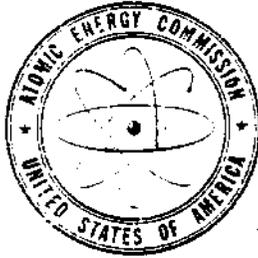


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NATIONAL
REACTOR
TESTING
STATION

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U. S. ATOMIC ENERGY COMMISSION

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HEALTH AND SAFETY DIVISION

ANNUAL PROGRESS REPORT, 1962

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Director

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Idaho Operations Office
U. S. Atomic Energy Commission

0029940

HEALTH AND SAFETY DIVISION
ANNUAL PROGRESS REPORT
1962

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NATIONAL REACTOR TESTING STATION NOMENCLATURE

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

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I. INTRODUCTION

(JOHN R. HORAN - DIVISION DIRECTOR)

This Progress Report summarizes for 1962 the significant health and safety data characterizing the protection program for over 5,000 persons at the National Reactor Testing Station in southeast 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.

The Health and Safety Division of the AEC's Idaho Operations Office is charged within its area of responsibility of maintaining a safe occupational environment throughout the Testing Station and of preventing any adverse effect upon near-by installations or off-site communities. In the discharge of its duties, the Division (1) maintains an extensive on-site and off-site environmental monitoring program to measure radioactivity in air, vegetation, milk and ground water; (2) provides personnel radiation dosimetry services to all organizations at the NRTS whose operations involve potential occupational exposure to ionizing radiation; (3) provides and services radiation monitoring instruments for all NRTS organizations; (4) maintains a radiochemistry analytical laboratory for research and for program support service in the evaluation of toxic substances; (5) provides dispensary facilities and occupational medical services at the major operating contractors' sites and at Central Facilities Area; (6) performs research in coordination with the U. S. Geological Survey in the hydrology and geology of the site to establish criteria for liquid and solid radioactive waste management; (7) coordinates meteorological services of the U. S. Weather Bureau group with reactor operations and tests which might have potential environmental effects; (8) administers a safety program, providing appraisal and consultation services of specialists in the fields of industrial and traffic safety, fire protection, industrial hygiene and health physics engineering; and (9) coordinates the training and operation of the NRTS Radiological Assistance Team for Region 6, which includes the states of Idaho, Wyoming, Utah, Colorado and Montana.

The year 1962 was a successful one for health and safety at the NRTS. Injury frequency and severity statistics reflect progress in the overall preventive program. Time lost from occupational injuries decreased in spite of increased construction activity and a near-record total man-hours worked. Property damage or loss due to fire and to vehicle accidents declined. Radiation exposures to NRTS personnel were less than the previous year's. There were no radiation incidents resulting in significant contamination or personnel exposures. While 27 employees received greater than 5 rem whole body exposure, none exceeded the guide value of 12 rem per year.

To highlight the accomplishments of the Division in its health and safety activities, the following major aspects of the 1962 program are noted:

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1. Broader occupational medical services were provided NRTS personnel with increased physical examinations, treatment and laboratory and X-Ray analyses. Emergency decontamination kits were developed for use in the event of serious radioactive contamination of personnel.
2. Experience with the whole-body counter has fully established its value as the preferred means of detection and surveillance of radionuclides in human subjects, especially in cases where classical bio-assay techniques are ineffective.
3. A method was developed for the analysis of trace levels of plutonium in relatively large amounts of urine which also affords excellent decontamination from fission products.
4. An automatic film reader, designed and constructed by the Instrument and Development Branch, was put into operation near the end of 1962. This unit provides increased accuracy and reliability, as well as time and labor-saving benefits, in the identification of personnel badges, measurements of radiation exposures and recording of identification and density data on punched paper tape.
5. A highly reliable determination of regional ground water velocity was made, based upon tritium migration studies. A flow rate of approximately two meters per day was indicated in the ground water over a distance of 5,000 meters between Idaho Chemical Processing Plant (ICPP) and Central Facilities Area (CFA).
6. The ID contractor safety appraisal program was firmly established during 1962, with formal reviews being conducted in the areas of fire protection engineering, industrial safety, industrial hygiene, health physics and nuclear safety outside reactors.
7. Preplanning forecast studies in meteorology by the U. S. Weather Bureau group at the NRTS proved most beneficial in conducting the SPERT-I destructive test in a safe manner.

On the following pages, one will find a résumé of the significant accomplishments of each Branch of the ID Health and Safety Division. The format employed should make selective or continuous perusal equally convenient for the reader. For those who desire further detail on certain aspects of the report, the publications referenced at the end of each section may provide more detailed information.

II. MEDICAL SERVICES

(GEORGE L. VOELZ, M.D. - BRANCH CHIEF)

1. SCOPE

The Medical Services Branch provides a comprehensive occupational medical service to the operating contractors at the NRTS. This inplant service is now provided to Aerojet-General Nucleonics, Argonne National Laboratory, Atomics International, Division of North American Aviation, General Electric Company, Phillips Petroleum Company and Westinghouse Electric Corporation. During 1962, arrangements were made to extend services to General Electric employees who will operate the S5G reactor project. Also, first-aid and emergency medical care are provided to construction contractor personnel at the NRTS.

2. MEDICAL SERVICES PROJECTS AND ACTIVITIES

2.1 Decontamination Capability

- A. Plans for the management of high-level radioactively contaminated persons have been considered since the SL-1 reactor accident. Two decontamination kits were assembled to demonstrate an approach to the problem of decontamination of persons in a habitable area nearest an accident. It is recommended that such kits should be available in various plant locations similar to safety showers. The only additional equipment needed is an available water faucet for a hose connection, preferably a mixing type faucet for water temperature regulation. Such a decontamination kit is shown laid out in Figure 1.



Fig. 1 Personnel Decontamination Kit.

The contents of this particular kit include:

(1) Protection of Recovery Personnel

Face masks, full face MSA with cannisters - 2
Coveralls - 2
Shoe covers
Surgical gloves - 6 pairs
Film badges - 2
200 R self-reading dosimeters - 2

(2) Clothing Removal

Jack knife - large
Bandage scissors - large
Plastic bags - assorted sizes - 8

(3) Hair Removal if Vacuuming or Washing are Ineffective

Extension cord - 50 feet
Hair clippers - electric
Hair clippers - manual
Scissors, pointed - 1

(4) Positioning for Unconscious Patient or Serious Leg Injuries - Vertical Position is Preferable for Decontamination

Rope - clothes line type - 100 feet
Rope - manila hemp - 15 feet
Harness - 1
Block and tackle - small with nylon rope - 1

(5) Detergent-and-Water Decontamination

Hose - 50 feet
Hoze nozzle
Detergent - 1 quart
Brush, long handle with detergent dispenser - 1

B. An emergency surgical kit has been assembled for use as a field unit. It is designed for use in removing embedded radioactive particles. This would be used only when radiation levels were sufficiently high to be life-threatening and contamination levels would not permit the use of hospital facilities.

C. In addition, plans are being formulated to build a central medical decontamination unit at the AEC Central Facilities Area Dispensary. This facility will be equipped to provide more definitive decontamination and medical care following preliminary field decontamination procedures.

D. In March, 1962, a one-day training meeting on Radiological

Safety and Practices in the Hospital was held in cooperation with the Idaho Department of Labor. About 80 hospital supervisory personnel from southeastern Idaho attended. The program included talks on basic radiological physics, principles of radiological decontamination, handling radioactively contaminated patients in the hospital, radiological hazards and safety in the X-Ray and radioisotopes departments. The function of the radiological assistance teams was described. It was apparent that the resources of this emergency capability have not been brought to the attention of hospitals.

2.2 Microfilmed Medical Records

About 5,500 inactive medical records were microfilmed to reduce file storage space. After two years' experience, it is apparent that projection of the film on a reader is used frequently for a review of records but that it is seldom necessary to reproduce the record on paper. The quality of microfilming must be observed very closely since the margin between satisfactory and illegible films is small.

2.3 Industrial Medical Consultations

During 1962 several significant toxic chemical exposure conditions were evaluated and treated by Medical Services. A few of the more significant examples are presented as follows:

- A. An irritant gas exposure of unknown type, probably oxides of nitrogen, occurred to two pipefitters and resulted in the hospitalization of one individual for 24 hours observation of the resultant pulmonary reaction. Both individuals recovered completely in a few days.
- B. An epoxy resin exposure resulted in dermatitis of the face and neck of a machinist. The short-term job using this plastic was completed by the time the dermatitis occurred. Although no disability was incurred, the condition required therapy for several weeks before subsiding.
- C. A serious lead fume exposure condition occurred in a construction area. A crew of nine lead burners installing a lead shield during a four-month period melted large quantities of lead in a confined space at the bottom of a large cement basin. Industrial hygiene surveys showed lead concentrations at the breathing zone ranged from 30 to 85 times the threshold level values (0.2 mg Pb/m^3). At the time this condition was discovered, the average lead concentration in the five highest exposed individuals was $.097 \text{ mg Pb/100 cc blood}$ and $.416 \text{ mg Pb/liter urine}$. Three of the men developed clinical symptoms of lead intoxication. One individual with lead colic was treated in the hospital with intravenous calcium EDTA for five days. The other two were treated with calcium EDTA as outpatients. Half-face respirators with type "F" filters were required in

the area as soon as the exposure was known. Blowers, 4"-diameter flexible ducts and hoods were installed to reduce air concentrations but were never adequate to reduce lead levels in the breathing zone of the burners below three to seven times the threshold limit values. Unfortunately, the workers with many years of work under similar conditions without controls were not conscientious with their respirators or the ventilation hoods despite close supervision. Weekly sampling of blood and urine showed variations more closely related to the intensity of work than to the attempts at controlling the exposures. One month after the original studies, the average of the same high-five was reduced to .066 mg Pb/100 cc blood, although the urine average was now .600 mg Pb/liter. The major portion of the job was completed by that time.

- D. An accidental radiation exposure of potential seriousness involved a radiographer who worked around a 30 curie iridium¹⁹² source for about five minutes. The major exposure occurred to the hands and was estimated to be about 40 rad. The whole body gamma exposure was less than 1 rad. The man had no signs, symptoms or blood count changes suggestive of radiation effect.

3. MEDICAL SERVICES STATISTICAL REPORT

3.1 Dispensary Visits

In 1962, the personnel visits for treatment and consultation at the CFA AEC dispensary increased 24% (from 5,408 to 6,690). Twenty-one per cent of the CFA treatment visits were for construction contractor personnel, approximately a three-fold increase over 1961. Treatment of Phillips Petroleum Company personnel comprised about 49% of the treatment visits. Three out of four treatments or consultations were done for non-occupational illnesses or injuries. The trend of the treatment at the CFA Dispensary from 1958 through 1962 is graphically shown in Figure 2.

Total CFA Dispensary visits include those for laboratory, X-Ray and physical examinations in addition to the treatment visits. Figure 2 also shows the trend of increase of total visits. A 9% increase (from 9,322 to 10,149) was experienced in 1962.

The treatment visits for all NRTS dispensaries are summarized in Table I. The 35,152 visits represents an increase of 14% over 1961. In contractor dispensaries, where a nurse is in attendance, seven out of eight visits are for non-occupational reasons, with the exception of the Fluor Corporation dispensary (ATR construction area) where occupational injuries account for approximately 55% of the visits. The grand total for all NRTS dispensary visits in 1962 was 45,281.

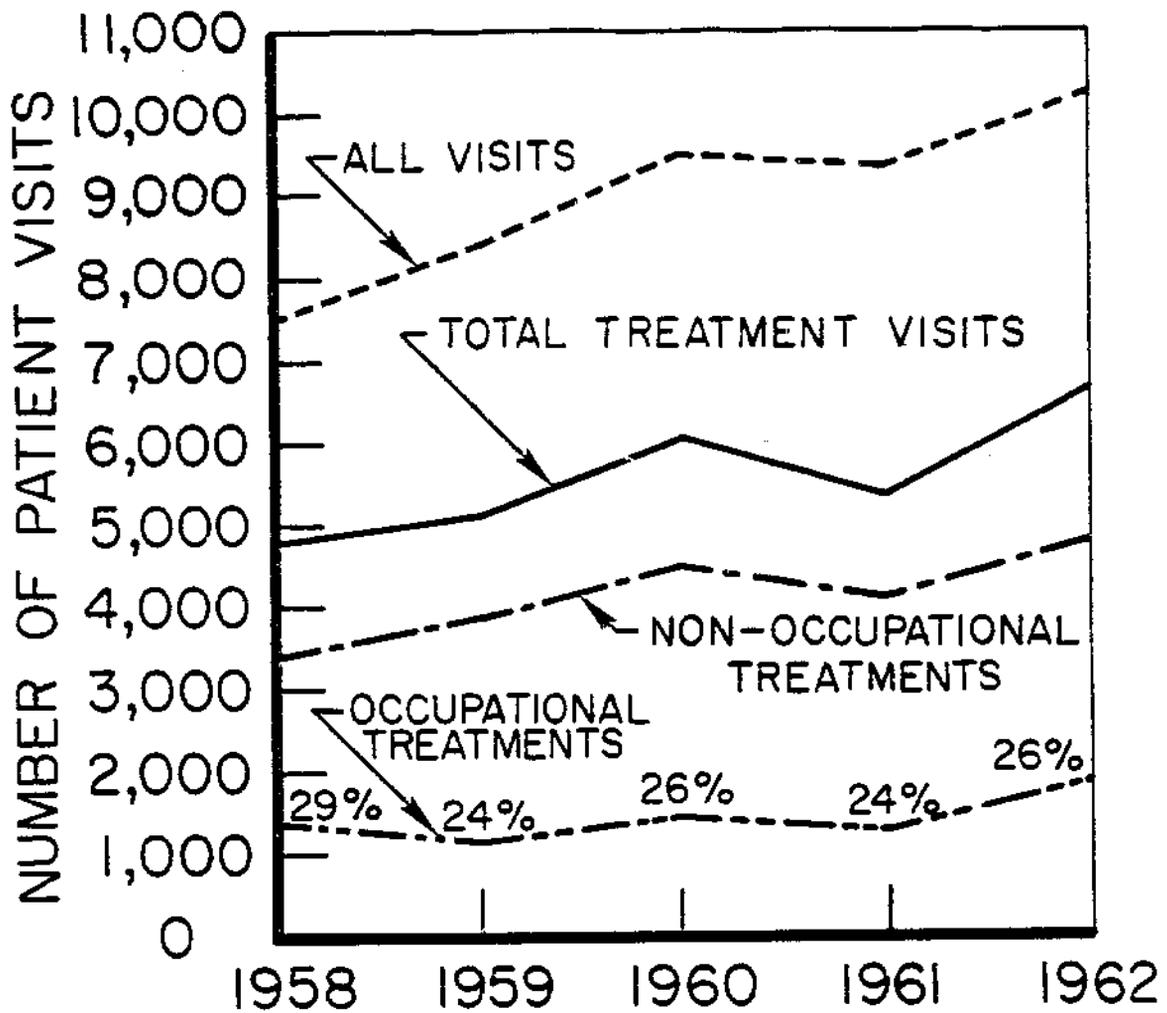


Fig. 2 CFA Dispensary visits, 1958-1962.

TABLE I

1962 NRTS Dispensary Treatment Visits

<u>Dispensary</u>	<u>Occupational</u>	<u>Non-Occupational</u>	<u>Total</u>
CFA (AEC-ID)	1,896	5,323	7,219
CPP (Phillips)	267	2,002	2,269
MTR-ETR (Phillips)	662	4,950	5,612
EBR-II (Argonne)	288	1,927	2,215
NRF (Westinghouse)	2,380	11,018	13,398
TAN (Phillips)	77	2,971	3,048
ATR Construction (Fluor)	1,062	858	1,920
First Aid Stations	256	462	718
TOTAL	6,888 (19%)	29,511 (81%)	36,399*

* 35,152 total was used to compare with previous year's since this figure includes 1,247 immunizations.

An analysis of 3,116 occupational injuries occurring at the NRTS showed a percentage distribution of injuries similar to that noted in previous years. Lacerations, abrasions and contusions of the extremities account for over 50% of the total injuries. The overall increase in occupational injuries and a 90% increase in eye injuries (from 224 to 428) reflects primarily the increased construction activities in 1962.

3.2 Physical Examinations

A total of 1,432 persons received physical examinations in 1962, an increase of almost 10% over 1961. This increase can be accounted for by the more active participation of the AEC-ID physicians at NRF and the termination physicals of the ANP personnel. The physical examination totals for the period of 1956 through 1962 are portrayed in Figure 3. The number of periodic examinations was essentially unchanged from the previous year; however, we must anticipate future increases as the NRTS population increases in size and the average age increases.

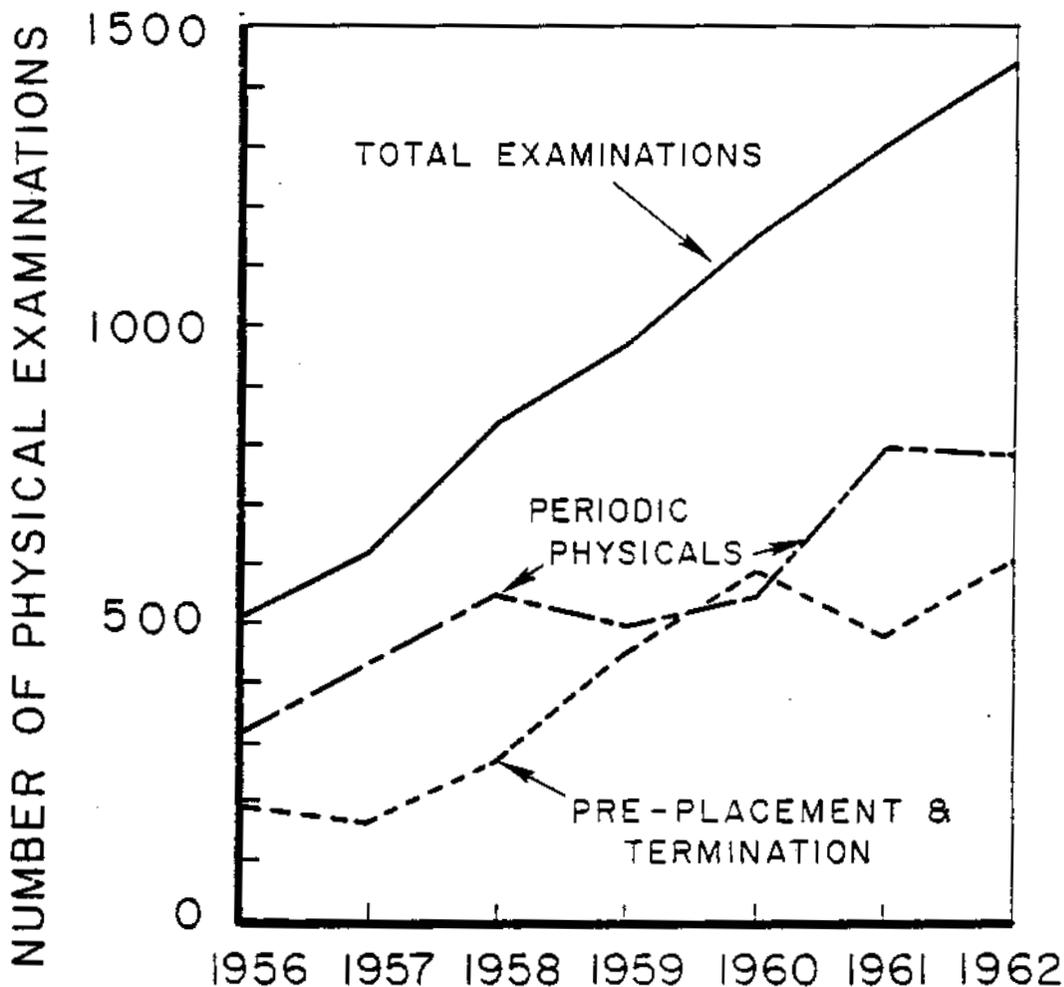


Fig. 3 Physical examinations performed by Medical Services Branch, 1956-1962.

Statistics were recorded on work restrictions recommended after preplacement and periodic physical examinations in 1962. These are summarized in Table II. Restrictions were imposed only when it was felt to have a direct bearing on the individual's job performance. Color vision deficiencies, although of relatively high frequency, seldom justify work restrictions and are not included because of lack of importance as related to job performance in most cases.

TABLE II

Classification of Restrictions on 1,082 Physical Examinations
(317 Preplacement and 765 Periodic Examinations)

<u>Restriction</u>	<u>Reason</u>	<u>Preplacement</u>	<u>Periodic</u>
1. Corrective lenses at all times	Vision 20/50 or worse	47	135
2. Corrective lenses for close work	Vision 14/20 or worse	9	62
3. Safety glasses in work area	Industrial blindness - one eye	9	9
4. Lifting restriction, 25 lb. or 50 lb.	a. inguinal hernia	1	6
	b. recurrent lumbosacral strain	5	10
	c. herniated intervertebral disc	0	14
	d. other	2	1
5. No high noise level area	a. hearing loss greater than 10%	1	17
	b. tinnitus	0	1
6. No high radiation areas	a. history of deep X-Ray therapy	0	2
	b. posterior subcapsular cataracts	0	2
	c. lymphoma	0	1
7. Sedentary work only	a. coronary heart disease	1	11
	b. rheumatic heart disease	1	2
	c. emphysema	0	2
8. Avoid pulmonary irritants	a. asthma	0	2
	b. chronic bronchitis	0	1
	c. sarcoidosis	0	1
9. Other (includes no climbing, no solvent exposures and no work around machinery)		0	6

3.3 X-Ray and Laboratory Work

During 1962 1,805 individuals had X-Ray examinations, an increase of almost 7% over 1961 (See Figure 4). These X-Rays include not only routine chest films but also special studies of ribs, spine, skull and extremities. Abnormalities were evaluated on 1,498 chest X-Rays: 103 showed evidence of previously known abnormal conditions and 25 were new diagnoses. The most frequent new diagnosis was acute pneumonitis.

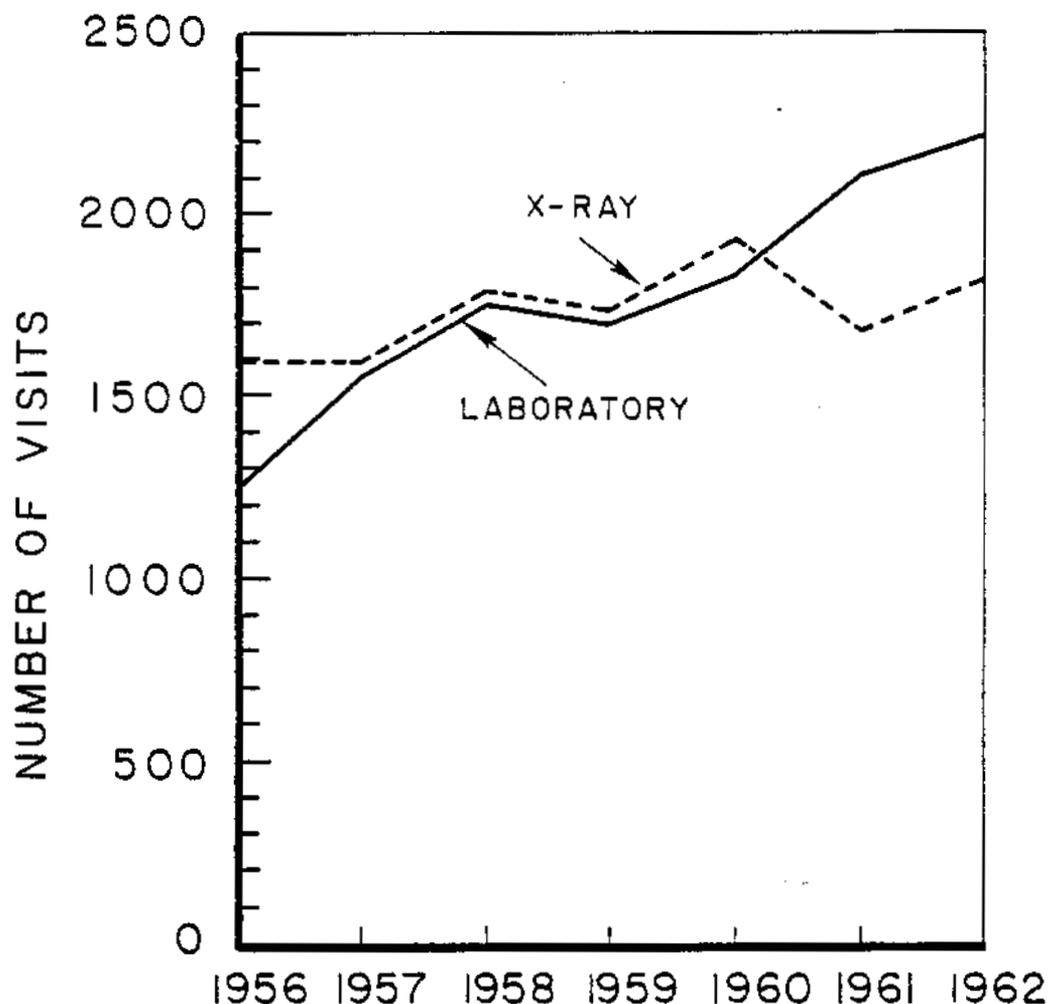


Fig. 4 Patient visits for X-ray and laboratory examinations at CFA Dispensary, 1956-1962.

The number of laboratory visits increased by 4.7% while the number of procedures increased by 7.6% in 1962. The laboratory technician, in accordance with a policy and procedure originated in 1961, collected blood and urine samples from 590 individuals in the plant areas. This procedure is done to reduce the time lost from work for routine screening laboratory work.

Electrocardiograms taken at the CFA Dispensary and at the NRF Dispensary were interpreted by the AEC physicians. Evaluation

of 308 of these tracings disclosed abnormalities in 58 (19%). Some of these abnormalities represent only minor variations from the normal electrocardiographic pattern. Post-exercise electrocardiograms were run on 23 individuals. These special tracings may indicate early coronary artery disease prior to changes seen on the usual resting electrocardiogram. Five of these tracings were interpreted as abnormal, but only long term evaluation will prove whether or not these abnormal findings have any prognostic value.

4. FUTURE PROGRAMS

4.1 Industrial Medicine at NRTS

Efforts to strengthen the industrial medical staff at NRTS are continuing. A leave of absence will be granted a physician in 1963 to complete a year's training in industrial medicine at a university center. Another physician will be recruited to add to the present staff. It is contemplated that an application will be submitted to the AMA Council on Residency Training for approval to serve as an accredited department to provide in-plant training for industrial physicians.

Expansion of the physical examination program to include construction and maintenance workers in radiation areas will be instituted next year. This is an area which has not previously had adequate attention.

4.2 Medical Record Research

About 1,000 special blood count questionnaires were completed at the same time that routine blood counts were performed in our laboratory. The study is designed to explore certain variables affecting blood counts. It should also provide an opportunity to compare blood counts of various radiation exposure groups to see if any significant trends or shifts are evident. The results are being compiled on IBM cards at present. A study is contemplated to see if the results will warrant further accumulation of this data.

Compilation of data from slit lamp eye examinations for cataracts and lens changes has been continued. This data has not been reviewed in the past two years. It will be reviewed again with the idea of determining the value of such examinations in the reactor industry.

4.3 Mortality and Morbidity Epidemiology

The application of epidemiological methods to AEC contractor records to study patterns of mortality and disease is receiving increased interest in a number of AEC installations. No work of this type has been done at NRTS. This is a logical direction for expansion of research and study by Medical Services depending on the availability of staff personnel time.

4.4 Personnel Decontamination Training

A vital part in the preparation of emergency capability is the training of personnel. Since the SL-1 reactor accident, it has been apparent that some type of training program for plant personnel (health physicists, security patrolmen, firemen, nurses and physicians) will be necessary to have the most effective response to any serious radiocontamination problem involving injured persons. When a medical decontamination facility is available, a comprehensive training course will be developed, including practice exercises, using the facility.

5. PUBLICATIONS

"Handling the Contaminated Patient in the Hospital" - Radiological Safety Practices and Procedures in the Hospital, Training Course by Idaho Department of Labor, Idaho Falls, Idaho.

III. PERSONNEL METERING (F. V. CIPPERLEY - BRANCH CHIEF)

1. SCOPE

The Personnel Metering Branch provides film badge service to the 18 operating and construction contractors at the 20 different areas on the NRTS. It has the responsibility of determining the extent of external exposure to radiation for NRTS personnel and of maintaining up-to-date exposure records. A continuing program is in effect to increase the overall accuracy and reliability of this service to the contractors.

2. MAJOR PROGRAMS

- 2.1. Automatic Film Reader - In October 1962, an automatic film reader designed and built by the ID Instrument and Development Branch was put into service. This unit reads film at the rate of 1 film every 4 seconds. The previous manual method of reading film on the densitometer took approximately 12 seconds per film utilizing two people - one for reading film and one for recording densities.

Personnel having film badges at the NRTS are assigned permanent health badge numbers. This number is X-rayed on the film with a binary code; therefore, one-half the film is used for identification and the other half for exposure evaluation. In processing developed film through the film reader, the unit automatically lifts each piece out of the plastic tray and photodiodes sense the binary code on the identification part of the film. The unit displays the badge number on a viewing screen and automatically punches the code on paper tape. Four matched diodes scan the densities corresponding to the aluminum, open window, silver and cadmium filters in the film badge. The density equivalent voltage is displayed on the viewing screen and is also automatically punched on paper tape after the badge number. A great deal of accuracy can be maintained by this unit due to the ultra stable regulated power supply and a high precision digital volt meter.

Temporary or visitor film not having the binary codes may be manually processed through the film reader. The temporary visitor film number may be punched on the paper tape by IBM keyboard input; therefore, the unit allows greater flexibility in the overall exposure evaluation procedure.

- 2.2. Data Processing Improvements - The new automatic film reader necessitated the development of suitable computer programs to convert the recorded data into equivalent densities and to determine the exposures they represented. Considerable effort was expended in analyzing the problem, determining the response characteristics of the film reader, and obtaining a functional relationship suitable for programming.

Awareness of the increased efficiency of processing data by com-

puter methods has resulted in expansion of the computer service to the Analysis Branch, Health Physics Branch, Ecology Branch, and US Weather Bureau. New programs are now in use by these Branches in the areas of data reduction, analysis, functional evaluation of prediction equations, and report generation.

- 2.3. Latent Image Study - Personnel Neutron Monitoring Film is used in the fast neutron monitoring program at the NRTS. Approximately 90% of the NRTS workers are covered by this program.

One of the inherent problems in using neutron film is the instability of the latent image. Many investigators have performed research in this area with varied results. It is known that latent image fading is due to an inherent property of the emulsion, and that the magnitude of the fading is a function of the emulsion characteristic, the flux, kind and energy of the particle, and of time and conditions of storage between irradiation and processing. The object of this latent image study was to determine whether the NRTS environmental conditions had a significant effect on this type of film.

From the experimental point of view the investigation followed two main lines: first, the stability of the latent image as a function of time; and second, the different factors involved in routine operational problems, such as "reader seeability".

Of the 280 film, one-half were wrapped and sealed in "mylar" and half retained in their original factory wrap. All of these film were exposed to a polonium-beryllium neutron source. The total exposure was 3.7×10^7 n_f/cm². This was used to produce 150 tracks per 40 microscope fields for this type film. Approximately 5 each of the wrapped and unwrapped film were developed and processed each day for 29 working days, weekends excluded. This covered a 42-day interval.

Between the time of irradiation and development the exposed film was stored under relatively non-controlled conditions in a room environment of 26 to 34% relative humidity and 20° to 23° C. The outside temperature and relative humidity ranged from -21° to 4° C and 50 to 90%, respectively. The outside humidity had little effect on internal relative humidity of the storage building.

The film which were processed on any given day were read by three Personnel Metering Clerks selected at random. The random selection was done to simulate routine operational procedure during the experiment. Each film was scanned 120 microscope fields by each clerk for a total of 360 fields per film.

It would be expected that if the environment has an effect on the film there would be a difference between the two groups. The mylar-wrapped film would show a constant number of tracks with a possible slight reduction in tracks over the period of investigation, due to thermal regression. The unwrapped film would show a lesser average number of tracks at the end of the investigation. This would be due to the latent image fading.

The average number of tracks as a function of time for both groups is shown in Figure 5. Since the average values of the wrapped and unwrapped film lie close together for the various points on the graph it would be reasonable to assume there was little, if any, difference between the two groups.

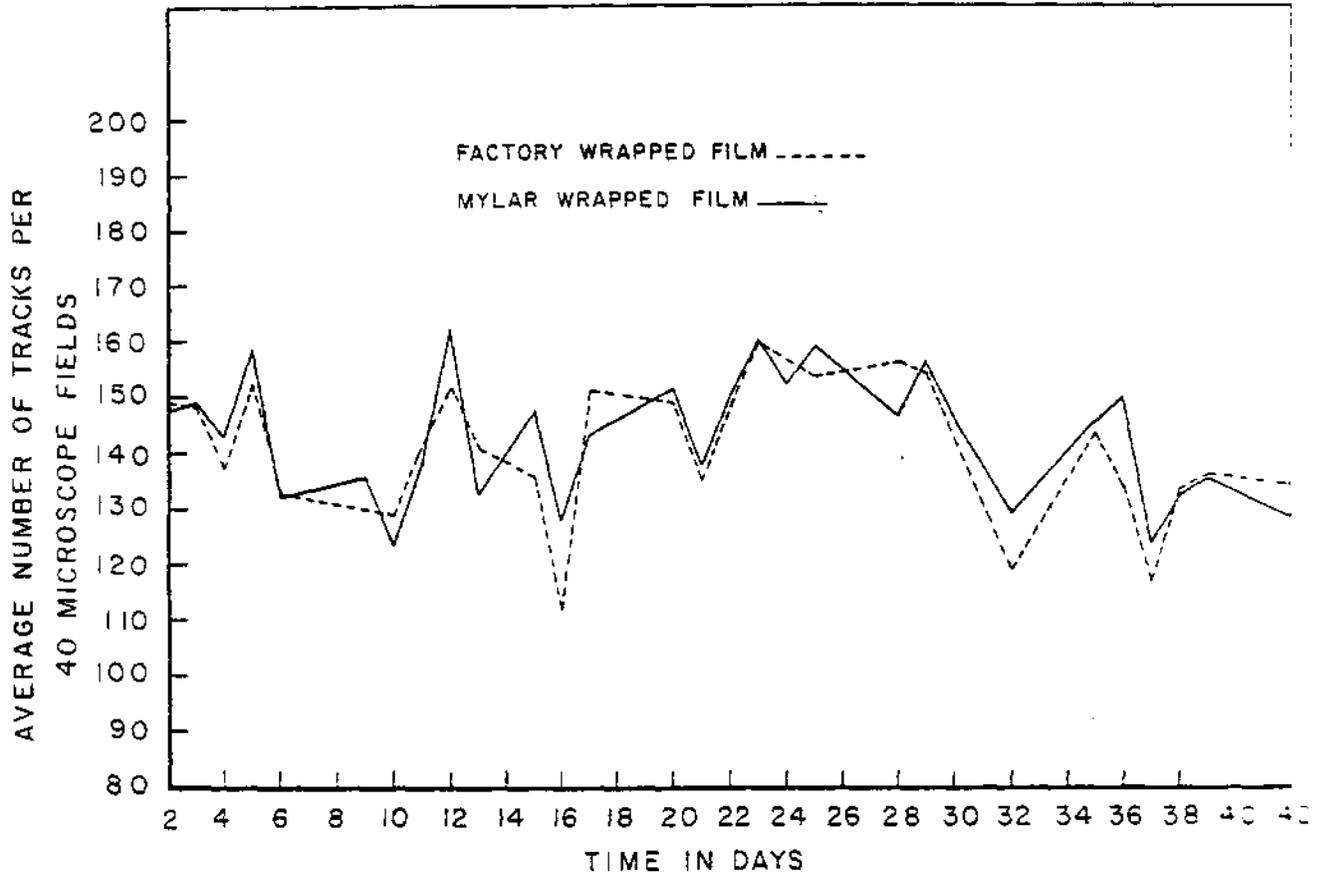


Fig. 5 Average value plot for all readers as a function of time.

An analysis of variance was performed and the F value obtained was not significant for the between-group treatment, although the F value for the within-group treatment was significant. There was a difference in the day-to-day variation, due mainly to the random selection of the clerks and not because of the latent image fading.

Temperature and humidity conditions of working environments at the NRTS are fairly stable and the film badges are normally kept in buildings with moderately controlled temperature and humidity. Therefore, it was concluded that the badge monitoring period (formerly two weeks) could be extended to one month with very little effect upon accuracy of dose determination.

- 2.4. Dose Determination at The SPERT I Destruction Test (Utilizing Personnel Metering Standard Man) - A test program was undertaken to study the reliability of film badge monitoring during a reactor excursion. Fourteen phantoms, 20-liter polyethylene carboys filled with tissue-equivalent solution (Figure 6), were placed in close proximity to the reactor vessel and surrounding building.

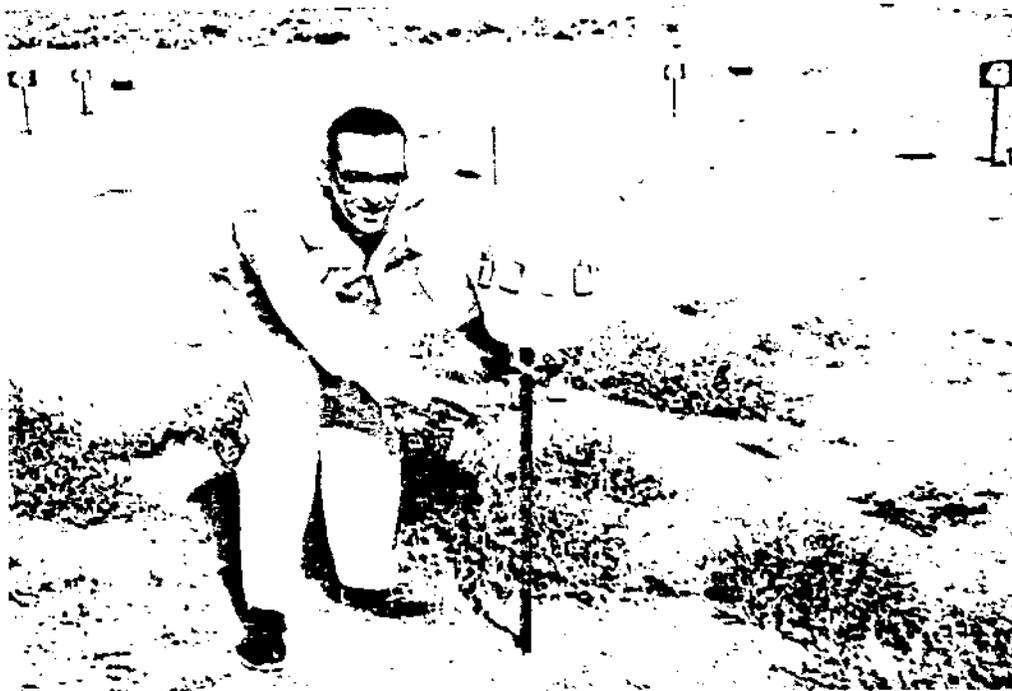


Fig. 6 Personnel Metering Standard Man Phantom.

Each phantom was surrounded with 12 film badges in clockwise order. Two film badges were placed under the carboy so that there would be a minimum of backscatter. Each phantom also contained a film badge sealed in polyethylene, positioned in the center of the solution. This particular film badge would yield an indication of depth dose. The tissue-equivalent solution was a mixture of sucrose, urea, sodium chloride and water. The effective Z number of the solution was 6.9 whereas that of a standard man is 7.02.

Ten of the phantoms were placed on standard "T" type fence posts, at distances of 8, 15, and 30 meters from the vessel center. One of these ten was placed at the top of the bunker, 8 meters from the vessel center and 2.5 meters above the reactor building floor. Four other phantoms were placed on wooden stands, one in each quadrant, 3 meters from the vessel center (Figure 7). The centers of all the phantoms were approximately 1 meter above ground or floor level, to simulate the torso of an average man.

All film were recovered 5.5 hours after the test. As expected, those film of each phantom facing the reactor received the highest exposures. The phantoms downwind from the reactor also received a greater exposure than those up-wind. The four phantoms placed 3 meters from vessel center showed a wide variation in average exposure values from phantom to phantom as follows:

Phantom	γ Avg. (Rem)	β Avg. (Rem)	Ratio (β/γ)
No. 11	14.8	249	17:1
No. 12	7.2	137	19:1
No. 13	2.9	59	20:1
No. 14	2.3	37	16:1

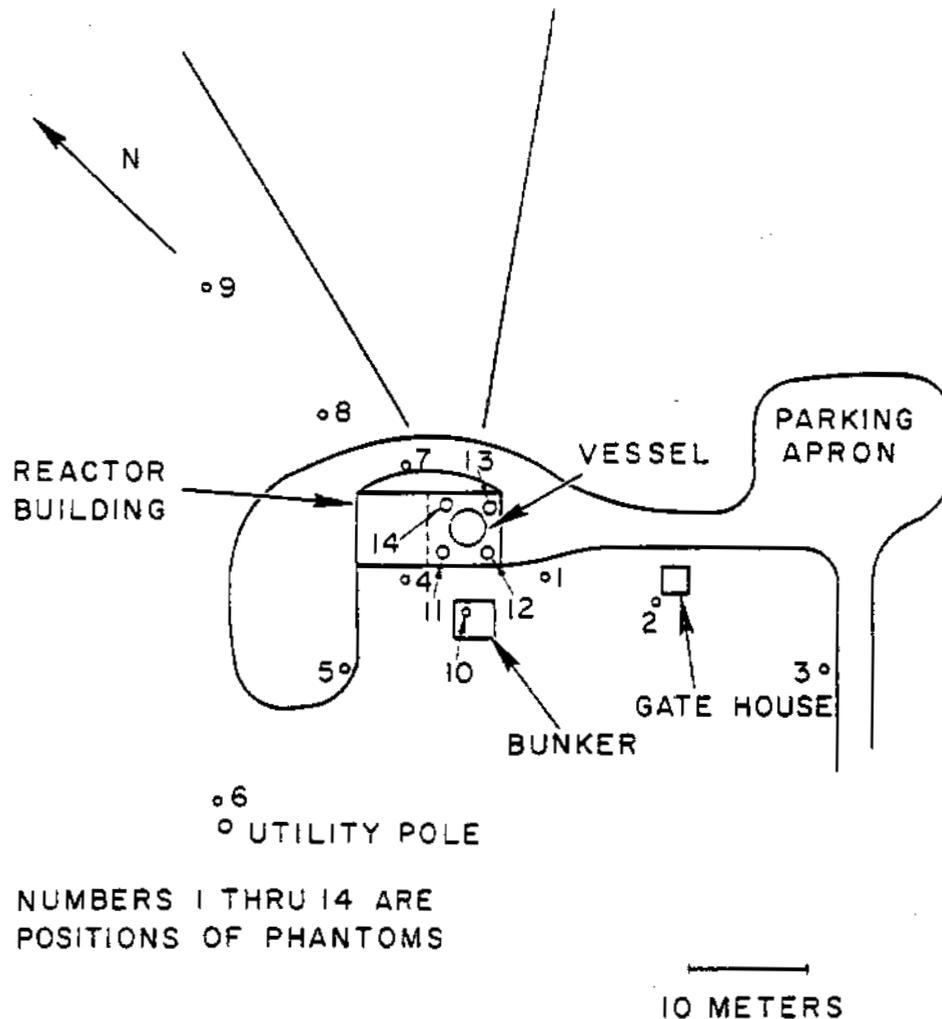


Fig. 7 Phantom placement during SPERT-I destructive test.

Phantom No. 11 had the greatest exposure with the least amount of equipment shielding it, and the reverse was true for Phantom No. 14. Very likely, factors such as equipment and water shielding and splash contamination contributed to the variations in exposure dose to these phantoms. The average external exposures of the phantoms outside the reactor building are as follows, in rem:

	<u>8 M</u>	<u>B</u>	<u>γ</u>	<u>15 M</u>	<u>B</u>	<u>γ</u>	<u>30 M</u>	<u>B</u>	<u>γ</u>
Upwind	No. 1	2.4	.73	No. 2	.08	.12	No. 3	0	.04
Upwind	No. 4	1.6	.95	No. 5	.91	.13	No. 6	0	.04
Downwind	No. 7	3.5	1.00	No. 8	4.10	.64	No. 9	.58	.14
Upwind	No. 10	1.6	.90						

The film badges inside the phantoms yielded the following doses, in rem:

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<u>3 M</u>	<u>γ</u>	<u>8 M</u>	<u>γ</u>	<u>15 M</u>	<u>γ</u>	<u>30 M</u>	<u>γ</u>
No. 11	5.2	No. 1	.34	No. 2	.06	No. 3	.02
No. 12	2.4	No. 4	.65	No. 5	.10	No. 6	.02
No. 13	1.5	No. 7	.66	No. 8	.32	No. 9	.06
No. 14	1.5	No. 10	.68				

For the front-to-back exposure ratios of the four close-in phantoms beta ratios were approximately 6:1 and gamma ratios were approximately 3:1. Analysis of neutron film and threshold detector elements indicated there were no neutron exposures to the phantoms.

It appears that reliable film badge information consistent with that expected can be obtained from an incident of this type. The data obtained is being used to determine what effect badge orientation on the phantom has on the calculated total exposure. This study will be continued in conjunction with other tests scheduled in 1963.

3. FUTURE PROGRAMS

3.1. Research in Film Dosimetry

- A. An investigation to determine techniques or methods of thermal neutron monitoring utilizing the present four filter system in the NRTS film badge will be conducted.
- B. A statistical study will be performed to determine the effect of aging on long-term storage of processed film at the NRTS.
- C. The problem of gamma fogging on neutron emulsion film will be investigated to determine what processing techniques may be utilized in order to reduce the fogging.

3.2 Automatic Data Processing Programs

- A. A comprehensive review and up-dating of procedures, programs and reports is planned for the computer now serving the H & S Division.
- B. A study is planned to compare the cost and efficiency of personnel radiation record maintenance obtainable from current methods versus new large capacity magnetic core disk storage units.

IV. ANALYSIS

(CLAUDE W. SILL - BRANCH CHIEF)

1. SCOPE

The Analysis 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 and of people who live in the surrounding communities.

2. MAJOR PROGRAMS

2.1 Whole-Body Counting

Results obtained from whole-body counting during 1962 confirm and re-emphasize the conclusion reached during the previous year, namely, that conventional urinalysis is grossly inadequate as a general method for detection of internal contamination from particulate sources. Since many, if not most, of the radioactive sources around operating reactors are extremely insoluble particulates, whether due to neutron activation of elements already contained in refractory particles or to production of such refractories by the high thermal temperatures existent, the critical dose will generally be to the lungs and/or gastrointestinal tract and the material will be excreted almost completely in the feces.

Six people were inadvertently exposed in the AREA Hot Cell to a mixture primarily of cerium 141-144, ruthenium 103-106, zirconium-niobium 95 and barium-lanthanum 140. The highest body burden was approximately 1.7 μ c. of zirconium-niobium 95. From the two individuals having the highest burden all urine and feces were collected for several days beginning immediately after the initial whole-body analysis. A significant decrease in body activity was apparent immediately, and identical spectra were obtained from the fecal sample (and from a smear taken from the work area) as were obtained from the whole-body count.

particularly informative to note that a fecal sample collected 45 hours after the incident contained several times more activity than one taken only 22 hours afterward. Thus, it should be emphasized that the largest activity will not necessarily be found in the sample taken soonest after exposure.

Mercury 203 is one nuclide whose presence was first detected by gross gamma counting of urine. Subsequent whole-body examination indicated a burden of 0.16 μc . Even after 50 days, the activity continued to be eliminated in both feces and urine with an effective half-life of about 40 days. This value is significantly longer than the 8 to 11 days quoted by the ICRP for different organs. The excretion appeared to follow an exponential model.

Manganese 54 has been seen for the first time in two individuals. The nuclide was definitely present in the feces, but could not be identified in a 24-hour urine sample. Whole-body counting and excretion analysis will be continued to determine its effective half-life and mode of elimination.

Although soluble cobalt salts are known to be excreted in the urine, previous experience from whole-body counting and excretion studies indicated that the particular cobalt 60 encountered was eliminated in the feces. To confirm these previous results, an elimination study was made on another individual who had received a small internal burden of iodine 131, cesium 137, cesium 134 and cobalt 60. Repeated analyses over a period of 6 days showed clearly the presence of cesium 137, cesium 134, and iodine 131 in the urine, but the cobalt 60 was excreted exclusively in the feces.

During the past 2 years, the experience gained with whole-body counting has resulted mainly from examination of people known to have been involved in an actual or potential exposure to radioactive materials. Because of the significant number of people involved, few of whom would have been detected through any kind of urinalysis program, a routine whole-body counting program was initiated both to afford better surveillance of personnel working in a radioactive environment and to be able to grasp any opportunity to obtain badly needed information concerning the metabolic fate of radionuclides in human subjects. The current whole-body counting program, projected to CY 1963, is as follows:

A. Research Interests (about 1,650 observations)

- (1) Examination of all known or suspected internal exposures.
- (2) Background study of the ratio of Cs 137 to K 40 at bi-weekly intervals on six people selected for low probability of contamination from reactor operations.

- (3) Background study of uptake of I 131.
- (4) Monthly analysis of approximately 15 people employed in sensitive work locations at six different NRTS sites;

B. Baseline Analyses (one-time counts on about 500 people)

- (1) Pre-employment check of personnel having prior occupational or medical exposure to radioactive materials.
- (2) Emergency or special-hazard personnel such as security, medical, health physics, fire department, etc.
- (3) Terminations of employees having work experience in radiation areas. This requirement will be fulfilled if the individual has been issued a film badge;

C. Periodic Analyses (about 400)

- (1) Individuals receiving greater than 1 rad whole-body penetrating radiation during the year.
- (2) One person each week from each plant to be selected by the health physics supervisor from a high-risk area or work assignment. Beta exposure as determined by film dosimeter might be useful as a criterion.

This program attempts to acknowledge and minimize the expense of working time lost during analysis including clothing changes, showers, transportation, etc. Showers are not required until activity in or on the body has been detected. Past experience has demonstrated that this occurs very infrequently and the risk is easily worth the cost of having to repeat a 10-minute count after showering when necessary. However, paper gowns are worn in the counter in all cases. Activities less than 0.1 μ c. are not quantified further except in the case of new or special nuclides or in unusual circumstances in which the interests of research would be served. This level is less than one-tenth of the maximum permissible body burden for most of the gamma-emitting isotopes and would result in elimination of perhaps 90% of the spectra now being reduced. Base-line analyses are not made on the average new employee nor those employed outside of radiation areas and who are not issued film badges.

2.2 General Activities of the Counting Room

A new low-background counter with an automatic sample changer which can accommodate 5-cm. planchets using an 8-cm. detector was obtained and put into operation. This unit has punched-paper tape output and a digital readout using an IBM typewriter.

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The use of the larger planchet with a larger sample, coupled with the lower background, have resulted in greater sensitivity in all of the determinations employing beta counting.

One of the two large steel vaults used routinely for gamma-ray spectrometry was modified by installing an 8-cm. thick steel divider which can be brought to the middle of the vault or stored at one side so that two detectors could be used simultaneously. The outputs of the two detectors are fed into a 400-channel analyzer which has two inputs and can be used as two 200-channel analyzers on a time-sharing basis.

A novel container of the re-entry or Marinelli type was designed to be used in gamma spectrometry primarily with milk samples. This container is unique primarily because of the materials from which it is fashioned. These consist of a 4-liter tin pail and an 8-cm. No. 304 tin can. An opening 8-cm. in diameter is made in the bottom of the pail and the tin can inserted into the opening with its open end down, and then soldered into position. This container will easily accommodate 3,400 ml. of milk and can be sealed for shipment using a press-down lid. Because they are relatively inexpensive they can be thrown away if there is any question about contamination from previous use. The use of this container with a larger size sample than could previously be used, coupled with gamma spectrometry and a one-hour counting time, now results in a detection limit of 10 pc./liter as compared to 50 pc./liter with the previous method.

2.3 Chemistry of the Actinides

Methods were studied for the separation and analysis of the transuranium elements in various types of sample. Since increased use of plutonium as a fuel on the NRTS is anticipated, most of the emphasis was placed on plutonium and some of its associated contamination hazards. Environmental contamination is determined by monitoring the air, vegetation, soil and water. Personnel are monitored by the analysis of urine and possibly fecal samples.

Classical methods for the extraction of plutonium usually require an oxidation adjustment of the element to the tetravalent state, and can involve long extraction times, as in the thenoyltrifluoroacetone method. A method was developed for the analysis of trace levels of plutonium in relatively large amounts of urine wherein the plutonium is extracted in the tetra-, penta-, or hexavalent state, and which also affords an excellent decontamination from fission products.

The method involves wet-ashing the urine with nitric acid and hydrogen peroxide. The plutonium is reduced to either the tri- or tetravalent oxidation state and is separated from the bulk of the urine salts by precipitation from 2 M nitric acid as the fluoride with a rare-earth carrier. The fluoride precipitate is then dissolved and the plutonium extracted as the chloride

complex with a secondary amine. It is back extracted with a reducing agent-complexing agent mixture. The plutonium is then electrolytically deposited on a platinum disc and alpha-counted.

A study of six one-liter urine samples, each spiked with 10^3 alpha counts per minute of Pu 239, showed an average chemical yield greater than 95%, and a coefficient of variation of about 5% at the 95% confidence level.

Teflon cells used for the electrodeposition absorbed small amounts of plutonium during the deposition, which contaminated subsequent samples. The contamination was not easily removed from Teflon even with boiling acids. As a result, glass cells are now being used.

2.4 Determination of Tritium by Liquid Scintillation Spectrometry

A transistorized Packard Tri-Carb liquid scintillation spectrometer with a punched tape readout system was installed. Computer programs were written for calculation of tritium concentration from the punched tape data, saving many man-hours of tedious hand calculation. The high stability of the new instrument permits use of counting times of 300 minutes resulting in a detection limit of 1.4 pc./ml. (approximately 400 tritium units) at the 95% confidence level. However, such long counting times are used only on special samples. The routine procedure employs a 30-minute count with a detection limit of 4 pc./ml. at the 95% confidence level. A total of 1,905 special and routine water samples and 5 urine samples were analyzed for tritium during 1962.

When analyses for tritium were first begun in June 1961, water samples from the Central Facilities Area (CFA) were found to contain concentrations of tritium significantly higher than the natural level. Since tritium is now known to be produced during fission, it seems possible that the excess tritium might be coming from the disposal well at the Idaho Chemical Processing Plant which discharges low-level wastes to the water table. If it is postulated that the discharge of tritium began with the start of operations in March 1953, the time of its arrival in CFA might provide a good indication of the transit time between these two critical points. It was fortunate that some aqueous solutions of chemical reagents that had been prepared at different times dating back to the fall of 1951 were still on hand and could be analyzed for tritium. A sample prepared in October 1958 was the earliest in which tritium was detected, containing 3.4 pc./ml. The tritium concentration increased to 13 pc./ml. in January 1959 and has remained fairly constant since. The distance between the two wells is approximately 5,000 meters giving an apparent average underground flow rate of about 2 meters per day.

2.5 Fluorometric Determination of Yttrium

A method for the fluorometric determination of yttrium employing

morin in alkaline solution was developed with a detection limit of 0.03 μg . and a precision to 1% on 10 μg . at the 95% confidence level. The procedure is interfered with strongly by several elements and separations are necessary before practical application can be made. Final data on the procedure are being obtained and a paper will be written for publication in Analytical Chemistry.

2.6 Precipitation of Submicrogram Quantities of Thorium by Barium Sulfate

Investigation of the precipitation of thorium by barium sulfate is nearly complete and an excellent method of separation and subsequent fluorometric determination is assured. Recovery of thorium is greater than 99.5% from carrier-free tracer levels up to about 100 μg . Since the fluorometric method with which the separation will be used will not measure quantities larger than 5 μg . the range is much longer than is necessary. The separation is not affected appreciably by acidity, type or concentration of salts, temperature, time of precipitation, or a wide range of other experimental conditions. Most of the non-volatile elements of the periodic table were checked for their effect both on the recovery of thorium in the barium sulfate and for their effect on the subsequent fluorometric determination after separation by barium sulfate. Only scandium, yttrium, lanthanum and the rare earths interfere seriously and these would not be expected in concentrations large enough to interfere in the types of sample for which this procedure is intended.

Methods of sample decomposition have been developed to permit determination of thorium in various types of biological and mineralogical samples with the following detection limits: rocks and meteorites, $2 \times 10^{-6}\%$; urine, 10^{-11} gram/ml.; blood, 2×10^{-10} gram/ml.; bone ash, $5 \times 10^{-7}\%$; feces, tissue and grain, $2 \times 10^{-8}\%$.

2.7 Geochemical Studies Related to Low-Level Waste Disposal

A. Sorption of Strontium, Cesium and Cobalt on Soil and Clinoptilolite

The exchange of cesium, strontium and cobalt from synthetic waste solutions was studied as a function of the chemical composition of the solution and the particle size of the exchanger. The variables studied have been incorporated in a 2^{12} factorial design, a 1/32 fractional replicate of which was used. The variables studied and the method of attack have been described elsewhere (1). From this work it is hoped that an equation will be obtained that will allow one to predict the exchange-behavior of cesium, strontium and cobalt

(1) Hawkins, D. B. (1961) "The Use of Inorganic Exchange Materials for Radioactive Waste Treatment." TID-7644, pp. 140-162

as a function of the variables studied.

The distribution coefficients of the different elements as function of varying concentrations of the chemical variables within the experimental design have been determined using batch-type equilibrium techniques. The remaining experimental portion of this work should be completed shortly. The results will be evaluated statistically to determine the variables having a significant effect upon the sorption of the different isotopes. Following this evaluation a new and much smaller experiment using the column apparatus shown in Figure 8 and based upon the significant variables will be designed.

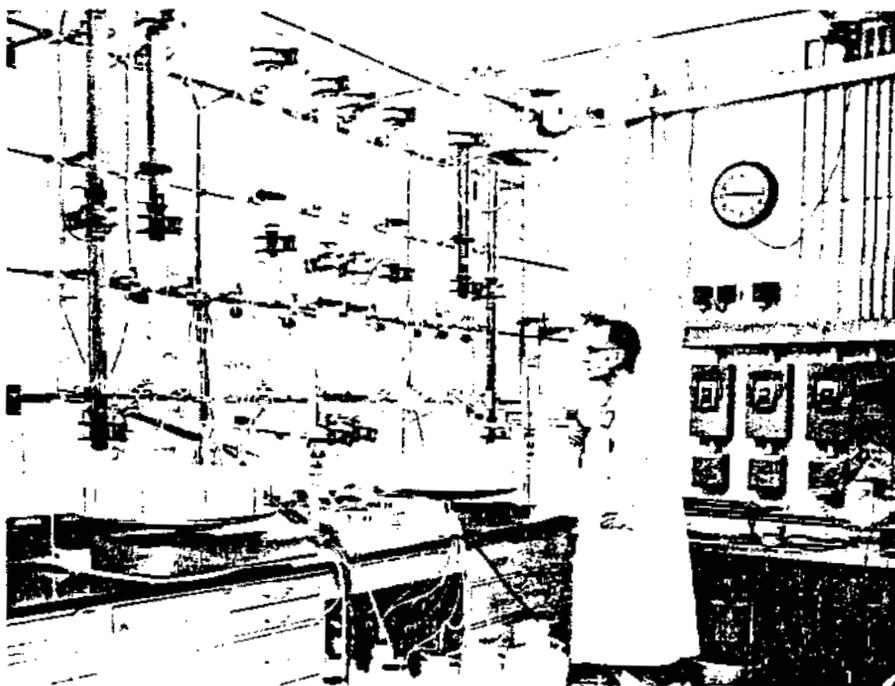


Fig. 8 Column apparatus for sorption studies on soil and clinoptilolite.

From the work to-date the following preliminary conclusions may be reached:

- (1) The pH of the influent solution, within the pH range 4-9, has no effect upon the exchange of cesium and strontium by the soil, since the soil contains much CaCO_3 which buffers the pH of the soil solution to pH 8;
- (2) For the concentration ranges of the different chemical variables studied, calcium appears to be the only ion having a significant effect upon the exchange of cesium and strontium by the soil or clinoptilolite. The retention of these isotopes decreases exponentially with

increasing calcium concentration;

- (3) In this system cobalt is generally removed from solution via precipitation, with ion exchange playing a minor part.

B. Sorption of Cesium from Dilute Solutions on Soil and Clay Minerals

Studies on this system were started when it was observed during the experiments described above that the selectivity of the soil for cesium increases markedly with decreasing cesium concentration. This effect is not due solely to the fact that the cesium is present in minute quantities since carrier-free quantities of cobalt and strontium do not show an abrupt change in selectivity. The change in selectivity for cesium is mainly a function of the clay mineralogy of the soil and the type of cation occupying the exchange sites of the clay minerals. Figure 9 shows the change in the distribution coefficient for cesium as a function of cesium concentration for the exchange of cesium on soil, illite, montmorillonite, potassium-saturated montmorillonite and clinoptilolite. The abrupt change in the distribution coefficient occurs usually in the region from 0.1 to 1.0 ppm. cesium and the saturation of montmorillonite by potassium enhances the cesium selectivity of this mineral.

Tamura and Jacobs (2) have discussed the effect of potassium upon the selective adsorption of cesium by certain clay minerals. According to these authors, cesium selectivity is favored by a 10 Angstrom unit (\AA) basal spacing of the clay lattice, the cesium being selectively adsorbed by edge fixation at this spacing. Saturation with potassium of an expandable lattice clay mineral such as montmorillonite reduces the usual basal spacing from about 12 \AA to 10 \AA , hence, the reason for the enhanced cesium selectivity shown by the potassium-saturated montmorillonite (Figure 9). It is tentatively concluded that the abrupt change in the distribution coefficient is due to the saturation of the cesium-selective edge-sites.

(2) Tamura, T. and Jacobs, D. G. (1960) "Structural Implications in Cesium Sorption." Health Physics, 2, pp. 391-398.

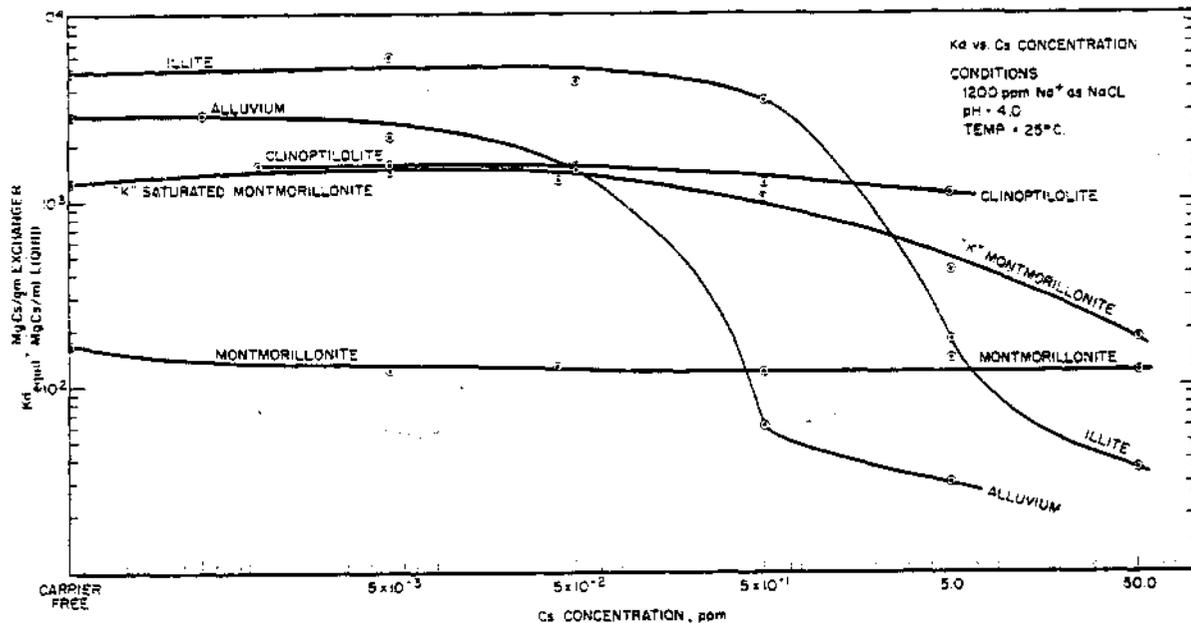


Fig. 9 Variation in the Cs distribution coefficient as a function of Cs concentration for different materials.

2.8 Use of Electronic Computers in Reduction of Analytical Data

Gamma spectrometry employing multichannel analyzers has rapidly become the method of choice for both qualitative identification and quantitative determination of gamma-emitting radionuclides. However, hand reduction of the large amount of data generated in a routine program involving both whole-body counting and conventional gamma spectrometry is a very tedious and time-consuming task. Use of a modern electronic computer has simplified the problem of data reduction enormously so that much more elaborate and complicated analyses became practical. For example, our gamma spectrometer is used to make 13 specific isotopic determinations under two different counting geometries, (Ce¹⁴⁴, Cr⁵¹, I¹³¹, Sr⁸⁵, Na²², Ru¹⁰⁶, Cs¹³⁴, Cs¹³⁷, Zr-Nb⁹⁵, Co⁶⁰, Ag¹¹⁰, Co⁵⁸, Ba-La¹⁴⁰), and the whole-body counter is used for 18 radionuclides (Ce¹⁴¹, Ce¹⁴⁴, I¹³¹, Ru¹⁰³, Sb¹²², Cs¹³⁴, Cs¹³⁷, Zr-Nb⁹⁵, Co⁵⁸, Mn⁵⁴, Ag¹¹⁰, Zn⁶⁵, Ta¹⁸², Co⁶⁰, K⁴⁰, Ba-La¹⁴⁰).

The punched paper tape readout from the analyzers is used as input to the computer which integrates selected channel bands representative of specified radionuclides. The output from this program is then used as input data to a second program which computes the quantities of specified radionuclides from the integrated values and calibration constants by means of a matrix inversion technique for the solution of simultaneous equations. As many as ten isotopes in a single spectrum may be quantified. The calibration constants used with the preceding program were calculated and arranged in the proper matrix order by a third computer program. A spectrum stripping program is used as an aid in qualitative analyses of complex spectra and as a means of determining the reliability of a

given analysis. Long background counts are normalized and complemented by means of still another program. A sixth computer program performs statistical analyses of various types of data.

3. SPECIAL ACTIVITIES

3.1 SPERT I Destructive Transient

Analytical support of field monitoring was provided during SPERT I destructive transient. Samples taken from the monitoring grid approximately five hours following the transient showed only daughters of the noble gases krypton and xenon. Strontium-yttrium 91, strontium-yttrium 92, barium 139 and barium-lanthanum 140 were the only isotopes identified.

In addition to analytical support of field monitoring, an effort was made to obtain neutron flux, neutron energy distribution, gamma-to-neutron ratio and total dose from activation of various foils and other materials which one might expect to find following a criticality incident. Multiple nuclear accident dosimeter (NAD) systems and a 3-meters length of copper wire were suspended above the reactor vessel. In addition, film badges and samples of whole blood, hair and various foils were placed near the reactor vessel. Examination of the samples following the transient indicated neutron activation in the gold foil of one NAD system and in the copper wire. The estimated thermal nvt was 1.2×10^8 and 3.4×10^7 , respectively. The gamma dose was below the detection limit of approximately 50 R of the chemical dosimeters in the NAD system.

4. ROUTINE ANALYSES

A numerical summary of routine analyses performed during the year is given in Table 3.

Table 3. Summary of Routine Analyses

Biological Samples (urine, feces, etc.)	10,678
Whole-body Analyses	1,012
Water Samples (potable, effluents, etc.)	5,632
Air Dusts	3,292
Ecological Samples (milk, animals, vegetation, etc.)	1,496
Mill Samples (water, air dusts, etc.)	196
Miscellaneous	<u>351</u>
Total	22,657

5. FUTURE PROGRAMS

5.1 Evaluation of Substituted Flavanols as Analytical Reagents

A group of organic compounds known as flavanols or 3-hydroxy-flavones contain the functional groupings necessary to permit formation of chelates with a large variety of metallic elements.

In addition many of the compounds contain chromophores or fluorophores that produce intense color or fluorescence in the resultant metallic complexes. One such naturally-occurring flavanol, morin, has been used particularly successfully in development of analytical procedures of high sensitivity and precision for beryllium, thorium and yttrium. Approximately 30 other substituted flavanols have been obtained from both synthesis and natural sources. A systematic study will be made to evaluate these compounds for possible use as colorimetric or fluorometric reagents having high sensitivity and/or selectivity for various metals. Experimental variables to be investigated will include type of element or flavanol, pH, complexing agents, extractability, color or fluorescence, etc.

5.2 Geochemical Investigations

Upon completion of the work described in section 2.7-A, a new experiment will be designated to study the effect complexing agents exert upon the retention of cesium, strontium, cerium, cobalt, and silver by the soil. The complexing agents to be used will be chosen from those present in the MTR low-level waste stream.

A study of the exchange of cesium and strontium on synthetic clay minerals as a function of controlled differences in the composition and structure of these minerals has been proposed. The need for this study arises from the fact that in the study of the ion exchange properties of clay minerals, the materials studied are limited to those supplied by nature. These materials are seldom pure end-members of a given clay-mineral series and rarely are they monomineralic. By first synthesizing pure clay minerals for which the composition and structure are known and then studying the ion-exchange behavior of these synthetic minerals, basic information regarding the ion-exchange properties of clay minerals as a whole may be obtained. In addition, the possibility exists that minerals may be synthesized which are highly selective for given elements.

5.3 Transuranium Elements

Work will continue on the analytical chemistry of plutonium to extend the determination to such samples as air-dusts, feces, soil and vegetation.

As more plutonium-fueled reactors come on stream at the NRTS, the plutonium problem is compounded by the formation of alpha-emitting transplutonium elements during reactor operations. These elements might produce similar or greater hazards than plutonium itself. Since the state of the analytical art for these elements is very poor, considerable attention will be given to an understanding of the chemistry involved and to the development of improved analytical procedures.

5.4 Liquid Scintillation Spectrometry

Additional effort will be expended to increase the sensitivity

of the present procedure for the determination of tritium. The present liquid scintillation method is not sufficiently sensitive to permit the detection of tritium at as low concentrations as is desirable for its use as a tracer of underground water flow. Liquid scintillation methods will also be investigated for the determination of pure alpha- and beta-emitters, including the use of different phosphors to minimize mutual interference, if possible.

5.5. Whole-body Counting

It is expected that a considerable amount of new information will be obtained from the new whole-body counting program being instituted in 1963 for the entire NRTS. In addition, a capability will be developed for the in-vivo determination of radioiodine in the human thyroid gland. The capabilities of an inexpensive, unshielded whole-body monitor will also be worked out in detail.

6. PUBLICATIONS

The following papers were published during 1962:

1. "Fluorometric Determination of Submicrogram Quantities of Thorium," Claude W. Sill and Conrad P. Willis, Anal. Chem., 34, 954 (1962).
2. "A Comparison of Two Methods of Sampling Gravel for the Evaluation of a Ground-Disposal Site for Radioactive Liquid Waste," Daniel B. Hawkins and Donald C. Foster, IDO 12027, 1962.
3. "The Beryllium Content of Some Meteorites," Claude W. Sill and Conrad P. Willis, Geochimica et Cosmochimica Acta, 26, 1209 (1962).

V. HAZARDS CONTROL (RALPH V. BATIE - BRANCH CHIEF)

1. SCOPE

The ID Hazards Control program serves the NRTS in the interest of reducing personal injury and property loss to the minimum by eliminating or controlling hazardous conditions. While the program from an administrative position covers only ID-AEC direct activities and ID contractors, it is designed to serve and coordinate the various activities of other AEC Field Offices at the NRTS. The ID Standard Health and Safety Requirements Manual implements the AEC Manual Chapter issuances pertaining to standards for health and safety and for protection of property from fire.

The Hazards Control Branch includes the following specialties: Safety Engineering; Fire Protection Engineering; Fire Protection Services; Industrial Hygiene Engineering; Nuclear Safety Outside Reactors; and Health Physics Engineering.

2. SAFETY ENGINEERING (Denver H. Dierks - Safety Engineer)

The objective of the NRTS industrial safety program is achieved through familiarization with authoritative standards, by incorporating such into guides for NRTS organizations, by design review of proposed new construction and modification of existing facilities, by appraisal review of NRTS construction and operational activities, by accident investigation and reporting, by collection and interpretation of safety promotional activities, and by consultations on special safety activities.

2.1 Disabling Injury Experience

- A. Frequency Rate - The NRTS disabling injury frequency rate (Figure 10) for 1962 was the second best in the history of the NRTS. The total number of disabling injuries (18) was the same as in 1961; however, the manhours worked at the NRTS increased 12.5% in 1962. This manhour increase occurred in the construction activities at the NRTS. The frequency rates of all AEC and all NRTS organizations show a stabilizing trend since 1955.
- B. Severity Rate - The severity rate (Figure 11) represents total days lost (all days lost from temporary total disability plus the total days charged in cases of fatality or permanent disability) per million manhours worked. There were no fatalities and only two permanent partial disabilities in 1962, with a resulting 540 days charged.

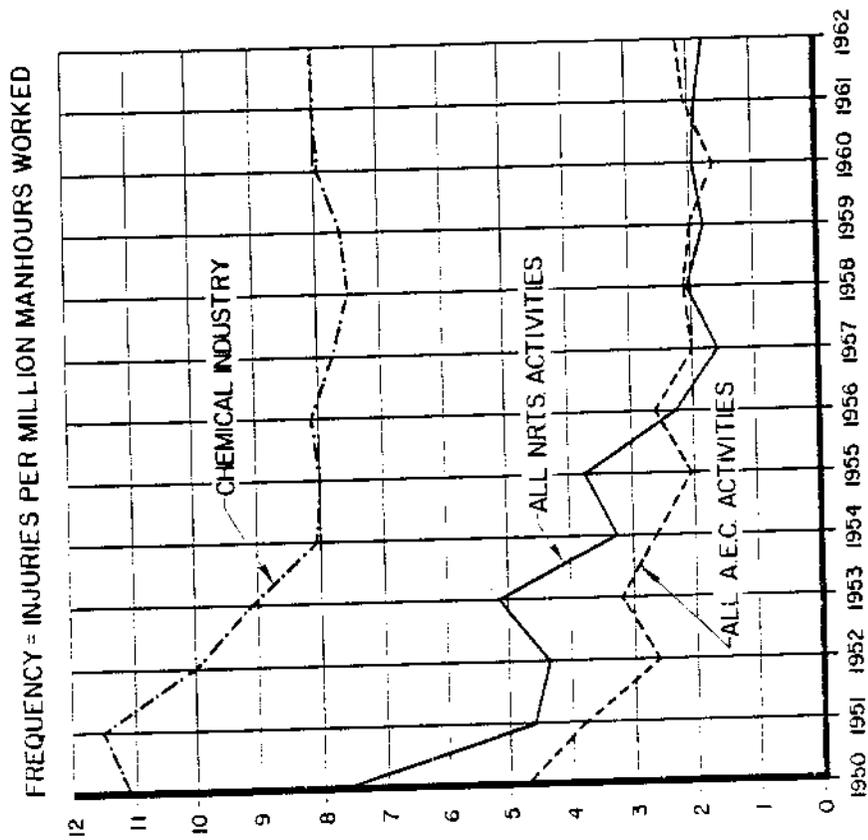


Fig. 10 Disabling injury frequency rate comparison.

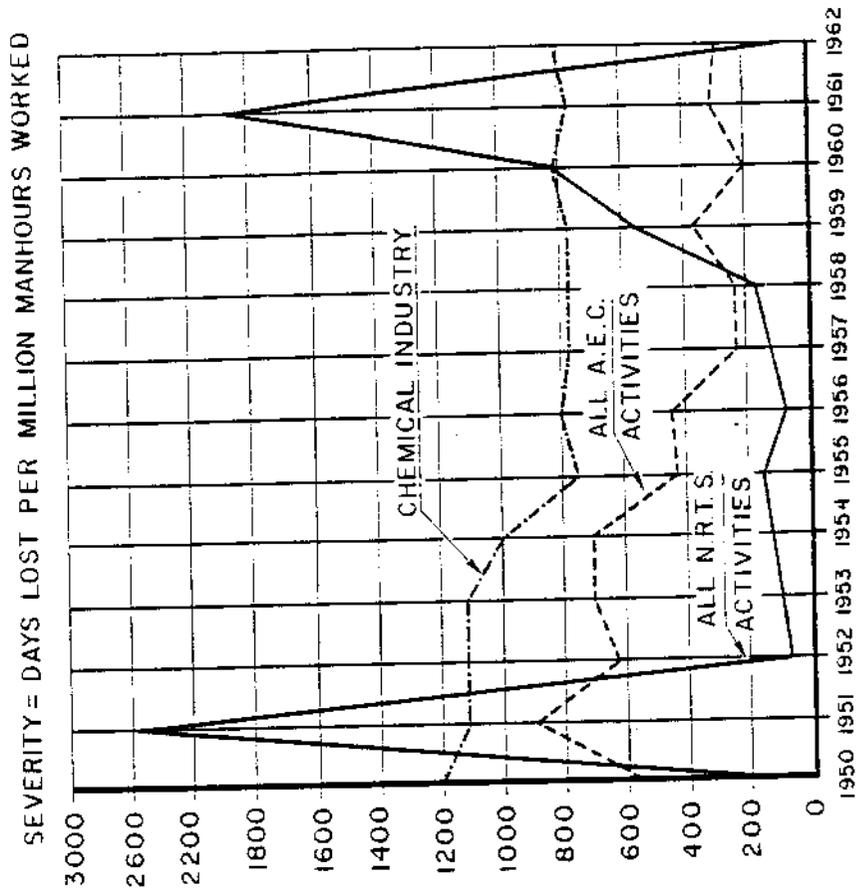


Fig. 11 Injury severity comparison.

The large difference between severity rates in 1961 and 1962 is due to three fatalities in one accident (SL-1) in 1961 with a resulting 18,000 days charged. The NRTS severity rate shows a large year-to-year fluctuation as a result of the effect of a major injury or fatality upon the relatively small manhour figure, as compared with that of all AEC and chemical industry.

2.2 Serious Injury Index

In July, 1962, a new statistical tool for a more realistic measurement of work injury experience was established at the NRTS. With the generally consistent low disabling injury rate, its use as a measure of injury experience is no longer as meaningful on a local comparative basis for the small operation or for the large operation over a short period of time. This serious injury index (Table 4), rather than measuring disabling injuries per million manhours worked, measures injuries requiring treatment by a physician per million manhours worked.

TABLE 4

NRTS SERIOUS INJURY INDEX (Last Six Months 1962)

<u>Organization</u>	<u>Manhours</u>	<u>Number of Injuries</u>	<u>Serious Injury Index*</u>
US AEC-ID	<u>502,351</u>	<u>0</u>	<u>0</u>
Aerojet-General	277,275	2	7.21
Argonne National Lab.	313,827	6	16.12
Phillips Petroleum Co.	1,967,071	10	5.08
Westinghouse Electric	<u>663,752</u>	<u>25</u>	<u>37.66</u>
Total Research	<u>3,221,925</u>	<u>43</u>	<u>13.35</u>
C. F. Braun & Co.	213,099	19	89.16
H. K. Ferguson Co.	89,125	1	11.22
Fluor Corporation, Ltd.	<u>394,770</u>	<u>87</u>	<u>220.38</u>
Total Cost-Plus Constr.	<u>696,994</u>	<u>107</u>	<u>153.52</u>
TOTAL NRTS	<u>4,421,270</u>	<u>150</u>	<u>33.93</u>

*Serious Injury Index = number of injuries requiring treatment by a physician per million manhours

2.3 NRTS Motor Vehicle Accident Experience

The NRTS Motor Vehicle Accident experience (Table 5) shows both the frequency (accidents per million miles) and government loss for 1962 to be well below that for the total period 1952 - 1962. The 1962 government loss per 1,000 miles was reduced 69% from the previous year.

TABLE 5

NRTS MOTOR VEHICLE ACCIDENT EXPERIENCE

Period Covered	Miles Traveled	All Accidents (regardless of cost)	Frequency	Loss		Govt. Loss/1,000 miles
				Govt.	Private	
1952 thru 1962	73,888,388	634	8.58	\$48,889	\$12,853	\$0.66
Year 1961	9,340,391	73	7.82	15,911	620	1.70
Year 1962	9,639,182	74	7.68	4,977	1,264	0.52

In 1962 one motor vehicle accident resulted in a fatality (non-employee) when the victim fell from a private vehicle into the path of an oncoming contractor-operated government bus. This was the second fatality involving an NRTS government vehicle in 11 years of operation and approximately 74 million miles of travel.

2.4 Property Damage Accidents

In 1962 there were nine government property damage accidents, exclusive of motor vehicle accidents and fires, with a resulting government loss of \$23,135. This is a reduction from 16 property damage accidents in 1961 with a government loss of \$4,535,037. Of the 1961 loss, \$4,350,000 accrued from one accident, the SL-1 excursion.

2.5 Special Activities

Seat belts have been provided in all NRTS government passenger vehicles (front seat only) and highway trucks since 1955. During 1962 the program was enlarged to include rear seat belts for passenger vehicles. The use of seat belts was credited with preventing serious injury, or possibly death, in two government vehicle accidents during 1962. A site-wide educational and promotional program for seat belts in personal vehicles was also successfully conducted.

2.6 Awards

AEC Award of Merit recognition was earned by four NRTS contractors from the following audited records of manhour accruals without a disabling injury:

<u>Company</u>	<u>Period Covered</u>	<u>Manhours</u>
H. K. Ferguson	12/1/58-2/28/62	724,098
Fluor Corporation, Ltd.	11/17/61-7/19/62	422,384
Phillips Petroleum Co.	11/20/61-8/5/62	2,500,000
Westinghouse Elec. Co.	12/2/60-4/30/62	2,005,404

Certification for State recognition was given for the two accruals over one million manhours. Idaho Operations Office Safety Awards were given to C. F. Braun & Co., J. F. Pritchard & Co., and F. C. Torkelson Company for noteworthy safety performance in the small contractor group.

3. FIRE PROTECTION ENGINEERING

(Richard J. Beers - Fire Protection Engineer)

Fire protection engineering services, available to all NRTS contractors, include the following: evaluation of NRTS fire protection costs and property damage vulnerability; detailed fire protection engineering surveys of existing facilities; evaluating and implementing new developments in fire extinguishing agents and techniques; development of plant fire prevention programs and fire equipment testing and maintenance programs; consulting services on special problems; development of NRTS fire protection standards; and coordination of facility design reviews.

3.1 Fire Loss Experience

Had fire losses occurred at the NRTS at the same frequency and severity as were experienced in the areas used for comparison, the property damage loss in 1962 due to fire at the NRTS would have been as listed in Table 6.

TABLE 6

ID AND NRTS FIRE LOSS EXPERIENCE COMPARISONS

<u>Year</u>	<u>NRTS Valuation</u>	<u>Actual ID Loss</u>	<u>AEC Comparative Loss</u>	<u>Improved Risk Comparative Loss</u>	<u>National Comparative Loss</u>
1962	\$423,140,000	\$2,627 ^{1/}	2/	\$118,479	\$634,710
5-year average 1957-61	284,000,000	8,600	\$12,000	81,800	446,600

TABLE 6
(Continued)

- 1/ Seventy-two percent of the ID 1962 fire loss resulted from one fire which occurred at an off-NRTS facility.
- 2/ Not Available.

3.2 Major Fire Protection Improvements

Fire protection improvements recommended in previous surveys and accomplished in 1962 include the following: sprinkler systems installed in NRF warehouse and craft shop; piped dry chemical systems installed at GCRE; piped CO₂ systems, hose reel and fire detectors installed at OMRE; detached building for storage of compressed gas cylinders erected at MTR/ETR; dangerous materials storage building erected at EBR-II; fusible link safety shut-off valves installed in oil lines at GCRE and CPP shops.

3.3 New Program Developments

- A. High Expansion Foam - The most significant fire protection program development at the NRTS during 1962 was the evaluation and acceptance of high expansion foam, a relatively new concept in fire control. High expansion foam is composed of a mass of bubbles of uniform size having an expansion ratio of approximately 1,000 volumes of foam for each volume of feed liquid. (Ordinary mechanical foam has an expansion ratio of approximately 20.) This material is effective on ordinary combustibles in building fires as well as on flammable liquid fires. High expansion foam also shows promise of control of radioactive gases and particulates released during a fire.
- B. "Purple-K" - This new dry chemical extinguishing agent is now commercially available in hand and wheeled extinguisher units. "Purple-K" is a potassium bicarbonate base dry chemical. Tests on a 400 sq. ft. flammable liquid fire indicate the new agent is about three times as effective as the old sodium bicarbonate dry chemical agent.
- C. Liquid Metal Fire Control - Pratt and Whitney Aircraft has developed an extinguishing sump which is designed to control liquid metal fires (ref. AEC R&D Report PWAC-347, "Liquid Metal Fire Control"). The extinguishing sump appears to be a significant improvement in liquid metal fire control and is being considered for several locations at the NRTS.

3.4 Future Programs

- A. The primary objective for the year 1963 will be to continue upgrading NRTS fire protection toward a level comparable to standards of "improved risk" insurance coverage. This program becomes less of a problem each year as new facilities being built meet these standards and as improvement is achieved in the older ones.

- B. Additional tests and evaluation of high expansion foam equipment will be conducted to develop as many conceivable uses as possible.
- C. Present plans also include complete revision of the ID Safety and Fire Protection Design Criteria Manual, IDO-12008.

4. FIRE PROTECTION SERVICES
(Austin M. Hess - Chief, Fire Department)

The Idaho Operations Office operates the professional Fire Department at the NRTS. The Department is trained and equipped to provide a number of services, in addition to fire protection, for all Site facilities and organizations. During its 12 years of operations, the NRTS has experienced a minimal fire loss record. This has been achieved through a well-balanced program of good communications, education of plant personnel through contractor fire prevention functions, engineering of fire protection safeguards into plant facilities, training of in-plant fire brigades backed up by the Fire Department, and mutual cooperation between all who are responsible for the protection of Site facilities.

- 4.1 Statistics - During 1962, the NRTS Fire Department responded to 66 fire alarms, fought 29 fires, and made 40 fire investigations. Actual NRTS fire losses for the year totaled \$972. Table 7 shows a breakdown of causes of fire at NRTS during 1962.

TABLE 7

FIRE CAUSES AT NRTS - 1962

Electrical Short	6
Cigarette.	4
Hot Metals	4
Unknown.	4
Malfunction of Oil Stoves.	3
Gasoline Spills on Hot Metal	2
Hot Ashes.	1
Light Bulb in Contact with Combustible Material.	1
Spontaneous Combustion	1
Overheated Tar Pot	1
Oil Leak	1

TABLE 7 (continued)

Santowax Spill from Defective Pump. 1
TOTAL FIRES. 29

4.2 Fire Protection Planning - The planning for NRTS Site fire protection is directed toward the handling of large scale incidents, including rescue operations, explosions and radioactivity, as well as the smaller conventional varieties. In order to accomplish this objective, potentially hazardous processes and occupancies are provided with built-in fire protection systems which automatically sound alarms when they are actuated. In addition, trained fire brigades composed of plant operations personnel attempt to control the situation until Fire Department personnel arrive. If the initially responding fire fighting crews cannot cope with the situation, additional crews are called to the scene from more distant stations. Further assistance and equipment can be obtained by calling in off-duty AEC fire personnel and firemen from surrounding municipalities with whom ID has mutual aid agreements.

4.3 Special Activities

- A. Special training was given to all Fire Department personnel for transporting and setting up emergency control center trailers and their related basic equipment.
- B. "Radiation Hazards in Firefighting," a three-day course, was presented to fifty police and fire department training personnel from throughout the state of Montana at Lewistown, Montana, by E. G. Dingman, Training Officer, of the NRTS Fire Department.
- C. The Fire Department training officer was elected to the position of president for the 1963 Idaho State Fire School Association.

5. INDUSTRIAL HYGIENE

(Bruce J. Held - Industrial Hygiene Engineer)

The ID Industrial Hygiene program provides functional and consultative services to all NRTS contractors and to the AEC Health and Safety Laboratory group. The Industrial Hygiene Engineer supervises the bacteriological water sampling program, is a member of the Aerial Monitoring Team, maintains the emergency respiratory equipment, clothing and food stockpiles, reviews respiratory equipment programs, reviews engineering drawings and project proposals, develops the industrial hygiene instruments library, and maintains a hazardous products file.

5.1 Routine Duties

- A. Industrial Hygiene Services - Services provided to AEC and contractors at NRTS include the following: information bulletins; specific toxicity data; consultations; surveys and

design of ventilation systems; analyses of noise problems and design of noise attenuating enclosures; surveys on heat problems; air-pollution and contaminant studies. A tabulation of industrial hygiene service requests by NRTS organizations in 1962 is as follows: PPCo. - 30; ID-AEC - 19; Westinghouse - 15; ANL - 11; Construction - 11; Atomics International - 8; General Electric - 2; Total - 96.

- B. Filter Advisory Committee - The ID Industrial Hygiene Engineer is Chairman of the NRTS Filter Advisory Committee (FAC). This committee, composed of AEC and contractor personnel, advises on filter problems, recommends filter standards, and conducts the in-line filter testing program. There were 16 requests for in-line filter tests in 1962. Over 60 different filters were tested, some more than once. An AEC vehicle was outfitted with a compressor capable of delivering 30 cfm of air at 80 psi for generating dioctyl phthalate (DOP) aerosol, an electric tail-lift for loading the smoke photometer, and a metal canopy. This vehicle is operated and maintained by ID and is available to all organizations at the NRTS.

5.2 Special Projects

- A. Respiratory Equipment Study - The NRTS respiratory equipment program was completed and summarized in report IDO-12020, "Respiratory Protection Program for the National Reactor Testing Station." Evaluations of new respiratory equipment included testing a new voice amplifying system for full-face masks, investigating the use of cryogenic self-contained air units at the NRTS, and mechanical leakage tests on some full-face masks.
- B. Air Conditioning Study - A study and report on the feasibility of conditioning air for comfort under local conditions at the NRTS was completed. The report included a means of determining the economic justification of cooling air in the summer months.
- C. Ventilation Test Unit - The PPCo. Industrial Hygienist and the ID Industrial Hygiene Engineer designed and had constructed a ventilation test unit for use in out-of-system filter testing. The unit has a small laboratory type hood, filter box for 2'x 2' filter of any thickness, 1200 cfm blower, and necessary duct-work. The unit has been used to test various filter efficiencies on perchloric acid, organic coolant, and dioctyl phthalate (DOP).
- D. Lead Fume Problem - A lead burning operation at a reactor construction site required close control over working conditions during the operation. The Industrial Hygiene aspects are included in the Medical Services Branch section of this report.

5.3 Future Programs

- A. Respiratory Equipment Testing - Mechanical leakage tests (exhaust valves, cannister seals, eye-pieces, etc.) of various

makes of respirator will continue in 1963.

- B. Ventilation Economics Survey - It is planned, with the aid of a summer industrial hygiene technician, to begin an economics survey of all reactor ventilation systems at the NRTS to determine which types are most desirable for future facilities.

6. HEALTH PHYSICS ENGINEERING
(Wm. Lyle Slagle - Health Physicist)

The objectives of the Health Physics Engineering function are to evaluate the quality of existing ID and ID-contractor health physics programs and to assure their conformity with AEC and ID standards, and to review design and construction drawings for radiation safety aspects. During 1962, all appraisal and design review functions of the Health and Safety Division were consolidated within the Hazards Control Branch. This resulted in the reassignment of a specialist from the Health Physics Branch to the Hazards Control Branch to pursue the appraisal and review functions as a safety specialty.

6.1 Design Reviews

All current design drawings and specifications for new nuclear and allied facilities were reviewed from the standpoint of health physics engineering. Particular attention was directed toward adequacy of radiation protection instrumentation, contamination control capability, personnel traffic control, layout of change rooms, ventilation, and waste disposal.

7. NUCLEAR SAFETY OUTSIDE REACTORS
(Aubrey O. Dodd - Nuclear Safety Engineer)

7.1 H&S Requirements Manual Chapter

A chapter on Nuclear Safety Outside Reactors was prepared for the ID Standard Health and Safety Requirements Manual. This chapter presents administrative requirements relating to nuclear safety in the storage, handling and shipping of fissile materials. It also contains an outline of recommendations for the preventing and handling of nuclear accidents. Outline topics are: Criticality Control Philosophy and Procedures; Emergency Procedures and Mutual Assistance; Area Radiation Monitor System; Communications; Personnel and Area Dosimeters; and Medical Services. It concludes with a list of sources of Nuclear Safety Standards.

7.2 ID Nuclear Safety Committee Participation

The Nuclear Safety Engineer, as a member of the ID Nuclear Safety Committee, participated in nuclear safety reviews of the SPERT

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Complex, ETR, ETRC, RMF, and ARMF. With the organization of the ID Nuclear Safety Division in 1962 and its acceptance of this review function, the Nuclear Safety Committee was dissolved.

7.3 Nuclear Accident Dosimeters

The Nuclear Accident Dosimeter (NAD) program at the NRTS is sponsored by ID Health and Safety Division, providing NAD units for all contractors regardless of Operations Office administration. An NAD test program was begun, in conjunction with the SPERT-I Destruct Test, to compare performance of the ORNL unit (in use at the NRTS) with models in use at Savannah River and Hanford facilities. Further tests in the SPERT-I series are necessary before data from the NAD's will permit an evaluation of relative performances.

7.4 Radioactive Materials Shipment Review

The ID review and check-out functions for NRTS radioactive material shipments were transferred to Hazards Control Branch from Health Physics Branch during June of 1962. The procedures were thoroughly reviewed and revised so that, by the end of the year, direct responsibility was assigned to the contractors, with only spot-check control to be exercised by the Hazards Control Branch. ID requirements for shipping radioactive materials, formerly a section of ID Manual Chapter 5201, were extensively revised and incorporated into Appendix L, "Safe Transport of Radioactive Material," in the ID Standard Health and Safety Requirements Manual. Form ID-109, "Radioactive Material Shipment Record," was also revised to reflect recent changes in ICC and AEC regulations governing transport of these materials.

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, management of solid and liquid radioactive waste disposal, and a physical monitoring program.

2. SITE SURVEY

(Clyde Hawley-Section Chief)

2.1 Environmental Monitoring

The ID Health and Safety Division has since 1959 released to the public semi-annually a compilation of off-site monitoring data. The 1962 summary is attached as Appendix A.

- A. Atmospheric Monitoring Program - Experience at the NRTS has shown that of all the radioactive isotopes which might be released to the atmosphere, both as a result of normal operations and of accidents at the NRTS, iodine would normally be the most hazardous in terms of human exposures. The atmospheric monitoring system is designed, therefore, to furnish data pertaining particularly to airborne iodine, as well as other isotopes. As can be seen from the map included in Appendix A, there are 14 off-site stations which are located on the basis of population concentrations and prevailing wind conditions. There are also 13 on-site stations located at the various facilities. A detailed description of the sampling and analytical equipment and methods can be found in the AEC document IDO-12021.

The highest concentration of airborne beta-gamma activity measured on-site for a one week period in 1962 was 7.6×10^{-11} $\mu\text{c}/\text{cc}$ which is 8% of the on-site Radioactive Concentration Guide (RCG), and the average for the year was 1.8×10^{-11} $\mu\text{c}/\text{cc}$ (2% of RCG). The highest concentration measured off-site for a one week period was 9.9×10^{-11} $\mu\text{c}/\text{cc}$ (99% of the off-site RCG) with an average of 1.6×10^{-11} $\mu\text{c}/\text{cc}$ (16% of RCG).

The RALA process at the ICPP was the major NRTS contributor of I-131 to the atmosphere. Table 8 is a summary of the radioactivity released to the atmosphere from that operation during 1962.

TABLE 8

RADIOACTIVITY RELEASED ^{1/} TO THE ATMOSPHERE DUE TO RALA OPERATIONS

Run No.	Date of Run	Radioiodine (curies)		Beta Activity Minus Iodine	Gross Alpha (curies)
		I-131	I-132		
67	January 10-11	1.1	13.4	27.9	1.92×10^{-3}
68	January 30-31	2.5	43.3	10.0	0.07×10^{-3}
69	February 20-21	1.5	13.1	4.2	0
70	March 13-14	3.2	14.6	11.5	0
71	April 24-25	2.7	25.6	6.6	0
72	August 14-15	1.6	7.9	1.7	0
73	September 18-19	2.4	2.8	2.2	2.3×10^{-3}
74	November 27-28 ^{2/}	11.5	0.9	0.6	0
75	December 11-12 ^{2/}	13.6	8.1	4.3	0
	Total Activity 1962 (9 runs)	<u>40.1</u>	<u>129.7</u>	<u>69.0</u>	<u>4.29×10^{-3}</u>
	Total Activity 1961 (17 runs)	42.1	226.6	68.5	-
	Total Activity 1960 (12 runs)	32.0	176.4	26.5	-
	Total Activity 1959 (16 runs)	227.2	1015.5	219.1	-

^{1/} Activity listed was released during the period from one RALA run to, but not including, the next.

^{2/} Increase of I-131 due to extensive decontamination operations, allowing release through Vessel Off-Gas (VOG) System which is not equipped with liquid and carbon bed scrubbers as is the Dissolver Off-Gas (DOG) System.

- B. Water Monitoring Program - Each source of drinking water on the NRTS was sampled and analyzed bi-weekly during 1962. In addition, potable water in 30 off-site locations was sampled and analyzed quarterly. All water samples were analyzed for alpha, beta, and tritium concentrations. The following (Table 9) reflects the activity concentrations found during 1962:

TABLE 9

POTABLE WATER ACTIVITY CONCENTRATIONS

<u>On-Site</u>	<u>% of RCG, High Sample</u>	<u>% of RCG, Average</u>
Alpha	12.0	3.0
Beta	1.4	0.3
Tritium	1.8	0.02
<u>Off-Site</u>		
Alpha	50.0	30.0
Beta	6.1	3.0
Tritium	0.1	0.1

Alpha activities found in the water are from natural alpha emitters. These concentrations have not significantly increased or decreased since the monitoring program was initiated in 1953.

- C. External Radiation Monitoring Program - Film dosimeters are located at 277 stations throughout the NRTS and surrounding areas as a means of monitoring external radiation and to furnish data in the event a nuclear accident were to occur. The packets are changed on a six-weeks period. With the exception of the stations surrounding the NRTS burial ground, there were no observed exposures significantly above the detection limit of 10 mrem. In the past an appreciable amount of data has been lost because of weather damage to the film. The use of hermetically sealed film packets is under investigation and it is expected that such will be used, and exchanged on a monthly basis, during 1963.

Radiation surveys of the ground around selected facilities on the NRTS were conducted. These surveys revealed no significant changes in activity levels from 1961. In addition, the road scanning equipment, which is described in detail in IDO-12021, was utilized to scan major highways on the NRTS. Approximately 100 particles were discovered and removed, ranging in activity from 1 to 1000 mrad/hr at contact. Because of the location and nature of these particles, it was concluded that they were a

result of the transportation of the SL-1 core and materials to hot cell facilities at TAN.

2.2 Special Activities

- A. Training - As a part of the newly organized AEC Health Physics Preceptor Training Program, two trainees were assigned to the Branch during 1962. Their training accrues from attending formal lectures, on-the-job general health physics work, and specialized training. The latter two functions are accomplished jointly by ID Health and Safety Division and PPCo. The training period is one year. In addition, three AEC Health Physics Fellows received 12 weeks of on-the-job training at the NRTS. The nature of the training is generally the same as that in the Preceptor program.
- B. SL-1 Decontamination - In July of 1962 a contract was let for the final decontamination work associated with the SL-1 reactor accident. This contract included the removal of approximately 3 km of the shoulders and slopes of the highway passing the reactor area, to a depth of 5 cm, and replacing with clean gravel. This also included the hauling and spreading of approximately 2600 m³ of soil to provide a 5 cm cover in and around the reactor area which had already been scraped. Approximately 1200 m³ of contaminated gravel was excavated from the highway edge and from contaminated areas along the west side of the SL-1 Site. Highly contaminated gravel from around the reactor building was disposed of in the SL-1 burial ground. Following the decontamination, a seal coat was applied to the highway. Subsequent surveys of the areas revealed that the radiation levels did not exceed 1 mrad/hr at 1 meter above the ground. Surveys inside the buildings revealed that there were particles embedded in the cracks between floor tiles which ranged from 2 to 1000 mrad/hr, primarily of beta radiation. Decontamination in the buildings reduced the radiation fields to acceptable levels, and the area was reoccupied by Army personnel in December.
- C. SPERT I Destructive Test - The SPERT I facility conducted the first of a new series of planned destructive nuclear excursions on November 5, 1962. The excursion reached a peak power of 2400 megawatts on a 3.3 milliseconds period. A nuclear energy release of 33 megawatt seconds was indicated. At the time of maximum power the pressure in the reactor tank reached a peak of 40 psi, but a few milliseconds later a pressure surge in excess of 5000 psi was observed. No explanation of this mechanism is yet available and, as a result, further investigation of this phenomenon is planned.

During the excursion, which expelled water and debris approximately 24 m above the open vessel, considerable

damage occurred to the control rod extensions, the core support structure, TV cameras within the reactor building, and various temperature and pressure sensors within the reactor tank. There was gross damage to the core. An estimated 7500 liters of water were expelled from the tank.

The radiological research efforts involved in the test were a joint effort of Phillips Petroleum Company, the U. S. Weather Bureau, and the Health and Safety Division. For this test, it was desired to obtain information on: (1) radiation levels experienced near the reactor vessel; (2) dependability of currently - used personnel dosimetry, determination of the neutron flux, neutron energy distribution, gamma-to-neutron ratio, and total dose from materials which one might expect to recover following a criticality incident; (3) amounts and types of radio-nuclides released to the atmosphere and their diffusion rates; (4) gross particle size determination and deposition velocity; and (5) cloud tracking data.

A rectangular sampling grid, established in 75m increments on N-S, E-W axes, extended downwind 1050 m from the reactor. High volume air samplers, particle size samplers, fallout plates (containing gummed paper, carbon, sand) and grass plots were placed at selected locations. Film dosimeters were placed at each grid station. Extensive pre-test meteorological studies were performed. Required meteorological control conditions for the SPERT I destructive test were a wind speed of 5-10 m/sec, direction of 180-260 degrees, lapse condition and no precipitation. Film dosimeters designed to record radiation from the power burst only were placed near the vessel, as were other film dosimeters and samples of whole blood, hair, and various other materials. Nuclear accident dosimeters (NAD) and copper wire were suspended over the reactor. Fourteen phantoms, made from 20-liter polyethylene carboys and filled with tissue-equivalent solution, were placed near the reactor. Twelve personnel film dosimeters were placed around each phantom and one in the center of each phantom. Tetroons (constant-level weather balloons) were released at the time of the test. The resultant cloud was tracked by an aerial monitoring team using a transistorized single-channel scintillation instrument.

The integrated dose from the power burst itself was 3 r at 61 cm horizontally from the reactor tank lip, 2.5 r at 1.6 m, and 900 mr at 2.5 m. An instantaneous dose rate of 1.2 mr/hr was recorded at the control center 880 m away. A beta-to-gamma ratio of 16 was measured at a point 1.5 m horizontally from the vessel. The average front-to-back dose ratio of the phantoms was 3. Determination of the thermal nvt from gold foil (from an NAD located at the reactor lip) and copper wire activations (2.4 m above reactor vessel) yielded values of 1.2×10^8 and 8.4×10^7 , respectively. These were the only samples

showing any measurable activation. An estimated 2.4×10^5 curies were released to the atmosphere, which represented 0.4% of the calculated fission product inventory. The fraction was computed by assuming a decay factor of $t^{-1.2}$. Using this source value, the computed center line doses were in good agreement with film dosimeter data. These film showed exposures ranging from 375 mr beta and 350 mr gamma at a point 30 m from the reactor to exposures of 0 beta and 20 mr gamma at 1,000 m. Gamma spectrometry of air samples showed the presence of Sr-Y⁹¹, Sr-Y⁹², Ba¹³⁹, and Ba-La¹⁴⁰, which are daughters of Kr and Xe. Iodine was detected only in the reactor water. At 750 m from the reactor the cloud was 210 m wide. Aerial monitoring tracked the cloud to a distance of 23.8 km, where the cloud was 600-m wide. The cloud followed closely to the mid-line of the grid. Air concentrations ranged from approximately $5 \mu\text{C}/\text{m}^3$ at 30 m, to about $0.2 \mu\text{C}/\text{m}^3$ at 750 m down the center of the plume. Deposition velocities averaged 5.5×10^{-3} m/sec across the grid. Eighty per cent of the activity collected was associated with particles having mean diameters less than 1.5 microns.

Only low level contamination was found in the reactor area following the test as a result of the negligible pre-excursion fission product inventory. During the test and following clean-up, no significant internal personnel exposures were detected, and there were no external personnel exposures in excess of 60 mr/day. The test was successfully and safely conducted, even though the damage to the reactor was greater than anticipated.

3. RADIOACTIVE WASTE MANAGEMENT (Bruce L. Schmalz - Section Chief)

3.1 Operational Data and Experience

Radioactive waste at the NRTS is directly related to reactor operations and to support facilities, such as irradiated fuel reprocessing, laboratories, decontamination, and laundry.

3.11 Liquid Waste - The total amount of liquid waste discharged to the surface and sub-surface environment in 1962 is summarized in Table 10. Unidentified activity is composed of isotopes with a half-life of less than 30 days and constitutes approximately 80% of the total waste activity. Installations discharging the major percentage of waste and their respective disposal methods are: MTR-ETR - Seepage Pond; ICPP - deep well and small seepage pits.

Waste disposal systems at the MTR-ETR facilities are being modified so that waste water from the cooling towers can be diverted to a disposal well. Waste from water treatment systems is diverted to a separate (non-radioactive) seepage pond.

Identification of isotopes in radioactive liquid waste by means of gamma spectrometry during 1962 reduced the analysis cost by about 50%. Approximately 90% of the activity with a half-life greater than 30 days is being identified by this method.

Table 11 lists the liquid waste which was specifically identified by isotopes and half-life for the beta-gamma activity. Total activity of alpha emitting isotopes amounted to less than 0.5 curie from all NRTS operations during 1962.

3.12 Radioactive Waste Released to the Atmosphere - Table 12 sets forth the gross amount of activity released to the atmosphere of the NRTS during 1962. Three installations, as shown, contributed 98.8% of the total. Alpha activity discharged to the atmosphere from NRTS installations was insignificant during 1962.

TABLE 10
LIQUID WASTE DISCHARGED TO THE GROUND AT NRTS - 1962

<u>NRTS Facilities</u>	<u>Volume of Waste (gallons)</u>	<u>Beta-Gamma Activity (curies)</u>
MTR-ETR	283,335,000	7,065
ICPP	266,659,600	419
NRF	28,127,000	41
CFA	47,095,000	3
ANL, GCRE, TAN, OMRE, SPERT	34,492,400	14
Total 1962	659,709,000	7,542
1961	495,177,000	3,592

TABLE 11
IDENTIFIED RADIOACTIVE ISOTOPES IN LIQUID WASTE DISPOSALS (CURIES)
1962

<u>Isotope</u>	<u>Half-Life</u>	<u>Beta-Gamma Activity</u>
Tritium	12 years	651
Chromium-51	26 days	203
Cerium-141-144	32 days, 292 days	173
Barium-Lanthanum-140	13 days, 40 hours	143
Ruthenium-Rhodium-106	1 year, 30 seconds	110
Iodine-131	8 days	98
Strontium-89	50 days	43
Cesium-137	33 years	30
Strontium-90	28 years	24
Cobalt-60	5 years	4
Zirconium-Niobium-95	65 days, 35 days	2
Cobalt-58	71 days	1
Total curies		1,482

TABLE 12
ACTIVITY DISCHARGED TO THE ATMOSPHERE - 1962

<u>Installation</u>	<u>Curies</u>	<u>Identified Isotopes</u>
MTR-ETR	349,334	A-41, Kr-88-89-90, Xe-137-138
Other (CFA, Laundry, GCRE, NRF, OMRE, SPERT)	601	Ce-141-144, Nb-Zr-95 Kr-91, Kr-92, Xe-139
ICPP	258	I-131, I-132
ANL	186	A-41
Total 1962	<u>350,379</u>	
1961	338,466	

3.13 Solid Radioactive Waste - The solid waste generated at the NRTS during 1962 amounted to a volume of 4473 m³ with an estimated activity of 112,369 curies. A total waste volume of 3607 m³ and 5586 curies of activity originating off-site was also disposed of at the NRTS burial ground. Off-site waste arrived in a more satisfactory condition and presented fewer problems than during 1961. Phillips Petroleum Company was assigned operational control of the NRTS burial ground beginning August 1, 1962.

3.2 Waste Disposal Research

3.21 Drilling - During 1962 a total of 8 new wells were drilled and 5 existing wells modified which includes 1515 m of hole and 1248 m of casing. A core hole was drilled to a depth of 78 m with 93.8% core recovery accomplished. Under the cooperative program with the U. S. Geological Survey, 213 m of small diameter casing (5 cm) were installed in the alluvium adjacent to the MTR-ETR seepage pond, and 165 m were installed similarly in the ICPP area. A total of 213 m of test hole was drilled in exploration of waste disposal sites. The purpose of these wells is to further research studies in geology, hydrology, and geochemistry of the subsurface of the NRTS. They provide sampling points to determine the attenuation, rate of movement, and perimeter of liquid radio-active waste discharged to the ground. (For further detail, see Report IDO-12022).

3.22 Tritium Investigation - During 1962, the most reliable determination to-date of regional ground water velocity was made. A flow rate of 2 m to 2.3 m per day was determined, based on tritium migration from the ICPP disposal well to CFA during the period from March, 1954, to October, 1958. (For further details, see Section IV, ANALYSIS, sub-section 2.4, Determination of Tritium).

A study of surface streams and sub-surface water using tritium as a tracer is being conducted to help determine the regional migration flow rates and direction. Tritium

investigations to date within the NRTS are presented in report IDO-12026.

3.23 Laboratory Research - Laboratory work was continued under an AEC contract with PFCo concerning ion exchange and other chemical properties of natural earth materials at the NRTS. A comparative investigation of sorption characteristics of synthetic organic resins and naturally occurring clay minerals was conducted for the purpose of developing a treatment system to be used at the ICPP storage basin. Preliminary results of these studies are presented in Section IV, ANALYSIS, sub-section 2.7, of this Progress Report.

3.3 Geophysical Logging

Two borehole geophysical logging units obtained from the Grand Junction Operations Office have been adapted to NRTS use. The hydrologger is capable of making water temperature and resistivity profiles. The lithologger is capable of making gamma logs, density logs and caliper logs. A small diameter gamma probe was added for detecting radioisotopes in cased auger holes. The gamma-density attachment provided the capability for detecting variations in rock density in cased wells. A motorized caliper probe serves to identify potential aquifers in uncased wells. Experimental work was initiated toward development of spectral gamma logging to facilitate identification of radioisotopes in the ground. Low activities present and instrument interference from power supply have made initial efforts unsuccessful.

3.4 Future Plans

3.41 Borehole Geophysics - Borehole geophysical logging will be continued. The movement and retention of radioisotopes in the lithosphere will be observed by this or such other methods as may be necessary.

3.42 Geology and Mineralogy - Mineralogy and chemical investigation of basalt and interflow sediments will be completed and appraised in the correlation of geologic structures.

Refinement of the geologic information is proposed. This will involve the precise delineation and determination of thickness of unsaturated sediments above the ground water table and the occurrence of sediment beds below the water.

3.43 Geo-hydrology - General investigation of the system of streamlines in the immediate vicinity of the ICPP disposal well was accomplished during 1962. Additional information remains to be obtained regarding the total dispersion and path of streams leaving the area. This also remains to be determined for other areas and facilities. Regional flow pattern information will be required for this purpose. This can only be determined by regional tracer tests,

geophysical surveys, hydrographic surveys and, probably, additional drilling. The tracing of tritium, from both fallout and waste disposal, offers the most promising possibility. It is expected that a seismic survey will be accomplished to supplement existing gravity and magnetic information. The behavior of the ground water, as determined by well hydrographs, is also a geophysical parameter. Collection and correlation of this type of data with chemical information will be continued.

- 3.44 Geo-physical - Interest continues in the ground disposal of high-level solid waste (fuel elements). The primary problem in these cases involves heat generation in the wastes and thermal conductivity of the geologic formations. Preliminary laboratory tests and development of field logging techniques for in-situ heat conductivity testing are expected to be accomplished during this period. A field test of burial techniques for high-level waste is proposed.

Plans will be implemented for a field study of formations to accept air or gases and to study the practicability of storage or permanent placement of gaseous waste in the lithosphere. This will involve the drilling or modification of a well or wells. This project will involve the appraisal of gas sorption by earth and clay minerals.

- 3.45 Geo-chemical - The movement of ground water, using tritium analysis, will be continued for the purpose of determining velocity and extent of movement and of defining underground systems. Water quality, as defined by dissolved solids, will also be of concern in this work.

The first phase of a factorially designed laboratory column study will be completed. A statistical evaluation will also be finished. This study concerns the retention of various radioactive isotopes of concern in liquid waste disposal. This investigation will include, in addition to the isotopes, such variables as chemical composition, pH, flow rate and temperature of the solution, column length, exchange material, including the alluvial sedimentary deposits at the NRTS with grain size variation. This work should result in a mathematical estimate of the capacity of the earth materials at the NRTS for radioactive waste.

4. REPORTS AND PUBLICATIONS

- (1) Report IDO-12026 "Retention and Migration of Radioactive Isotopes In the Lithosphere at the National Reactor Testing Station - Idaho" by Bruce L. Schmalz and W. Scott Keys.
- (2) Report IDO-12022 "Completion Report for Contract AT(10-1)-1054

and AT(10-1)1122 Well Drilling, Casing, Cementing and Logging" by W. Scott Keys and Joe H. Osloond.

- (3) "Progress Reports on Chemical, Physical and Ion Exchange Properties of Natural Earth Materials" by D. W. Rhodes and M. W. Wilding.
- (4) "Research in Geophysical Logging and Tracer Techniques in Connection with the Snake River Plains Aquifer," by W. Scott Keys, U. S. Department of Interior, Pacific Northwest Field Committee-Minutes of the 109th Meeting, October 31 - November 1, 1962.
- (5) Report IDO-22044-USGS "Hydrology of Waste Disposal, NRTS, Idaho, Annual Progress Report 1962," U. S. Department of Interior, Geological Survey.

VII. ECOLOGY

(RAY MCBRIDE - ACTING BRANCH CHIEF)

1. MAJOR STUDIES

1.1 NRTS Agroecology

The surveillance of radioisotopes contained in the biosphere at the NRTS is concerned mainly with correlations between radioactivities in the vicinity of nuclear facilities and in the off-site environs. Background or off-site radioactivity consists of natural radiation plus any addition from nuclear test fallout. A very sensitive correlation of NRTS-generated effluent radioactivity to natural background is established when the strontium-90 levels in jack rabbit bones collected on-site are compared with strontium-90 levels in jack rabbits collected off-site and in commercial milk produced just outside the NRTS perimeter.

At the NRTS the maximum strontium-90 values in jack rabbit bones (60 picocuries per gram of calcium) occurred after a fission product release in 1958, within a 5 km radius of the Chemical Processing Plant. (Figure 12)

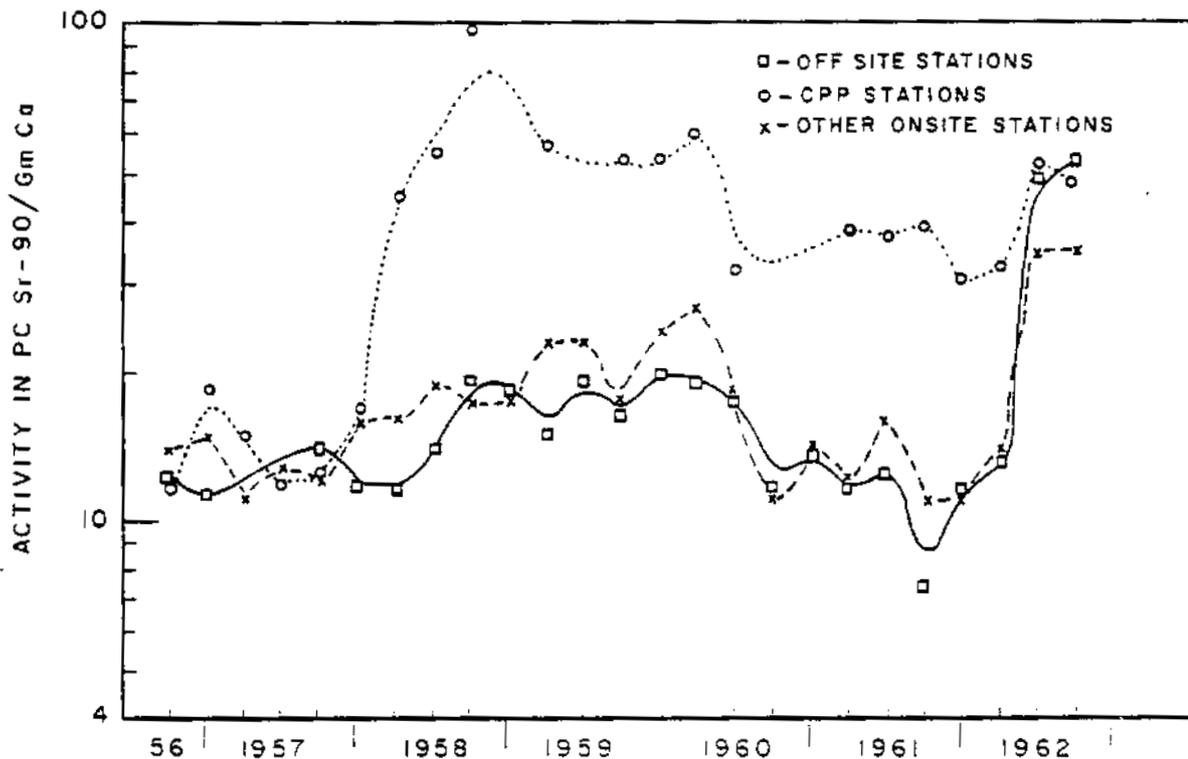


Fig. 12 Summary of Sr-90 found in jack rabbit bones (averages of individual samples).

These levels over the past five years have approximated four times those elsewhere on-site and those off-site, with a concomitant reduction of all levels to respective low points in 1961. Then with the onset of nuclear weapons testing a general upward trend of the strontium-90 levels in all samples of jack rabbit bone, including those around CPP and off-site, occurred. This resulted in a coalescence of values at CPP and off-site stations at about 50 picocuries per gram of calcium in 1962.

Strontium-90 in milk produced near the NRTS during 1962 reached an average high in July of 13 picocuries per liter, after which it declined to near February levels. It was noted that milk produced from last year's hay remained at low levels of 2 to 5 picocuries per liter all year long. At the time of the strontium-90 high point in mid-year, iodine-131 was readily detected in milk, averaging 160 picocuries per liter, but dropped significantly for the remainder of the year. (Figure 13). On the basis of strontium-90 and iodine-131 analyses, at no time during 1962 was the NRTS generated radioactivity detected in off-site milk or jack rabbit bone.

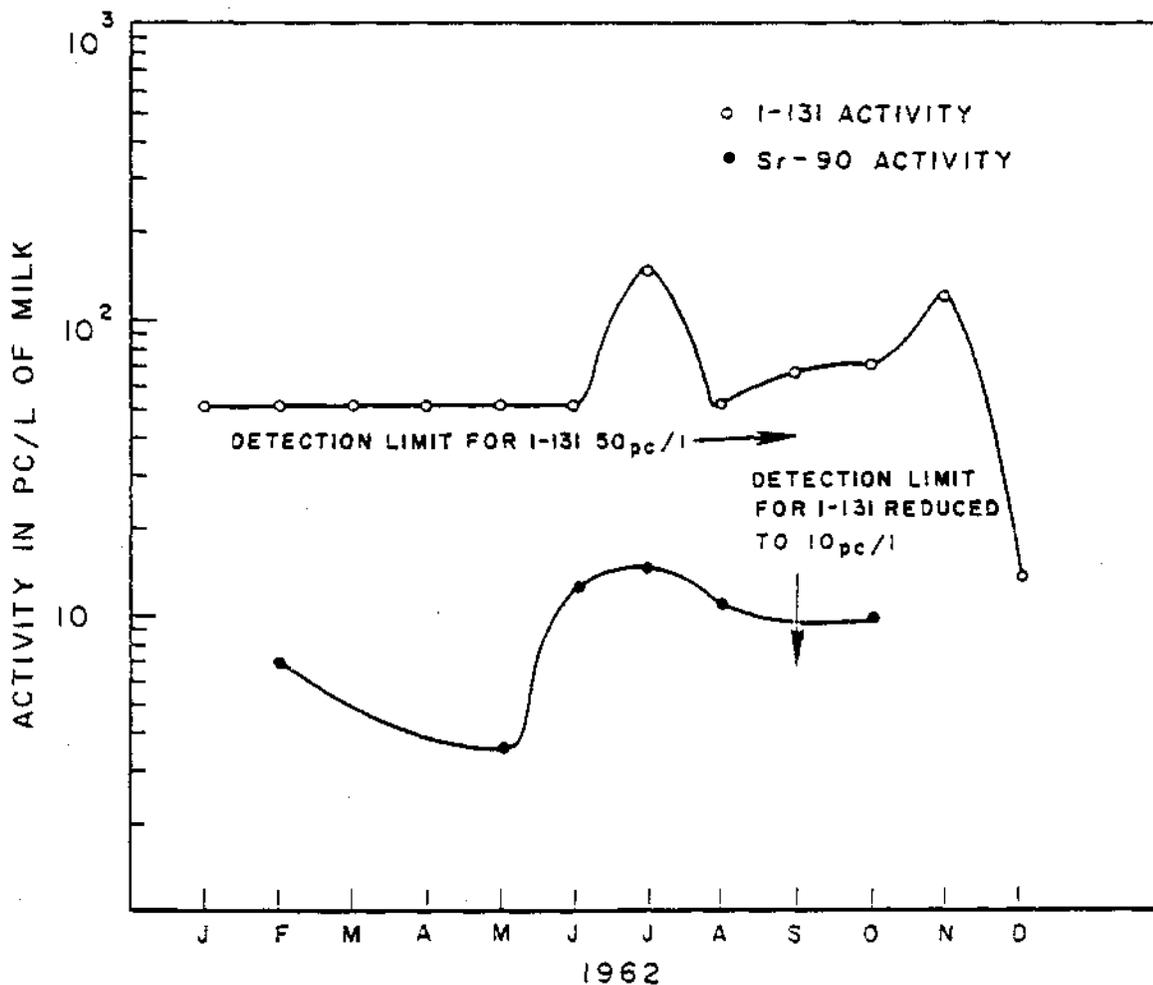


Fig. 13 Average I-131 and Sr-90 found in raw milk.

1.2 Mechanism of Wheat Contamination

To study the mechanism of radio-strontium contamination of wheat grain, two areas, each three meters square, were covered with green polyethylene sheeting during the period from grain head emergence to harvest, in order to eliminate absorption of current fallout debris. The ratio of strontium-90 levels in uncovered grain to covered grain was 3.3. It is known that strontium does not readily move from the leaves to the head. Consequently, it is concluded that about 30% of the strontium-90 in the grain of wheat plants grown in the open is absorbed from the soil. Samples of combined grain were compared with hand-harvested grain, both groups taken from the uncovered stand, to evaluate the possibility of grain contamination from blowing dust during harvest. There was no significant variance of strontium-90 activity between the two groups.

1.3 Radioisotope Inventory in a Contaminated Semi-Arid Area

The inadvertent release of fission product contamination to a 12 hectare area near the Fuel Element Cutting Facility in the fall of 1958 created a study area for the surveillance and inventory of these radioisotopes in this limited environment. Early surveys showed this contamination to be wind stable, considerably insoluble heavy particulate material, and readily removable from vegetation by ultrasonic washing.

The center of concentration and boundaries were established. A quarter quadrant grid of 16 squares of about 0.8 hectare each was established around this center. Two soil samples of one-tenth square meter each, one cm deep, were taken from each quarter quadrant. Vegetation was sampled by random line transects, cover and density were determined and quantitative samples were taken of each major species in each quarter quadrant. Density and species composition of resident mammals were determined by the circular trapline method of Calhoun. The major species were sampled in each quadrant.

All of the samples were analyzed for cesium-137 and strontium-90, the principal contaminants in the area. From these data the total inventory of cesium-137 in this 12 hectare area consists of 30,464 μc in the top cm of soil, 800 μc in the flora, and 3.6×10^{-3} μc in the fauna. The inventory of strontium-90 consists of 45,100 μc in the soil, 260 μc in the vegetation and 9.6×10^{-3} μc in the animals. This isotopic inventory technique appears readily adaptable to almost any contaminated environment to which access is available.

1.4 Calcined Radioactive Contaminants

The Waste Calcination Facility at the Chemical Processing Plant, once operations begin, will transform fission products in solution into dust-size particles of dry matter by rapid evaporation. Radioisotopes are firmly imbedded in the matrices of these particles. If any particulates were to escape from the

elaborate off-gas clean-up system of the calciner they would be deposited downwind on plants, animals and soil. These particulates could enter the food chain by absorption through roots and foliage or by direct ingestion. The amount taken from the environment by the absorptive and digestive processes will be indicative of the biological availability of the calcined radioisotopes.

To conduct studies on uptake and retention characteristics of calcined waste, radioactive calcined material was prepared by Argonne National Laboratories. It was analyzed by gamma spectrometry and found to contain approximately 1.0 μc of cesium-137 and 0.34 μc of cesium-134 per mg of material.

Three "Dutch" laboratory rabbits were given 800 mg each (1,080 μc of radiocesium) of calcined material in a gelatin capsule. The rabbits were gamma counted daily for 23 days and their release rates for cesium gamma were plotted. The release of these isotopes followed a complex three-compartment curve of the expression:

$$A = A_0 (0.54 e^{-1.38 t} + 0.27 e^{-0.31 t} + 0.19 e^{-0.05 t})$$

Release of the calcined material was fairly rapid. Twenty days after ingestion the rabbits retained only 6% of the ingested dose.

A study was performed to determine the effect of varying the method of contamination upon the uptake of calcined waste by plants. Bean and beet plants were grown in two-liter pots of soil contaminated with 1,350 μc of radiocesium in calcined waste. Application was by sprinkling on the soil surface and by thorough mixing into the soil. At maturity the plants were harvested and their uptake of contaminant determined. Uptake was very low, approximately 0.004%. Uptake was 60% greater from the soil-surface contamination than from the soil-mixed contamination. Although the difference in uptake effect has not been explained, the study suggests that plant uptake of cesium contamination may be significantly greater during the period shortly after deposition than after infiltration into and exchange with the soil, if such occurs.

2. FUTURE PROJECTS

2.1 Iodine-Milk Study

Plans are being formulated for the establishment of an irrigated pasture downwind from the Chemical Processing Plant in preparation for a series of controlled iodine-131 releases. This will be used to study the pasture-cow-milk-man food chain.

2.2 Contamination Control Through Feeding

A project is planned to study the variation of strontium-90 activity in milk produced between two grade-A dairies. One dairy will feed stored food on a year-around basis while the other will utilize fresh green pasture whenever it is available.

2.3 Uptake from Planned Field Releases

The planned field releases of SPERT-I and the SNAP tests will be studied for biological monitoring techniques and further research regarding plant and animal uptake of isotopes from their environment.

2.4 Waste Calcination in Birds and Algae

The levels of radioactivity in migratory game birds watering in low-activity settling ponds will be studied. Dispersal movements will be determined if possible. Radioactivity in settling pond water and algae will be checked periodically in the conduct of these studies.

2.5 Calcined Waste Biological Availability

The uptake of strontium-90 by plants and animals from soils and food contaminated with hot calcine wastes will be determined, to augment last year's study of gamma emitters in these wastes.

2.6 Fallout Deposition Ratios

Deposition ratios of several different plants in a fallout field will be determined to establish the activity relationships between these plants for use in biological monitoring.

3. PUBLICATIONS

1. "Use of the Jack Rabbit as a Bio-Indicator of Environmental Sr⁹⁰ Contamination," Z. M. Fineman, R. McBride and J. Dermer, Radioecology, Reinhold Publishing Company, 1963.

VIII. INSTRUMENT AND DEVELOPMENT

(MACK WILHELMSSEN - BRANCH CHIEF)

1. SCOPE

The Instrument and Development Branch serves the Health and Safety Division instrument maintenance and development needs. It also provides all contractors at the NRTS a supply of calibrated portable radiation detection instruments on a loan basis. Assistance is given to other Government Agencies on their instrument needs at the NRTS.

2. INSTRUMENT MAINTENANCE

2.1 Portable Instrumentation

The following shows the percentage of portable instrument service and calibration utilized by each NRTS operating group during 1962:

Phillips Petroleum Company	39%
Atomic Energy Commission	20%
Westinghouse Electric Corporation	14%
Argonne National Laboratory	12%
General Electric Company	6%
Aerojet-General Corporation	4%
Atomics International	4%

2.2 Fixed Instrumentation

Laboratory instrumentation utilized within the Division was supplemented by the addition of a Packard Tri-Carb liquid scintillation counting system and a Sharp Lo Background Counter. This system is capable of either alpha or beta counting and manual or automatic sample handling. Both units read out sample data in either digital or punched paper tape form.

3. INSTRUMENT DESIGN AND DEVELOPMENT

The primary development effort was spent on the Automatic Film Badge Reader, which is described below. Lesser projects consisted of: (1) a small, compact scintillation probe for gamma logging of wells, and (2) a noise study in scintillation counter preamps. Projects started but not completed were (1) a rotating film calibrator, and (2) a well-water-level logging instrument.

The Automatic Film Density Reading System is designed to accomplish automatically: (1) identification of a piece of dosimetry film with a film badge number preassigned to a particular individual; (2) measurement of film densities resulting from exposure to nuclear radiation for each of four fields corresponding to the exposure through four different filtering media; and (3) recording of this identification and density data on punched paper tape.

The system is composed of the following sub-systems, the first three being support components to the fourth:

1. Lead Insert Punch;
2. Contamination Detector and Badge X-Ray Unit;
3. Film Tray Loader; and
4. Film Identification and Density Reader.

3.1 Lead Insert Punch (Figure 14)

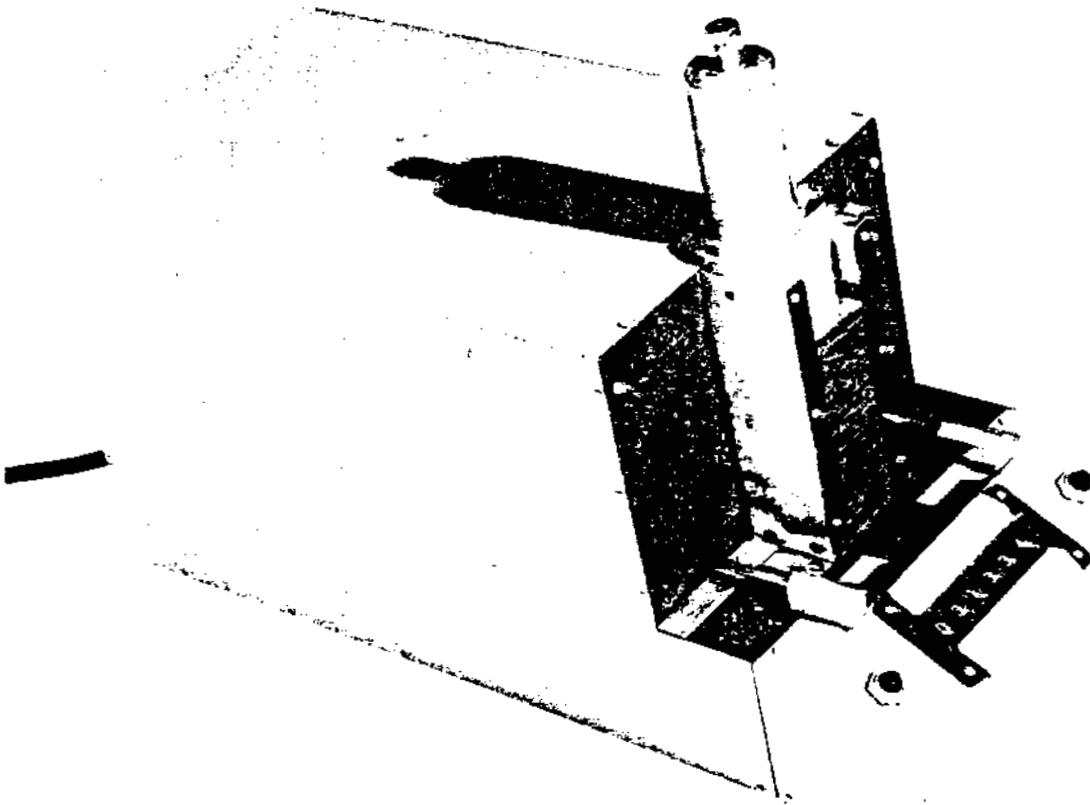


Fig. 14 Lead Insert Punch.

The lead insert punch is an electro-mechanical device which converts any six-digit decimal number into a binary form and perforates this number into a 0.5" x 1.6" leadstrip. Blank lead strips are stacked into a vertical holder for insertion under a punch block. Solenoids selected by binary number information are used to activate the desired punch pins and a motor-and-spring driven cam forces the punch pins through the lead to perforate the binary number. The insertion, punching and ejection of the lead insert is accomplished automatically after the decimal number is preset into the system and the punch energized by a push button switch. After being properly coded, the lead insert is permanently cemented within a film badge assigned to and worn by a particular individual.

3.2 Contamination Detector and Badge X-Ray Unit (Figure 15)

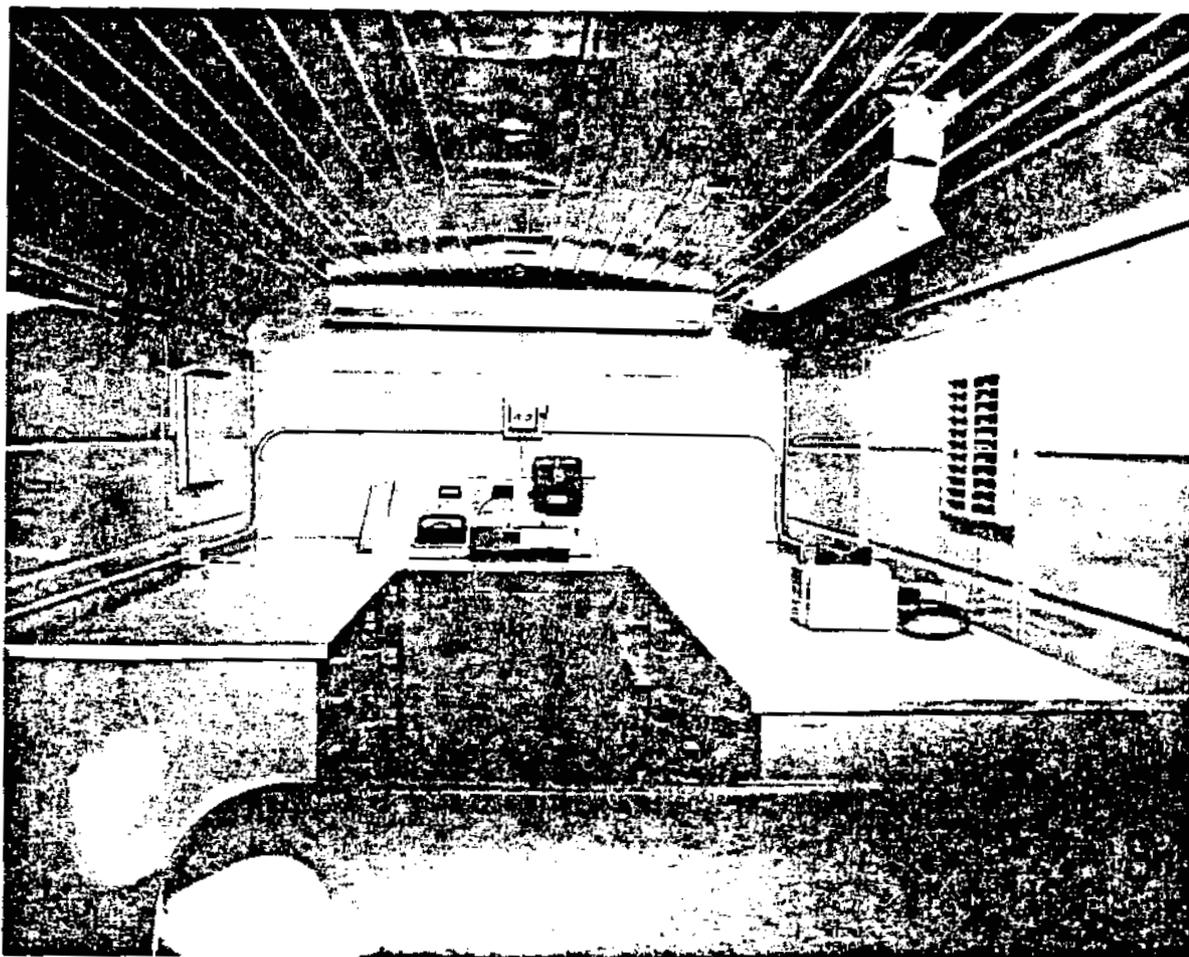


Fig. 15 Contamination Detector and Badge X-Ray Unit.

The Contamination Detector and Badge X-Ray Unit is a sub-system for registering any contamination on a film badge and simultaneously x-raying the image of the preassigned binary number coded lead strip within the badge onto the dosimetry film within.

After the film badges have been collected from the workers, they are stacked between sloping guide rails where they are allowed to drop one at a time onto a conveyor belt. Each badge, in turn, passes over a G.M. detector which is connected to a count rate meter and alarm system designed to stop the conveyor should a badge be radioactively contaminated. If contaminated, the badge is removed for special handling and decontamination. "Clean" badges move beyond the G-M detector and are accurately guided over a collimated x-ray port. When in position, each badge actuates a micro-switch and the X-Ray unit is energized. The collimated x-ray beam exposes only the number area of the film to produce the binary coded latent image. Badges are scanned and x-rayed at a rate of about 35 per minute.

3.3 Film Tray Loader (Figure 16)

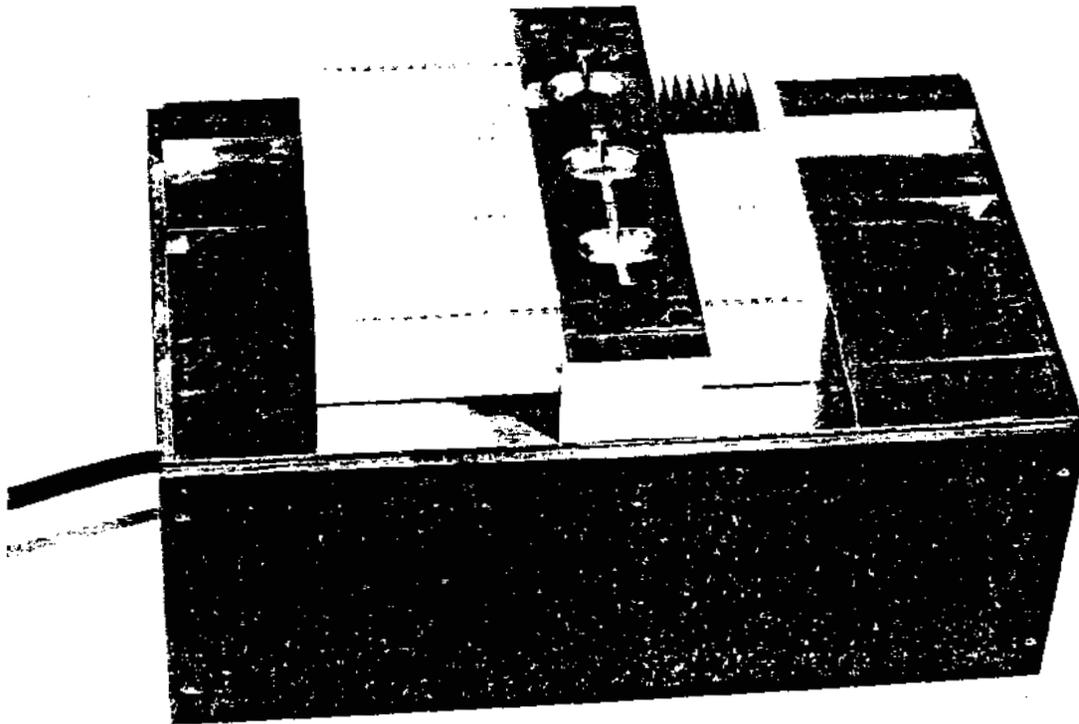


Fig. 16 Film Tray Loader.

The Film Tray Loader is a device for precisely positioning the slots of a film developing tray beneath finger guides to facilitate the loading of dosimetry film under dark room conditions. The tray loader is designed to be flush-mounted into a table top. A small stepping motor drives a timing belt which in turn engages the film tray to move it beneath the finger guides. As each slot is filled with film, a finger-actuated micro-switch energizes the drive to advance the tray one position.

3.4 Automatic Film Density Reader (Figure 17)



Fig. 17 Automatic Film Density Reader.

The Automatic Film Density Reader serves to automatically identify a prenumbered dosimetry film, observe the film density from four separate fields and record this data, together with other pertinent information, onto punched paper tape.

Physically, the Reader consists of a control console, keyboard, power supplies and paper tape punch. The control console includes function control, visual readout display (Figure 18), digital voltmeter, and all logic circuitry, together with a film changer and densitometer head which are mounted into the top of the console table. The power supplies and tape punch are housed external to the main console and cable-connected for ease of physical arrangement in a room.



Fig. 18 Visual Readout Display.

The logic and switching circuitry as well as the digital voltmeter are of modular construction, utilizing fiberglass-based printed circuit boards. The digital voltmeter, keypunch keyboard, power supplies and paper tape punch are standard commercial items modified for this application. Except for some vacuum tubes used within the digital voltmeter the reader is designed for solid state components. Four separate modes of operation can routinely be used: (1) automatic badge number insertion; (2) manual badge number insertion; (3) manual tape punch; and (4) test mode. All data and condition codes are displayed for the benefit of the operator by edge-lighted lucite panels. Data is recorded on 8-track punched paper tape in standard IBM coding. Readout time per film is approximately 4 seconds. The complete system concept utilizes odd-bit parity for validation checking purposes.

Exposed and processed film is loaded into prenumbered plastic trays. The film tray is inserted between guides and transported by a moving belt until the first film is positioned for insertion into the densitometer head. While moving into position, the identification of the tray number is accomplished by sensing two rows of pegs protruding along the side of the tray. The film number within the tray is counted consecutively from 00 to 31 as the tray is advanced through the reading head. Tray number as well as film number within the tray are displayed in decimal form for the benefit of the operator.

Prior to the reading of the first film in each tray, the reader automatically scans a fixed density filter. The reading from this filter is tested later by the computer to determine if the calibration of the reader has remained within the limits required. Following the reading of the calibration filter the first film is picked up by a vertical reciprocating arm, gripped by solenoid-actuated fingers, and raised into position for identification and density reading. The reading densitometer head consists of a light source, fan for cooling, constant-density filters and 39 photo-sensitive diodes. Thirty of these diodes are used for film identification and four for measuring density resulting from exposure through the four density media. The remaining five sensors are used to initiate control functions for operation of the reader.

As each film is raised into the densitometer head, the constant density filter is raised out of the light path. Badge number identification is made by viewing the opaque spots on the film created at the time of x-raying.

The photo-diode sensors control logic circuitry for storage of this data and subsequent readout, as well as binary-to-decimal converters for presentation of this number to the operator. The intensity of a light beam transmitted through the film is measured to determine the density of the four fields. Upon command the data is scanned, displayed and read out simultaneously for recording the identification and density data.

At completion of the readout cycle the film is lowered into the tray, the tray is advanced one position, and the next film is ready to be raised and read.

Performance testing of the Automatic Film Density Reading System has been satisfactory and the following characteristics are noted:

1. Stability --- less than .25 mr/hr drift (long term);
2. Temperature drift --- less than 1 mv/degree F change;
3. Reading reproducibility --- maximum deviation plus or minus 2 mv;
4. Resolution --- plus or minus 3 mr hard gamma;
5. Readout time --- approximately 4 seconds per film;
6. Number identification --- no incorrect number recordings to date.

The system is now installed, operative and in routine use by the Personnel Metering Branch. Complete description and technical data are available from ID Report No. ID-12029.

4. FUTURE PROGRAMS

Projects to be initiated and/or completed in the immediate future are:

- 4.1 Continued routine testing of the Automatic Film Badge Reader;
- 4.2 Modification of the telemetering system readout format to be compatible with IBM data processing equipment;
- 4.3 Automation of film badge calibration equipment for improved accuracy and production;
- 4.4 Construction of calibration well drive systems for installation in the new Health and Safety Laboratory;
- 4.5 Development of a well-water-level logging system for accurate water-level monitoring in wells; and
- 4.6 Continued testing and adaptation of solid state nuclear radiation detectors to detection and measurement problems at the NRTS.

IX. U. S. WEATHER BUREAU
(NORMAN F. ISLITZER - METEOROLOGIST IN CHARGE)

1. SCOPE

The Weather Bureau, under the auspices of the AEC, maintains an operational and research type weather station at the NRTS. Diffusion weather forecasts, required by the Health and Safety Division and the various contractors of the AEC for the safe conduct of reactor experiments, are supplied along with meteorological observations during the course of the experiments. The Weather Bureau also conducts an extensive observational program to provide the necessary climatological statistics for reactor siting and planning purposes.

2. SPECIAL ACTIVITIES

2.1 SPERT-I Destruct Meteorology

A. Preplanning-Forecast Studies

Three special wind stations were installed in July and August in support of the SPERT-I Destruct Test. One was located at SPERT-I, one on Stage Road and one on Shell Road. The latter two stations were about 5 km and 16 km northeast of SPERT-I, respectively. Since long-period climatological records exist for the Central Facilities Area (CFA) and forecasting personnel had a higher confidence value for forecast parameters in the CFA, studies were made comparing conditions at SPERT-I to those at CFA. The CFA is about 5 km west-southwest of SPERT-I. The meteorological forecast conditions required for the SPERT-I Destruct Test were set as follows: wind direction $220^{\circ} \pm 20^{\circ}$, wind speed 5-10 m/sec, temperature lapse conditions and no precipitation for a three-hour period.

B. Post-Test Meteorological Analyses

- (1) Meteorological Data. The meteorological data collected during the test for the 1220-1420 MST period are as follows:

<u>Station</u>	<u>Wind Speed (\bar{U}) (m/sec)</u>	<u>Wind Direction (θ)</u>	<u>σ_{θ}</u>
SPERT-I	10	226 $^{\circ}$	10.9 $^{\circ}$
5 km arc	13	238 $^{\circ}$	11.9 $^{\circ}$

The values of the standard deviation of the wind direction variations, σ_{θ} , are based upon instantaneous

readings at one-minute intervals for the SPERT-I station and upon instantaneous readings at alternating two- and three-minute intervals for the 5 km arc station. The ten-minute mean meander of the wind direction fluctuations was also subtracted from the σ_{θ} for SPERT-I, yielding a more appropriate σ_{θ} of 8.6° . The vertical temperature lapse rate was nearly neutral on the 75-m meteorological tower at Central Facilities.

For the purpose of computing plume centerline concentrations and concentration isopleths, the following Sutton parameters, based upon the general meteorological conditions, were used:

$$\begin{aligned}\bar{U} &= 12 \text{ m/sec} & n &= 0.25 \text{ (neutral)} \\ \theta &= 230^{\circ} & C_y &= 0.178 & C_z &= 0.118\end{aligned}$$

The diffusion parameters are typical for the NRTS during such meteorological conditions¹ with the assumption that C_z equals $2/3 C_y$.

- (2) Diffusion Calculations. Using the Sutton equation, plume axis dilution (X/Q) was computed for each arc downwind where high-volume air sampling data were available. The air concentration data, collected by the Health and Safety Division, consisted of the sum of the prefilter and carbon-trap measurements from the high-volume samplers in $\mu\text{c}/\text{m}^3$ over a two-minute sampling interval, back-corrected for decay to 1800 MST. The SPERT Destruct Test was initiated at about 1227 MST. The analysis of this data is not complete, so that comparisons of measured and computed radiation values are preliminary at this time. The crosswind distributions of concentration were plotted and analyzed (Figure 19) so that plume-centerline interpolated concentrations could be obtained. These interpolated centerline concentrations, X , were then divided by their appropriate X/Q values and averaged to obtain an estimate of the virtual source strength, Q , without correction for decay, which was 1.51 curies. Then, knowing the source strength, the computed values of the axial concentration versus distance downwind were plotted and compared to measured values (Figure 20). Computations of the axial concentration, based upon the method suggested by Pasquill², for two stability

¹ Diffusion Climatology of the National Reactor Testing Station. IDO 12015. G. A. DeMarrais and N. F. Isfizler. April 1960, 149 pp.

² Atmospheric Diffusion. F. Pasquill. D. Van Nostrand Company, Ltd., London, 1962, 297 pp.

classes are shown in Figure 20. Computed (Sutton) and measured isopleths of concentration were compared (Figure 21) in which the axis of the isopleths is directed along the mean wind direction. It can be seen that there is good agreement between the measured and computed concentrations.

It was found that the wind fluctuation data, σ_{θ} , could not be used to predict concentrations, probably because the telemetered wind data were not sufficiently detailed for use with reactor excursion data.

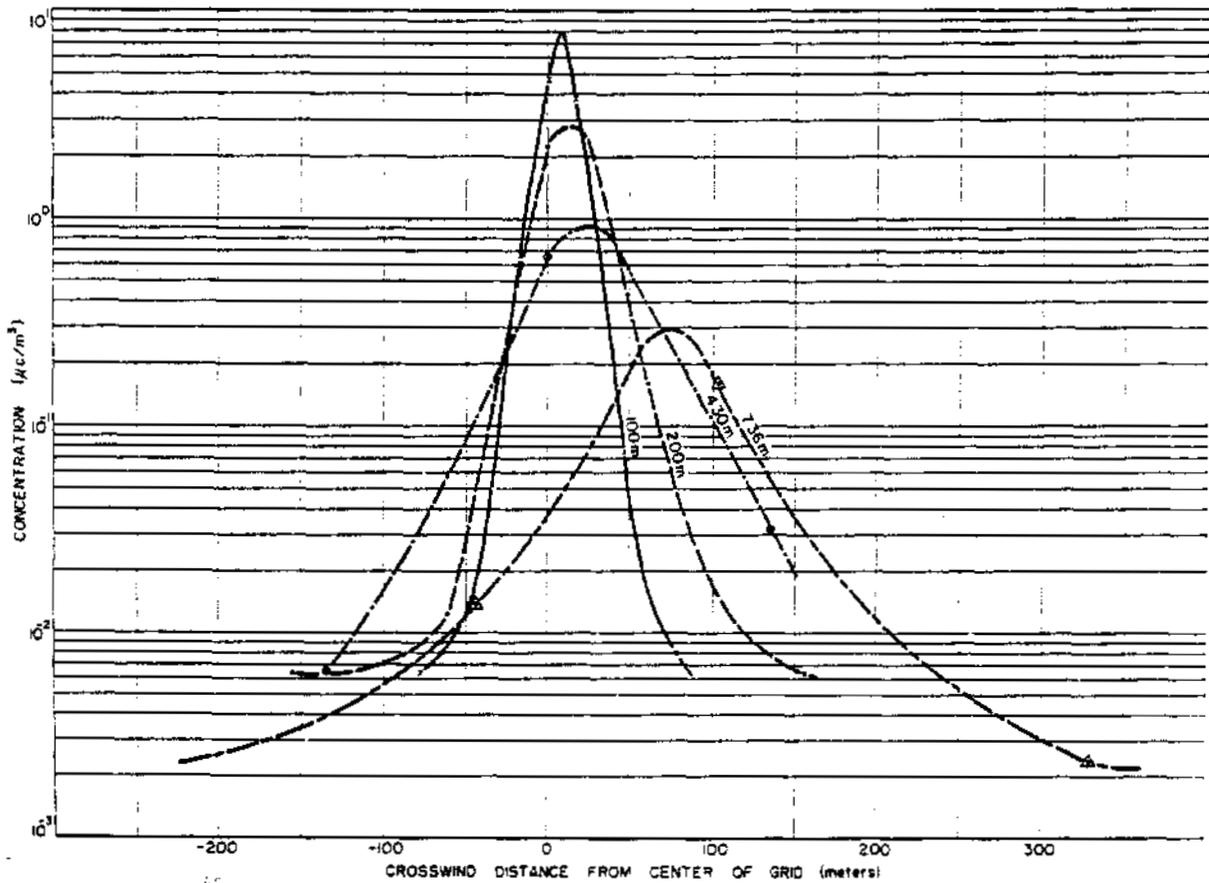


Fig. 19 The crosswind distribution of air concentration of mixed fission products ($\mu\text{c}/\text{m}^3$) for the SPERT I Destruct Test.

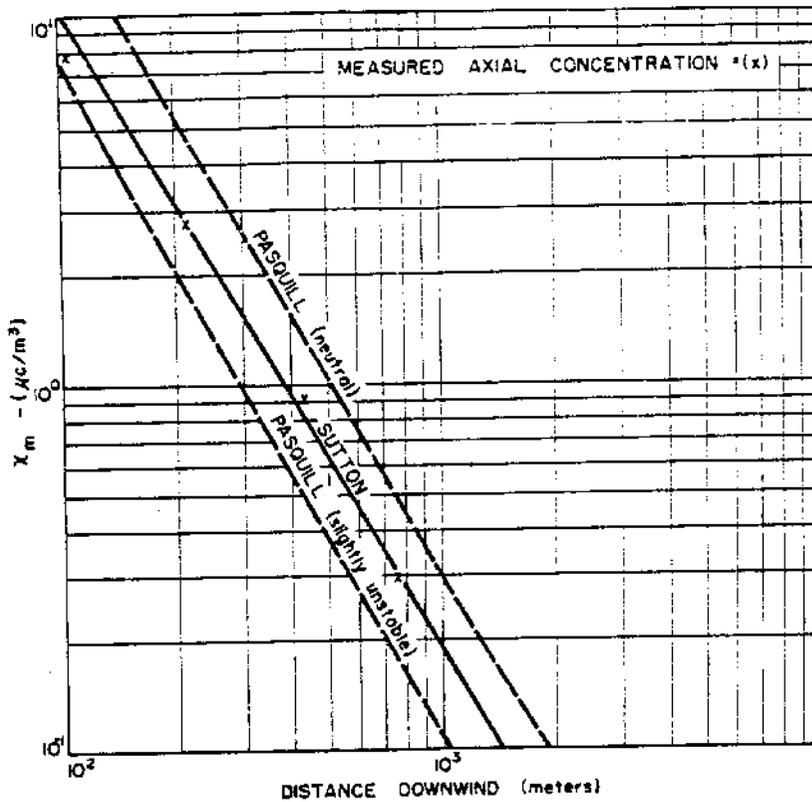


Fig. 20 Comparison of computed (shown by plots) and measured axial air concentrations for the SPERT I Destruct Test.

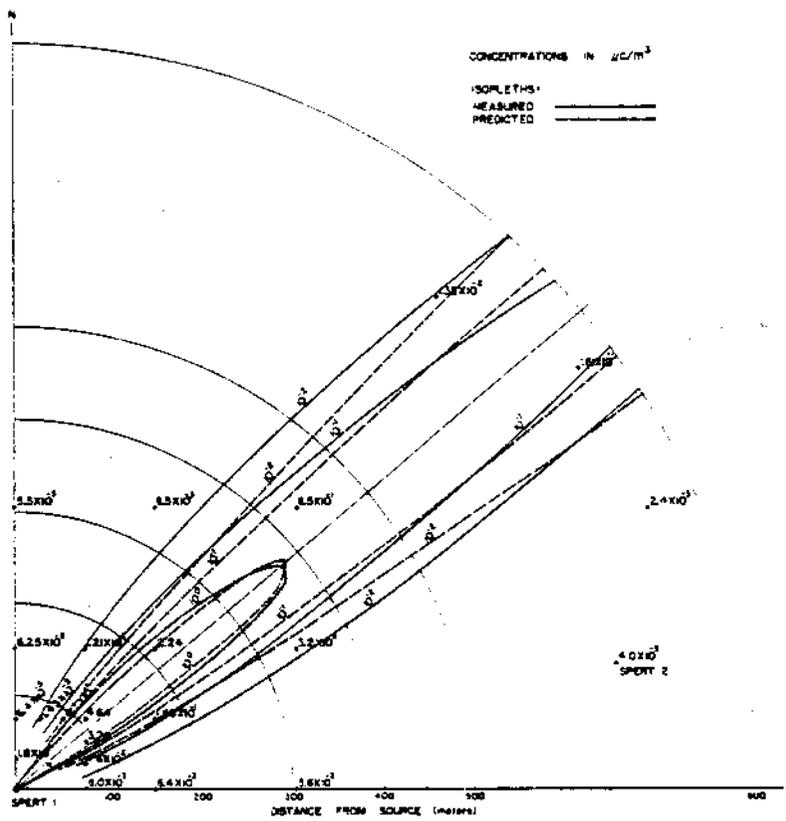


Fig. 21 Computed (Sutton) and measured isopleths of air concentration for the SPERT I Destruct Test.

- (3) Source Calculations. The source strength of 1.51 curies was back-corrected to the excursion time of 1227 MST by assuming a decay of $t^{-1.21}$. This yielded a calculated release of 2.42×10^5 curies into the atmosphere, which is equal to a 0.13 mw-sec release. For this computation it had to be assumed that the conversion factors for mixed fission products could be applied³, although preliminary indications are that mostly noble gases were released. The engineering estimate of the total release was 33 mw-sec. Therefore, it is estimated that 0.4% of the total generated fission products escaped into the atmosphere.

The film badge β and γ doses, as measured by the Health and Safety Division, were used as an independent check of the assumptions used in the atmospheric release computations. Measured doses interpolated to cloud centerline values were compared with calculated centerline doses⁴ using the calculated release into the atmosphere of 0.13 mw-sec (Figure 22). The β dose prediction is very close to the interpolated values and the γ dose predictions are about a factor of two or three lower than the interpolated doses. Therefore, it can be concluded that the fractional release of fission products into the atmosphere was equal to or slightly greater than 0.4% for this particular reactor excursion.

³ Meteorology and Atomic Energy, AECU 3066,
U. S. Weather Bureau, U. S. Government
Printing Office, 1955, p 102.

⁴ Ibid - p 104.

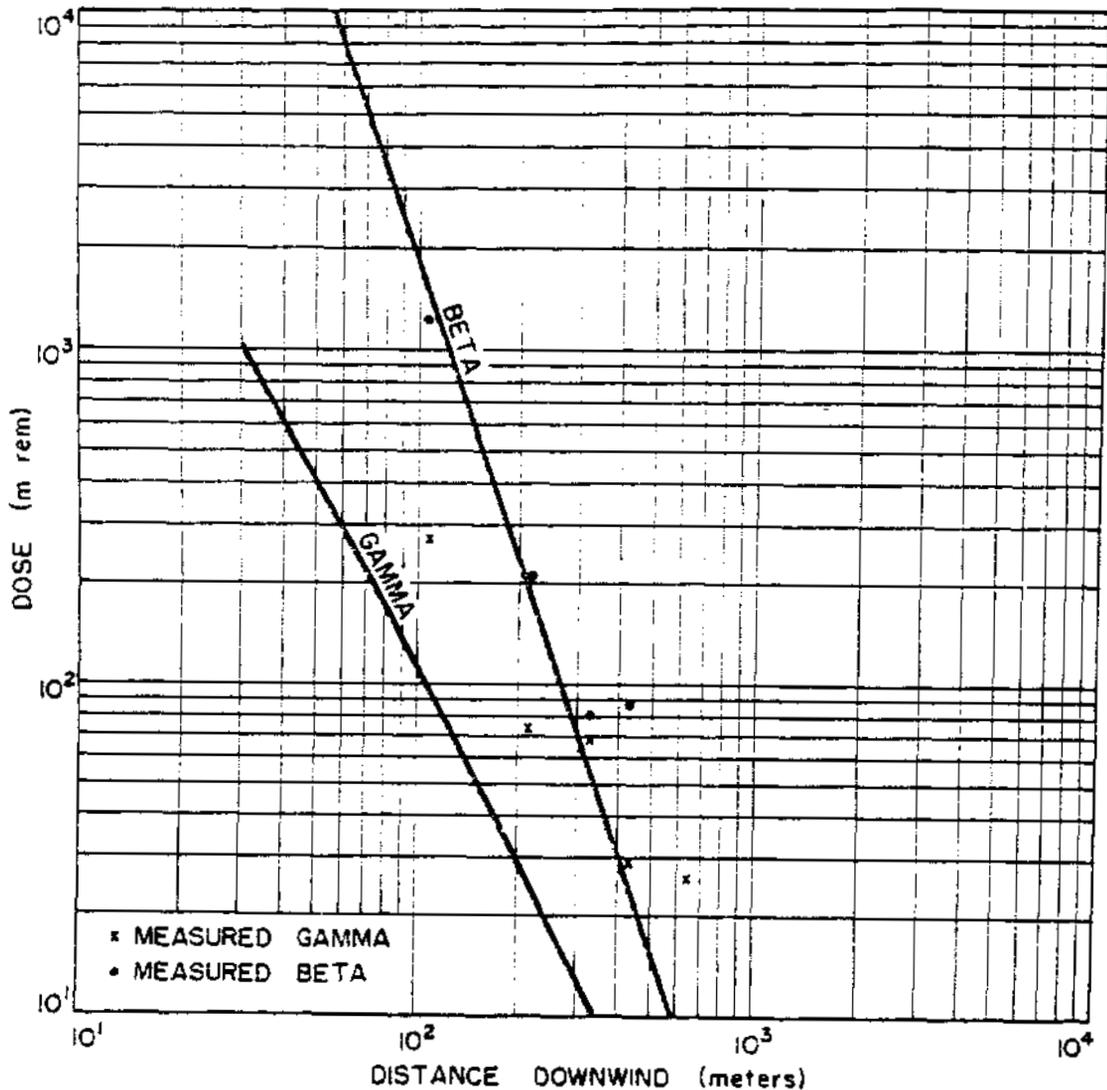


Fig. 22 Comparisons of measured and computed (shown by the solid lines) plume center γ and β doses from the SPERT I Destruct Test.

2.2 MTR-ETR Study

Bivanes and anemometers were installed on several sides of the MTR-ETR complex to measure the additional turbulence and, thus, atmospheric dilution that would be anticipated downwind of large reactor complexes at the NRTS. In addition, several smoke releases were conducted on both sides of the buildings and photographed with a movie camera to obtain some qualitative estimate of the size of the eddies. It was found that shortly downwind of the structures vertical eddies during lapse conditions rose to approximately the height of the MTR building, 24 m. Horizontal diffusion was also quite marked. A number of bivanometer recordings during both lapse and inversion conditions were conducted simultaneously on the northeast and southwest sides of the MTR-ETR complex. These records are analyzed in terms of the range of the direction variations during five-min. and 60-min. periods for both the vertical

and horizontal coordinates. From these the standard deviations of the horizontal and vertical direction fluctuations can be found by dividing by an appropriate factor. This factor has been found from previous studies to be approximately six. Since the bivanes do have some overshoot, five-sec. means of the direction readings are used to compute the range.

The results of five tests are shown in Table 13, in which the horizontal wind direction range, R_{θ} , and the vertical wind direction range, R_{ϕ} , for five-min. periods are shown along with the appropriate meteorological conditions. All the data are averages for the duration of the test shown in the second column of Table 13. It can be seen that there is a marked increase of the range and, thus, turbulence downwind of the structures and a tendency for the wind speed to be somewhat less. One can compare the relative dilutions anticipated on the two sides of the buildings by forming the ratio of the terms $R_{\theta}R_{\phi}\bar{U}$ for the downwind over the upwind sides of the structures. This ratio, called dilution ratio in Table 13, shows that an increase of dilution of at least a factor of two on the average for lapse conditions can be expected. This ratio increases to an average of about 3.5 for very strong inversion hours. Individual hourly averages of five-min. ranges show that this dilution ratio can approach a factor of five for strong inversion hours and about 10 for individual five-min. ranges. It appears unlikely that the additional dilution caused by the buildings in a complex, such as the MTR-ETR can be more than a factor of about 10 over that which would be computed for flat terrain for reactor hazards calculations. These studies are continuing, and it is planned to relate the vertical and horizontal dimensions of smoke plumes with the predictions from bivan data downwind of the reactor complex.

Table 13. Average Increased Atmospheric Dispersion Due To The Aerodynamic Effects From The MTR-ETR Buildings.

Test No.	Duration (hours)	Stability Class	--upwind--			--downwind--			Dilution Ratio
			R_{θ} deg.	R_{ϕ} deg.	\bar{U} m/sec	R_{θ} deg.	R_{ϕ} deg.	\bar{U} m/sec	
1	2	lapse	76	52	5.6	135	85	3.8	2.0
3	10	neutral	41	34	7.8	86	58	4.7	2.1
4	7	inversion	32	24	3.2	75	46	2.5	3.5
5	8	inversion	44	27	2.3	86	52	1.8	3.3
6	5	inversion	55	34	1.8	71	40	1.8	1.5

2.3 Digitization of Meteorological Observations

A high-speed data acquisition system was designed and built by Systron-Donner Corporation, San Francisco, California, to Weather Bureau specifications and delivered in August 1962. The data system was designed to rapidly store instantaneous values of micro-meteorological research parameters with an appropriate

digital output recording. The system has a capacity for a total of 40 inputs which can be connected directly to the input terminals. There are 10 channels each for vertical wind direction, horizontal wind direction, wind speed and temperature, as follows:

<u>Meteorological Parameter</u>	<u>Input Voltage Range</u>	<u>Output Range</u>
Vertical wind direction	0-9 volts	0-90.00°
Horizontal wind direction	0-36 volts	0-360.0°
Wind speed	0-9 volts	0-45 m/sec
Temperature	0-3 millivolts	-50-150° F

The system has a variable sampling capacity which can be manually controlled from a maximum of 10 channels per second down to one channel per second.

The main components of the data system are a 16-module transistorized programming chassis, a relay-operated scanning chassis, a Systron-Donner Model 230 Digital Voltmeter, a low-level DC amplifier chassis, a 10-channel Page reference junction, a teletype model BRPE-11 paper punch tape (110 characters per second) and associated power supplies. Checks of the data record on punched tape for short periods have been made with an analog system, revealing no systematic errors. These studies will continue before an exhaustive data collection program is undertaken.

2.4 Radar and Transponders

Early in the meso-scale wind program, the desirability and probable necessity of using a positive electromagnetic signal to track and identify the floating tetroon was recognized. The Cordin Company, under Weather Bureau Contract, constructed a series of prototype operational transponders for the WSR-57 radar system. To be successful and practical, these devices had to meet rather stringent requirements. They had to be sufficiently light to be carried by a small tetroon and to present no significant hazard to aircraft. They had to respond only to radar triggering by the WSR-57's. The transponders had to transmit identifiable signals over a period of several hours and with enough power to be detectable over several tens of km minimum. Furthermore, the cost of the operational production models had to be sufficiently low to permit quantity usage without recovery. These requirements were all met and tests were carried out to prove the transponder's feasibility as an appropriate instrument system to obtain air trajectories over many km at low altitudes, less than 1.5 km above the ground. The tests, carried out May 7 - 8, 1962, proved very successful, and the transponder signals provided positive, unambiguous target identification at ranges and altitudes where the ground clutter made direct reflective positioning impossible.

3. FUTURE PROGRAMS

3.1 Meteorological Control of Reactor Operations

- A. SPERT Destruct. Further tests similar to the SPERT-I Destruct Test of November 1962 are being planned. Weather Bureau support and data evaluation for these tests are expected to be similar to those discussed in section 2.1. This includes correlation of measured air concentrations of fission products and radioactive doses with meteorological predictions and estimates of the amount of fission products released into the atmosphere.
- B. SNAP 10A Transient Tests. A series of excursion-type tests of SNAP 10A fuel elements are expected to be conducted in the IET facility at TAN in the coming calendar year. During these tests, there is a possibility of significant releases of fission products which are to be collected on a densely instrumented sampling grid some 60° wide downwind of the test site. Meteorological support will include activation of several weather stations, detailed planning and diffusion forecasts, and weather monitoring during the experiment. It is anticipated that considerable data will be obtained which will be useful for studies of the dispersion and deposition of radioactive material over the NRTS.
- C. EBR-II. Operations in the EBR-II are expected to commence in 1963. A 72-m meteorological tower with wind and temperature sensors at several levels is being planned to provide the necessary meteorological information for conducting the experiments. Initial phases of the experiments, in which fission products may be released, are expected to require diffusion forecasts and possibly positioning of monitoring equipment to determine the levels of fission product release.

3.2 Radar Study

An M-33 radar, scheduled for delivery in 1963, when operational, will provide more versatility and detail to wind trajectory and diffusion programs. The use of radar allows winds aloft observations during inclement weather, while the current methods are limited and at times useless due to clouds and/or obstructions to vision. The use of the radar plus a transponder unit, when available, on the flight gear will provide greater range for meso-scale wind studies, especially at lower flight altitudes. It is planned to place a major emphasis upon long-range trajectory studies (20-100 km) using the radar and constant-level balloons (tetroons). Furthermore, turbulence statistics derived from the tetron flight are invaluable in studying various phases of the atmospheric dispersion process.

3.3 Dispersion Studies Near Reactor Complexes

Studies of atmospheric dispersion over non-ideal terrain such as downwind from large reactor complexes will be continued. These studies are necessary for a practical evaluation of potential reactor hazards in the immediate vicinity of the reactor complex. Measurements of turbulence and wind speeds, as well as smoke or fluorescent tracer studies, will be made downwind of the MTR-ETR complex.

3.4 Climatological

Since the publication of the "Diffusion Climatology of the National Reactor Testing Station" (IDO 12015) in 1960, a need for additional meteorological analyses for reactor hazards and siting purposes has arisen. Many years of records stored on IBM cards will be processed on the IBM 1620 to determine the probability of wind direction and wind speed persistence, inversion and lapse persistence, and the periodicity and duration of stagnant weather regimes. These studies will be appropriate to the reactor hazards evaluation of the accident in which fission products are assumed to be released over a relatively long period of time, such as occurred during the SL-1 accident. In addition, the extensive upper-level wind and temperature measurements conducted in recent years with the T-Sonde and pibals will be analyzed. This will provide information on the wind and dispersion patterns at elevations above the stack heights, between 100 and 1,000 meters. Probable trajectories under different meteorological conditions will also be summarized as more experience is obtained from the radar and double-theodolite tracking of constant-level targets.

3.5 Forecast Studies

An objective probability forecast technique of time-of-onset and time-of-duration of favorable winds on a given test grid would be very desirable. Time series data have been used successfully for this purpose at other stations and should be adaptable here. A study utilizing the 3000-m, 2100-m, and 75-m winds as observed at CFA will be made. A satisfactory period of record is available only for CFA, so once a workable technique is developed at this station, correlations between it and any other station on the NRTS can be made.

4. PUBLICATIONS

1. "The Role of Meteorology Following the Nuclear Accident in Southeast Idaho," Norman F. Isplitzer, IDO 19310, May 1962.
2. "Meteorological Tracer Techniques for Atmospheric Diffusion Studies," R. K. Dumbauld, Journal of Applied Meteorology, December 1962, Volume I, Number 4.

3. "A Method of Integrating Radiometer Output for Climatological Studies," C. Ray Dickson, Monthly Weather Review, Volume 90, Number 9, September 1962.

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APPENDIX A

U. S. ATOMIC ENERGY COMMISSION
 HEALTH AND SAFETY DIVISION - IDAHO OPERATIONS OFFICE
 ENVIRONMENTAL MONITORING DATA
 FOR
 THE NATIONAL REACTOR TESTING STATION
 ANNUAL SUMMARY

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 responsible persons to determine what radiological effect the installations have on the environment. Periodically, summary reports of the results of radiological surveillance are released to the public.

The Environmental Monitoring Data Report for the National Reactor Testing Station (NRTS) for the year 1962 discloses that the amount of radioactive materials in the environs of the NRTS during these months was below the Radiation Protection Guide (RPG) values recommended by the Federal Radiation Council 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 from that contributed by world-wide fallout from weapon debris.

The locations of the fixed stations around the NRTS where routine samples of air, water, and milk are collected to be analyzed for radioactivity are shown on the map at the end of this report.

ANALYTICAL LIMITS

The detection limits of the analytical methods used are given in the following table:

<u>Type of Sample</u>	<u>Isotope or Radiation Limit</u>	<u>Detection Limit</u>
Water	Alpha	3×10^{-9} $\mu\text{c/ml}$
	Beta	5×10^{-9} $\mu\text{c/ml}^*$
	Tritium	4×10^{-6} $\mu\text{c/ml}$
Milk	Iodine-131	10 $\mu\text{c/liter}^{**}$
	Strontium-90	1.5 $\mu\text{c/liter}$
Film Badges	Gamma	10 mrem
	Beta	10 mrem

* Reduced in October of 1962 from 1.5×10^{-7} $\mu\text{c/ml}$

** Reduced in September of 1962 from 50 $\mu\text{c/liter}$.

OFF-SITE UNDERGROUND WATER

Low-level activity liquid waste is 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 ground 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 prevalent direction of ground water flow.

A total of 119 samples were collected on a three-month basis from 30 sampling stations. The analyses of these samples showed that alpha, beta, and tritium activities were well below Radiation Concentration Guides (RCG) values.

ON-SITE PRODUCTION WELL WATER

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

For the entire year, 396 samples were collected from 21 sampling stations on a bi-weekly basis. Analyses of these samples showed that alpha, beta, and tritium activities were well below RCG values.

OFF-SITE AIR FILTERS

The off-site air samples are collected through 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. A high-volume air sampler is also operated in Idaho Falls to furnish information specifically related to weapons testing. A total of 675 air samples were collected from the 14 permanent stations and analyzed for radioactivity. A slight increase was noted in the fourth quarter which is attributed to weapons testing. All results obtained during the year were below RCG values.

OFF-SITE MILK

As was expected due to international nuclear tests, an increase of iodine in milk was noted throughout the country. During the year, 113 milk samples were collected on a monthly basis from 10 stations and analyzed for iodine-131. In addition, 46 of these samples were analyzed for strontium-90. As can be seen in the attached data sheet, the average iodine-131 levels have remained below the RCG values. There was no significant change in the strontium-90 concentration in the milk sampled. The reader should keep in mind that the guidelines established by the Federal Radiation Council point out radiation levels above which positive control measures should be considered. The levels specified must be maintained for some length of time before any hazard results. As can be seen in the data, the RCG number for iodine-131 in milk was exceeded. However, these were individual situations of short duration. The averages show that the RCG's have in fact not been exceeded.

AREA MONITORING BADGES

Film badge stations are located around the perimeter of the NRTS site at the same locations as the air sampling equipment. Badges were changed on a six-week basis. There was no film data for the third quarter. This was due to the inadvertent use of a defective lot of film which yielded undependable data. Analyses of other environmental monitoring data give no reason to believe that there was any appreciable change in direct radiation levels from those recorded for the other three quarters of the year.

ENVIRONMENTAL MONITORING DATA FOR THE NATIONAL REACTOR TESTING STATION

ANNUAL SUMMARY 1962

Type of Sample	Number of Stations	Approximate Frequency of Collection	Total Number of Samples	Maximum Activity of Single Sample	Average Activity Per Sample	Radioactivity Concentration or Radiation Protection Guides
Off-Site Underground Water	30	Three Months	119	α 5×10^{-9} $\mu\text{c/ml}$	α $<4 \times 10^{-9}$ $\mu\text{c/ml}$	α 10×10^{-9} $\mu\text{c/ml}$
				β 20×10^{-8} $\mu\text{c/ml}$	β $<10 \times 10^{-8}$ $\mu\text{c/ml}$	β 300×10^{-8} $\mu\text{c/ml}$
				H^3 $<4 \times 10^{-6}$ $\mu\text{c/ml}$	H^3 $<4 \times 10^{-6}$ $\mu\text{c/ml}$	H^3 $3,000 \times 10^{-6}$ $\mu\text{c/ml}$
On-Site Production Well Water	21	Two Weeks	396	α 12×10^{-9} $\mu\text{c/ml}$	α $<3 \times 10^{-9}$ $\mu\text{c/ml}$	α 100×10^{-9} $\mu\text{c/ml}$
				β 4×10^{-7} $\mu\text{c/ml}$	β $<1 \times 10^{-7}$ $\mu\text{c/ml}$	β 300×10^{-7} $\mu\text{c/ml}$
				H^3 63×10^{-6} $\mu\text{c/ml}$	H^3 $<6 \times 10^{-6}$ $\mu\text{c/ml}$	H^3 $30,000 \times 10^{-6}$ $\mu\text{c/ml}$
Off-Site Air Filters	14	Weekly	675	β 99×10^{-12} $\mu\text{c/ml}$	β 16×10^{-12} $\mu\text{c/ml}$	β 100×10^{-12} $\mu\text{c/ml}$
Off-Site Milk	10	Monthly	Iodine-131 320 $\mu\text{c/liter}$	Iodine-131 <40 $\mu\text{c/liter}$	Iodine-131 100 $\mu\text{c/liter}$	Iodine-131 100 $\mu\text{c/liter}$
Total for 1st, 2nd and 4th Qtr.				Maximum Period		
Off-Site Area Monitoring Badges	14	Six Weeks	164	α 10 mrem β 35 mrem	α 60 mrem β 85 mrem	α 500 mrem/yr β 3,000 mrem/yr

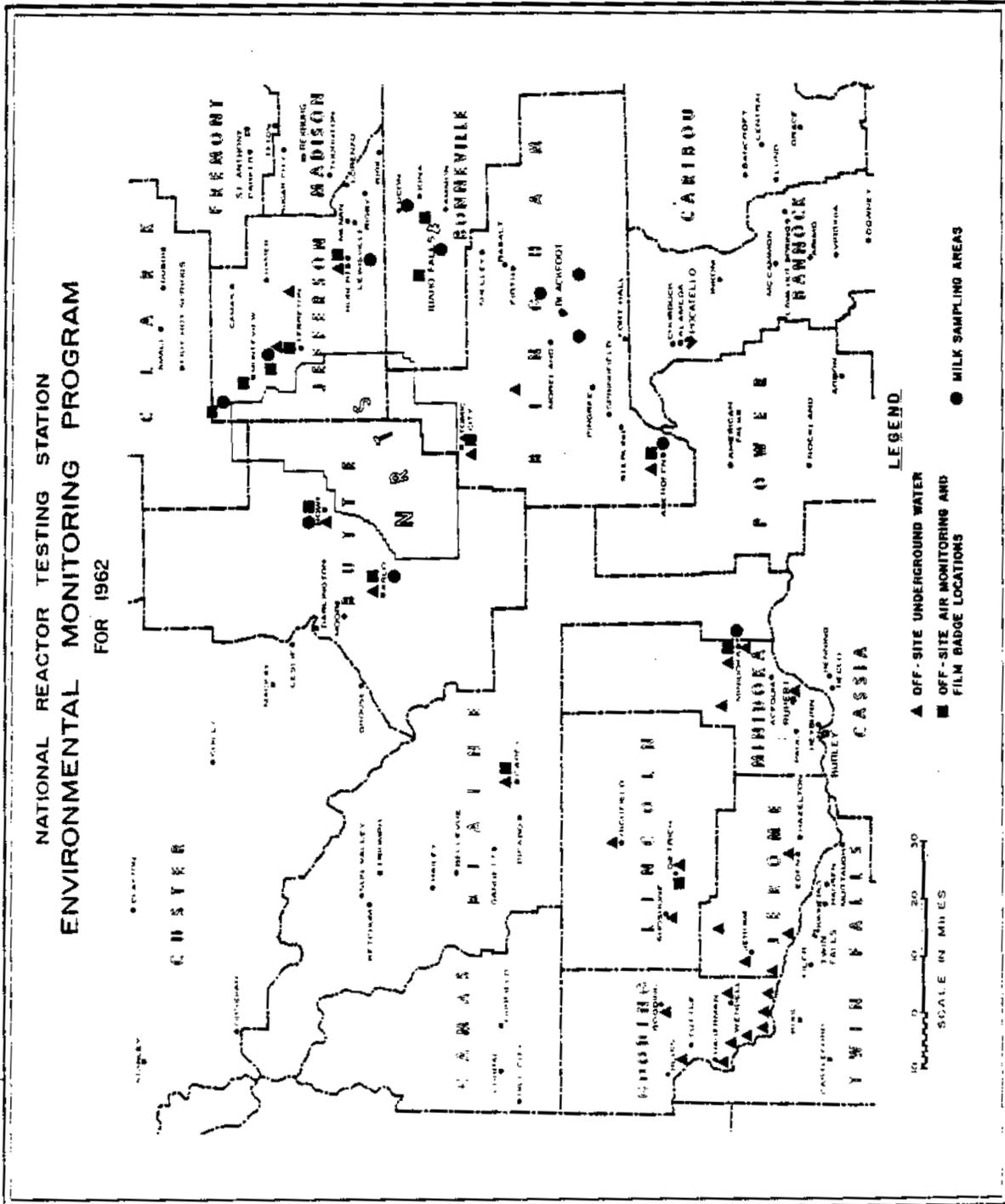


Fig. 23 Environmental Monitoring Program for 1962.