

Argonne National Laboratory

**A STUDY OF THE CORRELATION BETWEEN
HAND AND WRIST EXPOSURES**

by

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INTRODUCTION

Informal conversations with people associated with Health Physics work related to plutonium have brought out the fact that correlation studies of hand and wrist exposures have been made. These conversations have also pointed out the fact that it is impossible to arrive at a set ratio between hand and wrist exposures. Ratios of from 1:1 to 10:1 have been obtained. Variation in the ratio is attributable to the differences in the form of the material being handled, that is, solid, powders, and/or solutions, and the actual work that had to be performed on these materials. The general consensus is that a 4:1 ratio is a good ratio to use in determining hand exposures, based on results with wrist film badges.

Operations in the Plutonium Fuel Fabrication Facility, Building 350, at Argonne National Laboratory, have been confined thus far to the handling of plutonium in a solid form. It is quite possible that, although the major portion of future work will also be confined to solids, some work in the future will involve powders; but these will be maintained in some type of container, thus making the material comparable to a solid as far as handling is concerned.

At the present time there is no convenient means of attaching a film badge to the palm of the hand in order to obtain the total exposure to the palm. A film badge ring, to be worn on the finger, appeared to be the best substitute. The ring could be worn in close proximity to the palm of the hand. We obtained a supply of ORNL AEC Hand Exposure Meters (film badge rings) and requested operating personnel in Building 350 to wear them while working in the hood line gloves in such a manner that the face holding the film would be located on the palm side of the hand. Numerous faults were found with these film badge rings including the following:

1. Although the rings were supposed to fit all fingers, we found that they were too small in the majority of cases.
2. The face holding the film was too large to be conveniently worn with this face on the palm side of the hand.
3. Backs of fingers were pinched and irritated by the split ring construction.

4. Some films were light struck as a result of a loosening of the cover over the film.

We found ourselves in a position where we had a ratio between hand and wrist exposures (4:1) to use, but did not know if this was reliable in our case. At this point it was decided to simulate actual working conditions as close as possible and attempt to determine a reliable ratio.

PROCEDURE

Two things were needed to reproduce actual working conditions:

1. an extended source of radiation;
2. a holder for film badges that would simulate a hand.

Since we were not considering actual exposure from plutonium, but were interested in the ratio of exposure of hand to wrist, it was not imperative that the extended source be plutonium. An available extended source was composed of pieces of a ceramic crucible that had been used in a plutonium melt. The ceramic crucible was broken up to facilitate placing it in small can, about 3 in. in diameter and $4\frac{1}{2}$ in. high, which was sealed and pouched out of the system in a vinyl pouch, and placed in a one-gal paint can with a pressed lid (see Figure 1). The reading obtained through the side of the can with a 2.5-r Juno with the beta and gamma shields open was 110 mr/hr at 2 in.

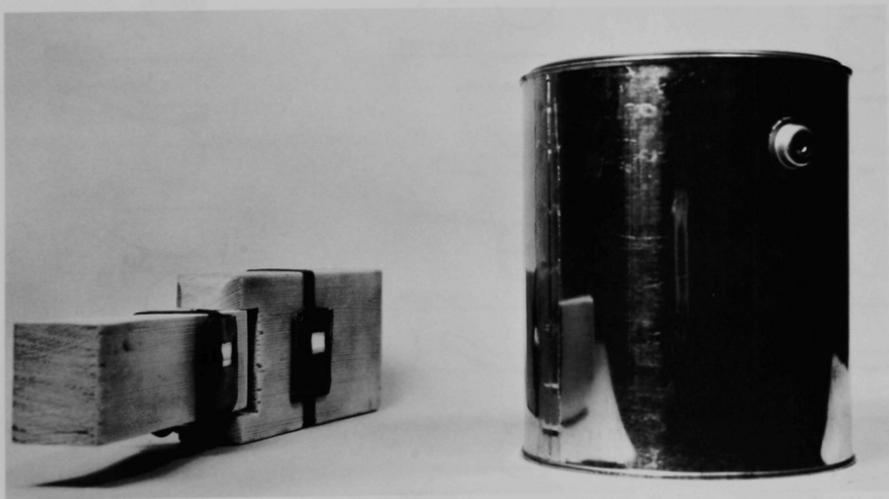


Figure 1

Figure 2 shows the holder for the film badges, made from a 2 x 4-in. piece of wood. A hinged joint provided simulation of wrist movement. The film badges were mounted so that they were 4 in. apart, center to center, which is the approximate position in which they would be found if worn by an individual.

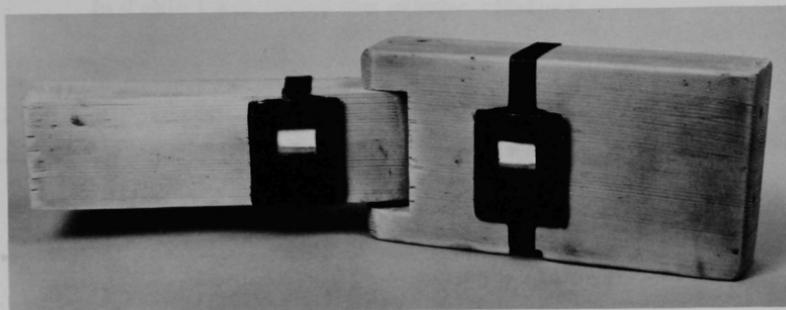


Figure 2

A template was made to position the source and the film badge holder. This helped us maintain the same relationship between the source and the film badges. Figure 3 shows the various positions used in determining the exposures received.

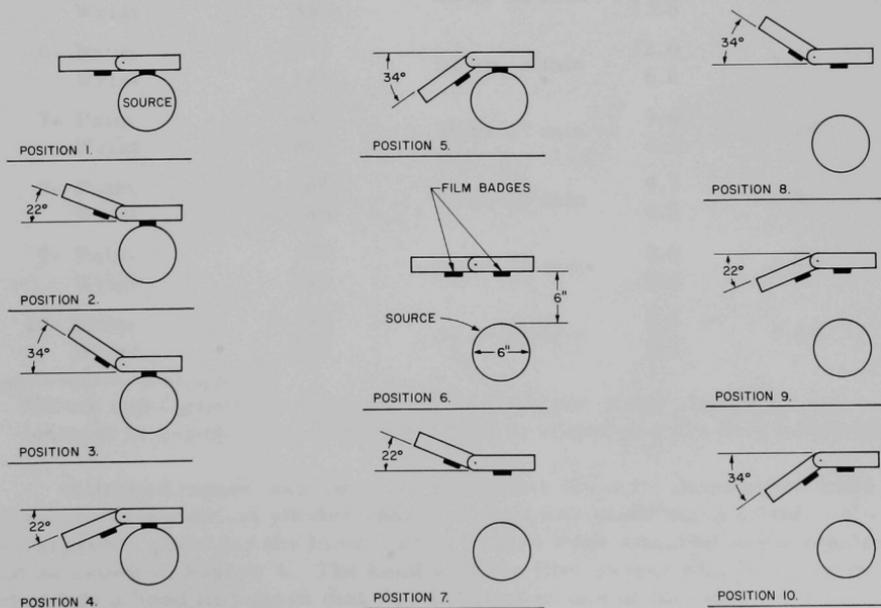


Figure 3

A brief study was made to determine the angle that would be found between the hand and the forearm while working. It was decided that the angle would vary between $\pm 34^\circ$ from a straight line without straining the arm over extended work periods.

In Table 1 are listed the results obtained.

Table 1

Film and Position (see Figure 3)	Total Exposure (mr)	Exposure Time	mr/hr	Ratio - Palm/Wrist
1- Palm	1075	65 hr 22 min	16.2	1.35
Wrist	800		12.0	
2- Palm	760	23 hr 46 min	31.8	1.96
Wrist	390		16.2	
3- Palm	1625*	24 hr 5 min	67.2	2.43
Wrist	660*		27.6	
4- Palm	720	24 hr 27 min	29.4	2.45
Wrist	300		12.0	
5- Palm	600	23 hr 52 min	25.2	1.83
Wrist	335		13.8	
6- Palm	275	22 hr 3 min	12.6	1.91
Wrist	145		6.6	
7- Palm	480	49 hr 27 min	9.6	2.29
Wrist	200		4.2	
8- Palm	300	30 hr 45 min	9.7	2.02
Wrist	145		4.8	
9- Palm	170	17 hr 38 min	9.6	1.14
Wrist	145		8.4	
10- Palm	220	23 hr 35 min	9.6	1.14
Wrist	200		8.4	

*These two figures are opposite those reported in the film badge report; it is assumed an error was made in identifying the film locations.

A second means was set up to determine the ratio between the hand and wrist exposures. A plaster cast of a hand was made using a latex rubber surgeon's glove for the mold. Film badges were attached to the plaster hand as shown in Figure 4. The hand with the film badges attached was inserted into a hood line glove that was in place on one of the hood lines. Plutonium metal, weighing approximately 41 g and covering an area measuring roughly $\frac{1}{2}$ by 2 in., was placed as shown in Figures 5 and 6. In one

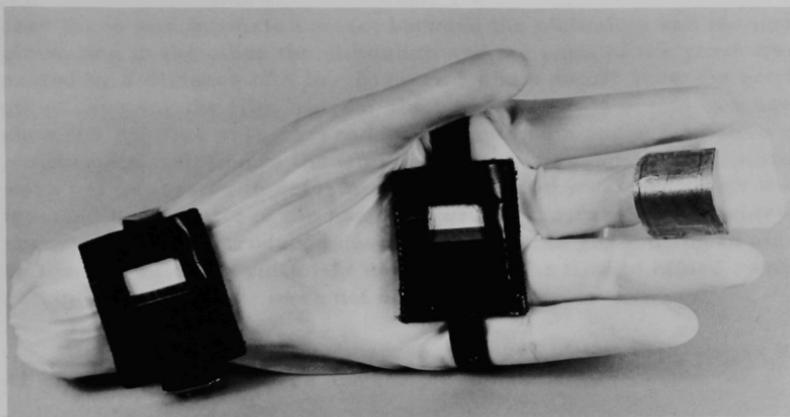


Figure 4

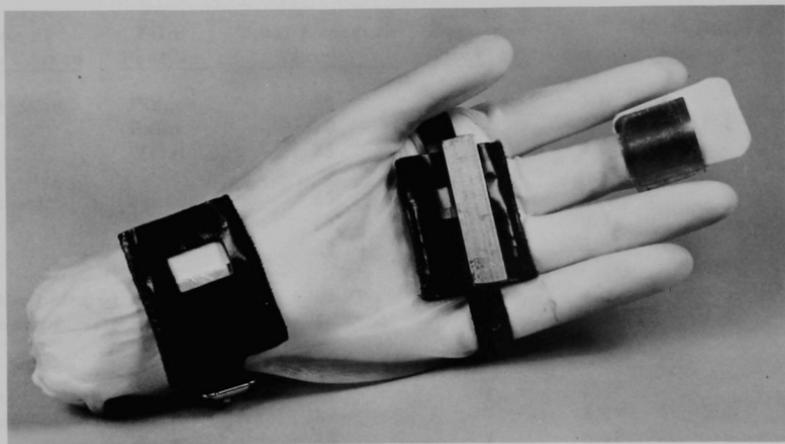


Figure 5

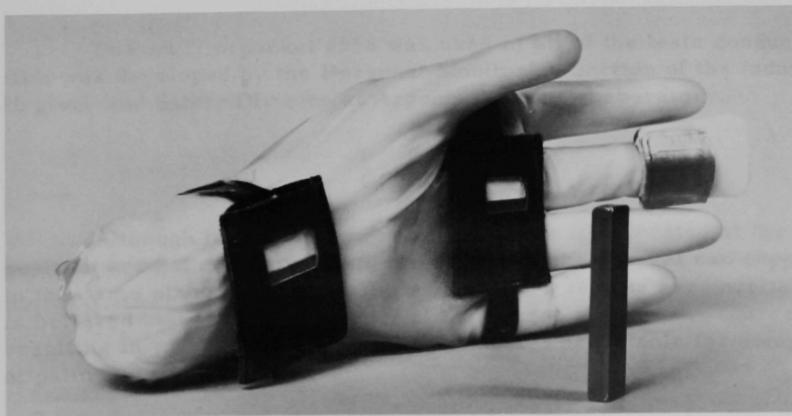


Figure 6

case there was intimate contact between the plutonium and the hood line glove, and in the other the plutonium and the palm of the glove were separated by a distance of 4 in. Figures 5 and 6 do not show the hood line glove covering the film badges; also, a piece of aluminum was used to show the relative area covered by the plutonium and the position of the plutonium in relation to the film badges. As previously mentioned, we were not interested in determining the hand exposures, but we were interested in the ratio of the hand and wrist exposures. Some shielding and absorption were introduced due to the hood line glove being in place, but as long as we had a sufficient darkening of the film to afford somewhat reliable readings, we were not concerned.

Table 2 shows the exposures received by the film badges using the 41 gram plutonium source and the plaster hand.

Table 2

<u>Location of Plutonium Source</u>	<u>Film Position</u>	<u>Total Exposure (mr)</u>	<u>Exposure Time (hr)</u>	<u>mr/hr</u>	<u>Ratio Palm/Wrist</u>
Contact at palm	Finger	65	17	3.8	8.4
	Palm	210	17	12.35	
	Wrist	25	17	1.47	
Contact at palm	Finger	55	7	7.86	3.25
	Palm	65	7	9.3	
	Wrist	20	7	2.86	
Opposite the palm at a distance of 4 in.	Finger	65	17	3.8	1.0
	Palm	40	17	2.35	
	Wrist	40	17	2.35	
Opposite the palm at a distance of 4 in.	Finger	25	7	3.57	1.0
	Palm	25	7	3.57	
	Wrist	25	7	3.57	

DuPont film packet #558 was used in all of the tests conducted. The film was developed by the Personal Monitoring Section of the Industrial Hygiene and Safety Division at Argonne National Laboratory.

CONCLUSIONS

Although the exposures received by the film located at the palm position are not consistent with the source in the one-gal can supposedly in the same place, it is not believed that these results are unreliable. It is believed that the heterogeneity of the source allowed the source to shift, resulting in varying readings. The ratios are acceptable for comparison of palm and wrist exposures.

The use of a 4:1 ratio in determining the exposure to the hand did allow for a safety factor of about 2 when working with good-sized sources.

It would be impossible to determine a hand-to-wrist ratio of exposure that would be reliable in all cases. Method of work, material worked with, individual dexterity, and individual idiosyncrasies are uncontrollable factors which must enter into the problem. It is agreed that a 4:1 ratio is one that can be used in most cases.

Small sources held directly in the palm of the hand would result in a greater exposure than would be indicated using a 4:1 ratio.

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