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~~SECRET~~

LAB-J-475

July 27, 1948

403351

OPERATION SANDSTONE RADIATION INJURIES

I. HISTORY

During the radiochemical operations at Knivetok immediately following the X, Y and Z Day detonations, the radiochemists removed from the drone planes the filter papers containing radioactive samples and packaged them for immediate shipment to the Los Alamos Laboratories. All these operations were directed by _____, and Exhibit A contains a detailed description of the procedures and practices involved. Exhibit B shows photographic enlargements of several frames of a movie sequence made during one of the operations.

It was during the operation at Knivetok that four of the personnel involved received excessive radiological exposure. The working groups of radiochemists for each test are listed below, and those showing no radiological injury are noted by "0", those with some injury by "**", and the more severe cases by "***":

BEST COPY AVAILABLE

X-Ray Test

_____	0
_____	0
_____	0
R. W. Spence	0
J. S. Gilmore	0

Yoke Test

_____	0
_____	0
_____	0
B. Warren	0

Zebra Test

_____	0
_____	0
_____	*
_____	**
_____	**

RG 326 US ATOMIC ENERGY COMMISSION

Location LANL
Collection Records Center (2091)
Folder Radiation Injuries
- Operation Sandstone

Immediately after Test X, Spence and Gilmore returned from Knivetok to Los Alamos with the samples; for Test Y, _____ and Warren returned; and for Test Z, _____ returned.

J. Dean
9/11/83



Subj: Operation Sandstone Radiation Injuries - 7/27/48 - Page 2

The first indication of possible overexposure was noted by _____, who reported to the Los Alamos Laboratory Health Division for examination (see Exhibits C and D). As noted by Dr. L. Hempelmann (Exhibit E), _____ received the least serious burns, and early examination of _____ injuries led to an erroneous diagnosis as being due to a bruise. This unfortunately resulted in the forward area's not being advised, before the Zebra Test, of the excessive dosages possible in the procedures used at KnivetoK.

Development of the film badges of the personnel involved in Zebra Test operations disclosed that _____ received appreciable doses. The film badges were developed at KnivetoK after the men had already departed for the States, but the information was passed on to the Laboratory by teletype (see Exhibit F).

The injuries received by _____ were sufficient so that no question was involved in the diagnosis, and altogether _____ were hospitalized on 16 May 1948. A public press release was made 17 May (see Exhibit G). Also on 17 May, Dr. J. G. Hoffman, a consultant, interviewed these men (see Exhibits H, I, J and K), and on 24 May he submitted reports on dosage estimates and general observations (see Exhibits L and M).

The injuries appeared to be due only to Beta radiation, and no sickness was incurred, although the men will be kept in the hospital until a new skin growth is assured. _____ was released on 28 May and _____ are still hospitalized (they are allowed to leave the hospital for exercise periods, but return for meals and sleeping). A medical history of the cases to date is given in Exhibit N.

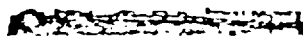
II. CONCLUSIONS

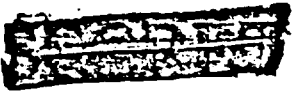
1. Radiological:

From the medical report, the injuries received by the men appear to be due only to Beta radiation, and from the estimates made by Dr. Hoffman, the Beta activities per sheet of filter paper were of the order of .5 curie or less; with this source strength a dose of 500 r e p at a depth of 2 to 3 mm could have been produced in 90 minutes (estimated time the men wore gloves), provided .1% of the Beta activity on a sheet was transferred to the gloves. The gloves used in the operations were destroyed immediately after use and no measures of radioactivity were made upon them.

2. Operational:

For handling the filter sheets tongs were provided, and it is believed that had they been properly used, excess dosages would not have





Subj: Operation Sandstone Radiation Injuries - 7/27/48 - Page 3

resulted. The use of tongs makes handling the filter papers, in the field, an awkward and prolonged operation. That the tongs which were available may not have been consistently used indicates that considerable practice in their use before a test (for familiarization) and rigid enforcement of their use during an operation appear necessary. Or perhaps a more workable substitute procedure can be invented for future operations.

In addition to maintaining a safe distance between worker and source, it is clear that gloves should be provided in sufficient quantities. Clean gloves should be exchanged for used ones several times during an operation, and an assistant should be provided for each worker to ensure that gloves are exchanged.

JCC:djw

John C. Clark

Enclosures:

- Exhibit A - Memo fr M. Bowman, 6/10/48, subj: "Rad Burns of J-2 Pers"
- Exhibit B - Photographs
- Exhibit C - Statement -
- Exhibit D - Statement - R.W. Spence
- Exhibit E - Ltr fr L. Hempelmann to Dr. R. Stone, 6/28/48
- Exhibit F - Teletypes
- Exhibit G - Memo LAB-DIB, 5/17/48, subj: "Recent Accident in Operation Sandstone"
- Exhibit H - Acct of Interview -
- Exhibit I - Acct of Interview -
- Exhibit J - Acct of Interview -
- Exhibit K - Acct of Interview -
- Exhibit L - Memo fr Hoffman, 5/24/48, subj: "Dosage Estimates on Sandstone Pers"
- Exhibit M - Memo fr Hoffman, 5/24/48, subj: "Notes on Sandstone Pers Receiving Beta Rad"
- Exhibit N - Memo fr Whipple, 7/23/48, subj: "Supplementary Radiation Acc Rpt" & Memo fr Hempelmann, 6/7/48, subj: "Rad Acc Rpt"

O } added later
P }



June 10, 1948

LAB-J-445

MEMORANDUM:

TO: Darol Froman

FROM: Melvin Bowman

SUBJECT: RADIATION BURNS OF J-2 PERSONNEL

Collection of filter paper from the drone planes at Eniwetok involved the following operations:

(1) Removal of the filter units from the drone planes. Each drone carried two filter units; one on the top of the fuselage just back of the pilot's seat, and one on the bottom of the fuselage just under the nose of the plane. The units were fastened to the planes by dowel pins which could be released by pulling lanyards attached to the pins. Each lanyard ran from its filter unit to a point just back of the wing. The handle of the lanyard was held at this point in a holder attached to the fuselage of the plane.

A special lift arrangement was carried by truck from plane to plane to lift the top filter unit. When this special lift was in position, one radiochemist would approach the plane, detach the lanyard handle from its holder and release the filter unit by pulling on the lanyard. The special lift would then carry the filter unit to a point about fifty feet from the plane where two radiochemists transferred the filter unit (by hand) from the special lift to the ground.

The bottom filter unit was allowed to fall to the ground when its lanyard was pulled. It was then dragged along the ground by the lanyard to a point about fifty feet from the plane.

(2) Removal of the paper holder from the filter unit. Each paper was held between two wire screens which were in turn attached to a section of the side of the filter unit. Each side section was fastened to the filter unit by eleven pins which were in turn held in position by wires running through holes in the pins. These wires were all attached on one handle so that one pull on the handle released the entire side section. The detached paper holder was then carried away from the main body of the filter unit. Each filter unit contained two filter paper holders so that after one holder was removed it was necessary to turn the entire unit over (by hand) in order to remove the second.

(3) Removal of filter paper from paper holder. The filter paper was removed from the paper holders by cutting two wires which held the two screens together, picking up the paper by tongs and carrying the paper to the lead shipping container.

Exhibit A

J. J. J. 9/17/85
 CLASSIFICATION CANCELLED
 BY AUTHORITY OF DOE/OC

COPY

Memo to D. Froman, 6/10/48, subj: "Radiation Burns of J-2 Personnel" (Cont'd)

The X-Ray Operation. The X-ray operation was performed by two radiochemists who were to accompany the samples to Los Alamos, (R. W. Spence and James Gilmore) and by myself, and Each of us performed each part of the operation during the course of the collection. The sequence of events was as follows:

1. Drone plane landed and was pulled into revatment by Air Forces personnel.
2. Top filter unit removed. In this operation the lanyard was pulled by a radiochemist and the special lift operated by Air Forces personnel. Radiochemists lifted the filter unit from the special lift to the ground.
3. The top filter unit was disassembled by a radiochemist and the filter paper holders removed from the filter unit.
4. The filter paper was removed from the paper holders, the filter paper was held in the tongs while an ionization chamber reading was taken and then transferred to the lead container.
5. All personnel waited until the next plane had landed and then repeated these operations.

After the last plane had landed and the paper removed from the top unit the bottom filter units were removed from all of the planes and the filter paper collected.

During the course of these operations, dosimeters worn by each man were read frequently to establish which operation gave the greatest exposure. It was found that pulling the lanyards on the planes to release the filter units gave the highest exposure, the next highest exposure was obtained in removing the filter paper holders from the filter units themselves. The next highest exposure was obtained in transferring the filter units from the special lift to the ground, and the least exposure was obtained in collecting the filter paper from the filter paper holders. However, it should be emphasized that tongs were always used during this last operation on X-ray day.

Gloves were carried by the Los Alamos group for use during these operations. However, the Rad Safe unit also had gloves available and these were used. Each man usually changed gloves after he had worked with two or three planes.

The Yoke Operation. and Mr. Warren replaced Spence and Gilmore during the yoke operation. Otherwise, the personnel were the same as for X-ray.



Memo to D. Froman, 6/10/48, subj: "Radiation Burns of J-2 Personnel" (Cont'd)

I instituted a change in the sequence of events with the purpose of lessening the exposure of the men. Whereas on X-ray day the filter paper was removed from the top filter unit as soon as a plane had landed, on yoke day the top filter unit was removed and placed on the ground as the planes landed, but the removal of the filter paper holders and the collection of the filter paper was deferred until after all the planes had landed. This meant that work with the first filter papers was deferred for approximately one and one half hours, and consequently the radiation from the filter paper at this time was less by a factor of about three over what it would have been if the X-ray procedure had been followed. In addition, the monitoring of the individual filter papers, while they were being held in the tongs, was eliminated. Instead, only one of the filter paper holders was monitored. This was done by carrying an ionization chamber to within about one foot of the holder as it rested on the ground.

During the yoke operation the work was divided. Albright and I pulled the lanyards to release the top filter units as the planes landed. This operation gave the greatest gamma exposure. and Warren transferred the filter unit from the special lift to the ground. This operation gave the second highest gamma exposure on yoke day, since the disassembly of the filter units (which had been the second hottest operation on X-ray day) was postponed until after all the planes had landed.

After the planes had all landed, the top filter units had been removed and were on the ground, but the units had not been disassembled and the bottom filter units were still on the planes. and I then walked down the line of these filter units and removed the filter paper holders. We then walked from plane to plane removing the bottom filter units and detaching the filter paper holders from each unit. After this, we left to shower and change clothes. and Warren followed down the line of filter units and removed the paper from the detached holders. was present during the X-ray operation and therefore was asked to remove the first filter papers from the holders and demonstrate the use of the tongs. After this demonstration, most of the filter papers were collected by Battizahn and Warren, while monitored the paper holders. These men showered and changed clothes as soon as the paper was collected.

Since received beta burns on his hands during the yoke operation, it is pertinent to point out that the use of tongs for handling the filter paper was abandoned early in the yoke operation and the paper was then carried by hand.

Gloves were again furnished by the Rad Safe unit and these were worn and changed occasionally by the men.

The Zebra Operation. replaced and Warren during the zebra operation. Otherwise, the personnel were the same as for yoke. The work was divided exactly as it was during the yoke operation.



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Memo to D. Froman, 6/10/48, subj: "Radiation Burns of J-2 Personnel" (Cont'd)

except that [redacted] alternated with [redacted] in removing the top filter units from the special lift. Also, the monitoring of the filter paper holders was eliminated with the purpose of reducing exposure. Consequently, [redacted] actually handled a greater share of the filter papers than he did during the yoke operation.

Since all of the men who worked directly with the filter papers during the zebra operation received beta burns on their hands, it is pertinent to mention the following:

(1) Gloves were not available from the Rad Safe unit for the zebra operation. The gloves in our possession were thin cotton gloves and rubber gloves. I explained the necessity for using the rubber gloves under the cotton to the other man. Three dozen pair of each type of gloves was available. Both [redacted] changed gloves after working with the first two planes. After this I did not watch to see that the men changed their gloves.

(2) Tongs were not used at all by the men working with the filter paper. I pointed out the tongs to the men just before they started to collect the paper, for the purpose of being sure the men knew where they were.

It is my opinion that the beta burns suffered by the men were due almost entirely to handling the filter paper without the use of tongs. It is possible that contamination on the gloves from handling the filter units, as well as exposure received during the actual handling of the filter units, contributed appreciably to the beta exposure. However, it should be emphasized that the surface of the filter units contained far less active material than did the filter papers themselves. In addition, the work performed by Albright and myself necessitated our handling the filter units for longer periods than the other men did. It is true that we changed gloves frequently, so the possibility that contaminated gloves were a factor in promoting excessive beta exposure to the hands of the other men cannot be eliminated.

After the yoke and zebra operations all of the men took showers and changed their clothes. No survey was made of clothes until after this change. The Rad Safe monitor checked the clothing of the man before they embarked on the sample planes. The monitor also checked my hands. No appreciable contamination was found in these surveys.

MB/jm

cc: Dyhre
Clark (2)
Bowman

-4-

Exhibit A
(Page 4)

PRIVACY ACT MATERIAL REMOVED

SECRET

SECRETLos Alamos, New Mexico
1 July 1948Statement - _____

For purposes of simplification I will assume that the event which may have given rise to the hand injury occurred during the removal of filter samples from the units mounted on the drone planes, which operation consisted of setting the top filter units on the ground after the hoist had lowered it from the top of the plane. The second manipulation was the removal of the filter paper from the unit and the placing of the paper in a suitable lead container. The time consumed for each operation was in the range of fifteen seconds and the total number of operations was ten.

Medium weight green cotton gloves were used at all times. Two feet long tongs were available for our use in grasping the filter paper, but the presence of a fairly strong wind made the grasping of the paper somewhat precarious. I chose not to use the tongs for this reason. Later events seemed to have proven this choice injudicious.

After returning to Los Alamos no immediate injury to the hand was noticed. Approximately one week later the index finger and the middle finger of the left hand showed a slight reddening. On May 11, twelve days after exposure, I had my hand examined by the medical group. Blood counts were taken on May 14 and 15. On May 16 along with the men from the third test I was admitted to the hospital. On May 28 the hand was sufficiently healed to warrant my release. On June 3 I returned to work.

PRIVACY ACT MATERIAL REMOVED

Exhibit C**SECRET**CLASSIFICATION CANCELLED
BY AUTHORITY OF DOE/OC*J. Dean*
9/17/85

~~SECRET~~

Los Alamos, New Mexico
1 July 1948

Statement - R. W. Spence

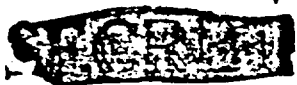
My first knowledge of any injury to hand
came approximately Tuesday, May 4. The discolored area of
hand was of a type I had not seen before, and I suggested to
that he have his hand examined by the Health Division in
case he had suffered a radiation burn. did have his hand
checked and a blood count taken on the same day and another blood count
taken on the following day. The doctor in charge, I believe, was Dr.
Knowlton, who did not believe that the injury was a radiation burn.
So far as I know the doctors did not consider the burn a radiation
burn until the arrival of with obvious
radiation burns. entered the hospital for treatment
at the request of Dr. Hempelmann on the 16th or 17th of May.

/s/ R. W. Spence
R. W. Spence

Exhibit D

~~SECRET~~

J. Diaz
9/17/88
Carl H. ...



Los Alamos, New Mexico
1 July 1948

Statement - R. W. Spence

My first knowledge of any injury to _____ hand
 came approximately Tuesday, May 4. The discolored area of
 hand was of a type I had not seen before, and I suggested to Mr.
 _____ that he have his hand examined by the Health Division in
 case he had suffered a radiation burn. _____ did have his hand
 checked and a blood count taken on the same day and another blood count
 taken on the following day. The doctor in charge, I believe, was Dr.
 Knowlton, who did not believe that the injury was a radiation burn.
 So far as I know the doctors did not consider the burn a radiation
 burn until the arrival of _____ with obvious
 radiation burns. _____ entered the hospital for treatment
 at the request of Dr. Hempelmann on the 16th or 17th of May.

/s/ R. W. Spence
R. W. Spence

Exhibit D



~~CONFIDENTIAL~~
ADMINISTRATIVE

COPY

EXHIBIT E

LAB:H

June 28, 1948

Dr. Robert Stone
University of California
Medical Center, Third and Parnassus Avenue
San Francisco 22, California

Dear Dr. Stone:

I have been intending to write to you for some time to tell you about the progress of patients with the beta ray burns. I will not go into all of the details, as I hope to show you our colored photographs some day.

The man who was exposed first shows the least serious burns. These are limited to the first three fingers of the left hand. They began to blister about the fourteenth day, reached their peak about the twenty-fourth day, and started to desquamate about the thirtieth day. The new epithelium seems to be perfectly good, and as of today you cannot tell new from old skin.

The three other men, exposed two weeks later, showed much more extensive involvement of fingers and palms. Only the left hand of one of these persons was injured but both hands of the others were damaged, the left hand of each more severely than the right in each case. All showed swelling the second day, erythema the third day, two showed blisters about the sixth day, and the third, who had very thick skin on the palms of his hands, showed no signs of blisters until about the tenth day. All of the blisters which first formed separately, gradually coalesced to form one blister on each hand. Two of the patients showed the peak of the reaction about the twenty-fifth day. The third showed the greatest reaction about the thirtieth day. The blisters have gradually been improving with drying and desquamation of the dead epithelium. We finally removed the dead skin several days ago, which, until recently, had formed a good protective coat. After debridement, one of the boys showed fairly good normal pink skin over most of the burned area, but there were still fairly large areas covered by a very thin epithelium. The second boy showed less epithelization and more granulation tissue which appeared quite healthy except for a small area the size of a dime on the first finger of the left hand. This area was dry, white and apparently necrotic. The third boy, whose injury is limited to the left hand, apparently showed deeper involvement with white dry necrosis of the superficial tissues. Unfortunately I did not see the last lesion at the operation so I don't know the details.

~~CONFIDENTIAL~~
ADMINISTRATIVE

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BY AUTHORITY OF DOE/OC
9/17/85

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LANL RC ✓

EXHIBIT E

~~CONFIDENTIAL~~
ADMINISTRATIVE

Dr. Robert Stone, June 28, 1948, page 2

The present conditions of all the boys are more or less satisfactory, except for leucocytosis and increased lymphocytic granulars which appeared at the beginning of the blister formation. The circulation of the fingers was good, but we observed thrombosis, dilatation, and tortuosity in the capillary vessels at the base of the finger nails.

I have given the above from memory, so the data may not be entirely accurate. Shields Warren was here recently and he wants us to publish the cases after a six month's follow-up. I would like very much to give you a preview of our excellent series of colored photographs. I learned several things from following the cases. The most interesting is that, beta ray burns can look a lot like a bruise. The first ones were completely mis-diagnosed by us because it was located in a place where we did not think radiation burns could occur. It was interesting to correlate changes in blood count with the visible day-by-day progress of lesions.

Let me apologize again for disturbing you Sunday afternoon six weeks ago, and thank you for your advice and reassurance. After the bandages are removed this week I hope I will feel as optimistic as you were when I last spoke to you.

Very sincerely yours,

Louis H. Hempelmann, M.D.
Health Division

LHH:rms

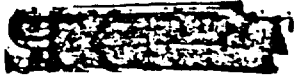
Exhibit E
(Page 2)

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COPY



TELETYPES

TO USAEC LOS ALAMOS NMEX
FROM CTG SEVEN POINT ONE
DTG 150405Z GR55

~~SECRET~~ PRIORITY

FOR SPENCE FROM FROMAN. CITE TEST DIRECTOR 552 SUGAR 261. STANLEY LEFT
AT 1500 ON 15 MAY WITH GROUND SAMPLES. BOTH RECEIVED
APPRECIABLE DOSAGE. SUGGEST BLOOD COUNTS AND NO FURTHER EXPOSURE. EXPOSED
WILL BE SENT YOU SOON.

TO US AEC LOS ALAMOS NEW MEXICO
FM CJTF DASH SEVEN DTG 170212Z

THIS IS SECRET. FOR LOUIS HEMPLEMANN FROM BRADBURY CITE TEST DIRECTOR 566
SUGAR 267. PLEASE SEND ME PRIORITY MESSAGE AT HONOLULU TO ARRIVE BEFORE
2000 EST 17 MAY CARE OF NELSON FRY ON CONDITION OF RADIO CHEMICAL SAMPLE
COURIERS AND ANY PROGNOSIS YOU CAN MAKE. SEND INFORMATION COPY TO FROMAN.

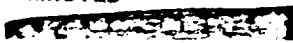
TO USS ALBEMARLE AV#5
FM DIR LOS ALAMOS SCIENTIFIC LAB LOS ALAMOS N MEX
NR 939 16/2230Z GR 75

SECRET TO FROMAN FROM SPENCE AND HEMPLEMANN LABJT 240 SPENCE 106.

SHOW SWELLING OF HANDS PRESUMABLY DUE TO HAND CONTACT
WITH FILTER PAPER. MILD INCONCLUSIVE BLOOD CHANGES NOTED IN
SUGGEST YOU SEND AND OTHERS ENGAGED IN ABOVE OPERATION TO
COLONEL COONEY. PLEASE TELETYPE US ALL AVAILABLE EXPOSURE DATA IMMEDIATELY,
REPEAT IMMEDIATELY.

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J. Diaz 9/17/85
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D. 1111 11/1/85



TO US AEC LOS ALAMOS NMEX

FM CTG SEVEN POINT ONE

DTG 160611Z GR85

~~SECRET~~

FOR SPENCE AND HEMPELMANN FROM FROMAN. CITE TEST DIRECTOR 562 SUGAR 265.

RECEIVED 17 REPEAT 17, 5 1/2 REPEAT 5 1/2, 4 REPEAT 4

ROENTGENS GAMMA RADIATION ABOUT 0800 MAY 15 LOCAL. WHIPPLE SUGGESTS

INTERDICTION TO ALL FURTHER EXPOSURE AND BELIEVES BLOOD AND SKIN

STUDIES INDICATED. FROMAN CONCURS AND WOULD LEAVE HANDLING OF OTHER

CASES TO YOUR DISCRETION.

TO US AEC LOS ALAMOS NMEX

FM CTG SEVEN POINT ONE

DTG 170240Z GR 128

SECRET

FOR SPENCE AND HEMPELMANN FROM GRAVES CITE TEST DIRECTOR 567 SUGAR 268.

REF LABJT 240 SPENCE 106. EXPOSURE DATA REQUESTED IN REFERENCE DISPATCH

FOLLOWS: 5500. 17000. 2000.

4200. 2100. ABOVE EXPOSURES INCURRED ON ZEBRA DAY. TOTAL

ACCUMULATED EXPOSURES PRIOR TO ZEBRA DAY ABOVE 100 PER DAY FOLLOWS. LANE

AND NONE, 740, 130, NONE. RECEIVED

1700 ON YOKE DAY AND FROM OUR RECORDS HAS RECEIVED NONE SINCE. ALL EXPOSURES

ARE IN MILLIROENTGENS.

~~SECRET~~

PRIVACY ACT MATERIAL REMOVED

TO US AEC WASHINGTON DC

PASS TO

NORRIS BRADBURY CARE NELSON FRY FT SHAFTER

TERRITORY OF HAWAII

FM DIR LOS ALAMOS SCI LAB LOS ALAMOS NMEX 17/2257Z

P R I O R I T Y

~~SECRET~~ FOR NORRIS BRADBURY CARE OF NELSON FRY INFORMATION TO DARCEL FROMAN FROM HEMPELMANN CITE LABJT 243 SPENCE 108. INJURIES SEEM TO BE DUE TO BETA RADIATION. SUCH INJURIES MANIFEST THEMSELVES PROMPTLY AND ARE NOT AS SERIOUS AS GAMMA RAY INJURIES. HANDS OF [REDACTED] ARE RED AND SWOLLEN. [REDACTED] INJURY MUCH OLDER AND PROBABLY LESS SERIOUS. GENERAL CONDITION OF ALL MEN EXCELLENT. NO SIGNIFICANT CHANGES IN BLOOD COUNT, INDICATING THAT TOTAL BODY EXPOSURE NOT TOO SEVERE,

TO US AEC LOS ALAMOS NMEX

FM CTG SEVEN POINT ONE

DTG 170622Z GR 56

S E C R E T

TO SPENCE FOR [REDACTED] FROM FROMAN AND GRAVES. CITE TEST DIRECTOR 570 SUGAR 271. WE REGRET EXCEEDINGLY THAT YOU RECEIVED EXCESS RADIATION IN DOING YOUR JOB FOR US. WE SINCERELY HOPE FOR A SPEEDY RECOVERY WITH A MINIMUM OF DISCOMFORT.

Exhibit F
(Page 3)

(3)

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TO COL JAMES COONEY

USS BAIROKO THROUGH USS AT MCKINLEY

FM DIR LA SCI LAB LOS ALAMOS NMEX

NR 980 191833Z GR 157

~~SECRET~~ FOR COL JAMES COONEY INFORMATION FROMAN FROM HEMPELMANN CITE LABJT 248
SPENCE 114. THE FOUR INDIVIDUALS MENTIONED IN LAST TELETYPE SHOW ERYTHEMA,
SUBSIDING SWELLING, AND SOME BLISTERING OF FINGERS OF LEFT HAND WHICH WE
BELIEVE TO BE DUE ENTIRELY TO BETA RADIATION FROM CONTAMINATED GLOVES AND
FILTER PAPER SAMPLES. THERE MAY BE AN ELEMENT OF TRAUMA RESULTING FROM
HANDLING OF HEAVY LEAD COFFINS. THEIR GENERAL CONDITION IS EXCELLENT. NO
CHANGES IN BLOOD COUNT. IMPOSSIBLE TO ESTIMATE RADIATION DOSAGE ACCURATELY
FROM THEIR STORIES. CAN YOU RESURRECT AND MEASURE ACTIVITIES OF GLOVES WHICH
THEY WORE AND CAN YOU SEND US SAMPLES OF THE RUBBER GLOVES, WHITE COTTON
GLOVES, AND GREEN COTTON GLOVES WORN IN THIS OPERATION. NO GREAT URGENCY
ABOUT THIS BUT WOULD LIKE TO HAVE THIS INFORMATION IF POSSIBLE IN ORDER TO
IMPROVE THE ACCURACY OF OUR ESTIMATES OF DOSAGE.

TO USAEC LOS ALAMOS NMEX

FROM CTG SEVEN POINT ONE

DTG 222204Z GR79

SECRET

FOR SPENCE AND REIRES FROM FROMAN CITE TEST DIRECTOR 609 SUGAR 297.

..... PLEASE DESCRIBE PRESENT CONDITIONS



~~SECRET~~

Exhibit F
(Page 5)

PRIVACY ACT MATERIAL REMOVED

TO DAROL FROMAN USS ALBEMARLE

FM DIR LA SCI LAB LOS ALAMOS NMEX

NR 1046 252242Z GR 134

~~SECRET~~ FOR FROMAN FROM HEMPELKN. CITE LABJT 258 SPENCE 123. FAIRLY
OBVIOUS NOW THAT THE INJURIES ARE MAINLY LOCAL SKIN BURNS. NOW
SHOWS BLISTERS ON FIRST, SECOND, THIRD FINGERS OF LEFT HAND BUT REACTION
SEEMS TO HAVE REACHED ITS PEAK AND IS SUBSIDING. OTHERS SHOW INCREASING
BLISTER FORMATION CHIEFLY ON LEFT HANDS. LOCAL LESIONS APPEAR MORE
SEVERE THAN THOSE OF OTHER TWO BOYS. GENERAL CONDITION AND MORALE GOOD.
NO BLOOD CHANGES. PROGNOSIS GOOD FOR SLOW HEALING OF SKIN IF JOE HOFFMAN'S
CALCULATION IS CORRECT WHICH ALLOWS US TO DISCOUNT EFFECT OF GAMMA RAYS.
EVENTUAL RESULT SHOULD BE COMPARABLE TO THAT FROM SECOND OR THIRD DEGREE
THERMAL BURN. NO MORE BULLETINS UNLESS SOMETHING UNEXPECTED HAPPENS.

Exhibit F
(Page 5)

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(5)

~~SECRET~~

PRIVACY ACT MATERIAL REMOVED

EXHIBIT G

May 17, 1948

TO: Distribution

FROM: L. H. Hempelmann and E. R. Jette

SUBJECT: Recent Accident in Operation Sandstone

SYMBOL: LAB-DIR

Four Los Alamos scientists, have sustained radiation injuries to their hands as a result of exposure to beta rays at Operation Sandstone.

The injuries consist of skin damage limited to the hands. The general condition of all men is excellent. There are no blood changes or other indications that they received a serious amount of total body gamma radiation. It should be pointed out that beta-ray injuries are more superficial and, in general, less serious than gamma radiation injuries. All men are under treatment at the Los Alamos Hospital.

This information is for the use of Laboratory personnel only.

/s/ Louis Hempelmann

Louis H. Hempelmann, M.D.
Health Division

/s/ E. R. Jette

E. R. Jette
Acting Director

Distribution:

Master Division and
Group Leader List
(Including Sandia)

PRIVACY ACT MATERIAL REMOVED

EXHIBIT G

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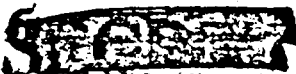
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Curt Wilson 6/26/83
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J. J. Jette 9/17/85



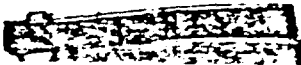
(Account of interview by Joseph G. Hoffman at Los Alamos Hospital, 2:50 P.M. May 17, 1948)

- Q. What time did you start to work on Friday, May 14? Were you sure of the time?
- A. It was either 7 or 8 A.M.
- Q. Just tell approximately what happened after approximately 7 o'clock when you arrived at the field.
- A. The drones started coming in at either 7 or 8 o'clock at intervals of maybe five minutes. These drones were taxied to the end of the runway and picked up by a truck, brought into a stall. We waited some distance away -- I don't know how far it was, at least 100 feet, until a truck with a fork lift went in and got its fork into position for the top filter units. Then Mel Bowman ran behind a wing and jiggered a lanyard for the upper unit, then the filter unit was loosened. The truck backed up about fifty feet from the plane, went on an angle diagonal to the plane, say about 25 feet, and stopped.
- Q. Did Commander Vandergriff make any measurements?
- A. Yes, at least during or before the fork lift went toward the plane he made a measurement. He made the measurement by running up toward the nose of the plane, it must have been the bottom filter unit, then ran away from the plane.
- Q. And that was a signal for you?
- A. He didn't give us any signal. (In regard to radiation) We had put on rubber gloves and white cotton gloves before we went near the plane. After the fork lift had stopped, and I trotted towards the lift.
- Q. Did you put the gloves on before or after the plane was in sight?
- A. I believe while it was in sight, I can't remember.
- Q. Where did you get the gloves?
- A. Mel Bowman made them available to us. We had protective clothing -- Heavy fatigues and the gloves.
- Q. What did you do after you trotted up to the plane?
- A. We tried to get there at the same time so that there would be no lost time. We grabbed the filter unit from the fork lift of the

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truck and set it down on the ground as fast as we could, we didn't care whether it bounced or not, just wanted to get away from there. We trotted back from the plane about 100 yards, I am guessing at the distance, then waited there until another drone was towed into the same stall. There were two planes in each stall. We repeated this procedure.

Q. Were the drones taken out of the stall?

A. No, they left them there. In order to do the eight, we moved down to another stall.

Q. Where did you walk?

A. I walked in front.

Q. How many filter units did you handle?

A. I did the first six top filter units. and I did the first four units together. I did the next two with

Q. What was the entire interval of time?

A. They were supposed to operate on a five-minute time schedule, that is the time the planes were in the stalls, and I believe they adhered to it.

Q. So approximately thirty minutes transpired?

A. At least, probably more -- it is very hard to say.

Q. In that interval, did you change your gloves?

A. I don't remember when I changed but I remember that I changed them because my hands were starting to itch inside. I thought at first it might be due to perspiration or extreme heat.

Q. Did you go far away to change?

A. About 100 yards away from the first drone. The gloves were in boxes.

Q. Was any radiation meter around at that time?

A. There may have been, but it wasn't being used. Sometime during this operation we found that our gloves were hot -- somebody had a meter nearby and they found out our gloves were hot. I don't know who had it. I assumed it was Commander Vandergriff.

(Hoffman: It should be noted that the lanyards for the upper filters on the first four drones were pulled by the last four were pulled by After the screens were on the ground, and clipped the wires that held the screens, together, which contained the filter paper, opened them up, took a filter paper from the front screen and placed it on top of the back screen.)

Q. How many filter papers did you personally handle?

A. I left after filter papers from the first seven units were placed in the coffin. The handling was done by taking hold of the dead corner. did most of the stapling.

Q. Was this filter paper work done on the ground?

A. We squatted. For stapling we did the same. The filter papers were long. Were stapled at four corners on the short side. There were eight top filter units; each one had two screens. There were more than sixteen pieces of filter paper because some had a backing. I can't remember exactly how many there were, but it could be figured out exactly.

Q. What happened after the filter papers were stapled?

A. One of us took hold of the filter paper, usually on the short ends, and just carried it and placed it in the coffin.

Q. The coffin was how many feet away?

A. The coffin was on a jeep which was as close to the filter units as we could get it -- a few feet.

Q. After the filter paper was placed in the coffin, you got ready for another drone?

A. No. The drones were all in. We jiggered all the filter paper off until all drones came in. In the meantime, had jiggered the lanyards off the filter units, then the filter screens were ejected from the unit.

Q. Then the total time interval in which the operation occurred was six times the five minutes -- or thirty minutes for the arrival of the planes?

A. I would say from 7:00 to 8:30. In that interval I was working with my gloves on.

Q. Were you told of any hot intensities that were near the planes?

- A. No, just my own observation. Commander Vandergriff mentioned that the intensity was over 20 R. He only monitored the bottom filters.
- Q. Were the rubber gloves fairly large? You estimated a 9½ size on an 8½ hand.
- A. Yes, but the cotton gloves fitted quite snugly. We had to work them on over the rubber gloves, one could see the dark color of the rubber gloves through the cotton mesh.

(Hoffman: A very important feature here is the black grimy material which adhered to the gloves of the personnel when they lifted these filter units from the fork. This black, non-powdery substance was hard to remove. Apparently this material was on the inner lining of the filter units. This material was probably the source of the high activity noted on the gamma meter.)

- Q. When did you change your gloves?
- A. I changed them just once, but I don't remember just when.
- Q. How did you take the gloves off?
- A. The cotton gloves only come over the palm. The rubber ones have a fairly long wrist to them. Just grasped the wrist of the rubber glove and pulled them inside out and threw them to the ground.
- Q. Did you have any other outer garments?
- A. Just Army fatigues, plus a pair of shoes.
- Q. Were your arms bare?
- A. I don't think so.
- Q. Were your hands or any other part of your body monitored after you finished?
- A. No.
- Q. No measurement was made for any radiation before you showered, to go to the plane?
- A. No.
- Q. Were any measurements made on you at all after you got on the plane? or arrived in the U.S.?

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- A. The first measurement was made by Dr. Hempelmann and Norman Knowlton at Los Alamos Hospital. They monitored our hands and chest. They have the record of what this was -- I believe it was just background. This was approximately midnight, Saturday, May 15, or about thirty-six hours after it happened.
- Q. What about pocket meters? When were you first given one, was it changed and did you know anything about reading them?
- A. We were given two dosimeters before we even got any place near the drones, while we were waiting for the drones to come in. One had a capacity of 200 milliroentgens and the other, a blue dosimeter, went up to 10 R. After three top filter units were lifted down off the fork, I was told that the blue dosimeter which went to 10 R. read 7 R., and Commander Vandergriff replaced this with another 10 R. dosimeter. He mentioned that it may have been leaking. This one I know read $3\frac{1}{2}$ R. I was given another dosimeter. What this read I don't know. The use of the 200 milliroentgen dosimeter was abandoned because they all went off scale. Had three of these. The film badge was placed in the same place as the dosimeter.
- Q. You had no occasion to touch any place at any time other than the filter units?
- A. None, and only the top filter units.

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(Account of interview by Joseph G. Hoffman at Los Alamos Hospital,
3:30 P.M., May 17, 1948)

- Q. Could you tell me the story of what happened, the time interval, how long you worked, etc.?
- A. I don't have a very clear conception of the time -- something from 7:30 until 9. The drones came in as fast as we could take care of them. As soon as we could get one unit off there was another unit put into the revetment. This was on the top units. I handled four with . . . spelled me for two. Then I handled two more. There were eight of those. Then . . . dropped out. I worked only with top units at the beginning.
- Q. This meant that two of you would take hold of the unit from the fork, lift it off, drop it on the ground, and leave it at a fast walk?
- A. Yes.
- Q. You were given dosimeters. Did you have special garments?
- A. We had protective clothing, an Army fatigues outfit, an old pair of shoes I had been wearing about, and gloves. The shoes I left out there.
- Q. Who gave you the gloves?
- A. . . . I had on rubber gloves and white undertaker's gloves. I think on the Yoke shot we used the cotton gloves. This time we used both the cotton and rubber gloves. I took the left rubber glove off because it seemed to be itching quite a bit.
- Q. After how many units did this itching start?
- A. About one. Very soon after we began working. After the first plane was taken care of.
- Q. Did they fit tight?
- A. Very loose.
- Q. Could you see the rubber through the cotton glove?
- A. No. I changed cotton gloves once, after we had taken off the first unit. They were dirty and black. It seemed that the monitor checking them found they were hot. Otherwise I wouldn't have changed them just because of the dirt. After we finished taking off the top units, Lang left to go back to quarters to shower and take a plane. In the meantime . . . had taken out all the filter papers from the bottom units. Just

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jiggered the lanyards on each side of the unit, both top and lower. Albright helped him.

Q. Did you have occasion to touch any plane at any time?

A. No.

Q. Were you told at any time about the radiation intensity?

A. No, other than that they were hot.

Q. How were you aware of that?

A. The Commander mentioned that the first one to come in was pretty hot. That's all he said. I had no idea of the kind of meter he was using. I don't think that was mentioned.

Q. How did you know your gloves were hot?

A. It seems to me that Vandergriff tested them. He kept looking at our dosimeters in our pockets.

Q. Did you have the same dosimeters?

A. The 10 R., yes; the 200 milliroentgen dosimeters were off scale. By the time Stanley and I had taken off all the top units we had the bottom units. We began clipping the wires, holding the screens together, labeled and stapled them and put them in lead coffins.

Q. How many filter papers do you think you handled?

A. I don't remember exactly. There were sixteen front papers and I probably handled all of them in some way. Maybe some of them more than some of the others.

Q. Can you do this in the wind?

A. There was some wind. We had to be careful to get them in the right order because it meant quite a bit as far as the results were concerned. That's why we handled them by hand. We had to clip the two copper wires; open up the screen, pick up the paper, separate them if there were two; take the front unit out, put them together. By this time Stanley had labeled and stapled them. Probably the left hand got more exposure in this operation because the right hand was using the stapler. Two of us worked together, kneeling down.

Q. You knelt down right over the screen?

A. Off to one side.

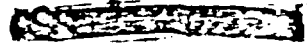
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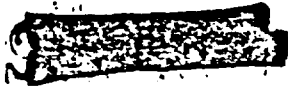
- Q. Did you have any special way of handling the paper?
- A. It goes into the coffin flat. After we had finished all of them we drove through the revetments in a jeep at about 10 miles an hour to check and make sure that we got all of them. There are two planes in each revetment, one behind the other. We circled between the two planes.
- Q. Do you think there was some radiation?
- A. Would pick up some, yes.
- Q. After the top and lower filter units were taken down, you put the filters in the coffin. Then how did you handle your gloves? Any special procedure for removal or disposal?
- A. Just threw them on the ground. We were told it didn't make much difference.
- Q. You finished about 9:00 o'clock?
- A. About that.
- Q. Were there any radiation measurements made on your person?
- A. No, other than when I removed my gloves. A monitor said they were hot.
- Q. Any radiation measurements made after you got back to the States?
- A. Not until Dr. Hempelmann and Captain Knowlton measured us in the emergency room at the Hospital (in Los Alamos).
- Q. What time was that?
- A. We arrived roughly about 9:00 P.M., May 15th.
- Q. Why did you come to the Hospital?
- A. As soon as I walked up the steps they asked me if my hands were red. I said yes. They suggested I go and have a blood count in Q Building. Lang was there, so was Captain Knowlton, and they had called Dr. Hempelmann.
- Q. If it had not been called to your attention, would you have noticed it?
- A. I knew they were red. I thought at first it might be from the rubber gloves, in a hot, moist climate. Then began to wonder a little bit about it. It seemed to vary in the intensity of the itching.
- Q. Was any radiation found on your person here?



- A. Yes. They have a record of it.
- Q. Didn't they have a monitoring system at Eniwetok?
- A. They had radiological safety people, but we took off in such a hurry there wasn't much time to check us. We washed and showered in our own quarters. We lived at the Vet's quarters. I took a good shower there because I figured I was hot.
- Q. Did you pull any lanyards?
- A. No.
- Q. Did you have any idea of the kind of discharge you were getting?
- A. Yes. I asked him once when he looked at it and he said I had about 7 R.
- Q. Was there any discussion at any time about the use of rubber and cotton gloves for this kind of work?
- A. Not that I know of. The monitor didn't give us any gloves at all. Mel Bowman had brought these from the ship the day before. Had planned to use them.
- Q. Was there any discussion of using tongs?
- A. Tongs were present. I wouldn't have been happy about using tongs. I was too interested in getting samples in the correct order.
- Q. You had that one pair of gloves on your right hand?
- A. The same rubber gloves but I did change cotton gloves.
- Q. On the left hand you had taken the rubber glove off completely and just wore cotton? And when you changed gloves you changed both cotton gloves?
- A. Yes.
- Q. How wide was the revetment?
- A. About 100 feet. (Drew diagram of revetments, etc.) The discharge on the coffin about six feet away would be tolerance at the time it went into the plane. We stayed six feet away during the entire trip. I handled the coffin only twice; once putting it into the plane. Picked up one side of it, raised it perhaps six inches and put it down again. No one seemed anxious to get it out of the plane, so I asked a security man to help me transfer it. That's all the handling I did.

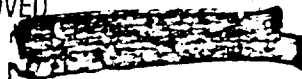
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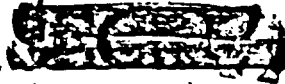
(Account of interview by Joseph G. Hoffman at Los Alamos Hospital, 3:15 P.M. May 17, 1948)

- Q. Do you think the injury to your hand is due to radiation?
- A. I don't know. I've never had sores like this before from the work I've done. I've lifted a lot of lead and think the lead may have brought it on. It's a deep bruise -- it started out by reddening and then blossomed out.
- Q. On what day did you work in the Pacific, and how long was it after the shot?
- A. It was one and one-half hours after the shot.
- Q. Did you wear rubber gloves?
- A. No, only green cotton gloves supplied by a group out there, a radiation safety group, I guess. There was a supply of them.
- Q. How many drones did you help with?
- A. I took the top filters off of seven.
- Q. You were not associated with touching the lower filters or any other part of the plane?
- A. I took the lower filter paper out after they were removed.
- Q. How do you take hold of the filter unit?
- A. With both hands with a fore and aft lift, two people working, one on each side. It's light, about twenty-five or thirty pounds, and is easy to lift.
- Q. You waited for the drone to come in and the truck goes up and gets the unit on the fork? Who pulled the lanyards?
- A. as far as I know.
- Q. Did you notice if there was a lot of gum on the gloves?
- A. I couldn't tell. The gloves were a dark green. We pulled the filters off, set them down and moved away. Anything like that wouldn't show on the dark green.
- Q. What was the time interval from the time you worked on the first drone until the time the last drone was completed, so far as the removal of the top filters was concerned?



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- A. About eighty minutes, counting the entire operation. I did not work all this time. I had the same gloves on from the first unit to the last. The planes were a good ten minutes apart. They seemed to take a long time to come down.
- Q. Did anyone tell you there was a lot of radiation, gamma or other?
- A. No one said any amount -- they merely said it was "hot". Our job was to get the filter units out.
- Q. Did you see any meter working? And if so, who was carrying it?
- A. There was one meter being carried around, but I don't know who was carrying it. I don't know any of the personnel.
- Q. Were you given pocket dosimeters?
- A. We started out with a 200 milliroentgen dosimeter. We walked near the first plane and they assumed that the first two had discharged, so they give us a 10 R. I don't know what happened to them. They didn't want us to handle them. I didn't look at mine. We should have had a 10 or 20 R. dosimeter for that operation. The meter was completely discharged. I did have a film badge.
- Q. How did you estimate the radiation if you had no meter?
- A. They did go up to the planes and say they were hot. They yelled out a reading to someone at the tail of the plane. I didn't pay much attention to that.
- Q. Who read your meters?
- A. A group of Army men -- they took them out of our pockets and read them. They replaced two 200 milliroentgen meters; they were either discharging or actually received that much.
- Q. Did you have a film badge on?
- A. Yes.
- Q. How did you take that off?
- A. The film badge was the metal type inserted into the pocket of the shirt. I took off my glove, then gave the monitor the film badge.
- Q. Were any radiation measurements made on your person at any time that you know of?

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- A. No. Not during the operation. When we finished, we removed our clothes, I had my hands monitored, took a shower and went home. Hands measured in the range of 10 milliroentgen, which is about background at that place.
- Q. How long after the shot?
- A. 7:30 first; 8:40.
- Q. How long after that did the plane come in?
- A. The plane left the field at 10:25. Waited on the field about an hour.
- Q. After you put the filters on the ground, who pulled the lanyards to release the filters?
- A.
- Q. Did you partake in any way in the handling of the screens and the filters?
- A. Yes, I would say in the range of 20 filters in the lead coffins, which meant that somebody snapped the wires, I removed the filter papers, just a few feet.
- Q. How did you handle it?
- A. I handled it with gloved hands, probably took about 10 seconds.
- Q. Did you make any effort to handle the dead edge?
- A. I think I did. It's difficult to say. There was about one-fourth inch facing to hold.
- Q. Did you handle the entire filter in any way? Did you roll it?
- A. May have placed my hand over or under it in pushing it down in the center. I may have pushed it with my left hand.
- Q. Does the wind enter into this at all?
- A. It was very windy. The paper wiggled.
- Q. There were eight filter units in all. In each filter unit there were two sets of screens, making approximately 16 filter papers that had to be put in the coffin. Did you handle all of the 16?
- A. I did handle all 16.

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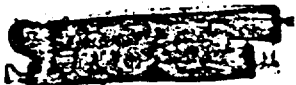


- Q. Did you handle any of the filter papers from the lower units?
- A. Yes, either four or six; all of the uppers, at least four of the lowers.
- Q. Were your gloves tight-fitting?
- A. Loose. They were big.
- Q. Were they loose mesh?
- A. They were fairly heavy, were soft cotton, felt fairly thick.
- Q. Did you have any instructions at all as to what kind of gloves to wear?
- A. I just took the ones that were given to me.
- Q. Was there any discussion on the use of rubber gloves or tongs?
- A. I don't remember anything about rubber gloves. Tongs were suggested. I would certainly use tongs if I had it to do over again.
- Q. Did you do any of the stapling?
- A. One. I held one while it was stapled, no more.
- Q. Did you pull any lanyards at any time?
- A. None.
- Q. When you took the gloves off, was there any particular procedure involved in removing or disposing of them?
- A. I think I put them in the jeep, just threw them in the back -- can't say for sure. I've been trying to remember. I stripped them both off and threw them off somewhere with my clothes when I stripped for a shower. We discarded all of our clothing in a heap.

(explained that since he returned he has been doing a lot of lifting of lead bricks in the range of 100 (?) about 30 pounds each, using both hands but using the left mostly to steady the weight since the right hand is stronger. He returned to Los Alamos about May 1, Saturday. He worked Sunday and Monday and part of Tuesday. About a week after his return from the Pacific he noticed a slight tenderness and reported it three days later when it began to swell somewhat under the skin.)

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(Account of Interview by Joseph G. Hoffman, May 21, 1948, at 11:30 A.M.)

worked on the first four planes that came in around 7:00 A.M. I got there about 7:30 A.M. We had put the lead pigs on the back of the jeep and went out and watched the shot for awhile. There was general radiation around from the drones which were parked on the airstrip. The meter read about 500 mr per hour at one spot where I was standing. I went over and started working about a half hour before the planes landed and was around the planes until about 9:00 A.M. I'm not quite sure when we finished.

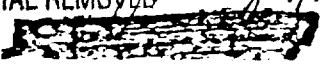
We had on green Navy fatigue clothes, which we had put on when we got up that morning around 2:00 A.M. I had on a pair of rubber surgical gloves and a pair of thin white cotton gloves just before I started working on the planes. They were fairly loose and you could see the dark rubber through the thin cotton mesh. Before that time I was pretty well away from anything. I had gone up fairly close to watch the planes, not closer than 50 feet before 7:30 A.M. We had put on pocket meters when the planes started landing around 7:00, and the monitor gave me one film badge and a dosimeter.

pulled all the lanyards that held the filter units. I helped take off the top filter units from the fork lift for the last four planes that came in. had taken off the first four; worked with me on the next two, and worked with me on the last two. I was standing around watching while the first four planes came in. There was the usual dust flying around. I noticed a black gummy substance which rubbed off the filter units onto the gloves. There were no measurements made on this substance, but I imagined that it was hot. They had washed down the planes with a degreasing solution of kerosene, and this may have caused the gummy substance.

As far as I know, there were no radiation measurements made around the filter papers. I made a measurement with a gamma ray survey meter (a Model 100 we had brought with us from Los Alamos) which had been used for all the shots, but I don't feel that it was contaminated. It covers a range from about 100 mr to 1 r. Vandergriff was the monitor. He would walk up to the plane after it had landed while they were going up to take off the filter units and take measurements off the tail of the plane as it stopped. He was not around while we were taking out the filter papers, but appeared when we were almost through. The pocket meter that I had recorded the intensity during the entire operation. It was a 10 r. dosimeter. Vandergriff took it from me together with the film badge. It read about 8½ r. but I thought it was leaking. It read 1 r. before I ever got close to the planes.

The lower filters were left on the planes. went around jerking out the sides, leaving them on the ground near the nose and and I went around with a jeep. I handled about all of the

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filter papers, around 20, because some of them had double thicknesses. I wrote the number of the plane down on a sheet of paper for identification while [redacted] knelt down by the filter unit, snipped open the wires holding the two screens together, opened it up and picked up the filter papers. If they were single, one of us put the two papers face to face, put the identification sheet on top and stapled the whole thing together. I had the stapler, held it with my right hand, grasping the side of the filter paper with my left hand. It was one of the small desk, push-type staplers about four inches long. I did this down on one knee, as close to the filter papers as [redacted] was, for instance. After left, [redacted] would open out the filter sides and be putting them together while I was writing down the identification number. I picked them up and put them into the lead coffin on the jeep, which was about 3 - 4 feet away. After we put the filter papers in the coffin, [redacted] made some measurements on the coffins after they were closed up. (This reading could probably be gotten from [redacted]) They were taken through the steel plate at the bottom and through the lead at the top. He said he was going to do it on all of them.

We got in the jeep around 9:00. [redacted] had left to shower and change clothes. Just as [redacted] and I finished we got in the jeep and met them after going around the mile; changed jeeps with them and they took the jeep with the samples and went back to the airstrip. We went on to our quarters. I took off the clothes I had, washed my hands pretty well, [redacted] took a shower. Then we went back to the airstrip. We weren't close to the planes which were on the opposite side and some distance from the operations. The Rad-Safety people had Victoreen meters which were quite sensitive. We stopped by their group and I got myself some clean clothes but I didn't have them check my hands. Measurements were made by Victoreen meters at the Los Alamos Hospital when we got back. They said my hands were giving off 1 mr at contact, shoes gave off about 1 mr. (I was wearing the same shoes I had on during the operation.)

In the previous shot, they had some difficulty with identification and they didn't want them stapled together. I thought it was best to handle the papers with our hands to do the job quickly and accurately. Tongs were there, but the papers were hard to handle and I assumed it would be better to use the hands and get less body radiation. It might have been better if we had taken the filter sides entirely away from the plane.

I know that on previous shots the gloves had gotten pretty hot. They had monitored them but I don't remember any figures. [redacted] had thrown their gloves away after they got through with four planes. I worked with mine during four planes, and took them off immediately after finishing, because I knew they were hot, as well as being sticky and hot internally.

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May 24, 1948

TO: L. H. Hempelmann, H-Division
 FROM: J. G. Hoffman
 SUBJECT: DOSAGE ESTIMATES ON SANDSTONE PERSONNEL BASED ON INTERVIEWS WITH

1. Rod Spence supplied the following data on the hottest filter papers measured at 10:05 p.m., Saturday, May 15, 1948. This is 36 hours after zero time:

Paper #1 @ 60" (153 cm), 14 γ MR/hr; or 450 mR/hr @ 2 hrs

Paper #2 @ 40" (108 cm), 18 γ MR/hr; or 600 mR/hr @ 2 hrs

The papers are about 10" x 18". The intensity at 36 hrs is based on a 1.2 power decay of γ intensity with time. It is assumed that we have a point source effect. The above sources referred to 1 cm distance become:

Paper #1 1.0×10^7 mR/hr @ 1 cm @ 2 hrs

Paper #2 7×10^6 mR/hr @ 1 cm @ 2 hrs

2. First we shall estimate the order of magnitude of beta curies on the filter sheets. From measurements on water boiler activation of NaCl for Na^{24} we found

betas: 8×10^4 β cpm/mgm NaCl

gammas: 0.72 γ mR/hr/mgm NaCl @ 1 cm dist

The relation between β and γ activity is then $8 \times 10^4 / 0.72$ or 1.1×10^5 β cpm/ γ mR/hr for Na^{24} . Filter paper #2 above then had at 2 hrs time:

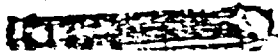
$$7 \times 10^6 \times 1.1 \times 10^5 = 7.7 \times 10^{11} \text{ cpm per sheet, total}$$

$$= 1.3 \times 10^{10} \text{ cps per sheet, "}$$

$$1.3 \times 10^{10} / 3.7 \times 10^{10} = 0.35 \beta \text{ curies @ 2 hrs per sheet}$$

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To: L.H. Hampelman, H-Div., 5/24/48, Subj: "Dosage Estimates on Sandstone Personnel Based on Interviews with

An alternate estimate is made as follows: assume 1 Mev gammas from the fission products. Then 2×10^9 γ quanta per R is the conversion constant from quanta to roentgens. Assume at 2 hrs 3 β per γ emitted. The second filter paper then gives $2 \times 10^9 \times 7 \times 10^3 = 1.4 \times 10^{13}$ γ /hr or $1.4 \times 10^{13}/3600 = 3.9 \times 10^9$ γ /sec. And at 3 β/γ we get $3 \times 3.9 \times 10^9 = 1.1 \times 10^{10}$ β /sec per sheet total. This result is of the same order of magnitude as the estimate given above and agrees with it closely. We concluded that the filter papers at 2 hrs time after zero had β activities total which were of the order of 1/2 curie or less.

3. We now compute the required beta uc and time required per cm^2 to give a dose of 500 rep at a depth of 2 to 3 mm. The experimental data show that independently of beta energy (0.5 to 3 Mev) the depth dose at depths are as follows:

$$2 - 3 \text{ mm depth, } 2.14 \times 10^{-4} \text{ rep/sec/1 } \mu\text{c}\beta/\text{cm}^2 \text{ (P}^{32}\text{)}$$

$$3 - 4 \text{ mm depth, } 7. \times 10^{-5} \text{ rep/sec/1 } \mu\text{c}\beta/\text{cm}^2 \text{ (P}^{32}\text{)}$$

In order to get 500 rep to the 2 - 3 mm depth we require then,

$$500/2.14 \times 10^{-4} = 2.3 \times 10^6 \text{ } \mu\text{c-secs/cm}^2$$

It is known that the personnel wore their gloves for 90 minutes or 5400 secs. This means that the density of beta activity would be

$$2.3 \times 10^6 / 5400 = 425 \text{ } \mu\text{c/cm}^2$$

If we round this figure out to 500 $\mu\text{c/cm}^2$ and assume an activity of 0.5 curies on a filter sheet then 0.1% of the activity on a sheet is needed to get from the filter to 1 cm^2 of glove to produce the dose required above.





To: L.H. Hempelmann, H-Div., 5/24/48, Subj: "Dosage Estimates on Sandstone Personnel Based on Interviews with

4. How we compute the source strength of the grimy, greasy or soot-like substance which the men got from lifting the filter units. It was visible as black gunk on the white cotton gloves. Also, a monitor had warned that their gloves were hot. There are not specific data on this gamma measurement of the hotness of the gloves. Suppose however that a gamma reading of 0.5 mR/hr were found at 1 meter distance. This is a low reading compared to the 20R per hour mentioned by as having been measured by Van der Griff at 25 feet from the nose of a plane. The reading of 0.5 mR/hr at 1 meter becomes 5×10^4 mR/hr @ 1 cm assuming a point source. From section 2 above we have 1.1×10^5 β cpm/ γ mR/hr which leads to:

$$\begin{aligned}
 1.1 \times 10^5 \times 5 \times 10^4 &= 5.5 \times 10^9 \beta \text{ cpm} \\
 &= 8.4 \times 10^6 \beta \text{ cps total activity on glove} \\
 \text{or} &= 220 \beta \mu\text{c total glove activity}
 \end{aligned}$$

The value of 220 β μ c on the glove falls within the order of magnitude of beta activity required on the gloves in order that a beta dose of 500 rep at the 2 - 3 mm depth be delivered. It also is a very small fraction of the total activity gathered on the filter papers.

5. Which source of radiation, namely: handling the filter papers or smearing the black gunk on gloves, is the major contributor is a matter of conjecture. For instance, Stanley helped lift down 4 filter boxes, then removed his gloves and bare-handed helped prepare about 20 filter papers for shipment. On the other hand, Lang lifted 6 filter boxes and helped staple papers keeping his gloves on all the while except for a change of gloves after lifting

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Exhibit L
(Page 4)

To: L. H. Hempelmann, H-Div., 5/24/48, Subj: "Dosage Estimates on Sandstone Pers Based on Interviews with

down 3 filter boxes. It is probable that radiation dosage came from both sources but in widely varying degrees from one individual to another.

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Exhibit L
(Page 4)

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May 24, 1948

TO: Louis H. Kempelmann, H-Division

FROM: Joseph G. Hoffman

SUBJECT: NOTES ON THE SANDSTONE PERSONNEL RECEIVING BETA RADIATION

On May 16 and 17 I interviewed Messrs. and . As a result of these interviews I have arrived at the following possible conclusions as to the nature of the radiation burns supposedly sustained by these personnel:

There are two main possible sources of radiation which could have affected the hands of these personnel. First, and most important, is that from the gunk which was on the filter units and which got on to the gloves of the personnel when they lifted the filter units off the fork of the carrier truck. were very conscious of this gunk because it was dark, grimy and sneary. It showed up very well on their white cotton gloves. They were informed by a monitor that it was hot as measured by gamma radiation. The other possible source of radiation is that of proximity to the filter papers which they removed from the filter units. Proximity to the filter papers does not present a strong source of radiation which would bombard skin surfaces consistently. It therefore seems that this second possibility is not the major source of radiation involved unless active material transferred from the filter to the glove. The first possibility accounts for several things, perhaps the most important of which is the fact that the left hands of these people show the most radiation effects. Since these are right-handed people, it is probable that the gunk was rubbed off, due to active use of the right hand, while that which stayed on the left hand was able to afford a sustained source of radiation. These people did not at any time touch any other part of the planes, and thereby pick up radioactive material on their gloves. for instance, points out that after working on the first drone that came in, he found it necessary to remove his left glove, that is, the cotton and rubber glove together, after which he put on only a cotton glove. He removed the first set of gloves because of a strong itching sensation. also described a similar phenomenon. After working with three of the drones, he changed both sets of his gloves and replaced them again with the combination of rubber and cotton gloves.

Concerning the case of Sattizahn, he reports that he wore green cotton gloves, which must have been thicker and more closely knit than the white cotton gloves worn by the other three individuals. He did not report seeing any kind of gunk on his gloves after lifting the upper filters down to the ground. This may be because he could not see the gunk against the green background of the gloves, or else there was none available. Both claimed that they desired to change their gloves after they saw the mess of black gunk on their gloves. But they changed their gloves primarily because of the itching and because

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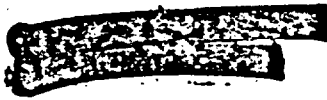
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Exhibit M

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To: Louis H. Hempelmann, H. Div., May 24, 1948, Subj: "Notes on the Sandstone Personnel Receiving Beta Radiation" (Cont'd)

the monitor informed them they were hot. said he knew from a previous shot that the gloves of personnel became hot.

Presence of gunk on the gloves of these personnel accounts for the fact that the burns seemed to be on the inner surfaces of the fingers toward the palm of the hand. One has difficulty in seeing how such a dose could be delivered by the handling of the filter papers. All four individuals named above mentioned seeing tongs for handling the filter paper; they also mentioned the fact that they handled the filter papers rather indiscriminately although they were aware that there was a quarter inch dead space on the periphery of each of these filter papers. The filter papers are about 10 x 18 inches. Although they handled these filter papers rather indiscriminately, it is hard to see how a sustained beta dosage to the skin surface could be given because the radioactive material on the paper probably was not in immediate contact with the body surfaces for any sustained length of time. And if any activity had come off the paper it would have caused burns on the ends of the index fingers and thumbs.

In their accounts of their work pointed out, for instance, that they kneeled down to pick up the two pieces of filter paper from each filter unit and stapled them together. One person held the two papers at the short ends with both his hands while the other person used the ordinary kind of stapler to pin them together. It is, therefore, probable that the faces of these people were on the order of half a meter from the hot filter paper surface. The filter paper as a source of radiation for the hands is to be contrasted with the gunk which obviously stuck to the cotton gloves and remained fairly close to the skin surface at all times.

A final word concerning the position of this gunk on the filter units: Apparently it was located on the inner wall of the filter unit, so that when the men took hold of the units to lift them through the ground the gunk stuck to the inner surface of the glove. No one mentioned seeing this black gunk on the white filters. Lang expressed the opinion that it was not wet or oily but rather was sooty.

story is of interest in that he helped take down four of the upper filter units having on rubber and cotton gloves. He then removed the gloves and proceeded to assist in preparing about twenty filter sheets with his bare hands. He expressed the idea that his exposure would be lower if he could work quickly (bare-handed).

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July 23, 1948

MEMORANDUM

TO: A. E. Dyhre, Business Manager

FROM: H. O. Whipple, M.D., H-Division

SUBJECT: SUPPLEMENTARY RADIATION ACCIDENT REPORT

REFERENCE: LAB: H

This report is to supplement the inter-office memorandum sent to your office by Dr. L. H. Hempelmann dated June 7, 1948 in regard to the four University of California employees, _____, who received radiation injuries as a result of exposure to radioactive samples.

The clinical courses of these four individuals have justified our initial conclusions that the whole body exposures were small enough to discount possible fatal consequences of the injuries. However, it has become evident in the past four weeks that the injuries sustained by the hands of three of the men (_____) are more serious than originally anticipated. In spite of the fact that the injuries were primarily the result of the beta activity of the samples, there was sufficient penetration into the dermal and vascular layers of the skin of the hands to cause fairly deep injury to these layers on some parts of the hands and fingers. It is quite possible that skin grafting to the hands may be necessary in the cases of Stanley and Lang.

The changes in the blood of all four individuals were compatible with ordinary thermal burns consisting of an increase in the total white blood count, increased sedimentation rate, and several other abnormalities. There has been no hematological evidence of whole body radiation injury.

The following is a short progress report on each of the four injured men:

_____ : This man's left hand, which was injured, now appears to be perfectly normal. There was a period of about two weeks after discharge from the hospital during which the hand was slightly tender and more sensitive to heat and cold. This has subsequently disappeared and now no abnormalities can be found. The right hand has never shown any evidence of radiation injury.

_____ was discharged from the hospital May 28, 1948. It is advised that he receive no exposure to radiation until further notice.

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A. E. Dyhre, Business Manager

July 23 1948

H. O. Whipple, M.D., H-Division

SUPPLEMENTARY RADIATION ACCIDENT REPORT - page 2

_____ : There was a continuation of the formation of blisters on both the right and left hands with the left hand being the more severe up to about the 7th of June. In view of the drainage from the blisters and the fact that healing was beginning, the hands were surgically debrided on June 23rd and wrapped in burn dressings. New dressings were applied on the 6th of July and at this time healing was continuing. The dressings were changed again on July 20th. The right hand at that time had healed except for the index and middle fingers, which still show unhealed areas. The left hand shows two ulcerated areas which do not appear to be healing and may require skin grafting in the future.

_____ : This man's burns began to subside during the second week in June and were surgically debrided and dressed at the same time as Lang's. On July 20th the right hand showed a complete covering of new skin. The left hand was covered with a very thin and sensitive layer of skin except for several very small areas which are still unhealed.

It is probable that there will be complete epithelization of both hands but that the skin of the left hand will be permanently thin and atrophic.

_____ : The right hand of this patient has never shown any evidence of injury. The left hand began to improve about the 13th of June after blisters had formed over the palmar surface of all four fingers, the thumb and about one-third of the palm. The burns were surgically debrided and dressed at the same time as Lang's and Balagna's. On July 20th the index and middle finger still showed ulcerated areas and it is felt that skin grafts may be necessary on the index finger.

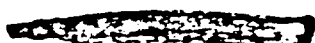
(Original signed by Harry O. Whipple)

Harry O. Whipple, M.D.
Health Division

cc: Dyhre
Clark
Medical Records
File

Exhibit H
(Page 2)

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INTER-OFFICE MEMORANDUM

DATE June 7, 1948

TO: A. E. Dyhre, Business Manager
 FROM: Louis H. Hempelmann, M.D., H-Division
 SUBJECT: Radiation Accident Report
 Reference: LAB:H

Four University of California employees,

, sustained radiation injuries to their hands as a result of exposure to radiation emitted by radio-active samples. It is believed that the injuries are due almost entirely to beta rays which makes their prognosis much more favorable than if the injuries had been due to gamma rays. The gamma ray exposure to their bodies was not excessive as indicated by film badges and pocket chambers worn at the time of the test. There have been no significant changes in the blood counts of any of these men or other indications that they have sustained general bodily injury. It is probable that there will be good healing of the burned areas in all cases, and that the eventual results will be comparable to those produced by second or third degree thermal burns. There is always the possibility, of course, that healing of the skin will not be complete because of damage to the blood vessels supplying this area. If healing is incomplete, surgical repair of the lesions on the hands will be extremely difficult if not impossible.

The following is a short summary of the exposure of each man and of the clinical progress of their injury at this date:

His exposure occurred on April 30 by handling samples of radioactive material. The total body exposure during the operation did not exceed 1.5 roentgens. The burn, which did not manifest itself for about ten days, was limited to the thumb and the first three fingers of the left hand. There was a gradual development of rather large blisters on the first and second fingers which were painful during the week of May 17 to May 21, but began to subside after the weekend of May 22. At the present time there is marked thickening of the skin in the region of the blisters, with the redness and discoloration still evident in the injured areas.

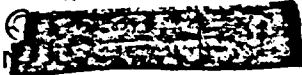
has been discharged from the hospital and has been allowed to go back to work in the technical area with specific instructions (1) to avoid use of the left hand in any type of manual operation, and (2) to receive no further exposure to radiation until further notice from us.

There were no significant changes in the blood count, and the skin of the right hand appeared perfectly normal since the exposure.

: This exposure occurred on May 14, in the identical fashion as in the case of . It is believed that this exposure of the hands to radiation was considerably greater than that reported above. noted a tingling of his hands during the operation and swelling and some redness began two hours after exposure. At the time of his return to the Los Alamos Project on May 15, 1948, both hands were rather markedly swollen and somewhat red. Blisters appeared on the first and second fingers of the

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Memo to A.E. Dyhre from L.H. Hempelmann, 6/7/48, subj: "Radiation Accident Report" (Cont'd)

left hand on the third day following exposure. Since then, there has been extension of the blistering process to involve all fingers, the thumb and part of the palm of the left hand. The right hand is similarly involved, with redness in the same areas, but the blister formation has not been quite as extensive, particularly on the third and fourth fingers. During the past several days there seems to be some improvement in the condition of the hands and it is believed that the healing process has begun. Lang's general body exposure was recorded as 6.5 roentgens. He has shown some equivocal changes in his blood count which may or may not be due to radiation.

This exposure of this man occurred at the same time and in the same manner as that described for . He also noted itching of his hands during the operation and the swelling of both hands several hours following exposure. When seen on arrival at the project May 15, 1948, there was some swelling of both hands, although not quite as extensive as in the case of . Erythema was noted on the third day with an increase in the swelling. These signs improved somewhat during the second week but during the third week there was increase in pain, particularly in the palm of the hand where there was gradual formation of a rather deep-seated blister which now involves the palm of the left hand, the thumb, and all four fingers. Although enormous blisters are still present on both hands, the reaction of the surrounding tissues seems to be subsiding, and it is believed that healing process has begun.

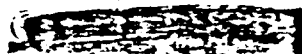
total body exposure was recorded as 17 roentgens, according to film badge data received from the Radiological Safety group at Eniwetok. This exposure seems to be somewhat out of line with that received by the boys who did a similar job, and may be high by as much as a factor of 2. His blood count has shown equivocal changes which are not believed to be due to radiation.

The exposure of occurred at the same time and in the same way as did that of . At the time of his arrival on the project May 15, 1948, there was some swelling and redness of the first and second fingers of the left hand. There was a gradual increase in the swelling of these fingers during the first week following exposure and there was a gradual development of blisters. The blister process now involves only the first and second fingers, but there is a rather marked erythema of the third and fourth fingers and the thumb which seems to be subsiding. injury does not seem to be as severe or as extensive as that sustained by

The total body exposure was recorded as 4.5 roentgens of gamma rays. The blood count shows no changes. The right hand appears to be perfectly normal.

/s/ Louis H. Hempelmann
Louis H. Hempelmann, M. D.
Health Division

LHH:rms
cc:medical records



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NO. [REDACTED], SERIES [REDACTED]

17 AUG 1948

INTERROGATION OF LTCDR VANDEGRIFT

BY COMMANDER WIHANT

Removal of Filter Samples from Drones - Test Zebra

It was necessary for the man accomplishing the mission to run in, re-lease the filter quickly and get out. The blue 10 r dosimeter was checked after each entry and as the operation progressed, it gradually built up to a total of 8 r in the case of Balagna. This reading would have given cause for alarm except for the fact that this particular dosimeter (inter-mediate range) has a consistent history of reading high by a factor of about three. We do not rate this blue pencil dosimeter type very highly, but for this particular operation it was the only instrument available because the ion chamber cannot be read "on the run." On this occasion the dosimeter read low.

Film badge exposures were as follows:

1.5 r

17. r

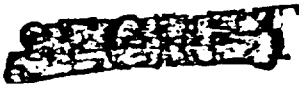
3.8 r

5.6 r

Methods used

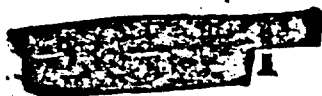
Drones landed, Long checked tail and ok'd hook on. Drones towed to parking revetment. Vandergrift checked nose for top filter box removal. Mason kept running record of dosimeter readings, logging and recharging 200 mr dosimeters as necessary. Drones were found to be exceptionally hot.

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Carl Wilson 6/24/83 41

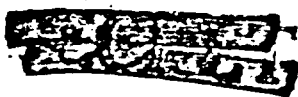
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Interrogation of LtCdr Vandergrift by Cdr Winant (Cont'd)

LAJ 2 personnel were kept constantly informed as to the general intensities of radiation and of their dosimeter reading. Island survey was commenced at Z minus 1 day and continued through Z plus 3 day. Slight fall out noted on Z day as shown on enclosed curves. Top filter boxes removed with lift on truck. tripped 4, Albright tripped 4. Top filter boxes taken from lift (two men required for each). removed six, re-
moved six and removed six. (This was accomplished by shifting relative positions during this phase). each pulled 4 of the filter holders from the top filter boxes. Without removing lower filter boxes from drones pulled filter paper holders from all lower filter boxes. (This was a departure from the method used at Yoko and is considered to have been more efficient).

Now, with all filter paper holders pulled clear of drones and filter boxes, removed all papers, took readings and placed papers in lead containers. Lang assisted in this during the removal of six filter papers from lower boxes. Gloves and 18" tongs were provided for this operation though a stapling machine was used to mark each paper. An accurate intensity reading of each paper was not taken by the RadSafe personnel, but a quick reading was made and the handling personnel advised of the intensities involved. At this point, during the collection of filter papers, it was realized that all personnel were near tolerance, but no relief personnel were available. To stop this operation would have resulted in a serious delay. The operation was continued to completion



~~SECRET~~Interrogation of LtCdr Vandergrift by Cdr Winant (Cont'd)

and the two sets of papers, in their lead containers, were loaded on two C-54's and, accompanied by _____, took off for the U.S. Film badges of _____ were sent immediately to the BAIROKO by helicopter.

The entire operation went smoothly and except for the faulty handling technique, is believed to have been efficient. It is obvious now that more remote handling of filters should have been used. The success of the technique on the previous tests gave a false value of the technique for 2 day.

Explanation

Because of the difficult conditions and extreme urgency of the work, no written record was developed during this operation. The foregoing contains the essential facts presented to me verbally by Lt. Cdr. Vandergrift at the earliest possible time after the operation.

/s/ FRANK I. WINANT, JR.

FRANK I. WINANT, JR.
Commander, U.S. Navy

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TO WHOM IT MAY CONCERN:

On the afternoon of Zebra test I received word that the drone planes were unusually active and that one of the men who removed filters had received 17 r units of radiation. I requested a conference on the USS BAIROKO with Commander Winant's staff and Lt. Commander Vandergrift who was the Head Monitor at Eniwetok for this test.

Vandergrift informed me that the planes were unusually active and that he realized that the participants were reaching their tolerances before their work was completed. He stated that he so informed Dr.

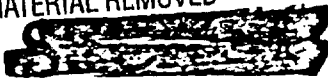
who was in charge of the group and they both decided that the blood dosimeters which they were using were leaking because this particular instrument had done so in the past. Upon developing the film badges it was found that had received a total of 17 r units. However, the other members of the party had received much less:

1.5 r

3.8 r

5.6 r

Two days later we received a wire from Dr. Louis Humpelmann at Los Alamos informing us that had arrived back at Los Alamos with swollen hands, also that from Yoke test was also showing some reaction. I immediately sent for Ogle and Linenberger and other members of their groups - blood counts were made on the entire group and were normal. There was no evidence of any lesions on their hands. I questioned who had participated in all three tests and he informed me that he had observed tearing off the filter papers with his gloved hands instead of using the wire clippers



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Cord Williams 47

that were supplied for this purpose. He told me that he tossed him a pair of clippers and told him to use them.

I have recently returned from a trip to Los Alamos where I made a complete study of the four men mentioned above. informed me that he received his injuries while clipping identification tags on the filter papers. His injuries included only his left hand. He held a paper with his left bare hand and clipped the identifying numbers with a clipping device which he held in his right hand. His right hand showed no injury. This demonstrates to me that the injury was due to beta radiation and could have been avoided by using the instruments supplied.

These men have received excellent medical care and are making very satisfactory recovery. It is anticipated at this time that recovery will be complete in all four cases. It is recommended that they be examined at least every six months for a period of years, and that they should not be allowed to use their hands in contact with radiation in the future.

/s/ JAMES P. COONEY

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