AD 274 167

USNRDL-TR-549

Copy 113

30 January 1962

DECONTAMINATION OF SHIPS' SURFACES.
II. DESIGN AND CONSTRUCTION OF EXPERIMENTAL FACILITIES

by
R.N. Anderson
R.M. Railey

U.S. NAVAL RADIOLOGICAL DEFENSE LABORATORY

SAN FRANCISCO 24, CALIFORNIA

12ND. P7463

ABSTRACT

A laboratory study of the fallout from a seawater nuclear detonation and its contamination of ships' surfaces requires special equipment to make the radioactive simulant, to generate and disperse the simulant on painted surfaces, and to decontaminate these surfaces by liquid methods.

The simulant is produced by evaporating 30 gal of seawater containing approximately 2 curies of a selected gamma-emitting radionuclide to a final volume of 3 gal. The concentrated solution is fed to a spinning disc generator which produces 200-μ diameter drops at flow rates from 0.06 ml/sec to 2.5 ml/sec.

The drops are generated at the top of a polyethylene-lined chamber 36 ft high, and, as they settle at terminal velocity, they are distributed by a rotating cluster of fans to uniformly deposit on plates 8.5 in. square. The plates are painted with Navy paints, and cover a floor area of 1256 ft^2.

The contaminated plates are counted, washed, and recounted at the rate of 50/hr in a machine which simulates firehosing and steam cleaning. The effects of solution temperature, spray pressure, spray time and chemical additives in the liquid decontamination methods may thus be evaluated.

1. INTRODUCTION

A nuclear detonation on the surface of the ocean mixes fission products with seawater and throws great quantities of the mixture into the atmosphere. A 20-kt weapon, for example, is estimated to throw several million tons of seawater and approximately 6×10^3 megacuries[1] (gamma activity at 1 hr after fission) of fission products into the atmosphere. The return of this material to earth constitutes a contaminating event. Tactical decontamination procedures must be established for Navy ships to accomplish successfully their assigned missions in such radiological environments. These procedures may best be determined by laboratory-controlled experiments modeled from field test data. Consequently an equipment complex for the investigation of the decontamination of fallout from ship's surfaces by liquid washdown methods was designed.

The investigation consists of a series of experiments, each of which studies the individual contamination-decontamination behavior of one of the chemical elements in fission products. A sufficient number of elements will be studied to determine the behavior of all the chemical groups embraced by fission products, emphasizing those containing or leading to important gamma emitters. The combined results will permit the prediction of contamination-decontamination behavior of mixed fission products for any period from minutes to months after fission, given initial radionuclide abundances such as those computed by Bolles and Ballou.[2]

To conduct the experiments with the desired control, a system of equipment and procedure was required for manufacturing a synthetic fallout, depositing it on painted plates, decontaminating the plates, and measuring the efficiency of decontamination. This report describes the equipment complex.* The decontamination data for each of the selected isotopes will be individually reported in subsequent reports. A computer solution of the general contamination problem for all fission products will conclude the series of experiments and reports.

*The first report in the series is in preparation now: W. B. Lane, Decontamination of Ship's Surfaces. I. Theoretical Aspects and Experimental Plan.

1.1 Single-Tracer Isotope Concept

Studies conducted at Operation HARDTACK[3] showed that certain radiochemical elements in the fallout were selectively concentrated. Moreover, the importance of the radio-elements with respect to their contribution to the total gamma emission varies with time after fission.[2,4] Therefore, a gross-fission-product decontamination experiment is applicable only to one special condition of contamination and cannot be interpreted as a general case. Miller[5] suggested that a general solution to the decontamination problem could be found from single-tracer experiments.

The approach is as follows:

Defining I = Initial counts/min
and R = Residual counts/min after decontamination
then F = R/I or fraction of activity remaining after decontamination

Each chemical element has its specific F value for a given set of contaminating conditions and decontamination method. The unfractionated amount of each specific radionuclide present at any time t has been calculated by Bolles and Ballou.[2] Therefore, if the F value of each isotope is multiplied by its contribution to the total gamma emission rate at time t, the sum of the products for all the nuclides represents an overall F value of fission products decontaminated at time t.

Fractionation present in the initial contaminant, such as was found in the HARDTACK studies,[3] would be taken into account upon calculation of the percent contribution of the nuclides.

The chemical elements listed in Table 1[6] comprise some of the more important gamma-emitters found in fission products from 1 hour to 3 years after fission. These elements may have decontamination characteristics which fall into groups according to similarities in their valences; therefore, as a guide to possible groupings, Table 1 includes the probable valence states.

1.2 Seawater Fallout

The single-tracer technique depends on the use of an inert total carrier solution composed of inert fission products, bomb products, and seawater products, so that any interaction which occurs in natural fallout would occur in the simulant. All available field test data and theory were utilized to formulate the simulant.

TABLE 1

Some Important Gamma-Emitters in Fission Products and Their Potential Valence States

Zr	4	Te	2,4,6	Nb	3,5
Ce	3,4	Pr	3,4,5	Np	4,5,6
Cs	1	La	3	Ba	2
Sr	2	I	1,3,5,7	Rb	1
Ru	3,4,6,8	Y	3	Nd	3

The theoretical chemical composition of the fallout from an ocean surface nuclear detonation was reported by Miller, et al.[7] The observed fallout particles from Operation REDWING were slurry drops[8] of seawater concentrated about 10-fold more than normal, and seawater-insoluble solids. The latter were derived to some extent from seawater salts, but the principal source lay in the materials of the shot barge and ballast. For a weapon burst at the water surface then, it is presumed that these insoluble solids would be absent and that the radioactivity would be found essentially in the liquid phase.

The formation of the slurry drops consists in a 3-step condensation process.[9] First primary particles, with calculated diameters between 10 and 100 Å, are formed from condensing material with high boiling points (such as Fe or Al). Second NaCl condenses, and at its melting point (801°C) many of the FP elements have condensed. Finally, water vapor and all remaining FP elements, except the rare gases, condense. Radioelements condensing into the solutions formed in the latter two processes constitute the soluble fraction of the activity.

In the course of a particle's descent from a high elevation, its water content varies with the temperature and humidity of the air through which it passes. If the data of Orr, et al.,[10] for submicron drops can be used, it appears that a saturated drop is metastable over a wide range (30 to 70 %) of humidity and that the water content would change appreciably only in the extreme humidity conditions which are experienced during field tests in the tropic region of Bikini. Such slurry drops, in the meteorological environment of Bikini, ranged in size from about 50 to 250 μ in diameter upon arrival at the surface.

Miller[5] introduced the concept of characterizing fallout by the mass contour ratio. The mass ratio, having dimensions of $mg/ft^2/r/hr$ at 1 hour, relates the deposited fallout mass to radiation intensity 3 feet

above a uniformly contaminated open area. On the basis of available data from Operation REDWING,[11] an average value of approximately 30 mg of seawater/ft^2/r/hr at 1 hr has been postulated for seawater fallout from a 100 % fission bomb. Therefore, a dose rate of 1000 r/hr at one hr is predicted from a deposit of ~ 30 g/ft^2 of seawater, or ~ 1 gm/ft^2 of residual seawater salts.

1.3 Experimental Conditions

In designing the system to simulate seawater fallout, the physical conditions reported in field tests were considered. Certain conditions and parameters were established as representing the most likely or realistic case, while others were arbitrarily set because they were judged to have little effect on the experiment.

The test postulated the fallout as being from a megaton weapon detonated in seawater sufficiently deep to prevent bottom material from being carried up in the cloud. The effect of weapon size on the concentration of fission products in the seawater is not pronounced;[5] hence concentration was fixed at a reasonable value for a megaton-range device. The direct effects of the weapon would be of greater hazard than fallout to ship targets concentrated in a harbor; therefore the inclusion of bottom mud, as would be found in fallout from a harbor detonation, was considered as a strategically less important case.

A contaminating event of 1000 r/hr at 1 hr was arbitrarily chosen, requiring, as indicated above, a surface deposition of approximately 1 gm of dried sea salts per ft^2. Dispersal apparatus and operating conditions were designed to produce a median mass diameter of ~ 200 μ.

A typical fallout arrival curve (as shown in Fig. 1) was established based upon theoretical considerations[11,12] and certain rules of thumb, such as that the peak rate of arrival occurs at twice the time interval between fission and initial time of arrival. The area under the idealized curve in Fig. 1 integrates to a total of 1 g/ft^2. The experimental approximation is superimposed in Fig. 1 as a step function.

Based upon these fallout parameters, equipment was designed and constructed to make a large-scale laboratory study possible. The test equipment is described in the order of use: hot cell for preparing the simulant, contamination chamber, and decontamination machine.

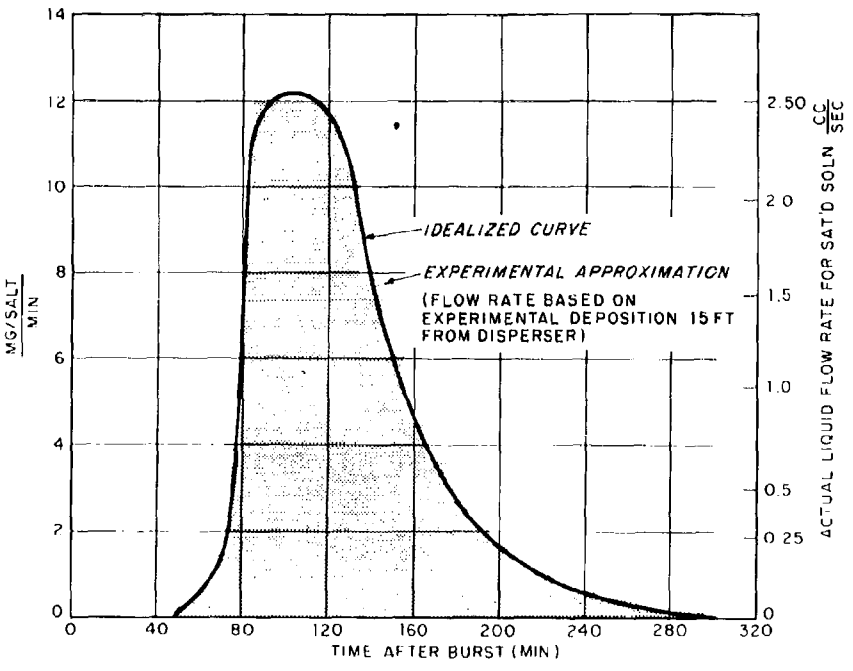


Fig. 1 Typical Fallout Arrival Rate

2. PREPARATION OF SIMULANT

Natural seawater, collected in polyethylene drums thirty miles off San Francisco, is tested for salinity, turbidity, and discoloration. It is then concentrated by a factor of 10, producing a solution saturated with respect to NaCl. At this concentration the insoluble sulfates precipitate, and the solution is actually a slurry. Ideally, the evaporation of the seawater below a concentration factor of 4 must be done at reduced temperatures to prevent premature salting out of the sulfates.[13]

Inert total carriers and the tracer isotope are added before evaporation is started to insure a realistic equilibrium with the precipitate and solution. Introducing the tracer after precipitate has formed might preclude the isotopes entering the crystal structure.

2.1 Process

Thirty gallons of the seawater, which provides a deposit density of 1 gm/ft^2 of salts over the floor area of the contamination chamber, are pumped from the storage containers to a jacketed steam kettle. Solutions of inert total carriers and 1 to 4 curies of the tracer radioisotope are added to the seawater in the kettle. The amount of radionuclide is dictated by its half-life and the response of the counting instruments to its emissions. Radionuclides with weaker gamma energies must be used in correspondingly greater amounts. The resulting solution is then evaporated at 1 atm and 212°F in the steam kettle to a volume of 7.5 gal.

Three gallons of concentrated seawater are transferred to the vacuum evaporation system, and the volume is maintained at 3 to 4 gal by frequent additions from the kettle until the 7.5 gal have been reduced to 3 gal. The simulant is then transferred to a glass bottle shielded with 2 in. of lead.

2.2 Hot Cell and Equipment

Shielding is required for the preparation of synthetic fallout, which contains as much as 4 curies. The cell is constructed of concrete with walls 2 ft thick and 8 ft high to form a U-shaped shield encompassing an area 8 ft by 8 ft. A pair of master-slave manipulators* are installed over the wall and a 2-ft thick, water-filled viewing window is placed in the front face. A sliding back door and a plywood roof are provided to insure that a slight negative pressure can be maintained by a 500-cfm exhaust system. Biological contamination of the water in the viewing window is controlled by the addition of 50 ppm of copper sulfate adjusted to pH 2 with HNO_3.

The evaporation equipment is shown schematically in Fig. 2. A steam kettle, powered by a 1.5-hp boiler, comprises the first stage, operating at 230°F. The evaporation rate in the kettle is 2.5 gph. A sight-gauge indicates the level of water in the kettle.

Further reduction below 7.5 gal is carried out in a vacuum evaporation apparatus consisting of a glass tube 4 ft high and 6 in. in diameter, which is electrically heated at the bottom and sides by three 500-watt heaters. The glass tube is insulated with 2 in. magnesia except for a vertical strip at the front which serves as a sight-gauge. A 2-hp pump provides a vacuum of at least 28 in. of mercury, causing the seawater to boil at 100°F or slightly higher, depending on salt

*Model 4 Manipulators, Argonne National Laboratory, Chicago, Ill.

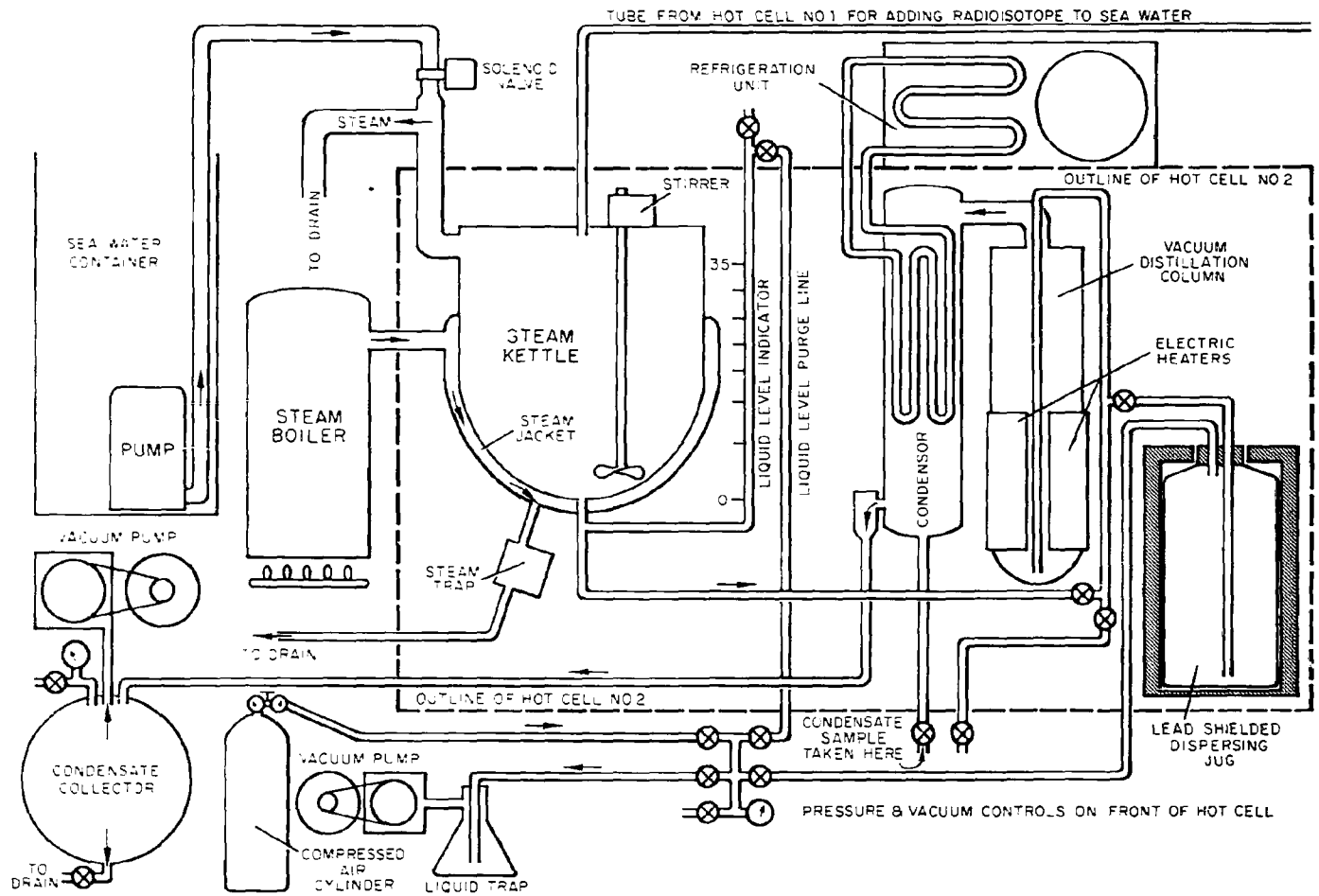


Fig. 2 Hot Cell #2 - Equipment for Steam and Vacuum Distillations of Seawater.

concentration. A 3/4 hp refrigerator unit removes heat from the condenser by passing coolant through 16 ft of folded fin tubing, thus insuring complete condensation of the evaporated water vapor. Rates of 0.6 gph are obtained in the vacuum apparatus.

Carry-over in the vacuum system is prevented by an entrainment screen. All condensate is collected and monitored. The condensate sample valve at the bottom of the condenser is used as an emergency relief valve in the event that the liquid foams up violently.

The transfer of liquid between the steam and vacuum units is accomplished through valves controlled by the master-slave manipulators. An additional system, accessible from the master side of the wall, allows close control of the air added to the vacuum tube to stir the liquid and prevent bumping.

The steam kettle and the vacuum tube are placed in the cell to allow a maximum of manipulator accessibility for other operations. Equipment for isotope separations and assay is mounted on portable tables and spotted under the manipulators.

3. FALLOUT SIMULANT DISPERSAL

The dispersing equipment is designed to allow duplication, as closely as possible, of the physical characteristics of the contamination event from natural fallout. Because of lack of information on the effects of droplet size and delivery rate on decontamination, it was desired to keep these conditions as realistic and reproducible as possible. A spinning disc sprayer[14] was found to meet the test requirement for generating fairly uniformly sized drops over the necessary range of flow rates, with the additional ability to handle slurries without clogging. Moreover, a single disperser in conjunction with a dispersal fan was adequate to cover the test area, eliminating problems arising from attempting to overlap several units.

The size of the drops is dependent upon the size of the disc, the speed at which it is rotated, and, to a lesser extent, the liquid and flow rate used. In general, increasing the diameter and speed of the disc reduces the size of the droplets; larger discs tend to produce a more uniform size. Since it is generally considered that the shape of the disc rim has only a minor effect on performance, a 45° knife-edge was used in all tests, and was found satisfactory.

The discs were initially made from polished aluminum, but corrosion problems necessitated a change to plastic. This change altered the particle size, and investigation showed that an 8-1/8-in. lucite disc was equivalent to the first 8-in. aluminum model. Surface texture and smoothness may explain these differences, although no investigations were made to establish the reason. Long runs at low flow rates resulted in salt crystal growth on the periphery of the disc, but a momentary increase in flow rate washed away the incrustation.

3.1 Drop-Sizing Equations

Two equations were used to guide the selection of speed and disc diameter for trial runs. Sizing tests were conducted, however, to determine the exact diameter and speed of the disc which would yield the required 200-μ (mass-average) droplets.

Walton and Prewett[15] give the equation:

$$d\omega\,(D\rho/\tau)^{1/2} = \text{Constant} \qquad (1)$$

where d = drop diameter (cm)
ω = disc angular velocity (rads/sec)
D = disc diameter (cm)
ρ = liquid density (g/cm^3)
τ = liquid surface tension (dyne/cm)

The empirically determined dimensionless constant ranges from 3.36 to 2.67 for water, decreasing with increasing disc size. For pure water ρ = 1, τ = 73, and, assuming the constant = 3.0 and the disc size is 8 in. or 20 cm, we arrive at:

$$\omega = \frac{3.0}{d(D\rho/\tau)^{1/2}} = \frac{3.0}{0.5246d} = 286 \text{ rads/sec}$$

for a 200-μ particle. This is equivalent to 286 x 60/628 = 2730 rpm.

The second equation, presented by Mugele,[16] is:

$$\frac{x}{D} = A(D\rho\ V/\mu_d)^B(\mu_d V/\sigma)^C, \qquad (2)$$

where A = 1.73, B = -0.50, and C = -0.45
D = diameter of the disc (cm)
ρ = density of droplet phase (water)
V = dispersed phase velocity ($D\omega/2$)
σ = interfacial tension (dynes/cm)
μ_d = viscosity of droplet phase (g/cm sec)
x = maximum stable droplet diameter

The constants A, B and C have been developed from experimental data. Taking D = 20 cm, ρ = 1 g/cm^3, μ_d = 0.01 g/cm sec, σ = 73 dynes/cm or g/sec^2, and V = 10 rads cm/sec, we get:

$$x \text{ cm} = (20 \text{ cm})\ 1.73 \left(\frac{20 \text{ cm} \times 1 \text{g/cm}^3 \times 10\omega \text{ cm/sec}}{0.01 \text{g/cm sec}} \right)^{-.50} \times \left(\frac{0.01 \text{g/cm sec} \times 10\omega \text{ cm/sec}}{73 \text{ g/sec}^2} \right)^{-.45}$$

which gives x = 200 μ for a 3000-rpm disc speed.

A large number of subsequent trial and error experiments demonstrated that an 8-1/8-in. diameter lucite disc, rotated at 3000 rpm, produces an optimum particle size distribution (Fig. 3) for the test requirements. This is in reasonable agreement with Eq. 2, considering that values for pure water are used in the equation and not those of a salt slurry.

Figure 3 also shows the effect of flow rate on the drop size. As the liquid flow rate on the disc is decreased, the size spread diminishes and the number of very fine (satellite) drops is reduced.

Several methods of drop sizing were investigated. Measurement of the crater diameters resulting from impaction of the drops on slides coated with MgO[17] was insensitive to the small drop sizes. Catching the drops in flour, followed by baking, sieving, and weighing the resulting pellets, was also inadequate for the small drops.

The reagent film method[18,19,20] of sizing was found to be the simplest and most accurate. As the drops deposit on a film uniformly coated with a layer of silver chromate, the chloride ions react with the silver ions to form insoluble silver chloride. The films are developed in air saturated with water vapor at a temperature of 70°C. In this atmosphere the silver chloride reaction goes to completion and the silver chloride distributes itself uniformly over a circular area. The dots produced are grey, in contrast with the reddish brown color of the film, and sharply defined. The area of the spots is proportional to the mass of the salt in the drop, hence the diameter of the drop can be calculated when the salt concentration is known.

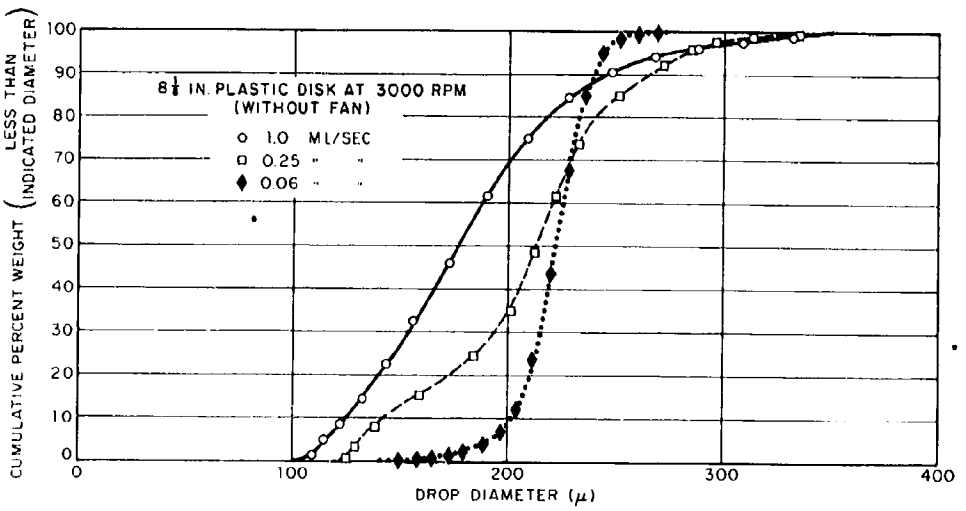


Fig. 3 Droplet Size Determined by Reagent Film Method

3.2 Disperser

The dispersing system (Fig. 4) is mounted on a pallet, 2.5 ft square, which lowers to the floor for servicing and/or inserting the simulant after which it is lifted and secured to a catwalk 36 ft above the floor for the contamination procedure. This height was chosen to allow sufficient time to distribute the droplets radially out to 20 ft by air-moving equipment under the disperser. Power is supplied to the disperser by a 20-conductor cable running to a relay rack at the base of the catwalk. The complete system, through the relays, is remotely controlled from a panel of switches at the end of 300 ft of shielded cables.

The system consists of: (1) a lead-shielded glass bottle containing the simulant; (2) a supply of distilled water to flush the disperser following contamination; (3) a contaminant recycle pump; (4) a positive-displacement metering pump;* and (5) a system of selsyns, solenoids, and connecting tubing to control flow while contamination and flushing occur.

*Simplex metering pump, model DPO, Clark-Cooper Co., Palmyra, N. J.

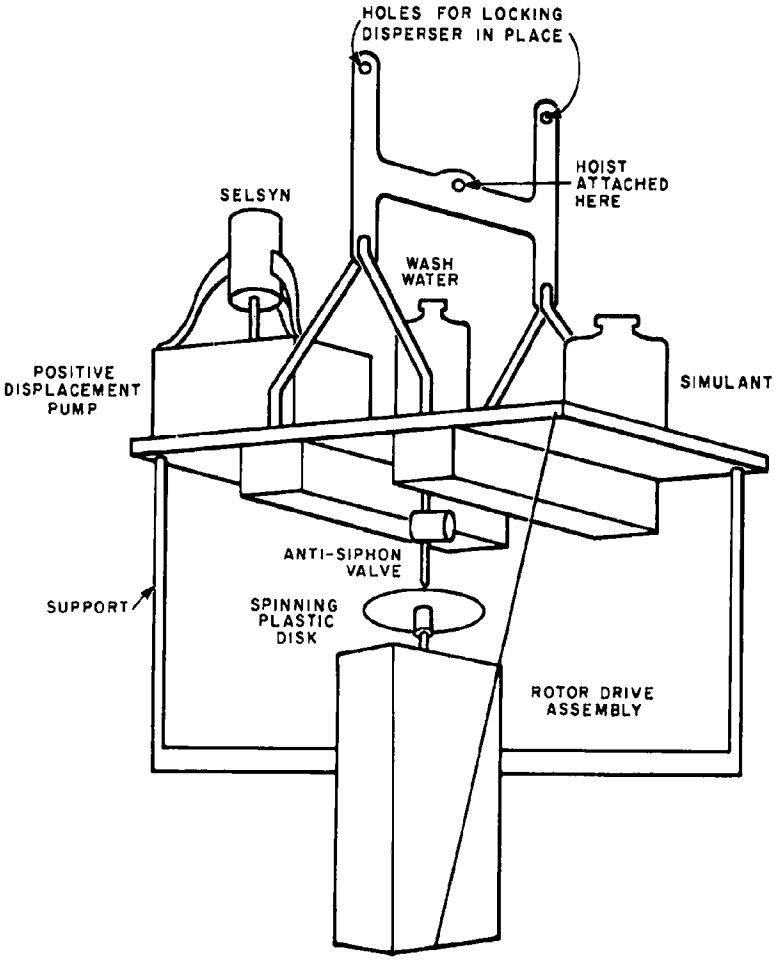


Fig. 4 Diagram of Dispersing Pallet

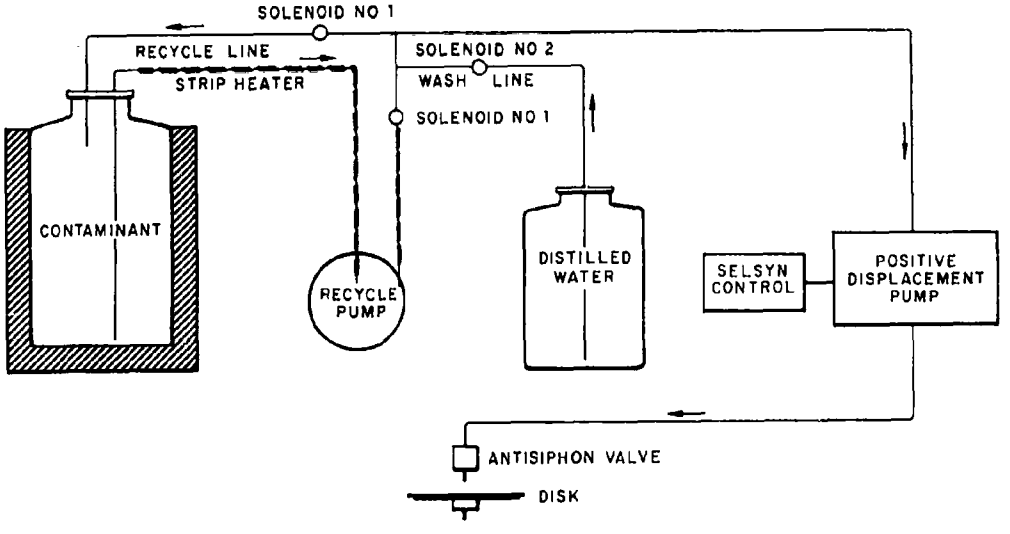


Fig. 5 Flow Diagram of Simulant Disperser

Beneath the pallet is the 8-1/8 in. plastic disc spun at 3000 rpm by a geared synchronous motor.

Solenoid #2 (Fig. 5) controls the distilled water flushing while solenoids #1 (two wired together) open and close the simulant recycle line. The flow of liquid is directed through the positive displacement pump, through an anti-siphon valve (fluid will normally flow through the pump any time the outlet pressure is less than the inlet pressure), through a length of 1/8 in. copper tubing and onto the center of the disc. A 500-watt heating cord is used on the contaminant recycle line to warm the solution to about 40°C and thereby minimize precipitation. A thermocouple indicates temperature of the solution. A pair of selsyns, one mounted on the pump and the other on the control panel, permit control of the flow rate through the positive displacement pump. Five complete revolutions of the selsyns change the flow rate linearly from 0 to 2.8 ml/sec.

The auxiliary air currents necessary to distribute the contaminant over the entire contaminating area are supplied by a rotating cluster of fans located 24 ft above the floor atop a 2 in. pipe mounted firmly in

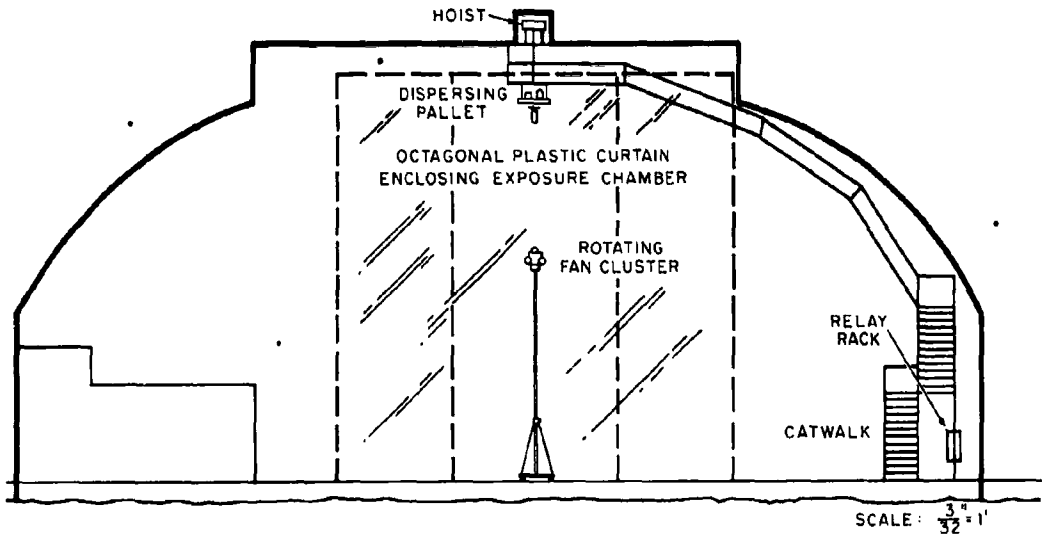


Fig. 6 Diagram of Contaminating Chamber

a 3 ft square concrete base. The entire unit is mounted on casters enabling it to be rolled back when the pallet is lowered. During contamination, it is placed directly beneath the disperser. The cluster consists of three fans, aimed parallel to one another, each driven by a 1/6-hp motor at 1100 rpm. The fans are placed so that their blades (each 18 in. diameter) form a "close pack." The triple fan cluster and rotation speed of 1.9 rpm was found to be the most desirable combination in over 100 individual tests. It is not known how sensitive the deposition pattern on the floor is to vertical separation of the fans from the disperser.

3.3 Exposure Chamber

The contamination is carried out in a 50 x 100 ft room. The entire room has been carefully sealed to prevent the escape of radioactive aerosol to the rest of the building. A plastic-shrouded exposure chamber 40 ft in diameter (Figs. 6 and 7) is provided by 8 overlapping plastic curtains, 36 ft in height. The tops of the curtains are fastened to an

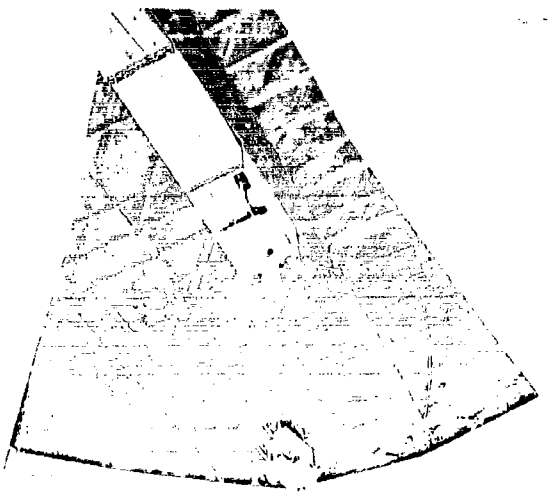


Fig. 7 View From Floor of Dispersing Platform in Position Below Catwalk. Fan system is centered below. Plastic curtain surrounds contamination area.

octagonal frame of 3/4 in. pipe which is supported from the roof by 8 ropes. The ropes are of sufficient length to allow the entire curtain to be lowered and replaced if it becomes contaminated beyond acceptable limits. The bottoms of the curtains are fastened to the floor by wood stringers which prevent their being moved by air motion within the chamber. The floor of the chamber is also covered with several layers of removable plastic sheets and disposable heavy paper, although it should be recognized that the floor never becomes wet due to the realistically low delivery rates used.

3.4 Deposition Pattern

The deposition patterns, measured in mass per unit area versus radius, were determined by a solution of NaCl and using either Mohr's[21] titration or conductivity measurements to measure the amount of salt.

The titration method consisted of collecting the saturated NaCl drops directly in casseroles, washing down with distilled water, and titrating with $AgNO_3$ to a dichromate end point.

With the conductivity method, cups of approximately 500 ml capacity were filled with distilled water and placed at selected positions in the test area. The amount of salt in the water was read directly from the meter and converted to mg/ft^2. The conductivity method was the fastest, hence it was used almost exclusively. The deposition profile was then integrated to determine the total amount deposited. Since the volume dispersed is known, a material balance is then possible.

A continuous remote reading of conductivity measured the continuity of dispersal during the radioactive seawater experiment. The method consists of an electrode beaker in which the cell (of constant 1.0) is immersed in distilled water, and stirred by means of a magnetic stirring bar. As the concentrated sea salt droplets fall in the cup the conductivity change is read remotely.

The deposition patterns 36 ft below the disperser, resulting from free-fall of the droplets generated by the spinning disc, are shown in Fig. 8a. The curves are normalized to give the amount of NaCl per unit area for a given volume of material dispersed. This permits direct comparison of different flow rates and their normal deposition patterns. All 3 curves in Fig. 8a give a nearly equal amount of salt on the floor when integrated over the total circular area. The steep peak for the low flow rate (0.6 cc/sec) suggests that the drop sizes are more uniform and fewer satelites are formed than at higher flow rates.

Definite fractionation in drop size was found to occur with distance from the disperser. Figure 8b shows the average drop size versus floor radius for three different flowrates. The average number of drops for a given floor radius may be calculated from the data given in Figs. 8a and 8b, and is given by the equation:

$$\frac{\text{Number of Drops for a Given Radius}}{\text{ft}^2 \text{ sec}} = \frac{\frac{\text{mg NaCl}}{\text{ft}^2 \text{ ml soln}} \times (\text{flow rate}) \frac{\text{ml soln}}{\text{sec}} \times \left(\frac{1}{\text{conc}}\right) \frac{\text{ml soln}}{\text{mg NaCl}}}{\frac{4}{3}\pi \left(\frac{\mu \text{ diam}}{2}\right)^3 \times \frac{\text{cm}^3}{\mu^3}}$$

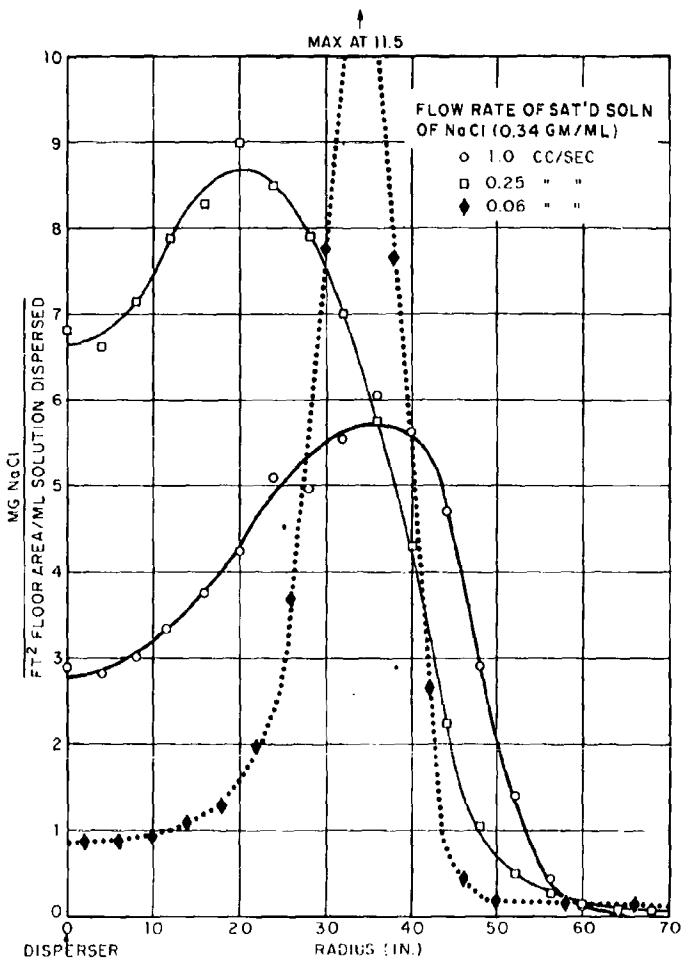


Fig. 8A Spinning Disc Deposition Pattern. Dispersal from 36 ft, without fan.

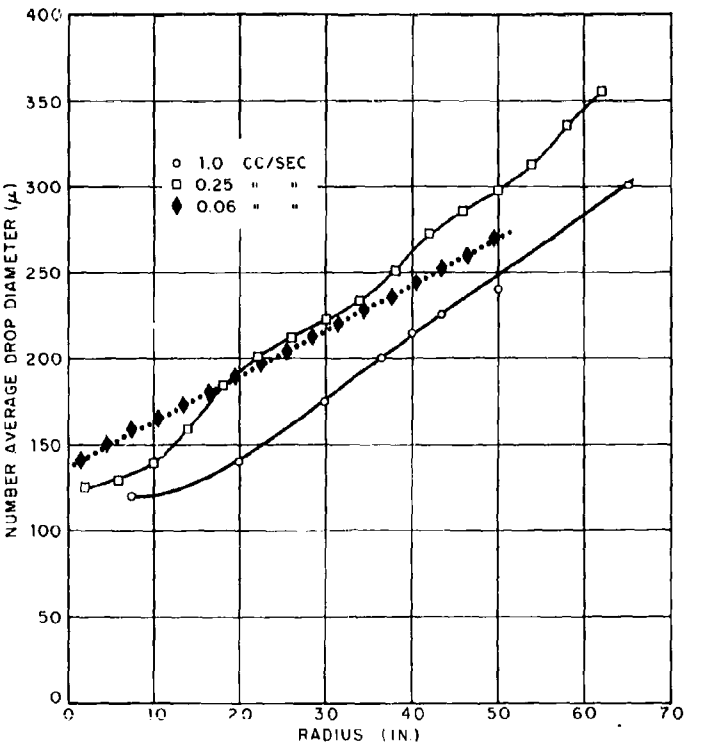


Fig. 8B Average Drop Size as a Function of Lateral Distance From Centerline of Disperser. Dispersal from 36 ft, without fan.

The maximum flow rate is limited only by the capacity of the metering pump (~ 2.8 cc/sec) and the flooding rate on the disc. However, the drop size distribution spreads with increasing flow rates (as seen in Fig. 3).

The deposition pattern which results from the falling droplets after distribution by the rotating cluster of fans is shown in Fig. 9 (salt mass measurement and La^{140} measurement). In both cases more than 80 % of the total area (between 8 and 20 ft from the center) is covered by a mass deposit which is sensibly uniform. While the fine droplets

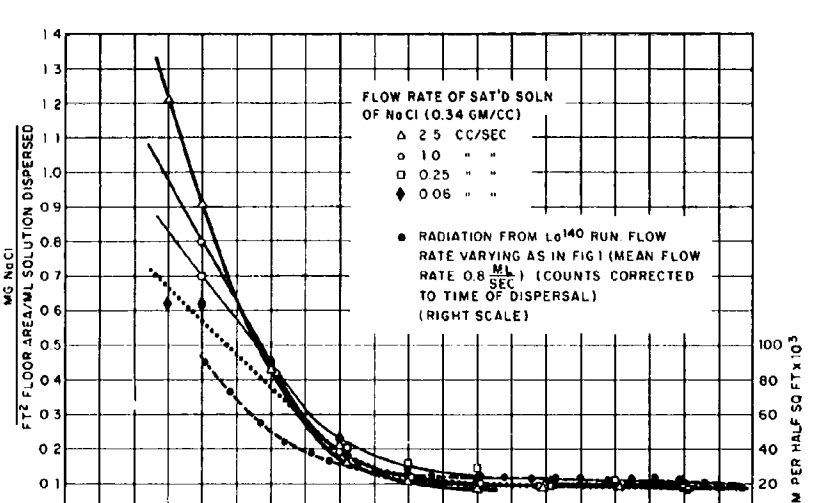


Fig. 9 Spinning Disk Deposition Pattern With Fan On

are predominantly in the center of the free-falling pattern as noted above, the rotating fans reverse the trend and greater numbers of fine droplets are found at the curtain. However, the small drops (under 100 μ diameter) in all cases contribute less than 3 % of the total mass.

Figure 10 (radioautograph) taken at 14 ft, illustrates the uniform deposit over a section of a test plate. The active spots are uniform in size and the surface is nearly saturated.

3.5 Operation

The shielded contaminant container is transported to the dispersing site and placed on the dispersing pallet with a forklift. The pallet is hoisted into position just below the catwalk and locked by remotely operated pins. The fans, disc and recycle line are activated and their satisfactory operation visually verified. The chamber is sealed, air monitoring started, and subsequent operations controlled remotely. The metering pump is started and the flow controlled by the selsyn to follow the programmed fallout rate. At the conclusion of the test the recycling is stopped and distilled water is passed through the pump for several

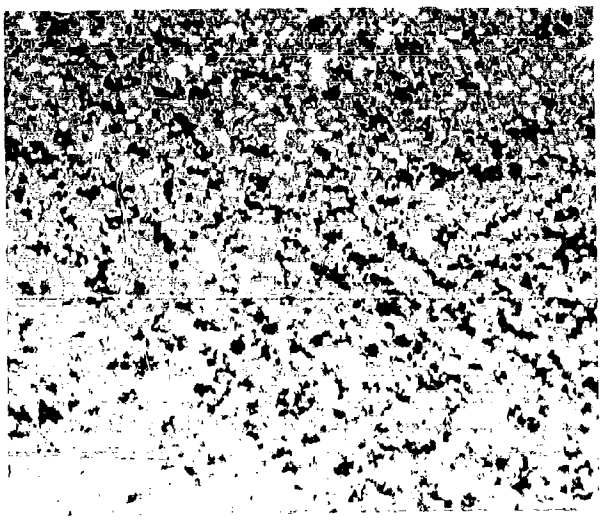


Fig. 10 Radioautograph Taken 14 ft From the Center of the Dispersing Area Showing Surface of a Test Plate After a La^{140} Experiment. Scale is 1:1. Seawater mass is about 0.8 g/ft^2 with an actual activity of 4000 cpm. For the most part contamination appears to be quite uniform.

minutes. This effectively cleans the equipment until servicing can take place.

No significant radioactive aerosol is produced in spaces adjoining the contamination room, and one hour after a test is completed it is possible to enter the curtained area without respirators. The usual rad-safe dress-out equipment (coveralls, booties, gloves, and cap) is worn when removing samples from the chamber. A preliminary test with 750 mc of La^{140} demonstrated that the system was workable. Operating personnel received less than 30 mr of external radiation from the entire experiment.

The study of particle size distribution and deposition patterns required that the dispersing equipment be operated for several hundred hours. No major difficulties were encountered during this time, and the length of the operations enabled formulation of a preventive maintenance schedule.

4. DECONTAMINATION

Two important factors that effect fallout removal were investigated: (1) the physical condition of the surface at the time of fallout, and (2) the parameters of liquid washing.

The condition of the surface and environmental factors (such as temperature, paint type, and humidity) at the time of contamination have proved to be extremely important and can affect recovery factors appreciably.

The parameters of liquid decontamination under investigation include spraying with tap water at varying temperatures, pressures, and spray times, as well as testing the effect of surfactents (surface active agent). Soaking the samples is also used as a control method of removing the activity.

4.1 Sample Plates

Steel plates were cut into 8.5 in. squares and primed with Navy #116 Primer on both sides. Approximately 6000 samples were painted on one side with Navy #20 Deck Gray paint and an equal number with #5 Haze Gray. A limited number of plates (800) were painted with Non-slip deck Gray #20. Figure 11 illustrates the production method used in painting the large number of samples.

The painted samples were weathered under simulated shipboard conditions. The high humidity and atmosphere of diesel fuel residues required were found at the Naval Fueling Depot at Point Malote. An inquiry at the Paint Laboratory at Mare Island Naval Shipyard on the average age of painted surfaces aboard ships led to a weathering period of 90 days.*

Racks with a capacity of 4000 sample plates were placed as shown in Figures 12 and 13. Samples were given a southern exposure at an angle of 60° to the ground.

4.2 Spray Decontamination Machine

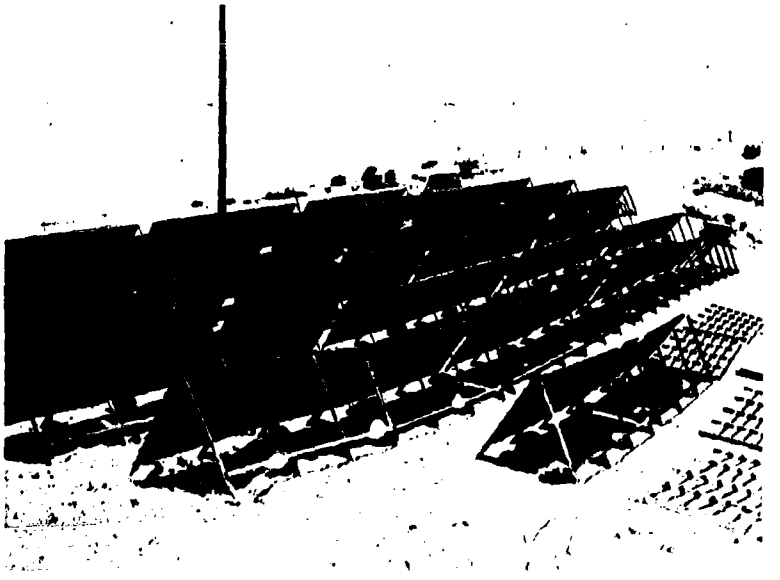
The decontamination machine, shown in Figs. 14, 15, and 16, consists of two lead-shielded counting chambers, mounted on opposite sides of a spray chamber. All three units are in line and a double-acting pneumatic ram transfers the sample plates one at a time from the sample

*Private communication, John Saroyan.

Fig. 11 Sample Plates Being Painted.

feeding box, through the machine. The plate moves to counter #1 for a 1 min. count, then to the spray chamber for decontamination, and finally to counter #2 for another 1-min. count after which it is ejected from the machine. The samples, guided by rails and moved by the ram, are always centered at the same location under the counting detectors and the spray nozzle.

The lead shielding on the counting chambers is 2 in. thick except counter #1 where an additional 2 in. is on the side adjacent to the box of active plates in the feeder. A 1-1/2 in. thick lead insert was added between the spray chamber and counter #2. The detectors are located 18 in. above the centers of the samples. Each detector consists of a 1.5-in. diameter, 1/2-in. thick, NaI (Tl) crystal viewed by a 6292 multiplier phototube, with a cathode follower that is connected to a 1091-3 Systron-Donner scaler with digital recorder.



Figs. 12 and 13 Test Plates Being Weathered at Point Malote.

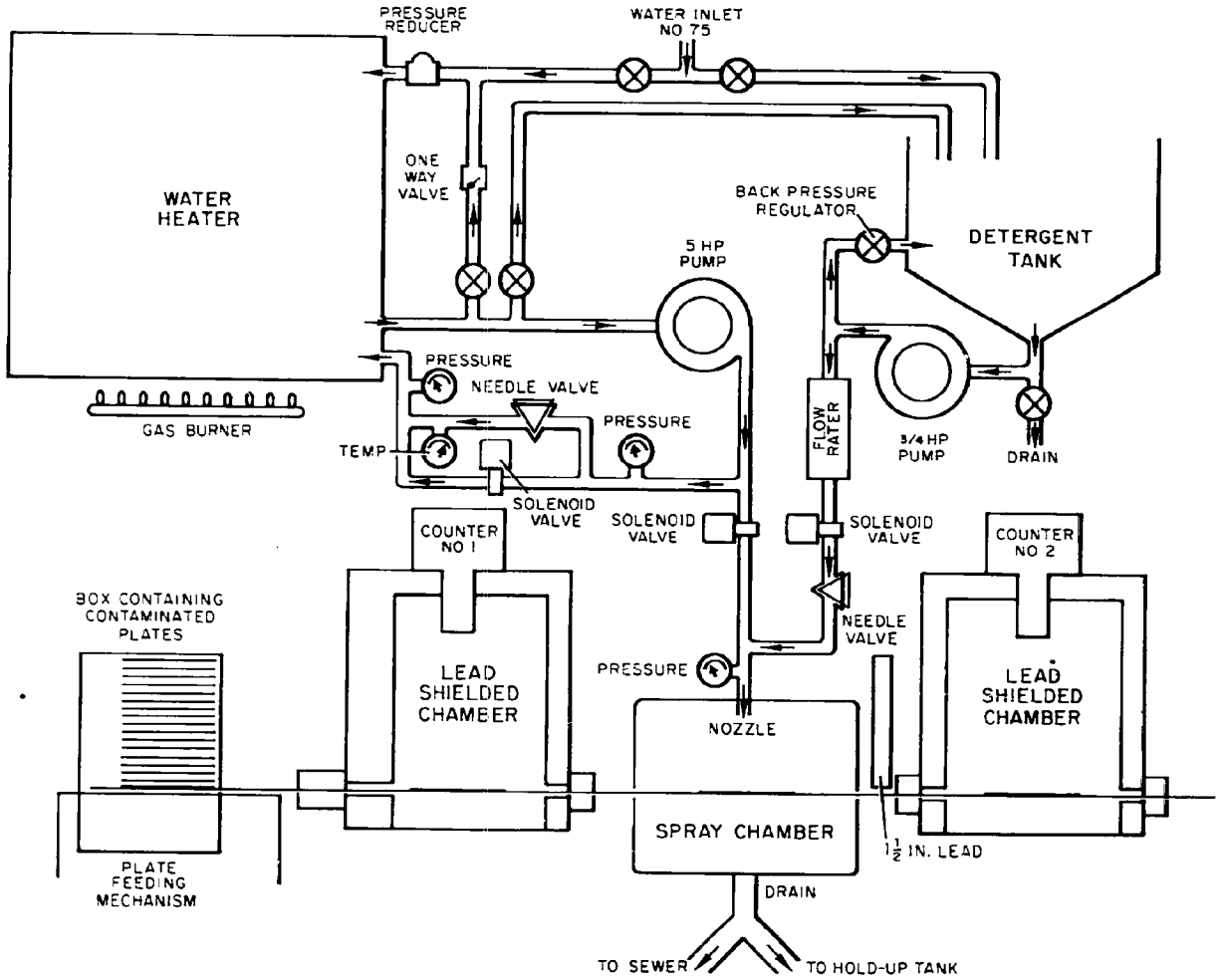
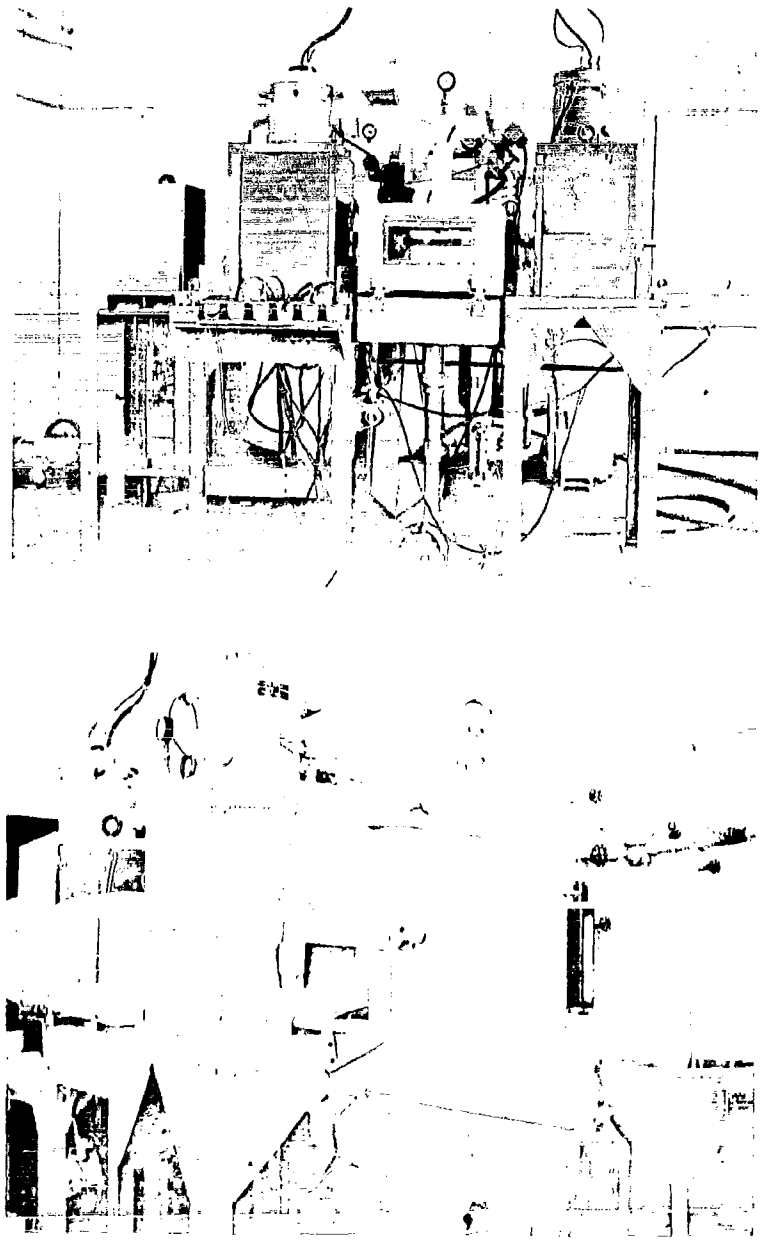


Fig. 14 Flow Diagram of Decontamination Machine.



Figs. 15 and 16 Front and Side Views of Decontamination Machine.

Lead doors, of the same thickness as the walls, cover the slots through which plates enter and leave the counting chambers. These doors are opened and closed by another pneumatic ram. A manually opened door in the front of each counter permits access to the chambers for purposes of cleaning.

The decontamination chamber consists of an aluminum box with plastic windows front and back. A spray nozzle* is mounted 7 in. above the center of the plates being washed. Inside the chamber, baffle plates and doors, which are connected to the lead counting chamber doors, prevent the spray water from escaping through the plate slots. A small exhaust fan on the chamber maintains a slight negative pressure, which eliminates aerosol problems.

Washed plates are subjected to an air blast to remove water prior to entering counter #2. The air jet was investigated and found to have no decontamination effect of its own. A 2-hp compressor supplies air for the doors, the ram, and the air jet.

The functions of the equipment - rams, spraying, and counting - are controlled by individual switches mounted on the front of the machine. The possibility of automating the cycle, except for setting spray conditions and changing boxes, has been investigated and may be instituted in the future.

The equipment has been calibrated and a nomograph was constructed to facilitate the selection of settings. During decontamination, parameter changes are scheduled to require minimum effort.

At intervals during the decontamination, standards are counted in both counters to determine the activity-to-count ratio of each. Background counts are taken several times an hour. With a counting time of 1-min, a rate of 50 plates per hour can be maintained.

4.3 Spray Equipment

Tap water at 70 psi is fed to a 135-gal, 700,000-BTU water heater** through a pressure reducer. A 5-hp pump recirculates the water from the heater so that hot water is always available at the nozzle. A balanced pair of solenoids, with a metered by-pass, allows diversion of the steam to the spray nozzle or to the heater (Fig. 14). Gauges indicate water temperature and pressure in the recycle line and at the nozzle. An air leg on the recycle line provides a cushion against water hammer when the solenoids divert the stream. A thermocouple mounted in the spray chamber

* Fullject Nozzle #3/4HH50SQ, Spraying Systems Co., Bellwood, Ill.
**Model No. 136G, Bock Corp., Madison, Wisconsin.

near the surface of the plate and in the spray pattern is connected to a Brown millivolt recorder which indicates the temperature directly in ^{o}F.

Surfactent solutions, 5 to 10 % by weight, are mixed in a 25-gal stainless steel tank. A 3/4-hp pump recycles and injects the solution into the main water stream just ahead of the nozzle. A flowrator is used to control the surfactent concentration in the spray.

The drain from the spray chamber may be directed to the sewer, or to a 12,000-gal sunken holding pit adjacent to the building. The concrete pit is equipped with a plastic swimming pool liner which facilitates total decontamination and prevents seepage. The pit is covered with a removable aluminum roof and surrounded by a chain-link fence.

4.4 Decontamination Parameters

In this experiment the relative importance and optimum values of the parameters involved in shipboard decontamination are investigated. The ranges of the variables provided by the equipment are as follows:

Parameter	Equipment Range
Spray Temperature	Room temperature($\sim 60^{o}F$) to + $170^{o}F$
Nozzle pressure	10 to 150 psig
Flow rate	5 to 20 gpm
Spray time	Flexible from 0.5 sec and up
Surfactent type	any non-corrosive liquid
Surfactent conc.	0 to 4 % by weight

5. SUMMARY

The equipment for realistic surface contamination and precise control of decontamination was designed, constructed, and tested as the first step in a systematic study of vulnerability of ships' surfaces to the fallout from a sea-surface nuclear detonation.

The simulant, which closely approximates the characteristics of natural seawater fallout, was formulated from data provided by field tests.

The study will involve the use of individual tracer isotope experiments to provide general contamination-decontamination information, and not specific information that is limited by the fission product composition which changes with time and condition.

REFERENCES

1. The Effects of Atomic Weapons, Atomic Energy Commission, 1950, p. 251.

2. R. C. Bolles, N. E. Ballou. Calculated Activity and Abundances of U^{235} Fission Products. U. S. Naval Radiological Defense Laboratory Report, USNRDL-456, August 1956.

3. W. B. Lane. Decontamination Studies with Navy Gray Paint Surfaces Contaminated at Operation HARDTACK. U. S. Naval Radiological Defense Laboratory Technical Report, USNRDL-TR-384, September 1959.

4. C. F. Miller, P. Loeb. Ionization Rate and Photon Pulse Decay of Fission Products From the Slow-Neutron Fission of U^{235}. U. S. Naval Radiological Defense Laboratory Technical Report, USNRDL-TR-247, August 1958.

5. C. F. Miller. Theory of Decontamination, Part I. U. S. Naval Radiological Defense Laboratory Report, USNRDL-460, July 1958.

6. W. J. Heiman. Contribution of Different Chemical Elements to the Rate of Gamma Radiation at Various Times After an Underwater Burst. U. S. Naval Radiological Defense Laboratory Report, USNRDL-387, November 1952 (Classified).

7. C. F. Miller, R. Cole, W. J. Heiman. An Investigation of Synthetic Contaminants for an Atomic Burst in Deep Seawater. U. S. Naval Radiological Defense Laboratory Report, USNRDL-411, August 1953 (Classified).

8. N. H. Farlow, W. Schell. Physical, Chemical and Radiological Properties of Slurry Particulate Collected During Operation REDWING. U. S. Naval Radiological Defense Laboratory Technical Report, USNRDL-TR-170, May 1957.

9. C. F. Miller. "The Formation and Properties of Seawater Fallout." Proceedings of Tripartite Symposium on Technical Status of Radiological Defense in the Fleets, Volume II. U. S. Naval Radiological Defense Laboratory, May 1960 (Classified).

10. J. Orr, F. K. Hurd, W. P. Hendrix and W. J. Corbett. An Investigation into the Growth of Smaller Aerosol Particles with Humidity Change. Project No. A-162, Engineering Experimental Station, Georgia Institute of Technology, December 31, 1956.

11. T. Triffet, P. D. LaRiviere. Characterization of Fallout (Operation REDWING). U. S. Naval Radiological Defense Laboratory Report, WT-1317, March 1961 (Classified).

12. P. D. LaRiviere. The Relationship of Time of Peak Activity From Fallout to Time of Arrival. U. S. Naval Radiological Defense Laboratory Technical Report, USNRDL-TR-137, February 1957.

13. F. C. Standiford, J. R. Sinek. "Scale Prevention", Chemical Engineering Progress, Vol. 57, No. 1, 1961, pp. 58-63.

14. W. R. Marshall. "Automization and Spray Drying", Chemical Engineering Progress Monograph Series, No. 2, Vol. 50, 1954, Chapt. III.

15. W. H. Walton, W. C. Prewett. Proceedings of the Physical Society, Sec. B., Vol. 62, Part 6, No. 354B, June 1949, p. 23.

16. R. A. Mugele. Chemical Engineering Journal, Vol. 6, No. 1, 1960, p. 3.

17. K. R. May. Journal Scientific Instruments, 22:187, 1945.

18. N. H. Farlow, F. A. French. Journal of Colloid Science 11:1956, 177-183.

19. N. H. Farlow. Journal of Meteorology, Vol. 15, No. 2, 1958, pp. 228-230.

20. N. H. Farlow. Analytical Chemistry, 29:883, 1957.

21. N. Howell Furman, Scotts Standard Methods of Chemical Analysis, D. Van Nostrand Co., 5th Edition, 1939, p. 272.

DISTRIBUTION

Copies

NAVY

1-3	Chief, Bureau of Ships (Code 335)
4	Chief, Bureau of Ships (Code 320)
5	Chief, Bureau of Naval Weapons (RRMA-11)
6-7	Chief, Bureau of Yards and Docks (Code 74)
8	Chief of Naval Operations (Op-07T)
9	Chief of Naval Research (Code 104)
10	Commander, New York Naval Shipyard (Material Lab.)
11-13	Director, Naval Research Laboratory (Code 2021)
14	Office of Naval Research (Code 422)
15-20	Office of Naval Research, FPO, New York
21	CO, Naval Unit, Army Chemical Center
22	CO, U.S. Naval Civil Engineering Laboratory
23	U.S. Naval School (CEC Officers)
24	Commander, Naval Air Material Center, Philadelphia
25	Naval Medical Research Institute
26	U.S. Naval Hospital, San Diego
27	U.S. Naval Postgraduate School, Monterey
28	Office of Patent Counsel, San Diego
29	Director, Institute of Naval Studies, Newport
30	CO, Naval Medical Field Research Laboratory, Camp Lejeune

ARMY

31	Chief of Research and Development (Atomic Div.)
32	Chief of Research and Development (Life Science Div.)
33	Deputy Chief of Staff for Military Operations
34	Office of Assistant Chief of Staff, G-2
35	Chief of Engineers (ENGMC-EB)
36	Chief of Engineers (ENGMC-DE)
37	Chief of Engineers (ENGRD-S)
38	Chief of Engineers (ENGCW-C)
39	Chief of Transportation (TC Technical Committee)
40	Chief of Ordnance (ORDTN-RE)
41	CG, Ballistic Research Laboratories
42	Chief Chemical Officer
43	Chief Chemical Officer (Director for Safety)
44	CG, Chemical Corps Res. and Dev. Command

45	Hq., Chemical Corps Materiel Command
46	President, Chemical Corps Board
47-49	CO, BW Laboratories
50	CO, Chemical Corps Training Command
51	Commandant, Chemical Corps Schools (Library)
52	CO, Chemical Corps Field Requirements Agency
53	CO, Chemical Research and Development Laboratories
54	Commander, Chemical Corps Nuclear Defense Laboratory
55	Hq., Army Environmental Hygiene Agency
56	CG, Aberdeen Proving Ground
57	Office of Chief Signal Officer (SIGRD-8B)
58	CO, Army Medical Research Laboratory
59	Director, Walter Reed Army Medical Center
60	Hq., Army Nuclear Medicine Research Detach., Europe
61	HQ., CONARC (CD-CORG Library)
62	CG, Quartermaster Res. and Eng. Command
63	Quartermaster Food and Container Institute
64	President, Quartermaster Board, Fort Lee
65	Hq., Dugway Proving Ground
66-68	The Surgeon General (MEDNE)
69	CO, Army Signal Res. and Dev. Laboratory
70	CG, Army Electronic Proving Ground
71	CG, Engineer Res. and Dev. Laboratory
72	Director, Office of Special Weapons Development
73	CO, Office of Ordnance Research
74	CO, Watertown Arsenal
75	CG, Ordnance Tank-Automotive Command
76	CO, Ordnance Materials Research Office, Watertown
77	CO, Picatinny Arsenal (ORDBB-TW6)
78	CO, Frankford Arsenal
79	Jet Propulsion Laboratory
80	Army Ballistic Missile Agency
81	Commandant, Command and General Staff College

AIR FORCE

82	Assistant Chief of Staff, Intelligence (AFCIN-3B)
83-88	Commander, Aeronautical Systems Division (ASAPRD-NS)
89	Commandant, Institute of Technology (Sherwood)
90	Directorate of Civil Engineering (AFOCE-ES)
91	Director, USAF Project RAND
92-93	Commandant, School of Aerospace Medicine, Brooks AFB
94	CG, Strategic Air Command (Operations Analysis Office)
95	Office of the Surgeon (SUP3.1), Strategic Air Command
96	Office of the Surgeon General
97	Commander, Special Weapons Center, Kirtland AFB
98	Director, Air University Library, Maxwell AFB
99-100	Commander, Technical Training Wing, 3415th TTG
101	Commander, Electronic Systems Division (CRZT)

OTHER DOD ACTIVITIES

102-104	Chief, Defense Atomic Support Agency (Library)
105	Commander, FC/DASA, Sandia Base (FCDV)
106	Commander, FC/DASA, Sandia Base (FCTG5, Library)
107	Commander, FC/DASA, Sandia Base (FCWT)
108	Assistant Secretary of Defense (Supply and Logistics)
109-118	Armed Services Technical Information Agency
119	Director, Armed Forces Radiobiology Research Institute

OCD

120	Office of Civil Defense, Washington
121	Office of Civil Defense, Battle Creek

AEC ACTIVITIES AND OTHERS

122	Research Analysis Corporation
123	U.S. Weather Bureau, Washington (Special Projects Section)
124	Aerojet General, Azusa
125	Aerojet General, San Ramon
126	Alco Products, Inc.
127	Allis-Chalmers Manufacturing Co., Milwaukee
128	Allis-Chalmers Manufacturing Co., Washington
129	Allison Division - GMC
130-131	Argonne Cancer Research Hospital
132-141	Argonne National Laboratory
142	Atomic Bomb Casualty Commission
143	AEC Scientific Representative, France
144	AEC Scientific Representative, Japan
145-147	Atomic Energy Commission, Washington
148-151	Atomic Energy of Canada, Limited
152-155	Atomics International
156-157	Babcock and Wilcox Company
158-159	Battelle Memorial Institute
160	Beryllium Corporation
161-164	Brookhaven National Laboratory
165	Bureau of Mines, Albany
166	Bureau of Mines, Salt Lake City
167	Chance Vought Aircraft, Inc.
168	Chicago Patent Group
169	Columbia University (Cropper)
170	Combustion Engineering, Inc.
171	Combustion Engineering, Inc. (NRD)
172	Committee on the Effects of Atomic Radiation
173-174	Convair Division, Fort Worth
175	Defence Research Member
176	Denver Research Institute
177	Division of Raw Materials, Washington
178	Dow Chemical Company, Rocky Flats
179-181	duPont Company, Aiken

182	duPont Company, Wilmington
183	Edgerton, Germeshausen and Grier, Inc., Goleta
184	Edgerton, Germeshausen and Grier, Inc., Las Vegas
185	General Atomic Division
186-187	General Electric Company (ANPD)
188-191	General Electric Company, Richland
192	General Electric Company, St. Petersburg
193	Glasstone, Samuel
194	Goodyear Aircraft Company, Akron
195-196	Goodyear Atomic Corporation
197	Grand Junction Office
198	Hawaii Marine Laboratory
199	Hughes Aircraft Company, Culver City
200-201	Iowa State University
202-203	Knolls Atomic Power Laboratory
204	Lockheed Aircraft Corporation
205-206	Los Alamos Scientific Laboratory (Library)
207	Mallinckrodt Chemical Works
208	Maritime Administration
209	Martin Company
210	Massachusetts Institute of Technology (Hardy)
211	Massachusetts Institute of Technology (Thompson)
212	Monsanto Chemical Company
213	Mound Laboratory
214	NASA, Lewis Research Center
215	National Bureau of Standards (Library)
216	National Bureau of Standards (Taylor)
217	National Lead Company of Ohio
218	New Brunswick Area Office
219	New York Operations Office
220	Nuclear Materials and Equipment Corporation
221	Nuclear Metals, Inc.
222	Oak Ridge Institute of Nuclear Studies
223	Patent Branch, Washington
224-227	Phillips Petroleum Company
228	Power Reactor Development Company
229-232	Pratt and Whitney Aircraft Division
233	Princeton University (White)
234-235	Public Health Service, Washington
236	Public Health Service, Las Vegas
237	Public Health Service, Montgomery
238	Purdue University
239	Radiation Applications, Inc.
240	Sandia Corporation, Albuquerque
241	Sandia Corporation, Livermore
242	Sylvania Electric Products, Inc.
243	Technical Research Group
244-246	Union Carbide Nuclear Company (ORGDP)
247-250	Union Carbide Nuclear Company (ORNL)
251	Union Carbide Nuclear Company (Paducah Plant)
252	United Nuclear Corporation (NDA)

253	U.S. Geological Survey, Denver
254	U.S. Geological Survey, Menlo Park
255	U.S. Geological Survey, Naval Gun Factory
256	U.S. Geological Survey, Washington
257	U.S. Geological Survey, Washington (WR Div.)
258-259	University of California Lawrence Radiation Lab., Berkeley
260-261	University of California Lawrence Radiation Lab., Livermore
262	University of California, Los Angeles
263	University of Puerto Rico
264	University of Rochester (Atomic Energy Project)
265	University of Utah
266	University of Washington (Donaldson)
267-268	Westinghouse Bettis Atomic Power Laboratory
269	Westinghouse Electric Corporation
270	Yankee Atomic Electric Company
271-295	Technical Information Service, Oak Ridge

USNRDL

296-325	USNRDL, Technical Information Division

DISTRIBUTION DATE: 10 April 1962

Naval Radiological Defense Laboratory
USNRDL-TR-549
DECONTAMINATION OF SHIPS' SURFACES.
II. DESIGN AND CONSTRUCTION OF EXPERIMENTAL FACILITIES
by R.N. Anderson and R.M. Railey
30 Jan 1962 32 p tables illus 21 refs
UNCLASSIFIED

A laboratory study of the fallout from a seawater nuclear detonation and its contamination of ships' surfaces requires special equipment to make the radioactive simulant, to generate and disperse the simulant on painted surfaces, and to decontaminate
(over)

1. Fallout - Simulation.
2. Seawater - Radiological contamination.
3. Radiological contamination - Countermeasures.
4. Ships - Decontamination.
5. Radioactivity - Test facilities.

I. Anderson, R.N.
II. Railey, R.M.
III. Title.
IV. S-F011 05 08.

UNCLASSIFIED

Naval Radiological Defense Laboratory
USNRDL-TR-549
DECONTAMINATION OF SHIPS' SURFACES.
II. DESIGN AND CONSTRUCTION OF EXPERIMENTAL FACILITIES
by R.N. Anderson and R.M. Railey
30 Jan 1962 32 p tables illus 21 refs
UNCLASSIFIED

A laboratory study of the fallout from a seawater nuclear detonation and its contamination of ships' surfaces requires special equipment to make the radioactive simulant, to generate and disperse the simulant on painted surfaces, and to decontaminate
(over)

1. Fallout - Simulation.
2. Seawater - Radiological contamination.
3. Radiological contamination - Countermeasures.
4. Ships - Decontamination.
5. Radioactivity - Test facilities.

I. Anderson, R.N.
II. Railey, R.M.
III. Title.
IV. S-F011 05 08.

UNCLASSIFIED

Naval Radiological Defense Laboratory
USNRDL-TR-549
DECONTAMINATION OF SHIPS' SURFACES.
II. DESIGN AND CONSTRUCTION OF EXPERIMENTAL FACILITIES
by R.N. Anderson and R.M. Railey
30 Jan 1962 32 p tables illus 21 refs
UNCLASSIFIED

A laboratory study of the fallout from a seawater nuclear detonation and its contamination of ships' surfaces requires special equipment to make the radioactive simulant, to generate and disperse the simulant on painted surfaces, and to decontaminate
(over)

1. Fallout - Simulation.
2. Seawater - Radiological contamination.
3. Radiological contamination - Countermeasures.
4. Ships - Decontamination.
5. Radioactivity - Test facilities.

I. Anderson, R.N.
II. Railey, R.M.
III. Title.
IV. S-F011 05 08.

UNCLASSIFIED

Naval Radiological Defense Laboratory
USNRDL-TR-549
DECONTAMINATION OF SHIPS' SURFACES.
II. DESIGN AND CONSTRUCTION OF EXPERIMENTAL FACILITIES
by R.N. Anderson and R.M. Railey
30 Jan 1962 32 p tables illus 21 refs
UNCLASSIFIED

A laboratory study of the fallout from a seawater nuclear detonation and its contamination of ships' surfaces requires special equipment to make the radioactive simulant, to generate and disperse the simulant on painted surfaces, and to decontaminate
(over)

1. Fallout - Simulation.
2. Seawater - Radiological contamination.
3. Radiological contamination - Countermeasures.
4. Ships - Decontamination.
5. Radioactivity - Test facilities.

I. Anderson, R.N.
II. Railey, R.M.
III. Title.
IV. S-F011 05 08.

UNCLASSIFIED

these surfaces by liquid methods.

The simulant is produced by evaporating 30 gal of seawater containing approximately 2 curies of a selected gamma-emitting radionuclide to a final volume of 3 gal. The concentrated solution is fed to a spinning disc generator which produces 200-μ diameter drops at flow rates from 0.06 ml/sec to 2.5 ml/sec.

The drops are generated at the top of a polyethylene-lined chamber 36 ft high, and, as they settle at terminal velocity, they are distributed by a rotating cluster of fans to uniformly deposit on plates 8.5 in. square. The plates are painted with Navy paints, and cover a floor area of 1256 ft^2.

The contaminated plates are counted, washed, and recounted at the rate of 50/hr in a machine which simulates firehosing and steam cleaning. The effects of solution temperature, spray pressure, spray time and chemical additives in the liquid decontamination methods may thus be evaluated.

UNCLASSIFIED

these surfaces by liquid methods.

The simulant is produced by evaporating 30 gal of seawater containing approximately 2 curies of a selected gamma-emitting radionuclide to a final volume of 3 gal. The concentrated solution is fed to a spinning disc generator which produces 200-μ diameter drops at flow rates from 0.06 ml/sec to 2.5 ml/sec.

The drops are generated at the top of a polyethylene-lined chamber 36 ft high, and, as they settle at terminal velocity, they are distributed by a rotating cluster of fans to uniformly deposit on plates 8.5 in. square. The plates are painted with Navy paints, and cover a floor area of 1256 ft^2.

The contaminated plates are counted, washed, and recounted at the rate of 50/hr in a machine which simulates firehosing and steam cleaning. The effects of solution temperature, spray pressure, spray time and chemical additives in the liquid decontamination methods may thus be evaluated.

UNCLASSIFIED

these surfaces by liquid methods.

The simulant is produced by evaporating 30 gal of seawater containing approximately 2 curies of a selected gamma-emitting radionuclide to a final volume of 3 gal. The concentrated solution is fed to a spinning disc generator which produces 200-μ diameter drops at flow rates from 0.06 ml/sec to 2.5 ml/sec.

The drops are generated at the top of a polyethylene-lined chamber 36 ft high, and, as they settle at terminal velocity, they are distributed by a rotating cluster of fans to uniformly deposit on plates 8.5 in. square. The plates are painted with Navy paints, and cover a floor area of 1256 ft^2.

The contaminated plates are counted, washed, and recounted at the rate of 50/hr in a machine which simulates firehosing and steam cleaning. The effects of solution temperature, spray pressure, spray time and chemical additives in the liquid decontamination methods may thus be evaluated.

UNCLASSIFIED

these surfaces by liquid methods.

The simulant is produced by evaporating 30 gal of seawater containing approximately 2 curies of a selected gamma-emitting radionuclide to a final volume of 3 gal. The concentrated solution is fed to a spinning disc generator which produces 200-μ diameter drops at flow rates from 0.06 ml/sec to 2.5 ml/sec.

The drops are generated at the top of a polyethylene-lined chamber 36 ft high, and, as they settle at terminal velocity, they are distributed by a rotating cluster of fans to uniformly deposit on plates 8.5 in. square. The plates are painted with Navy paints, and cover a floor area of 1256 ft^2.

The contaminated plates are counted, washed, and recounted at the rate of 50/hr in a machine which simulates firehosing and steam cleaning. The effects of solution temperature, spray pressure, spray time and chemical additives in the liquid decontamination methods may thus be evaluated.

UNCLASSIFIED

Naval Radiological Defense Laboratory
USNRDL-TR-549
DECONTAMINATION OF SHIPS' SURFACES.
II. DESIGN AND CONSTRUCTION OF EXPERIMENTAL FACILITIES
by R.N. Anderson and R.M. Railey
30 Jan 1962 32 p tables illus 21 refs
UNCLASSIFIED

A laboratory study of the fallout from a seawater nuclear detonation and its contamination of ships' surfaces requires special equipment to make the radioactive simulant, to generate and disperse the simulant on painted surfaces, and to decontaminate
(over)

1. Fallout - Simulation.
2. Seawater - Radiological contamination.
3. Radiological contamination - Countermeasures.
4. Ships - Decontamination.
5. Radioactivity - Test facilities.

I. Anderson, R.N.
II. Railey, R.M.
III. Title.
IV. S-F011 05 08.

UNCLASSIFIED

Naval Radiological Defense Laboratory
USNRDL-TR-549
DECONTAMINATION OF SHIPS' SURFACES.
II. DESIGN AND CONSTRUCTION OF EXPERIMENTAL FACILITIES
by R.N. Anderson and R.M. Railey
30 Jan 1962 32 p tables illus 21 refs
UNCLASSIFIED

A laboratory study of the fallout from a seawater nuclear detonation and its contamination of ships' surfaces requires special equipment to make the radioactive simulant, to generate and disperse the simulant on painted surfaces, and to decontaminate
(over)

1. Fallout - Simulation.
2. Seawater - Radiological contamination.
3. Radiological contamination - Countermeasures.
4. Ships - Decontamination.
5. Radioactivity - Test facilities.

I. Anderson, R.N.
II. Railey, R.M.
III. Title.
IV. S-F011 05 08.

UNCLASSIFIED

Naval Radiological Defense Laboratory
USNRDL-TR-549
DECONTAMINATION OF SHIPS' SURFACES.
II. DESIGN AND CONSTRUCTION OF EXPERIMENTAL FACILITIES
by R.N. Anderson and R.M. Railey
30 Jan 1962 32 p tables illus 21 refs
UNCLASSIFIED

A laboratory study of the fallout from a seawater nuclear detonation and its contamination of ships' surfaces requires special equipment to make the radioactive simulant, to generate and disperse the simulant on painted surfaces, and to decontaminate
(over)

1. Fallout - Simulation.
2. Seawater - Radiological contamination.
3. Radiological contamination - Countermeasures.
4. Ships - Decontamination.
5. Radioactivity - Test facilities.

I. Anderson, R.N.
II. Railey, R.M.
III. Title.
IV. S-F011 05 08.

UNCLASSIFIED

Naval Radiological Defense Laboratory
USNRDL-TR-549
DECONTAMINATION OF SHIPS' SURFACES.
II. DESIGN AND CONSTRUCTION OF EXPERIMENTAL FACILITIES
by R.N. Anderson and R.M. Railey
30 Jan 1962 32 p tables illus 21 refs
UNCLASSIFIED

A laboratory study of the fallout from a seawater nuclear detonation and its contamination of ships' surfaces requires special equipment to make the radioactive simulant, to generate and disperse the simulant on painted surfaces, and to decontaminate
(over)

1. Fallout - Simulation.
2. Seawater - Radiological contamination.
3. Radiological contamination - Countermeasures.
4. Ships - Decontamination.
5. Radioactivity - Test facilities.

I. Anderson, R.N.
II. Railey, R.M.
III. Title.
IV. S-F011 05 08.

UNCLASSIFIED

these surfaces by liquid methods.

The simulant is produced by evaporating 30 gal of seawater containing approximately 2 curies of a selected gamma-emitting radionuclide to a final volume of 3 gal. The concentrated solution is fed to a spinning disc generator which produces 200-μ diameter drops at flow rates from 0.06 ml/sec to 2.5 ml/sec.

The drops are generated at the top of a polyethylene-lined chamber 36 ft high, and, as they settle at terminal velocity, they are distributed by a rotating cluster of fans to uniformly deposit on plates 8.5 in. square. The plates are painted with Navy paints, and cover a floor area of 1256 ft^2.

The contaminated plates are counted, washed, and recounted at the rate of 50/hr in a machine which simulates firehosing and steam cleaning. The effects of solution temperature, spray pressure, spray time and chemical additives in the liquid decontamination methods may thus be evaluated.

UNCLASSIFIED

these surfaces by liquid methods.

The simulant is produced by evaporating 30 gal of seawater containing approximately 2 curies of a selected gamma-emitting radionuclide to a final volume of 3 gal. The concentrated solution is fed to a spinning disc generator which produces 200-μ diameter drops at flow rates from 0.06 ml/sec to 2.5 ml/sec.

The drops are generated at the top of a polyethylene-lined chamber 36 ft high, and, as they settle at terminal velocity, they are distributed by a rotating cluster of fans jo uniformly deposit on plates 8.5 in. square. The plates are painted with Navy paints, and cover a floor area of 1256 ft^2.

The contaminated plates are counted, washed, and recounted at the rate of 50/hr in a machine which simulates firehosing and steam cleaning. The effects of solution temperature, spray pressure, spray time and chemical additives in the liquid decontamination methods may thus be evaluated.

UNCLASSIFIED

these surfaces by liquid methods.

The simulant is produced by evaporating 30 gal of seawater containing approximately 2 curies of a selected gamma-emitting radionuclide to a final volume of 3 gal. The concentrated solution is fed to a spinning disc generator which produces 200-μ diameter drops at flow rates from 0.06 ml/sec to 2.5 ml/sec.

The drops are generated at the top of a polyethylene-lined chamber 36 ft high, and, as they settle at terminal velocity, they are distributed by a rotating cluster of fans jo uniformly deposit on plates 8.5 in. square. The plates are painted with Navy paints, and cover a floor area of 1256 ft^2.

The contaminated plates are counted, washed, and recounted at the rate of 50/hr in a machine which simulates firehosing and steam cleaning. The effects of solution temperature, spray pressure, spray time and chemical additives in the liquid decontamination methods may thus be evaluated.

UNCLASSIFIED

these surfaces by liquid methods.

The simulant is produced by evaporating 30 gal of seawater containing approximately 2 curies of a selected gamma-emitting radionuclide to a final volume of 3 gal. The concentrated solution is fed to a spinning disc generator which produces 200-μ diameter drops at flow rates from 0.06 ml/sec to 2.5 ml/sec.

The drops are generated at the top of a polyethylene-lined chamber 36 ft high, and, as they settle at terminal velocity, they are distributed by a rotating cluster of fans jo uniformly deposit on plates 8.5 in. square. The plates are painted with Navy paints, and cover a floor area of 1256 ft^2.

The contaminated plates are counted, washed, and recounted at the rate of 50/hr in a machine which simulates firehosing and steam cleaning. The effects of solution temperature, spray pressure, spray time and chemical additives in the liquid decontamination methods may thus be evaluated.

UNCLASSIFIED

UNCLASSIFIED