purcell and Hal McGary, IDO-12029. 1963.

IX. U. S. WEATHER BUREAU
(Norman F. Islitzer, Meteorologist in Charge)

1. SCOPE

The Weather Bureau, under the auspices of ID-AEC, maintains an operational and research weather station at the NRTS. Diffusion weather forecasts are supplied and monitoring of weather conditions is performed for those reactor experiments that are conducted under meteorological control. An active observational and research program, involving the atmospheric transport and dispersion characteristics of the NRTS, is provided for reactor siting and operations.

2. SPECIAL ACTIVITIES

2.1 Spert I Destructive Test Meteorology

The second in a series of Spert I destructive tests, using a low-enrichment uranium oxide core, was conducted on November 10, 1963, under meteorological conditions and control similar to those of the Spert I destructive test of the previous year. Meteorological pre-planning and post-test analyses were comparable to those discussed in the 1962 Annual Progress Report (IDO-12033).

Observed meteorological conditions for the second Spert I destructive test (shown in Table XVII) were quite similar to those of the first test except for

TABLE XVII

OBSERVED METEOROLOGICAL CONDITIONS FOR THE 30-MINUTE PERIOD FOLLOWING SPERT I DESTRUCTIVE TEST ON NOV 10, 1963 (HEIGHT 6 METERS)

Location	Wind Direction (degrees)	Wind Speed (m/sec)
SPERT	238	6.7
Shell Road	233	6.3
Stage Road	232	5.4
Temperature lapse (75-6 meters)	-3.7°F	

No precipitation

Horizontal wind direction standard deviation (σ_θ) = 13.1°

Vertical wind direction standard deviation (σ_ϕ) = 5.3°

Wind speed standard deviation (σ_μ) = 1.3 m/sec

(Averaging time, 4 seconds)

wind speeds. Average speeds of 10 and 6.7 m/sec were measured for the first and second tests, respectively. Further meteorological considerations are treated separately in Appendix C of this report.

In support of the Spert I destructive test, a tetroon with transponder was flown over Spert I shortly before initiation of the test. This target was followed by an M-33 radar (Figure 10) positioned several miles to the west of the test site on Grid No. 3. The tetroon appeared to travel somewhat to the east of the centerline of the radioactive effluent plume, the latter having gone only a few degrees to the right of grid-center. The more easterly direction of the tetroon was due to the delay of some four minutes after the tetroon passed over Spert I before initiation of the test. Shortly before test initiation a temporary shift of the wind to a more westerly direction was measured.

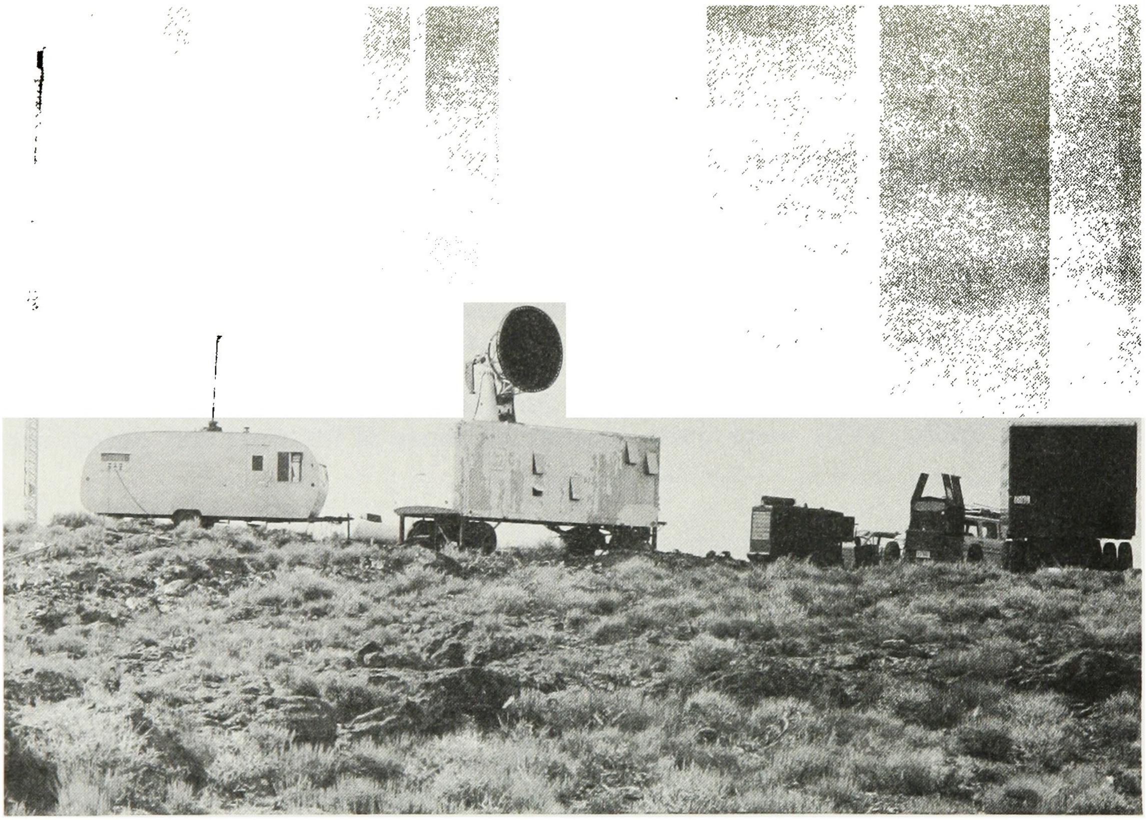

FIG. 10 M-33 RADAR UNIT.

2.2 Controlled Environmental Radioiodine Test (CERT) Meteorology

Meteorological studies were undertaken at the CERT site in advance of the planned test date in order to ensure that the sampling grid be properly oriented and to achieve the desired amount of I-131 activity in the cows' milk. Meteorological requirements were (a) wind direction downgrid (WSW), (b) wind speed 5-10 m/sec, (c) lapse stability conditions, and (d) no precipitation.

Forecasting was commenced on May 20, 1963, the first test day by which preparations were complete. On May 27, conditions were favorable and the iodine release was accomplished. Average meteorological conditions during the one-half hour release over the sampling grid were as follows:

Location	Height (m)	Wind Direction (°)	Wind Speed (m/sec)	Temperature (°C)
Grid	6	242	6.6	
Tower	1	231	5.2	22.3
Tower	4	236	7.1	21.1
Tower	16	235	8.4	20.5

Horizontal wind direction standard deviation (σ_θ) = 14.3°

Vertical wind direction standard deviation (σ_ϕ) = 6.1°

(Averaging time, 2 sec)

Wind speed, air temperature, and hourly precipitation were recorded for several weeks after the test release for possible meteorological evaluation of the change of I-131 activity on the grass with time. Post-test meteorological evaluations of air concentration and deposition data are presented in Appendix D of this report.

2.3 Radar-Transponders

Reflecting targets, such as constant level balloons (tetroons), have been used and tracked successfully some 15 to 20 kilometers at the NRTS with the M-33 radar. This range is too limited for many practical studies, so a transponder was developed for extended ranges. The transponder is an electronic transmitting beacon which is carried by the tetroon and indicates on the radar scope the position and range of the tetroon-transponder. Several prototypes of the transponder have been developed for the M-33, with basic design changes over the WSR-57 transponder discussed in the 1962 report. Successful tracking has been achieved out to 90 kilometers, which is the present range of the M-33 radar scales. A large number of transponders are being purchased for extensive studies and support of reactor operations in 1964. Radar and transponder were used in meteorological support of the second Spert I destructive test. The radar also was used for precise positioning of the aerial monitoring team during the Spert I test.

2.4 Incident Emergency Capability

The meteorological capability at the various reactor areas has been increased by the addition of meteorological towers and recording anemometers. Fifteen-meter meteorological towers with an anemometer at the top have been installed at Spert, EBR-I, ML-1, and NRF and are recorded either in the health physics or reactor operating room in the respective areas. A 73-meter tower has been erected at the EBR-II site with winds and temperatures at several levels supplied both to the contractor area and, by telemetry, to the Weather Bureau office at Central Facilities. This installation will supply the meteorological information for the EBR-II - TREAT area. A 61-meter stairway-type tower for both meteorological research and operational purposes has been installed at Grid No. 3, about 1.6 kilometers from both the ICPP and TRA areas. Wind data from the top level of this tower will be telemetered to ICPP and TRA. This network of meteorological stations (Figure 11), in addition to those already at TAN and CFA, will supply the meteorological information needed for coping with any nuclear events in which radioactive material might be emitted into the atmosphere.

2.5 TRA Diffusion Studies

Twelve releases of a fluorescent tracer, uranine dye, were conducted at the southwest side of the MTR building to simulate the release of radioactive effluents from the building in case of a reactor accident. The purpose was to

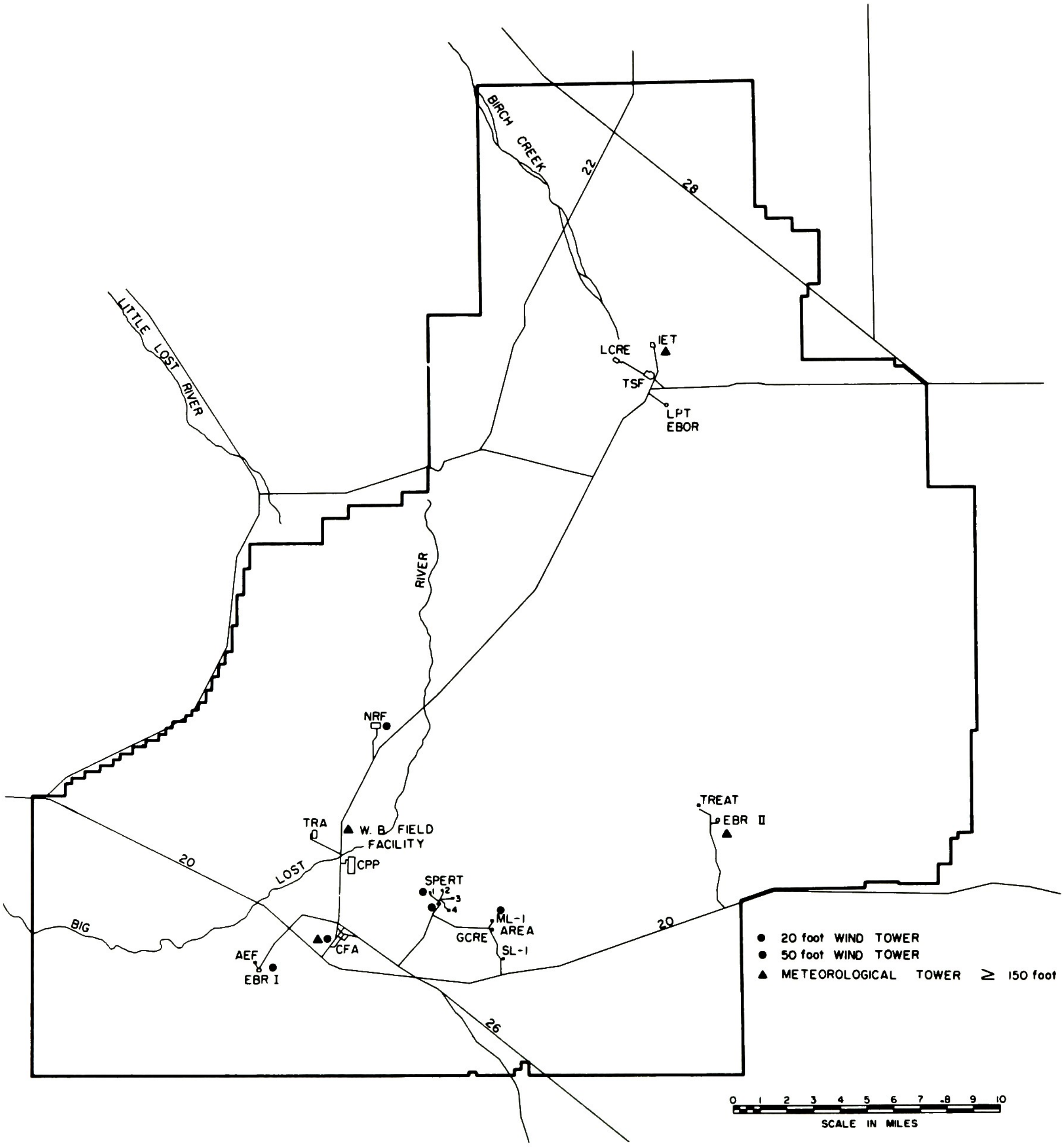

FIG. 11 LOCATIONS OF METEOROLOGICAL INSTRUMENTATION ON THE NATIONAL REACTOR TESTING STATION.

determine the effect of the buildings upon the normal dispersion characteristics experienced over a flat plain. Releases were conducted over the sampling grid extending to 800 meters downwind for 30-minute periods in conjunction with sampling of the wind turbulence and speed by bivanes and anemometers at various distances downwind. The results of 10 releases during lapse conditions indicated that about a factor of four increase of diffusion could be expected in the first 100 meters downwind, compared to the average case over a flat plain, decreasing to a factor of two at 800 meters. The results of two similar attempts during inversion conditions were inconclusive because it was difficult to obtain a well-defined wind over the sampling grid under such conditions in the MTR area. It appears unlikely that the diffusion, as affected by buildings for inversion cases, would exceed the flat plain case by more than a factor of five for the first 400 meters. From these studies, it appears that the effect of the buildings upon diffusion in the first few hundred meters downwind of a large reactor complex would not decrease concentration by more than a factor of five for all meteorological cases.

2.6 Diffusion Climatology

Wind direction persistence is a meteorological statistic of increasing importance for reactor siting or for tests such as the LOFT, for which long-period effluent releases (hours to days) are planned. Persistence is defined as the uninterrupted period in which the wind, once it has started blowing in a certain direction, persists at that direction without a break. Records of wind direction from past years taken at the CFA were studied to determine the probability of wind direction persistency for any given length of time. The results are shown in Figure 12, indicating that the probability of any one wind direction persisting for more than four hours is quite low. The wind direction is taken to

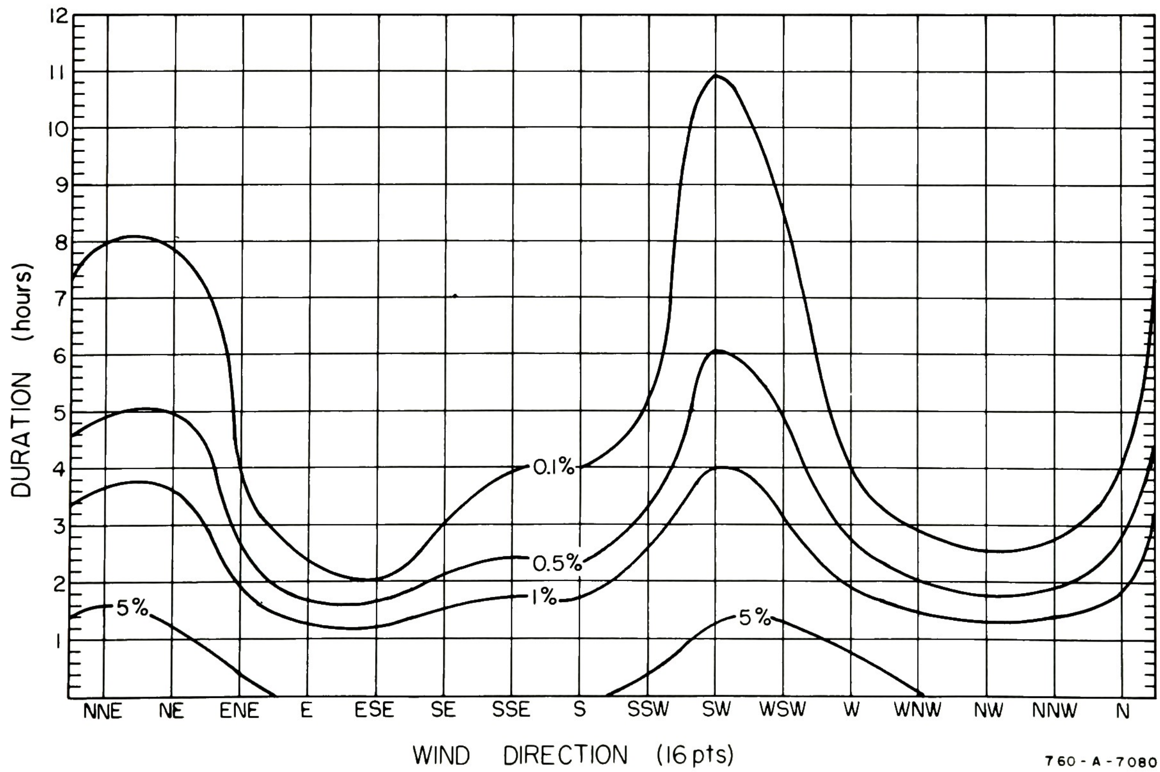

FIG. 12 CFA WIND DIRECTION PERSISTENCE.

the nearest 16th point of the compass, which indicates a 22-1/2° sector. It can be seen that the probability of the wind's blowing from one direction for more than 11 hours is less than 0.1 percent. The longest durations are from the southwest or northeast quadrants. A current study involving automatic processing of large quantities of data will explore the persistence of wind direction based upon two or more sectors. This information will indicate the probability of doses being confined to a small area from long-period sources.

3. FUTURE PROGRAMS

3.1 Meteorological Support of Reactor Test and Plant Operations

3.11 Spert Destructive Tests. Additional tests in the Spert I destructive series are planned for 1964, and meteorological support and analysis will continue in the same manner as with the first two destructive tests. Several modifications have been suggested to the Health Physics Branch with respect to data sampling and deposition measurements which will render the modifications even more meaningful for meteorological analyses. For example, it would be desirable to make better measurements of cloud arrival time, passage time, peak radioactivity, etc. This could be accomplished by the use of wider range monitors, higher speed recorders, and more precise chart timing equipment.

3.12 SNAPTRAN Test. The SNAPTRAN 2/10A-3 excursion, to be conducted at the IET facility, may result in the release of a significant amount of radioactive material which will be ideal for diffusion studies. Extensive meteorological support of this test is planned, including the radar and transponder capability. It is planned to locate the radar several miles east of IET on Circular Butte, which provides a good observation point for the entire area. Several bivanes will be placed on the IET tower to record turbulence statistics for deposition and diffusion calculations. A telemetered wind station will be placed downwind on the grid to supplement the meteorological instruments now on the IET tower. It is anticipated that the dispersion and transport parameters during the test will be precisely determined for optimum evaluation of radiation measurements and source calculations.

3.13 Waste Calciner. The air sampling, deposition, and animal studies by the Health Physics Branch for the Waste Calciner operations will be evaluated for meteorological purposes as the data become available. Meteorological information for these studies will be supplied by the Grid No. 3 installation. Sampling in the latter part of 1963 indicated that there was enough radioactive material collected to make meteorological studies feasible.

3.2 CERT

The CERT tests for the summer of 1964 will be conducted under meteorological control with extensive sampling of micrometeorological variables for deposition calculations. More detail on the relationship between deposition velocities and different types of media also will be investigated. The information should shed further light on the magnitude of I-131 ingestion doses via the milk chain.

3.3 Radar Studies

Some 100 to 150 transponder runs with the M-33 radar are contemplated for 1964 studying special meteorological situations both at TAN and Grid No. 3 sites. Support of special tests such as Spert and SNAPTRAN destructive tests also will be carried out. It is expected that from these studies wind conditions such as the wind shear line between the south and north ends of the site, as well as the nocturnal wind reversal, will be better understood. Trajectories to 80 kilometers are anticipated, and possibly, a diurnal trajectory of 24 hours in length will be obtained.

3.4 Climatology

Wind direction persistence studies using the computer, along with other specialized statistics, will be the basic material for a 1964 addendum to the Diffusion Climatology of the NRTS, (IDO-12015) published in 1960. The new report will contain statistics needed for the calculation of diffusion for long-period sources. It is hoped that the report will be completed by the end of 1964. In the interim, special information-type write-ups will be distributed as the material is obtained.

3.5 Iodine-129 Technology Study

If the development of the dissemination, collection, and analysis of I-129 appears suitable, it is proposed to perform studies at Grid No. 3 in the summer of 1964. The feasibility studies will be designed to determine the characteristics of I-129 for use as a meteorological tracer. A private contractor is developing the laboratory techniques for preparation and analysis of the tracer and also the means of sampling the gaseous form. Both gaseous and particulate tracers are being prepared, and part of the experiment on Grid No. 3 is to check the differences in dispersion between the two different forms.

3.6 Multiple Tracer Development

A feasibility study for a multiple tracer meteorological technique will be conducted with the Analytical Chemistry Branch. Various elements, particularly copper and manganese, will be irradiated and analyzed after dissemination and collection in the atmosphere. Background level, sensitivity, and cost for each selected element will be provided if the idea proves useful. The possibility of quantitative analysis of each tracer, when several elements are disseminated and collected simultaneously, will also be explored.

4. PUBLICATION

"Atmospheric Diffusion-Deposition Studies over Flat Terrain", Norman F. Islitzer and R. Keith Dumbauld, Int. J. Air Wat. Poll., 1963, Vol. 7, pp 999-1022.

APPENDIX A

ENVIRONMENTAL MONITORING DATA FOR THE NATIONAL REACTOR TESTING STATION

ENVIRONMENTAL MONITORING DATA FOR THE NATIONAL REACTOR TESTING STATION

(C. A. Hawley, Jr. and George J. Ball, Health and Safety Division, ID-AEC)

Continuous radiological surveillance of air, water, and food is conducted in the vicinity of Atomic Energy Commission installations throughout the country. The data gained through such studies enable a determination of what effect the installations have on the environment. Semiannually, summary reports of the results of radiological surveillance are issued to the public.

The Environmental Monitoring Data Report for the National Reactor Testing Station (NRTS) for the year 1963 discloses that the amount of radioactive materials in the environs of NRTS was below Radiation Protection Guide (RPG) values recommended by the Federal Radiation Council (FRC) as a threshold of concern. The environmental radioactivity reported represents activity from all sources. No attempt has been made to separate activity contributed by NRTS operations (if any) and that contributed by fallout from weapons test debris.

The locations of the fixed stations around the NRTS where routine samples of air, water, milk, and wheat are collected to be analyzed for radioactivity are shown in Figure A-1.

1. ANALYTICAL LIMITS

The detection limits resulting from the sampling and analytical methods used are given in Table A-1.

2. OFF-SITE UNDERGROUND WATER

Low-level activity liquid wastes are introduced to the ground water by means of disposal wells and ponds located near the various facilities. These wastes are monitored before disposal. In addition, off-site underground water samples are collected at regular intervals for monitoring purposes. Most of these samples are taken from an area southwest of the site since this is the most prevalent direction of underground water flow.

A year's total of 127 samples was collected on a quarterly basis from the 32 sampling stations. Analysis of these samples showed that alpha, beta, and tritium activities were no more than 40, 1.0, and 0.2 percent of the respective Radioactivity Concentration Guide (RCG) values.

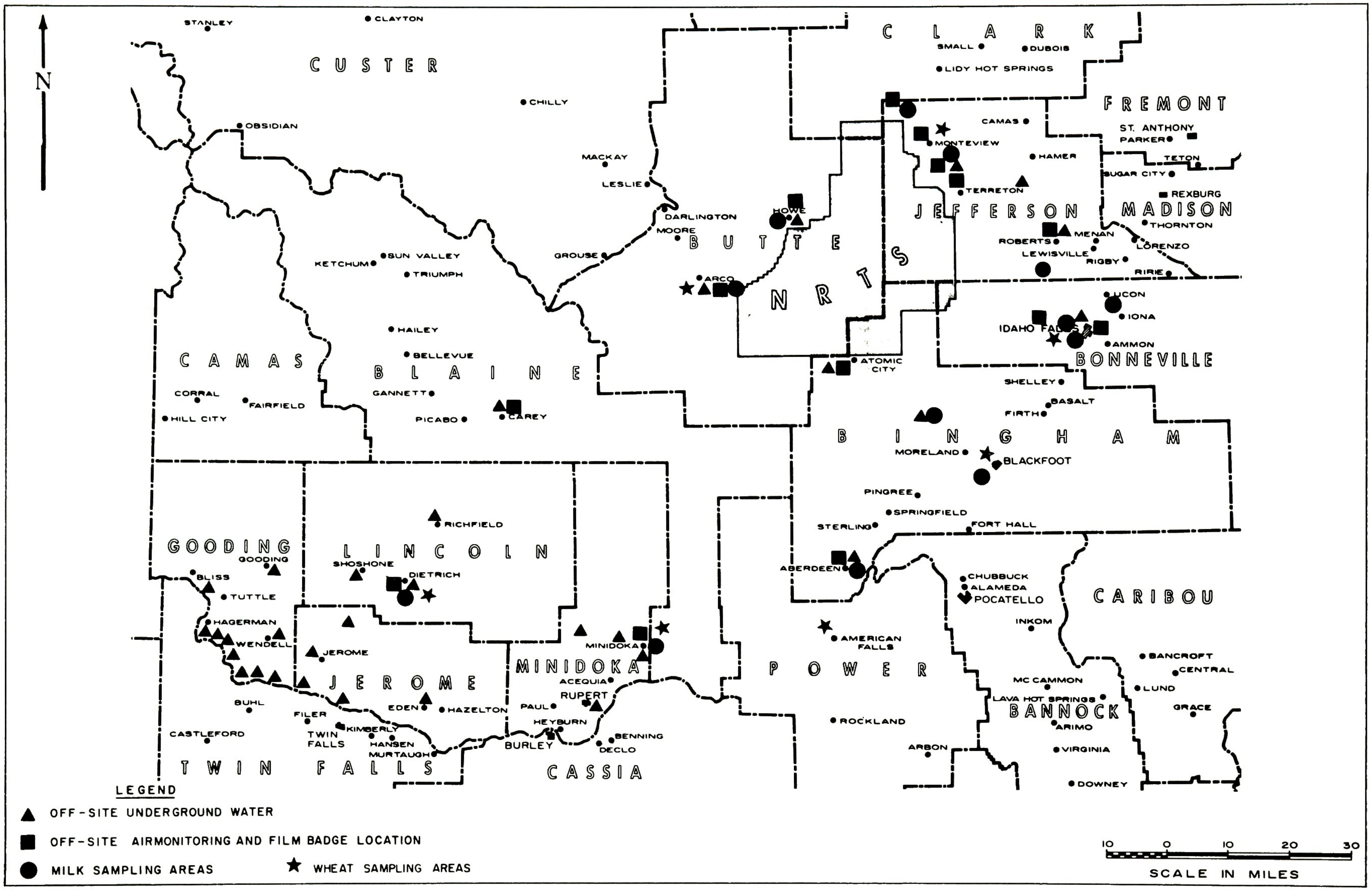

FIG. A-1 NRTS ENVIRONMENTAL MONITORING PROGRAM FOR 1963.

TABLE A-1

DETECTION LIMITS RESULTING FROM THE SAMPLING AND ANALYTICAL METHODS

Type of Sample	Nuclide or Radiation Type	Detection Limit
Water	Alpha	3×10^{-9} μc/ml
	Beta	6×10^{-9} μc/ml
	Tritium	4×10^{-6} μc/ml
Milk	Iodine-131	20 pc/l [a]
	Strontium-90	1.5 pc/l
Film Badges	Gamma	10 mrem
	Beta	10 mrem
Low Volume Air	Gross beta-gamma	1×10^{-16} μc/ml
Wheat	Strontium-90	6×10^{-8} μc/g
	Cesium-137	1×10^{-7} μc/g

[a] Due to the changing percentage of iodine-131 relative to other fission products from weapons testing, the detection limit for iodine-131 in milk was changed from 10 to 20 pc/l in August of 1963.

3. ON-SITE PRODUCTION WELL WATER

On-site samples were taken from production wells in and near the plant sites in order to monitor water used for NRTS personnel consumption.

During 1963, 459 samples were collected from 22 sampling stations on a biweekly basis. Analyses of these samples showed that alpha, beta, and tritium concentrations were no more than 4, 0.07, and 0.02 percent of their respective RCG values. The RCG values are ten times more restrictive for water which may be consumed by people living off-site than those applied to the water which may be consumed by "radiation-workers" during the course of their on-site work. It will be noted that the on-site percentages are about 1/10 of the off-site percentages, which shows that there is little difference between the radioactivity in on-site and off-site water.

4. OFF-SITE AIR FILTERS

The off-site air samples are collected through the use of a dual filter and a low-volume vacuum pump. The dual filter consists of a paper filter backed by a tube of activated charcoal. This filter is capable of entrapping both particulate and gaseous forms of radioactive material.

Beginning in January of 1964, this system will be replaced by a radiation monitoring telemetry system, which will be described in more detail in subsequent reports.

A total of 704 low-volume air samples was collected from the 14 permanent off-site stations. Results of analyses of these samples showed the concentration to be no more than 15 percent of the RCG values.

5. OFF-SITE MILK

During the year, 199 samples were collected and analyzed for I-131. The resulting yearly average was no more than 20 pc/l. The average for the entire year of 1962 was no more than 60 pc/l. This indicates a significant drop in I-131 concentration in milk during 1963.

During 1962, Sr-90 analyses were run on milk from eight of the sampling stations taken bimonthly. It was decided that this sampling period and number of samples should be increased to reflect the changes in strontium concentrations which are caused by seasonal changes in dairy feeding practices. Therefore, Sr-90 analyses during 1963 were made on milk from ten of the stations on a monthly basis. While the I-131 levels in milk have decreased significantly, the levels of Sr-90 continue to increase as predicted by the current fallout model. The 1962 average concentration was 9 pc/l, whereas the 1963 concentrations show an average of 25 pc/l. This average concentration is about 13 percent of RCG values. In reviewing the attached data sheet, it is noted that the maximum activity of Sr-90 in one of the samples collected during 1963 was greater than the listed RCG number. Subsequent sampling showed levels to be less than the RCG number, indicating the high reading sample was not valid. It should be kept in mind that the guidelines established by the FRC point out radiation levels above which positive control measures should be considered. However, the levels specified must be maintained for years before any apparent biological damage could result. The average concentration for the year (13 percent RCG value) indicates that the recommended guide value has not been exceeded.

6. AREA MONITORING BADGES

Off-site area film badges were collected on a monthly rather than a six-week basis throughout the year. Eighty-three badges were issued at 14 fixed stations, and indicated exposures well below those recommended by the FRC. The results of data analysis show no significant direct radiation above normal background.

7. WHEAT MONITORING

The analysis of Sr-90 and Cs-137 in wheat was started in 1963, as another aspect of monitoring radioactivity in the NRTS area. Sr-90 in wheat was determined by chemical processing of the strontium from a 25 gram sample and a subsequent 30 minute count in a low background beta counter. Of the 16 samples analyzed, 10 were less than the detection limit of 0.06 pc/g with the high observed value being 0.17 pc/g.

Cs-137 activity levels in wheat were determined by gamma spectrum analysis of 3 liters (approximately 2200 g) of wheat in a Marinelli-type container. Cs-137 levels in wheat were from 100 to 0.80 pc/g with an average of 0.45 pc/g. From the spectra made during the Cs-137 analysis, the presence of a gamma emitter with an energy of 0.84 MeV was observed. This energy was identified as being emitted by Mn-54 and later substantiated by chemical analysis. Mn-54 values ranged from 0.50 to 100 pc/g with an average of 0.41 pc/g.

Although no RCG's pertaining to wheat have been established, consideration of the above data indicates that the wheat is not a significant contributor to the radiation dose to the local population.

APPENDIX B

NATIONAL REACTOR TESTING STATION WHOLE-BODY COUNTER

NATIONAL REACTOR TESTING STATION WHOLE-BODY COUNTER

(C. W. Sill and DeRay Parker, Health and Safety Division, ID-AEC)

Whole-body counters for the direct invivo measurement of internal radioactive contaminants in human subjects have become nearly indispensable tools for routine personnel monitoring of radiation workers, as well as for research purposes. This is particularly true for the early detection of insoluble particulates in the lungs which are not generally detected by conventional methods of bioassay. However, the heavy steel shields generally used with whole-body counters to obtain very low backgrounds are expensive and immobile. If whole-body counting is used routinely for monitoring personnel from several reactor areas located at considerable distances from the counting facility, the continuing costs, resulting from working time lost while subjects are being transported to and from the facility, are even greater. Consequently, this very sophisticated technique is not as widely used as it would be if the costs were lower.

A portable whole-body counter has been built by the Analysis and Instrumentation Branches at the ID Health and Safety Laboratory for routine use at the National Reactor Testing Station. The prototype (shown in Figure B-1) weighs only 650 pounds and can easily be mounted in a small van to permit moving the counter routinely to all areas desiring service, while keeping operating costs to a minimum. Shielding of the subject is limited to a 1/2-inch lining of lead underneath the chair and around its back. The detector consists of a 3- x 3-inch thallium-activated, sodium iodide crystal with an integrally-coupled multiplier phototube in a 3/4-inch lead shield. The end of the shield is flared out from the crystal to permit an angle of view of about 130° when the end of the detector is in contact with the subject. The complete detector head assembly weighs about 60 pounds, but is easily positioned.

Under normal conditions, approximately 0.01 μc of most gamma-emitting nuclides (such as Cs-137) can be detected in a human subject in a 10-minute count with the Portable Whole-Body Counter. Even in reactor areas, the sensitivity is decreased by less than a factor of ten due to the increased background, a level that is completely adequate for practical personnel protection. Although choice of counting equipment is optional and can amount to many thousands of dollars, a complete instrument with a 100-channel, pulse-height analyzer and printer can be obtained for about $7000.

FIG. B-1 NRTS PORTABLE WHOLE-BODY COUNTER.

APPENDIX C

HEALTH PHYSICS ASPECTS OF SECOND SPERT I DESTRUCTIVE TEST, NOVEMBER 10, 1963

HEALTH PHYSICS ASPECTS OF THE SECOND SPERT-I DESTRUCTIVE TEST, NOVEMBER 10, 1963

(John P. Cusimano, Robert W. Henry, Donald R. Percival, and Delbert F. Bunch, Health and Safety Division, ID-AEC)

The program for the second Special Power Excursion Test (Spert) I had as its primary objective the study of the nature of the destructive effects which could be produced by a severe power excursion in a low-enrichment, uranium oxide core. The primary responsibility of the ID Health and Safety Division has been to ensure that the series of Spert destructive tests was conducted in such a manner as to preclude the possibility of radiological hazards, both on NRTS and off-site. In addition to its safety responsibilities, the Health and Safety Division has undertaken numerous research studies to gain information of value in making evaluations of the hazards associated with a future test or similar type of accident. These interests include: (a) radiation levels near the reactor vessel; (b) capability of currently-used personnel dosimetry for determining neutron flux, neutron energy distribution, gamma-to-neutron ratios, and total dose; (c) amounts and types of radionuclides released to the atmosphere, gross particle size determination, and deposition velocity; and (d) cloud tracking measurements and techniques.

The power excursion of the core (stainless steel fuel rods containing low-enrichment, uranium oxide powder) had approximately a 2.1-msec period with a total energy release of 155 MW-sec. Core damage was negligible in this test, with perforation occurring in only two fuel pins and with no apparent metal-water reaction. This was in contrast to the gross damage to the first core (plate-type fuel assemblies of highly enriched, uranium-aluminum alloy, aluminum clad) in the 1962 destructive test.

1. DOSIMETRY

Personnel dosimetry tests, using standard NRTS film badges positioned on phantoms (20-liter polyethylene carboys, filled with tissue equivalent solutions, were conducted to compare results with 1962 Spert test data). Ten of the phantoms were placed on "T"-type fence posts, at distances of 8, 15, and 30 meters from the vessel center. Four phantoms were placed on stands inside the reactor building three meters from vessel center. The centers of the phantoms were one meter above ground to approximate the standard man.

On each phantom was a belt with 12 badges equally spaced and serially numbered, with No. 12 facing the reactor (Figure C-1). Inside each phantom was a badge sealed in polyethylene, to simulate detection of internal dose. Two badges were placed below each phantom to determine exposure in the absence of a scattering medium. A total of 210 badges was used. Results from badges on the four phantoms in the reactor building showed the presence of both beta and gamma radiation. Badges on the four phantoms at eight meters indicated only gamma exposure, and the rest indicated statistically zero readings. The averages of all the film from each phantom that gave readings are as follows:

Belt No.	Beta (mrem)	Gamma (mrem)	Beta/Gamma Ratio
11	1620	530	3 : 1
12	1336	573	2.3 : 1
13	973	567	1.7 : 1
14	1252	358	3.5 : 1
1		< 10	Average Beta/Gamma
4		< 10	Ratio: 2.6 : 1
7		< 10	
10		27	

Internal doses indicated by the badges within the phantoms are as follows:

Belt No.	Gamma (mrem)
11	315
12	375
13	355
14	195

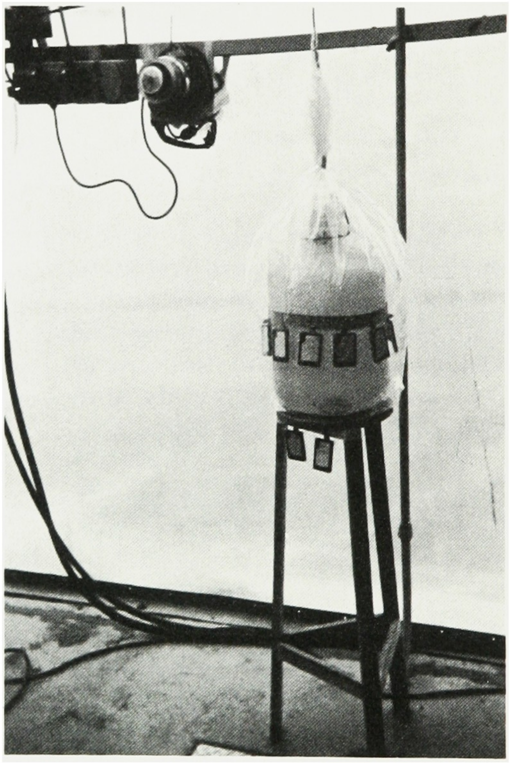

FIG. C-1 FILM DOSIMETERS ON STANDARD MAN PHANTOM.

The front-to-back ratios for the phantoms nearest the reactor were approximately 6 to 1 for beta and 3 to 1 for gamma. Although the doses were much lower for the current test, the ratios correspond to those of the 1962 test. The readings from the badges on the phantoms were compared to those of the badges in free air. The ratios were found to be 1.1 to 1 for beta and 1.4 to 1 for gamma, indicating that the phantoms did act as a substantial backscattering medium. Correlations of neutron and gamma doses have not been determined to date and will be presented in the 1964 Progress Report.

Graphs were drawn, plotting dose on the ordinate and badge number on the abscissa. A graph is shown in Figure C-2. The solid line principally represents prompt gamma dose; the dashed line represents beta dose; and the crosses indicate data from the free air badges (13 and 14) and the internal badge (15). The badge numbers are plotted circumferentially, beginning with the badge

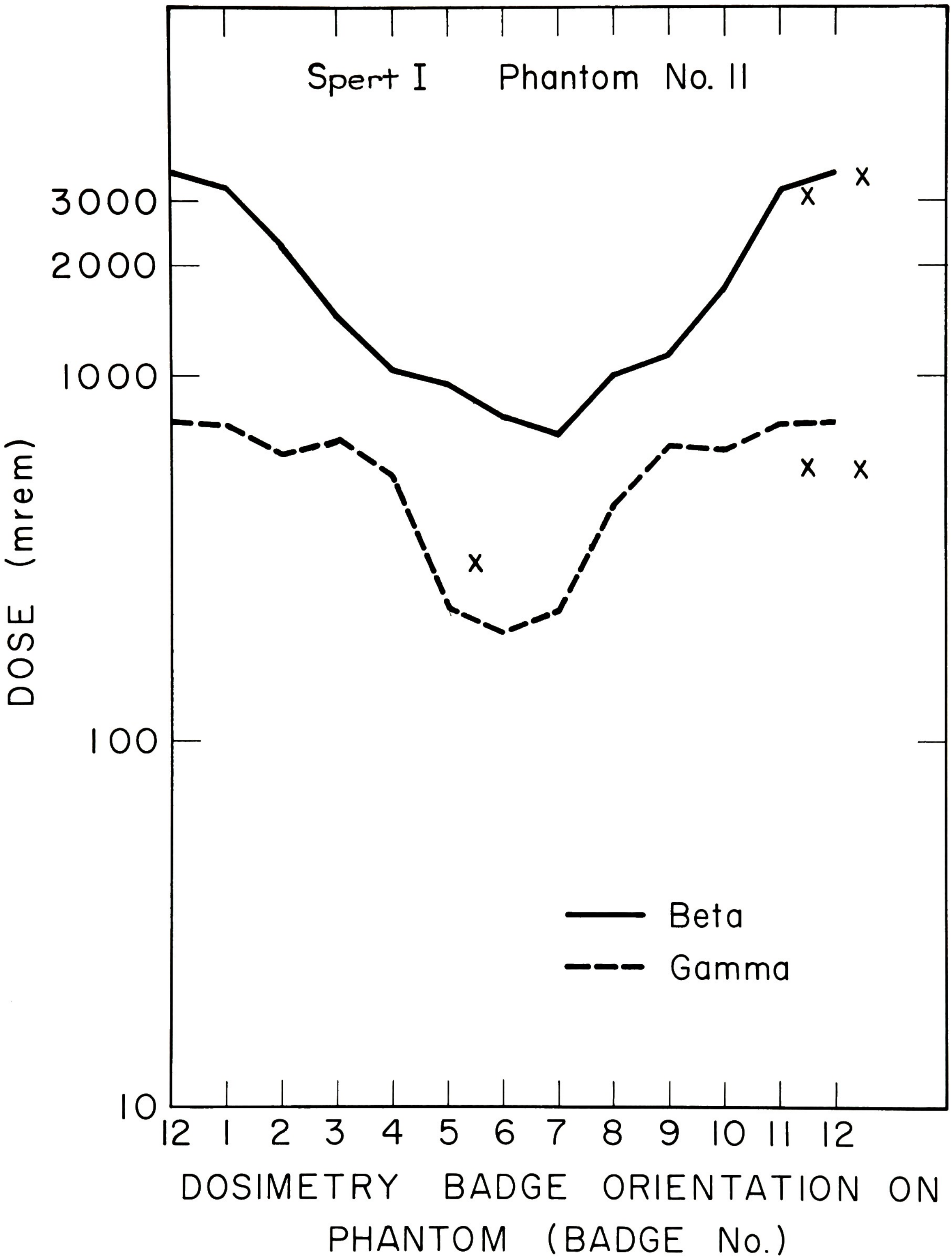

FIG. C-2 DOSE VS DOSIMETER BADGE ORIENTATION ON PHANTOM.

nearest the front. The dip in the curve indicates absorption in the tissue equivalent solution. Since badges 12, 15, and 6 lie in a straight line through the solution, a coefficient of absorption can be estimated. The value is approximately 0.06 cm^{-1}, which corresponds to a gamma energy of approximately 1 MeV.

2. ANALYTICAL

Development of analytical capability relative to criticality accidents was continued. Biological samples, nuclear accident dosimeters, and assorted materials were analyzed following the Spert I destructive test. In-116 and Cu-64 were the only activation products found. Calculations based on the Cu-64 activity found in a 50-g sample showed an integrated flux of 9.3×10^5 thermal neutrons. An integrated flux of 8.4×10^7 thermal neutrons was calculated for the 1962 test.

Analyses for short-lived fission products (eg, Mo-99, Zr-97, Ce-143) were made on samples of the reactor water. Amounts of each were computed and back-corrected to the time of the excursion. From these values, estimates of total excursion fissions were computed as follows: (a) from Zr-97 - 3.9×10^{17}; (b) from Mo-99 - 1.4×10^{19}, and (c) from Ce-143 - 3.6×10^{19}. These estimates compare with 5×10^{18} fissions calculated from a 155 MW-sec excursion.

3. ENVIRONMENTAL MONITORING

The sampling grid was similar to that of the first Spert I destructive test conducted in 1962. High volume air samplers, particle size samplers, fallout plates, grass plots, and film dosimeters were placed at grid stations. Meteorological control requirements and post-test analyses were quite similar to those of 1962.

Integrated air concentrations of radioactive debris were a factor of 100 less for this test than for the first test (1962). This is seen (Figures C-3 and C-4) comparing crosswind curves of integrated air concentrations of collected fission products for the two tests.

Comparison was made of the activity found on grass samples with air sample activity. A mean deposition velocity ($\bar{V}g$) of 0.04 m/sec was derived from these comparisons. This is close to results from the first test. In both destructive tests, most of the airborne activity was associated with particle sizes less than 1.5 μ.

Aerial monitoring of the test was performed using a GM and scintillation counter. At 2500 feet from the reactor the cloud was 700 feet wide with readings of about 1 mr/hr. Monitoring was continued downwind for about 15 miles with readings not significantly above background. Meteorological tracking of the cloud also was accomplished by Weather Bureau personnel using tetroon with transponder and M-33 radar system. Only low level contamination was found in the reactor area following the Spert I destructive test, and there was no residual contamination beyond the immediate test area. During the test and following

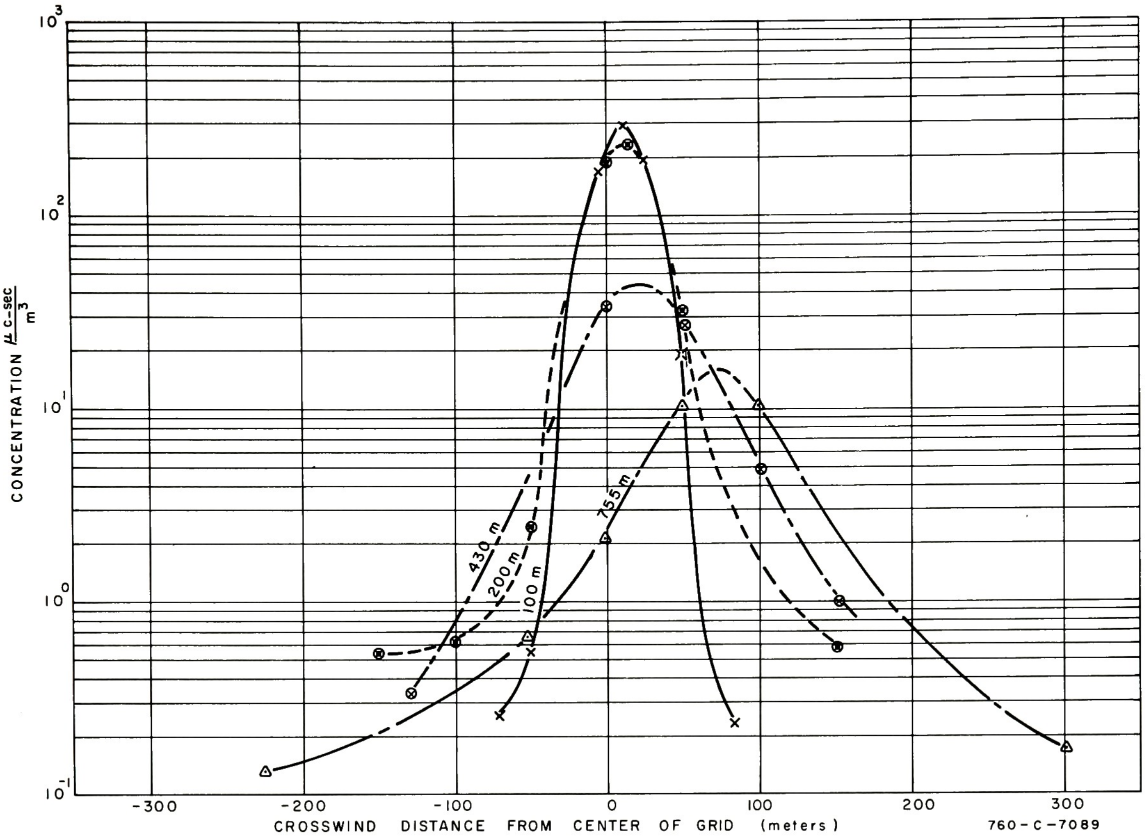

FIG. C-3 CROSSWIND CONCENTRATION CURVES FOR DOWNWIND DISTANCES FROM FIRST SPERT I DESTRUCTIVE TEST, NOVEMBER 5, 1962.

cleanup, no significant internal personnel exposures were detected, and there were no external personnel exposures in excess of 60 mr/day.

4. CONCLUSIONS

No halogens were detected in this test by gamma spectrometry. Estimates of the detection limits of I-131 and I-135 indicated that the maximum possible releases for these isotopes were both less than 0.01 percent.

Concentrations of airborne radioactivity appeared to be a factor of 100 less; the release fractions a factor of 350 less; although the period of the second test was about one millisecond shorter, and the energy release about five times greater, than in the first test.

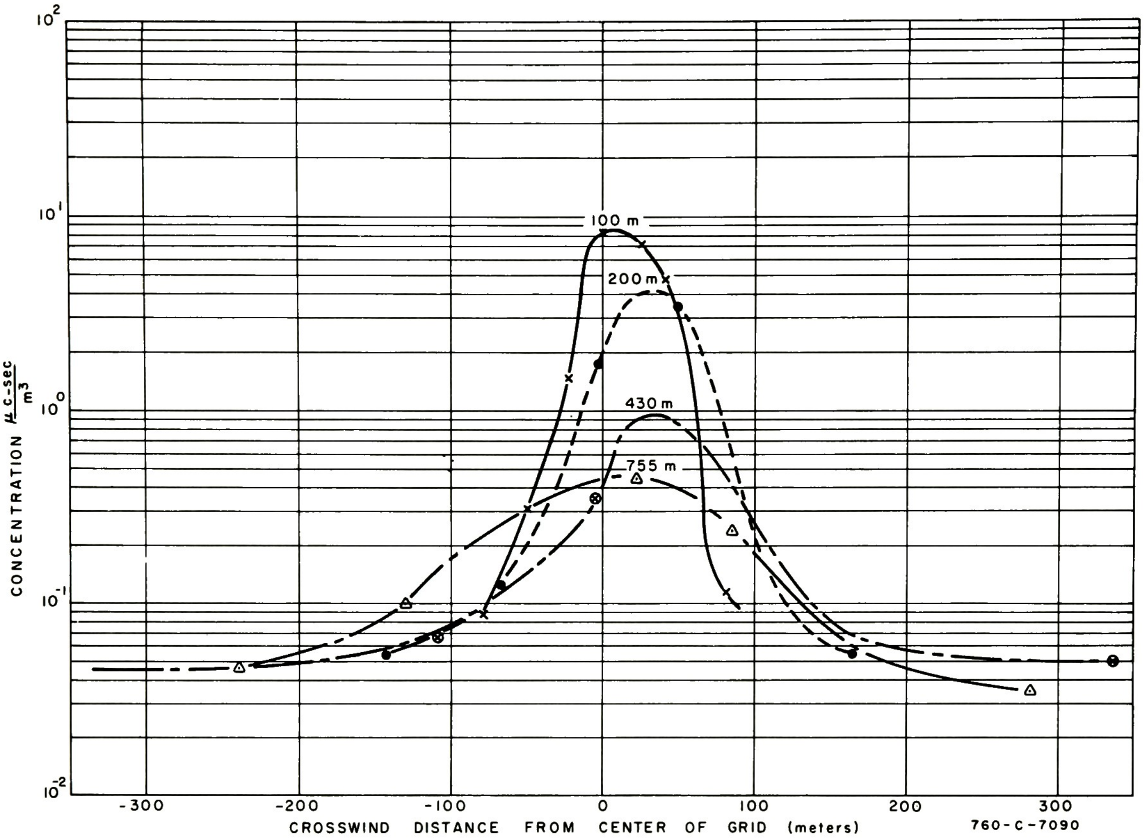

FIG. C-4 CROSSWIND CONCENTRATION CURVES FOR DOWNWIND DISTANCES FROM SECOND SPERT I DESTRUCTIVE TEST, NOVEMBER 10, 1963.

APPENDIX D

CONTROLLED ENVIRONMENT RADIOIODINE TEST AT THE NATIONAL REACTOR TESTING STATION

CONTROLLED ENVIRONMENT RADIOIODINE TEST AT THE NATIONAL REACTOR TESTING STATION

(C. A. Hawley, Jr., C. W. Sill, G. L. Voelz, Health and Safety Division, ID-AEC, N. F. Islitzer, U. S. Weather Bureau)

1. INTRODUCTION

Questions pertaining to the behavior and effects of radioiodine as a hazard to the population are currently receiving considerable attention. Studies in the laboratory yield information which is limited in application to a large portion of a natural environment. Where radioiodine is released into the environment, the portion of the environment affected, as well as the extent of the effect, depends on a sizable number of variables. The CERT project was designed to ascertain if these variables could be defined, controlled, measured, and reproduced under actual field conditions within the limits of modest effort and expense.

2. DISCUSSION

The CERT project consists of a series of planned releases of radioiodine over different vegetation and during various meteorological conditions, with the objective being to measure the amounts of radioiodine through the air-vegetation-cow-milk-human chain. This discussion deals with the first, or preliminary, experiment in the CERT series at the National Reactor Testing Station (NRTS) in southeastern Idaho. The preliminary experiment consisted basically of releasing radioiodine (I-131) gas over a natural Crested Wheatgrass pasture and using contaminated grass for milk cow grazing. The resultant radioactive milk was fed to seven human volunteers whose thyroid radioactivity was subsequently analyzed to determine radioiodine uptake. It was desired from this experiment to determine if the experimental design would establish, under known natural release conditions, three basic relationships:

(1) the amounts of radioiodine in the air to those on the soil and vegetation;

(2) the amounts of radioiodine on the vegetation to those in the milk, and

(3) the quantities in the milk to those in the human thyroid after drinking the milk.

Two 4.65 hectare pasture areas with an initial grass density of 150 g/m^3 and an average height of 13 cm were established, one for contamination (hot) and one for control or background (cold). Figure D-1 shows layout of experimental area. Five I-131 generators, with the I-131 gas and nitrogen gas, were oriented along a 150-meter line normal to the expected prevailing wind, to simulate a short line source. The source line was 50 meters upwind from the "hot" pasture. A dense sampling grid based on pre-test meteorological studies was established

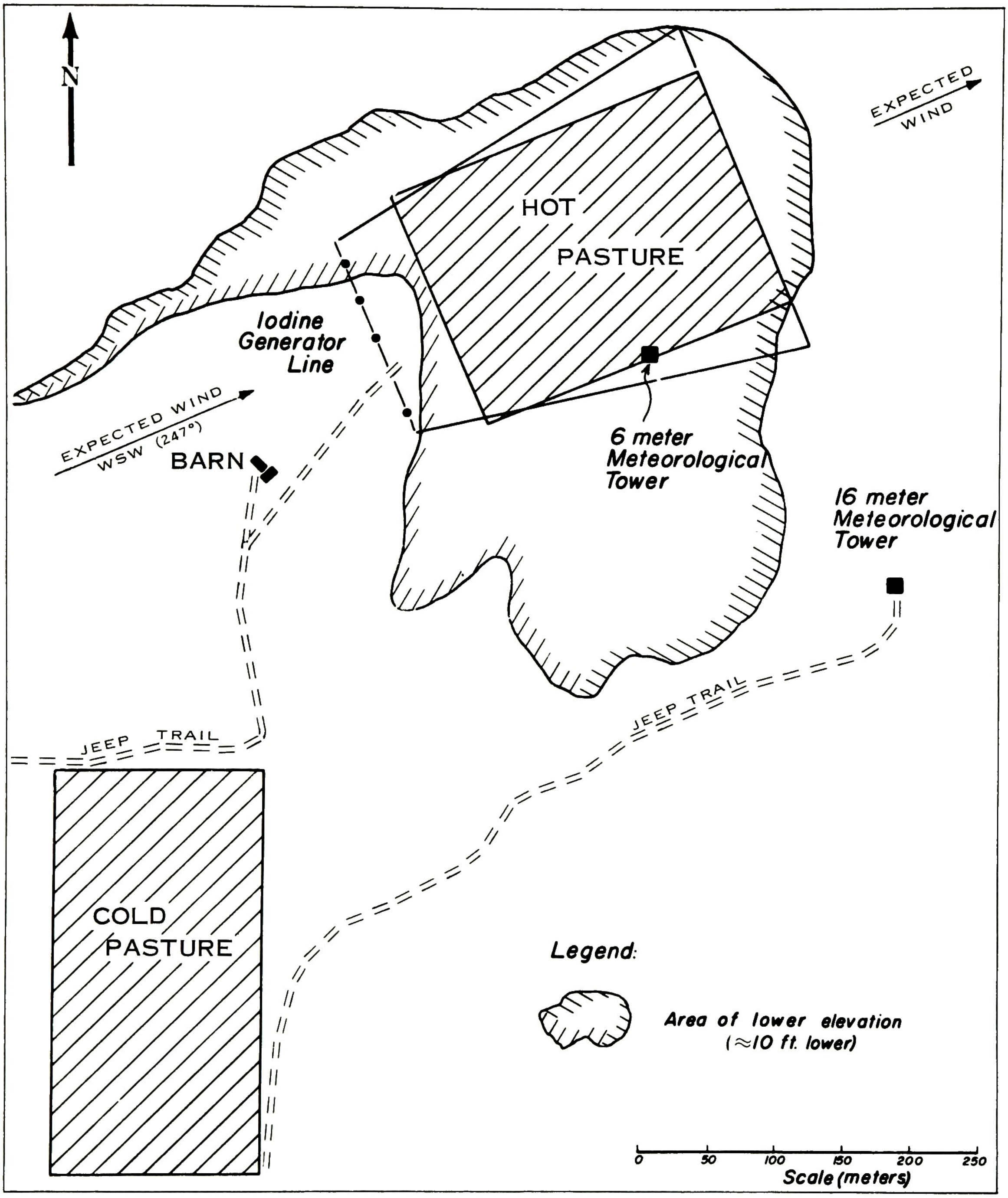

FIG. D-1 CERT EXPERIMENTAL AREA LAYOUT.

to 300 meters downwind. Background activities on soil and vegetation, as well as grass consumption and growth rates, were measured before and after iodine release.

Milk production and activity levels were measured. The six cows used during the test were 1200-pound to 1600-pound, fresh, purebred Holsteins. Arrangements were made to maintain the cows on their normal feed supplements, and the cows were acclimated to the natural grass and new surroundings for two weeks prior to placing them on the contaminated pasture. The cows were milked at 6:00 a.m. and 6:00 p.m. daily. Milk from the evening and morning milking of one cow was combined, pasteurized, counted, and consumed by seven volunteers over an 18-day period. Human thyroid activities were measured with a NaI crystal, 256-channel analyzer, in a low background whole-body counting vault over a 39-day period.

A total of 970 mc of I-131 gas was released at 1500 hours MST on May 27, 1963, near ground level over a 30-minute period under moderately unstable meteorological conditions and an average wind speed of 6.6 meters per second. About 13 percent of the total released iodine was deposited on the grid as indicated in Figure D-2 with 1.5 percent being actually on grass. The Crested Wheatgrass covered about 15 percent of the total plot, the remaining surface being soil cover. Deposition velocities ranged from 0.4 to 0.8 cm/sec, with an average of 0.6 cm/sec. The activity on the carbon fallout plates was found to be representative of the grass measurements.

Controlled grazing, which consisted of daily changes of 0.2 hectare crosswind grazing strips progressing from 300 meters downwind toward the source, enabled the quantitative measurement of grass consumption and activity. The effective half-life of I-131 on grass was found to be about 3.5 days. The "effective" cow consumption measurement, which represents the accumulation of activity within the cow from the current and previous days' grazing, based on a one-day "half-life" retention factor and the measured activity in the milk, showed a good correlation. The ratio of activities of milk and grass (pc/l:pc/g) was 240 ± 35. The average human thyroid uptake of ingested I-131 in milk was 19 percent. A model to predict thyroid activity levels was developed and shown to be quite accurate. Integrated thyroid doses to the volunteers averaged 0.39 rad. Curves of thyroid iodine activities are shown on Figure D-3.

3. CONCLUSION

The preliminary experiment showed that the basic operational procedures were adequate for obtaining the necessary data. Subsequent tests in the series will employ the same general procedures for investigating the behavior of radioiodine under various meteorological and physical conditions. Although information applicable to all locations is improbable, the CERT project will furnish information applicable to the NRTS and its particular environs. The results should contribute to and facilitate accurate decision making in the event of a major contamination incident. It also should aid in developing better reactor siting criteria and in reviewing safety analysis reports. A more complete discussion of test objectives, data, and conclusions may be found in IDO-12035.

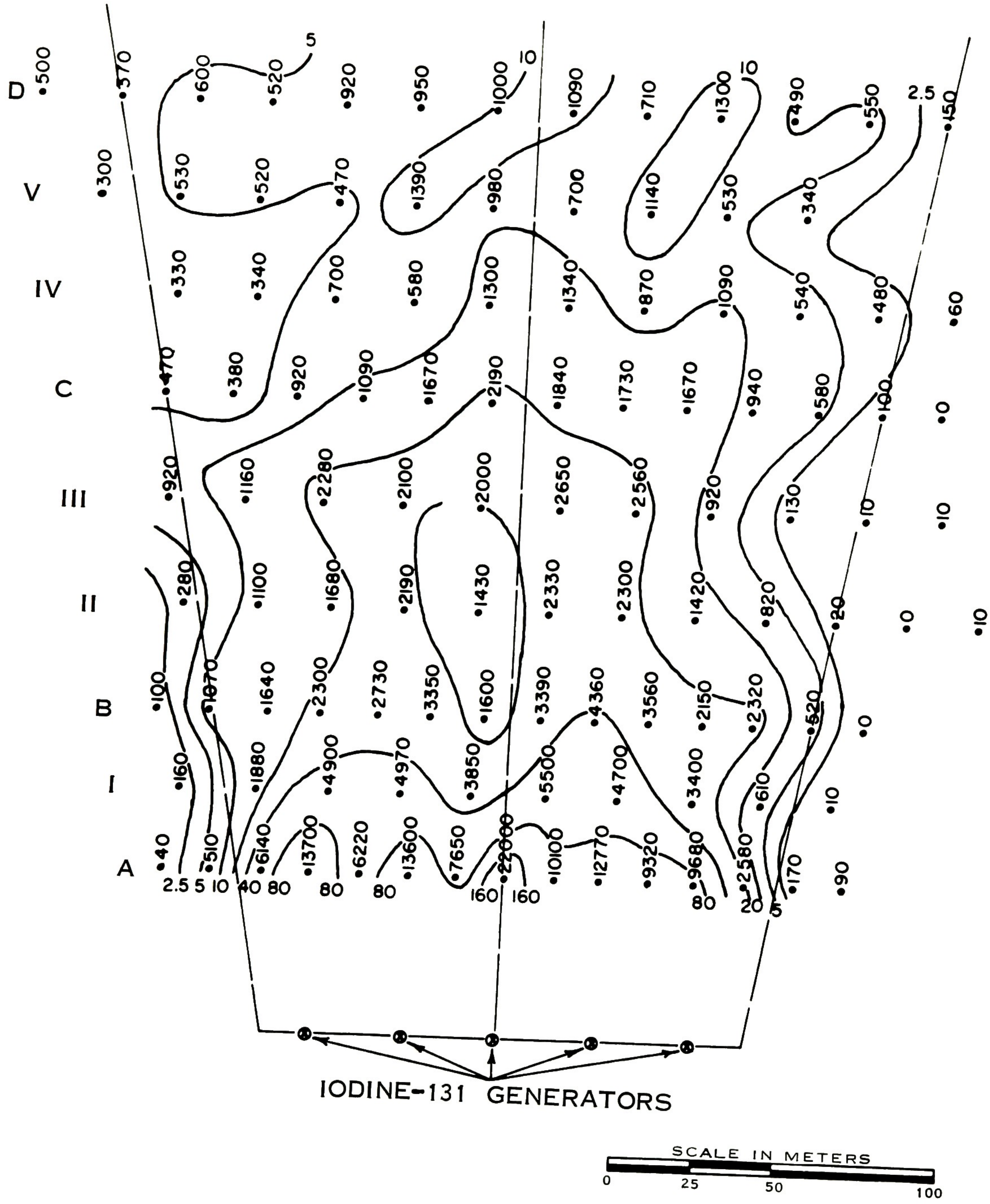

FIG. D-2 ISOPLETHS OF I-131 ON CERT PASTURE.

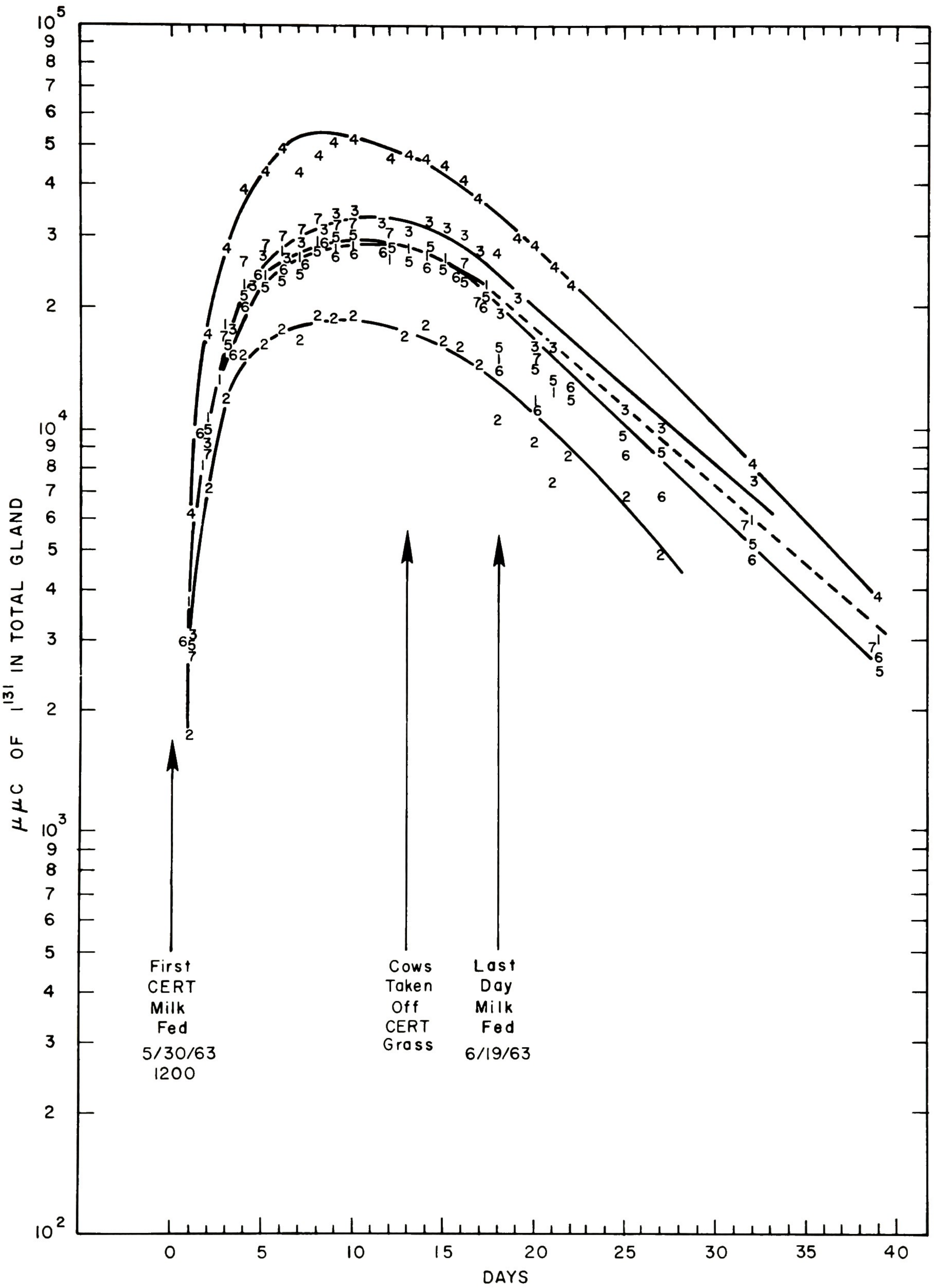

FIG. D-3 THYROID I-131 ACTIVITIES OF CERT INDIVIDUALS.