(REVISED)

NUCLEAR NOTES NUMBER 2

THE ARMY NUCLEAR SURVIVABILITY PROGRAM

NUMBER TWO 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

U.S. ARMY NUCLEAR AND CHEMICAL AGENCY
FORT BELVOIR, VIRGINIA 22060

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FOREWORD

The series of papers, "Nuclear Notes," prepared by the US Army Nuclear and Chemical 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. The dissemination of these Nuclear Notes will hopefully provide to the US Army accurate, up-to-date information of importance in understanding the use of nuclear weapons on the battlefield.

The authors of the original version of this paper were CPT Martin L. Bowling and CPT Steven W. Ader (1974) of the US Army Nuclear Agency. Revising authors are MAJ Joe A. Sims, Jr. and SP5 Anthony F. Portare (1980) of the US Army Nuclear and Chemical Agency. The paper reflects the general philosophy and methodology used in the Quadripartite Standardization Agreement (QSTAG) 244, Nuclear Survivability Criteria for Military Equipment (reference 1). Comments and views of readers are desired and should be forwarded to: Commander, US Army Nuclear and Chemical Agency, 7500 Backlick Road, Bldg. 2073, Springfield, VA 22150.

This paper supersedes Nuclear Notes Number 2, October 1974.

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The US Army Nuclear and Chemical Agency recommends that issues of Nuclear Notes be retained and filed in a loose leaf binder. Current issues are:

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

Nuclear Notes Number 2 - The Army Nuclear Survivability Program, January 1980 (Revised)

Nuclear Notes Number 3 - The New Nuclear Radiation Casualty Criteria, May 1975

Nuclear Notes Number 4 - Nuclear Blackout of Tactical Communications, August 1976

Nuclear Notes Number 5 - Rainout, December 1976

Nuclear Notes Number 6 - A Primer on Nuclear Weapons Capabilities, June 1977

Nuclear Notes Number 7 - Collateral Damage, April 1978

Nuclear Notes Number 8 - Armored Vehicle Shielding Against Radiation, May 1979

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THE ARMY NUCLEAR SURVIVABILITY PROGRAM

WHY HAVE THE PROGRAM?

The different nature of the tactical nuclear battlefield requires a unique approach toward insuring equipment survivability. In recognition of this fact, the Army Nuclear Survivability Program was established to insure that developmental items of critical Army equipment will be able to operate effectively on the nuclear battlefield.[1] The objectives of this program are to identify developmental items that will be critical to mission performance in a nuclear conflict, establish mission related and cost effective nuclear survivability design criteria, incorporate nuclear hardness by design of the equipment, test the equipment against the specified criteria, and maintain the nuclear hardness during production and deployment.

WHAT IS NUCLEAR SURVIVABILITY?

Nuclear survivability is the capability of a system to perform its defined functions after exposure to specified levels of nuclear weapon effects. The criteria for nuclear survivability are those specified levels of nuclear weapon effects which a given system must survive. The criteria depend on the system itself, its location on the battlefield, the yields of nuclear weapons likely to be employed near its location, the relationship of the operating personnel to the equipment, and the mission of the unit using the system.

WHAT IS THE PHILOSOPHY?

The philosophy of the Nuclear Survivability Program is to insure that equipment survives whenever enough of the personnel required to operate the equipment remain combat effective. It is important to note that the equipment is not being made survivable to protect the operating personnel, as shown in Figure 1.

HOW DOES IT WORK?

Equipment and personnel survivability is dependent upon the distance from the point of nuclear detonation (or ground zero), as seen in Figure 2. As a practical matter, the closer to ground zero that the equipment is expected to survive, the more severe are the nuclear environments to which the equipment will be exposed. The more severe the environments, the greater the costs, and the greater the technological impacts on continuing efforts to meet required operational characteristics. For example, it is desirable to make sophisticated communications equipment, which is critical to effective command and control and frequently configured in truck-mounted shelters, as survivable as possible. However, excessive nuclear survivability requirement levels would probably increase costs by requiring more highly sophisticated components and could significantly degrade mobility by increasing weight. As shown in Figure 3, the concept of providing the Army with nuclear survivable equipment must preclude over-designing the equipment to the point where it can survive the nuclear environment but can no longer operate in the manner for which it was originally intended. It is also not feasible to expect equipment that sustains a direct hit to survive. Therefore, a methodology is required that will provide rational, meaningful, and achievable levels of nuclear survivability criteria. Analysis has indicated that an initial optimal goal for equipment survivability is to design and build the equipment so that it will survive those levels of effects at which the minimum number of crew members needed to operate the equipment will remain combat effective for up to several days.

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[1] The Department of the Army approved policy on the Army Nuclear Survivability Program may be found in AR 70-60 (reference 6).

FIGURE 1 - EQUIPMENT SURVIVABILITY DOES NOT PROTECT PERSONNEL

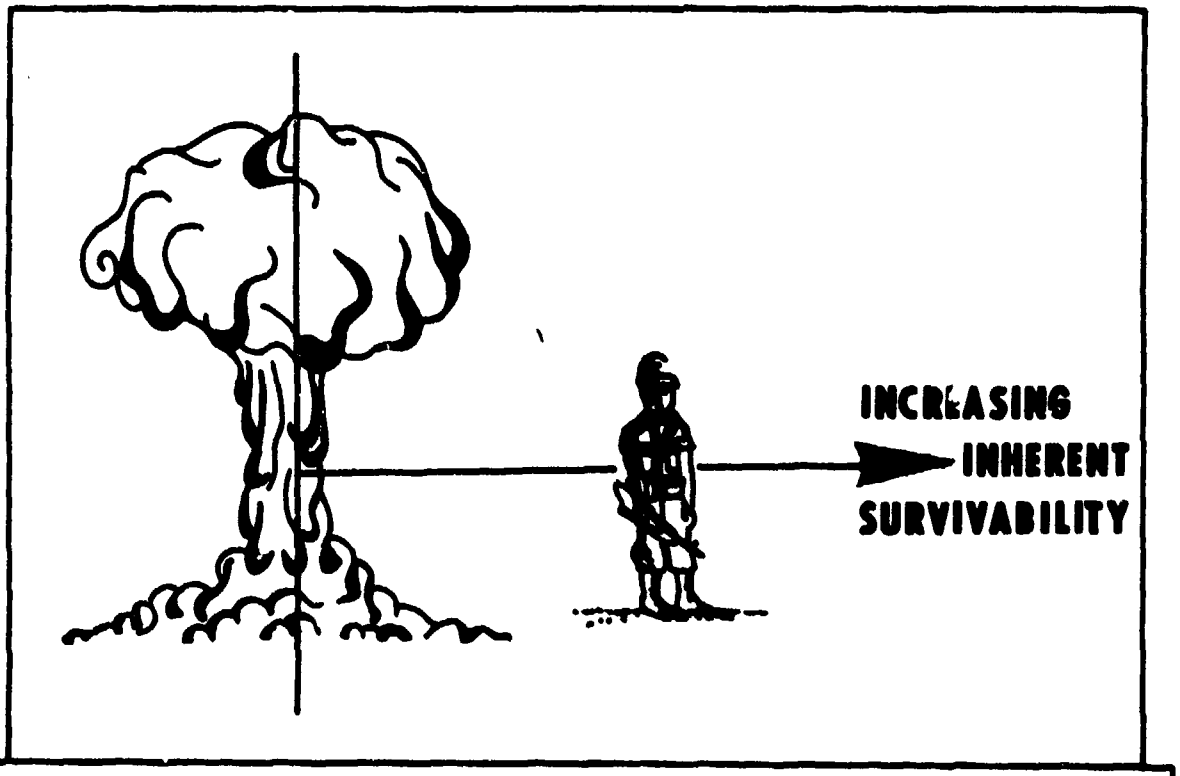


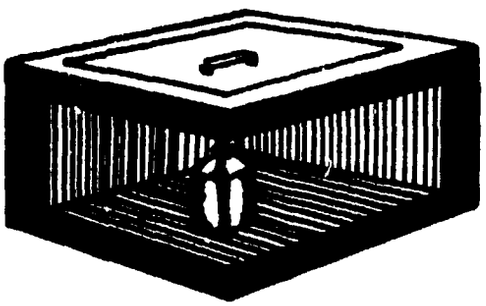
FIGURE 2 - WHERE SURVIVABILITY?

M-1 NUCLEAR PROTECTOR

(CANTEEN)

CHARACTERISTICS:

MATERIAL-LEAD



WEIGHT-100 LBS

COST-$100.00

FIGURE 3 - OVER PROTECTED?

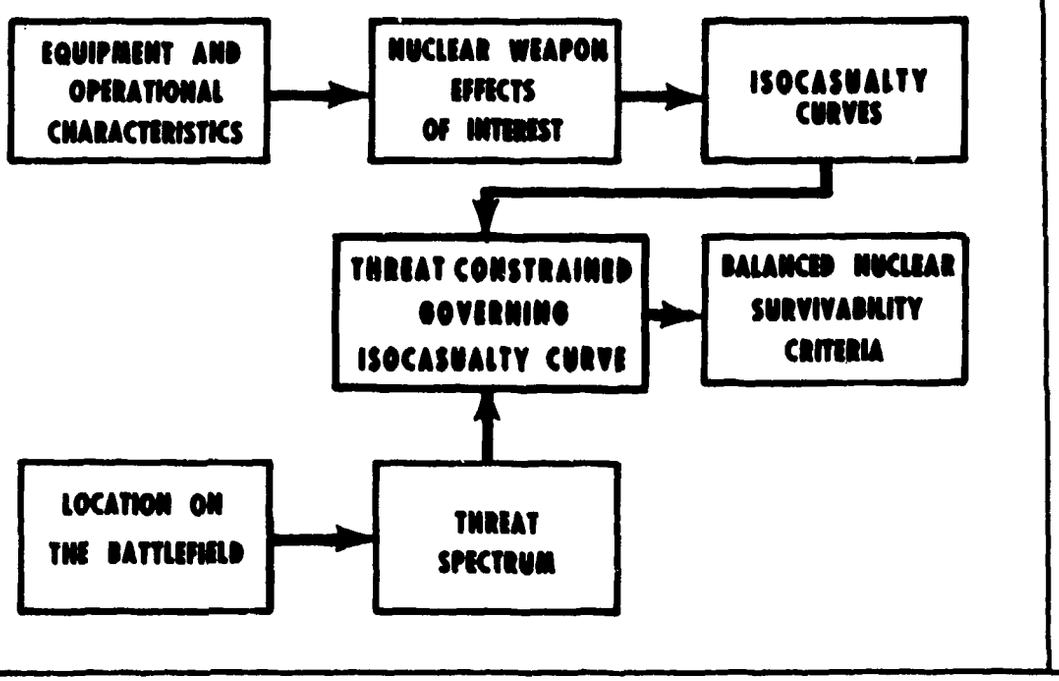


FIGURE 4 - GENERATION OF BALANCED SURVIVABILITY CRITERIA

HOW ARE CRITERIA DETERMINED?

Nuclear survivability criteria are developed by using the above logic to relate personnel casualty categories to the equipment that is to be made survivable. The results of these relationships are equipment vulnerability categories. These categories depend on operational and deployment factors, particular nuclear weapon effects, and the degree of personnel protection that the equipment inherently provides. Each of these categories may be represented by drawing curves of constant casualties as a function of range from ground zero and weapon yield. These curves are called isocasualty curves. The weapon yield spectrum of potential enemy use is superimposed on the isocasualty curves to determine the threat constrained governing isocasualty curve. This curve is used to predict the predominant nuclear weapon effects for the given spectrum of weapon yields. Figure 4 illustrates this procedure schematically. The discussion which follows describes the procedure in detail.

WHAT ARE THE PERSONNEL CASUALTY EFFECTS CONSIDERED?

Man is vulnerable to the nuclear radiation (neutrons and gamma rays), thermal radiation, and air blast effects of a nuclear detonation. Another effect, the electromagnetic pulse (EMP),[2] exists but only affects certain types of equipment, and not man. Each of these effects, except EMP, can create personnel casualties depending on the effects levels and the particular operational situation (e.g., the degree of protection that personnel may receive from operating in a foxhole, or tracked or wheeled vehicle). Based on a detailed analysis of the biomedical aspects of nuclear weapon effects on personnel, the following categories of casualty effects to personnel are considered to be the most dominant and predictable for use in the development of nuclear survivability criteria:[3]

Immediate transient incapacitation (ITI) to personnel from initial nuclear radiation. ITI is a temporary condition where personnel perform at 50% or less of their preirradiation performance level. It occurs within 5 minutes after sufficient nuclear radiation is received and can last for 30-45 minutes.

Second degree burns under chemical protective overgarment.

Injuries (producing combat ineffectiveness) due to blast induced foxhole collapse.

Severe lung damage to foxhole occupants due to blast effects.

Injuries due to blast induced moderate II damage to vehicles.

Injuries due to blast induced vehicle overturn (on back).

Injuries due to solid impact of translated prone personnel.

[2] A general discussion of EMP is available in reference 4.
[3] References 2 and 3 offer a detailed study of personnel risk and casualty criteria.

WHAT COMBINATIONS OF PERSONNEL AND EQUIPMENT ARE CONSIDERED?

As previously discussed, the basic philosophy for the development of nuclear survivability criteria is that equipment should be made survivable to those levels where the minimum number of crew members required to operate the equipment remain combat effective. This requires that the above casualty-producing categories for personnel be related both to the particular item of equipment and degree of personnel protection. The vulnerability categories which relate items of equipment and degree of personnel protection are:

Personnel and equipment to be made survivable are both exposed to the free-field nuclear effects environment.

Personnel and equipment are thermally protected in wheeled or tracked vehicles, or in communications-electronics (C-E) shelters.

Equipment is exposed and personnel are thermally protected in wheeled or tracked vehicles, or C-E shelters.

Personnel and equipment are in foxholes, or personnel are in foxholes and equipment is exposed to the free-field nuclear effects environment.

Personnel are exposed to the free-field nuclear effects environment and equipment is thermally protected in wheeled or tracked vehicles, or C-E shelters.

HOW ABOUT AN EXAMPLE?

The particular vulnerability category which is applicable for a new item of equipment will determine which personnel casualty effect or effects are of principal concern. For example, if the item of equipment to be made survivable is a communications device located inside a truck-mounted C-E shelter, the pertinent casualty producing effects to the operating crew (also located inside the shelter) will be immediate transient incapacitation from radiation and injuries due to blast induced moderate II damage to wheeled vehicles. (It is assumed that if the vehicle is moderately damaged or overturned on back, the crew members in the vehicle and shelter will become combat ineffective.) Burns are not considered as a casualty-producing mechanism in this example because the shelter walls will protect the crew members from thermal radiation. These dominating personnel casualty effects can then be graphed as a function of yield and range from ground zero in order to produce a governing isocasualty curve.

HOW ABOUT ANOTHER EXAMPLE?

Figures 5 through 7 illustrate the relationship between personnel casualty effects and the generation of nuclear survivability criteria. Consider, for example, that a proposed new backpack radio is to be made survivable for use at battalion and lower levels. The vulnerability category for this item of equipment is "personnel and equipment both exposed to the free-field nuclear effects environment." The casualty categories for exposed personnel which are of interest are immediate transient incapacitation, second degree burns under chemical protective overgarment, and injuries due to blast induced solid impact of translated prone personnel. These casualty categories are graphed in Figure 5 as a function of weapon yield and distance from ground zero to which this type of casualty mechanism can be expected. Figure 6 shows the range-yield combinations (diagonal shaded area) of Figure 5 at which personnel can be expected to become casualties. The upper boundary of this shaded area (shown by the dark boundary line in Figure 6) is designated as the governing isocasualty curve and signifies the points at which the

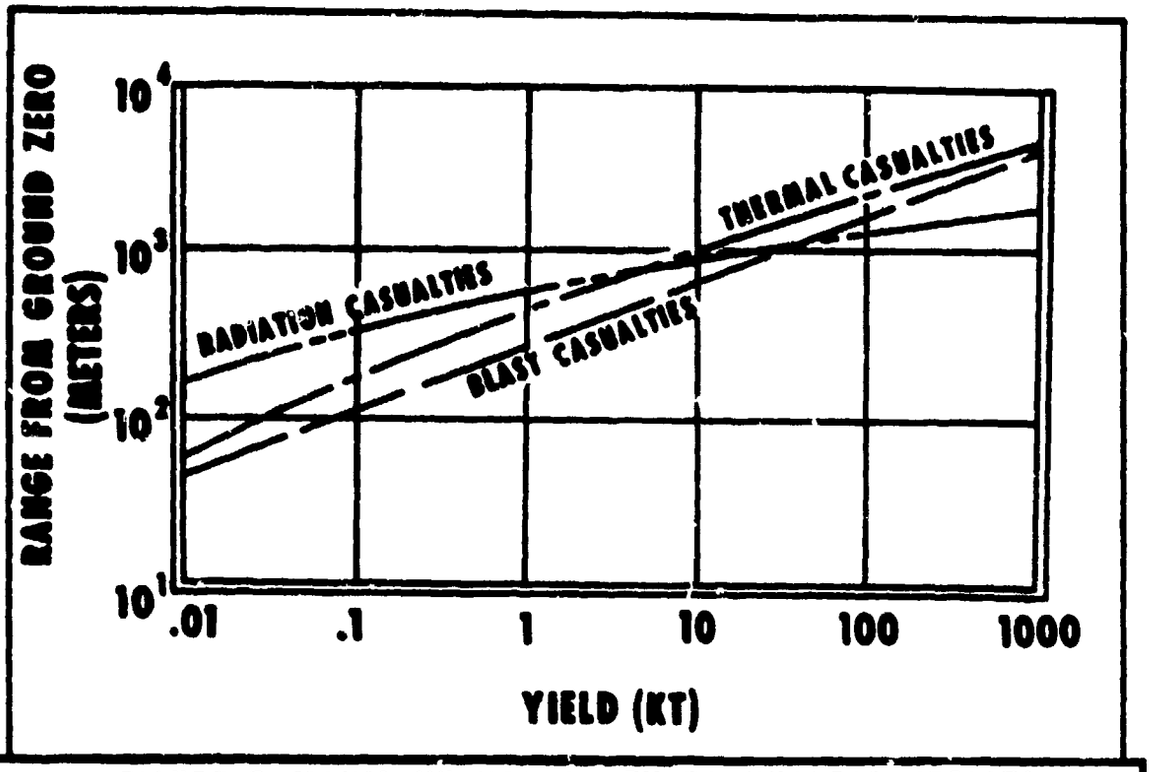


FIGURE 5–MAN'S VULNERABILITY TO NUCLEAR EFFECTS

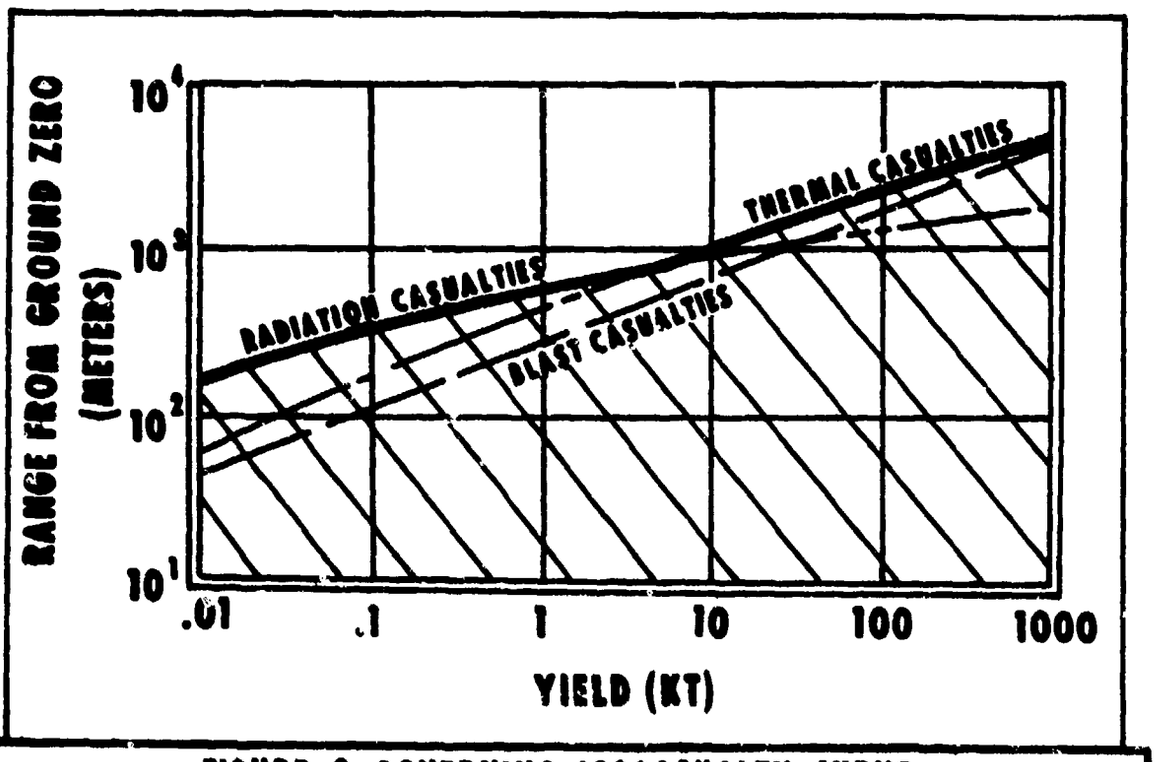


FIGURE 6–GOVERNING ISOCASUALTY CURVE

personnel will just remain combat effective. The basic principle of nuclear survivability (i.e., the equipment should survive whenever the minimum number of the crew members required to operate the equipment remain combat effective) demands that the item of equipment be designed to survive the nuclear effects associated with the governing isocasualty curve in Figure 6.

Since the item of equipment is to be used only at battalion and lower unit levels, the nuclear threat probably will not include excessively large nuclear yields. A hypothetical spectrum of threat yields for this item of equipment has been superimposed on Figure 6 and is shown in Figure 7 by the vertical dotted lines. Once the threat spectrum is applied to the governing isocasualty curve, the curve is redesignated as the threat constrained governing isocasualty curve, since it represents those points at which sufficient personnel will remain combat effective and at which equipment should be designed to survive based on the expected threat yield spectrum. Balanced nuclear survivability criteria for air blast, initial nuclear radiation, thermal radiation, and EMP parameters are then calculated[4] at each of the yield-range points along the threat constrained governing isocasualty curve in Figure 7. The maximum values of these parameters are specified as the nuclear survivability criteria for the proposed backpack radio.

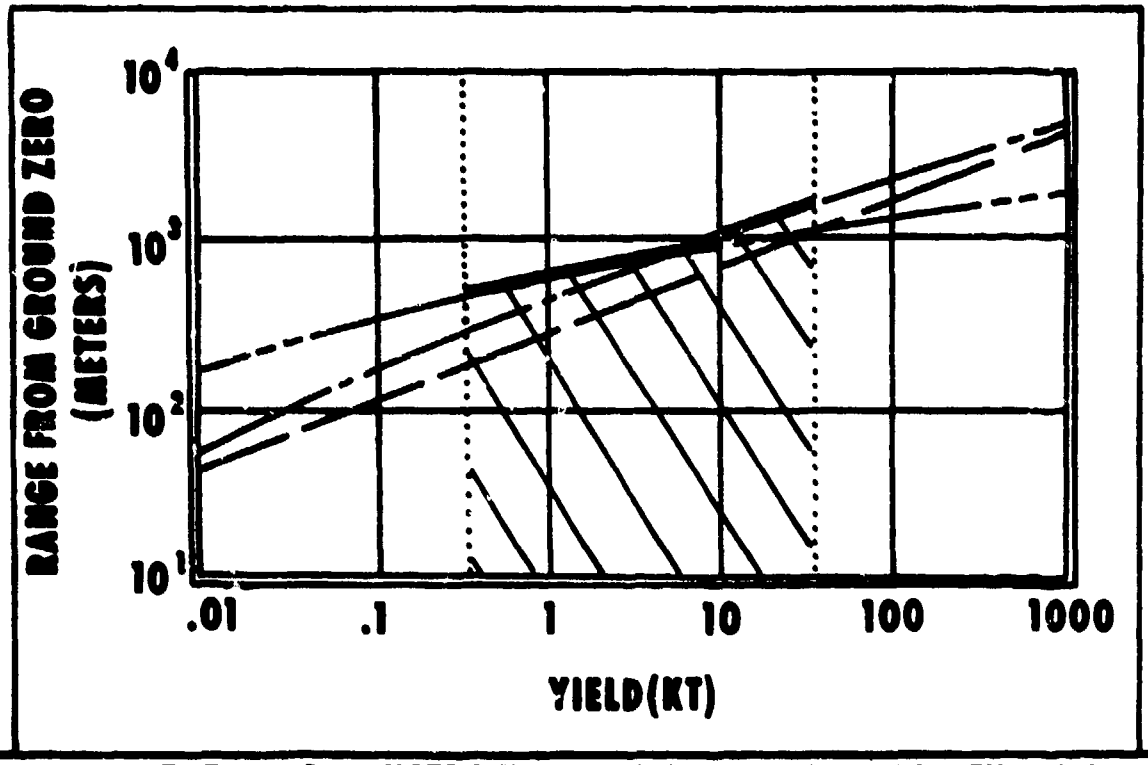


FIGURE 7-THREAT CONSTRAINED GOVERNING ISOCASUALTY CURVE FOR DEVELOPMENT OF NUCLEAR SURVIVABILITY CRITERIA

[4]These calculations are normally performed by the US Army Nuclear and Chemical Agency using a variety of computer codes. The criteria can also be determined manually, however, by using reference 1.

WHAT SHOULD SURVIVE?

The nuclear survivability criteria must now be used in the materiel acquisition process. It is neither intended nor necessary that all developmental items of equipment be made nuclear survivable. The decision as to whether or not nuclear survivability is a required operational characteristic is made by the proponent combat developer by answering the following questions:

> Will the item of equipment be used on the nuclear battlefield?
>
> Is the item of equipment critical to mission accomplishment in a nuclear conflict?
>
> Does the item of equipment exist in sufficient quantities for timely replacement of damaged items?

After the proponent combat developer has considered these questions (based on intended use, criticality, and replacement availability), a statement of the need for nuclear survivability is made in the requirements document. Once the decision is made to include the requirement for nuclear survivability in this document, the combat developer requests nuclear survivability criteria from the US Army Nuclear and Chemical Agency for inclusion in the Outline Acquisition Plan. These criteria are incorporated into this and key documents that lead up to this plan such as the concept formulation package and the appropriate test plans. The equipment is then designed and tested to the levels stated.[5]

WHAT IF THE NUCLEAR SURVIVABILITY CRITERIA CANNOT BE ACHIEVED?

The initial balanced nuclear survivability criteria specified in the Outline Acquisition Plan are both rational and meaningful, but still may not be achievable because of complex technological design considerations, operational degradation (e.g., increased weight resulting in decreased mobility), and expense.

If this is the case, then the criteria must be modified. However, this cannot be determined for an item of equipment prior to the development cycle. In other words, until the developing contractor actually attempts to reach the levels specified, he cannot tell how much it is going to cost or how difficult it will be to reach that level.

Should one of the specified levels require modification, some of the remaining levels may have to be modified to maintain the proper balanced relationship of weapon effects. In order to accomplish this process, the developer must answer two questions: first, what levels can be met, and secondly, what the cost (dollar and operational) versus hardness tradeoffs are.

At this point, the materiel developer must request a waiver in accordance with AR 70-60 from the Nuclear Survivability Committee. This committee is the only authority empowered to modify nuclear survivability criteria; the materiel developer does not have this authority. For further information on the procedure for modifying criteria, contact the US Army Nuclear and Chemical Agency, 7500 Backlick Road, Bldg 2073, Springfield, VA 22150.

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[5] A general discussion of considerations in determining what should survive is available in reference 6.

THE GOLDEN RULES.

To insure that the Army Nuclear Survivability Program is successful, all of the following precepts must be strictly observed:

Nuclear survivability criteria are developed for materiel and not for personnel.

Nuclear survivability criteria are based on the philosophy that the equipment should survive whenever enough of the personnel required to operate the equipment remain combat effective.

Nuclear survivability criteria for equipment are based on the levels of effects that are associated with personnel casualties and the personnel-equipment relationship.

Nuclear survivability criteria consist of nuclear weapon effects parameters (i.e., initial nuclear radiation, air blast, thermal radiation, and EMP) which are balanced to the threat constrained (system specific) governing isocasualty curve.

The need, or lack of need, for nuclear survivability must be stated in the requirements document.

The criteria provided for the Outline Acquisition Plan are the initial balanced criteria and may have to be refined due to technical, operational, or economic reasons.

Tradeoff analyses of initial balanced criteria should be conducted from a balanced nuclear survivability standpoint.

Requests for waivers of nuclear survivability criteria must be addressed to the Nuclear Survivability Committee in accordance with AR 70-60.

WHAT IS THE STATUS AND WHAT IS EXPECTED?

The Army Nuclear Survivability Program, which originated some years ago, was elevated to the mainstream of equipment development activities by the issuance of AR 70-60, Sep 1977. To date, there are few systems that have been fielded with balanced nuclear survivability. There are a large number of developmental systems, however, that currently have nuclear survivability criteria in their design specifications and are being designed to survive on the battlefield. In addition, nuclear survivability retrofit is being given to a limited number of already fielded systems. The ramification of this "gearing up" of the Army Nuclear Survivability Program is that the current generation of equipment associated with the force structure will be mixed with respect to nuclear survivability. It is conceivable that nuclear survivable equipment may be temporarily dependent on unhardened equipment for effective system operation. By understanding and supporting this program, however, you will help insure the nuclear survivability of future equipment so that the evolving Army is able to operate effectively in a nuclear environment.

REFERENCES

1. Quadripartite Standardization Agreement (QSTAG-244), Nuclear Survivability Criteria for Military Equipment (U), Edition No. 3. (CONFIDENTIAL)

2. USACDCINS Final Study, Personnel Risk and Casualty Criteria for Nuclear Weapons Effects (U), 2 August 1971, US Army Combat Developments Command Institute of Nuclear Studies, Fort Bliss, TX. (CONFIDENTIAL)

3. Addendum to Personnel Risk and Casualty Criteria for Nuclear Weapons Effects (U), March 1976, US Army Nuclear Agency, Fort Bliss, TX. (UNCLASSIFIED)

4. DNA EM-1, Capabilities of Nuclear Weapons (U), 1 July 1972, Defense Nuclear Agency, Washington, D.C., Parts I and II. (SECRET-RESTRICTED DATA)

5. Nuclear Notes Number 1, The Electromagnetic Pulse (EMP), June 1974, US Army Nuclear Agency, Fort Bliss, TX. (UNCLASSIFIED)

6. Letter, ATCD-N, HQ TRADOC, 25 August 1978, amended by 8 September 1978 letter, Subject: Procedures for Implementing Nuclear Survivability Criteria into the Materiel Development and Acquisition Process. (UNCLASSIFIED)

7. AR 70-60, Army Nuclear Survivability, 20 September 1977, HQDA, Washington, D.C. (UNCLASSIFIED)