714762

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STATE OF CALIFORNIA

EARL WARREN, Governor

A STUDY OF THE DISPERSAL OF RADIOACTIVE AEROSOLS OVER CALIFORNIA

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INTRODUCTION

Report number one* under this project X-762 gave an account of the symptoms produced by exposing individuals twice daily to a pressure altitude of 20,000 feet. Inasmuch as symptoms appeared as frequently under control as under experimental conditions it was considered advisable to repeat the investigation. In planning the second experiment particular attention was given to establishing adequate control conditions thus avoiding insofar as possible the factor of suggestion.

METHODS

Twenty-five healthy men ranging in age from 18 to 25 years served as subjects. As a control procedure, for the first five days these subjects were decompressed twice daily to a pressure altitude of 5,000 feet. The rate of decompression was 2,500 feet per minute. On the following 28 consecutive days the subjects were decompressed to a pressure altitude of 20,000 feet. The rate of decompression on the 20,000 feet exposures was 10,000 feet per minute. Oxygen apparatus, diluter-demand with the A-14 demand mask, was used from sea level to maximum altitude on both the 5,000 feet as well as the 20,000 feet exposure. The temperature inside the decompression chamber varied from 70° to 80°Fahrenheit. During each decompression the subject exercised every five minutes for a period of 30 seconds. The exercise consisted of stepping up alternately with each foot to a height of 18 inches at a rate of one step-up per second. The duration of each exposure to decompression both on the control as wel

* See report number one. This second report is an addendum to the previous report.

ACKNOWLEDGEMENTS

Although the persons listed as authors of this report are responsible for its writing, it was made possible by the most excellent assistance and cooperation of a large number of people, among them:

1. The other members of this division, T. L. Edwards, William Wooten, and Mrs. Efra Zollinger.

2. Personnel of local Health Departments of Bakersfield, Fresno, Los Angeles, San Bernardino, San Diego and Santa Barbara.

3. Personnel of US Weather Bureau Stations at Eureka, Red Bluff, Sacramento, San Francisco and Susanville.

4. Personnel of Civil Aeronautics Administration Stations at Blythe, El Centro, Salinas, Thermal and Ukiah.

5. Personnel of State of California Plant Inspection Stations at Benton, Daggett and State Line.

INTRODUCTION

The function of the Division of Radiological Services of the State of California, Office of Civil Defense, is to provide for maximum possible protection of the civilian populace of the state against injury from ionizing radiation following atomic attack. This responsibility takes many forms, among them being: stockpiling and maintenance of instruments, education and training, and developing workable plans for both emergency and long range operations — together with the formation of an organization to carry out such operations. In many important areas the necessary information for the effective implementation of such a program is inadequate, unavailable, or even nonexistent. It, therefore, becomes the province of this organization to initiate action to secure as much information as possible of the type that will allow it to effectively discharge its responsibilities.

The danger from radioactive products following atomic attack may be divided into two general classes: 1) that from material which remains external to the body and 2) that from material inhaled or ingested into the body. Some information is available on the first of these, very little on the second. In at least some instances, casualties caused by inhalation or ingestion of radioactive materials may be more severe than those from external radiation, both as to numbers and to type of damage caused. This would become increasingly the case as distance from ground zero becomes greater.

Considerable attention is being given in our planning to hazards that would arise from airborne radioactivity following attack. This planning must include such things as: 1) securing and developing suitable sampling devices, 2) developing techniques for sampling and radioassay, 3) determination of background levels, 4) instituting procedures to be used in emergency operations, and 5) training of technicians for such operations. A closely allied problem is that of the use of meteorological information in prognosticating the patterns of dissemination of radiological materials.

Such things should be worked out in as much detail as possible prior to an emergency. The occasion of the atomic bomb tests in Nevada in the fall of 1951 afforded us an opportunity to gain valuable information and experience with respect to the problems mentioned in the last paragraph.

Consequently, air samplers were set up in nineteen localities throughout the state (see Fig. 1) during the period of the Nevada tests. Cooperation in operating the samplers was secured from local Health Departments, and stations of the US Weather Bureau, the Civil Aeronautics Administration, and the Plant Quarantine Service. The samplers were operated continuously from October 6 to December 5, 1951, except for a short period between the two test series in November.

This report comprises the information obtained from the study. It has been extremely valuable in the over-all development of our program. We feel that it may be of value to others.

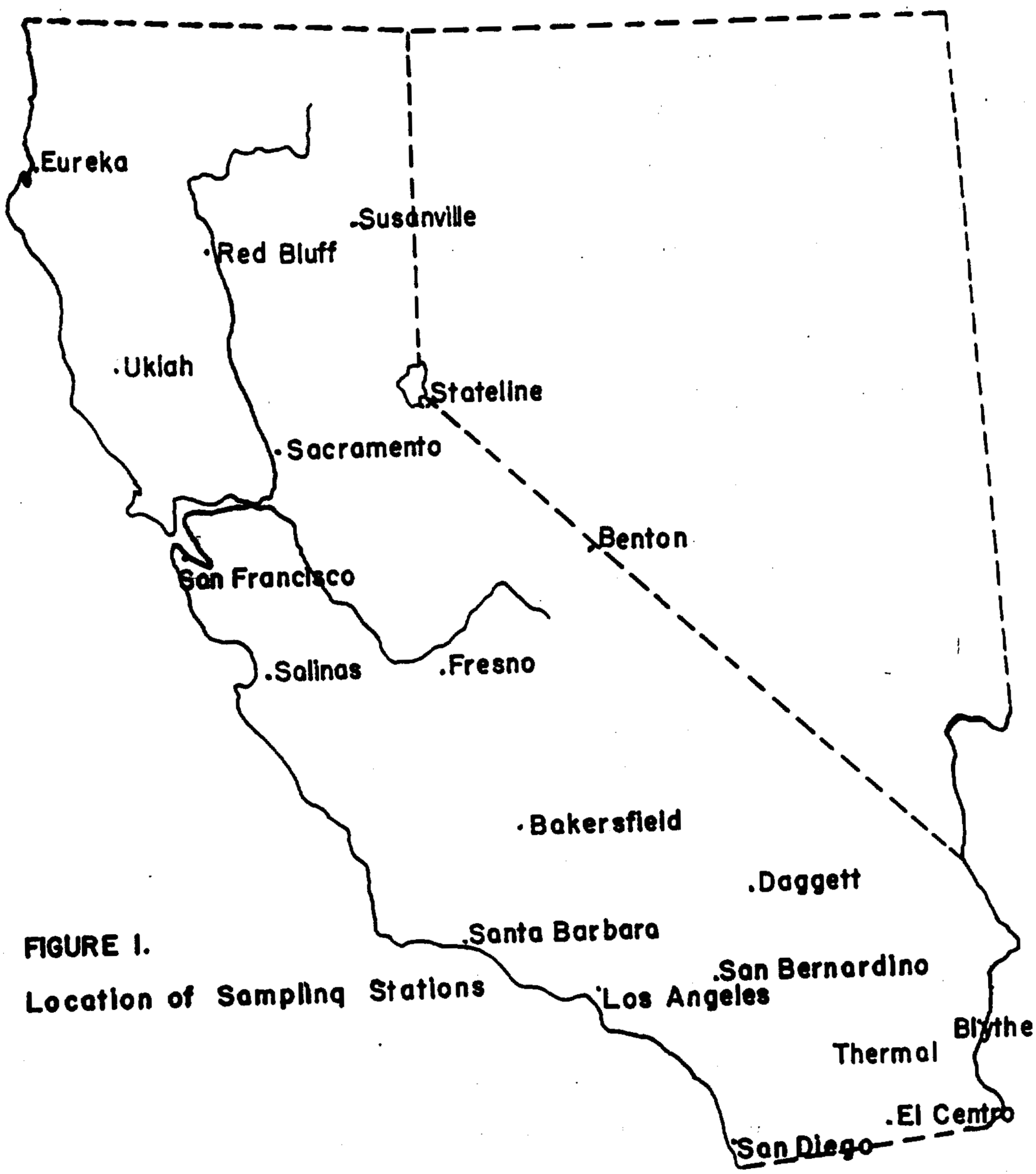

FIGURE 1.
Location of Sampling Stations

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MATERIALS AND METHODS

1. Sampling Procedure

Aerosol samplers consisted of air movers pulling air through filter paper at a predetermined sampling rate. Generally, filter papers were changed at six-hour intervals. The characteristics of sampling are outlined below:

Air mover - 350 watt Electrolux tank-type vacuum cleaner.

Sampling head - Electrolux demothing attachment (see Fig. 2), attached to end of hose on suction side of air mover.

Filter paper - Hollingsworth and Vose, Type H-70, .009" thick, water repellent grade. Cut in 3" diameter circles to fit sampling head.

Sample rate - 1 CFM air moved; adjusted by means of air bypass and variable resistor.

Calibration - With E. Greiner "Flowmeter". Although samplers were adjusted at time of installation, it is not to be assumed that the sampling rate remained entirely constant throughout the test period.

Particle size - Not definitely known. Paper claimed to be efficient to diameters as low as 0.5 microns. A distribution of particle sizes was undoubtedly collected.

2. Counting Procedure

After collection, aerosol samples were mailed to the laboratory in Sacramento for radiological assay. The samples were counted directly for beta-gamma activity. Alpha counting of the samples has not progressed to the point where any significant observations can be made in this respect.

No attempt was made to discriminate between beta and gamma activity, or to determine energy values. No chemistry was performed.

DISCUSSION OF EXPERIMENTAL RESULTS

As seen in Tables 1 and 2, significant amounts of airborne radioactivity were collected in all sections of California during the time of this study. The results obtained may be discussed as follows:

A. Dispersal of fission products from bomb of October 22, 1951

Data in Tables 1 and 2 indicate that products from this bomb were detected at possibly all of the sampling stations. Though levels of activity were not high, its presence was of greater interest to us than that from any of the other bombs. As will be shown in the next section, prevailing wind patterns at the time of and after this explosion were such that no material from it was expected over California. Yet significant amounts, apparently from this bomb, were collected in widely scattered localities of the state. Further, the activity persisted, and even appeared to be replenished for periods up to a week following.

B. Dispersal of fission products from bomb of October 28

Radioactive material from this bomb reached California the night of October 28, and was present in the State until November 4. The products were identified at fourteen sampling stations, and may have been present at all. Levels of activity were relatively high. One stream of material appears to have swept directly over Bakersfield and Santa Barbara.

The pattern of arrival at the six southern-most stations is interesting. It was almost as if a whirlpool was set up around this area, dipping down and depositing material at first one place and then another. Los Angeles received least. San Bernardino had two peaks, on the 30th and 31st. Blythe had a peak on the 30th, El Centro on the 31st. Material came into San Diego for thirty hours before reaching a peak on November 1. Thermal was reached last, but had two peaks, the 31st and 2nd.

Central California stations (Fresno, Salinas, Benton, Sacramento, San Francisco) also received appreciable amounts of activity from this bomb. Little, if any, reached the four northern-most stations.

C. Dispersal of fission products from bomb of October 30

Products from this bomb arrived in California the night of October 30 and persisted until November 3. It was identified at seven stations. Small amounts probably reached at least eight others. Levels were higher than those from any of the other bombs.

Again the dispersal pattern is of interest. The fissioned material apparently headed directly for Fresno (missing Benton), then turned south (missing Salinas). Bakersfield was hit next, followed by Daggett, Blythe, El Centro, Los Angeles, and San Bernardino in that order. Thermal and San Diego received little, if anything, from this bomb. The same was true for Santa Barbara and the stations north of Fresno.

D. Dispersal of fission products from the bombs of November 1 and 5

Material from these two bombs was identified at only two sampling stations for each bomb. That from the bomb of November 1 reached Fresno in moderately high amounts on the 2nd and persisted until the 5th. Comparatively small amounts moved into Los Angeles November 4-6.

Products from the November 5 explosion were collected in substantial quantities at Fresno and San Diego on the 6th and 7th. Radioactive aerosols, in amounts too small to identify, were collected at most of the other sampling stations in the state at times such that they could have arisen from these two bombs.

E. <u>Bombs of November 19 and 29</u>

No identifiable quantities of radioactive materials from either of these bombs were detected in California.

EVALUATION OF RESULTS

The data presented in this report give an indication of the degree of dispersal of the products of an atomic bomb. Two factors stand out by virtue of the fact that they were unexpected; 1) the levels of activity found, which were considerably higher than anticipated, and 2) the persistence of relatively high concentrations of material for long periods of time at some locations.

It should be pointed out that the accuracy of any analysis of the data is limited by the small number of samplers, their location, and the small area that each sampled; i.e., the efficiency of over-all sampling was very low. The number of sampling stations was limited by the number of samples that could be handled in the laboratory. The location of the samplers was planned so as to give as representative a picture as possible, but was limited to those localities where personnel were available who would cooperate in the program. Additional samplers, or placement in different locations, might have altered the picture considerably in some cases.

It would be of considerable interest if information existed that would allow a comparison between surface contamination and aerosol activity at a given location. We have only scant information regarding this, but the following facts are pertinent. It was reported from the Los Angeles region that extensive areas of relatively heavy surface contamination were detected, presumably due to material from the bombs of either October 28 or 30. Individual particles were isolated as large as 60 microns diameter, and containing as much as 1 microcurie of activity. Yet our Los Angeles air sampler collected relatively small amounts of activity during the same period.

On the other hand, the activity of aerosol samples from the Bakersfield and Fresno areas during the period of October 29-31 (from the 28th and 30th bombs) was very high. Yet survey teams from this laboratory could detect virtually no surface contamination in these areas on November 1-2.

No good explanation of this apparent discrepancy can be offered. The implication is that surface contamination measurements may give no good indication of air contamination and vice versa. It would seem that particles contributing most to surface contamination are those of such a size that they settle out of suspension due to the force of gravity. The air samplers, on the other hand, would collect principally those particles which are so small as to remain in relatively stable suspension. Of course, meteorological conditions might be such in some cases as to cause a growth of particles to the point where they would fall out.

The rather surprising length of time that airborne contaminants remained in an area cannot be explained merely by the slow fall-out of small particles. In order to maintain the same concentration, additional material must be brought into the area; otherwise dilution, fall-out, and radioactive decay of the fission products, would lower the concentration rapidly.

Predictions of areas of contamination on the basis of meteorological information were only fair. Material from two of the bombs (Oct. 22, Nov. 1) reached California in significant amounts when it was thought none would. That from another, (Nov. 5), did not contaminate California as much as expected. Patterns from two others, (Oct. 28, 30), were accurately predicted in a general way, but some localized discrepancies were apparent. It was predicted that no material from the last two bombs (Nov. 19, 29) would reach California, and apparently none did, at least by December 5.

The dispersal of the fission products should be entirely dependent on the size distribution of particles, the initial dispersion due to the explosion, and the meteorological conditions prevailing at the time of and following the burst. The discrepancies noted between predicted and detected areas of contamination must be explained by lack of sufficient data to make accurate prognostications. More weather reporting stations would be helpful but probably would not solve the problem. Too many complex variables apparently enter into accurate determination of dissemination patterns, especially over long distances and times.

It is of great interest, and some concern, that activity from the Nevada bombs and from other sources became so widespread over the state. As far as could be ascertained from unclassified sources, all of the bombs detected in California, with the exception of the first, were air bursts. It has generally been considered that danger from radiation from air bursts is relatively slight. Perhaps greater distinction should be made between radiation and contamination, and increased importance be attached to the latter. It is true that the levels of contamination detected in this study probably were not hazardous, but the nearest sampling station was over 200 miles away from the bomb test site. Of some concern, also, is the persistence of activity in an area, and the fact that it continues to reappear days and weeks after an explosion. For example, high activity was reported from the San Francisco area December 14-17, presumably from Nevada.

On the basis of the findings in this study, at least three questions seem pertinent:

1. Will the continued use of atomic materials and testing of atomic weapons serve to raise the natural radioactive "background"?

2. What will be the long-range effects on plants and animals in being subjected to steadily increasing low level radioactive contamination?

3. In view of the amounts of radioactive material spread under conditions when attempts were made to minimize it, what might these amounts be if an enemy set out to bring about maximum contamination?

SUMMARY

1. Purpose: Development of equipment and techniques, training, determination of background levels, and determination of routes by which radioactivity may be dispersed over California.

2. Recent Nevada tests offered excellent opportunity to conduct program. Air samplers were set up in 19 localities scattered over California. Cooperation of Health Departments, Weather Bureaus, CAA, and Plant Inspection Stations was secured. Samplers were operated from October 6 to December 5, 1951.

3. Air samplers consisted of tank-type vacuum cleaners equipped with demothing attachment, and special filter paper. Samplers were regulated to pull 1 CFM of air with resistor and air by-pass. Filter papers were changed every six hours and sent to Sacramento, where radioactivity determinations were made. Beta-gamma measurements have been completed. Alpha counting has been begun.

4. Daily wind pattern maps were studied, attempting to predict the paths that materials from the Nevada bombs would take. Agreement between predicted and detected areas of contamination was only fair.

5. Radioactive decay curves were run on selected samples. By comparing these with plot of $A = A_oT^{-1.2}$, it was determined which bomb the material came from; and corrections were made on this basis back to sampling time.

6. Data indicate that some fissioned material from all five bombs of the first test series, (Oct. 22, 28, 30, Nov. 1, 5) reached California. No identification of material from the last two bombs (Nov. 19, 29) has been made.

7. Perhaps most interesting, from our standpoint, was the bomb of October 22. This possibly was a "baby" bomb, and wind patterns were such that it was predicted no material from this bomb would reach California. Such material, however, appeared in California, continuing to arrive in significant amounts until at least October 31. This material was detected in at least 17 locations and possibly all.

8. Highest concentrations of radioactive material over California came from the bombs of October 28 and 30. The former was identified at 13 and the latter at 7 of the sampling stations. The southern part of the state received the largest amounts by far. The sample with the highest activity contained approximately .03 microcuries beta-gamma radiation at time of sampling. Material from these bombs was fairly accurately predicted and tracked on the basis of meteorological information.

9. Comparatively small amounts of material entered California from the bombs of November 1 and 5. They were definitely identified at only two stations each.