CHAPTER 7

VULNERABILITY AND HARDENING TECHNOLOGY

A. General Information

This chapter provides guidance for determining if historical records containing NSI, pertaining to vulnerability, hardness, and hardening of nuclear weapon delivery vehicles to nuclear weapons effects are to be declassified or have their classification retained beyond 25 years in accordance with the provisions of E.O. 12958. ***Documents containing RD and FRD are not addressed by this document and retain present classification.***

The susceptibility of a weapon system or its parts to damage or destruction as a result of a defensive effort, such as a nuclear burst, or to the effect of a nearby explosion of a U.S. nuclear weapon (fratricide) is its vulnerability. Vulnerability and hardening information pertaining to nuclear weapons and weapon components is RD or FRD and not a subject of this guide. Vulnerability and hardening information pertaining to delivery systems (e.g., missiles or aircraft) is NSI and is a subject of this guide.

It is important to separate the concepts of hardening and hardness. Hardness refers to resistance to damage from radiation or other effects; hardening refers to steps taken to increase hardness. Many factors, including materials of construction, space, and weight limitations affect hardness. Hardness of a weapon or component may result from intrinsic hardness, hardening measures, or both.

Vulnerability to an enemy's defenses or fratricide effects is a vital concern. Hardening is more often required in long-range strategic weapons than in tactical missiles, aircraft delivered bombs, or battlefield weapons.

When a system or component is to be hardened, the maximum severity of the environment in which it is to operate is specified. Hardness specification cannot be arbitrarily high, as cost, space, weight, and technology limit what can be achieved. The objective of hardening is to improve a weapon's resistance to fratricide and to substantially increase the effort an adversary would have to make to defeat it, and, therefore, to increase the weapon's deterrent value.

Delivery vehicles may be hardened against nuclear outputs and effects including: neutrons, x-rays, gamma rays, nuclear electromagnetic pulse (EMP), blast, and thermal effects. The maximum severity of each effect to which a nuclear weapon system is to be hardened, also referred to as system level, is specified in the stockpile-to-target sequence document.

Various forms of radiation shielding are used to accomplish hardening with materials and techniques selected for each specified effect. Due to the high energy of gamma rays and the weight and thickness of shielding required to stop them, shielding a weapon system against gamma rays is impractical. Hardening against gamma rays is primarily concerned with protection against the effects of gamma rays interacting with the media surrounding the burst. This interaction is responsible for EMP which in turn causes electrical currents and voltages to be generated within the system and may result in either transient or permanent damage. Blast protection is often provided by paying special attention to the mechanical ruggedness of weapon structures present for other purposes. Hardening of electronic systems and discrete semiconductor devices to x-ray effects is a major technical discipline in its own right. Hardness is generally achieved by special design techniques and carefully controlled processing or fabrication measures.

B. Broad Guidance

Vulnerability, hardness and hardening information is classified to deny an adversary information that might help defeat that weapon or to develop similar hardening capabilities. These concerns apply equally to information regarding current and past systems.

Although most generic information about the nature and physics of weapon x-ray output and effects has been declassified, nearly all information about x-ray hardening materials and shielding techniques remains classified.

When not applied to a particular weapon's hardening measures, 25-year old information about most materials and methods used to harden against effects other than x-rays is not classified. This is true for two main reasons: (1) materials and general shielding methods of practical use against each nuclear burst effect can be deduced from the unclassified physics of that effect; and (2) many hardening techniques come from, or are the same as, unclassified techniques used in nuclear energy production. Other applications of this technology are: radiation and neutron shielding for reactor and space-borne systems, electromagnetic radiation and radio frequency shielding and avoidance methodology, and shielding for radiation effects in semiconductors and electronics. Nearly all generic hardening information has been declassified, or never was classified. New developments in hardening technology were often classified until their importance was evaluated and need for continued classification was determined.

Classified information about a delivery vehicle (e.g., aircraft, missile) and its components is NSI and is under the purview of the DoD. The same is true for design information, hardware, and test analyses that reveal a specific delivery vehicle's overall vulnerability or hardness level for any effect. Information describing adverse conditions related to delivery vehicles that seriously jeopardize a strategic or other major weapon capability may be TSNSI and should be referred to the DoD for a classification determination. Hardening information that does not reveal hardness levels for a given nuclear weapon delivery vehicle is nearly all unclassified, except in the area of x-ray hardening. In dealing with any effect, however, all classified weapon output information is RD. Weapon outputs are neutrons, gamma rays and x-rays.

NOTE: Vulnerability and hardening information concerning nuclear warheads is FRD. Some vulnerability and hardening technology is RD. Because nuclear weapon delivery systems are usually designed to balance the performance of the delivery vehicle with that of the warhead, documents that reveal delivery vehicle information may also reveal RD or FRD warhead information that is not appropriately marked. Similarly, threat levels may be based on outputs of U.S. weapons which are RD or FRD. Reviewers must be particularly alert to this possibility and refer all questions to the Office of Classification and Information Control.

Historical records, 25 years or older, containing DOE/NNSA NSI pertaining to vulnerability, hardness, and hardening of nuclear weapon delivery vehicles to nuclear weapons effects not covered by the specific guidance below are unclassified. This does not include records containing information classified by statute such as RD and FRD (AEA of 1954, as amended). These records shall be handled, protected, classified, downgraded, and declassified in accordance with the provisions of the AEA and regulations issued under that Act. Reviewers who are not authorized by DOE/NNSA to classify or declassify such documents should not attempt final determinations. Refer to appendix A for information on identifying and handling documents containing potential RD/FRD. In all cases where there is a question concerning the sensitivity of the information, it should be referred to the DOE HQ classification office for a classification determination.

Topics describing information likely to contain or closely related to RD or FRD are marked "(potential for RD/FRD)".

C. Topics

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7.1	Direct intelligence information concerning the output of other than United States or United Kingdom nuclear weapons *NOTE:* Refer to the cognizant Intelligence organization for review.	**Refer (potential for RD/FRD)**
7.2	Vulnerability, hardness, or hardening of a specified delivery vehicle *NOTE 1:* This includes threat levels, minimum sure kill level, maximum sure-safe level and full-scale test levels. *NOTE 2:* Refer to DoD for review.	**Refer (potential for RD/FRD)**
7.3	Delivery vehicle component hardness that reveals overall delivery vehicle hardness level *NOTE:* Refer to DoD for review.	**Refer (potential for RD/FRD)**
7.4	Delivery vehicle component hardness to:	
	7.4.1 X-ray effects *NOTE:* Refer to DoD for review.	**Refer (potential for RD/FRD)**
	7.4.2 Other effects *NOTE:* Unclassified subject to limitations of topics 7.5 and 7.14.	**U**
7.5	Information that can be used for an evaluation of a delivery vehicle's susceptibility to weapon effects *NOTE:* Refer to DoD for review.	**Refer (potential for RD/FRD)**
7.6	Test levels for simulation testing	
	7.6.1 Corresponding to a delivery vehicle hardness level *NOTE:* Refer to DoD for review.	**Refer (potential for RD/FRD)**
	7.6.2 Otherwise	**U**
7.7	Information revealing the effects on the performance of delivery vehicles and their individual components resulting from x-ray exposure at any level *NOTE:* Refer to DoD for review.	**Refer (potential for RD/FRD)**
7.8	Identification of material(s) or constructs used for x-ray hardening, delivery vehicle specified or unspecified *NOTE:* Refer to DoD for review.	**Refer (potential for RD/FRD)**

7.9	The selection of a material for a particular delivery vehicle use because it is less vulnerable to hot or cold x-ray effects *NOTE:* Refer to DoD for review.	**Refer (potential for RD/FRD)**
7.10	Design information for countering x-ray effects which reveals hardening or vulnerability levels of delivery vehicles, e.g., shielding thickness or components thereof *NOTE:* Refer to DoD for review.	**Refer (potential for RD/FRD)**
7.11	Packaging and arrangement techniques that are designed to reduce x-ray vulnerability of delivery vehicles which reveal hardening or vulnerability levels of the delivery vehicle or their components *NOTE:* Refer to DoD for review.	**Refer (potential for RD/FRD)**
7.12	Test specifications, results, or analyses pertaining to x-ray vulnerability or hardening of delivery vehicles which reveal materials or constructs used for hardening, vulnerability or hardness levels, or significant degradation of a delivery vehicle or its performance *NOTE:* Refer to DoD for review.	**Refer (potential for RD/FRD)**
7.13	Packaging and arrangement techniques that are designed to reduce neutron vulnerability of delivery vehicles which reveal overall hardening or vulnerability levels of the delivery vehicle (especially neutron shielding materials and techniques) *NOTE:* Refer to DoD for review.	**Refer (potential for RD/FRD)**
7.14	Information revealing overall delivery vehicle hardness levels to blast or thermal effects *NOTE:* Refer to DoD for review.	**Refer (potential for RD/FRD)**