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ARGONNE LOW POWER REACTOR HEALTH PHYSICS MANUAL

by

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Idaho Division

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DISCLAIMER

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF EXHIBITS

LIST OF EXHIBITS

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PREFACE

The Argonne Low Power Reactor (ALPR) Health Physics Manual is designed for use by Department of Defense personnel with limited experience and training in applied radiation safety techniques. The treatment is nonmathematical and is directed toward specific use with the Argonne Low Power Reactor. Included are a brief summary of initial operating experience and a series of detailed operating instructions.

SECTION I. INTRODUCTION

A. General

The Health Physics Manual for the Argonne Low Power Reactor (ALPR) is specifically written for field use at the National Reactor Testing Station (NRTS) site by Department of Defense enlisted personnel assigned to Health Physics duty. It is anticipated that such personnel will have, at minimum, the equivalent of a high school education, a short formal course in Health Physics theory, and some experience in practical applications.

The manual was purposely designed to be nonmathematical and nontheoretical; adequate treatments of these phases of Health Physics have been published elsewhere. Emphasis has been placed on practical applications for the Argonne Low Power Reactor, although many of the procedures could be applied to other reactor types.

Sections II and III of this manual are devoted to discussions of experience in the Health Physics aspects of boiling water reactors in general, and in particular to the initial operation of ALPR. Data quoted in Section III apply to the first 600 hours of ALPR operation and may not be valid for long-term operation.

Section IV consists of a set of specific instructions or Standard Operating Procedures on various phases of Health Physics work at ALPR. These instructions may be replaced or revised individually as operating experience is gained.

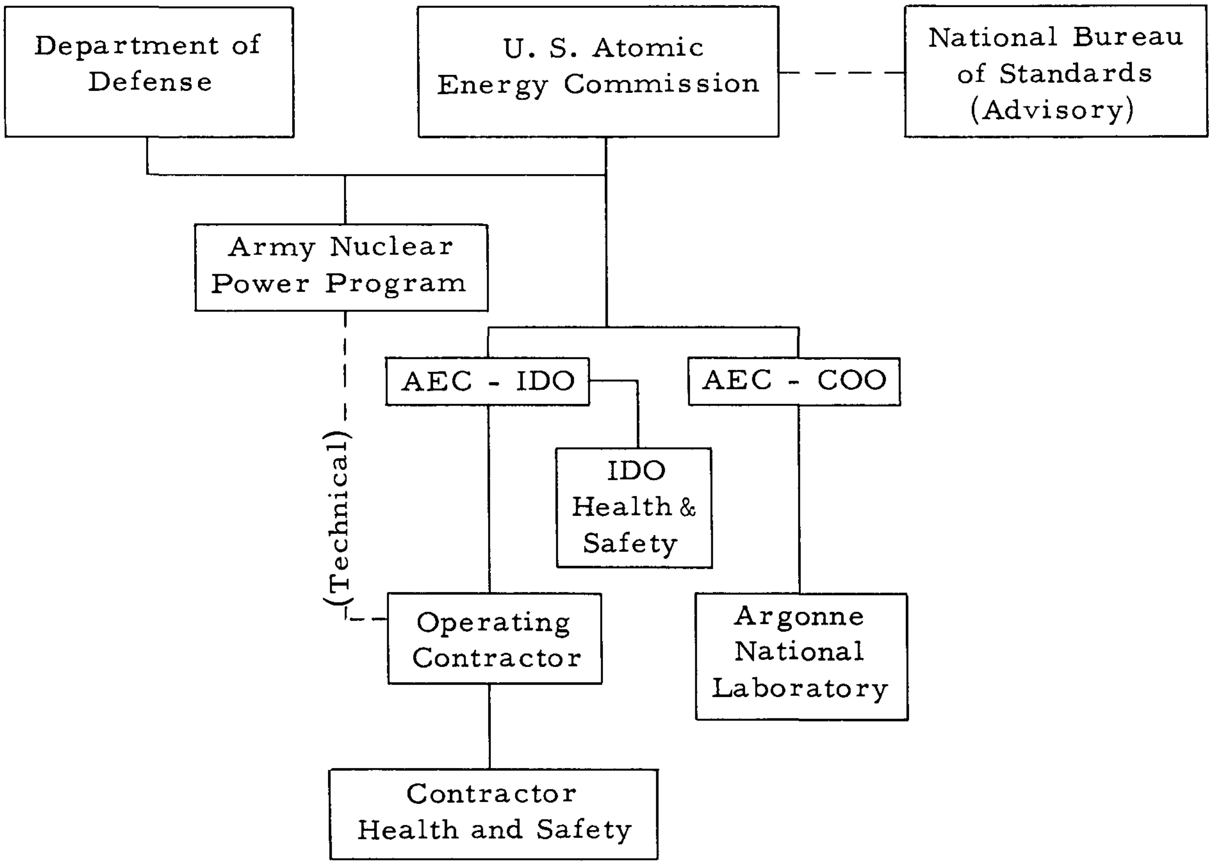
Sections V, VI and VII are devoted to reference material applicable to Health Physics operation.

B. Reporting Agencies

The standards in use at ALPR are adapted from regulations and recommendations published by federal regulating agencies and from Argonne National Laboratory operating experience. Exhibit 1 below shows the channels through which Health Physics regulations and recommendations for ALPR operations are transmitted. Specific regulations and recommendations are outlined in detail elsewhere in this manual.

Exhibit 1

Organization of Reporting Agencies



SECTION II. REACTOR HEALTH PHYSICS

A. General Aspects of Boiling Water Reactor Health Physics

The boiling water reactor presents three basic sources of radiation:

1. neutron leakage;
2. gamma-ray leakage; and
3. beta-gamma-emitting air contaminants.

Under certain conditions, other radiation problems may arise but these are either uncommon or are of lesser importance during routine operations.

The boiling water reactor, like any other reactor, is basically an intense source of neutrons. This uranium-fueled, light water-moderated boiling reactor is known as a thermal reactor, since most of the fissions are caused by the absorption of neutrons of thermal energy. Neutrons of much higher energy, ranging to approximately 10 Mev, are present in the reactor core. Depending on the efficiency of the reactor shield, a certain number of neutrons of a wide range of energies will escape from the reactor. This is called Stray Neutron Leakage.

The Health Physicist divides these stray neutrons into two groups: thermal neutrons (energies of 0.03 ev or less), and epi-thermal neutrons (energies above 0.03 ev).

The MPL (Maximum Permissible Level) for exposure to thermal neutrons is 2,000 n/(cm^2)(sec). This is the flux of thermal neutrons which will produce an exposure rate of 7.5 mrem/hr and will allow an exposure of eight hours per day. The distribution of energies of stray neutrons is difficult to measure. When the "long" counter is used, the MPL is taken as 40 n(fast)/(cm^2)(sec). This is the MPL for neutrons of 2 Mev. (The long counter detects neutrons of all energies with about the same efficiency; a conservative estimate is obtained by assuming that all neutrons detected are high-energy neutrons, although we know that the majority are of a lower energy.)

A second type of fast neutron counter is "tissue sensitive," i.e., has a response similar to that of the human body. This instrument, the proton recoil neutron survey meter, is calibrated directly in mrem/hr and is reasonably accurate in detecting neutrons in the energy range from 0.2 to 10 Mev.

Gamma, beta, and alpha radiations are all present in the reactor core during operation and after the reactor has been shut down. Alpha and beta radiations are contained within the core or in the shield and do not present any problem in background radiation or leakage through the reactor shield. Gamma radiation produced in the core is attenuated exponentially in the reactor shield. Because of this, some gamma radiation is always preent outside the shield, although the actual level may be low. The MPL for gamma radiation only is 7.5 mr/hr for an eight-hour exposure. Gamma-radiation levels are measured with ionization chamber meters such as the "JUNO" and Jordan "Radector." Geiger-Mueller counters are sensitive to gamma radiation but should not be used to measure dosage rates where accuracy is important.

For a given reactor, gamma and neutron-background levels are essentially proportional to the reactor power level; i.e., doubling the reactor power approximately doubles the gamma and neutron leakage.

Gamma radiation and neutrons leak through the reactor shield in two ways. The first is by diffusion through the shield body. This leakage can be reduced by increasing the density of the shield, by changing the shielding materials to alter the shielding absorption factors, or by increasing the size of the shield. These methods are seldom practicable after construction is completed. The second way in which gamma and neutron radiation may leak through the shield is by "streaming" through cracks and voids in the shield material. The effect of "streaming" may be reduced by locating the "hot spots" or "beams" in the reactor shield by careful surveying and then locally shielding these spots with lead or concrete block.

ALPR is designed to deliver 9000 lb steam per hour at a pressure of approximately 300 psig to a turbine. The steam produced in the reactor core is radioactive; its radioactive components are mainly N^{16} and O^{19}, which have extremely short half-lives but are capable of producing appreciable gamma-radiation levels in the steam lines. Gamma levels are higher in the reactor end of the system than at the turbine end because of the rapid decay of the above-mentioned radioactive components in the steam as it moves through the system.

Some leakage of steam is inevitable. This means that radioactive steam will escape into the atmosphere, but normally the quantities of N^{16} and O^{19} released are so small that they may be considered to be negligible.

In both EBWR and BORAX IV some fission product radioactivity was detected in the steam. Such activity is also present to a small extent in ALPR. These products are the result of fissions in trace quantities of uranium which remain as contaminants on the surface of fuel plates. Only the fission product gases Xe^{138} and Kr^{88} have been observed. For these gases the MPC (Maximum Permissible Concentration) in air has been set at 5×10^{-5} $\mu c/m\ell$ of air at STP.

A fuel element rupture producing similar effects of a much higher order of magnitude and involving an undetermined quantity of exposed fuel was observed at BORAX-IV. Although BORAX-IV produced very high levels of air and surface contamination, the rates of decay of the isotopes present were very rapid. In one typical case, 16 hours of decay time was sufficient to reduce a level of 50 r/hr to less than 1 mr-hr.

During operations, there will be a constant, though low, activity level in the reactor floor air as a result of uranium contamination on the fuel plate exteriors. The activity will be carried through the steam system. If a fuel element should rupture, high-level, short half-life airborne contamination would result. Operating experience on BORAX-IV indicates that short of complete core destruction the amount of long-lived material escaping from the system would be minute.

B. Exposure Philosophy for Reactor Operations

Regulations on radiation exposure specify that long-term exposure to radiation (i.e., several years or more) must be kept to an average of less than 100 mrem per week.

This should not be taken to mean that an exposure of 100 mrem or more in a given week is an overexposure. The limitations specified in the regulations are that any exposure in excess of 300 mr per week shall be considered a reportable overexposure and that no person shall receive a dose in excess of 15 rem per year. Another requirement is that exposure should average less than 5 rem per year over a period of several years. Since Department of Defense personnel are expected to be assigned to reactor work for a period of not less than three nor more than twenty years, the average of 5 rem per year should not be exceeded. Access to radiation areas should be minimized for personnel whose exposure is approaching the above limits.

Individual exposures should be kept to a practical minimum. If, for example, an operator assigned to a particular duty would receive regularly a dosage five times that received by the average operator, rotation of personnel should be planned to distribute dosage more evenly.

Every effort should be made to keep background radiation levels and air-contamination levels to a minimum. If an increase in the reactor area ventilation air flow would result in a decrease of air contamination, the air flow should be increased. Where shielding of a practical nature would materially reduce background radiation, such shielding should be installed. Such changes and modifications should, however, be reasonable. For example, it is not reasonable to require that the reactor and the steam system be shielded so that no measurable radiation escapes. This is economically and practically impossible where space and weight are at a premium.

SECTION III. ALPR HEALTH PHYSICS

A. The ALPR Health Physics Program

1. General

The ALPR Health Physics Program is the responsibility of the operating contractor and is governed by AEC and Federal Government regulations. The Health Physics Section consists of one Health Physicist in charge (contractor employee) and one Department of Defense Health Physicist (enlisted man of the ALPR Cadre).

Laboratory counting equipment is supplied and maintained by the operating contractor. Portable survey meters, personnel dosimeters, film-badge service, urinalysis service, and waste disposal service are available from the Idaho Operation Office of the AEC-IDO. Environmental monitoring outside the perimeter of the reactor area fence is the responsibility of AEC-IDO.

All Health Physics operations inside the perimeter fence are the responsibility of the operating contractor.

2. Personnel and Equipment

a. Personnel

The Health Physicist in charge shall be responsible for the implementation of an effective Health Physics program at ALPR and will be responsible for the orientation and training of any assigned Health Physics trainees. An effective Health Physics program will include at least the following essentials:

(1) a thorough continuous program of monitoring and evaluation of all possible radiation and contamination conditions;

(2) Health Physics orientation for all personnel assigned to ALPR;

(3) the effective limitation of personnel exposure to a practical minimum; and

(4) the keeping of a concise, yet complete, record of all section activities, personnel exposure, and other pertinent data.

b. Equipment

Table 1 is a list of sampling, counting, and monitoring equipment in use at ALPR. This list is not an optimum for peak Health Physics efficiency, but should be adequate for presently forseeable needs.

Table 1

HEALTH PHYSICS EQUIPMENT AT ALPR

Quantity	Description	Function
1	Model PC 1-A Proportional Gas Flow Counter (NMC)	Low-level counting of air samples, surface smears, etc. for alpha and beta-gamma.
2	Model 206 (RIDL) Scaler	Used with shielded GM tube for counting air samples. Used with BF_3 tube for neutron counting. Can be used with air-filled proportional counter for alpha counting.
1	Iron shield (pig) RCL	Used to reduce background in low-level laboratory counting.
1	Hand and foot counter (Anton)	Checking hands and feet for contamination.
1	Constant air monitor model AM-2A (NMC)	Constant monitoring of airborne particulate activity.
2	Staplex Hi-Vol air sampler	Spot sampling of airborne particulate activity.
4	G-M type survey meter: 0-20 mr/hr	Low-level beta-gamma monitoring.
4	Juno ionization chamber: 0-25 r/hr	High-level beta-gamma monitoring.
4	Juno ionization chamber: 0-5 r/hr	High-level beta-gamma monitoring.
2	Jordan Radector: 0-50 r/hr	High-level beta-gamma monitoring.
1	Jordan Radector: 0-500 r/hr	High-level beta-gamma monitoring.
2	BF_3 Neutron Survey Meter	Thermal neutron monitoring.
2	Raychronix fast neutron dosimeter	Fast neutron monitoring.
2	2-liter gas sampler (ANL design and fabrication)	Spot sampler for measurement of gaseous airborne activity (beta-gamma only.)
50	Landsverk L-50 dosimeter: 0-200 mr	Personal exposure measuring device.
1	Vacuum cleaner, Electrolux automatic	Used for removal of active dusts.

3. Routine Reactor Operations

The schedule for routine Health Physics coverage for normal power operation is as follows:

a. Area Surveys - Daily
b. Air Samples - Continuous and spot samples
c. Air Ejector Gases - Daily
d. Special Surveys - As requested
e. Surface Smears - Daily
f. Neutron Monitoring - Weekly, or on request
g. Dosimeters - Daily
h. Film Badges - Weekly

a. Area Surveys:

Radiation surveys are made daily with portable survey meters. Areas of particular interest are:

(1) reactor shield blocks
(2) simulated heat load heat exchanger
(3) air ejector
(4) purification system
(5) steam lines
(6) hot well
(7) condensers
(8) control room
(9) fan floor

Special survey points are established at each of the above locations for uniformity in interpreting the results of the surveys. Also of interest is the average background radiation level in the area.

Radiation levels on the reactor operating and fan floor could result in time restriction for occupancy by personnel. This was anticipated in the design of the reactor system. The presence of operating personnel during reactor operation is required only during turbine startup and during routine inspections and maintenance. This time normally amounts to less than two hours per person per operating shift.

Area surveys are performed routinely at least twice each day by Health Physics personnel. Whenever a change in operating conditions occurs, such as a change in reactor power or steam pressure, a series of surveys is made to measure resulting changes in the levels of radiation. Surveys are made hourly until the new equilibrium levels are established. In the absence of Health Physics personnel, supplemental surveys are performed twice during each operating shift by reactor operating personnel.

Records of area surveys are kept on file in the Health Physics office. These records must include information as to the time, location, reason for survey, instrument used, results, etc.

b. Air Samples

Continuous air sampling for beta-gamma-emitting particulates is provided by a Nuclear Measurements Corporation Model AM-2A constant air monitor. Its detector views a stationary paper filter through which air is drawn at the rate of 4.8 cfm. The detector-filter assembly is shielded from background radiation by a thick iron shield. Sample results are continuously recorded on an Esterline Angus Recorder. Graphs are kept on permanent file in the Health Physics office.

Continuous sampling is supplemented by "spot" air samples. These are taken with the Staplex "Hi-Vol" samplers on high-efficiency filter paper. The samples are taken in various locations and are counted with low-background laboratory counting equipment located in the Health Physics office. The results are entered and evaluated on Air Sample Data Sheets and are kept on permanent file in the Health Physics office.

Atmospheric radioactivity on the reactor operating floor is composed of a combination of the natural decay products of radon and the reactor-produced decay products of the fission gases xenon and krypton.

The source of the fission products which escape into the reactor room air is probably a trace level of contamination of the fuel assembly cladding. The main fission products which escape into the water and steam are the gases xenon and krypton, which decay into particulate isotopes.

The activity is carried into the system steam lines. From the steam lines, turbine, condenser, and air ejector, there is leakage of a small amount of steam into the air in the reactor building.

At EBWR, the atmospheric concentration within the containment building was about 2×10^{-5} $\mu c/ml$ at a reactor power level of 20 Mw (thermal). The concentration on the ALPR operating floor is 1.46×10^{-9} $\mu c/ml$ at 2.8-Mw reactor power.

The value for the maximum permissible level (MPL) of xenon and krypton decay products adopted by Argonne National Laboratory (ANL) is 5×10^{-5} $\mu c/ml$. This value is not specified in the National Bureau of Standards (NBS) handbook on permissible concentrations, but was computed at ANL by the methods used by the NBS.

The occurrence of a fuel plate rupture will be detected rapidly on the constant air monitor. The time delay between the occurrence of the sudden rupture and detection through a rise in operating floor air activity is expected to be no longer than one to two minutes. Such detection triggers both visual and audible alarms on both the Constant Air Monitor and the Control Room Alarm Panel.

c. Air Ejector Gases

Gases in the air ejector are typical of the gases escaping with the steam from the system. A check on these gases is an aid in evaluating the atmospheric radioactivity on the reactor floor and is a measure of total stack effluent activity.

A 2-liter brass flask with a built-in GM tube is used for gas samples. A sample is taken directly from the air ejector line with the brass sampler. The sampler is connected to a laboratory scaler for counting. (See Standard Operating Procedure No. 13, p. 80.)

d. Special Surveys

Special surveys include any surveys made at the request of the operating personnel. The equipment and methods used are at the discretion of the Health Physicist. Results of such surveys are recorded in the Health Physics Daily Log Book. Any unusual conditions noted in such surveys should be carefully evaluated.

e. Surface Smears

Smears of surfaces in all areas are made daily. Smears are counted in the Health Physics office on the laboratory counter. Results are kept on file in the Health Physics Log. A smear is the most sensitive method available for detection of surface contaminants. A typical smear is made by rubbing a one-square foot area of floor or work surface with a two-inch-diameter circular disc of filter paper. A count is made of the radioactivity content of the material wiped up with the paper and is interpreted as a number of disintegrations per minute per square foot of surface. Permanent records which reflect the presence or buildup of contamination in the various areas are kept.

f. Neutron Monitoring

A routine neutron survey of the reactor area is made weekly. The purpose of this survey is to ascertain that no unexpected changes in neutron background have occurred. Changes of this type might occur with the shifting of shield gravel. Changes in background neutron levels will occur with changes in reactor power.

In addition to routine surveys, special surveys may be made at various levels of reactor power or at the request of operating personnel.

g. Dosimeters

Dosimeters are assigned to regular operating personnel but are not available in sufficient quantity to be used by visitors.

A dosimeter rack is located at the entrance to the control room. Dosimeters are returned to the rack at the end of each operating shift. All dosimeters are read daily by a Health Physicist and are recharged when necessary. Dosimeter readings are recorded on a daily log. Weekly totals are entered in a permanent log book.

h. Film Badges

Film badges are issued to all personnel at the perimeter guard post. Regularly assigned personnel have exchange badges which incorporate an identification badge and a film packet. This badge is exchanged for a plastic identification pass as the individual goes through the guard post. Visitors and temporary personnel are issued similar badges which do not incorporate an identification photograph. Regular and temporary badges are processed weekly. Visitor badges are processed daily.

All badges are furnished, exchanged and processed by AEC Health and Safety at the NRTS Central Facilities area. No action is required on the part of ALPR Health Physics personnel to obtain film badges for new personnel since they are issued automatically at the time of issuance of the security pass or badge.

Each badge contains a beta-gamma-sensitive packet and a fast-neutron sensitive packet (NTA). Both film packets are processed after exchange. AEC Health and Safety prepares a weekly summary of film badge readings for the area. All beta-gamma films are measured and recorded. Neutron films are processed but are not read unless a specific request is made.

B. ALPR Startup Operations

1. Pre-Operation Background Evaluation

Health Physics coverage for ALPR was begun prior to the initial loading of the core. The purposes of this pre-operational evaluation were: (1) to determine the natural radioactivity background levels in the area, and (2) to determine whether the Health Physics program was fully operational.

Pre-operational coverage consisted of the collection and analyses of air samples to determine natural radioactivity in the air, collection and analyses of surface smear samples to determine background contamination levels, and area monitoring with low-level scintillation detection survey meters to determine the natural radioactivity in the area.

2. Installation of Antimony Source

Operational coverage began with the receipt at ALPR of the cylindrical, 1000-curie, gamma-emitting Sb-124 startup source rod. The ALPR fuel-loading cask was used for shipment of the source. Maximum leakage of radiation from the cask was 160 mr/hr, in the form of a beam through the bottom of the cask. General radiation leakage over the cask surface was less than 1 mr/hr. The loading procedure consisted of filling the reactor pressure vessel with water and lowering the cask vertically until its lower end was immersed in twelve inches of water. The bottom plug of the cask was opened and the source was lowered by means of a winch. As the source was lowered, the radiation level at the edge of the reactor rose to 2.6 r/hr. The radiation level was 1 mr/hr with the source submerged in four feet of water and 0.015 mr/hr in the final position. Personnel exposure was limited by restricting access of personnel to the reactor floor and by requiring them to remain several feet back from the reactor pit during the lowering operation. The winch operator received an exposure of 30 mr and one observer received an exposure of 10 mr.

3. Fuel Element Contamination

All fuel assemblies were carefully surveyed upon receipt. Smears taken of the end fuel plate surfaces of the fuel assemblies showed some to be slightly contaminated. The contaminants were not identified positively but, since both alpha and beta radiations were emitted, it is assumed that the activity was due to uranium. All of the assemblies had been subjected to rigorous examination by means of nondestructive testing methods during and after fabrication. These tests showed that the cladding was free from potentially dangerous holes and scratches and was well bonded to the meat of the fuel plate.

It is believed that air contamination at EBWR was caused by fuel assembly contamination and it is also believed to be the major source of air contamination at ALPR. All fuel assemblies were washed and scrubbed in a hot detergent solution in an effort to reduce the contamination to a low level. The effect of this process on the unscrubbed interior surfaces could not be determined, and it is assumed that some fixed contamination remains on the exterior surfaces of the assemblies.

4. Loading and Critical Experiments

Loading and critical-experiment phases are not a part of normal day-to-day operation and therefore are treated separately here. This discussion applies only to clean critical experiments at ALPR.

The general schedule for Health Physics coverage is similar to that for routine reactor operation:

Area Meter Survey	Daily
Air Samples	Continuous and spot samples
Special surveys	As requested
Surface Smears	Daily
Neutron Surveys	As requested
Dosimeters	Checked daily
Film Badges	Changed weekly

The Health Physics phase at these times differed from that during routine reactor operations in the amount and type of surveillance required. As with any new reactor, the conditions peculiar to the installation had to be thoroughly investigated and analyzed. This required that the Health Physics section spend a great deal of time on seemingly unimportant details and attack the problem from several different angles, many of which may have been unnecessary in the final analysis.

The first loading and first critical experiments were conducted simultaneously. A rough outline of the steps in bringing ALPR to criticality follows:

a. The fuel assemblies were cleaned.

b. The startup neutron source was loaded.

c. All control rod drives were tested to be certain that each rod dropped to the full in-position within two seconds.

d. Four fuel assemblies with no burnable poison strips attached were loaded into the core, one at a time.

e. The first criticality test was performed; the reactor was subcritical, as expected.

f. One fuel assembly was added and the criticality test was repeated.

g. Step (f) was repeated until the reactor could be brought to criticality by the withdrawal of control rods.

h. The reactor was shut down.

The safety restrictions in force during the loading and criticality phases of the operation are described below and, in general, can be applied to any similar operation:

a. Access to the reactor floor during loading of assemblies was kept to an absolute minimum.

b. During the withdrawal of control rods in the criticality experiments, the reactor operating floor was placed "Off Limits" to ALL personnel. No exceptions were permitted.

c. During loading of fuel assemblies, radiation levels were observed by the control console operator, by a qualified supervisor, and by the health physicists present. If any sudden change in level was noted by any one of the above personnel, the insertion of the assembly was halted until the safety of the continuation of this loading was established.

d. Prior to a loading, one or more control rods were withdrawn partially to be inserted rapidly in the event of an emergency. The loading position was selected to provide a margin of control greater than the increase in reactivity expected from the incremental loading.

e. Double instrumentation for measurement of period and flux levels was installed. One set of instruments was read at the control console, the other on a panel positioned temporarily on the reactor floor adjacent to the reactor pit.

f. Air samples were taken for each loading and criticality experiment. At intervals, surface smears were taken of equipment and floors.

g. Personnel were checked for contamination after leaving the reactor operating floor.

h. All personnel working on the reactor operating floor were supplied with self-reading dosimeters and with standard film badges.

i. During criticality experiments when the reactor floor was "Off Limits," meter surveys were made in accessible areas to determine possible increases in radiation background.

A survey of the ALPR operating floor immediately following shutdown after the first critical showed the gamma-radiation background to be less than 0.1 mr/hr. Floor smears for contamination and air samples for atmospheric activity were negative. A series of critical experiments followed. These involved adding fuel assemblies, changing fuel assembly locations, adding boron strips to fuel assemblies, and heating the reactor water. Some of the critical experiments required the removal of one or more assemblies from the core following reactor operation at very low power. Some radioactivity was induced in the fuel assemblies at very low power, but it was found that ten minutes after shutdown, the radiation level of each fuel assembly was reduced to less than 100 mr/hr at a distance of two inches from the assembly. Fuel assemblies were handled manually for very short periods of time. Hand exposures were of the order of 10% of maximum permissible exposure limits. In the entire process of handling irradiated fuel assemblies, no instance of contamination of personnel, clothing or equipment was noted.

No Health Physics difficulties were encountered in any of the critical experiments. The use of the precautions outlined above resulted in a trouble-free operation with a minimum of radiation exposure to personnel.

C. Preliminary Operating Experience

1. General

In the period 1 August 1958 through 15 December 1958, the ALPR core was assembled, criticality tests were run, and the reactor system was brought into full power operation. During this period, the reactor was operated as a zero-power critical experiment for approximately 100 hours and at power levels of from 2 to 3 Mw (thermal) for 615 hours with the turbine and simulated space heat system on the line. These operations included one 40-hour continuous run and one 500-hour essentially continuous power run at full rated plant capacity.

2. Personnel Exposure

Average weekly exposure for 31 operating personnel over a 19-week period was less than 6 mr. (It should be noted here that the minimum quantity of gamma radiation which can be detected on a film badge is 10 mr, and that even this is subject to error. Film badges in use are reliable only in the range above 30 mr.)

At present, film badges are exchanged weekly. If further operating experience indicates that biweekly film-badge exchange is practical (and preliminary operating experience indicates that it is) a recommendation will be made to this effect.

Day-to-day monitoring will continue to be provided through self-reading dosimeters. Film badges of personnel with high dosimeter readings can be withdrawn at any time and processed and evaluated within eight (8) hours.

In Table 2 a summary is presented of film-badge exposure during preliminary operation of ALPR.

Table 2

OPERATING PERSONNEL FILM-BADGE EXPOSURE DURING ASSEMBLY, CRITICALITY EXPERIMENTS, AND INITIAL FULL-POWER OPERATION OF ALPR

Report Period: 26 July 58 through 10 December 58

Film Badge No.	Maximum Weekly Exposure (mr)	Total Exposure for 19 Weeks (mr)	Average Weekly Exposure* (mr)	Film Badge No.	Maximum Weekly Exposure (mr)	Total Exposure for 19 Weeks (mr)	Average Weekly Exposure* (mr)
026	30	40	2.1	045	10	10	<1
027	50	190	10	046	20	30	1.6
046	10	10	<1	047	20	30	1.6
073	35	85	4.5	051	70	210	10.1
001	80	80	4.2	052	150	180	9.5
032	160	255	13.4	053	10	20	1.05
033	60	155	8.2	054	10	10	<1
034	0	0	0	056	120	355	18.7
035	30	70	3.7	057	120	180	9.5
036	30	40	2.1	060	50	160	8.4
037	20	40	2.1	061	100	360	19.0
040	70	190	10	062	65	135	7.1
041	20	20	1.05	063	40	50	2.1
042	20	20	1.05	064	70	130	6.8
043	55	105	5.5	065	70	185	9.7
044	60	100	5.3				

*Note: Since 10 mr is the minimum which can be detected on a film badge, weekly exposures which average less than 10 mr are not absolute values.

3. Area Background

The average gamma-radiation background on the reactor operating floor was about 4 mr/hr at 2.8 Mw (see Fig. 1). Minimum and maximum readings ranged between 1 mr/hr at the entrance door to 350 mr/hr at a point behind the purification system panel. There were three significant sources of radiation which caused local increases in gamma-background levels. These were:

Simulated Heat Load
Heat Exchanger: Maximum - 350 mr/hr @ contact

Resin Column Vault: Maximum - 1.5 r/hr @ contact

Steam Trap: Maximum - 250 mr/hr @ contact

Additional shielding for these items has been installed.

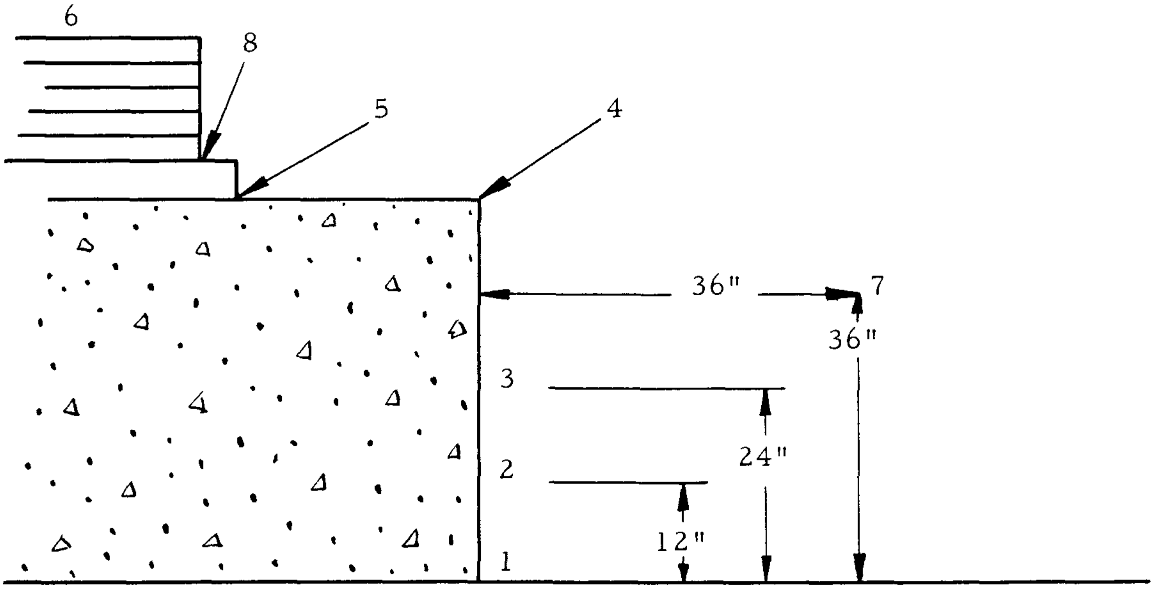
Figure 1

Radiation Levels

CROSS SECTION THROUGH SHIELD BLOCK #1

POWER: 2 MW (DURING 500-HOUR POWER RUN)

(Maximum over top)



(1) 15 mr/hr
(2) 9.5 mr/hr
(3) 4.3 mr/hr
(4) 1.7 mr/hr
(5) 10.4 mr/hr
(6) 0.9 mr/hr
(7) 3.2 mr/hr
(8) 2.9 mr/hr

4. Air Activity

Airborne particulate radioactive contamination averaged 3,200 dpm/m^3 (1.46 x 10^{-9} μc/ml) at zero decay time (at equilibrium during full-power runs). The major components of the contamination were beta-gamma emitters which decayed with short half-lives. Disintegration rates on average samples decreased by a factor of 100 in 55 minutes. In all cases, long-lived activity was less than 50 dpm/m^3 after seven-day decay time. Alpha emitters were present only as normal atmospheric radon daughters.

A malfunction of the turbine gland seal air ejector resulted in the leakage of radioactive steam from the turbine shaft seal at the exhaust end of the turbine. Samples of reactor room air under this condition were as high as 75,000 dpm/m^3 (3.4×10^{-8} μc/ml). Room-air activity was reduced to that under normal operating conditions by ventilating the escaping steam through a blower unit which exhausted the air contaminant to the atmosphere outside the building. The malfunction was repaired after two days and the blower unit was removed.

The concentration of air contamination under normal operating conditions is caused by the escape of small quantities of radioactive steam from several points in the reactor steam system. The major radioactive components are the normal fission product gases.

The maximum permissible level (MPL) for this combination of radioisotopes in air has been calculated at ANL, using NBS methods, to be 5×10^{-5} μc/ml or 1.1×10^{8} dpm/m^3.

The maximum concentration so far encountered at ALPR was 3.4×10^{-8} μc/ml. The average concentration was 1.46×10^{-9} μc/ml.

The above were results of "spot" air samples. Continuous monitoring by the NMC Constant Air Monitor (CAM) provided constant sampling and enabled rapid detection of unusual conditions. The CAM normally operated at about 1,600 cpm, or 80% of full scale on the low or 2K scale. This was a combination of both area gamma background and air activity. During periods when air activity rose because of steam leaks the CAM operated on the 10K and 20K scales (full scale 10,000 and 20,000 cpm, respectively). On two occasions, the CAM registered off-scale; both of these incidents occurred during the ejector malfunction mentioned above. The bell alarm system of the CAM was wired into a warning system panel in the control room to provide an instantaneous warning to the operating crew should an unusual condition arise when no personnel were present on the reactor operating floor.

5. Area and Personnel Contamination

Hand and shoe contamination of up to 2mr/hr was found on several occasions. All incidents were connected with leaks or spills from the purification system and all involved reactor water. The contaminant was of short half-life and in all cases levels were reduced to less than 0.1 mr/hr by cleaning with soap and water. Some low-level contamination of less than 0.1 mr/hr could not be removed by the above method but decayed to undetectable levels in less than eight hours.

Several spills of reactor water were of sufficient magnitude to warrant the mandatory use of shoe covers until the spills could be cleaned up. Since the spills were mainly water, waterproof plastic shoe covers were required. To keep tracking of contamination to a minimum, personnel access was limited to essential personnel until cleanup could be accomplished. The Constant Air Monitor (CAM) showed that very little of the contaminating material became airborne. Cleanup followed standard decontamination procedures and no unusual problems were encountered.

6. Instrument Operating Experience

Certain instruments used by the Health Physics section were in continuous operation from 1 August 58 through 15 December 58 while others were in use on an intermittent basis. This is a brief summary of operating experience which may help in determining future instrument requirements. For detailed information on the instruments and their operation, see Standard Operating Procedures No. 4, 8, and 13.

The Constant Air Monitor (CAM) and the Hand and Foot Monitor were in constant use throughout the period. Downtime on the CAM was one day, caused by a break of the fan belt of the blower drive unit. Downtime on the Hand and Foot Monitor was less than one hour, caused by an accidental break of the main power cord, which cannot be charged to equipment failure. Both units have had no electronic failures in the report period.

Sample-counting equipment consisted of one (1) PC-1A proportional counter and two (2) RIDL Model 206 decimal scalers which served a variety of counting chambers and devices. These were in continuous operation for the duration of the 500-hour power run and were in intermittent operation for about 40 hours per week for the balance of the period from 1 August 58 through 15 December 58. The RIDL scalers had no operating failures in this period. The PC-1A was out of operation for one week (prior to the 500-hour run) because of electronic trouble in the preamplifier section.

Portable survey meters were in intermittent use throughout the period. There were no reported electronic failures in the period. All of the meters in use are battery operated and are subject to battery failure in from one to four months of intermittent operation. No effort is made to replace batteries before the instrument goes out of operation. The number of instruments on hand is sufficient to allow full section operation in the event of failure of 50% of the portable survey meters.

7. Resin Change

Transfer of either mixed-bed or cation resins from the resin column to the disposal tanks involves the movement of a quantity of highly radioactive material from a point on the purification panel to a disposal tank over a distance of some 15 feet. Maximum radiation from the transfer piping is 50 to 75 r/hr as determined by a Jordan Radector in contact with the pipe. Gamma background fifteen feet away from the pipe is 50 to 75 mr/hr.

As originally designed, the change system involved the use of rubber hose between the purification panel connection and the disposal tank. This was modified so that galvanized iron pipe could be used, since rubber hose is subject to breakage under the pressure which may be encountered in the event of a line stoppage.

The resin disposal tank is positioned some fifteen feet below the floor surface in a waste storage sump and is covered by four to six feet of water. Connection to the galvanized iron pipe is by copper tubing. Resin is removed from the column (located in the shield gravel) by back-flushing. The resin is carried out by the flush water through the galvanized pipe, down the copper tubing to the disposal tank. A screen on the outlet side of the disposal tank stops the resin but allows the flush water to flow through into a copper return line to floor level, and then into a rubber hose connected to the reactor water storage tank.

The major portion of the active material is concentrated at the input of the resin column in perhaps 5 to 10% of the total resin charge. The highly radioactive portion of the resin is the last of the charge to be carried over in flushing, so that the operators should not become careless if the radiation levels are low as the first part of the resin comes through the system.

Personnel exposures are kept at a minimum by first making sure all connections are made properly, and then observing the operation from a safe distance. Access to the reactor operating floor is restricted during resin changes and, if the reactor is in operation, the reactor operator in charge is notified to anticipate high-level radiation readings on the control console monitor system.

8. Evaluation of the Effectiveness of the Gravel Shield

A survey to determine the effectiveness of the gravel shield surrounding the ALPR core and pressure vessel was made. It was required to determine quantitatively the dose rate of gamma and neutron-radiation leakage through the vertical side of the reactor building and the neutron and gamma-radiation dose rate in the air space in the piling zone under the reactor building. (Note: ALPR was built on pilings to simulate Arctic area perma-frost conditions.)

a. Side Leakage

Points were established at intervals of two feet vertically on the side of the reactor building along the uncovered spiral staircase (emergency exit stairs). Considering the top of the pilings to be the base of the building, readings are given at two-foot intervals of elevation. Readings were made at a power level of about 2.8 Mw after 250 hours of continuous operation (see Table 3).

Table 3

RADIATION LEVELS[a] ALONG THE OUTSIDE STAIRS

Elevation	Gamma	Neutron (f)	Neutron (th)
0	0.12 mr/hr	<0.01 mrem/hr	<20 $n_{th}/(cm^2)(sec)$
2	0.042	"	"
4	0.035	"	"
6	0.031	"	"
8	0.029	"	"
10	0.031	"	"
12	0.036	"	"
14	0.055	"	"
16	0.26	"	"
18 (Floor level)	0.75	"	"

Gamma:	Readings made with a Mt. Sopris scintillation counter, minimum sensitivity of 0.001 mr/hr. Readings include normal background of 0.003 mr/hr.
Neutron (f):	Readings made with Raychronix Fast Neutron Dosimeter[b] (Red-Nose) using "integrate" scale; no detectable reading in ten-minute observation period; rated minimum sensitivity of 0.01 mrem/hr.
Neutron (th):	Readings made with Nuclear Measurements Corporation BF_3 portable survey meter, minimum sensitivity of 20 $n_{th}/(cm^2)(sec)$.

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[a] Table 3 is based on readings at selected locations only. Much of the surface of the reactor building above head level remains unsurveyed. It is believed that the uniformity of the gravel shield is such that all readings for a given elevation should vary by no more than 10% from the values in Table 3.

[b] The fast neutron dosimeter is sensitive to neutrons in the energy range above 0.2 Mev while the BF_3 meter is sensitive to neutrons of less than 0.03 ev. No determination was made of neutrons in the energy range from 0.03 ev to 0.2 Mev. If suitable measuring devices can be obtained, a survey of this energy range will be made.

b. Bottom Leakage

Building height restrictions on ALPR (design specifications) limited the space available for vertical shielding of the reactor pressure vessel. It was determined that the shielding should be so arranged as to provide maximum shielding above the reactor and somewhat less shielding below the reactor, since the area over the reactor would be occupied by personnel on a part-time basis, while the area under the reactor does not require access by personnel.

The design estimate for gamma-radiation leakage in the piling area at a point directly below the reactor pressure vessel was 100 r/hr.

A survey was made by taping film-badge packets (both beta-gamma and neutron types) to a long pipe which was placed under the reactor building for a period of one hour. The results from the neutron film packets were inconclusive. Results from the beta-gamma film packets are shown in Table 4.

Table 4

RADIATION LEVELS UNDER REACTOR BUILDING
(Piling Zone)

Beta-gamma film packets exposed for one hour
with reactor at ~2.8 Megawatts

Distance from Outer Edge (ft)	Film Packet No.	Exposure (mr)	Distance from outer Edge (ft)	Film Packet No.	Exposure (mr)
0	1	0	15	16	2,850
1	2	0	16	17	4,700
2	3	0	17	18	8,400
3	4	0	18	19	10,000
4	5	0	19	20	9,400
5	6	0	20	21	10,000(Center)
6	7	25	19	22	10,000
7	8	130	18	23	10,000
8	9	210	17	24	7,200
9	10	435	16	25	5,800
10	11	435	15	26	4,700
11	12	760	14	27	2,700
12	13	970	13	28	1,455
13	14	1,355	12	29	950
14	15	1,920	11	30	550

9. Radioactivity Release to the Atmosphere

Release of radioactive material to the atmosphere is confined to the output of the two air ejectors in the reactor steam system. Material is released through a one-inch line through the building roof some 50 feet above ground level on the side of the building air intake and exhaust system.

In the original building design, the air ejector effluent was to be discharged through the building air-exhaust system. Because of the close proximity of the building air-intake and exhaust systems, it was apparent that recirculation would occur under certain meteorological conditions. To minimize the effect of recirculation of radioactive materials, it was decided to relocate the air ejector stack at its present position.

Isotopic analysis of the air ejector effluent activity (radioactive isotopes only) is as follows:

For ALPR operating at a power level of 2.4 Mw:

Kr-88	9×10^2 dpm/cc
Xe-138	7×10^3 dpm/cc
Xe-133	1.8×10^2 dpm/cc

10. Summary - Routine Reactor Operations

The primary concern of Health Physics at ALPR under routine operating conditions is not the reactor core, per se, but the equipment associated with the reactor, such as the turbine, piping, valves, water-purification system, steam condenser, air ejector, etc.

Some radiation escapes from the reactor through the shielding material but this level of radiation is low and, from the standpoint of personnel exposure and safety, it is of secondary importance in comparison with the other components mentioned above.

Radioactive material is produced in the reactor core by neutron bombardment and by the production of fission products exterior to the fuel cladding. The steam generated in the core carries some radioactive materials through the steam system. Steam leaves the reactor vessel through the main steam line and then flows either into the turbine steam line or the auxiliary steam line. The major portion of the steam passes through the turbine and then to an air-cooled condenser. The auxiliary steam line leads to the Simulated Heat Load Heat Exchanger and then to the air-cooled condenser. The condensate goes to the hot well from which it is pumped back into the reactor vessel.

Approximately 2 gpm of reactor water is circulated through a filter and ion exchange system to maintain high quality of the reactor water and to control its pH. This loop is another active portion of the reactor system from which radiation leakage can be detected. Potentially active gases such as entrapped air, products of water dissociation and fission product gases are removed from the steam system by the condenser air ejectors and the turbine gland seal air ejector.

Local areas of high-level gamma radiation are found near the Simulated Heat Load Heat Exchanger and around the purification system control panel. The activity at the heat exchanger is caused by a concentration of N^{16} near its exhaust end. The activity level is dependent on the bypass steam flow rate and to total reactor power. With the reactor at full power the maximum activity level external to the heat exchanger rises to about 300 mr/hr with 1500 lb/hr of steam bypass. The average background in the immediate vicinity of the heat exchanger is about 15 mr/hr. This area includes the turbine control panel and is occupied by personnel for short periods of time during turbine startup and during routine inspections.

A portion of the radiation level at the rear of the purification panel was attributed to radiation leakage from the resin column vault which is buried in the gravel shield below floor level. Leakage through the shield plug was about 100 mr/hr at floor level. During initial power runs a leak of up to 350 mr/hr was found, but since then this has been corrected by the addition of concrete block and gravel shielding in the void between the floor plates and the subfloor around the resin column vault.

A one-inch stainless steel pipe in which reactor water is flowing will measure 150 to 200 mr/hr at contact with the JUNO survey meter. Since there are a number of 1-inch to 2-inch pipes which carry reactor water located behind the purification panel, their total contribution to the radiation background is significant.

The neutron background on the reactor floor has been low. The maximum neutron flux detected was 200 $n_{th}/(cm^2)(sec)$, which is about 12 per cent of MPL for thermal neutrons. The fast neutron radiation level is less than 0.1 mrem/hr.

SECTION IV: STANDARD OPERATING PROCEDURES FOR HEALTH PHYSICS (ALPR)

NO. 1 - STANDARD OPERATING PROCEDURE FOR DISPOSAL OF RADIOACTIVE WASTES

A. General

Radioactive wastes are divided into two categories for disposal: "DRY ACTIVE WASTES" and "LIQUID ACTIVE WASTES." The terms are self-explanatory. Where liquids are held in or on solid materials, such as filters, oily rags, blotter paper, etc., such material is considered to be dry waste so long as the material is not "dripping wet."

IDO Health Physics maintains a burial ground for subsurface disposal of dry radioactive wastes. This is located west of the EBR-I area. Permission of IDO Health Physics is required to obtain access to this area.

IDO Health Physics has no facilities for disposal of contaminated liquids. Each area is provided with a leaching pond for disposal of low-level liquid wastes (see Section C, below). The ALPR leaching pond is located 100 feet south of the reactor building.

B. Disposal of Dry Active Wastes

1. Collection Facilities for Dry Active Wastes:

A number of galvanized iron (GI) cans (30-gallon size) and "oily waste" cans have been painted yellow and magenta and designated as "Dry Active Waste" cans. These cans, located at a number of points throughout the area, are used only for waste materials which are either known or suspected to be contaminated.

Dry active waste cans are checked daily by Health Physics personnel. When enough material has been accumulated, a cardboard carton to serve as a tight disposable container is prepared. The most commonly used carton is 2 x 2 x 3 feet, obtainable from the Central Facilities warehouse. The contents of the "Dry Active Waste" cans are carefully dumped into the cardboard carton in a controlled area. The carton is sealed and is then ready for transfer to the burial ground.. The recommended sealing material is two-inch-wide paper masking tape. Several strips should be used for each seam to assure a tight, firm seal.

Items of unusual size, weight, or shape which do not fit in the recommended cardboard cartons may be wrapped or sealed in plastic film, or may be sealed in wooden boxes. Where this is not practicable or satisfactory, IDO Health Physics should be contacted for advice or assistance. (Telephone: Ext. 2334).

2. Preparation of Form ID-110:

Form ID-110 must be completed for each shipment. This form is obtained by the ALPR Health Physicist from IDO Health Physics. A typical form ID-110 is shown on page 42.

The ALPR Health Physicist must notify IDO Health Physics and must schedule a time and date for pickup or delivery of the container(s). There are few restrictions on the type of material which may be sent for disposal so long as personnel safety regulations are observed. If unusual conditions exist, IDO Health Physics should be consulted.

C. Disposal of Liquid Active Wastes

The disposal procedure for liquid active wastes is largely dependent on the nature of the liquid involved and on the concentration of radioactive contaminants in the liquid.

1. Low-level Contamination in Water:

If the waste material is water with a concentration of radioactive contaminants less than ten times the maximum permissible concentration (MPC) for drinking water (see Table 5, p. 41), such waste may be dumped in the area leaching pond without notification of, or permission from, IDO Health Physics.

2. Intermediate-level Contamination in Water:

If the waste material is water with concentrations of radioactive contaminants in excess of ten times the MPC for drinking water, such waste may be dumped into the area leaching pond, provided permission for such dumping is given in writing by IDO Health Physics. In order to receive this permission, a sample of the waste to be dumped must be submitted to IDO Health Physics Chemistry Laboratory together with a Form IHP-33 (Sample Record Sheet) requesting permission for dumping. If such permission is denied, see paragraph 3, below.

3. High-level Contamination in Water:

Where the concentrations of radioactive materials in water are above the levels permitted for dumping, some form of treatment is required. Three such methods are dilution, solidification and chemical treatment.

a. Dilution is often used for relatively small quantities of waste (10 to, perhaps, 500 gallons). This is simple and economical and is practicable so long as the required dilution factor is not excessive.

b. Solidification is a practical method where the waste material is small in volume and has a very high concentration of radioactive contaminants. This method is also of value where the contaminant is carried in suspension in the liquid. The general method involves filling a container such as a bucket or GI can about half full of the contaminated liquid waste and adding enough cement or plaster of Paris to make a thick slurry. This is allowed to harden and the resultant product is disposed of as dry active waste.

c. The chemical treatment of water usually involves running the water through a suitable resin column. The efficiency of the resin columns is dependent on such factors as the type of resin, the size of the column, and the rate of flow through the column. The efficiency of the column may be such that one pass through the column will decontaminate the water to acceptable levels or it may be such that the water must be recycled several times. The resin column treatment is particularly effective for large volumes of water, such as might be required when dumping the water from the reactor pressure vessel. The resin column decontaminates the water by extracting contaminating materials by ion exchange and holding them in the resin. This means that the resin becomes contaminated. The resin may be disposed of by sealing it in an adequate metal container for burial. This will be done by oral agreement between ALPR Health Physics and IDO Site Survey.

4. Contaminated Chemicals:

Water solutions of contaminated chemicals are neutralized to a pH of about 6 to 7. These are then treated as liquids as in paragraphs 1, 2 and 3 above.

5. Contaminated Liquids Not Soluble in Water:

Oils and greases may be mixed with absorbent materials such as sawdust, or earth. The resulting material may be disposed of as dry active waste.

Other insoluble liquids may be solidified by chemical methods. For specific processes, a chemist, should be consulted.

6. Above Statements Subject to the Following Restrictions:

a. All contaminated water dumped to the leaching pond must be analyzed. Records must be kept of each analysis and of the quantities dumped.

b. A monthly report will be submitted to IDO Health Physics. This will include the total number of gallons dumped , the total curie content, and the isotopic composition.

c. The average annual radioactivity concentration for all water dumped to the leaching pond may not exceed three (3) times the maximum permissible concentration for drinking water (see Table 5).

Table 5

MAXIMUM PERMISSIBLE CONCENTRATIONS FOR DRINKING WATER

Gross Beta:	$10^{-7}\,\mu c/ml$
Sr^{90}	$8 \times 10^{-7}\,\mu c/ml$
Uranium:	$7 \times 10^{-5}\,\mu c/ml$

EXHIBIT 2

ID-110
(R11-58)

WASTE DISPOSAL REQUEST AND AUTHORIZATION

SECTION I - (TO BE COMPLETED BY ORIGINATING ORGANIZATION)

ORIGINATING ORGANIZATION__________

DESCRIPTION OF WASTE: (Complete applicable parts)

Liquid_____ Solid_____ Volume_____ Weight_____
Radioactive: Yes_____ No_____ Curies_____
Mr/hr at container surface_____ at one meter_____
SS Material Type_____ Amount: Net_____ Isotope_____
Classification: Secret_____ Confidential_____ Category: I___ II___ III___
Composition:__________

Capital Equipment No.__________
Associated Hazards:__________

CONTAINER: Type_____ Destroy_____ Save_____
MODE OF TRANSPORTATION__________
APPROVAL:

Originator			
SS Account. Rep.			
HP Rep.			
	(Signature)	(Title)	(Date)

SECTION II - (TO BE COMPLETED BY IDO SS MATERIALS SECTION IF SS MATERIALS ARE INVOLVED IN DISPOSAL OPERATION)

Authorization Number__________

(Signature) (Title) (Date)

SECTION III - (TO BE COMPLETED BY IDO HEALTH AND SAFETY DIVISION)

Method of Disposal:__________
Prescribed Precautions:__________

APPROVAL:

Site Survey Branch		
Analytical Branch		
S&FP Branch		
	(Signature)	(Date)

SECTION IV- (TO BE COMPLETED BY PERSON WITNESSING DISPOSAL)

Disposal was made by means of __________
at_____ on_____
(Location) (Date)

(Signature) (Date)

NO. 2 - STANDARD OPERATING PROCEDURE FOR CONTAMINATED LAUNDRY

A. General

Contamination of clothing at ALPR will be primarily due to beta-gamma emitters with a short half-life. Contaminated clothing is to be treated as such until processed at the Central Facilities Laundry, even though the contaminant has decayed to background level.

Contaminated and uncontaminated items are processed at the same laundry facility. The laundry requires that contaminated and uncontaminated items be segregated and packaged in separate, distinctly marked bags.

B. Collection of Laundry

Two racks are provided for laundry bags in the ALPR men's locker room: one is marked for contaminated clothing and the other for uncontaminated clothing.

Laundry shipments are prepared twice weekly. Each item of clothing is surveyed with a GM survey meter. Those items which show any degree of contamination are placed in the "hot" laundry bag and those which are not contaminated are placed in the "clean" laundry bag. Each bag is surveyed and the "hot" bad is then tagged with a radiation warning tag showing the maximum radiation reading through the bag.

C. Preparation of Form IHP-30

Form IHP-30, obtained from IDO Health Physics, must be prepared in triplicate for each laundry shipment. ALPR Health Physics will retain one (1) copy and will forward two (2) copies with the laundry shipment.

A sample form of this type is shown on page 44.

Exhibit 3

FORM IHP 30 (Rev 1 57)

U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
OPERATIONS DIVISION

RADIOACTIVE SHIPMENT RECORD

DETAILS OF SHIPMENT

SHIPPER

Experiment No ____ Charge No ____ Size ____
Classification ____ Type of Container ____ Weight ____ lbs
Principal Radioactive Material ____ No of Curies ____
Estimated Date of Shipment ____ Location ____
Collect ____ Or Prepaid ____
From ____ Via ____
To ____

Check where applicable ☐ U 233 ☐ U 235 ☐ Normal U ☐ Depleted U ☐ Pu239 ☐ Th ☐ None

1 Does this shipment exceed ICC minimum requiring packaging and labeling? ____
2 If not, is it packaged to prevent leakage under transportation conditions? ____
3 If ICC packaging and labeling is required, what is the ICC No ? ____, or B of E No ____, or is this a courier shipment? ____
4 Have all the lugs, bolts, etc been tightened for shipment? ____
5 Is the shipment palleted? ____
6 Have all liquids been drained from container? ____ If not attach explanation

Date ____ Signature of Shipper ____

HEALTH PHYSICS MONITORING RESULTS

CONTRACTOR-HP

Notify IDO HP Date ____ Time ____
Max Radiation at Surface ____, One Meter ____, 15 ft ____
Evidence of Contamination ____
Remarks ____
Date ____ Log No ____ Health Physics Monitor ____
Signature

IDO-HP APPROVAL OF SHIPMENT

IDO HEALTH AND SAFETY

Log No ____ B of E Special Permit No ____
Remarks ____
Date ____ Approval to Ship Safety ____
Health Physics ____

TRAFFIC AGENT CERTIFICATION OF SHIPMENT

TRANSPORTATION

This is to certify that the above named articles are properly described and are packed and marked and are in proper condition for transportation according to the regulations prescribed by the Interstate Commerce Commission

Date ____ Traffic Agent ____
Signature

NO. 3 - STANDARD OPERATING PROCEDURE FOR SHIPMENT OF RADIOACTIVE MATERIALS

Any transportation of radioactive materials outside the area is considered a shipment and must be handled accordingly. All shipments must meet existing Interstate Commerce Commission regulations covering the shipment of radioactive material and any local AEC regulations that may be applicable.

ICC regulations are listed in "Regulations, Tariff #10" published by H. A. Campbell, Agent, 30 Vesey Street, New York, New York. A copy of this regulation is in the Health Physics Office.

A. Commercial Shipments

Shipments of active material via railway express, rail freight, parcel post, air express, air freight or any motor vehicle not having an escort specially designated by the AEC are considered commercial shipments and should be made as follows:

The shipper shall:

1. Obtain from the Contractor Health Physics five (5) copies of Form IHP-30 (see p. 47).
2. Fill in pertinent information under section "Details of Shipments." Assistance, if needed, may be obtained from the Health Physicist.
3. Sign and date the complete section.

The Health Physicist shall:

1. Ascertain that all ICC and AEC regulations are met. This includes regulations about radiation levels, contamination, curie content, etc.
2. Fill in Section Two, "Contractor HP," and sign.
3. Notify IDO Health Physics, Telephone: Ext. 2334, giving all pertinent information and requesting such permits and authorization as may be required. This should be done as far in advance as possible.
4. Obtain approval and assistance from the Special Materials representative if needed to make actual shipment.

5. Make distribution of IHP-30 copies as follows:

Original	- ALPR HP Files
1 copy	- Shipper - ALPR
1 copy	- IDO-AEC Health Physics
1 copy	- IDO-AEC Security, if concerned
1 copy	- Accompanies shipment

B. Courier-escorted Shipments

Tariff #10, ICC, states the conditions under which shipments may be made by the Commission or its contractors when escorted by specially designated escorts of the AEC. IDO-AEC Security Division provides this service in conjunction with escorts of a security nature. Truckload shipments to various installations are scheduled on a routine basis by IDO Security. For additional information contact H. R. Lichty, Chief, Services Section, Telephone: Ext. 2208 or 2209. To process a courier shipment, complete all steps listed under commerical shipments.

Exhibit 4

FORM IHP 30 (Rev 1 57)

U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
OPERATIONS DIVISION

RADIOACTIVE SHIPMENT RECORD

SHIPPER

DETAILS OF SHIPMENT

Experiment No ______ Charge No ______ Size ______
Classification ______ Type of Container ______ Weight ______ lbs
Principal Radioactive Material ______ No of Curies ______
Estimated Date of Shipment ______ Location ______
Collect ______ Or Prepaid ______
From ______ Via ______
To ______

Check where applicable ☐ U 233 ☐ U 235 ☐ Normal U ☐ Depleted U ☐ Pu239 ☐ Th ☐ None

1 Does this shipment exceed ICC minimum requiring packaging and labeling? ______
2 If not, is it packaged to prevent leakage under transportation conditions? ______
3 If ICC packaging and labeling is required, what is the ICC No ? ______, or
B of E No ______, or is this a courier shipment? ______
4 Have all the lugs, bolts, etc been tightened for shipment? ______
5 Is the shipment palleted? ______
6 Have all liquids been drained from container? ______ If not attach explanation

Date ______ Signature of Shipper ______

CONTRACTOR-HP

HEALTH PHYSICS MONITORING RESULTS

Notify IDO-HP Date ______ Time ______
Max Radiation at Surface ______, One Meter ______, 15 ft ______
Evidence of Contamination ______

Remarks ______

Date ______ Log No ______ Health Physics Monitor ______
Signature

IDO HEALTH AND SAFETY

IDO-HP APPROVAL OF SHIPMENT

Log No ______ B of E Special Permit No ______
Remarks ______

Date ______ Approval to Ship - Safety ______
Health Physics ______

TRANSPORTATION

TRAFFIC AGENT CERTIFICATION OF SHIPMENT

This is to certify that the above named articles are properly described and are packed and marked and are in proper condition for transportation according to the regulations prescribed by the Interstate Commerce Commission

Date ______ Traffic Agent ______
Signature

NO. 4 - STANDARD OPERATING PROCEDURE FOR BETA-GAMMA DETECTION AND MEASUREMENT

A. General

1. Properties of Gamma and Beta Radiations

Gamma radiations are short-wavelength electromagnetic radiations of nuclear origin, with a range of wavelengths from 10^{-9} to 10^{-12} cm. The units of measurement for gamma radiations are the "roentgen" (r), and the "rad." The roentgen is the unit in most common use as of this writing and will be the unit used in this Standard Operating Procedure.

Beta radiations are electrically charged particles emitted from the nuclei of atoms and having a mass and charge equal in magnitude to those of the electron. The units of measurement are the "rep" (roentgen equivalent physical) and the "rad."

From the standpoint of definition, beta and gamma radiations would seem to be quite different. However, they frequently co-exist, have similar effects, and are detected by similar methods. Beta and gamma radiations co-exist in air, water and surface contamination and in radioactive materials such as uranium. Only gamma rays are detectable when beta-gamma emitters are shielded by massive materials. This is the case in gamma leakage through the reactor shield.

In beta and gamma-radiation monitoring and dosimetry, two types of measurement are involved. These are rate of exposure and total exposure.

2. Requirements for Portable Survey Meters (Rate Detectors)

Requirements for portable survey meters include light weight, portability, battery operation, accuracy, and ease of operation and interpretation. All meters in current use are calibrated for gamma radiations in units of milliroentgens per hour or roentgens per hour.

3. Requirements for Personnel Dosimeters (Total Exposure)

Requirements for dosimeters or total-exposure-measuring devices for use by individuals include small size, low leakage, range of 0 to 200 milliroentgens, self-reading, high shock resistance, ease of charging, and accuracy. Units are calibrated in milliroentgens and are considered accurate to plus or minus 10%.

A second device, widely used as a standard for measuring total radiation exposure, is the film badge. This is discussed in the Standard Operating Procedure on Film Badges (see p. 55).

B. Detection

1. General

The instruments in current use at ALPR detect radiation by means of ionization of a gas within an electrode system, and scintillation (production of light flashes) in special crystals. Ionization of gases is utilized in the "Geiger" counter, in the ionization chamber survey meter, and in the quartz fiber electrometer dosimeter. Scintillation is used in the "Scintillator" survey meter and the scintillation counter.

2. Ionization in Gases

Beta and gamma radiations cause ionization as they pass through a medium. If the medium is a gas contained within a charged two-electrode system, the ions produced are attracted to the electrodes. A current, which is proportional to the number of ions formed and therefore to the quantity of radiation present,is developed in the exterior circuit.

The ratio of the number of ions collected to the number of ions produced is, to a degree, dependent on the voltage applied between the electrodes. At zero voltage, no ions are collected and the ions tend to recombine.

If a small voltage is applied, some ions are collected on the electrodes and some ions recombine. As voltage is increased gradually, more ions are collected and fewer ions are permitted to recombine, until a point is reached at which all of the produced ions are collected and there is no recombination of ions. Within limits, further increase of voltage beyond this point does not increase the number of ions collected on the electrodes. This voltage zone is called the "ionization chamber region." In some electrode systems, the ionization chamber region may extend for several hundred volts.

If a sufficiently high voltage is applied to the system, more ions will be collected than were produced in the original ionizing event. This occurs when the applied voltage produces an electrical field strong enough to accelerate ions to a speed sufficient to cause "secondary" ionization of the gas molecules. This can be considered as a form of amplification. Within a limited voltage region, the number of ions collected is proportional to the number of ions produced in the original ionizing event and to the voltage applied. This voltage zone is called the "proportional" region.

Further increase in voltage beyond the proportional region also amplifies or increases the number of ions collected at the electrodes,

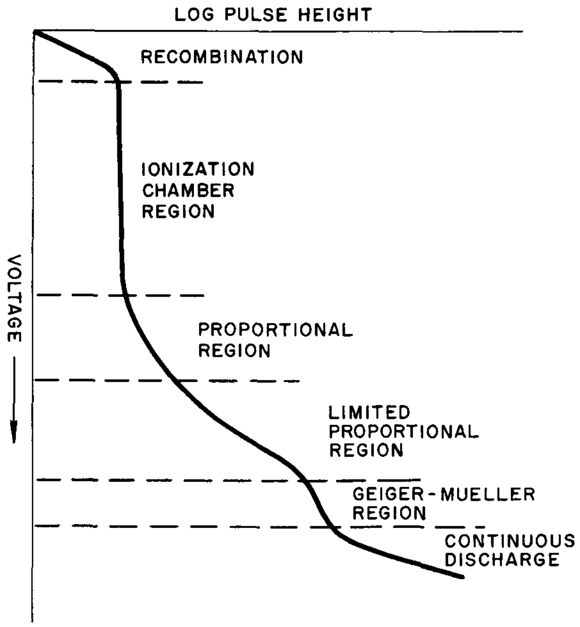


Figure 2. Voltage Characteristics of a Counter Tube

but the number of ions collected is no longer truly proportional to the number of ions produced in the original ionizing event. This voltage zone is called the "limited proportional" region.

At the high end of the limited proportional region, a point is reached at which all ionizing events, regardless of the number of ions originally produced, cause approximately the same number of ions to be collected at the electrodes. This is the lower end of the "Geiger Counter" region. Figure 2 illustrates the various voltage regions.

The ionization chamber survey meter, as typified by the JUNO portable survey meter, operates in the ionization chamber voltage region. The Geiger-Mueller counter, or "Geiger" counter, operates in the "Geiger" voltage region. A proportional counter, such as the PC1A laboratory counter, operates in the proportional voltage region.

3. Scintillation Detectors

When radiations pass through certain substances, they give up a portion of their energy and produce small flashes of light, or scintillations. If that substance is transparent, the light flashes may be detected by sensitive photoelectric devices. An electronic circuit may be devised to utilize the output of the photoelectric device to energize counting circuits.

A typical scintillation counter of the portable survey meter type might use a one-inch cube crystal of thallium-activated sodium iodide cemented to the end of the multistage photomultiplier tube as a detector for gamma radiations.

C. Ionization Chamber Survey Meters

1. The JUNO Portable Survey Meter

The JUNO survey meter is the instrument mostly used at ALPR for beta-gamma measurement. Two models with maximum ranges of 5 r/hr and 25 r/hr, respectively are used. The 0-5 r/hr model has been produced by a number of manufacturers, while the 0-25 r/hr model has been produced only by Technical Associates, Inc. All models are basically similar. A main switch has six positions: OFF; ON; SET; X1; X10; X100. A zero-adjustment potentiometer permits balancing of a bridge circuit to correct the zero position of the meter pointer. A system of shields on the lower side of the detecting chamber permits discrimination between the various types of radiation (alpha, beta, and gamma radiations). All meters are battery operated and are of about the same size and weight (6 x 10 x 4 inches, 6 pounds).

To put the instrument into operation, the following sequence should be followed:

a. Turn selector switch to "ON," wait 15 seconds.

b. Turn selector switch to "SET," turn "ZERO" knob until meter pointer rests on zero.

c. Turn selector switch to range position X1. If no radiation is present, meter pointer will remain at zero. If the radiation level falls within the range limits, the meter pointer will rise slowly to that level. If the radiation level is above the limits of range X1, the meter pointer will rise slowly to the off-scale position; in this case turn the selector switch to the X10 or X100 position, as required. If the meter pointer "snaps" to the full-scale position, it is probable that the instrument has had either an electronic or battery failure. It is also possible that the radiation level is excessively high. In either case, another instrument should be procured and the radiation level rechecked.

At ALPR, the JUNO is used for determination of beta-gamma and gamma levels; that is, the meter may be used to determine the level of a combination of beta and gamma radiations, as in surface contamination, or may be used to determine the level of gamma radiation only. This is best accomplished by using the combination of retractable shields on the lower side of the instrument beneath the ionization chamber. One shield is made of aluminum of a thickness sufficient to stop beta radiations; this allows gamma radiations to pass through into the chamber but shields out the beta radiations. A second shield is made of plastic material, such as Lucite or Plexiglas, of a thickness sufficient to stop alpha radiations; this allows gamma radiations and intermediate and high-energy beta radiations to pass through into the chamber. With both shields closed, the JUNO "sees" only gamma radiations. With the aluminum shield retracted and the plastic shield closed, the JUNO sees a combination of beta and gamma radiations. With both shields retracted, the bottom of the ionization chamber is covered with only a thin film of nylon, mylar, or rubber hydrochloride which allows penetration of alpha, beta, and gamma radiations. Alpha contamination is not anticipated at ALPR.

JUNO survey meters used at ALPR are maintained and calibrated by AEC-IDO Health and Safety personnel. ALPR personnel should not attempt to repair or calibrate these instruments. If an instrument is suspected or known to be out of calibration, that instrument should be returned to AEC-IDO Health and Safety.

2. The RADECTOR Portable Survey Meter

The Jordan RADECTOR survey meter is used for determination of high-level beta-gamma activities at ALPR. Two basically similar models with maximum ranges of 50 r/hr and 500 r/hr, respectively, are available. The RADECTOR has two range settings, marked in mr/hr and r/hr. Scales are logarithmic, with three decades covered on each range setting. The unit has a five-position selector switch and does not require zero adjustment. A calibration source is built in and the instrument is calibrated by means of two set screws located on the top of the meter. Beta-gamma discrimination is provided by a movable metal plate at the base of the ionization chamber.

Procedure for placing the instrument in operation is as follows:

a. Turn selector switch to TEST. Meter pointer should come to approximately half-scale and should stop within the marked bracket.

b. Turn selector switch to BAT. This is the battery test. Meter pointer should rise to the full-scale position. If the instrument does not respond as in steps a and b, the instrument is faulty and another instrument should be used.

c. Turn the selector switch to the desired range position. If there is no response on the "mr/hr" range, the level of radiation present is below the sensitivity of the instrument. If the meter pointer rises to the full-scale position, turn the selector switch to the "r/hr" range. (NOTE: If the meter pointer "snaps" to full scale on the r/hr range, the meter is probably defective, since the meter time constant is long, even in the presence of high-level radiation. If the meter slowly rises to full scale on the r/hr range, evacuate the area until another meter can be obtained to verify the reading.)

D. Geiger-Mueller Counter Survey Meters

A number of models of portable Geiger-Mueller counter survey meters are used at ALPR but all are similar in basic design. The typical survey meter consists of a metal case containing a battery power supply and associated electronics and an extension probe or cable terminated with a Geiger-Mueller detector tube. The instrument has a single control or selector switch with settings of "OFF," "0-0.2 mr/hr," and "0-20 mr/hr." Some meters also have a switch position for battery check.

The GM survey meter is sensitive to beta and gamma radiations and permits some degree of discrimination by rotating a shield sleeve which exposes or covers the GM tube. The GM survey meter may be quantitatively calibrated against a known standard but, since the response is somewhat energy sensitive, readings taken of radiation of a different energy spectrum are not truly quantitative.

Read-out is accomplished by a standard microammeter and provision is made for incorporation of a headset to indicate aural indication of pulse rate. A typical unit measures about 6 x 10 x 4 inches and weighs about 6 pounds.

E. Proportional Counters

At this writing, no proportional counters are in use at ALPR for portable survey monitoring. One laboratory-type proportional counter is used in the Health Physics office for low-level counting of air samples, water samples, and floor smears. This is the PC-1A proportional gas flow counter.

The PC-1A is composed of three basic units: the counting chamber, preamplifier, and the scaler unit (which incorporates a regulated high-voltage power supply for the counting chamber). The instrument is a self-contained unit with the exception of the required gas cylinder which supplies a mixture of 90% argon and 10% methane as a gas filling for the counting chamber.

Detailed instructions on the use of the PC-1A counter will be found in the Standard Operating Procedure on Sample Counting, p. 65.

F. Personnel Dosimeters

The dosimeter is an adaptation of the quartz fiber electrometer and operates in the ionization chamber voltage region. The dosimeter used at ALPR is the Landsverk Model L-50 and covers the range between 0 and 200 milliroentgens. Each dosimeter has a built-in reading device so that the user may observe his dosage at any time. The unit requires an external charging device to reset the indicator to zero. ALPR dosimeters are supplied by AEC-IDO Health and Safety. Dosimeters are charged and read by ALPR Health Physics personnel.

The dosimeter is essentially a capacitor system with a device for measuring an electrostatic charge on the capacitor. The measuring device is a very sensitive quartz fiber which is fixed at its end to a conducting plate. An electrical charge on the system causes the fiber to be repelled from the plate by repulsion of like charges. The distance between the plate and the fiber is proportional to the applied charge on the entire capacitor system. ($Q = CE$, where Q is charge, C is capacitance, and E is voltage. The system capacity cannot be changed, so Q is dependent on voltage.) An optical system is provided for viewing the quartz fiber. Included in the optical system is a calibrated reticle for measurement of the position of the fiber. The charging device is connected to the dosimeter and the applied voltage is varied until the fiber appears at the zero point on the reticle. Exposure to radiation causes part of the system charge to be dissipated and results in a change in the position of the fiber on the reticle. This change in position is proportional to the quantity of radiation exposure and the reticle is calibrated directly in milliroentgens.

The dosimeter is a total-dosage-measuring device and is used to supplement personnel film badges. Dosimeters are not considered to be reliable enough for use as an official record of exposure since they are subject to leakage, false readings, and accidental discharge due to mishandling or dropping.

G. Scintillation Counter Survey Meters

A scintillation counter survey meter is used for very low-level radiation detection. The only instrument of this type available from AEC-IDO Health and Safety is the Mt. Sopris Model SC-129. The instrument is extremely sensitive and will respond at low levels to an increment of as little as 0.001 mr/hr. The instrument will read up to 5 mr/hr.

The instrument has a selector switch with positions of 0-0.025 mr/hr, 0-0.05 mr/hr, 0.25 mr/hr, 0-0.5 mr/hr, 0-2.5 mr/hr, 0-5 mr/hr, and ZERO set. A second switch has three positions: OFF; FAST (Instrument ON, fast time constant); SLOW (Instrument ON, slow time constant). A covered adjustable knob provides for zero adjustment with the range switch on ZERO and the other switch on either FAST or SLOW.

To put the instrument into operation, the following sequence should be followed:

a. Turn range selector switch to ZERO.
b. Turn ON-OFF switch to FAST or SLOW.
c. Adjust meter pointer to zero.
d. Turn range selector switch to desired range.

NO. 5 - STANDARD OPERATING PROCEDURE FOR FILM BADGES AND DOSIMETERS

A. General

The accepted means of recording cumulative personnel radiation exposure at the ALPR is film badge dosimetry.

The film badge in use at ALPR is a combination Security-Health Physics badge containing two film packets. The Beta-Gamma film packet, type 552 DuPont, is calibrated to measure doses from 10 mr to 30 r. The neutron film packet, Kodak NTA, is calibrated to measure doses produced by neutrons having an energy from 0.5 to 8 Mev.

Film badges are provided and processed by AEC-IDO personnel. Badges for permanently assigned personnel are processed and repacked once per week. (The current change day is Wednesday at 2000 hours).

Nonroutine and visitor badges are processed daily, with all results being forwarded to the ALPR Health Physicist. The recorded exposures are available from his files for the individual or his supervisor. The processed film is returned to ALPR as part of the permanent legal record.

B. Routine Film Badge Dosimetry

Routine film badge dosimetry shall be carried out as follows:

1. Upon entering the ALPR area the individual will exchange his wallet security pass for the film badge identification badge.
2. The film badge is secured to some portion of the outer clothing at or above the waist level. The badge should be visible. If, however, it is necessary to work in a known area of airborne or removable contamination, the badge will be worn in a pocket or underneath the outer clothing to protect the spread of contamination to personnel handling the badge.
3. If the occasion should arise to require a change of clothing, the badge will be transferred to any outer clothing worn.
4. If it is known or felt that an exposure higher than usual has been received, the Health Physicist can arrange for a special overnight processing of the badge.
5. The badge is exchanged at the security gatehouse when leaving the area. Nonroutine and visitor badges will be handled as above.

C. Self-Reading Dosimeters

Self-reading dosimeters or "pencils" in use at the ALPR cover a range of from 0 to 200 mr.

Dosimeters are issued to all permanently assigned personnel and are checked daily, the readings being recorded. They are located in a rack in the hallway outside of the control room. Visitors are not required to use dosimeters except by Health Physics request.

It is the duty of the Health Physicist to maintain a supply of charged, serviceable dosimeters and to inspect dosimeters in use once per day, recording the readings in his file.

NO. 6 - STANDARD OPERATING PROCEDURE FOR NEUTRON BADGES AND DOSIMETRY

There are certain locations around the reactor area where exposure to neutrons can routinely be encountered. Operating experience has proven that under normal operation these levels are below MPL.

Neutron monitoring is accomplished by two methods:

A. Film Badges

As previously mentioned, each film badge contains two packets, one for beta-gamma and one for neutron detection.

The neutron film is an "Eastman NTA" type capable of detecting "fast neutrons" with an energy of 0.5 Mev and above. Exposure is determined by making use of the charged particles from neutron reaction with materials in or near the film emulsion, thus producing microscopic tracks. The tracks are produced by recoil protons from the emulsion and film base.

Routine processing of the film is done by Personnel Metering, AEC. The personnel exposure is not determined unless requested by the ALPR Health Physicist.

Periodically, films are calibrated to determine the number of neutrons to produce one track on the film. The resulting track density is a measure of the neutron flux. The tracks are measured by microscopic examination of the processed film. A magnification of 1000X, oil immersion, dark field illumination is used. The operator counts both the number of fields and the number of tracks. A portion of the fields are counted and random distribution is assumed. Final determination of exposure is made by converting, by a known calibration, from tracks per number of fields to mrem exposure. The current conversion figure is 1 track per 40 fields equal 10 mrem. Final results are given in mrems of exposure. It is not uncommon to receive "background" readings of 10 and 30 mrem due to processing techniques and film age. Due to the low total exposure received by ALPR personnel and to be on the safe side, this reported exposure is normally accepted as chargeable exposure.

B. Instrumentation

Two types of portable neutron survey instruments are available from AEC-IDO and are in use at ALPR. They are:

1. A portable BF_3, gas-filled "slow neutron" counter, requiring a two-minute warmup period and having a battery life of approximately 1,000 hours. This instrument reads directly in $n/cm^2/sec$.

2. RUDOLF, an argon-methane-filled chamber for the detection of fast neutrons in the range from 0.2 to 10 Mev. Warmup time is ten seconds and the battery life is approximately 400 hours. This instrument reads mrem/hr directly.

NO. 7 - STANDARD OPERATING PROCEDURE ROUTINE AREA SURVEYS

A. General

Surveys made in the reactor operating area during initial power-run tests indicate that operating conditions will be such as to require some restriction or limitation of personnel access or work time during full-power operation.

Gamma-radiation background on the reactor operating floor averaged 4 mr/hr at 3.0 megawatts with the turbine on line. Isolated hot spots measured from 10 to 350 mr/hr but did not significantly raise the general-area background because they acted essentially as point sources and radiation levels decreased rapidly with distance.

Neutron leakage did not significantly add to the total radiation dose, the combined effect of thermal and fast neutron fluxes being less than 1 mrem at any point on the reactor operating floor.

Internal exposure from gaseous and particulate radioactive material in air was less than 10% of MPL. Particulate radioactive material was a combination of normal atmospheric radioactivity and reactor-produced, short half-life material.

The total body exposure is the combination of the average gamma background, neutron leakage, and air contamination. A conservative figure for total body exposure on the reactor operating floor (under currently existing conditions) is 10 mrem/hr.

It is desired to maintain personnel exposure at less than 100 mrem per week for routine operating conditions. In order to meet this requirement, a time limit of ten (10) hours per week per man is suggested for occupancy of the reactor operating floor during power operations. The estimate of 10 mrem/hr for total body exposure is conservative, thus making the ten-hour time limit conservative. Operations specifications estimate the average time occupancy at eight to ten hours per week per man. The ten-hour-per-week time limit should impose no hardship on the operating crew.

B. Routine Surveys

1. Surveys by Health Physics Personnel

The ALPR Health Physicist and/or the Health Physics technician is required to make routine surveys at a minimum of twice daily during operation of the reactor at all power levels exceeding 100 kw of reactor thermal power. When the reactor is shut down or is operating at less than 100 kw, routine surveys will be made at least once daily. The results of the routine surveys are to be entered on the Routine Survey Log Sheet. (See Exhibit 5, p. 63).

Survey measurements are to be made at the positions noted on the Routine Survey Log Sheet. The exact locations of survey points are marked with a painted black circle, two inches in diameter (Items 6, 15 and 19 are area surveys where the reading is an average taken over a wide area). The routine survey points are described below in more detail than is given on the Routine Survey Log Sheet.

1) Control Room. Behind the NEMCO Switchgear panel, on east wall, 36 inches above floor level. G-M meter survey.

2) Lower Landing. First landing going up covered staircase. Near engraved nameplate, 48 inches above landing floor level. G-M meter survey.

3) Between Lower and Middle Landing. 48 inches above 6th step up from lower landing. G-M meter survey.

4) Middle Landing. Wall, 52 inches above landing floor level. G-M meter survey.

5) Doorway, Chest Height. Side of door frame, 48 inches above floor level. G-M meter survey at low power, JUNO meter survey at 2.5-3.0 Mw.

6) Average Around Shield. With the JUNO survey meter at about waist height, walk slowly around the perimeter of the reactor shield blocks. Note maximum and minimum readings. Record the average reading.

7) Hot Well. Located above head level over feedwater pumps. JUNO meter survey.

8) Simulated Heat Load Heat Exchanger. Located three feet south of the turbine control panel. Activity is concentrated in the east end of the heat exchanger. Activity level is subject to extreme fluctuation and is proportional to bypass steam flow. JUNO meter survey.

9) Auxiliary Steam Line. Steam line directly above simulated heat load heat exchanger, 65 inches above floor level. JUNO meter survey.

10) Main Steam Line. Steam line four feet east of turbine control panel, 65 inches above floor level. JUNO meter survey.

11) Middle, Turbine Control Panel. Center of turbine control panel, 44 inches above floor level. JUNO meter survey.

12) Turbine Casing. East side of turbine cover, 50 inches above floor level. JUNO meter survey.

13) Main Steam Line, By Exit Light. Main steam line, overhead, above emergency exit door, near exit light, 90 inches above floor level. JUNO meter survey.

14) Purification Panel. Purification panel, north edge of reactor shield, below schematic diagram of system, 60 inches above floor level. JUNO meter survey.

15) Resin Vault. Behind purification panel. Floor level on vault shield plug. Maximum reading. JUNO meter survey.

16) Feedwater Filter. Behind purification panel, west end, 16 inches above floor level. JUNO meter survey.

17) Main Steam Line, Behind Panel. Steam line behind purification panel, against outer wall, 56 inches above floor level. JUNO meter survey.

18) Air Ejector Flow Meter. Between Feedwater Pump No. 2 and main cargo door, six (6) feet above floor level. JUNO meter survey.

19) Reactor Top, Center. Average reading around and over top shield plug. JUNO meter survey.

2. Survey by Reactor Operations Personnel

Reactor operating personnel are required to make routine radiation surveys in the absence of Health Physics personnel. Since Health Physics coverage is provided normally only on the day shift, Monday through Friday, shift personnel will be required to perform radiation survey work of a limited nature during periods of power operation.

A form has been prepared for operator use. This is the Operator's Survey Log Sheet (see Exhibit 6, p. 64).

Points covered on this survey are:

a. Reactor Shield Blocks
b. Simulated Heat Load Heat Exchanger
c. Turbine Panel
d. Purification Panel
e. Entrance, Operating Floor

Operators will be required to perform this survey at least twice on each operating shift (when no Health Physics personnel is present).

C. Methods

The Geiger-Mueller counter portable survey meter is used for areas and points in which the radiation level is below 1 mr/hr. The low-range JUNO portable survey meter is used for areas and points in which the radiation level is in excess of 1 mr/hr (note: ideally, the same survey meter should be used for the entire survey; however, the survey meters currently available are limited in their ranges of sensitivity. Neither the Geiger-Mueller counter nor the JUNO is capable of spanning the wide range between the minimum and maximum values encountered in a typical survey. It is possible, however, to use the same set of survey meters for a series of surveys).

Routine surveys should be supplemented by "search" surveys of the entire area. This is best done with a G-M survey meter equipped with a headset for aural indication of radiation intensities. Any "hot" spots detected in search surveys should be thoroughly investigated and the cause corrected where possible.

D. Nonroutine Surveys

The Health Physics section will be required to make surveys as requested by operating personnel. The equipment and techniques used in such surveys will be as required by the conditions of the situation. Such surveys will be listed in the Health Physics Log Book as Special Surveys.

The Health Physicist and/or the Health Physics technician(s) will be responsible for performing special surveys as soon as possible following receipt of verbal or written requests for such surveys. Results of special surveys will be recorded in the Health Physics Log Book and pertinent information concerning the results of the special surveys will be conveyed to the requestor as soon as possible.

When unusual, hazardous, or potentially hazardous, conditions are discovered in the performance of either routine or special surveys, such information, together with appropriate recommendations, should immediately be brought to the attention of the reactor operating shift supervisor.

Exhibit 5

ROUTINE SURVEY LOG SHEET DATE: ____________________

HEALTH PHYSICS SURVEYOR: ____________________

TIME			
POWER LEVEL			
1. CONTROL ROOM			
2. LOWER LANDING			
3. BETWEEN LOWER AND MIDDLE LANDING			
4. MIDDLE LANDING			
5. DOORWAY, CHEST HEIGHT			
6. AVERAGE AROUND SHIELD BLOCKS			
7. HOT WELL			
8. SIMULATED HEAT LOAD HEAT EXCHANGER			
9. AUXILIARY STEAM LINE			
10. MAIN STEAM LINE			
11. MIDDLE, TURBINE CONTROL PANEL			
12. TURBINE CASING			
13. MAIN STEAM, BY EXIT LIGHT			
14. PURIFICATION PANEL, FRONT			
15. RESIN VAULT COVER			
16. FEEDWATER FILTER			
17. MAIN STEAM LINE, BEHIND PURIF. PANEL			
18. AIR EJECTOR FLOW METER			
19. REACTOR TOP, CENTER			

COMMENTS:

Exhibit 6

OPERATOR'S SURVEY LOG SHEET

DATE: ____________________

SHIFT: ____________________

SURVEYOR: __________________

INSTRUCTIONS: This survey is to be made at least twice during each operating shift. The shift supervisor is responsible for assuring that the survey is performed. The "JUNO" survey meter ("White Face" or Low Range Model) will be used. Meters will be found on the operating floor or in the Health Physics Office.

TIME				
REACTOR SHIELD BLOCKS				
SIMULATED HEAT LOAD HEAT EXCHANGER				
TURBINE PANEL				
PURIFICATION PANEL				
ENTRANCE, OPERATING FLOOR				
POWER LEVEL (Mw)				

ALL READINGS IN MILLIROENTGENS PER HOUR

COMMENTS:

NO. 8 - STANDARD OPERATING PROCEDURE FOR AIR SAMPLING

A. The Constant Air Monitor

1. General

The unit used for measurement at ALPR is the Nuclear Measurements Corporation Model AM-2A. The electronics chassis contains a count rate meter, automatic range changing mechanism, alarm system, and low and high-voltage power supplies. Continuous chart recording is provided with an Esterline Angus Recorder. Air is drawn through a filter paper cylinder, collecting atmospheric dusts on the surface of the filter. The filter is viewed by a cylindrical, metal-wall, halogen-quenched Geiger-Mueller tube. The filter and detector assembly is shielded from background radiation within a thick-walled iron cylinder. Air is drawn through the filter by a unit consisting of a rotary-positive-displacement blower powered by a 1/2-hp electric motor. Motor and blower are mounted in such a manner that blower speed is variable and motor speed is constant. Air flow is measured by a "Magnehelic" gauge. The unit operates on 110 volts ac, is self-contained, weighs 450 pounds, and is 36 inches high, 16 inches wide, and 36 inches long.

2. Preventive Maintenance:

The following procedure should be followed once monthly:

a. Shut off motor.

b. Remove top oil-fill plug from blower.

c. Open lower petcock on blower.

d. Add 30W (SAE) motor oil through top oil-fill hole until oil flows out of petcock.

e. Wait until oil flow stops.

f. Close petcock; replace top oil-fill plug.

g. Restart unit.

3. Repair

Repair and electronic maintenance are the responsibility of the Electronics Section.

4. Operation

The unit will be kept in operation at all times.

5. Operating Procedure

a. Check to assure that the unit is ready for operation. Be sure that a filter has been installed (for installation see paragraph 6, below). Sixty-cycle test switch should be off. A chart should be in place (see paragraph 7, below).

b. Turn on main power switch. Wait thirty seconds.

c. Turn on high-voltage switch.

d. Motor should be running. If not, open top of monitor, turn on toggle switch at right rear of case.

e. Adjust blower speed by turning knob below motor. Turn knob until air flow gauge reads two inches of water. This corresponds to an air flow of 4.8 cfm.

f. The panel meter has two adjustable contacts, one for the low end of the scale, the other for the high end. These affect the automatic range-changing mechanism. Considering the meter face to read from 0 to 10, set the low-end contact at 0.5 and the high-end contact at 9.0.

g. Three lights set close together on the front panel of the instrument indicate the range on which the instrument is operating. If the radiation level is low, the meter indicator will touch the low-end contact. This should cause the automatic range-changing mechanism to cycle downward. The cycle of indicator lights is red, amber, white, red, amber, white, etc. When the white light comes on, move the low-end contact below the zero point. This will stop the cycle and the count rate meter will stay on the low range until the radiation level rises above 9.0 on the meter face. If the meter indicator shows a steady level above 1.0, move the low-end contact to 0.5. This contact should not be positioned above this point.

The unit will normally be operated on the main floor of the reactor building.

6. Filter Change

Filters will be changed once weekly except when air concentrations are high enough to require more frequent changes.

Filter change procedure:

a. Turn off motor-blower unit.

b. Open shield by unscrewing hand wheel; pull access door open.

c. Pull out filter holder.

d. Remove old filter.

e. Cut new filter from stock of HV-70 filter paper, size 3 x 5-1/2 inches.

f. Wrap new filter around filter holder; hold in place with rubber bands at each end.

g. Insert filter unit in shield; start motor.

7. Chart Change

The chart used in the recorder is the Esterline-Angus Record Chart No. 4305-C. Chart speed is three inches per hour. Each chart roll will run for fourteen days, making chart change necessary once every two weeks.

Chart-change procedure is not complicated but it is best learned by observation and practice. Any electronics technician or reactor operator should be able to demonstrate the correct procedure for changing charts.

8. 60-cycle Test

Once each day, the CAM should be checked for correct operation. The procedure is as follows:

a. Turn on 60-cycle test switch. Count rate meter indicator should rise to the 3,600-cpm point on the 10,000-cpm scale. The warning bell should ring for about 15 seconds and the amber light should flash continually.

b. Turn off 60-cycle test switch. Count rate meter indicator should drop to almost zero on the 10,000-cpm scale. After an interval of from one to three minutes, the automatic range-changing mechanism should downshift to the 2,000-cpm scale and the amber light should stop flashing.

c. After completion of 60-cycle test, mark the date and time on the chart record.

NOTE: During reactor operation, the CAM will normally operate on the 10,000-cpm scale and the amber flashing light will be on continually. In this case the changing mechanism will not downshift to the 2,000-cpm scale after the 60-cycle test.

9. Alarm System

The three ranges of the CAM are designed to function on three levels of sensitivity. The low range is sensitive to airborne radioactive contamination of relatively safe, low concentrations. The intermediate range is sensitive to airborne radioactivity bordering on the maximum permissible concentrations. The high range is sensitive to levels in excess of maximum permissible concentrations. The bell alarm system is tied to the control room signal panel board.

a. Low range: 0-2,000 cpm. Small white indicator lamp on front panel is lit.

b. Intermediate range: 0-10,000 cpm. Small amber indicator lamp on front panel is lit. Large amber light on top of the unit flashes at intervals of approximately one second. When the unit first switches to this range, the alarm bell rings for approximately fifteen seconds.

c. High range: 0-20,000 cpm. Small red lamp on front of panel is lit. Large red lamp on top of unit flashes at intervals of approximately one second. Alarm bell rings continually.

B. "Spot" Air Sampling

1. General

The air sampler used at ALPR is the "Hi-Vol" sampler made by the Staplex Co. This is a light weight, hand-portable unit operating on 110 volts ac. The motor operates at approximately 18,000 rpm and its speed is not adjustable. Air is drawn through a four-inch diameter filter located at one end of the unit. Filters must be removed from the unit for analysis.

2. Preventive Maintenance

No preventive maintenance is required.

3. Repair

Facilities for repair of this unit are not available at ALPR or on the NRTS. Units must be returned to the manufacturer for repair and parts replacement.

4. Operation

The Hi-Vol sampler is used to supplement air monitoring by the Constant Air Monitor (Model AM-2A). Operational procedure is as follows:

a. Carry unit to desired sampling area; plug into 110-volt ac line.

b. Unscrew filter-holder cap. Hold sampler vertical; align filter support spider.

c. The filter to be used for most sampling is the TFA #41, a thin paper filter, four inches in diameter. Place the filter over the support spider, tighten filter-holder cap, making sure that the filter is firmly supported.

d. Place sampler in position. Unit must be horizontal and the intake and exhaust ports must have a minimum of three inches of clearance from any other object. Unit may be placed on the floor or on any horizontal surface, or may be suspended by its handle.
<u>CAUTION</u>: The unit has considerable starting torque. Make sure that the unit is in a safe position or is firmly supported during start. Turn on line switch.

e. Make a note of the air flow as shown by the indicator at the rear of the unit. A unit in good condition will draw 15 to 20 cfm of air through the TFA #41 filter.
<u>CAUTION</u>: This unit, when used with the TFA #41 filter, should not be operated continuously for more than one hour. Operation in excess of one hour will cause overheating, with probable damage to bearings and brushes.

f. Samples taken with this unit must be counted for radioactivity content with laboratory type counters. For details, see Standard Operating Procedure No. 13 on sample counting.

NO. 9 - STANDARD OPERATING PROCEDURE FOR DECONTAMINATION

A. General

All materials, equipment, or areas that become contaminated with radioactive materials, either by accidental means or by intent, must be decontaminated to prevent spread of radioactive materials to clean areas. For purposes of this discussion decontamination is divided into three sections: tools and equipment, permanent surfaces (floors, wall, etc.), and personnel.

B. Tools and Equipment

All tools and equipment will be surveyed by Health Physics on a routine basis. All tools and equipment used in contaminated or potentially contaminated areas must be surveyed by Health Physics prior to their release to other areas. If, in either of the above instances, contamination is found, decontamination shall proceed as follows:

1. Set up a temporary decontamination station under the direction of Health Physics,which shall include (a) floor covering of either plastic or blotter paper, (b) containers for liquid decontaminant, (c) containers for disposable material, (d) an adequate supply of protective clothing with hampers or containers for used clothing.

2. Small hand tools may be decontaminated by immersion into a container containing an available degreasing agent. In many cases, these tools should be scrubbed with a small hand brush which is available. After rinsing and drying, tools may then be surveyed and released if decontamination is successful. For larger tools and major pieces of equipment which cannot be immersed in the containers of liquid, adequate decontamination may be obtained by scrubbing and degreasing.

3. At the completion of decontamination all equipment must be surveyed before release. All contaminated liquids and materials used for decontamination must be disposed of as active waste. This will be done under the direction of Health Physics.

C. Permanent Surfaces, Floors, Walls, Etc.

For routine reactor operation the allowable smearable contamination of floors, walls, and other permanent surfaces shall not exceed 1,000 dpm beta-gamma/square foot. If the level of smearable contamination exceeds 1,000 dpm/square foot, decontamination shall proceed as follows:

A temporary danger zone shall be established. An area shall be roped off and tagged to eliminate the use of the area by personnel while decontamination is in progress. Decontamination can be effected most easily by normal scrubbing with a strong solution of detergent (such as Tide) which is available in the Health Physics office. It is recommended that two containers be supplied, one with the detergent solution and another with the rinse water. Mops, either rag type or sponge mops, both of which are in stock shall be used for this operation. Scrub-down operations shall be performed in a normal manner, except that caution shall be exercised to start scrubbing at the outer extremities of the area, working inward. Personnel performing the operation shall be equipped with plastic shoe covers or rubber boots and rubber gloves. If, after scrubbing and rinsing, surveys indicate that the decontamination was not successful, the above procedure should be repeated until contamination is no longer measurable. If it appears that decontamination with the detergent solution will not be successful, additional solvents or degreasing agents may be recommended. In some cases of low-level contamination not removable by ordinary means, it is permissible to fix the contamination to the surface. This may be done by painting, masking tape or other means. If the contaminant is in the form of dust or small dry fragments, the use of a vacuum cleaner reserved for purposes of decontamination is recommended. This machine is available at all times from the Health Physicist.

D. Personnel

If contamination of the hands, feet, clothing, shoes, or of any part of the body is detected the individual concerned should in all cases alert the Health Physicist. If the activity of the material is of a low level, and contamination is to the hands only, this can most easily be removed by washing with soap and water. If this method is not successful, it is recommended that a strong detergent be used. If it appears that neither of these methods are successful, the Health Physicist will recommend various chemical solutions to be used and will assist in decontamination.

If contamination is detected on the shoes or feet, it is recommended that the individual concerned remain at his location until assistance can be provided. If, when working in an area of known airborne or removable contamination, the individual becomes totally contaminated, it is recommended that clothing change be effected at the location. Caution should be exercised in removing outer clothing so that the materials do not come in contact with the body. In cases of this nature, Health Physics assistance should be requested. At the completion of clothing removal, it is recommended that the individual shower, put on clean clothing, and be surveyed by Health Physics prior to returning to normal duties. Standard operation procedure shall include hand-and-foot checking with a portable survey meter upon leaving the reactor operating area and the mandatory use of the hand-foot monitor located between the control room and the shop area.

NO. 10 - STANDARD OPERATING PROCEDURE FOR URINE SAMPLES

Personnel working with or near radioactive material may frequently be exposed to airborne radioactive contamination, resulting in ingestion of this and other active material.

Biologically, the human body eliminates much of this material along with body wastes. One of the best methods to determine the body concentration of active material and the dose received is by urine samples.

The ALPR urinalysis program is on a routine basis but is subject to change if necessary.

Arrangements have been made with AEC Medical to take urine samples on all new employees. These samples are processed by AEC Chemical Laboratory and results forwarded to the operating contractor. Background samples of all military personnel now working at ALPR have been taken and results are on file in the ALPR Health Physics Office.

Routinely the Health Physicist will schedule urine samples as follows:

1. Post on Bulletin Board names of all scheduled personnel.
2. Procure from AEC Health and Safety Chemical Laboratory, Telephone: Ext. 2263, one or two boxes of sample bottles.
3. Using Labelon tape, identify each bottle with person's name.
4. Place bottles in Locker Room.
5. Collect filled bottles, fill in Form ID-104 in triplicate and send bottle and form to AEC Chemical Laboratory CF 646.
6. Post results of analysis in Health Physics Log and file completed sample record sheet in permanent file.

Routine urinalysis will be done every six months. Nonroutine samples will be done, in the same manner upon request or if deemed necessary, by Health Physics.

ID 104
(R 1 55)

U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH AND SAFETY BRANCH

ROUTINE__ **SPECIAL** ___

IDO H & S SAMPLE RECORD SHEET

Serial No.________________

Sample from: ________________

Collected by ________________

Date submitted ________________

Samples Received ________________

Analysis Completed ________________

Analyzed by ________________

Method End Window__, Prop counter__, Spectrophotometric__, Fluorometric__, Polarographic__

Sample No	Date	Hour	Sample Description	Anal for	Quant used, ml	U^{+6} or K^{+} Trans	Count time, min	Total Count	Gross Count, c/m	Bkgd, c/m	Net count, c/m	K^{40} corr, c/m.	Foreign activity	
													c/m	d/m

Notified ________________ Time ________________

Resampling recommended Yes____ No____

Approved ________________
Chief, Analysis Section

Exhibit 7

NO. 11 - STANDARD OPERATING PROCEDURE FOR PERSONNEL SAFETY

A. General Instructions

1. Health Physics Responsibilities

The safety program at ALPR is the responsibility of the operating contractor's Health Physicist. The Health Physicist will be responsible for implementing a program of regular inspections to assure the safety of plant personnel. This program should consist of regular plant inspections, thorough investigations of any and all accidents, investigations of employee complaints or suggestions concerning personnel or plant safety, and orientation of all assigned personnel in good safety practices and regulations.

Safety equipment will be procured by the Health Physicist through the regular purchasing channels and will be distributed according to needs. The Health Physicist will at all times maintain a limited stock of such expendable safety equipment items as: plastic goggles or safety glasses; hard hats; rubber, neoprene, and leather gloves; face shields; dust respirators; and other equipment of like nature.

Nonexpendable safety equipment such as self-contained air supply systems (Scott Air Paks), fire extinguishers and First Aid kits will be procured, installed, and maintained by the Health Physicist and will be kept in areas accessible to all personnel.

The Health Physicist will be responsible for the procurement and installation of safety warning signs and markers denoting potentially hazardous conditions.

2. Individual Responsibilities

Each individual worker is expected to do his part in helping to make the plant a safe place in which to work. He is expected to follow the recommendations of the Health Physicist, to perform his job in a manner consistent with good safety practices, and to notify the Health Physicist and/or his fellow workers if he notices or believes a particular operation or job to be potentially hazardous.

The individual and the Health Physicist must work as a team if the ultimate in good safety practices is to be achieved. Safety rules laid out by the Health Physicist should not be so onerous as to invoke resentment on the part of the workers. Conversely, laxity in the enforcement of safety rules leads to a high accident rate. The individual should feel that he is a part of a cooperative effort.

No individual should work alone in isolated areas or in potentially hazardous areas. This applies equally to work on electrical systems, moving machinery, areas of poor ventilation or where toxic materials or gases might be present, or where there is a possibility of falling from a height.

B. Safety Rules

1. Mechanical Safety Rules

Defective or makeshift tools should never be used. In most cases, defective tools should be discarded. Items like screwdrivers with badly worn or broken tips, hammers with chipped or scarred heads, pliers with bent handles or worn jaws, saws with broken teeth, unbalanced or chipped grinding wheels, and worn or distorted wrenches should be replaced, since repair of such items is seldom satisfactory and costs more, in terms of time and inconvenience, than replacement with new tools. One exception to this rule would apply where replacement of a part of a tool would restore the tool to its original condition. An example of this would be replacement of a wooden hammer handle.

When using grinding wheels or when doing any type of work in which fragments could strike the eye, as in chipping concrete, for example, safety goggles are required. One pair of safety goggles is kept on a rack above the grinding machine at all times. A supply of goggles is maintained in the Health Physics office.

2. Electrical Safety Rules

Repair of maintenance work on "live" or "hot" electrical power circuits is forbidden. When performing work on electrically powered equipment, be sure that the power switches for the equipment are "OFF" and tagged with "lock-out" tags to prevent someone from inadvertently energizing the circuit. The person who places such tags on switches must sign his name with the time and date at the time of placing the tag. When the job is completed, all tags must be removed without delay by the person whose signature appears on the tag. All personnel are cautioned to adhere strictly to the conditions marked on the tag and should never, under any cicumstances, move the switch.

Many accidents and near-accidents have occurred through violation of lock-out tags. Personnel are warned that severe action may be taken against anyone who violates or misuses a lock-out tag.

Personnel working with electrical gear are cautioned against using makeshift equipment, jumpers, oversize fuses, or deliberately overloading circuits and equipment. All 110-volt ac outlets in the area are of a three-wire, grounding type, and all portable electrical gear and/or tools should be equipped with standard three-conductor line cords. Exposed conducting portions of such gear should be grounded, through the proper line cord conductor.

Any item of electrical equipment which fails, overheats, arcs excessively, or in any other way acts abnormally, should be inspected and either repaired before being used again or discarded.

All electrical line cords should be inspected by the personnel using the equipment, and should be replaced at the first sign of wear or abuse. All line cord connectors should be examined regularly and either repaired or replaced if defective in any way.

3. Materials Handling

The handling of materials involves more than the mere transfer of an item from one location to another. Correct handling techniques enable the job to be done with a minimum of effort and time and with a maximum of safety.

Perhaps the most important single thing in materials handling is to know the limitations of equipment. This applies both to "muscle power" and to mechanical equipment. One should not hesitate to call for help if the object is too large or too heavy to handle individually. When two or more persons are carrying an object they should decide beforehand how it is to be carried and check the route and clearances to be followed.

4. Housekeeping

A clean place to work is necessary for safety. Materials and other equipment should be kept out of aisles and returned to their proper storage place after use. A serious accident may be prevented if tripping hazards, such as nails, pieces of wire and scraps, are picked up.

Many falls occur because oil, water or other liquids have been spilled upon the floor. Protect others by cleaning the spills immediately.

Oily rags should be placed in the covered metal containers provided.

5. Fire Protection

a. Fire Alarms

The ALPR Fire Alarm System is an automatic system installed by ADT and recording in the Central Facilities Fire Station. The detection devices are preset to trip at 165°F, with the exception of the fan loft device which is set to trip at 225°F.

The alarm is signalled by an audible gong than can easily be heard throughout the building and the signals are coded to give the location of the alarm.

There is some history of false alarms. This does not lessen the responsibility to investigate any alarm that might sound. Investigation should be made by both ALPR personnel and the AEC Fire Department. If it is known to be a false alarm, a responsible person at the ALPR should notify the Fire Department, Telephone: Ext. 2212, thus saving an emergency trip.

In addition to the automatic detection devices, an alarm may be sent from any of the alarm boxes. Instructions are on each alarm box.

b. Fire Extinguishers

All fire extinguishers at the ALPR are CO_2 extinguishers. These may be used on any type of fire. Instructions for use are on the individual extinguishers. Inspection of the extinguishers is made once each month by the AEC Fire Department. Listed on the individual extinguishers is the charged weight. If at any time an extinguisher is less than fully charged, it should be delivered to the Fire Department, where it will be filled.

6. Respiratory Protection

The respiratory hazards encountered at the ALPR may be both of an industrial nature and of a radiological nature. Hazards of an industrial nature will include dusts, fumes, smoke and gases that normally occur in an industrial plant. These are somewhat limited but in many cases respiratory protection could be needed.

Respiratory hazards of a radiological nature can be due to any of the above-mentioned items that are contaminated with radioactive material. Respiratory protection for either condition, depending upon the seriousness, may be gained by using one of the following:

a. Self-contained Fresh Air Supply Masks

This type is used when the air supply is limited or when the available air supply is contaminated beyond safe breathing limits. The mask is a "Scott Air Pak" having a full face mask and strap-on bottle of breathing air. Under normal working conditions the air supply is good for approximately thirty minutes. A new air-supply bottle can be attached in a matter of minutes. Air-supply bottles may be recharged at the AEC Fire Station. It is recommended that frequent drills in the use of this equipment be held so that all personnel are familiar with its use.

b. Filter Masks

These are used for all general industrial dusts that may be encountered from sawing, sanding, chipping etc. and for certain radiological conditions where low-level contaminated particulate material is encountered. The masks are equipped with a disposable filter that is easily replaced. In all cases where respiratory protection is needed, it shall be the responsibility of the Health Physicist to determine the type to be used and to supply same.

NO. 12 - STANDARD OPERATING PROCEDURE FOR TREATMENT OF INJURIES

A. General:

Despite safe work habits, injuries, both minor and major in nature, can be expected to occur.

Minor injuries considered are of two types:

1. Injuries occurring in contaminated areas.
2. Injuries occurring in clean areas.

If an injury occurs in a contaminated area, the injured should:

1. Force bleeding on cuts and open wounds, thus keeping contamination from entering the blood stream.
2. Call or report immediately to Health Physics for survey.

The Health Physicist shall:

1. Make complete survey of wound and surrounding skin surface.
2. Decontaminate if injury is such that time allows.
3. If injured is contaminated and sent to CF First Aid, advise Doctor or nurse on duty of the condition.

B. Noncontaminated Injuries:

Minor injuries received in nonactive areas shall be treated as follows:

1. Proceed to the First Aid kit located in the Health Physics office and apply first aid.
2. Report injury to his supervisor. If, in the opinion of the supervisor, further treatment is needed, he shall send the injured directly to CF 603 (AEC First Aid) or make arrangements with the Health Physicist to do so.

C. Major Injuries

Major injuries should be referred immediately to the AEC Physician at CF 603, Telephone: Ext. 2356. The Physician is on duty 8:00 a.m. to 4:00 p.m., with registered nurses on duty at all times.

Ambulance service is available on a 24-hour call by telephoning Ext. 2356, 2212, or "O" (Operator).

In requesting ambulance and/or nurse, give all pertinent information such as location, type of injury, severity, and type of service required.

NO. 13 - STANDARD OPERATING PROCEDURE FOR SAMPLE COUNTING

A. General

The Health Physics Section is equipped with laboratory-type radiation-detection equipment for quantitative radioactivity analysis of certain sample materials. The items of prime concern are air samples (samples of atmospheric particulates taken by drawing air through a high-efficiency paper filter), smear samples (samples of removable or "loose" contamination taken by wiping or "smearing" a surface area with a circle of filter paper) and gas samples (samples of air taken with an evacuated cylinder so as to contain gases which would be passed by a filter). Water sample analysis is done by AEC-IDO Health and Safety.

Covered in this Standard Operating Procedure are specific methods and procedures used at ALPR for background and yield (geometry or efficiency) determination, sample collection, and sample counting and evaluation for air and gas samples.

The procedures outlined are simplified for use by field personnel, since it is anticipated that personnel assigned by the Department of Defense will have only a rudimentary background in Health Physics. Items such as resolution loss, coincidence, self-absorption, backscatter, and probability are not specifically covered. Elimination of these correction factors will, in most cases, limit absolute counting accuracy to ± 20%. Since the limits set up by Health Physics are conservative, this degree of accuracy is considered to be acceptable.

B. Equipment

Sample-counting equipment of the ALPR Health Physics section includes the following:

One (1) Nuclear Measurements Corporation Model PC-1A Proportional Counter. This is a windowless, preflush gas flow counter using a 90% argon - 10% methane gas mixture. It has a binary scaler unit with scaling factors of 8, 16, 32, 64, 128, 256, and 512. The counting chamber is an integral part of the unit. A preset timer is built into the unit.

Two (2) Radiation Instrument Development Laboratory Model 206 decimal scalers. Each unit features a built-in preset timer and an optional preset count circuit. The scaling factor is 10 000. Provision is made for external connection of a variety of counting devices, including Geiger-Mueller, proportional, and scintillation detectors. The unit supplies counter voltage up to 5,000 volts. Gain settings are variable and there is an adjustable pulse-height descriminator. At present, the scalers are used with a mica end-window Geiger-Mueller tube.

C. Calibration and Background Determination

Calibration and background determination for each scaling unit is accomplished daily, Monday through Friday, for each counting device in regular use. Procedures are given below for each item of equipment.

1. PC-1A

The PC-1A may be used for counting alpha radiations at one voltage setting and beta-gamma radiations at another voltage setting. Typical voltage settings are: alpha - 1,100 volts; beta-gamma - 1,750 volts.

Average efficiency or yield is as follows:

Alpha: 51%

Beta-Gamma: 55-75%

Average background count is as follows:

Alpha: 1 count per hour

Beta-Gamma: 100 counts per minute.

Any large deviation from the above values indicates either chamber contamination or electronic troubles and should be investigated by competent personnel.

The daily procedure for background and yield counting is given below:

(1) If the counter has been turned "OFF," turn the master switch "ON." Allow a minimum of five (5) minutes for warm-up. If counter is normally left "ON," proceed immediately to step 2.

(2) Open main gas-cylinder valve. Pressure-adjustment valve should not be moved. (The exception to this rule applies only when the equipment has been out of service for repairs. In this case, see the instrument manual for instructions).

(3) Turn high-voltage switch "ON." Adjust high voltage to correct setting marked on meter face. (If the operator is not familiar with the equipment, the settings of 1,100 volts for alpha or 1,750 volts for beta-gamma detection will produce satisfactory results on any PC-1A counter in good operating condition.) Normal procedure at ALPR is to count beta-gamma first, alpha radiation last.

(4) Turn sample drawer knob counterclockwise to release lock; withdraw sample drawer. Remove any sample which may be present; wipe sample tray. Close drawer gently; turn knob clockwise 180° to locked position.

(5) Turn purge selector switch to the "100" setting and press the reset lever. Interpolation lights and mechanical register will clear and gas-purge cycle will begin. Wait approximately two (2) minutes or until purge stops.

(6) Turn dial of preset timer to the thirty (30)-minute position. Depress "ON-OFF" switch on timer to start counting.

(7) At end of count time, record reading on the "Background and Yield Log Sheet" (Exhibit 8, p. 92). Calculate background in terms of counts per minute.

(8) Release sample drawer lock, pull out sample drawer, place appropriate radiation standard on sample tray or pedestal, gently close drawer, and lock in place.

(9) Purge as in step 5, above.

(10) Turn dial of preset timer to the one (1)-minute position. Turn switch "ON."

(11) At end of count time, record reading on the "Background and Yield Log Sheet."

(12) Yield Calculation.

a. Subtract background from count obtained in Step 11. This gives net counts per minute.

b. Each radiation calibration standard is calibrated in disintegrations per minute. Divide net counts per minute by disintegrations per minute and multiply by 100 to obtain per cent yield (also called "efficiency" or "geometry").

Example:

Background: 95 cpm

Gross Count: 34,859 cpm

Standard: 62,150 dpm

Gross count - background = Net Count

34,859 - 95 = 34,764 cpm

$$\text{Yield} = \frac{\text{Net cpm}}{\text{Standard dpm}} \quad \text{x}100$$

$$\text{Yield} = \frac{34,764 \times 100}{62,150} = 55.8\%$$

$= 56\%$ (to two (2) significant figures)

(13) If steps 1 through 12 were carried out for beta-gamma radiation, repeat for alpha, using the lower voltage setting. If alpha count was done first, repeat for beta-gamma, using the higher voltage setting.

2. RIDL Model 206 Scaler with Mica End-window GM Tube in Lead Pig

The end-window GM tube is used in counting beta-gamma radiations. The lead pig or shield serves to reduce counter-tube background.

Operating characteristics of the counter tube are approximately as follows:

Operating Voltage: 1,000 to 1,100 volts

Efficiency or Yield: 4%

Background: 15 to 20 cpm.

The daily procedure for background and yield counting is as follows:

(1) If the counter has been turned "OFF," turn the power switch to "ON" (Note: Make sure that the high-voltage switch is "OFF" before turning on power.) If the counter is normally left "ON," proceed immediately to Step 2.

(2) Open door of pig, remove any sample which may be present, and wipe cavity clean with tissue paper. Close door.

(3) Turn high-voltage switch (marked "H.V. Adj. Coarse") to position "1." Turn high-voltage fine control (marked "H.V. Adj. Fine") to correct voltage (marked on face of high-voltage meter). (If the operator is not familiar with the equipment, use a voltage setting of 1,000 volts.)

(4) Turn dial of preset timer to 30-minute position. Depress "ON-OFF" switch on timer to start counting.

(5) At the end of the count time, record the reading on the "Background and Yield Log Sheet." Calculate background in terms of counts per minute.

(6) Open pig door, place beta-gamma radiation standard on shelf No. 2, directly below the end of the GM tube (approximately one (1) inch below tube end). Close pig door.

(7) Reset or clear counter and turn dial of preset timer to the one (1)-minute position. Turn switch "ON."

(8) At end of count time, record the reading on the "Background and Yield Log Sheet."

(9) Yield Calculation:

a. Subtract background from count obtained in Step 8. This gives net counts per minute.

b. Each radiation calibration standard is calibrated in disintegrations per minute. Divide net counts per minute by disintegrations per minute and multiply by 100 to obtain per cent yield or efficiency.

Example:

Background: 18 cpm

Gross Count: 2,472 cpm

Standard: 62,150 dpm

Gross count - Background = Net count

2,472 - 16 = 2,456 cpm

$$\text{Yield} = \frac{\text{Net cpm}}{\text{Standard dpm}} \times 100$$

$$\text{Yield} = \frac{2,456 \times 100}{62,150} = 3.96\% \text{ or } 4\%$$

(Note: Yield values are normally computed to two (2) significant figures.)

D. Air Sample Counting: PC-1A

1. Sample Preparation

a. Collect sample. Use the Staplex Hi-Vol sampler unit with a Staplex TFA #41 filter paper. Record filter data to include location, date, time ON, time OFF, flow rate in cfm.

b. Cut a two (2)-inch diameter circle from the filter sample (to fit the PC-1A chamber). Area is one-fourth of the area of the whole filter, making the sample volume to be counted one-fourth of the whole sample.

2. Sample Counting

   a. Insert two (2)-inch diameter sample into counting chamber; lock chamber, purge chamber, and clear register and interpolation lights. Wait until purge cycle is complete.

   b. Select counting time to allow a minimum of 500 counts or a maximum of five (5) minutes of counting time, whichever occurs first.

   c. Record count data on the AIR SAMPLE DATA SHEET (Exhibit 9, p. 93).

   d. Several counts should be made on each sample. It is recommended that counts be made (1) as soon as possible after sample collection, (2) one hour, (3) four hours, (4) 24 hours after sample collection. Counts may be discontinued when dpm/m^3 is less than 200 dpm/m^3.

3. Computation for Air Sample Data Sheet

   a. Use a new sheet for each sample. Record counter type and number, date, time sample ON, time sample OFF, total collection time in minutes for sample, and sampler flow rate. Compute sample volume in both cubic feet and cubic meters (1 cubic meter = 35.3 cubic feet). Under SAMPLE INFORMATION, enter reason, place, and any other pertinent information. If 2 in. diameter sample is used, remember that sample volume is one-fourth of entire sample.

   b. Count first for total alpha-beta-gamma (see part C of this Standard Operating Procedure for setting counter for alpha-beta-gamma or alpha alone). Follow "C" through "k" for alpha-beta-gamma, then change setting and repeat for alpha only.

   c. For each count record date, time count was started, total minutes counted, and total gross count.

   d. Divide gross count by minutes counted to obtain counts per minute (cpm).

   e. Enter background (see part C of this Standard Operating Procedure).

   f. Subtract background from gross cpm to obtain net counts per minute (NET cpm).

   g. Enter yield (see part C of this Standard Operating Procedure).

   h. Divide NET cpm by yield to obtain dpm (disintegrations per minute).

i. Divide dpm by sample volume (in cubic meters) to obtain dpm/m^3 (disintegrations per minute per cubic meter).

j. Maximum permissible level (MPL) for beta-gamma-emitting, short half-life particulate air activity is 5×10^{-5} μc/ml or 1.1×10^7 dpm/m^3. (Note: Where decay time is less than 24 hours, use MPL = 1.1×10^8 dpm/m^3.) Divide sample dpm/m^3 by MPL dmp/m^3 and multiply by 100 to obtain percent of MPL. (Alpha MPL'S: short half life - 22,000 dpm/m^3; Long half life - 70 dpm/m^3; Pu^{239} - 18 dpm/m^3.)

k. Determine decay time. For Health Physics purposes, this is considered to be the time interval between the end of sample-collection time and the start of the sample count.

4. Decay Patterns for Air Samples (Applicable to PC-1A and End-window GM Counters)

a. Count rates in excess of 50,000 cpm are not reliable because of counter losses (i.e., apparent values are less than actual values). Where count rates are above 50,000 cpm wait until sufficient decay time has elapsed to drop the count rate below 50,000, take several counts at selected intervals, plot the results, and extrapolate back to the higher count rate.

b. When computing MPL values for short half-life activities, extrapolate back to zero decay time for proper evaluation of actual air-contamination conditions.

c. When computing MPL values for long half-life activities, extrapolate values to a minimum of one (1)-week decay time, or follow decay for several days to determine the values of long half-life contaminants.

d. A suggested pattern for following long half-life activities is as follows (elapsed time): Immediate; thirty (30) minutes; one (1) hour; four (4) hours; one (1) day; seven (7) days; one (1) month. If sample activity persists after thirty (30) days, discard sample after last count.

e. A suggested pattern for following short half-life activities is as follows (elapsed time): Immediate; one (1)-minute counts at intervals of two (2) minutes for the first thirty (30) minutes; one (1)-minute counts at intervals of ten (10) minutes for the first two (2) hours; hourly for the balance of the first eight (8) hours; one (1) day; seven (7) days; one (1) month. If sample activity persists after thirty (30) days, discard sample after last count.

f. Samples may be discarded after any count if the count rate is at background levels.

E. Air Sample Counting: End-window Geiger-Mueller Counter

1. Sample Preparation

Prepare sample as in part D1 for PC-1A counter.

2. Sample Location

The counter tube is mounted in the vertical iron pig. For low-level samples, use sample shelf No. 2, located about one inch below the tube face. For high-level samples, use sample shelves No. 3, 4, or 5, located below No. 2, to reduce yield. Close door.

3. Sample Counting

a. Clear scaler register and interpolation lights.

b. Select counting time to allow a minimum of 500 counts or a maximum of five (5) minutes of counting time, whichever occurs first.

c. Record count data on the AIR SAMPLE DATA SHEET.

4. Computation for Air Sample Data Sheet

Proceed as in Part D3 of this Standard Operating Procedure.

5. Decay Patterns for Air Samples

See part D4 of this Standard Operating Procedure.

F. Smear Sample Counting: PC-1A

1. Sample Preparation

a. Collect sample. Use a two (2)-inch diameter circle of Whatman filter paper. Smears may be taken dry or with solvents. Surface areas covered with a smear should be approximately one square foot. Handle smear samples carefully to prevent loss of material or cross-contamination from other sources.

b. Record smear data to include time, date, location, and reason.

c. If solvents were used, allow smear sample to dry thoroughly before counting.

2. Sample Counting

a. Insert sample into counting chamber, lock chamber, purge, and clear register and interpolation lights. Wait until purge cycle is complete.

b. Select counting time to allow a minimum of 500 counts or a maximum of five (5) minutes counting time, whichever occurs first.

c. Record data on the SMEAR SAMPLE DATA SHEET (see Exhibit 10, p. 94).

3. Computation for the Smear Sample Data Sheet

a. Several sample results may be entered on a single sheet. It is advisable to start a new sheet for each distinct group of samples (i.e., samples taken at the same time or in the same area).

b. Record counter type and number.

c. For each sample counted record location, number of minutes counted, and total gross count.

d. Divide total gross count by minutes counted to obtain gross cpm.

e. Enter background.

f. Subtract background to obtain NET cpm.

g. Enter yield.

h. Divide NET cpm by yield to obtain dpm/ft^2.

G. Smear Sample Counting: End-window Geiger-Mueller Counter

1. Sample Preparation

Prepare sample as in part F for PC-1A samples.

2. Sample Location for Counting

The counter tube is mounted in the vertical pig. For low-level samples, use sample shelf No. 2, located about one inch below the tube face. For high-level samples, use sample shelves No. 3, 4, or 5, located below No. 2, to reduce yield. Center the sample directly below the tube face. Close pig door before beginning.

3. Sample Counting

a. Clear register and interpolation lights.

b. Select counting time to allow a minimum of 500 counts or a maximum of five (5) minutes of counting time, whichever occurs first.

c. Record count data on the SMEAR SAMPLE DATA SHEET.

4. Computation for the Smear Sample Data Sheet

Proceed as in Part F3 of this Standard Operating Procedure.

5. Decay Patterns for Smear Samples

a. Decay of smear samples is not routinely observed.

b. In special cases, where it is desired to identify a contaminant by its decay pattern, take sample counts at intervals determined by observation of each sample (i.e., if sample appears to be decaying rapidly, take counts at close intervals of time; if sample appears to be decaying slowly, take counts at widely spaced intervals of time).

H. Gas Sample Counting

1. General

a. Under certain conditions, gaseous air contamination may be present in the reactor area. Sampling techniques for airborne particulate contamination do not retain such gases. Special techniques and equipment are required and are described below. Detection is limited to beta-gamma activity.

b. The gas sampler used at ALPR consists of a brass cylinder with an internal capacity of two (2) liters. A Victoreen Type 10B85 GM tube is mounted axially within the cylinder. A simple pressure-vacuum gauge, calibrated from 0 to 30 psi, and a brass tube, terminated with a Hoke valve, are mounted externally. A vacuum pump may be connected to the sampler through the valve with a rubber hose. To use the sampler, it is necessary to evacuate to a vacuum of -30 psig, carry the sampler to the desired location, open the Hoke valve to let air into the chamber, and return the sampler to the Health Physics Laboratory for counting.

c. In counting, the sampler is connected to the RIDL scaler input terminal. The sampler unit is uncalibrated. A similar unit of identical size and using the same type GM tube yielded 2 ± 0.2%, based on an argon-41 standard. A yield of 2% has been assumed for the ALPR sampler for lack of a better calibration factor.

2. Sample Preparation

a. Determine background of sampler prior to the taking of each sample. High backgrounds can sometimes be reduced by repeatedly evacuating the sampler.

b. Evacuate the sampler, carry to desired sampling point, open valve to collect sample, return to counting lab.

c. Record data to include location, date, time and reason. All gas samples will be assumed to have a volume of two (2) liters.

3. Sample Counting

a. Connect scaler leads to sampler terminals. Turn high voltage ON. Clear register and interpolation lights.

b. Select counting time to allow a minimum of 500 counts or a maximum of five (5) minutes counting time, whichever occurs first.

c. Record data on AIR SAMPLE DATA SHEET.

4. Computation for the Air Sample Data Sheet for Gas Samples

a. Use a separate sheet for each sample. Record counter type and number, date, time sample was collected, and sample volume (2 liters). Under SAMPLE INFORMATION, enter reason, place, and any other pertinent information.

b. For each count, record date, time count was started, total minutes counted, and total gross count.

c. Divide gross count by minutes counted to obtain counts per minute.

d. Enter background (determine prior to sample collection).

e. Subtract background from gross cpm to obtain net counts per minute (NET cpm).

f. Enter yield (assume 2%).

g. Divide NET cpm by yield to obtain dpm.

h. Divide dpm by sample volume in cubic meters (2 liters equals 0.002 m^3) to obtain dpm/m^3.

i. Maximum permissible level (MPL) for beta-gamma-emitting short half-life isotopes (both gaseous and particulate) associated with steam radioactivity in a boiling water reactor facility is 1.1×10^8 dpm/m^3. Divide sample dpm/m^3 by MPL dpm/m^3 and multiply by 100 to obtain percent of MPL.

j. Determine decay time. For Health Physics purposes, this is considered to be the time interval between the sample collection time and the start of the sample count.

5. Decay Pattern for Gas Samples

a. Samples taken directly from the air ejector system should be allowed to decay for at least thirty (30) minutes prior to beginning counting. This will allow the contaminant to decay to a level which can be counted without jamming the counter tube. Subsequent counts should be made at approximately 30-minute intervals for three to four hours in order to establish a decay curve. Scalar high voltage should be turned off between counts.

b. Samples of atmospheric activity taken under routine conditions can be counted immediately after collection. Counts should be taken at ten (10)-minute intervals for the first half-hour, at thirty (30)-minute intervals for the first three (3) hours, and as required if the count rate has not reached background levels after three hours.

c. A count rate in excess of 50,000 cpm is of little absolute value because of counter losses. It is preferable to allow time for decay, take several counts at a later time, and then plot the results and extrapolate back to the higher count rate.

Exhibit 8

SCALING COUNTER BACKGROUND AND YIELD

DATE	COUNTER	BACKGROUND			YIELD					
		MINUTES COUNTED	GROSS COUNT	NET CPM	MINUTES COUNTED	GROSS COUNT	GROSS CPM	BKGD	NET CPM	% YIELD

AIR SAMPLE DATA SHEET

DATE: ____________________ COUNTER: ____________________

TIME ON: ______ TIME OFF: ______ TOTAL TIME: ______ Minutes. FLOW RATE: ______ SAMPLE VOL: ______

SAMPLE INFORMATION ____

____

DATE	TIME ON	MIN CTD	TOTAL COUNT	c/m	BKGD	NET c/m	YLD	d/m	d/m/M^3	% MPL	DECAY TIME	

Exhibit 9

Exhibit 10

SMEAR SAMPLE DATA SHEET

Date:
Counter:

LOCATION	GROSS COUNT	MINUTES COUNTED	GROSS CPM	BKGD	NET CPM	YIELD	DPM/FT^2

No. 14 - STANDARD OPERATING PROCEDURE FOR RADIATION PROTECTION PRACTICES FOR OPERATING PERSONNEL

A. General

1. The Health Physics section is responsible for the radiation protection program at ALPR. The section functions in an advisory capacity. The contractor's Health Physics supervisor is responsible to the contractor's area supervisor. The Health Physics supervisor in turn exercises operational supervision over personnel assigned to duty with the Health Physics section. Where these personnel are enlisted men of the ALPR cadre, administrative supervision is provided through the Operations Officer of the ALPR Department of Defense cadre.

2. The operational philosophy of the Health Physics section is briefly outlined below:

   a. The section will implement a sound program providing for the maximum safety of all personnel.
   b. The section will operate in such a manner as to provide for a minimum of interference with operation of the ALPR facility.
   c. A certain level of personnel exposure must be accepted as a consequence of the most efficient mode of operation. The Health Physics section must be constantly on the alert to keep exposures to the practical minimum.
   d. The Health Physics section must establish and maintain an atmosphere of cooperation with all operating personnel.
   e. The Health Physics section will establish a program of training in job safety, to include radiation safety, industrial safety, and industrial hygiene.

B. General Limits

1. Maximum permissible levels (MPL's) have been set up in accordance with regulations. MPL values are given for both external radiation and air contamination. MPL values are based on the eight (8)-hour day, five (5)-day work week. For example, the MPL for gamma radiation is 7.5 mr/hr, which in a standard 40-hour work week would produce an exposure of 300 mr.

2. Total body exposure is the sum of exposures to gamma, beta, and neutron radiations from external sources and the exposure received internally through breathing contaminated air. Thus, if the average air contamination is 10% of MPL, the gamma radiation background

averages 40% of MPL, and the neutron background averages 15% of MPL, the total exposure is the sum of all of these percentages, or 65% of MPL. (The percentages quoted are fictional.)

3. A reportable overexposure is any exposure which exceeds the equivalent of 300 mr/wk. By equivalent, we mean the total exposure from all sources, computed in mrem. (The mrem is the equivalent measure for the various types of radiation.) This figure is arrived at by adding the reported beta-gamma exposure, the reported neutron exposure, and the computed exposure from air contamination.

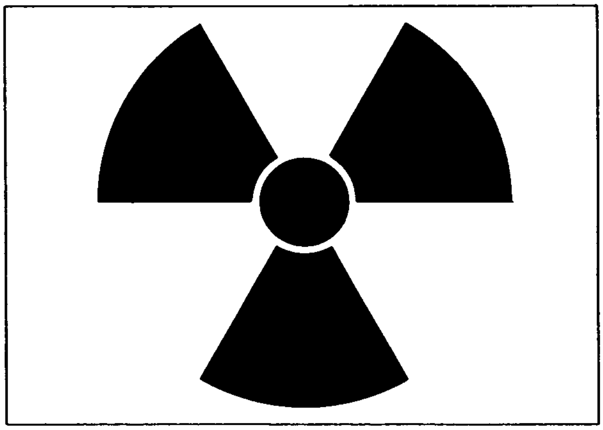
4. The general MPL values which are applicable to ALPR are listed below:

a. Gamma radiation: 7.5 mr/hr
b. Beta radiation: 7.5 mrep/hr
c. Mixed beta-gamma, as read with ionization chamber instruments: 7.5 mr/hr
d. Thermal neutrons: 2,000 $n/cm^2/sec$
e. Fast neutrons (energy in excess of thermal): 40 $n/cm^2/sec$ or 7.5 mrem/hr
f. Beta-gamma air activity or contaminants:
Short half-life: 5×10^{-5} $\mu c/ml$ or 1.1×10^8 dpm/m^3
Long half-life: 1×10^{-9} $\mu c/ml$ or 2.2×10^3 dpm/m^3

C. Radiation Warning Signs and Symbols

1. The standard radiation-warning sign colors are magenta and yellow. This combination of colors may be used only in conjunction with radiation sources, radiation areas, or items of equipment which are used with radiation.

2. The standard radiation symbol is shown below. The symbol is magenta and is always used on a yellow background.



3. The Health Physics section uses a number of signs or tags imprinted with the radiation symbol. Care is exercised in the use of these signs and in making sure that all posted signs and warnings are current and valid. Operating personnel should observe all signs and should follow all recommendations posted with the signs.

D. Film Badges and Dosimeters

1. All permanently assigned personnel must exchange an identification pass for a combination security badge and film badge upon entering the ALPR area. Each badge contains an identification photo and two packets of film. These film packets are the permanent legal record of personnel exposure within the confines of the security fence. It is required that the badge be worn by all personnel at all times within the area.

2. Visitor personnel are issued a temporary badge which contains a printed and typewritten pass and one packet of film. It is required that visitor personnel wear this badge at all times while in the area.

3. Regularly assigned personnel who lose, forget, or mislay their identification pass are issued a temporary pass identical to that issued to visitors.

4. Film badges are processed weekly. Results are recorded in an IBM record system at AEC-IDO Health and Safety. Three copies of the record are sent to the operating contractor for his files.

E. Equipment Locations

1. Radiation survey instruments are kept in the Health Physics office in a gray equipment cabinet. Some instruments in this cabinet may have a red grease pencil "x" on the meter face; such instruments are defective and should not be used.

2. The dosimeter recharger unit is kept on the desk in the Health Physics Office. Unassigned dosimeters are located in the regular dosimeter rack in the corridor leading to the control room.

3. Scott Air-Paks are located in the corridor leading to the control room. Units are on the floor below the fire alarm panels. Three units are available. Additional units may be procured from the Fire Department in an emergency.

4. Extra coveralls, shoe covers, caps, gloves, decontamination chemicals, soap, and brushes are kept in a gray cabinet marked "EMERGENCY EQUIPMENT" in the Health Physics office.

5. The First Aid Kit is located in the men's locker room.

6. The constant air monitor is located on the reactor operating floor, immediately to the right of the main entrance door. Spare filters and charts for the CAM are located in a drawer on the front side of the unit.

F. Routine Power Operation

1. Health Physics personnel will normally be on duty on the day shift, Monday through Friday.

2. Operating personnel will be responsible for limited Health Physics coverage during shift operations. This will consist of an eight-point survey to be performed at least twice on each operating shift. This survey is required only when the reactor is at power. The form used to record survey results is shown in Exhibit 6 (Page 64).

3. Film badges are issued at the guard post as part of the security badge. Personnel are required to wear the badge at all times while in the area. Permanently assigned personnel are issued a self-reading dosimeter. Operating personnel will be required to wear the dosimeter while performing duties on the reactor operating floor. Dosimeters should be picked up from the rack upon entering the control room and should be returned to the rack at the end of each shift.

4. Operating personnel will be required to wear coveralls and safety shoes when on the reactor operating floor during power operation. When the reactor is shut down, personnel performing maintenance work are required to wear coveralls and safety shoes; personnel performing routine inspections are not required to wear coveralls and safety shoes.

5. The constant air monitor is wired into the control room panel alarm system. Under normal conditions, the CAM will operate on either the low scale or the intermediate scale. On the intermediate scale, the warning bell rings for fifteen seconds and a yellow light on the top of the CAM flashes continuously. The warning bell also triggers the control room panel alarm. Either of the two conditions above can be considered normal for ALPR. If the CAM should switch to the high scale, the red light will flash continually and the warning bell will ring continually on both the CAM and the control room panel alarm. If this occurs, contact the Health Physicist as soon as possible.

G. Nonroutine Operations

The Health Physics section will provide direct coverage for nonroutine operations or will provide specific instructions for shift personnel at the time of the operation. No new or unusual operation should be started without approval of the Health Physicist. To this date, work permits have not been required because of the small size of the installation and the close cooperation between all personnel concerned.

No. 15 - STANDARD OPERATING PROCEDURE FOR RECORDS AND REPORTS

A. General

1. The Health Physics section is required to keep certain records and to make reports of its activities. It is the purpose of this Standard Operating Procedure to outline the requirements for the various records and reports.

2. Records and reports are required both for convenience in referring to past activities and in compliance with the needs of supervising agencies.

3. Records will be maintained and filed in the Health Physics section office. Records should be complete but not overly time- and space-consuming.

4. Copies of all reports submitted by the Health Physics section will be filed in the Health Physics office and in the main office file of the operating contractor. Copies will also be submitted to requesting agencies.

5. Reports should be submitted through regular operating contractor channels.

B. Records

1. Daily Records

Daily records must be kept up-to-date at all times. All significant section activities should be reported in some part of the daily record.

a. Health Physics Section Log

A daily log of all section activities will be kept on permanent file in the Health Physics section office. The recommended form is a bound notebook, of a size suitable for permanent filing. All entries should be made in ink. Items to be entered should include special surveys, short summaries of unusual incidents, contamination incidents, reactor power levels, number of air samples and smears taken, short summaries of injuries or safety violations, and other information of interest.

b. Dosimeter Log

Dosimeter readings should be made daily or as frequently as necessary. All readings will be entered in ink in the Dosimeter

Log Book, a bound notebook of a size suitable for permanent filing, kept on permanent file in the Health Physics section office.

c. Area Survey Sheets

Area surveys will be recorded on an Area Survey Log sheet (Exhibit 5, Page 63). This form is a mimeographed or "ditto" sheet listing the routine survey points covered daily. A separate log sheet is made out for each operating shift during reactor power operation. Log sheets will be kept in a loose-leaf notebook until the last day of each month, when they will be removed and placed in an individual file folder for entry in the permanent file in the Health Physics section office.

d. Air Sample Data Sheets

All air samples will be computed on Air Sample Data Sheets (Exhibit 9, Page 93). Data sheets will be kept in a loose-leaf notebook until the last day of each month, when they will be removed and placed in a permanent binder (one binder will be used for all air samples taken in a calendar year) in the permanent file in the Health Physics section office.

e. Smear Sample Data Sheets

All smear samples will be computed on Smear Sample Data Sheets (Exhibit 10, Page 94). Data sheets will be kept in a loose-leaf notebook in the Health Physics office until the end of each month, when they will be removed and placed in a permanent binder (one binder will be used for all smear samples taken in a calendar year). The binder will be placed in the permanent file in the Health Physics section office.

f. Background and Yield

Laboratory counter background and yield will be recorded daily on the Background and Yield Determination Record (Exhibit 8, Page 92). This is a mimeographed form used in the loose-leaf binder for air samples. A record for the entire year will be kept in the loose-leaf binder and will be transferred to the permanent air sample binder at the end of the calendar year.

2. Weekly Records

Weekly records as of this writing are composed of the weekly film badge reports received from AEC-IDO Health and Safety. This is an IBM form reporting total weekly exposure, exposure for the year to date, and total exposure history at NRTS. This form is filed as it is received in a permanent binder, which is on permanent file in the Health Physics section office. Other copies are furnished for the contractor's main office Health Physics record.

3. Nonroutine Records

Nonroutine records are filed as they are completed or received in the Health Physics section office. These are placed in a temporary file until the end of each month, when they are removed and placed in the appropriate permanent file in the Health Physics section office.

a. Water Samples

Water sample analysis is performed by AEC-IDO Health and Safety. Routine well water samples are submitted weekly for background determination. Special water samples are submitted by Health Physics as required. (Example: Sample submitted for approval to dump water from the retention tank to the leaching pond.) Requests are submitted in triplicate and one copy is returned to Health Physics as a record of analysis. AEC-IDO Form ID-104 (Exhibit 7, Page 73) may be used.

b. Waste Disposal

AEC-IDO Form ID-110 (Exhibit 2, Page 42) is submitted in triplicate for each shipment of solid radioactive waste to the NRTS Burial Ground. One copy is retained in the Health Physics section office for the record.

c. Radioactive Shipments

All shipments of radioactive material, whether intra-site or off-site, must be accompanied by AEC-IDO Form IHP-30 (Exhibit 4, Page 47). Two copies of this form are sent with the shipment and one copy is kept for the section file.

d. Laundry

All laundry shipments must be accompanied by AEC-IDO Form IHP-30 (Exhibit 3, Page 44). Two copies of this form are sent with the shipment and one copy is kept for the section file.

e. Urine Samples

Urine samples are submitted for analysis once each six months by all personnel and further samples may be requested as needed. Requests for analysis are submitted in triplicate and one copy is kept for the section file. Use AEC-IDO Form ID-104 (Exhibit 7, Page 73).

4. Monthly Records

Monthly records consist of copies of reports compiled from records of section activities for the month (see monthly reports for details). Monthly reports are placed in the permanent file in the Health Physics section office upon completion.

C. Reports

1. Daily Reports

None

2. Weekly Reports

None

3. Monthly Reports

a. Health Physics Section Report to the Operating Contractor

A monthly section report will be compiled by the contractor Health Physicist. This report should be completed prior to the fifth working day of the succeeding month. Items to be covered are listed below:

(1) Summary of unusual incidents
(2) Summary of safety activities
(3) Exposure totals
(4) Summary of air samples
(5) Summary of smear samples
(6) Summary of routine and nonroutine surveys
(7) Instrumentation operating experience
(8) Waste disposal (to include stack, water, solids)

b. Radioactive Waste Report to AEC-IDO (Exhibit 11, Page 104)

Report to be submitted monthly. To contain the following information:

(1) Liquids dumped to leaching pit (total curie content)
(2) Airborne or stack release (total curie content)
(3) Solid wastes to Burial Ground (total curie content)

c. AEC Form 13: Monthly Summary - Accident, Occupational Disease, and Fire Experience (Exhibit 12, Page 105)

This form is to be submitted to AEC-IDO not later than the seventh (7th) day of the following month. Two copies are to be forwarded. One copy will be retained in the Health Physics section permanent file and one copy will be forwarded to the contractor's main office.

4. Nonroutine Reports

a. Accident Reports

Any accident involving a government vehicle assigned to ALPR must be investigated and Standard Form 91A, INVESTIGATION REPORT OF MOTOR VEHICLE ACCIDENT (Exhibit 13, Page 106), will be completed and submitted to AEC-IDO Safety. One copy will be retained in the Health Physics section permanent file. A follow-up report will be prepared concerning action taken as a result of the investigation.

b. Incident Reports

Major or unusual incidents will sometimes require the preparation of special reports. One copy of this report will be retained in the Health Physics section permanent file and other copies will be distributed as required.

c. Overexposure Reports

AEC-IDO Form ID-102 (PERSONNEL EXPOSURE QUESTIONNAIRE, Exhibit 14, Page 107) will be prepared in all cases of personnel overexposure (in excess of 300 mrem per week) or in all cases of lost film badges. One copy of this report will be submitted to AEC-IDO Health and Safety and one copy will be retained in the Health Physics section permanent file.

Exhibit 11

ID-127(11-58)

U.S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE

RADIOACTIVE WASTE REPORT

Area or Plant Facility __________
For the Month of __________ 19 ___

Date __________
Prepared by __________
Approved by __________

LIQUID				AIRBORNE			SOLID		
Disposition	Volume	Total Activity		Form	Total Activity		Material Description	Total Activity	
		Alpha	Beta-Gamma		Alpha	Beta-Gamma		Alpha	Beta-Gamma
Total									
Composition				Composition		☒		Composition	
Isotope	Relative Percentage	Concentration	MPC Ratio	Isotope	Percentage		Volume and/or weight	Isotope	Percentage

REMARKS:

Exhibit 12

Form AEC-13
(Rev. 1-55)

UNITED STATES ATOMIC ENERGY COMMISSION

Form approved.
Budget Bureau No. 38-R013 9.

MONTHLY SUMMARY—ACCIDENT, OCCUPATIONAL DISEASE, AND FIRE EXPERIENCE

SECTION I—IDENTIFICATION OF REPORTING UNIT

1. REPORTING ORGANIZATION OR OFFICE				2. CONTRACT NO		
3. LOCATION				4. AREA OR OPERATIONS OFFICE		
5. TYPE OF OPERATION (*Check one*)	GOVERNMENT	RESEARCH	PRODUCTION	CONSTRUCTION	SERVICES	OTHER (*Specify*)
6 DATE PREPARED				7. MONTH AND YEAR OF REPORT		

SECTION II—PERSONAL INJURY ACCIDENTS

CLASS OF ACCIDENT	A NUMBER OF ACCIDENTS	OCCUPATIONAL INJURIES							OTHER	
		B MEDICAL TREATMENT CASES	DISABLING INJURIES					H. DAYS LOST AND CHARGED	I FATAL	J NON-FATAL
			C. FATAL	D PERM TOTAL	E PERM PARTIAL	F TEMP TOTAL	G TOTAL			
1 MOTOR VEHICLE										
2 AIRCRAFT										
3 FIRE										
4 OTHER										
5. TOTAL										

K. TOTAL EMPLOYEES	L. TOTAL HOURS	M. FREQUENCY RATE	N SEVERITY RATE	SINCE LAST LOST TIME INJURY	
				O. TOTAL MAN-HOURS	P. CALENDAR DAYS

SECTION III—MOTOR VEHICLE ACCIDENTS

TYPE OF VEHICLE	A TOTAL NUMBER OF VEHICLES	B MILES OF TRAVEL	C NUMBER OF ACCIDENTS	D. FREQUENCY RATE	ESTIMATED DAMAGE OR LOSS		
					E. GOVERNMENT	F OTHER	G. TOTAL
1. PASSENGER CARS					$	$	$
2. TRUCKS, BUSSES							
3. TOTAL					$	$	$

SECTION IV—AIRCRAFT ACCIDENTS

A. TOTAL NUMBER OF AIRCRAFT	B HOURS OF FLIGHT	C. NUMBER OF ACCIDENTS	D. FREQUENCY RATE	E. GOVERNMENT DAMAGE	F. OTHER DAMAGE	G TOTAL DAMAGE
				$	$	$

SECTION V—FIRES

NUMBER OF FIRES		LOSS THIS MONTH		LOSS THIS YEAR	
A. THIS MONTH	B. THIS YEAR	C. GOVERNMENT	D OTHER	E. GOVERNMENT	F OTHER
		$	$	$	$

G TOTAL EVALUATION OF GOVERNMENT PROPERTY HELD	PROJECTED FIRE LOSS RATIO		MUNICIPALITIES		
	H THIS MONTH	I. THIS YEAR	J POPULATION	K PROJECTED LOSS PER CAPITA THIS MONTH	L PROJECTED LOSS PER CAPITA THIS YEAR
$	¢	¢		$	$

SECTION VI—OTHER PROPERTY DAMAGE ACCIDENTS

A. NUMBER OF ACCIDENTS	B. GOVERNMENT LOSS	C. OTHER LOSS	D. TOTAL LOSS
	$	$	$

16—59147-7

SECTION VII—SUMMARY OF INDIVIDUAL INCIDENTS

A. IDENTIFICATION OF INCIDENT (NAME OF INJURED, E. G.)	B. DATE OF INCIDENT	ESTIMATED LOSS ($)		E. NATURE OF INJURY OR PROPERTY DAMAGE
		C. GOV'T	D. OTHER	

SUBMITTED FOR REPORTING UNIT BY—

(SIGNATURE)

(TITLE)

INSTRUCTIONS

SECTION II: *Account for all accidents resulting from the employer's operations in injury to any person. Injuries sustained by persons other than employees on duty will be entered in columns I and J. Employment will be reported as of the last payroll period in the calendar month.*

SECTIONS III, IV, V, AND VI: *Summarize all accidents and fires, irrespective of damage, even though some may have been included in section II due to personal injuries involved*

SECTION III:

$$\text{COLUMN D} = \frac{\text{Number of Accidents (Col C)} \times 100{,}000}{\text{Miles of travel (Col B)}}$$

SECTION V: *The projected fire loss ratio represents the forecasted annual government loss, in cents, per $100 evaluation of government property.*

$$\text{ITEM H} = \frac{\text{Loss (Item C)} \times 120{,}000}{\text{Property Evaluation (Item G)}} \qquad \text{ITEM I} = \frac{\text{Cumulative Loss (Item E)} \times 120{,}000}{\text{Property Evaluation (Item G)} \times \text{Months Covered}}$$

The projected fire loss per capita represents the forecasted annual loss, in dollars, per person

$$\text{ITEM K} = \frac{\text{Government Loss (Item C)} + \text{Other Loss (Item D)} \times 12}{\text{Town Population (Item J)}}$$

$$\text{ITEM L} = \frac{\text{Cumulative Government Loss (Item E)} + \text{Cumulative Other Loss (Item F)} \times 12}{\text{Town Population (Item J)} \times \text{Months Covered}}$$

SECTION VII: *List all accidents and fires resulting in lost time injury or $50 or more damage to property. Use a continuation sheet, if necessary.*

U S GOVERNMENT PRINTING OFFICE 16—59147-5

STANDARD FORM 91A (REV JUNE 1953)

INVESTIGATION REPORT OF MOTOR VEHICLE ACCIDENT

____
(Department or establishment)

1. _______________
(Name and location of reporting unit)

2. GENERAL LOCATION, DATE, DAY AND HOUR OF ACCIDENT

IF ACCIDENT IN CITY, GIVE CITY OR TOWN AND STATE; IF OUTSIDE CITY LIMITS, INDICATE MILEAGE OR DISTANCE TO NEAREST CITY OR TOWN

_______________ (City or town)

_______________ (Miles) (Direction) FROM: Limits ☐ Center ☐

_______________ (County and State)

DATE	DAY OF WEEK	HOUR A. M. P. M.

3. EXACT LOCATION OF ACCIDENT

ACCIDENT OCCURRED ON _______________ (Street) (Highway)

NOTE: CHECK AND COMPLETE ONE. Name (or otherwise identify) nearest intersecting street house number power or telephone pole (give number) highway curve bridge railroad crossing filling station alley, driveway culvert guardrail milepost underpass or other identifying landmark Show exact distance.

☐ AT INTERSECTION WITH _______________ (Street or alley)

☐ NOT AT INTERSECTION _______________ (Distance) (Direction) of _______________

AND _______________ (Distance) (Direction) of _______________

4. FEDERAL VEHICLE (Fed.) (Includes Privately Owned Federally Operated)

YEAR	MAKE	BODY TYPE
REGISTRATION NO	KIND OF CARGO	NUMBER OF PASSENGERS
WAS CARGO DAMAGED? YES		NO
PARTS OF VEHICLE DAMAGED AND NATURE OF DAMAGE		
GOING (Direction)	ON (Street or highway)	
DISTANCE DANGER NOTICED (Feet)	ESTIMATED SPEED THEN (m. p. h.)	ESTIMATED SPEED AT IMPACT (m p h.)
LAWFUL SPEED (m. p. h.)	DISTANCE TRAVELED AFTER IMPACT (Feet)	
MAXIMUM SAFE SPEED (m. p. h.)	OPERATOR'S PERMIT ☐ FEDERAL	☐ STATE
TYPE OF PERMIT	(Issuing State)	(Permit number)
☐ CHAUFFEUR	☐ TRUCK DRIVER	☐ OPERATOR
LIMITATION OF PERMIT		
DRIVER'S NAME		SEX AGE
ADDRESS		
NUMBER OF HOURS ON DUTY PRECEDING ACCIDENT	YEARS DRIVING EXPERIENCE	EXPERIENCE THIS TYPE VEHICLE

5. OTHER VEHICLE (2)

YEAR	MAKE	BODY TYPE
REGISTRATION NO	KIND OF CARGO	NUMBER OF PASSENGERS
WAS CARGO DAMAGED? YES		NO
PARTS OF VEHICLE DAMAGED AND NATURE OF DAMAGE		
GOING (Direction)	ON (Street or highway)	
DISTANCE DANGER NOTICED (Feet)	ESTIMATED SPEED THEN (m p h.)	ESTIMATED SPEED AT IMPACT (m p h.)
LAWFUL SPEED (m p h.)	DISTANCE TRAVELED AFTER IMPACT (Feet)	
MAXIMUM SAFE SPEED (m p h.)	OPERATOR'S PERMIT	
TYPE OF PERMIT	(Issuing State)	(Permit number)
☐ CHAUFFEUR	☐ TRUCK DRIVER	☐ OPERATOR
LIMITATION OF PERMIT		
DRIVER'S NAME		SEX AGE
ADDRESS		
NAME AND ADDRESS OF OWNER (Include phone number)		

PROMULGATED BY BUREAU OF THE BUDGET CIRCULAR A-5 (REV)

16—67414 3

6. WITNESSES

A. NAME	PHONE NO.	B. NAME	PHONE NO.
ADDRESS		ADDRESS	
LOCATION OF WITNESS AT TIME OF ACCIDENT		LOCATION OF WITNESS AT TIME OF ACCIDENT	

7. KILLED OR INJURED

A. NAME	SEX AGE	B. NAME	SEX AGE
ADDRESS		ADDRESS	
CHECK ONE ☐ KILLED ☐ INJURED	CHECK ONE ☐ DRIVER ☐ HELPER ☐ PASSENGER ☐ PEDESTRIAN	CHECK ONE ☐ KILLED ☐ INJURED	CHECK ONE ☐ DRIVER ☐ HELPER ☐ PASSENGER ☐ PEDESTRIAN
CHECK ONE ☐ IN FED VEHICLE ☐ IN OTHER VEHICLE	WHERE IN VEHICLE?	CHECK ONE ☐ IN FED VEHICLE ☐ IN OTHER VEHICLE	WHERE IN VEHICLE?
FIRST AID GIVEN BY		FIRST AID GIVEN BY	
TAKEN TO		TAKEN TO	
TAKEN BY	REGISTRATION NO	TAKEN BY	REGISTRATION NO

8. PEDESTRIAN

PEDESTRIAN WAS GOING _______________ (Direction) ☐ ON ☐ ACROSS _______________ (Street highway No etc.) FROM _______________ (SW cor W side etc.) TO _______________ (NE. cor W side, etc.)

PEDESTRIAN WAS (Check one)

- ☐ 1 CROSSING AT INTERSECTION WITH SIGNAL
- ☐ 2 SAME—AGAINST SIGNAL
- ☐ 3 SAME—NO SIGNAL
- ☐ 4 SAME—DIAGONALLY
- ☐ 5 CROSSING NOT AT INTERSECTION COMING FROM BEHIND PARKED CARS
- ☐ 6. SAME—NOT COMING FROM BEHIND PARKED CARS
- ☐ 7 COMING FROM BEHIND PARKED CARS TO ENTER VEHICLE
- ☐ 8 WAITING OR GETTING ON OR OFF AT STREET CAR SAFETY ZONE
- ☐ 9 NOT AT SAFETY ZONE
- ☐ 10 GETTING ON OR OFF ANOTHER VEHICLE
- ☐ 11 PLAYING IN ROADWAY
- ☐ 12 WORKING IN ROADWAY
- ☐ 13 WALKING IN ROADWAY—WITH TRAFFIC
- ☐ 14. WALKING IN ROADWAY—AGAINST TRAFFIC
- ☐ 15 WALKING IN ROADWAY—SIDEWALKS AVAILABLE
- ☐ 16. WALKING IN ROADWAY—NO SIDEWALKS AVAILABLE
- ☐ 17 HITCHING ON VEHICLE
- ☐ 18 LYING IN ROADWAY
- ☐ 19 NOT IN ROADWAY (Explain)

9. DAMAGE TO PROPERTY OTHER THAN MOTOR VEHICLES OR CARGO

NAME OBJECTS, SHOW OWNERSHIP STATE NATURE OF DAMAGE

10. KIND OF LOCALITY (Check one)

- ☐ 1 MANUFACTURING AND INDUSTRIAL
- ☐ 2 SHOPPING AND BUSINESS
- ☐ 3 RESIDENTIAL
- ☐ 4 SCHOOL AND PLAYGROUND
- ☐ 5 OPEN COUNTRY
- ☐ 6 INDUSTRIAL PREMISES
- ☐ 7 HOME OR DOMESTIC PREMISES
- ☐ 8 OTHER (Specify)

11. LIGHT (Check one)

- ☐ 1. DAYLIGHT
- ☐ 3. DAWN
- ☐ 2. DUSK

DARKNESS WITH:

- ☐ 4. ARTIFICIAL LIGHT
- ☐ 5 NO ARTIFICIAL LIGHT

12. WEATHER (Check one)

- ☐ 1 CLEAR
- ☐ 2. RAINING
- ☐ 3. SNOWING
- ☐ 4 FOG
- ☐ 5 OTHER (Specify)

16—67414-1

Exhibit 13

13. CO 'N OF DRIVER AND PEDESTRIAN

Check for each pe

FED 2 PED

- ☐ ☐ ☐ 1A HAD NOT BEEN DRINKING
- ☐ ☐ ☐ 1B. HAD BEEN DRINKING, IF SO:
- ☐ ☐ ☐ 2. ABILITY IMPAIRED
- ☐ ☐ ☐ 3 ABILITY NOT IMPAIRED
- ☐ ☐ ☐ 4. NOT KNOWN WHETHER IMPAIRED

Check one or more

FED 2 PED

- ☐ ☐ ☐ 5 PHYSICAL DEFECT
- ☐ 6 OTHER HANDICAPS CARRYING BUNDLES UMBRELLAS ETC.
- ☐ ☐ 7 SLEEPY, FATIGUED, ETC.
- ☐ ☐ 8 APPARENTLY ASLEEP
- ☐ ☐ ☐ 9 APPARENTLY NORMAL

14. CONDITION OF VEHICLE

Check one or more for each vehicle

FED 2

- ☐ ☐ 1 DEFECTIVE BRAKES
- ☐ ☐ 2 ONE HEADLIGHT OUT
- ☐ ☐ 3 BOTH HEADLIGHTS OUT
- ☐ ☐ 4 TAILLIGHT OUT OR OBSCURED
- ☐ ☐ 5 DIM COWL OR FENDER LIGHTS ONLY
- ☐ ☐ 6. SIGNAL LIGHTS DEFECTIVE
- ☐ ☐ 7 OTHER LIGHTS OR REFLECTORS DEFECTIVE

FED 2

- ☐ ☐ 8 TIRE BLEW OUT
- ☐ ☐ 9 DEFECTIVE STEERING MECHANISM
- ☐ ☐ 10 NO APPARENT DEFECTS
- ☐ ☐ 11 OTHER DEFECTS (Specify)

15. VISION OBSCURED BY

Check where applicable

FED 2

- ☐ ☐ 1 RAIN, SNOW, ETC., ON WINDSHIELD
- ☐ ☐ 2 CRACKED WINDSHIELD
- ☐ ☐ 3 DIRTY WINDSHIELD, WINDOWS
- ☐ ☐ 4 WINDSHIELD, WINDOWS NOT GLASS
- ☐ ☐ 5 TREES, CROPS, ETC.
- ☐ ☐ 6. BUILDING

FED 2

- ☐ ☐ 7 EMBANKMENT
- ☐ ☐ 8 SIGNBOARDS
- ☐ ☐ 9 PARKED VEHICLE
- ☐ ☐ 10. MOVING VEHICLE
- ☐ ☐ 11 OTHER (Specify)

16. ROAD CHARACTER

Check one in each section

- ☐ 1 STRAIGHT
- ☐ 2. SHARP CURVE OR TURN
- ☐ 3 OTHER CURVES

- ☐ 1. LEVEL
- ☐ 2. UP HILL
- ☐ 3. HILL CREST
- ☐ 4. DOWN HILL

17. ROAD SURFACE

Check one

- ☐ 1. CONCRETE
- ☐ 2 BRICK
- ☐ 3 BLACK TOP
- ☐ 4 GRAVEL SAND, OR DIRT—OILED
- ☐ 5 GRAVEL, SAND, OR DIRT—UNOILED
- ☐ 6. OTHER (Specify)

18. ROAD CONDITION

Check one

- ☐ 1 DRY
- ☐ 2. WET
- ☐ 3 MUDDY
- ☐ 4. SNOWY
- ☐ 5 ICY

Check one or more

- ☐ 6. LOOSE MATERIAL ON SURFACE
- ☐ 7. HOLES, DEEP RUTS
- ☐ 8. DEFECTIVE SHOULDERS
- ☐ 9. NO DEFECTS
- ☐ 10. OTHER DEFECTS (Specify)

WAS ROAD UNDER CONSTRUCTION OR REPAIR?

☐ YES ☐ NO

19. TRAFFIC CONTROL

Check one or more

Functioning	Not Functioning	
☐	☐	1 R. R. CROSSING GATES
☐	☐	2. R. R. AUTOMATIC SIGNAL
☐	☐	3. OFFICER OR WATCHMAN
☐	☐	4. STOP AND GO LIGHT
☐	☐	5. STOP SIGN
☐	☐	6. WARNING SIGN OR SIGNAL
☐	☐	7. FLAGS OR FLARES
☐		8. NO CONTROL PRESENT

20. DRIVER'S ACTIONS

Check one for each driver

FED 2

- ☐ ☐ 1 MAKING RIGHT TURN
- ☐ ☐ 2. MAKING LEFT TURN
- ☐ ☐ 3 MAKING U TURN
- ☐ ☐ 4 GOING STRAIGHT AHEAD
- ☐ ☐ 5 SLOWING DOWN, STOPPING
- ☐ ☐ 6 OVERTAKING, PASSING
- ☐ ☐ 7 FORWARD FROM PARKING SPACE

FED 2

- ☐ ☐ 8 BACKWARD FROM PARKING SPACE
- ☐ ☐ 9. OTHER BACKING
- ☐ ☐ 10 STOPPED IN TRAFFIC LANE
- ☐ ☐ 11. OTHER (Specify)

Check if applicable:

FED 2

- ☐ ☐ 12 SKIDDING
- ☐ ☐ 13 AVOIDING VEHICLE, OBJECT, OR PEDESTRIAN
- ☐ ☐ 14 EMERGING FROM ALLEY OR DRIVEWAY

FED 2

- ☐ ☐ 15 DISABLED VEHICLE, PARKED
- ☐ ☐ 16. GAVE WARNING (Horn, Signal, Indicator)

21. VIOLATIONS

Check one or more

FED 2

- ☐ ☐ 1 EXCEEDING LAWFUL SPEED
- ☐ ☐ 2 DID NOT HAVE RIGHT OF WAY
- ☐ ☐ 3 ON WRONG SIDE OF ROAD
- ☐ ☐ 4 DROVE THROUGH SAFETY ZONE
- ☐ ☐ 5 PASSING STANDING STREETCAR
- ☐ ☐ 6 PASSING ON HILL
- ☐ ☐ 7 PASSING ON CURVE
- ☐ ☐ 8. CUTTING IN
- ☐ ☐ 9 FOLLOWING TOO CLOSELY
- ☐ ☐ 10. FAILURE TO SIGNAL OR IMPROPER SIGNAL
- ☐ ☐ 11 WIDE RIGHT TURN
- ☐ ☐ 12. CUT CORNER ON LEFT TURN

FED 2

- ☐ ☐ 13 TURN FROM WRONG LANE
- ☐ ☐ 14. DISREGARDED STOP SIGN
- ☐ ☐ 15 DISREGARDED WARNING SIGN OR SIGNAL
- ☐ ☐ 16. DISREGARDED STOP AND GO LIGHT
- ☐ ☐ 17 DISREGARDED POLICE OFFICER
- ☐ ☐ 18 IMPROPER STARTING FROM PARKED POSITION
- ☐ ☐ 19 IMPROPER PARKING
- ☐ ☐ 20. NO IMPROPER DRIVING INDICATED
- ☐ ☐ 21 OTHER IMPROPER ACTION (Specify)

22. ROAD WIDTHS AND LANES

WIDTH OF ROAD OR PAVEMENT	NUMBER OF LANES
WERE LANES MARKED?	WERE LANES SEPARATED?
BY WHAT?	

23. POLICE ACTION, IF ANY

CHARGE

NAME OF PERSON CHARGED

NAME, BADGE NUMBER, AND DEPT OF POLICE OFFICER

16—67414-1

24. INDICATE ON THIS DIAGRAM HOW ACCIDENT HAPPENED

Use one of these outlines to sketch the scene of the accident, writing in street or highway names or numbers.

1 Number Federal vehicle as 1—other vehicle as 2—additional vehicle as 3, and show direction of travel by arrow (*Example* ⟶ 1 2 ⟵)

2 Use solid line to show path before accident ——— 2

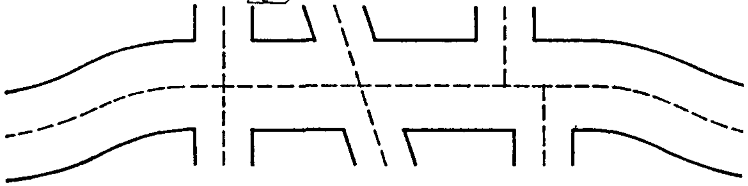
Broken line after accident - - - - - - - 2

3 Show pedestrian by ———————

4 Show railroad by ┼┼┼┼┼┼┼┼┼┼┼┼┼┼┼┼

5 Give names or numbers of streets or highways

6 Indicate north by arrow in this circle ○



26. DESCRIBE WHAT HAPPENED

REFER TO VEHICLES BY "FED" AND "2"

27. SIGNATURE OF INVESTIGATOR	TITLE	DATE

28. STATEMENT OF REVIEWING OFFICIAL

WAS THE DRIVER ACTING WITHIN THE SCOPE OF HIS EMPLOYMENT? ☐ YES ☐ NO
STATE BASIS FOR ANSWER

WHAT CAUSED THE ACCIDENT?

HOW COULD IT HAVE BEEN PREVENTED?

WHAT ACTION HAS BEEN TAKEN?

USE THIS SPACE TO SHOW CONSEQUENCES OF ACCIDENT AFFECTING AGENCY PERSONNEL REPORTED IN SECTION 7

A. ☐ MILITARY PERSONNEL	☐ CIVILIAN PERSONNEL
PROBABLE DISABILITY	NATURE OF INJURY AND PART OF BODY
DATE STOPPED WORK	
DATE RESUMED WORK	
B ☐ MILITARY PERSONNEL	☐ CIVILIAN PERSONNEL
PROBABLE DISABILITY	NATURE OF INJURY AND PART OF BODY
DATE STOPPED WORK	
DATE RESUMED WORK	

SIGNATURE OF REVIEWING OFFICIAL	TITLE (Civilian or military)	DATE

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Exhibit 14

FORM IHP 24 (Rev 10 1 56)

PERSONNEL EXPOSURE QUESTIONNAIRE

Date ______________________

Name of employee ______________________		Badge Number ______	
Area ______________________		Exposure Date ______________________	

Reason fc Investigation

( ) A reportable weekly daily pocket meter reading total of ______________________

( ) Weekly film total of 300 mr or more

( ) ______________________

Film total covers period extending from ______________________ through ______________________

FILM RESULTS

BETA	GAMMA

EXPOSURE RESUME

Week Ending	Meters	SUN	MON	TUES	WED	THURS	FRI	SAT
	Pocket Meters							
	Badge Meters							

Remarks ______________________

Investigation

a Findings of Health Physics Representative and or Supervisor

b Recommendations

Investigated by ______________________ Date ______________ Noted ______________________

Health Physics Supervisor

CODE:

"W" Weekly total, beta plus gamma, greater than 300 mrem

"Q" Quarterly total, beta plus gamma, greater than 3750 mrem

"H" Requested by plant health physicist

'R" Badge not in rack

"L" Badge lost

"D" Flim damaged (wet, torn, etc.)

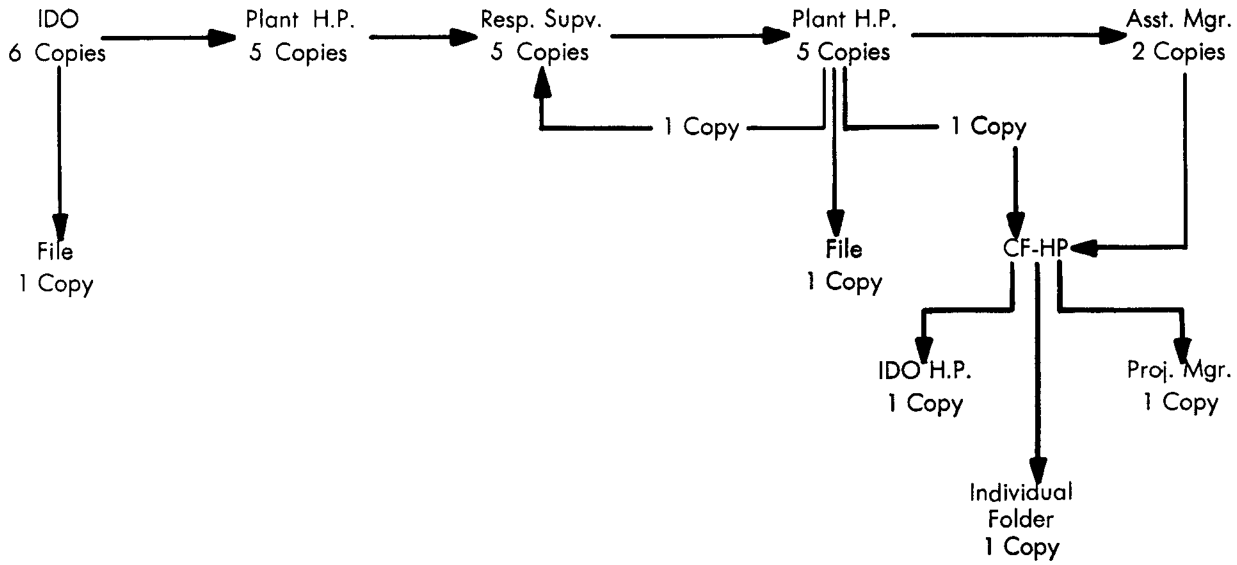
"N" Reading not applicable, badge exposed while not being worn

'P" Possible light leak

"X" Film density affected by X-ray

"A" Film reading lost or altered in processing

"O" Other reason, explain under "remarks"



SECTION V. DEFINITIONS

Active Area: Any area in which radioactive materials are either present or used. Also used to denote reactor area or radiation area.

Acute Exposure: Radiation exposure of short duration.

Air Sample: Sample taken by drawing a volume of air through a suitable filter so as to remove atmospheric dust from the air. The filter sample, when counted, is a measure of the particulate radioactive content of the air.

Alpha, Alpha Particle, Alpha Ray: A nuclear radiation with a mass of 4 atomic mass units (amu) and a positive electrical charge of two units. Has little penetrating power and can be stopped readily by a sheet of paper.

Background: Radiation arising from radioactive material other than the one directly under consideration. Background may be caused by cosmic rays or natural radioactivity. There may also be background radiation due to the presence of radioactive substances in other parts of the building, in the building material itself, etc. At ALPR, the background radiation may vary with reactor power.

Beta Particle, Beta Radiation, Beta Ray: A nuclear radiation that is essentially a high-speed electron emitted from the nucleus. Mass of 1/1840 amu and a negative charge of one unit. Will penetrate a few millimeters of skin tissue.

Binary Scaler: A scaler whose scaling factor is two (2) per stage.

Biological Specimen: A body waste sample, usually all urine passed between leaving work at night and reporting for work the following morning. Samples are analyzed for radioactivity.

Bone Seeker: Any compound or ion which migrates in the body to the bone preferentially.

Calibration: Determination of variation from standard of a measuring instrument to obtain necessary correction factors.

Charger, Charger-Reader: Charging unit for dosimeters or pocket chambers. Charger-reader is often called a "minometer."

Chronic Exposure: Term used to denote radiation exposure of long duration.

Coffin: Term used to denote a heavily shielded container used in transporting radioactive sources or spent fuel assemblies.

Contamination (Radioactive): Deposition of radioactive material in any place where it is not desired.

Control Rod: Reactor control mechanism consisting of a rod or assembly containing a neutron-absorbing material such as cadmium or boron.

Core: The central reactive portion of a reactor. This is the location of the fuel assemblies and control rods.

Count: In radiation measurements, the external indication of a device used to enumerate ionizing events. It may refer to a single detected event or to the total registered in a given period of time.

Critical Experiment: A reactor experiment at low power levels, used to determine physical characteristics of the reactor core.

Cumulative Dose, Accumulated Dose: The total dose resulting from repeated exposures to radiation over a period of time.

Curie: The quantity of radioactive material having associated with it 3.7×10^{10} disintegrations per second (dps).

Dry Active Waste: Radioactive waste in a solid form. Dry active wastes are to be deposited in marked containers.

Decade Scaler: Scaler unit whose scaling factor is ten or a power of ten.

Decay: Disintegration of the nucleus of an unstable isotope by spontaneous emission of charged particles and/or photons.

Decontamination: The removal of radioactive material from an item or surface.

Dose or Dosage: The amount of radiation delivered to a specified area, volume, or to the whole body.

Dosimeter: Instrument used to detect and measure an accumulated dosage of radiation. Commonly, a pencil-sized ionization chamber with a built-in self-reading electrometer, used for personnel monitoring.

End-Window Counter: Any counter device using a mica end-window, as in an end-window Geiger-Mueller tube. Used in counting low-energy beta radiation.

External Radiation: Ionizing radiation from a radiation source located outside the body.

Fast Neutron: Neutron with energy above thermal energy (Health Physics usage only).

Film Badge: A device consisting of a holder and one or more packets of sensitive film used for personnel monitoring.

Fission Products: Isotopes, resulting from the fission process.

Fuel Element, Fuel Assembly, Fuel Rod: A fuel assembly for use in nuclear reactors. Usually an array of fissionable material, clad in an impervious jacket, and mounted in a rigid frame or box.

Gamma Radiation: Short-wavelength electromagnetic radiation of nuclear origin, with a range of wavelengths of from 10^{-9} to 10^{-12} cm.

Gas Flow Counter: A radiation counter in which an appropriate atmosphere is maintained in the counter volume by allowing a suitable gas to flow slowly through the counting chamber.

Geiger-Mueller (GM) Counter: A sensitive gas-filled radiation-detection device which operates at voltages sufficiently high to produce avalanche ionization. Used primarily to detect beta and gamma radiations.

Geometry: Term sometimes used to denote the efficiency or yield of a particular counting array.

Half-Life, Radioactive: Time required for a radioactive substance to lose 50% of its activity by decay.

Hand- and-Foot Counter: A self-inspection device for detecting contamination of the hands, feet, and clothing.

Hardness: A relative specification of the quality or penetrating power of X rays and gamma radiations. In general, the shorter the wavelength, the "harder" the radiation.

Health Physics: A term used to denote that branch of radiological science dealing with the protection of personnel.

Heterogeneous Reactor: A nuclear reactor in which the fissionable material and moderator are arranged as discrete bodies of such dimensions that a nonhomogeneous medium is presented to the neutron flux of the reactor.

Homogeneous Reactor: A nuclear reactor in which the fissionable material and the moderator (if any) are combined in a mixture such that an effectively homogeneous medium is presented to the neutron flux of the reactor.

ICC Regulations: Regulations of the Interstate Commerce Commission governing the shipment of radioactive materials by carriers operating in interstate commerce.

Induced Radioactivity: That radioactivity produced in a substance after irradiation with neutrons or other particles.

Initiator: In a reactor, an external source of neutrons providing a constant flux of neutrons for startup of the reactor.

Internal Radiation: Exposure to ionizing radiation when the radiation source is within the body as a result of deposition of radioactive isotopes in body tissues or organs.

Ion: Atomic particle, atom, or chemical radical bearing an electrical charge, either positive or negative.

Ion Chamber, Ionization Chamber: An instrument designed to measure quantity of ionizing radiation in terms of the charge of electricity associated with ions produced within a defined volume.

Ionization: The act or result of a process by which a neutral atom or molecule acquires a charge of either sign, or by which electrons are liberated.

Ionizing Event: Any event in which ionization is produced.

Irradiation: Exposure to radiation.

Isotope: One of several different nuclides having the same number of protons in their nuclei, and hence having the same atomic number, but differing in the number of neutrons, and therefore in the mass number.

Laboratory Counting Equipment: Radiation-counting equipment designed for the counting of small quantities of radioactive material. Usually nonportable.

Long Counter: Term referring to a neutron counter array consisting of a boron trifluoride counting tube operated in the proportional voltage region, a scaler, and a high-voltage power supply. A paraffin moderator is used for the counting of fast neutrons. The counter is sensitive to slow and thermal neutrons with flux levels less than 1 $n/cm^2/sec$.

Maximum Permissible Concentration (MPC): An established maximum concentration of a radioactive contaminant in drinking water, air, etc.

Maximum Permissible Level (MPL): A defined maximum for safe operating exposure to nuclear radiations. Computed values are for occupational exposure (i.e., 8-hour day, 5-day week).

Microcurie: One-one millionth of a curie. 3.7×10^4 disintegrations per second. Abbreviated "μc."

Millicurie: One-one thousandth of a curie. 3.7×10^7 disintegrations per second. Abbreviated "mc."

Milliroentgen: One-one thousandth of a roentgen. Abbreviated "mr."

Moderator: Material used in a nuclear reactor to moderate, or slow down, neutrons from the high energies at which they are released in the fission process.

Monitoring: Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present in an occupied area, as a safety measure for purposes of health protection.

NBS Handbooks: A series of handbooks outlining radiation protection recommendations of the National Bureau of Standards and of the National Committee on Radiation Protection. This is the operating guide used by the AEC. Copies are available from the Government Printing Office.

Neutron: Elementary nuclear particle with a mass of 1.00893 amu (approximately the same as that of a hydrogen atom). It is electrically neutral.

Operating Voltage: The voltage at which a detector tube is operated; the voltage across the electrodes in the detecting chamber required for proper detection of an ionizing event.

Overexposure: Radiation exposure in excess of the maximum permissible level.

Permissible Dose: The amount of radiation which may be received by an individual within a specified period of time with expectation of no harmful result to himself (see Section VI G).

Personnel Metering: The systematic periodic check of the radiation dose each person receives during his working hours.

Photographic Dosimetry: Determination of the cumulative dosage of radiation by the use of photographic film.

Pig: In radiation counting, a shielded container or enclosure for a counting device. It is used to reduce counter background.

Pile (Obsolete term): Nuclear reactor.

Planchet: Sample holder specially designed for counting of sample radioactivity. A round shallow pan made of stainless steel, aluminum, or glass.

Plateau: The plateau is the characteristic horizontal portion of the curve of the counting rate versus voltage.

Pot: A shielded container for storage or transfer of radioactive materials.

Probe: In radiation detection, a detector mounted at one end of a flexible cable leading to the instrument case or box. This has the advantages of flexibility, light weight, size, and convenience.

Proportional Counter: Gas-filled or air-filled detection tube or chamber in which the pulse produced is proportional to the number of ions formed in the gas by the primary ionizing radiation.

Quality: A measure of the "hardness" or "softness" of radiation.

Quenching: The process of inhibiting continuous or multiple discharge in a counter which uses gas amplification. In a self-quenching GM tube, a polyatomic or halogen vapor is used to "quench" or extinguish avalanche ionization.

Rad: The unit of absorbed dose recommended and adopted by the International Commission on Radiological Units at the Seventh International Congress of Radiology, Copenhagen, 1953. The rad is one hundred (100) ergs of radiation energy absorbed in one (1) gram of material.

Radiation: The process by which energy is emitted from molecules and atoms owing to internal changes. The term radiation, when unqualified, usually refers to electromagnetic radiation; such radiation is usually classified according to frequency, as infrared, visible, ultraviolet, X ray, and gamma ray. Some corpuscular emissions, such as alpha and beta particles are commonly called radiations.

Radioactivity: The process whereby certain nuclides undergo spontaneous disintegration in which energy is released, generally resulting in the formation of new nuclides. The process is accompanied by the emission of one or more types of radiation, such as alpha particles, beta particles, and gamma photons.

Reactor: A chain reacting system in which the energy from the fission of uranium or plutonium is released at a controlled rate.

Relative Biological Effectiveness: The ratio of gamma-ray or X-ray dose to the dose that is required to produce the same biological effect by the radiation in question.

RHM or rhm: Roentgen-hour-meter, or roentgen per hour at one meter. A measuring unit which has some convenience when measuring radiation source of unknown strength. Not commonly used.

Roentgen: That quantity of X or gamma radiation which will produce, in one cubic centimeter of air at STP, one electrostatic unit of charge of either sign.

REM (rem) or Roentgen Equivalent Man: That quantity of any type of ionizing radiation which, when absorbed by man, produces an effect equivalent to the absorption by man of one (1) roentgen of X or gamma radiation.

Roentgen Equivalent Physical (rep): The amount or quantity of any ionizing radiation which will result in the absorption in tissue of 83 ergs of energy per gram. (Recent authors have suggested a value of 93 ergs per gram.)

Routine Survey: A survey made as part of a regular routine. A routine survey might consist of measurement of background radiation, a floor survey, a general room survey, and smear sampling of random floor and work surfaces.

Scaler: An electronic device which registers pulses received over a period of time. Often used as an electronic divider to reduce the rate of pulses being fed to a mechanical recorder.

Scattered Radiation: Radiation which, during its passage through a substance, has deviated in direction.

Scintillation Counter: A combination of phosphor, photomultiplier tube, and associated external circuit for counting light emissions produced in the phosphor through absorption of radiation energy.

Scram: Shutdown of a reactor by dropping the control rods rapidly.

Self-Absorption: Absorption of radiations emitted by radioactive atoms by the matter or material in which the atoms are located. Self-shielding.

Sensitive Volume: That portion of a counter tube or ionization chamber which responds to a specific radiation.

Skyshine or Shine: In radiation, a reflected or scattered radiation occurring in the vicinity of high-intensity radiation sources which are not shielded vertically.

Slow Neutron: Neutron with an energy less than 0.01 ev.

Smear: A smear is made by wiping an area of floor, work surface, etc., with a paper disk. The smear sample is analyzed for radioactivity to obtain a measure of the quantity of loose contamination present on the sample surface.

Source: Any emitter of radiation. Often used to describe a radiation standard.

Special Survey: A radiation survey which is not a part of normal routine.

Specific Activity: Total radioactivity content of a given sample per gram of material.

Specific Ionization: Number of ion pairs per unit length of path of the ionization particle in a medium such as air or tissue.

Spill: Any incident, usually accidental, in which radioactive contamination occurs.

Spot: Any relatively small, isolated contaminated area on a floor or work surface, as opposed to general over-all contamination.

Starting Voltage: The minimum voltage which must be applied to a detector tube to cause it to function, with the particular recording circuit which may be attached.

Streaming: Process by which neutron radiation may penetrate a shield by following cracks, slots, etc., in the shield.

Survey Meter: A portable radiation detection meter designed for radiation survey work.

Tolerance Dose: A misused synonym for "permissible dose." No dose should be "tolerated."

Track: Indication of the path of an ionizing particle in a cloud chamber or nuclear emulsion.

Yield: A calibration factor used in radiation measurements. Yield is commonly calculated in percentage. Yield is determined by counting a standard or known sample and dividing the resultant count by the known disintegration rate.

SECTION VI. TABLE OF MAXIMUM PERMISSIBLE LEVELS

A. Air Contamination (Gases and Particulates)

1.	Short-half-life beta-gamma-emitting decay products from reactor steam	1.1×10^8 dpm/m^3
2.	Long-half-life beta-gamma emitters from any source	2.2×10^3 dpm/m^3
3.	Short-half-life alpha-emitting radon daughters	2.2×10^4 dpm/m^3
4.	Long-half-life alpha emitters from any source	70 dpm/m^3
5.	Soluble plutonium-239	18 dpm/m^3

B. Maximum Permissible Levels for Surface Contamination

1. "Loose" or "Smearable" Contamination

a.	Reactor area	beta-gamma	1,000 dpm/ft^2
		alpha	100 dpm/ft^2
b.	Administrative area	beta-gamma	100 dpm/ft^2

2. "Fixed" Contamination

a.	Reactor area	beta-gamma	2 mr/hr
		alpha	1,000 dpm/100 cm^2
b.	Administrative area	beta-gamma	None detectable
		alpha	None detectable

C. Maximum Permissible Levels for Personnel Contamination

1.	Hands and all skin surfaces	beta-gamma	None detectable
		alpha	None detectable
2.	Work clothing	beta-gamma	0.1 mr/hr maximum
		alpha	None detectable

3.	Street clothing	beta-gamma	None detectable
		alpha	None detectable
4.	Shoes	beta-gamma	0.1 mr/hr maximum
		alpha	none detectable

D. <u>Maximum Permissible Levels of Contamination for Tools and Equipment</u>

Certain tools and equipment are to remain on the reactor operating floor at all times. All such portable gear is identified by a purple paint stripe. Other tools and equipment may be moved from the reactor area to the administrative or shop area with the permission of Health Physics.

1. Hand tools (Reactor area only)

a.	Smearable contamination	1,000 dpm/ft^2 (beta-gamma)
		100 dpm/ft^2 (alpha)
b.	Fixed contamination	2 mr/hr (beta-gamma)
		100 dpm/100 cm^2 (alpha)

2. Hand tools (Shop or administrative area)

a.	Smearable contamination	100 dpm/ft^2 (beta-gamma)
		50 dpm/ft^2 (alpha)
b.	Fixed contamination	None detectable (beta-gamma)
		None detectable (alpha)

3. Nonportable Equipment (Reactor area only)

a.	Smearable contamination	1,000 dpm/ft^2 (beta-gamma)
		100 dpm/ft^2 (alpha)
b.	Fixed contamination	5 mr/hr (beta-gamma)
		1,000 dpm/100 cm^2 (alpha)

4. Nonportable Equipment (Shop and/or administrative area)

a.	Smearable contamination	100 dpm/ft^2 (beta-gamma)
		50 dpm/ft^2 (alpha)

E. Maximum Permissible Levels for Off-site Shipments of Radioactive Materials

1. AEC Contractors or Licensees.

   a. Internal radioactivity. Not limited.

   b. External gamma radiation through container:

1)	Contact	200 mr/hr
2)	Distance of one meter	10 mr/hr

   c. External alpha and beta radiation through container.

   None permitted. Container should shield out all alpha and beta radiation.

   d. External contamination of container:

   None permitted.

   e. Neutron radiation through container:

   See ICC Tariff 10.

   f. Packaging requirements:

   See ICC Tariff 10.

   g. Courier shipments:

   Exempt from ICC limits. Contact AEC-IDO Health & Safety for details and limits.

2. Outside Vendors

   No shipments of radioactive materials or contaminated items will be made to outside vendors unless they possess valid AEC licenses for the handling and processing of radioactive materials.

F. Maximum Permissible Levels for On-site (Intra-site) Shipments of Radioactive Materials

In general, on-site shipments are required to meet ICC limits as specified in ICC Tariff 10. Exceptions can be made if the shipment is to be escorted by AEC couriers and if prior arrangements are made through AEC-IDO Health and Safety.

G. Maximum Permissible Levels for External Radiation Exposure of Personnel

1. Maximum permissible levels for work areas: The maximum permissible level for external radiation exposure of personnel is 7.5 mrem/hr for a 40-hour per week exposure, including dosage from all types of radiation encountered.

a.	Gamma radiation alone	7.5 mr/hr
b.	Beta radiation alone	7.5 mrep/hr
c.	Neutron radiation alone	7.5 mrem/hr
	1) Fast neutrons	40 n/cm^2/sec
	2) Slow neutrons	2,000 n/cm^2/sec

(NOTE: Gamma, beta, and neutron exposures are reported in different units: the mr, mrep, and the mrem, respectively. All of these units can be directly converted to mrem without introducing serious errors. Cumulative exposures at ALPR are reported in mrem for total beta-gamma-neutron exposure.)

2. Cumulative Exposure Limits.

a.	Weekly limits:	
	1) Short term	300 mrem/week
	2) Long term	100 mrem/week
b.	Quarterly limits:	
	1) Short term	3 rem/quarter
	2) Long term	1.3 rem/quarter
c.	Annual limits:	
	1) Short term	15 rem/year
	2) Long term	5 rem/year
d.	Lifetime limits:	

$$\text{MPD} = 5\,(N-18)\ \text{rem}$$

where

N = age in years at end of calendar year
MPD = total maximum lifetime dose

Limitation: No yearly increment shall exceed 15 rem

e. Reportable Overexposures:

1)	Weekly	Over 300 mrem/week
2)	Quarterly	Over 3 rem/quarter
3)	Yearly	Over 15 rem/year
4)	Lifetime	Over MPD

SECTION VII. BIBLIOGRAPHY

National Bureau of Standards Handbooks:

- 42 Safe Handling of Radioactive Isotopes
- 48 Control and Removal of Radioactive Contamination in Laboratories.
- 49 Recommendations for Waste Disposal of Phosphorous-32 and Iodine-131 for Medical Users
- 50 X-ray Protection Design
- 51 Radiological Monitoring Methods and Instruments
- 52 Maximum Permissible Amounts of Radioisotopes in the Human Body and Maximum Permissible Concentrations in Air and Water
- 53 Recommendations for the Disposal of Carbon-14 Wastes
- 54 Protection Against Radiations from Radium, Cobalt-60, and Cesium-137
- 55 Protection Against Betatron-Synchrotron Radiations up to 100 Million Electron Volts
- 57 Photographic Dosimetry of X and Gamma Rays
- 59 Permissible Dose from External Sources of Ionizing Radiation
- 60 X-ray Protection
- 61 Regulation of Radiation Exposure by Legislative Means

H. A. Campbell, Tariff #10, Interstate Commerce Commission Regulations for Transportation of Explosives and Other Dangerous Articles by Land and Water in Rail Freight Service and by Motor Vehicle (Highway) and Water (1957, with supplements)

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