OPERATION HARDTACK II, NEVADA TEST SITE

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We returned to Nevada in August of last year specificall, to test [redacted] device. We were told that the yield on this device would be somewhere [redacted] Lt Colonel William Moncrief, MC, USA, was our project leader, and operationally and technically our end of the project went very well. We did have multiple problems, particularly with respect to yield variations, weapons failures, and changes of the date. We were originally scheduled to go out there 15 September 1958.

I would like to have the first slide. Our primary objective on this project--4.2.1: To determine the immediate lethal response to all effects of the [redacted] device. Originally just the radiation effects were to be evaluated, but we soon realized that blast was going to be important in ranges where radiation levels were high enough to produce anything near what we thought would be sufficient radiation for immediate biological effects. Major Roger Sherman, MC, Walter Reed Army Institute of Research, and I were responsible for this project. (1

4.2.2 - The RBE (Relative Biological Effeciency) in swine and weapon neutrons was a project of Lt Colonel Rothe, a very fine Army veterinary officer from Walter Reed Army Institute of Research. The RBE for swine for weapon neutrons had never been determined. It was attempted in the 1957 project but due to weapons failures the project was wiped out. We had 350 swine in this project.

4.2.3 - The radiation response of small mammals, mice, was 4.2.3 project. This was a project of Major Mike Dacquisto, MC, also of Walter Reed, as was the evaluation of aminoethylthiouronium, AET, a pre-protective drug which Major Dacquisto studied on mice. He gave them this drug orally in doses of 1000 milligrams per kilogram of mouse. Orally this drug lasts for about six hours.

Next slide. The secondary objectives were radiation measurements from prompt neutrons and gamma, as well as residual radiation in the area under the weapon. ~~This was~~ important from the standpoint of exploiting this area personally. We were interested in getting measurements of neutron induced activity and any local fallout in the area. Next objective was the Na^{24} biological dosimeter. This shows considerable promise as a method of determining neutron dose received. If you know something about the neutron-gamma ratio of the weapon, and can measure the amount of sodium 24 in the animal, you can calculate what dose of neutron radiation was received and what dose of gamma radiation was received. This was done on swine. The sodium 24 was counted both at Walter Reed with (2)

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the low level whole body counter and a well counter was also shipped out to Nevada. However, unfortunately, the cloud from one of the weapons went over the shack where the counter was kept and at the time we needed the counter the background was too high. Measurements obtained at Walter Reed were worthwhile, however. A report was made on Na^{24} after the Oak Ridge accident and has been used to calculate dose. Alpha hazards: [redacted] The DT 60 dosimeter, the type that the Air Force and the Navy are now wearing daily, was studied by Lt Colonel Ballinger from Los Alamos. He was interested in the response of this dosimeter to neutrons of various energies, as well as to the gamma. Some of them were cadmium coated to convert neutrons to gamma and absorb thermal neutrons.

Finally, damage to field fortifications: This was a project of the Engineer Research and Development Laboratory.

Next slide.

Now, on the first project--4.2.1, our mission was to determine the immediate lethal response of swine following exposure to detonation of th[redacted]type nuclear weapons. We used exactly the same type swine used in 4.1 on operation PLUMBBOB, Trimble Manor Farms in Missouri, and these were in standard field fortifications, namely, open foxholes, two-thirds closed foxholes, offset foxholes, and armor (we used M46 tanks and M59 APC's). Then we also had to determine the safe distance for the user of this device. [redacted] and it was important to see if this was really safe for them to do this.

Next. Then the problem of "immediate" came up. What do you mean by immediate? "Immediate" to me meant <u>right now</u>. It meant that we had to be right there with the pigs at the time (4)
of detonation. This was rather undesirable because our nearest fortification was 5 yards away from the base of the tower. So finally it was decided that 8 to 10 minutes would suffice for "immediate." Then, how would it be determined whether these animals were living or dead? Colonel Moncrief felt that personal observation or, as he called it, "the old M1 eyeball," was the best method of determining the condition of the swine and it turned out to be the only effective method. The arrival time for observers had to be calculated, ~~and~~ how long it would be safe for them to remain in the area. (5)
We were about a mile away at the time of detonation. We expected to encounter some residual radioactivity and the sooner you get there after a detonation, the higher ~~it~~ is. (6)
This residual radiation is "hot" from fission products and neutron induced activity. The Nevada soil contains a lot of

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aluminum, which is quite radioactive after the detonation. It also contains manganese, sodium and silicon which also becomes radioactive. Other means of observation were considered, including photography. Of course you can't take pictures when the level of radiation is several hundred r per hour, without fogging the film. Television equipment wouldn't stand the overpressures of several hundred pounds per square inch. Telemonitoring was considered and a very fine Navy team came out and telemonitored many of our animals, 15 of them. They put microphones under the skin to detect heart beat and breath sounds. EKG leads were sutured to the animals and hard wire was run well over a mile to get electrocardio graphic tracings. Helicopter observation was another thing that was considered, but you saw the dust on the previous PLUMBBOB film and it is impossible to see anything by helicopter after one of these weapons goes off on the Nevada Desert.

Next. Then we had to decide what whole body residual radiation exposures we might get. When we first started calculating we thought that if we were going to go in there within 6 to 10 minutes after the detonation, we were going to run into pretty high levels of radiation and we would have to get special permission to absorb more radiation. We got permission to receive up to 25 r per person for eight of us and we calculated on the basis of not receiving more than 15 r if we

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[redacted]

could help it. At 6 minutes we couldn't go in above or beyond the 238 r per hour line and stay 18 minutes or we'd get too much. If ~~it was hotter~~ [illegible handwritten insertion] than this when we arrived, we would have to wait for 12 minutes. If you wait longer you get diminishing returns.

Next. This is a diagram of 4.2.1 experimental array. Neutron flux would be lower on this axis than on this axis. [redacted] So this was the (8
high neutron axis. Our project was on the high neutron flux axis. Now, out here at the safe distance end, we had 20 (9
animals, in these pens, at 600-800 ~~700-750~~ yards. Now we will see a close-up of this section right here in a second. This is 80 yards north, 30 yards across, and 70 yards south. The whole project was close to ground zero

Next. This is a blowup of the section you just saw, here is ground zero, this is the northern section. These are offset foxholes, these are two-thirds closed, these are open fox- (1
holes. In the ends of these particular ones the Navy teams had telemonitoring equipment. These are tanks and APC's. There was another APC over here that you can't see. These (11
were the transmission factors that we used to calculate the radiation dose that would get into the foxholes. Now, we had to spread these foxholes out so that you have some close enough if the yield was [redacted] and far enough away if the yield [redacted] This means you have to have considerable numbers of stations to cover all these yield possibilities.

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[redacted]

We made our calculations on this basis. These first three figures are from NRDL on the transmission factors for fortifications. The offset foxholes 7 feet deep through a tunnel underneath the soil transmitted only 2 percent of the neutrons and 3/10 of a percent of the gamma, which is pretty good radiation protection. But these offset foxholes had the unfortunate trait of doubling the blast overpressures. Whatever the blast level was on the surface, it was roughly twice that inside. In this particular tank, the M46, 50 percent of the neutrons were expected to enter, 15 percent of the gamma. In the armored personnel carrier, 80 percent of the neutrons, and 60 percent of the gamma were expected to enter.

Next. These are the predicted figures for the HAMILTON shot at 5 yards where we had our first stations. The thermal level if the yield [redacted] would be greater than 100 (U) calories per square centimeter, blast greater than 1000 pounds per square inch, at 5 yards. Whatever radiation was delivered here would be of academic interest. For [redacted] again in rems, the prompt air dose was expected to be [redacted] well over 1,000,000 combined neutron and gamma.

The offset foxhole dose, however, 17,700 neutrons plus gamma. M59, 855,000 neutrons plus gamma if it had been at 5 yards.

Next, at 70 yards, you can see how rapidly this falls off. [redacted] 14 calories per square centimeter for thermal blast. 22.5 psi and radiation, prompt air dose here, [redacted] Only 778 rem, which still, of course, is a lethal dose, would enter the offset foxholes at 70 yards, and the APC at this distance is 27,000. (13)

Next slide. Now, the Project 4.2.3, or the RBE experiment, was set up to bracket 250 rads to 700 rads to try to get this RBE factor. So there were 350 swine here. This was the high neutron axis. This was the low neutron axis. A paraffin shield was put here next to the end of the weapon to further absorb more neutrons so that the gamma neutron axis here was [redacted] on this side, whereas here it was [redacted] give you a differential. (14)

Next slide. This photograph is what the project actually looked like, what you just saw. These are the pens for the swine. There is the tower 50 feet, and the bomb is here. (15)

Next. Now the mouse project, 4.2.3, was interspersed in the RBE project. Actually, you can break it down to three different categories. These open circles are mice in lead hemispheres on the high neutron axis, these big lead hemispheres weigh almost a ton and filter out the gamma almost completely while allowing the neutrons to enter. These mice in aluminum hemispheres were not protected from neutrons or gamma by the aluminum. This is the high flux axis. Again there was no (16)

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such protection on the low neutron axis.

Next. This photograph is what it looked like, actually. These are the aluminum hemispheres. A lead hemisphere is a tremendous dome and has to be carried in by big truck. This photo is looking from the tower. (U

Next, the dosimetry involved in this project. We had internal dosimeters in the animals, chemical gamma-neutron dosimeters, and neutron foils. (18 Then externally, outside of the foxhole or the tank, in the environment with the animals, (19 we again have dosimeters. This enables us to compare what the internal dose was to what the dose was in the animal's (20 environment. This, then, could be compared to what the dose was outside the environment.

Next. This is the array shortly before the detonation. As you can see, these are the foxholes and this is the armor (21 on either side, the high neutron flux axis, these are the weaponeers up here, ~~practically~~ assembling this weapon, and this is the low neutron flux axis, the RBE experiment and the mouse experiment.

Next. This is immediately after or soon after the detonation. We were about a mile away and saw this device detonate, we could tell that it was a nuclear yield, but you can't tell what the yield is by looking at it. So as planned, eight of us went in, four on the north and four on the south, and got our data. We found all the animals, except two that were

[redacted] [redacted]

buried by blast, in the foxholes were alive and well, showed no ill effects whatsoever. This made us suspect that the yield was low. The condition of the holes was pretty good.

Next. In going in at 8 minutes at 400 yards we encountered only 900 mr per hour, but as we got close and into our project at 80 yards, our first installation, at 10 minutes, it was 10 r per hour. By the time we got into our closest station, the reading was 340 r per hour at the 17 yard slant range station. Now our pocket dosimeters were reading from 16 to 18 r. The film badges later came back at about 9 r. (22

Next. Now, that project was wiped out because the weapon yield was only 1 ton. Our efforts had largely been in vain. (23 All the animals had received some radiation, enough radiation that they couldn't be used for anything else and the observers had also received enough radiation that they could (24 not be used on another project to a significant degree. That demonstrated again the problem of going in with an extensive (25 biomedical project on a weapon of unpredictable yield. This weapon was supposed to go on 15 September and it actually went on the 15th of October, and the pigs had grown 1½ pounds a day in the meantime. Instead of 2-man pigs they were now (26) 4-man pigs from the handling standpoint.

This next event, the HUMBOLDT shot, went on the 29th of October, 2 days before the moratorium. However, we didn't (27) know where ground zero was going to be on this project until

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less than 48 hours before it went off. So all of the foxholes and all the arrangements were made during the 48-hour period before the actual shot. Now, from the previous shot (HAMILTON) we learned a few things that served in good stead here. We knew, for example, that this soil was not as good as the soil at Frenchman Flat. We expected that these foxholes would cave in if this weapon went with any significant yield, so aluminum liners were put inside the foxholes. The pigs were put inside those aluminum liners. We were afraid that the residual radiation level in this area would be prohibitive, and that we couldn't personally observe because of the high radiation levels and this turned out to be correct. This, incidentally, was the high neutron flux axis of this particular weapon, but it was only by accident we happened to get on this axis which we wanted. We couldn't repeat the other two experiments (4.2.2 or 4.2.3). So, since we didn't think we could get into this area in time, we put 20 animals into these M59 APC's, heavily dosimetered them and connected 3000 foot steel cables to each of those APC's. A bulldozer was attached to the other end of each cable, and as soon as the weapon went off, the bulldozers pulled these two APC's out in a radiologically cooler area so we could observe the animals.

Next. Here we are putting the animals in the APC's. You see the dosimeters hanging up here. These are environmental dosimeters. The swine had internal dosimeters in them also, and we also had dosimeters on the outside for external air dose.

Next. This is the placement of the animals in the foxholes and this is the 25 foot tower on this particular weapon.

Next. This is the weapon as it was detonated. We were a little over a mile away. We went right into the area.

Next. We couldn't get into the foxholes for about 10 hours because the residual radiation level was many hundred r per hour in these foxholes. At 10 hours we did get in. The level was 40 r per hour and higher, and we saw that all the foxholes had been caved in by the blast and these animals suffocated. This was a 5 ton yield weapon but the higher prompt radiation levels were of academic interest in the foxholes, where blast was the immediate killer.

Next. This is what the APC's looked like when we dragged them out. They were buckled in. They had been subjected to about 90 pounds per square inch at 27½ yards from ground zero. The APC hulls were reading about 100 r per hour from induced activity when we got them out at H + 12 minutes.

Now, would you show that 3-minute film please. We will now show you the recovery of these APC's beginning about 3 minutes after detonation. They were pulled out on this cable by a bulldozer. This hull is really radioactive. The neutron flux has activated the manganese in the steel. It was hard to get the door open because the blast has buckled the door. Here are the animals 12 minutes after detonation. You see they will hardly move at all. They are very stunned but this lasts only a short while and they temporarily improve. Notice this effect because I will mention it on the higher

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dose-effects graph later. They are stunned immediately and later on temporarily recover somewhat. This is one that was very close to the front of the APC at 25 yards and he is manifesting the central nervous system syndrome, due to acute central nervous system radiation injury. All these animals were alive at the time we got the APC's back. All 40 of them had received an average dose of about ~~50,000~~ 40,000 rads. They were all alive for at least 2½ hours. See how stunned all these animals are. This is radiation effect, not blast. These animals in APC's were not burned and were not injured by blast. See how apathetic they are. Later on they pick up a little bit, temporarily. Now they are a little bit more active, notice. This all occurs within about 25 or 30 minutes, from the stunned, initial appearance to this more active state. Some of them went right on down hill and never did quite evidence temporary improvement. The residual radiation level here was not very high except in the hulls of those APC's when we pulled them out. We had no one left with "radiation reserve" to send to the foxhole area, which was still quite "hot" at this time. Colonel Moncrief made a quick pass by the foxholes, saw that they were all collapsed, stuck his radiac set out of the jeep and it went off scale at 500 r per hour.

Here we are back at the pens. The pigs wouldn't eat. They were all quite sick and they started dying very promptly. Here is one manifesting typical central nervous system injury. Vomiting and diarrhea started very promptly. Some of them were vomiting and had diarrhea when we took them out of the APC. It is hard to compare human patient and a pig but I think some of them certainly would have been incapacitated immediately, had they been human.

Next slide. Now these are the results of ~~that last~~ shot. M59 Armored Personnel Carrier. All of them are alive at recovery. The first death occured at 2½ hours and the last animal died in 30 hours. There were no blast and no thermal injuries. This is a pure, prompt neutron-gamma radiation injury. The prompt exposure from radiation, gamma neutron flux inside the APC's averaged about 40,000 rem; I say average because the level in front of the APC was considerably higher than the back of the APC. That much distance with these particular weapons makes a difference of several thousand rads at this range. Outside, 58,000 rads. Only 18,000 difference between the inside and the outside.

Next. The open foxholes. All were dead at H plus 10 when we got there. The blast had destroyed all the structures. The aluminum liners had been collapsed, wrapped around the animals in many instances. There was no evidence of any thermal injury. The radiation level inside at 9 yards, was 188,000 rads; 21 yards, 22,000 rads; outside in the open, over 200,000 rads at 9 yards, and 5000 at 21 yards.

Next slide. In the 2/3 closed foxholes, we did find four of these animals alive at 10 hours. They were in the two back lines farthest away from ground zero and all of them had secondary blast injuries, lacerated by the collapse of the aluminum liners. All of these died by the third day. Blast destroyed these structures. This weapon was ~~good at~~ effective in destroying these structures, and killed in this way close to ground zero in field fortifications.

Now, I want you to take this handout,please. Colonel Cavender wanted me to give these results of the high radiation dose conference that was held in Washington in January. We have been getting, understandbly, requests from commanders, repeatedly, concerning how much radiation it takes to kill a human immediately, or how much radiation it would take to stop an infantryman in his tracks, or prevent him from driving a truck, or prevent him from pulling a trigger. As physicians, we don't like to be in this kind of business, but we may be asked for an opinion by line commanders. How much does it take, instantaneously delivered? Well, obviously, no one can give an exact answer on this with respect to human beings, but following our experience in the field last year, it was decided a knowledgeable group should get together and come up with the best possible figures they could devise. Such a group met at Walter Reed Army Institute of Research last January. Representatives of civilian installations, [redacted] Los Alamos, [redacted] the Army, Navy, Air Force were all represented, and these are the results. Notice these are incapacitating doses in rads. Now rads are used here because they are a pure physical unit. You avoid the RBE argument. If you use rem, you have to deal with RBE, which is still an unknown quantity in humans. If you say "incapacitating," then you have to specify, incapacitated for what. So we ~~have~~ had command advice from line officers—Colonel Hutchison and some other experienced line commanders who were there to give us advice on what military functions are most important in combat and how efficient they thought a person had to be to perform these certain military functions. The group decided a person had to be 10 percent efficient to fire a fixed weapon, i.e., just pull a trigger; to assault a position with any hope of survival, he should be 90 percent efficient. You will notice for hand to hand combat, 90 plus percent efficient. This is for 50 percent of the troops, not all of them. These specific tasks and times are indicated here.

Now you will notice, to fire a prelayed weapon, this is how this thing works. The K stands for thousand, 3000 rads for example. If a commander is interested in incapacitating 50 percent of a group of troops, so that 50 percent of them cannot pull a trigger, cannot fire a prelayed weapon, and the time he is interested in is 5 minutes, then 3000 rads would be necessary. Now, if he is interested in a later time, say 30 minutes, it would be necessary to deliver 5000 rads rather than 3000 because, as you remember in the pigs, they were initially stunned, then there was a temporary recovery. Although the animal was already in the prodromal phase, there was a temporary recovery within the prodromal phase before more severe radiation sickness took over, so more radiation is required. If the commander were interested, say, in a period of one hour, he would have to deliver 10,000 rads to incapacitate 50 percent of these troops so that they couldn't pull a trigger. Now, at 8 hours the dose is reduced again because now radiation sickness is taking over and by 24 hours 1000 rads would have sufficed initially. Now you can see it takes less as you go on to more complex functions and more efficiency is required. 1000 rads for 5 minutes to assault a position and by the time 24 hours have elapsed, allowing for biological variations somewhere between 200 and 500 rads would suffice to make 50 percent of the troops less than 90 percent efficient at that time. Now with respect to killing immediately, no one knows how much radiation it would take to kill 50 percent of a unit within 5 minutes. The dose would certainly be most fantastic. At 30 minutes it is estimated that the dose would still be greater than ~~1000,000~~ 100,000 rads. It would take greater than ~~1000,000~~ 100,000 rads to kill half of a group of humans within 30 minutes. One hour, 50,000; 8 hours, 15,000; 24 hours, ~~half of them, if they have received~~ 10,000 rads. ~~will be dead within 24 hours.~~ Are there any questions on this handout? It might be a useful reference for you some day, but I hope most sincerely you never have to use it for its intended purpose to advise commanders.

Thank you very much.