THE NEW NUCLEAR RADIATION CASUALTY CRITERIA

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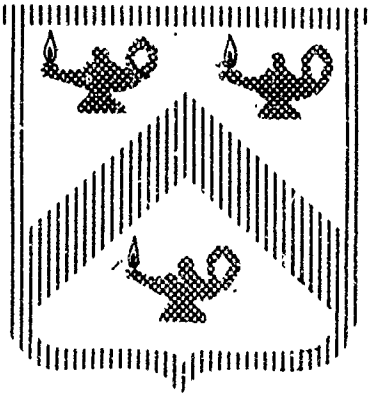
THE NEW NUCLEAR RADIATION CASUALTY CRITERIA

NUMBER THREE IN A SERIES OF INFORMATION PAPERS ON TOPICS ASSOCIATED WITH NUCLEAR WEAPONS, PRINCIPALLY DESIGNED FOR USE BY TRADOC SCHOOL INSTRUCTORS AND MAJOR COMMAND STAFF OFFICERS.

CAC  NUA

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PREPARED BY THE

UNITED STATES ARMY NUCLEAR AGENCY

FORT BLISS, TEXAS 79916

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Nuclear Notes Number 1 - The Electromagnetic Pulse (EMP), June 1974

Nuclear Notes Number 2 - The Army Nuclear Survivability Program, October 1974

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FOREWORD

The series of papers, "Nuclear Notes", prepared by the US Army Nuclear Agency is intended to clarify and explain various aspects of nuclear weapons phenomenology and usage. These papers are prepared in as nontechnical a fashion as the subject matter permits. They are oriented toward an audience assumed to be responsible for teaching or in some way evaluating the tactics and techniques of employing nuclear weapons in a conflict situation. Their dissemination will hopefully provide to the US Army accurate, up-to-date information of critical importance to a reasoned understanding of nuclear weapons on the battlefield.

The principal author of this paper is CPT A. S. Warshawsky of the US Army Nuclear Agency. The new nuclear radiation casualty criteria discussed herein have been approved by the Joint Chiefs of Staff for use by all US Armed Services in nuclear weapons target analysis and selection procedures for land battlefield targets. Comments and views of readers are desired and should be forwarded to: Commander, US Army Nuclear Agency, Fort Bliss, Texas 79916.

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THE NEW NUCLEAR RADIATION CASUALTY CRITERIA

Why are new radiation casualty criteria necessary?

Many years of detailed analysis and experimentation have produced an improved understanding of nuclear weapons technology and phenomena, and of human and animal response to nuclear radiation. This improved understanding has resulted in the adoption by the US Army of new concepts for the use of nuclear radiation as a battlefield casualty producer. The purposes of this Nuclear Note are first, to briefly describe the information and data used to develop new radiation casualty criteria, and second, to show how these criteria can be used by the battlefield commander and staff in planning nuclear strikes to inflict enemy casualties. The radiation criteria discussed in this note apply only to initial radiation doses resulting from a single nuclear detonation; they do not apply to doses resulting from exposure to radioactive fallout (residual radiation). Moreover, the criteria do not consider synergistic effects (compounding of injuries) due to the air blast and/or thermal energies that accompany initial radiation.

What is initial nuclear radiation and how is it expressed?

Initial nuclear radiation is defined as all of the neutron and gamma radiation emitted within the first minute following a nuclear detonation. The amount of radiation that a body absorbs is expressed in rads, which is an acronym for Radiation Absorbed Dose (rad). Other terms, for example roentgens and rem, are also used but the fine distinctions between them are of interest primarily to the scientist. It is sufficient to note that all Army radiation casualty criteria are expressed in rads and all our radiation instruments can be read in rads.

How does man respond to radiation?

Radiation affects man by disrupting the biochemical makeup of body cells. This disruption is brought about by the many processes that occur as the radiation transfers its energy to the cells. Knowledge of the effects of radiation on man has been developed over the years from three main sources of information: 1) irradiation experiments using laboratory test animals, 2) radiation accidents, and 3) observations of patients who received radiation therapy. Not all individuals respond in the same fashion when exposed to identical doses. Age, physical condition, and emotional state all contribute to these variations in response. Response to whole body radiation is usually grouped into one of three syndromes, one for each of the three organ systems that seem to most reflect the effects of radiation on man. Each syndrome has a threshold dose, which is the number of rads that must be absorbed for the average person to show the syndrome's characteristic symptoms. In addition to the three syndromes, exposure to radiation usually causes an initial period of radiation sickness which is best described as being similar to severe airsickness or seasickness. The severity of this initial radiation sickness is not necessarily related to the severity of the subsequent syndrome symptoms. A brief description of each of the three radiation syndromes follows:

Central Nervous System (CNS) Syndrome: The threshold dose is several thousand rads. CNS symptoms are usually visible within minutes of exposure, and depending upon the dose, initial radiation sickness symptoms may or may not be present. Typical symptoms range from apathy and drowsiness to convulsions and collapse. Death occurs within about a week or less.

Gastrointestinal (GI) Syndrome: The threshold dose is approximately five hundred rads. An initial period of radiation sickness lasting as long as 2 days will be followed by the appearance of the GI syndrome symptoms, which are usually first seen from 3 to 5 days following exposure. Typical symptoms progress from a loss of appetite and vomiting to severe diarrhea, high fever, coma, and death within about a month.

Hemopoietic (blood) Syndrome: The threshold dose is about one hundred rads. Despite the name, the blood itself has not been affected; the blood-forming organs have been damaged, principally the bone marrow. The initial period of radiation sickness normally does not continue beyond the first day. Blood syndrome symptoms are usually not seen until 2 to 3 weeks after exposure. Typical symptoms are chills and fever, headaches, and rapid exhaustion following exertion. Few deaths are expected due to the blood syndrome and these usually occur within about 2 months.

How does time effect these responses?

It should not be assumed from the above discussion that only one organ system at a time is affected by the radiation. They are all affected. If death occurs within the first day from the CNS syndrome, the GI and blood syndrome symptoms will not be observed -- not because the organs have not been affected -- rather because the person did not live long enough for the effects to be noticed. However, if the person survives for at least a week or two, the effects on each of the systems will be observed and each of these effects contributes to the overall injury to the person's body. Doctors and scientists usually call the delay between exposure to the radiation and onset of symptoms the "latent period", however, tactical planners and analysts commonly refer to the delay between cause and effect as the "time delay". It is this time delay that makes nuclear radiation such a unique casualty producer.

What are casualty criteria?

The first step that must be taken in any discussion of casualty criteria is to pin down what the words "casualty criteria" are intended to mean. For the purposes associated with radiation, a casualty is defined as a person who is unable to perform his assigned job. Casualty criteria are levels of effects at which half or more of the personnel exposed to those levels become casualties. Furthermore, it is necessary to define what constitutes being unable to perform. Thus, a casualty is defined as a person who performs at 50% or less of his pre-irradiation performance level.

How can radiation defeat an enemy?

An enemy force can generally be defeated by reducing the effectiveness of its personnel and/or equipment to a degree such that the enemy force can no longer influence the outcome of a battle. As with most weapon systems, a nuclear weapon can affect both equipment and personnel. However, a nuclear weapon need neither kill nor visibly wound enemy personnel outright to reduce their effectiveness. An appreciation of the expected responses of soldiers exposed to radiation along with a careful consideration of the time delay, will make it apparent that an enemy force can be defeated by inflicting radiation casualties. However, to properly choose the radiation levels which will defeat enemy personnel, the dose-response relationships and the time delay aspect of radiation injuries must be considered in detail. Figures 1 and 2 show the expected response of soldiers for various combinations of dose received and time elapsed since exposure. Figure 1 shows the expected response of personnel performing physically demanding tasks, as are most combat tasks, and Figure 2 shows the expected response of personnel performing physically undemanding tasks such as pushing a button.

What do these figures show?

The data on which these figures are based were developed from irradiation experiments on laboratory test animals with the results adjusted to apply to soldiers. The vertical axes show radiation dose in rads and the horizontal axes show time elapsed since the detonation of the nuclear round (note that both scales are logarithmic). Dose and time ranges were selected to encompass the responses that result in casualties and to show the effect of the time delay of these responses. The terms incapacitated and functionally impaired which are shown in the figures are formally defined as follows:

Incapacitated: An incapacitated individual is one who performs at 50% or less of his pre-irradiation performance level. Incapacitation is manifested by shock and coma at the higher dose levels. At lower dose levels, incapacitation is manifested by a simple slowing down of the rate of performance due to physical inability and/or mental disorientation.

Functionally Impaired: Functionally impaired personnel are those who, while not incapacitated, will be exhibiting some decreased ability to perform their assigned tasks. These personnel will be suffering radiation sickness in varying degrees of severity and at changeable times. Radiation sickness will be manifested by various combinations of projectile vomiting, propulsive diarrhea, 'dry heaving', nausea, lethargy, depression, and mental disorientation. Although these effects will be transitory, whenever an individual is experiencing them he will generally be unable to perform his assigned task. Performance levels will be lower than pre-irradiation levels.

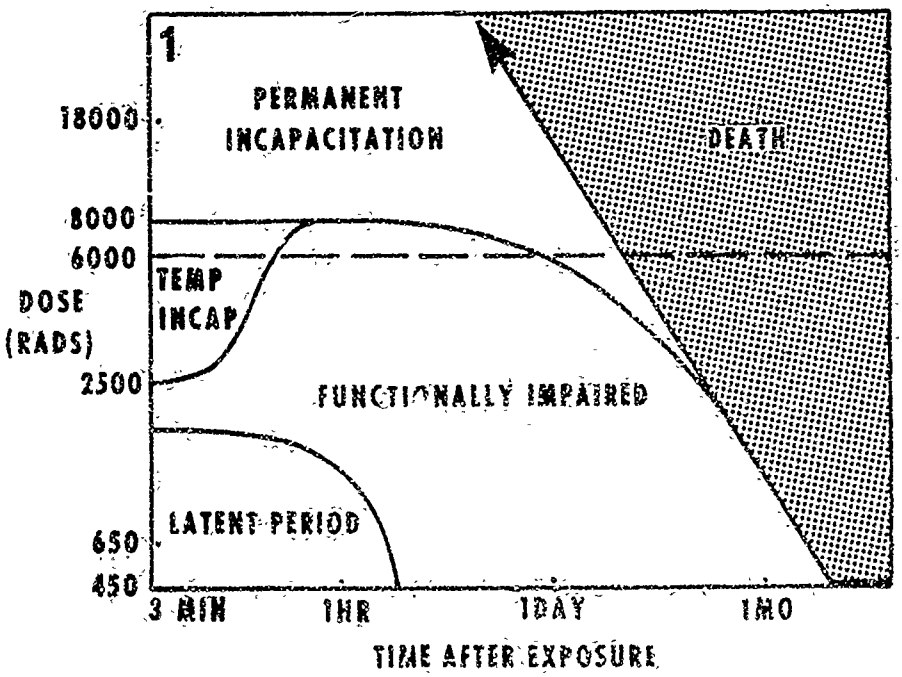

FIGURE 1. PHYSICALLY DEMANDING

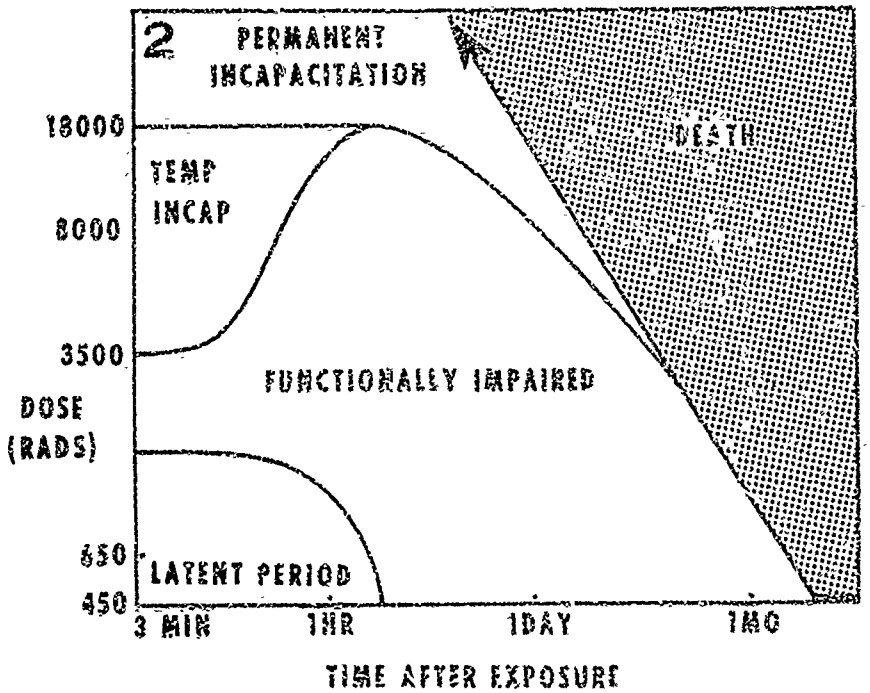

FIGURE 2. PHYSICALLY UNDEMANDING

In other words, incapacitated people cannot perform their jobs and, therefore, are casualties. Functionally impaired personnel are not yet casualties, but they cannot perform as well as they could before they received the radiation. Functionally impaired personnel may eventually become casualties. As an example, consider the expected responses of a group of people, whose jobs involve physical tasks and who receive 6,000 rads of radiation. From the dashed line on Figure 1 it can be seen that the group will become temporarily incapacitated about 3 minutes after exposure. This group will remain temporarily incapacitated for about half an hour, after which the people in the group will have recovered sufficiently to categorize the group as functionally impaired. The group will remain functionally impaired for about 18 hours after which the conditions of the people in the group will deteriorate enough to again place the group in the incapacitated category. Death can be expected about 3 days after exposure.

What are the new radiation casualty criteria?

Figures 1 and 2 were used to develop new criteria appropriate for use by the Army in the field. As shown by Figures 1 and 2, someone performing a physically undemanding task (radiotelephone operator, radar operator, FDC plotter) must be exposed to a much higher dose of radiation to be categorized as an early casualty than must someone performing a physically demanding task (vehicle driver, infantryman, tank loader). Because of the seriously debilitating effects that can occur during a lengthy time span, it is more constructive to understand the expected response of a radiation casualty than to worry solely about the time at which permanent complete incapacitation (PCI) occurs. The radiation casualty doses used in the 1970 version of FM 101-31-2 (the Nuclear Weapons Employment Manual) are doses that were expected to cause PCI within 15 minutes, 1 hour, and a few hours -- and are called immediate, prompt, and delayed, respectively. The experiments and other available data since those criteria were formulated led to the construction of Figures 1 and 2, and have now made it apparent that the descriptions of the expected radiation casualty responses in the 1970 manual are inaccurate. The radiation casualty criteria doses which are being used for the revision of FM 101-31-2 are 18,000, 8,000, 3,000, and 650 rads and are explained below. While these dose criteria are presented as single dose values for simplicity, they actually represent the midpoints of bands or spreads of doses which more realistically recognize the variation in individual human response to radiation. The new radiation casualty criteria doses bring about responses as follows:

Immediate Permanent Incapacitation (IP):

18,000 rad band (17,000 - 19,000 rads) - Personnel will become incapacitated within 5 minutes of exposure and for <u>any</u> task will remain incapacitated until death. Death will occur within 1 day.

8,000 rad band (7,000 - 9,000 rads) - Personnel will become incapacitated within 5 minutes of exposure and for <u>physically demanding</u> tasks will remain incapacitated until death. Death will occur in 1-2 days.

Immediate Transient Incapacitation (IT):

3,000 rad band (2,500 - 3,500 rads) - Personnel will become incapacitated within 5 minutes of exposure and will remain so for 30-45 minutes. Personnel will then recover but will be functionally impaired until death. Death will occur in 4-6 days.

Latent Lethality (LL):

650 rad band (500 - 800 rads) - Personnel will become functionally impaired within 2 hours of exposure. Personnel may respond to medical treatment and survive this dose; however, the majority of exposed personnel will remain functionally impaired until death in about 2 weeks.

What do these criteria mean?

Unless radiation criteria are properly used during the targeting process, they are of little value. Based on the expected response of personnel to the above four radiation casualty criteria doses, the commander and staff can select the criterion which will best meet the situation. In most cases, it will be desirable to select the lowest dose criterion which is consistent with the desired effect on the target. Examining the four doses in terms of distances on the ground gives additional insight into criterion selection. As an example, consider a hypothetical 1 KT fission

weapon detonated as a low air burst on a target consisting of exposed personnel. The approximate radii of damage (R_D) to which doses of initial nuclear radiation corresponding to the four radiation casualty criteria extend are shown below:

Criterion	Dose (rads)	R_D (m)
IP - undemanding tasks	18,000	400
IP - demanding tasks	8,000	500
IT	3,000	640
LL	650	760

It is readily seen that even though the differences between the criteria appear very large in terms of rads, the differences are not as significant in terms of actual distances from ground zero. Figure 3 shows these distances schematically. (For comparison purposes, the range to which the air blast casualty criterion extends is also shown. For personnel targets and most tactical yields, initial radiation is usually the governing casualty producing mechanism.) It is especially important to recognize that the response descriptions apply only to personnel on the edge of the applicable circle in Figure 3. All personnel closer to ground zero than the applicable circle will have received a higher dose and are expected to respond accordingly. To illustrate the point: 71% of the area inside the LL coverage circle (650 rads) would have received the IT criterion dose (3,000 rads) or higher, and 43% of the area would actually have been covered by 8,000 rads or more. Thus, selection of the most severe radiation dose criterion may neither be required nor desired since selection of a lesser dose inherently produces severe casualties to significant portions of the area covered.

How are the radiation casualty criteria chosen?

The details of the tactical situation greatly affect the casualty criterion selected. How soon must the enemy be defeated? If, for example, the target is a supply depot or a transportation battalion in the rear echelon, it would probably not be important for casualties to occur immediately and the Latent Lethality criterion (650 rads) could be appropriate. But what if the intended target is a combat unit at or near the FEBA? If the commander determines that an enemy unit can jeopardize the accomplishment of his mission only during a short period of time, then the Immediate Transient criterion (3,000 rads) might be most appropriate. Should the situation require that the weapon immediately and permanently incapacitate part of the targeted force, then one of the Immediate Permanent criteria is indicated. A review of the personnel tasks generally performed during combat shows that nearly all tasks require some degree of physical activity. Thus, the 8,000 rads Immediate Permanent criterion would almost always be the highest needed for producing the desired immediate and permanent casualties. For those few cases when individuals could have some significant impact on the outcome of a battle by performing a physically undemanding task after recovering from the transient incapacitation, e.g., performing a command and control function, the 18,000 rads criterion would be more appropriate.

What are the effects of doses lower than 650 rads?

As previously mentioned, individuals exposed to doses in the low hundreds of rads experience the initial period of radiation sickness followed by the blood syndrome symptoms. Nausea and vomiting will occur intermittently for the first two days followed by a prolonged period during which individuals will be rapidly exhausted by even mild exertion. This can generally be considered as a period of intermittent functional impairment. While personnel receiving such doses can be saved by medical treatment the degree of treatment required may very well be beyond the capabilities of field hospital facilities.

What should be remembered?

Enemy soldiers exposed to any of the four new radiation casualty criteria doses of initial nuclear radiation will become casualties regardless of whether or not an immediate visible response occurs. The proper selection of radiation casualty criteria requires an understanding of the expected response of soldiers to a dose of radiation with particular attention being paid to both the time delay aspects of that response and the distribution of the doses on the ground. Thus, using this knowledge, a commander and staff can more effectively employ tactical nuclear weapons in support of their mission.

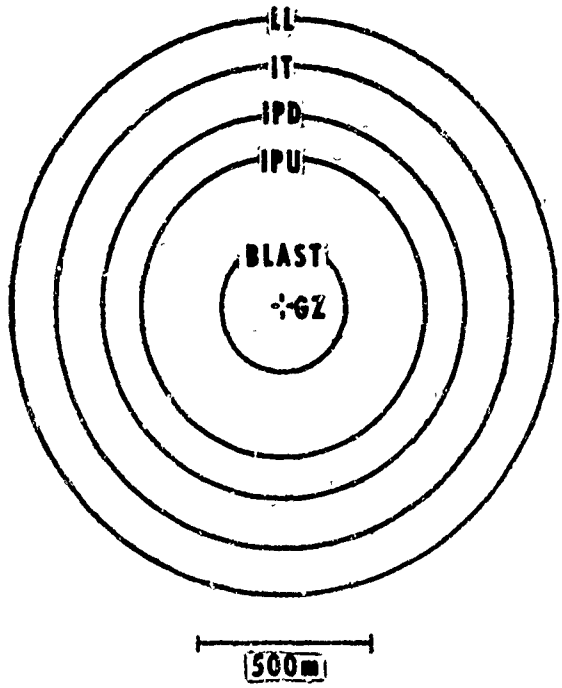

FIGURE 3. RELATIVE RADII OF DAMAGE,
EXPOSED PERSONNEL,
1 KT HYPOTHETICAL FISSION WEAPON