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DEPARTMENT OF DEFENSE STANDARD PRACTICE

NUCLEAR HARDNESS AND SURVIVABILITY PROGRAM REQUIREMENTS FOR ICBM WEAPON SYSTEMS

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FOREWORD

1. .This standard is approved for use by the Department of the Air Force and is available for use by all Departments and Agencies of the Department of Defense (DoD).

2. This revision of MIL-STD-1766 contains a significant update and revision to the 9 September 1994 version. It includes some new and revised text and tables, along with a new table that essentially replaced Section 5.2. Definitions have been updated in Appendix A. Also featured included completely revised flow diagrams in Appendix B with major additions to the operations and support phase. It also includes the incorporation of lessons learned during the application of MIL-STD-1766B to intercontinental ballistic missile (ICBM) procurements. The key features of the revision are summarized in this foreword.

3. System Requirements Analysis for ICBM Systems (ICBM-HDBK-01) is an essential companion document to MIL-STD-1766. It should be noted that MIL-STD-1766 provides very little in the way of prescribing exactly how to design, produce, deploy, and maintain a hardened ICBM. What it does do is provide a sound definition of HCI and then describe NH&S-related tasking for different types of contractors and the government so that when the Air Force moves forward to do these activities, the people involved can select the necessary tasks and put them on contract along with the data needed to 1) prove the design meets requirements (Critical Design Review/CDR), 2) prove the hardware built according to design meets the requirements (Qualification and Hardness Assurance), 3) and once fielded, maintain it in the hardened state (Hardness Assurance Maintenance and Surveillance/HAMS). It is not a step-by-step procedure. One must become familiar with the entire document and then make a plan to select the portions that apply for either a particular contract or a particular Air Force effort.

4. The scope and content of the document have been expanded in the following ways:

a. All phases of the system life cycle are included and a more complete and balanced treatment of each phase is given. In contrast, MIL-STD-1766B focused primarily on the engineering and manufacturing development (EMD) phase and did not address the operations and support phase.

b. Nuclear hardness and survivability (NH&S) program requirements associated with the weapon system facilities, real property installed equipment (RPIE), assembly and checkout (A&CO) installation hardware, and as applicable, maintenance support equipment (MSE) are covered. In contrast, MIL-STD-1766A addressed only aerospace vehicle equipment (AVE) and operational support equipment (OSE) configuration items (CIs).

c. All the various categories of contractor functions required to acquire, deploy, and maintain an ICBM weapon system are covered. Moreover, the role of each type of contractor during each system life cycle phase is explicitly discussed. In contrast, MIL-STD-1766A dealt almost solely with the responsibilities of the AVE and OSE CI contractor.

d. Nuclear hardness and survivability program requirements associated with the use of non-developmental hardware items (NDI), particularly commercial items, were introduced for the first time in MIL-STD-1766B. This important matter is of increasing concern for the procurement and maintenance of hardened weapon systems. In addition, NH&S program requirements associated with the use of government furnished equipment (GFE) were explicitly discussed for the first time in MIL-STD-1766B. MIL-STD-1766C clarifies the tasks needed to ensure that although the government may direct the use of GFE, the contractors perform the necessary tasks to ensure that the hardness requirements for the new system using the GFE are met. This was not entirely clear using the B revision.

e. All the technical activities that comprise a comprehensive weapon system NH&S program are covered. Thus, both contractor and government activities are defined. In addition to contractor requirements, the NH&S activities of a technical nature performed by both the program office element within the SPO responsible for a particular procurement and the SPO organization responsible for system survivability in the operations and support phase are identified. The previous revision, rev. B, had four government entities (implementing command (design, produce, deploy), supporting command (maintain through logistics and repair), operating command, and using command. Due to many Air Force restructures, these are simply now the SPO (design, produce, deploy, maintain, perform logistics) and operating command. Even though the term, SPO, is considered by some to be obsolete, its meaning is universally understood in the ICBM community and is retained in this Revision C.

f. The set of definitions in Appendix A has been updated based on lessons learned. The definitions include not only dictionary-like definitions of the terms addressed, but also additional comments that supply useful NH&S background and tutorial information. A careful reading of this appendix is required to ensure a full and complete understanding of the key concepts and tasks that form the underpinning of this standard.

g. Five appendices, are included that provide information and instructions not generally available. The information has resulted from years of lessons-learned applying the standard. The topics covered include mandatory and non-mandatory portions as follows:

(1). an extensive listing of definitions in appendix A.

(2). a comprehensive flow diagram overview of the system life cycle NH&S program process;

(3). instructions on the generation of system-level NH&S related program plans by the Air Force during the support & operations phase; and

(4). clarification of the details on hardness critical item (HCI) identification and documentation and tailoring considerations that can be used in contracting to acquire the data necessary to execute the operations & support phase.

(5). details of a typical process for dealing with semiconductor selection and radiation performance and qualification of the selected parts that increases the confidence of relatively uniform and specification-compliant radiation hardness throughout the system.

h. The data item descriptions (DIDs) necessary for data delivery of key items needed for development and for life-cycle hardness support have been updated. During acquisition reform of the mid-1990's, several of the DIDs associated with MIL-STD-1766 were cancelled. The ones remaining in the ASSIST system are not adequate for ICBMs and so several new DIDs have been reinstated to address this dearth of essential data products. The hardness assurance (HA), hardness maintenance (HM), and hardness surveillance (HS) plans have been integrated into the overall NH&S program so that only one DID (DI-ENVR-82097, NH&S Program Plan) is needed for all of these plans, but the content of the NH&S program plan must therefore evolve over the development and acquisition so that all the necessary content is provided at the appropriate time. The DID revisions reflect both the lessons learned and the expanded scope and content of this revision.

5. Section 5 has been revised in a way that makes it easier to follow. While some changes to the text have also been made, the primary change is that the tasks and requirements have been grouped to hardness program components of Requirements Definition and Allocation, Assurance, Maintenance, and Surveillance. Since DoD regulations and Air Force instructions center all hardness activity around a HAMS (Hardness Assurance, Maintenance, and Surveillance) Program, it makes more sense to organize this standard with that frame of reference. A second significant change in Section 5 is the manner in which Sections 5.1 and 5.2 are presented and intended to be used. These two sections are "maps" to the tasks of Sections 5.3 and 5.4. Sections 5.1 and 5.2 are requirements whose purpose is to guide the contractor to the tasks and requirements that apply to each kind of contractor or government organization performing the hardness tasking or to each kind of equipment that may be used to satisfy the requirements. This new structure of the text is organized around the following four key themes:

a. Mapping of contractor categories to tasks and responsibilities (see Section 5.1). This section identifies the categories of contractor involved in each phase of the system life cycle and their NH&S responsibilities during each phase. It is the government's responsibility to match the hardware type and contractor type to the correct set of tasks and requirements indicated and include them in the contract.

b. Hardware category NH&S requirements (see Section 5.2). This section identifies the NH&S requirements associated with each category of hardware, including commercial hardware, employed in an ICBM weapon system.

c. NH&S program tasks (see Section 5.3). This section contains a complete menu of all the NH&S program tasks associated with the system life cycle of an ICBM weapon system. To assist the Air Force in identifying the specific tasks applicable to each category of contractor during each phase and to each category of hardware used in the weapon system, in addition to Table I, tailoring instructions for contractual application are identified in 6.4.

d. Hardness trade study, analysis, and test requirements (see Section 5.4). This section identifies the requirements associated with the three types of support activities (hardness trade studies, hardness analysis, and hardness testing) utilized to accomplish the NH&S program tasks delineated in Section 5.3.

6. Lessons learned from the application of MIL-STD-1766B to ICBM procurements have been incorporated. These address:

a. identification of hardness tasks associated with non-developmental hardware and GFE;

b. treatment of system elements in addition to CIs;

c. clarification of life cycle hardness (LCH) tasks to be performed during development that are necessary in order to be prepared for the operations and support phase; and

d. modification of some aspects contractor tasks that result in data. The purpose of these changes is to enhance program efficiency and cost-effectiveness over the system life cycle; among these are:

(1). the requirement for an HCI list drawing has been deleted. This requirement just added another document that could potentially be inconsistent with all other program documentation relative to its HCI markings. The NH&S design analysis report (NH&S DAR), with its HCI index is to be used and maintained as the configuration-controlled document containing the master HCI list for the program and the source for all other program HCI annotations. The NH&S DAR was previously just a report and not a configuration-controlled document. It's role as the documentation of rationale for HCIs and the details of design proof are critical elements in life-cycle support and thus are vital to operations and support phase;

(2). the requirement for a system hardness analysis report (SHAR) has been transformed into a tasking that will result in a system level NH&S DAR to document the results of the system level hardness evaluation activity. No SHAR was ever produced or delivered as part of an ICBM program and with government emphasis on minimizing DIDs and CDRLs, having a different type of report for which no Data Item Description (DID) exists (i.e., the SHAR) was deemed counter-productive and not cost-effective;

(3). the requirement for a NH&S DAR devoted to facilities, RPIE, and A&CO installation hardware is retained and necessary to the system level analysis and for life-cycle hardness; and

(4). the cancellation of DIDs (some time after revision B was released) for the separate hardness assurance, maintenance, and surveillance plans (respectively, DI-ENVR-80263, DI-ENVR-80264, and DI-ENVR-80265) calls for integration of the tasking which created that data into a consolidated NH&S planning effort for the NH&S program plan which is then documented through contract data requirements via DI-ENVR-82097, NH&S Program Plan.

e. Section 5.5 and expanded content in Figure 3 has been added to provide an overview of the operations and support phase details. AFI 63-101/20-101, the governing regulation for survivability of Air Force systems, refers to life-cycle survivability but then defaults to a 23-year-old Defense Nuclear Agency HAMS (Hardness Assurance, Maintenance, and Surveillance) document that just deals with the acquisition phase and contains essentially nothing about the operations & support phase (Sustainment). Even the acquisition phase requirements are the wrong specifics for ICBM systems (good for systems with hardness based on a man-in-the-loop and therefore may be appropriate to many aircraft, but which is inadequate for ICBM hardness levels). Previously, MIL-STD-1766 just said "Implement Hardness Maintenance" and "Implement Hardness Surveillance" with no details. The new Section 5.5 provides the overview of a complete HAMS program for the operations & support phase. It is not intended to be all-encompassing but is only a top level view of all key functions.

f. The flow diagrams of Appendix B have been changed to a mandatory part of the standard. They were confusing and difficult to understand. While still complex, the revised diagrams are an essential part of understanding the time sequencing of tasks.

g. Section 5.2 was very difficult to understand and apply. This section has been changed primarily into the new Table II. This visual reference makes the concepts much more understandable and allows easier correct application.

h. Hardness surveillance program (HSP) planning tasking was not specific enough. The tasks a contractor and the government can perform during the design phase are somewhat limited so more specific direction is provided as follows:

(1). During design, the contractor is required to envision methods and develop design concepts that will allow or facilitate testing without removing the hardness protection (e.g., access points inside a drawer to measure EMP induced transients without having to open the drawer but also without adding a vulnerability with such a probe).

(2). The contractor is required to identify and prepare to transition equipment (used during design proof testing or during production) which is also needed to perform surveillance to the government for execution of HS. Alternatively, if the equipment will be unavailable when needed for HS, then he is to plan to build another set of the equipment

(3). The standard indicates HSP will begin within one year after IOC. There has been confusion on the part of many thinking that hardness assurance testing during production were providing the measure of fielded system hardness. While they provide an initial deployment confidence, they do not address the primary mode of system degradation which is human interaction (i.e., system maintenance and errors of the fallible humans involved). If HSP does not begin rapidly then important information is lost and assessment cannot begin.

i. The concept of HCI application (HCI-A) annotation via flag notes in parts lists, in addition to other HCI marking, is introduced to address the problem of not knowing which applications of a part really affect hardness (see the concept explanation in A.3.66 for more detail).

j. The NH&S DAR was not updated after Functional Configuration Audit (FCA). The DAR needs to be a "living" document that is constantly updated and tasking has been added to the operations and support phase as well as an updated DID which requires a production phase update of the DAR.

k. Appendix E had a confusing treatment of MIL-STD vs. Commercial parts with different margin break points. This confusion has been eliminated.

l. The support to drawing preparation task has an added requirement to address the situation where EMD phase design margins are no longer valid (during operations and support phase, e.g., anytime more than three years after DMs were established) and drawings need to include instructions on reinstating tests eliminated based on DMs and/or increasing test frequency/ sample size where reductions were made during EMD based on DMs.

m. Additions have been incorporated to address cancelled DIDs: (1) reinstate a DID for NH&S DAR and add an example nuclear environment and effects hardware element matrix (NEEHEM) to that DID and reinstatement of the NH&S program plan DID, as well as the addition of a DID for Hardness Data Manual updates.

7. Comments, suggestions, or questions on this document should be addressed to the Defense Standardization Program Office (DSPO), 1551 Wyoming Blvd. SE Kirtland AFB, NM 87117-5624 or emailed to afnwc.dspo.workflow@us.af.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST online database at https://assist.dla.mil.

CONTENTS

PARAGRAPH		PAGE
	FOREWORD	iii
1	SCOPE	1
1.1	Purpose	1
1.2	Application	1
1.2.1	Tailoring	1
2	APPLICABLE DOCUMENTS	3
2.1	General	3
2.2	Government documents.	3
2.2.1	Department of Defense (DoD) Documents	3
2.2.2	Other government documents.	3
2.3	Order of precedence	4
3	DEFINITIONS.	5
3.1	Definitions	5
4	GENERAL REQUIREMENTS.	7
4.1	NH&S Program	7
5	DETAILED REQUIREMENTS.	9
5.1	Mapping of Contractor Categories/Types to Tasks and Responsibilities	10
5.1.1	Materiel solution analysis phase.	11
5.1.1.1	SPO	11
5.1.1.2	System support and integration (SS&I) contractor	12
5.1.2	Technology maturation and risk reduction phase.	12
5.1.2.1	SPO.	12
5.1.2.2	AVE/SE contractor	12
5.1.2.3	SS&I contractor	12
5.1.2.4	Facilities architectural and engineering (A&E) contractor	13
5.1.3	Engineering and manufacturing development (EMD) phase	13
5.1.3.1	SPO	13
5.1.3.2	AVE/SE contractor	13
5.1.3.3	SS&I contractor	13
5.1.3.4	Facilities A&E contractor	14
5.1.3.5	Facilities construction contractor	14
5.1.4	Production and deployment phase.	14
5.1.4.1	SPO	14
5.1.4.2	AVE/SE contractor	14
5.1.4.3	SS&I contractor	14
5.1.4.4	Facilities A&E contractor	14

CONTENTS

PARAGRAPH		PAGE
5.1.4.5	Facilities construction contractor	15
5.1.4.6	A&CO contractor	15
5.1.5	Operations and support phase	15
5.2	Hardware category NH&S requirements	15
Table I	NH&S Task Summary	17
Table II	ICBM Hardness & Survivability Program Equipment Types and Scope of Requirements	23
Table III	Typical NH&S task applicability (AVE/SE contractor).	25
Table IV	Typical NH&S task applicability (Other contractors).	26
5.3	NH&S program tasks	27
5.3.1	NH&S program definition.	27
5.3.1.1	SPO NH&S program planning.	27
5.3.1.2	Contractor NH&S program planning	27
5.3.1.2.1	WSE nuclear environment/effect hardware element matrix (NEEHEM)	27
5.3.2	WSS hardness requirements.	27
5.3.2.1	SPO development of WSS hardness requirements	28
5.3.2.2	Contractor support to development of WSS hardness requirements	28
5.3.2.3	WSS hardness requirements allocations	28
5.3.3	WSE hardness requirements.	28
5.3.3.1	AVE/SE hardness requirements.	28
5.3.3.1.1	Development of AVE/SE hardness requirements	28
5.3.3.1.2	Hardness interface control requirements	29
5.3.3.1.2.1	Electromagnetic pulse (EMP)	29
5.3.3.1.2.2	Nuclear radiation	29
5.3.3.1.2.3	Mechanical (x-ray, thermal radiation, blast, shock, and debris)	29
5.3.3.2	Facilities hardness requirements.	30
5.3.3.2.1	Development of facilities design criteria hardness requirements	30
5.3.3.2.2	Support to development of facilities design criteria hardness requirements	30
5.3.3.2.3	Review of facilities drawings.	30
5.3.3.3	A&CO installation hardware hardness requirements	31
5.3.4	WSE hardness design.	31
5.3.4.1	Hardness design development.	31
5.3.4.1.1	Concept design	31
5.3.4.1.2	Preliminary design	31
5.3.4.1.3	Detail design	31
5.3.4.1.4	Final design	31
5.3.4.2	Considerations for specific NH&S disciplines	32
5.3.4.2.1	EMP	32
5.3.4.2.2	Nuclear radiation	33

CONTENTS

PARAGRAPH		PAGE
5.3.4.2.3	Mechanical	33
5.3.5	WSE hardness evaluation.	34
5.3.5.1	WSE hardness verification	34
5.3.5.2	WSE hardness qualification	34
5.3.6	System level hardness evaluation.	34
5.3.6.1	System level hardness testing and analysis	34
5.3.6.2	System level hardness verification	34
5.3.7	System level assessment.	35
5.3.7.1	SPO system level assessment	35
5.3.7.2	WSE level support to system level assessment	35
5.3.7.3	System level support to system level assessment	35
5.3.8	Life cycle hardness (LCH) tasks	36
5.3.8.1	HCI/HCP identification	36
5.3.8.1.1	System master HCI list and NH&S DAR library index	36
5.3.8.1.2	HCI application identification	37
5.3.8.2	NH&S support to drawing preparation	37
5.3.8.3	NH&S support to LSA preparation	38
5.3.8.4	NH&S support to TO preparation	38
5.3.8.5	NH&S support to A&CO TA preparation	38
5.3.8.5.1	LCH during A&CO implementation	38
5.3.8.6	Hardness maintenance planning & preparation	39
5.3.8.7	Factory support equipment (FSE)/depot support equipment (DSE) hardness requirements	39
5.3.8.8	Hardness assurance planning	39
5.3.8.9	Hardness assurance resource definition and acquisition	39
5.3.8.10	Hardness assurance implementation	40
5.3.8.11	WSE hardness surveillance planning	40
5.3.8.12	SPO system hardness surveillance preparation planning	40
5.3.8.13	Hardness surveillance preparation support	40
5.3.8.14	Hardness surveillance implementation	41
5.3.8.15	Hardness surveillance implementation support	41
5.3.8.16	Hardness maintenance implementation	41
5.4	Hardness trade study, analysis, and test requirements	41
5.4.1	Hardness trade studies	41
5.4.1.1	EMP	42
5.4.1.2	Nuclear radiation	42
5.4.1.3	Thermal radiation	43
5.4.1.4	Blast	43
5.4.1.5	Shock	44
5.4.1.6	Debris	44
5.4.2	Hardness analysis	45
5.4.2.1	EMP	45
5.4.2.2	Nuclear radiation	45

CONTENTS

PARAGRAPH		PAGE
5.4.2.3	Thermal radiation	46
5.4.2.4	Blast	47
5.4.2.5	Shock	47
5.4.2.6	Debris	48
5.4.3	Hardness testing	48
5.4.3.1	EMP	48
5.4.3.2	Nuclear radiation	49
5.4.3.3	Thermal radiation	50
5.4.3.4	Blast	50
5.4.3.5	Shock	50
5.4.3.6	Debris	51
5.5	System sustainment program for hardness assurance, maintenance, and surveillance (HAMS)	51
5.5.1	Maintain weapon system specification and lower level hardness requirements	51
5.5.1.1	Evaluate NH&S impact(s) of changes in requirements	52
5.5.1.2	Allocate NH&S requirements	52
5.5.1.3	Define new NH&S requirements	52
5.5.2	Perform hardness assurance (HA) for system sustainment	52
5.5.2.1	Review technical data packages for adequacy during spares procurement	52
5.5.2.2	Perform hardness assurance (HA) test and/or inspections and/or analysis on spares 52	
5.5.2.3	Qualify new suppliers to meet hardness requirements	52
5.5.2.4	Perform HAMS efforts for system modifications	52
5.5.3	Perform hardness maintenance for system sustainment	53
5.5.3.1	NH&S review of technical order (TO) changes	53
5.5.3.2	Provide hardness awareness training	53
5.5.3.3	Maintain master HCI list	53
5.5.3.4	NH&S review of shop maintenance procedures	53
5.5.3.5	NH&S review of drawing changes (engineering orders, EOs)	53
5.5.3.6	Maintain NH&S DAR and HDM library	53
5.5.4	Perform hardness surveillance (HS) for system sustainment	53
5.5.4.1	Detect degradation (monitor hardness margins)	54
5.5.5	Perform system survivability assessment	54
5.5.5.1	Survivability impact evaluation	54
5.5.5.2	Perform trade studies of mitigation alternatives	54
5.5.5.3	Identify system hardness risks and plan mitigation (risk management)	54
5.5.6	Maintain test facilities and/or monitor test facilities at outside agencies	54

CONTENTS

PARAGRAPH		PAGE
6	NOTE	55
6.1	Intended use	55
6.2	Acquisition requirements	55
6.3	Associated Data Item Descriptions (DIDs)	55
6.4	Tailoring information for contractual application	56
6.4.1	Special considerations affecting tailoring and proposal evaluation.	56
6.4.1.1	Tailoring information for the System requirements review/system functional review (SRR/SFR)	56
6.4.1.2	Hardness capability of GFE	56
6.4.1.3	Facilities hardness design tasks	56
6.4.1.4	Scope of hardness qualification analysis	57
6.4.1.5	Development testing data requirements	57
6.4.1.6	Tailoring for system level testing and analysis	57
6.4.1.7	NH&S program plan requirements	57
6.4.1.8	Hardness surveillance planning and preparation	57
6.4.1.9	Tailoring information for the NH&S Design Analysis Report (DAR) 57	
6.4.1.9.1	Tailoring the NH&S DAR for CI WSE	57
6.4.1.9.2	Tailoring the contract data requirements for the NH&S DAR for non-CI WSE	58
6.4.2	Explicit tailoring information	58
6.4.2.1	AVE/SE contractor.	58
6.4.2.1.1	Materiel solution analysis phase	58
6.4.2.1.2	Technology maturation and risk reduction (TMRR) phase.	58
6.4.2.1.2.1	Contractor furnished equipment.	58
6.4.2.1.2.1.1	Developmental items	59
6.4.2.1.2.1.2	Non developmental items/commercial.	59
6.4.2.1.2.1.2.1	Unmodified commercial NDI	59
6.4.2.1.2.1.2.2	Modified commercial NDI	59
6.4.2.1.2.1.3	Non-developmental items/military.	59
6.4.2.1.2.1.3.1	Unmodified military NDI	59
6.4.2.1.2.1.3.2	Modified military NDI	59
6.4.2.1.2.1.4	Government furnished equipment	59
6.4.2.1.3	Engineering and manufacturing development phase.	59
6.4.2.1.3.1	Contractor furnished equipment.	59
6.4.2.1.3.1.1	Developmental items	59
6.4.2.1.3.1.2	Non-developmental items/commercial.	59
6.4.2.1.3.1.2.1	Unmodified commercial NDI	59
6.4.2.1.3.1.2.2	Modified commercial NDI	59
6.4.2.1.3.1.3	Non developmental items/military	60
6.4.2.1.3.1.3.1	Unmodified military NDI	60
6.4.2.1.3.1.3.2	Modified military NDI	60

CONTENTS

PARAGRAPH		PAGE
6.4.2.1.3.1.4	Government furnished equipment.	60
6.4.2.1.4	Production and deployment phase.	60
6.4.2.1.4.1	Contractor furnished equipment.	60
6.4.2.1.4.1.1	Developmental items	60
6.4.2.1.4.1.2	Non developmental items/commercial.	60
6.4.2.1.4.1.2.1	Unmodified commercial NDI	60
6.4.2.1.4.1.2.2	Modified commercial NDI	60
6.4.2.1.4.1.3	Non developmental items/military	60
6.4.2.1.4.1.3.1	Unmodified military NDI	60
6.4.2.1.4.1.3.2	Modified military NDI	60
6.4.2.1.4.1.4	Government furnished equipment.	60
6.4.2.1.5	Operations and support phase	61
6.4.2.2	System support/integration contractor.	61
6.4.2.2.1	Materiel solution analysis phase	61
6.4.2.2.2	Technology maturation and risk reduction phase	61
6.4.2.2.3	Engineering and manufacturing development (EMD) phase	61
6.4.2.2.4	Production and deployment phase	61
6.4.2.2.5	Operations and support phase	61
6.4.2.3	Facilities A&E contractor.	61
6.4.2.3.1	Materiel solution analysis phase	61
6.4.2.3.2	Technology maturation and risk reduction phase	61
6.4.2.3.3	Engineering and manufacturing development phase	61
6.4.2.3.4	Production and deployment phase	61
6.4.2.3.5	Operations and support phase	61
6.4.2.4	Facilities construction contractor.	61
6.4.2.4.1	Materiel solution analysis phase	61
6.4.2.4.2	Technology maturation and risk reduction phase	61
6.4.2.4.3	Engineering and manufacturing development phase	62
6.4.2.4.4	Production and deployment phase	62
6.4.2.4.5	Operations and support phase	62
6.4.2.5	A&CO contractor.	62
6.4.2.5.1	Materiel solution analysis phase	62
6.4.2.5.2	Technology maturation and risk reduction phase	62
6.4.2.5.3	Engineering and manufacturing development phase	62
6.4.2.5.4	Production and deployment phase	62
6.4.2.5.5	Operations and support phase	62
6.4.2.6	Hardness surveillance support contractor.	62
6.4.2.6.1	Materiel solution analysis phase	62
6.4.2.6.2	Technology maturation and risk reduction phase	62
6.4.2.6.3	Engineering and manufacturing development phase	62
6.4.2.6.4	Production and deployment phase	62
6.4.2.6.5	Operations and supply phase	62

CONTENTS

PARAGRAPH		PAGE
6.4.2.6.6	Subject term (key word) listing	62
6.5	Changes from previous issue	63
A.1	SCOPE.	65
A.1.1	Purpose	65
A.1.2	Application	65
A.2	ACRONYMS/ABBREVIATIONS	65
A.3	DEFINITONS.	68
A.3.1	Acquisition Life Cycle	68
A.3.2	Aerospace Vehicle Equipment (AVE)	68
A.3.3	Airblast	69
A.3.4	Allocation	69
A.3.5	Analysis	69
A.3.6	Analysis of Alternatives (AoA)	69
A.3.7	Assembly and Checkout (A&CO)	69
A.3.8	Assembly and Checkout (A&CO) Contractor	69
A.3.9	Assembly and Checkout (A&CO) Installation Hardware	69
A.3.10	Assembly and Checkout Technical Analysis (A&CO TA)	69
A.3.11	Assessment	70
A.3.12	Attenuation	70
A.3.13	AVE/SE contractor	70
A.3.14	Blast	70
A.3.15	Capability Development Document (CDD)	70
A.3.16	Circumvention and Recovery (C&R)	71
A.3.17	Commercial-Off-The-Shelf (COTS)	71
A.3.18	Commercial Product	72
A.3.19	Concept Design	72
A.3.20	Configuration Item (CI)	73
A.3.21	Contractor	73
A.3.22	Critical Design Review (CDR)	74
A.3.23	Contractor Furnished Equipment (CFE)	74
A.3.24	Debris	74
A.3.25	Depot support equipment (DSE)	74
A.3.26	Design constraints	75
A.3.27	Design margin (DM)	75
A.3.28	Design Reviews	77
A.3.29	Detail Design	78
A.3.30	Developmental Item	78
A.3.31	Development Tests	78
A.3.32	Electromagnetic Pulse (EMP)	78
A.3.33	Engineering and Manufacturing Development (EMD) Phase	78
A.3.34	Evaluation Tests	79
A.3.35	Facilities	79
A.3.36	Facilities A&E Contractor	79

CONTENTS

PARAGRAPH		PAGE
A.3.37	Facilities Construction Bid Package	79
A.3.38	Facilities Construction Contractor	79
A.3.39	Facilities Criteria Input	79
A.3.40	Facilities Design Criteria	80
A.3.41	Facilities Design Criteria Contractor	80
A.3.42	Factory Support Equipment (FSE)	80
A.3.43	Figure A (Fig A)	80
A.3.44	Final Design	80
A.3.45	Fragility.	80
A.3.46	Fragility Analysis	81
A.3.47	Fragility Curve	81
A.3.48	Fragility Tests	81
A.3.49	Functional Configuration Audit (FCA)	81
A.3.50	Functional Failure	81
A.3.51	Government Furnished Equipment (GFE)	81
A.3.52	Ground Shock	81
A.3.53	Hardening	81
A.3.54	Hardness	82
A.3.55	Hardness Allocation	82
A.3.56	Hardness Allocation Analysis	82
A.3.57	Hardness allocation trades	82
A.3.58	Hardness Analysis	82
A.3.59	Hardness Annotations	83
A.3.60	Hardness Assessment	83
A.3.61	Hardness Assurance	83
A.3.62	Hardness Assurance Inspections	83
A.3.63	Hardness Assurance Lot Acceptance Testing (HALAT)	84
A.3.64	Hardness Assurance Tests	84
A.3.65	Hardness Critical Item (HCI)	84
A.3.66	Hardness Critical Item - Application (concept and use)	85
A.3.67	Hardness Critical Process/Procedure (HCP)	86
A.3.68	Hardness Data Manual (HDM)	86
A.3.69	Hardness Design	87
A.3.70	Hardness Design Analysis	87
A.3.71	Hardness Design Constraints	87
A.3.72	Hardness Design Feature	87
A.3.73	Hardness Design Trades	87
A.3.74	Hardness Evaluation	87
A.3.75	Hardness Fragility	88
A.3.76	Hardness Inspections	88
A.3.77	Hardness Maintenance	88
A.3.78	Hardness Performance Requirements	89

CONTENTS

PARAGRAPH		PAGE
A.3.79	Hardness Qualification	89
A.3.80	Hardness Requirements	89
A.3.81	Hardness Surveillance	89
A.3.82	Hardness Surveillance Inspections	90
A.3.83	Hardness Surveillance Support Contractor	90
A.3.84	Hardness Surveillance Tests	90
A.3.85	Hardness Tests	90
A.3.86	Hardness Trade Studies	91
A.3.87	Hardness Verification	91
A.3.88	Hardness Verification Analysis	91
A.3.89	Hardware Category	91
A.3.90	High Altitude Electromagnetic Pulse (HEMP)	92
A.3.91	Inherent Hardness	92
A.3.92	Initial Capabilities Document	92
A.3.93	Inspections	92
A.3.94	Interface Control Drawing (ICD)	92
A.3.95	Interface Control Working Group (ICWG)	92
A.3.96	Internal Electromagnetic Pulse (IEMP)	93
A.3.97	Key Performance Parameter (KPP)	93
A.3.98	Key System Attribute (KSA)	93
A.3.99	Life Cycle Hardness (LCH)	93
A.3.100	Logistic Support Analysis (LSA)	93
A.3.101	Logistic Support Analysis Record (LSAR)	94
A.3.102	Maintenance Support Equipment (MSE)	94
A.3.103	Materiel Solution Analysis Phase	94
A.3.104	Non-Developmental Item (NDI)	94
A.3.105	Nuclear Environment/Effect Hardness Element Matrix (NEEHEM)	94
A.3.106	Nuclear Environments	95
A.3.107	Nuclear Event Protection (NEP)	95
A.3.108	Nuclear Hardening	95
A.3.109	Nuclear Hardness	95
A.3.110	Nuclear Hardness and Survivability Design Analysis Report (NH&S DAR)	95
A.3.111	Nuclear Radiation	96
A.3.112	Nuclear Radiation Characterization	96
A.3.113	Nuclear Survivability	96
A.3.114	Nuclear Weapon Effects/Environments (NWE)	96
A.3.115	Operating Command	97
A.3.116	Operational Requirements Analysis (ORA)	97
A.3.117	Operational Support Equipment (OSE)	97
A.3.118	Operations and Support Phase	97
A.3.119	Performance Requirements	97

CONTENTS

PARAGRAPH		PAGE
A.3.120	Physical Configuration Audit (PCA)	98
A.3.121	Preliminary Design	98
A.3.122	Preliminary Design Review (PDR)	98
A.3.123	Prime Item Development Specification (PIDS)	98
A.3.124	Production and Deployment Phase	98
A.3.125	Qualification	99
A.3.126	Qualification Tests	99
A.3.127	Real Property Installed Equipment (RPIE)	99
A.3.128	Shielding Topology	99
A.3.129	Shock	99
A.3.130	Source Region Electromagnetic Pulse (SREMP)	99
A.3.131	Support Equipment (SE)	99
A.3.132	Survivability	99
A.3.133	Survivability Assessment	100
A.3.134	System Engineering and Technical Assistance (SE/TA) Contractor	100
A.3.135	System Functional Review (SFR)	100
A.3.136	System Generated Electromagnetic Pulse (SGEMP)	100
A.3.137	System Level Analysis	100
A.3.138	System Level Trade Study	100
A.3.139	System Life Cycle	100
A.3.140	System Program Office (SPO)	100
A.3.141	System Readiness Review (SRR)	101
A.3.142	System Requirements Analysis (SRA)	101
A.3.143	System Support/Integration (SS&I) Contractor	101
A.3.144	System Level Tests	101
A.3.145	Technical Order (TO)	102
A.3.146	Technology Maturation and Risk Reduction (TMRR) Phase	102
A.3.147	Testing	102
A.3.148	Test and Evaluation Master Plan (TEMP)	102
A.3.149	Test Planning Analysis (TPA)	103
A.3.150	Thermal Radiation	103
A.3.151	Thermomechanical Response	103
A.3.152	Trade Studies	103
A.3.153	Transfer Function	103
A.3.154	Validation/Validate	103
A.3.155	Verification	103
A.3.156	Vulnerability	103
A.3.157	Weapon System Element (WSE)	104
A.3.158	Weapon System Element Contractor	104
A.3.159	Weapon System Specification (WSS)	104
A.3.160	Withstand	104

CONTENTS

PARAGRAPH		PAGE
A.3.161	Worst-Case Circuit Analysis (WCCA)	104
B.1	SCOPE.	105
B.1.1	Scope	105
B.2	APPLICABLE DOCUMENTS	105
B.3	DEFINITIONS.	105
B.3.1	Definitions.	105
B.4	FLOW DIAGRAM CONTENT.	105
B.4.1	Flow diagram content considerations	105
B.5	FLOW DIAGRAM FORMAT.	107
B.5.1	Flow diagram format considerations	107
B.5.1.1	Contractor categories	107
B.5.1.2	Task designation	107
B.5.1.3	Documentation categories	107
C.1	SCOPE.	113
C.1.1	Scope	113
C.2	APPLICABLE DOCUMENTS.	113
C.2.1	General	113
C.2.2	Non-Government publications	113
C.3	DEFINITIONS.	113
C.3.1	Definitions.	113
C.4	SPO GENERATED NH&S RELATED PROGRAM PLANS.	113
C.4.1	System level NH&S program plan	113
C.4.1.1	Model outline	114
C.4.2	System level hardness maintenance plan	116
C.4.3	System level hardness surveillance plan	117
C.5	ANNOTATIONS TO ENGINEERING DRAWINGS AND PARTS LISTS.	118
C.5.1	Description/purpose	118
C.5.2	Preparation instructions for tailoring of ASME Y14.100 and ASME Y14.24 in contracts where applicable	118
C.5.2.1	Tailoring of ASME Y14.100.	118
C.5.2.1.1	Tailoring to definitions of ASME Y14.100	118
C.5.2.1.2	Tailoring to paragraph 7.6.1 of ASME Y14.100	118
C.5.2.1.3	Tailoring to Section 7, Figure 1, Symbology of ASME Y14.100	119
C.5.2.1.4	Tailoring to paragraph E5.1 Hardness Critical Note in ASME Y14.100	119
C.5.2.1.5	Tailoring to Table E1 ACRONYMS FOR SPECIAL ITEMS AND PROCESSES	120
C.5.2.2	Tailoring of ASME Y14.24.	120
C.5.2.2.1	Tailoring of ASME Y14.24, paragraph 8, CONTROL DRAWINGS	120
C.5.2.2.2	Prohibited drawing type	120
C.5.2.3	Parts List Format for HCI identification	120

CONTENTS

PARAGRAPH		PAGE
C.5.2.4	Tailoring to paragraph E5.1 Hardness Critical Note in ASME Y14.100 for use in TO preparation.	121
D.1	SCOPE.	123
D.1.1	Scope	123
D.1.2	Purpose	123
D.2	APPLICABLE DOCUMENTS	123
D.3	DEFINITIONS.	123
D.3.1	Definitions.	123
D.4	HCI IDENTIFICATION.	123
D.4.1	Clarification of the HCI identification process	123
D.4.1.1	HCI identification for hardware not originally designed to be hard	125
D.4.1.2	Relationship of potential vulnerabilities to HCI identification	125
D.4.1.3	Responsibility for HCI identification.	125
D.4.2	Significance of the HCI identification process	125
D.4.3	Clarification of HCI rationales.	126
D.4.3.1	Clarification of rationales 1-3	126
D.4.3.1.1	Clarification of rationale 1	126
D.4.3.1.2	Clarification of rationale 2	127
D.4.3.1.3	Clarification of rationale 3	128
D.4.3.2	Clarification of rationale 4	128
D.4.3.2.1	Relationship to HCI identification of distinction between hardness critical process and hardness critical procedure	129
D.4.3.3	Clarification of rationale 5	130
D.5	HCI DOCUMENTATION AND APPLICATION.	130
D.5.1	HCI listings and annotations	130
D.5.2	Other HCI related documentation	131
D.5.2.1	Utilization of HCI documentation	131
E.1	INTRODUCTION.	134
E.1.1	Purpose	134
E.1.2	Scope	134
E.2	PARTS CONTROL FOR WEAPON SYSTEM EQUIPMENT.	134
E.2.1	Background	134
E.2.2	Equipment categories	135
E.2.2.1	Contractor Furnished Equipment (CFE)	135
E.2.2.2	Government Furnished Equipment (GFE)	135
E.2.2.3	Commercial equipment (COMM or COTS)	136
E.2.2.4	Military equipment (MIL)	136
E.3	RADIATION TEST PROGRAM STRUCTURE	136
E.3.1	Radiation characterization testing	137
E.3.2	Radiation qualification testing	139
E.3.3	Hardness assurance/lot acceptance testing (HALAT)	141

CONTENTS

PARAGRAPH		PAGE
E.3.4	Options for semiconductor parts radiation testing	142
E.4	RADIATION TESTING BASED ON DESIGN MARGIN (DM)	142
E.4.1	Guidelines for HALAT	143
E.4.2	DM tracking	144
E.5	GUIDELINES FOR THE USE OF EXISTING TEST DATA	144
E.5.1	Considerations for acceptability of similar data	144
E.5.1.1	Options relative to age of the data	145
E.5.1.2	Options relative to device and manufacturer similarity tradeoffs	145
E.5.2	Qualification of advanced technology parts	145
E.6	CATEGORIES AND HARDNESS CRITICAL ITEMS (HCIs)	146
E.7	ACRONYM LIST	147
	Index	149
	CONCLUDING MATERIAL	155

FIGURE		
Figure 1	Materiel Solution Analysis Flow and Technology Maturation and Risk Reduction Process Flow	109
Figure 2	Engineering and Manufacturing Development Process Flow	110
Figure 3	Production & Deployment, and Operations & Support Process Flow	111
Figure 4	Model Format for SPO NH&S Program Plan	115
Figure 5	Model Outline for System Level HSP Plan	118
Figure 6	ICBM Weapon System Definition of HCI	124

TABLE		
Table I	NH&S Task Summary	17
Table II	ICBM Hardness & Survivability Program Equipment Types and Scope of Requirements	23
Table III	Typical NH&S task applicability (AVE/SE contractor).	25
Table IV	Typical NH&S task applicability (Other contractors).	26
Table V	Radiation test and parts control requirements vs design margin	139

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1. SCOPE

1.1 Purpose. This standard defines nuclear hardness and survivability (NH&S) requirements, procedures, and practices for use during the acquisition life-cycle phases of the intercontinental ballistic missile (ICBM) weapon systems (see A.3.2). For the design, development, production, deployment, and operation of ICBM weapon systems, it implements Department of Defense Directive (DODD) 5000.01 which requires programs to address survivability as part of the acquisition process and it implements the NH&S aspects of Air Force Instructions (AFI) AFI 63-101/20-101, Acquisition and Sustainment Life Cycle Management and AFI 10-2607, "Air Force Chemical, Biological, Radiological, and Nuclear (CBRN) Survivability."

1.2. Application. This standard is intended to be tailored to the requirements and scope of each specific ICBM program and is applicable to Air Force personnel and contractors engaged in the design and development, production, and deployment of aerospace vehicle equipment (AVE), support equipment (SE), including operational support equipment (OSE), survivable real property installed equipment (RPIE), and facility weapon system elements that have nuclear hardness requirements.

The document is not organized around any specific organizational structure in order to avoid becoming obsolete upon a reorganization. Instead, it is organized around the generic equipment types (e.g., AVE) and thus remains applicable and relevant to both existing ICBM programs and future ICBM programs. However, in order to use the standard effectively one must map the tasking into specific hardware designs and into specific organizations. To do this, Air Force personnel must determine which type of hardware (as outlined herein) they are responsible for, what type of contractor (as outlined herein) they are seeking, and the tasks associated with it. For the sustainment phase, the mapping of tasks will be to Air Force organizational entities rather than contractors. With the mapping of tasks to responsible party, the standard can then be tailored as noted in 1.2.1 for the specific program. Using that mapping, program managers and engineers will see how to apply the standard to their specific program, system design concept, and contract structure.

1.2.1 Tailoring. Department of Defense (DoD) policy is to selectively apply and tailor standardization documents to ensure their cost-effective use in the acquisition process. Individual requirements (sections, paragraphs, or sentences) of this standard should be evaluated to determine the extent to which they are suitable for a specific acquisition program or spares procurement, and to identify modifications to ensure that each requirement achieves an optimal balance between need and cost. Therefore, in general, contractual documents will not merely cite this standard, but will also list the specific portions that apply to each contract. Tailoring of data requirements consists of the deletion of requirements from data item descriptions (DIDs). Each program office should carefully consider within DoD and service guidelines the benefits and costs of imposing this standard on each specific acquisition. Explicit recommendations for the tailoring.

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2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in Sections 3, 4, or 5 of this standard. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in Sections 3, 4, or 5 of this standard, whether or not they are listed.

2.2 Government documents.

2.2.1 Department of Defense (DoD) Documents. The following documents require survivability to be addressed during a system's life cycle. They are for Air Force compliance and for guidance of contractors:

DEPARTMENT OF DEFENSE DIRECTIVE/INSTRUCTIONS

DoDD 5000.01	The Defense Acquisition System
DoDI 3150.09	The Chemical, Biological, Radiological, and Nuclear (CBRN) Survivability Policy
DoDI 3222.3	DOD Electromagnetic Environmental Effects (E3) Program

(Copies of this document are available online at http://www.dtic.mil/dtic/.)

2.2.2 Other government documents. The following other government documents are additional basic authority requiring that survivability be addressed throughout the system life cycle. They are mandatory for the Air Force and for guidance of contractors.

AIR FORCE INSTRUCTIONS (AFIs)

Air Force Instruction, AFI 63-101/20-101	Integrated Life Cycle Management
AFI 10-2607	Air Force Chemical, Biological, Radiological, and Nuclear (CBRN) Survivability

(Copies of these documents are available online at http://www.e-publishing.af.mil.)

ICBM Systems Directorate (ICBMSD, Office Symbol AFNWC/NI)

ICBM-HDBK-01	System Requirements Analysis ICBM Systems (July 2011)

(Copies of this document are available from the ICBM Systems Directorate, 6008 Wardleigh Rd (Bldg. 1580), Hill AFB, UT 84056.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS.

3.1 Definitions. The definitions and acronyms/abbreviations that apply to this standard are contained in Appendix A.

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4. GENERAL REQUIREMENTS.

4.1. NH&S Program. The contractor shall establish and conduct an NH&S program in accordance with this standard as tailored in the applicable statement of work (SOW) (see 6.4). If the contractor chooses to use subcontractors to perform NH&S tasking as part of the program, the contractor shall either:

a. contractually impose the applicable SOW tasks on the subcontractor, ensure the subcontractor is performing the tasks, and report and document the subcontractors' work and progress on those tasks at program design reviews or,

b. perform the applicable SOW tasks in lieu of and for his subcontractor(s).

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5. DETAILED REQUIREMENTS.

All tasks in this section may be performed by government entities (as well as by contractors) as long as they possess the appropriate expertise. This is especially true for tasks associated with the System Support & Integration contractor. The identification of a responsible party is to be interpreted as typical but the contract tailoring needs to address the specifics that apply to each contract. Therefore, although many paragraphs begin, "the contractor shall," this phrase is intended to allow direct application of paragraphs to contractors via their contract rather than dictating that the government must use a contractor to perform the task. In the case where the government choses to perform the task, the wording would then be, "the government shall."

Section 5 of this standard is comprised of four sections and includes four tables. Section 5.1 primarily corresponds to Table I. Section 5.2 discusses and provides Table II, Table III, and Table IV. For clarity purposes, all four tables are located at the end of Section 5.2. There is a natural division between Sections 5.1, 5.2 and Sections 5.3, 5.4 due to content and purpose. Section 5.3 lists the tasks to be accomplished throughout a program that develops a new ICBM system or that develops a replacement, modified, or new capability subsystem in an existing ICBM system. Section 5.4 is a companion of section 5.3 and is a list of the trade studies which typically need to be conducted during the course of such programs.

The technical and program terms used throughout this standard to state the NH&S requirements are defined in Appendix A, which is a mandatory part of this standard. In addition, the flow diagrams of Appendix B, which is a mandatory part of this standard, coupled with Section 5 provide a complete picture of the tasks and the program phase in which they are to be performed. Technical tasks performed by the system program office (SPO) are included in Section 5 for information purposes in order to provide a complete definition of the technical content of a comprehensive NH&S program.

Given this outline, the manner in which the various sections and tables are to be used by the government and by the contractor is explained next.

The sections and tables are to be used by the government to specify in contract documents, the applicable tasks for the contractor category and program phase(s) for which the contract is being written. It is to be used by the contractor as a guide to the tasks that should apply and to provide the specific statements of overall tasking. In this capacity, the contractor can assist the government to ensure that all necessary tasks are included in the contract. Recommendations for the tailoring of this standard for contractual application are given in Section 6.4.

Table I lists all NH&S program tasks (from Section 5.3) and then identifies which tasks typically apply to each category of contractor. Section 5.1 correspondingly states the top-level overview of each contractor type's tasking but also adds the dimension of program phases. In other words, Table I organizes Section 5.3 tasks by contractor type and then Section 5.1 explains what is to be done in which phase of the program

Table II and Table III are a complementary set. Table II is an overview of how the Section 5.3 tasks apply to different hardware categories. Its purpose is to show to both the government and the contractor the subtle differences between the tasking for various hardware categories and to provide a visual picture of how they are similar regardless of category. Table III lists only the specific tasks of Section 5.3 which apply to different hardware categories. Because these two tables deal with hardware categories, they apply only to the AVE/SE contractor category. These tables direct the government in contract document preparation and guide the contractor in working with the government to ensure all necessary tasks are included in the contract. Both government and contractor should note that, regardless of hardware category, there is a need to completely demonstrate compliance with system NH&S requirements and that hardware category designations do not generally relieve the program from performing the tasks which demonstrate such compliance. Tailoring recommendations are given in 6.4.

Table IV applies to the other categories of contractors (besides the AVE/SE contractor) and lists the applicable Section 5.3 tasks. The other contractor roles do not provide hardware and are therefore organized by program life-cycle phase only. Table IV's purpose is the same as Table II and Table III, which is to direct the government and guide the contractor to the necessary tasking for contract tailoring (see Section 6.4).

This may be summarized as follows:

Section Description	**Tables Corresponding to the Section**	
Section 5.1 - Overview requirements for contractor categories with program phase divisions.	Table I (Section 5.3 task applicability by contractor category)	Table IV (Section 5.3 task applicability for non AVE/SE contractor categories with program phase divisions)
Section 5.2 - Overview requirements by hardware category requirements (AVE/SE contractor)	Table II (General program task overview by hardware category)	Table III (Section 5.3 task applicability by hardware category)
Section 5.3 - Overview requirements for facilities and A&CO contractors	Table IV (Section 5.3 task applicability for non AVE/SE contractor categories with program phase divisions)	

5.1 Mapping of Contractor Categories/Types to Tasks and Responsibilities. The contractor shall implement the NH&S tasks that are applicable to:

a. the program role performed by the contractor (see Table I and A.3.21);

b. the particular system life cycle phase(s) under contract; and

c. the particular categories of hardware selected by the contractor or dictated by the government to be used to fulfill the contract.

Table I identifies the NH&S program tasks (see 5.3) that typically apply to each category of contractor. Table I, Table III, and Table IV show typical task applicability. Table II identifies the NH&S tasks applicable to the AVE/SE contractor as a function of life cycle phase and hardware category (see 5.2) and more clearly shows the relationship between the terms, developmental and non-development item, modified and unmodified, contractor furnished and government furnished, as well as commercial and military. Table III identifies the task applicability as a function of the life cycle phase for the contractor categories besides those for AVE/SE. Explicit recommendations for the tailoring of this standard for contractual application to ICBM programs are contained in 6.4 but the tables and Appendix B could also be used as the guide for tailoring. Technical tasks performed by the system program office (SPO) are included throughout the standard for information purposes to provide a complete definition of the technical content of a comprehensive NH&S program. The technical and program terms used throughout this section to describe the NH&S requirements are defined in Appendix A, which is a mandatory part of this standard. Reference to this appendix is necessary for full and correct understanding of the intended content and purpose of each task defined.

5.1.1 Materiel solution analysis phase.

5.1.1.1 SPO. Based upon the need for specific operational capabilities, the commands involved will define and select alternative system concepts, one or more of which may result in further development. Among the factors considered during the definition and selection process, are financial and technical constraints and military need. If the Initial Capabilities Document includes a nuclear threat, one of the technical factors considered must be NH&S. In this case, the SPO will perform survivability trade studies (see 5.4.1) during the Analysis of Alternatives (AoA) to determine the optimum and most cost-effective system design approach. Among the alternative survivability approaches that are considered are mobility, spacing, replication, concealment, deception, and hardening. Each candidate approach is evaluated by means of iterative and parametric engagement analysis of the approach under consideration with the threat. Results and recommendations as to special nuclear hardening considerations will be documented and evaluated together with the other selection criteria in support of any decision to proceed to the subsequent technology maturation and risk reduction (TMRR) phase. For NH&S, approval to the SPO to proceed will be based upon assurance that:

a. mission/performance/threat envelopes are adequately defined, technically feasible, and capable of being achieved within reasonable cost and schedule constraints:

b. technical and economic objectives are sound, needed, reasonable, and well defined;

c. major uncertainties are identified for further investigation during the technology maturation and risk reduction phase; and

d. preliminary cost and schedule estimates are based upon sound analyses.

The desired system key performance parameters (KPPs) and key system attributes (KSAs), as well as other important performance and system characteristics, are documented by the government in the capability development document (CDD).

5.1.1.2 System support and integration (SS&I) contractor. During the Materiel Solution Analysis Phase or TMRR, the contractor shall perform the Section 5.3 tasks (as defined in the contract) necessary to support the conduct of a proof-of-concept development activity for the alternative system concept selected by the SPO as an acceptable candidate approach for satisfying a specific operational need.

5.1.2 Technology maturation and risk reduction phase.

5.1.2.1 SPO. The SPO will establish weapon system hardness requirements based upon the nuclear threat. The SPO will consider the allocation of hardness requirements in the selection of major subsystems for procurement. The hardness requirements for the weapon system will be documented in the weapon system specification (WSS). The SPO will conduct system level simulations (perhaps, via a selected contractor) and subsystem prototype testing, to support development of a concept design and weapon system requirements. The SPO will identify future tests and analyses to support the hardness evaluation of the system in its test and evaluation master plan (TEMP). For weapon systems that do not require a formal technology maturation and risk reduction phase, the SPO will accomplish these activities both during the final part of the materiel solution analysis phase and/or the first part of the engineering and manufacturing phase as appropriate.

5.1.2.2 AVE/SE contractor. The contractor shall accomplish the following as part of performing the tasks of Section 5.3 (as defined in the contract):

a. develop concept designs to the extent that configuration item (CI) selection can be evaluated in terms of hardness allocation strategies and hardness interface requirements with other AVE/SE contractors as well as verifying that parts and assemblies planned for purchase will be available for EMD and Production phases and are likely to meet hardness requirements;

b. in early EMD, optimize the allocation of weapon system hardness requirements to the weapon system elements (WSEs) to be developed under contract and demonstrate traceability of the allocations and evaluate the technical risk(s) relative to the probability of successful design during the EMD phase; and

c. formally present the results of these tasks at a system requirements review/system functional review (SRR/SFR) and a preliminary design review (PDR).

5.1.2.3 SS&I contractor. The contractor shall perform the Section 5.3 tasks (as defined in the contract) necessary to support:

a. the SPO in the evaluation of alternate system/subsystem designs with respect to the feasibility of proposed hardening techniques and their associated technology risk, and the impact of NH&S considerations on critical interfaces, cost, and schedule;

b. system level test planning and conduct to support refinement of the concept design(s) and weapon system requirements; and

c. the inclusion of hardness requirements in the facilities design criteria in a manner that is compatible with all other facility/hardware interfacing requirements.

5.1.2.4 Facilities architectural and engineering (A&E) contractor. The contractor shall perform the Section 5.3 tasks (as defined in the contract) necessary to prepare facilities drawings that incorporate all the hardness requirements identified in the facilities design criteria.

5.1.3 Engineering and manufacturing development (EMD) phase.

5.1.3.1 SPO. The SPO will develop models to support implementation of system level NH&S assessments and will initiate the assessment activity.

5.1.3.2 AVE/SE contractor. The contractor shall perform the Section 5.3 tasks (as defined in the contract) necessary to:

a. evaluate the optimization, traceability, and technical risk associated with the allocation of weapon system hardness requirements to the weapon system elements (WSEs) under contract;

b. develop concept designs to the extent that configuration item (CI) selection can be evaluated in terms of hardness allocation strategies and hardness interface requirements with other AVE/SE contractors;

c. derive and/or allocate the AVE/SE hardness requirements IAW the Weapon System Specification and other constraints of the contract;

d. accomplish the design, evaluation, verification, and qualification of CIs that satisfy these hardness requirements;

e. accomplish the planning, preparation, and implementation of activities required in preparation for production and in support of life cycle hardness;

f. support to the system level hardness evaluation activity; and

g. support to the SPO's system level assessment activity.

The contractor shall also support the development of facility and assembly and checkout (A&CO) installation hardware hardness requirements.

5.1.3.3 SS&I contractor. The contractor shall perform the Section 5.3 tasks (defined in his contract) necessary to:

a. accomplish system level hardness evaluation;

b. support the SPO's system level assessment activity;

c. derive and/or allocate the facility and RPIE hardness requirements (IAW the Weapon System Specification and other constraints of the contract) for incorporation in the facilities design criteria; and

d. accomplish the correct incorporation of these facility and RPIE hardness requirements in the facility design drawings.

5.1.3.4 Facilities A&E contractor. The contractor shall perform the Section 5.3 tasks (as defined in the contract) necessary to develop and complete facilities drawings that incorporate all the hardness requirements identified in the facilities design criteria. The contractor shall ensure that the facility, as constructed, contains all required hardness design features.

5.1.3.5 Facilities construction contractor. The contractor shall perform the Section 5.3 tasks (as defined in the contract) necessary to accomplish the construction of facilities in a manner that preserves the hardness provided for in the facility design.

5.1.4 Production and deployment phase.

5.1.4.1 SPO. The SPO will complete its system level assessment and document the results.

5.1.4.2 AVE/SE contractor. The contractor shall perform the Section 5.3 tasks (as defined in the contract) that are necessary to maintain the as-designed hardness levels achieved in EMD throughout the production and deployment phase. Any design changes implemented during the production and deployment phase shall undergo appropriate hardness evaluation (requalification) to verify hardness adequacy. Any such changes that have an LCH impact shall be fully included in LCH activities and documentation, as appropriate.

5.1.4.3 SS&I contractor. The contractor shall perform the Section 5.3 tasks (as defined in the contract) necessary to support:

a. the accomplishment of system level hardness evaluation; and

b. the SPO's system level assessment activity.

Any design changes implemented during the production and deployment phase that may affect system level hardness shall undergo appropriate system level hardness evaluation update to verify hardness adequacy. Any system level changes that have an LCH impact shall be fully included in LCH activities and documentation, as appropriate.

5.1.4.4 Facilities A&E contractor. The contractor shall perform the Section 5.3 tasks (as defined in the contract) necessary to prepare a facilities design package that satisfies the hardness requirements contained in the facilities design criteria and supports the construction of facilities in a manner that will satisfy these hardness requirements.

5.1.4.5 Facilities construction contractor. The contractor shall perform the Section 5.3 tasks (as defined in the contract) necessary to accomplish the construction of facilities in a manner that preserves the hardness provided for in the facility design.

5.1.4.6 A&CO contractor. The contractor shall perform the Section 5.3 tasks (as defined in the contract) necessary to accomplish the deployment of the weapon system in a manner that:

a. preserves the hardness integrity of all system elements; and

b. results in a deployed weapon system that satisfies all specified hardness requirements.

5.1.5 Operations and support phase. The operations and support phase activities are discussed in Section 5.5 of this standard.

5.2 Hardware category NH&S requirements. The contractor shall implement NH&S program tasks (as defined in the contract) for each category of equipment in accordance with Table II, using the specifics of Table I, Table III, and Table IV. Table II is a high-level overview to help scope the required effort and provide understanding of how a few tasks differ for the equipment categories. Before choosing to use a non-developmental item (NDI), the contractor shall show the following during the preliminary design (5.3.4.1.2) and hardness requirements allocation efforts (5.3.2.3) and receive Air Force approval:

1). the feasibility of meeting hardness requirements is a low risk, and

2). the life-cycle cost (LCC) for producing and maintaining it in the hardened state (i.e., cost of maintaining the required hardness throughout the life cycle) is equal or less than DI solutions.

The contractor shall accomplish this by (any one or any combination needed for the demonstration):

1). identifying existing NDI that already satisfy ICBM requirements (or can be shown to do so by added testing and analysis),

2). using design features in the host system that will protect the NDI from the nuclear environments, thereby minimizing or eliminating the hardness requirements applied directly to the NDI, or

3). adding protection around the NDI that causes it to satisfy the ICBM requirements. Examples of measures to protect are shielding, shock isolation, and electrical surge protection.

If such additions or design changes are made to the NDI rather than the host system, then the HCI List, NH&S DAR, and PIDS of the host system will need to be updated to reflect these added features. If the host system documentation cannot be updated, then the added protections must be treated as separate DIs so that the appropriate evaluations, verifications, testing, and documentation are addressed as part of the program.

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TABLE I. NH&S Task Summary

NH&S TASK (Grey areas are titles only or tasks that do not apply to contractors)		CONTRACTOR TYPE						
			SS&I					
		AVE/SE	System Integration Role	Facilities/RPIE Design Criteria Role	Facilities A&E	Facilities Construction	A&CO	Hardness Surveillance Support
5.3	**NH&S Program Tasks.**							
5.3.1	**NH&S Program Definition.**							
5.3.1.1	SPO NH&S program planning.							
5.3.1.2	Contractor NH&S program planning.	●	●	●			●	●
5.3.1.2.1	WSE nuclear environment/effect hardware element matrix (NEEHEM).	●		●				
5.3.2	**WSS hardness requirements.**							
5.3.2.1	SPO development of WSS hardness requirements.							
5.3.2.2	Contractor support to development of WSS hardness requirements.		●					
5.3.2.3	WSS hardness requirements allocations.	●	●	●				
5.3.3	**WSE hardness requirements.**							

TABLE I. NH&S Task Summary (Continued)

	NH&S TASK (Grey areas are titles only or tasks that do not apply to contractors)	**CONTRACTOR TYPE**						
			SS&I					
		AVE/SE	**System Integration Role**	**Facilities/RPIE Design Criteria Role**	**Facilities A&E**	**Facilities Construction**	**A&CO**	**Hardness Surveillance Support**
5.3.3.1	AVE/SE hardness requirements.							
5.3.3.1.1	Development of AVE/SE hardness requirements	●						
5.3.3.1.2	Hardness interface control requirements.	●	●	●				
5.3.3.2	Facilities hardness requirements.							
5.3.3.2.1	Development of facilities design criteria hardness requirements.			●				
5.3.3.2.2	Support to development of facilities design criteria hardness requirements.	●						
5.3.3.2.3	Review of facilities drawings.			●				
5.3.3.3	A&CO installation hardware hardness requirements.	●	●					
5.3.4	**WSE hardness design.**							
5.3.4.1	Hardness design development.	●		●	●			

TABLE I. NH&S Task Summary (Continued)

NH&S TASK (Grey areas are titles only or tasks that do not apply to contractors)		CONTRACTOR TYPE						
			SS&I					
		AVE/SE	System Integration Role	Facilities/RPIE Design Criteria Role	Facilities A&E	Facilities Construction	A&CO	Hardness Surveillance Support
5.3.4.1.1	Concept design.	●		●	●			
5.3.4.1.2	Preliminary design.	●		●	●			
5.3.4.1.3	Detail design.	●		●	●			
5.3.4.1.4	Final design.	●		●	●			
5.3.4.2	Considerations for specific NH&S disciplines.	●		●	●			
5.3.5	**WSE hardness evaluation.**							
5.3.5.1	WSE hardness verification.	●		●				
5.3.5.2	WSE hardness qualification.	●						
5.3.6	**System level hardness evaluation.**							
5.3.6.1	System level hardness testing and analysis.	●	●	●				

TABLE I. NH&S Task Summary (Continued)

NH&S TASK (Grey areas are titles only or tasks that do not apply to contractors)		CONTRACTOR TYPE						
			SS&I					
		AVE/SE	System Integration Role	Facilities/RPIE Design Criteria Role	Facilities A&E	Facilities Construction	A&CO	Hardness Surveillance Support
5.3.6.2	System level hardness verification.		●					
5.3.7	**System level assessment.**							
5.3.7.1	SPO system level assessment.							
5.3.7.2	WSE level support to system level assessment.	●	●	●				
5.3.7.3	System level support to system level assessment.		●					
5.3.8	**Life cycle hardness (LCH) tasks.**							
5.3.8.1	HCI/HCP identification.	●		●				
5.3.8.2	NH&S support to drawing preparation.	●			●			
5.3.8.3	NH&S support to LSA preparation.	●						
5.3.8.4	NH&S support to TO preparation.	●						

TABLE I. NH&S Task Summary (Continued)

NH&S TASK (Grey areas are titles only or tasks that do not apply to contractors)		CONTRACTOR TYPE						
			SS&I					
		AVE/SE	System Integration Role	Facilities/RPIE Design Criteria Role	Facilities A&E	Facilities Construction	A&CO	Hardness Surveillance Support
5.3.8.5	NH&S support to A&CO TA preparation.	●	●	●				
5.3.8.5.1	LCH during A&CO implementation.						●	
5.3.8.6	Hardness maintenance planning & preparation.	●						
5.3.8.7	Factory support equipment (FSE)/depot support equipment (DSE) hardness requirements.	●						
5.3.8.8	Hardness assurance planning.	●		●				
5.3.8.9	Hardness assurance resource definition and acquisition.	●				●		
5.3.8.10	Hardness assurance implementation.	●				●		
5.3.8.11	WSE hardness surveillance planning.	●		●				
5.3.8.12	SPO system hardness surveillance preparation planning.							
5.3.8.13	Hardness surveillance preparation support.	●		●				

TABLE I. NH&S Task Summary (Continued)

NH&S TASK (Grey areas are titles only or tasks that do not apply to contractors)		CONTRACTOR TYPE						
			SS&I					
		AVE/SE	System Integration Role	Facilities/RPIE Design Criteria Role	Facilities A&E	Facilities Construction	A&CO	Hardness Surveillance Support
5.3.8.14	Hardness surveillance implementation.							
5.3.8.15	Hardness surveillance implementation support.							●
5.3.8.16	Hardness maintenance implementation.							

TABLE II. ICBM Hardness & Survivability Program Equipment Types and Scope of Requirements

Equipment Type	Develop?	Modified?	Commercial/ Military	ID	NH&S Test/Analysis and Documentation Requirements
CFE	DI			A	Meet performance during/after applicable Nuclear environments; Full NH&S Program/Tasks per Sections 5 3 & 5 4 (See Tables III and IV) Drawing HCI Annotations; T O HCP annotations Configuration Control with complete design disclosure drawing package Hardness Design Analysis/Test Hardness verification and qualification documented in DAR/HCI List (Before using commercial suppliers for subassemblies or parts, must be able to perform tasks of Sections 5 3 & 5 4 and must demonstrate to governments satisfaction that life-cycle cost of hardness while meeting all mission requirements using such items is the same or lower than using newly developed items)
CFE	NDI (Evaluate potential to meet all hard-ness req'ts early in pre-liminary design and change to DI if not adequate or if high risk of not meet-ing req'ts)	UNMODIFIED	Commercial (Often called COTS)	B	Commercial items used in ICBM systems must meet the system requirements even if not originally designed for hardness If it must be changed from its original design in order to meet system requirements, it is modified commercial (See "D" below) However, for ICBM use the system design can add shielding, isolation, and/or protection to allow its use without modification In addition, demonstrating inherent capability to meet requirements by test supplemented with analysis is also acceptable for such items In addition to meeting system requirements, NDI Unmodified COTS can only be used in HCI application if the following two tasks can accomplished: a Engineering drawings are provided which fully disclose design features/characteristics that result in the required hardness along with HCI/HCP identification , and b Cost-effective test and inspections are implemented to ensure future purchases of spares will be just as hard (i e , qualification & acceptance tests in the drawings)
CFE	NDI	UNMODIFIED	Military (from previous program)	C	Full NH&S Program of "A" above except may use previous program's documentation (e g , drawings and NH&S DAR or equivalent) to eliminate tasks that can be shown complete using such documentation as long as: a The documentation shows item meets the new program's requirements and b The item is obtained only from the approved sources documented in drawings and c Manufacturing processes for the new program are the same as the previous program, and d The government agrees that drawings and other documentation already comply with "A" above and are adequate for lifetime support or are updated to do so (includes DAR for HM) NOTE: "a" above means the item must have previous qualification test data and analysis that demonstrates it meets requirements If not, then either: i Perform added Test/Analysis and documentation update, or ii Can shielding or other attenuation be added to meet hardness? If yes, do "i" above with those additions (Added items require design disclosure, qualification, and documentation) If not, then the item must be changed to a developmental item or a modified item (it shall not be used as is) (If unmodified item as used in ICBMs is not completely interchangeable with the original item, a new ICBM unique part number is required)
CFE	Government must ensure that GFE meets all hard-ness req'ts before direct-ing its use by the program	MODIFIED[1]	Commercial Military (from previous program)	D	An ICBM unique part number is required for all modified equipment or the changes must be implemented backward compatible to the previous program(s) Contractor shall recommend, with rationale, (subject to SPO approval) whether the item should be (The basis for these recommendations shall emphasize minimized life-cycle cost while meeting mission requirements): 1) Treated as a developmental item (DI), with requirements per "A," above, OR 2) Tested to show greater capability than the previous program demonstrated which satisfies new program requirements, OR 3) Designated as changed a "small" amount as determined by the SPO NH&S OPR and with SPO System Chief Engineer's approval for both its use and for designation as a "small change item", THEN treat MODIFIED PORTIONS the same as "A" above and treat UNMODIFIED PORTIONS the same as the applicable one of "B" or "C" above
GFE		UNMODIFIED		E	Same as "C" above (Ensure GFE is included in Hardness Surveillance planning)
GFE		MODIFIED		F	Same as "D" above (Ensure GFE is included in Hardness Surveillance planning)
Facilities/ RPIE		The contractor shall implement all applicable hardness requirements in facilities/RPIE specifications, design, documentation, construction, procurement, assembly, and installation			
A&CO Installation Hardware		The contractor shall implement all applicable hardness requirements in A&CO installation hardware specifications, design, documentation, fabrication, procurement, assembly, and installation			
NOTE 1: Before modifying do one: 1) seek to use techniques of "B" to eliminate need for mod , 2) Find alternate that meets requirement w/o mod , or 3) use combination of 1) and 2) to eliminate need for modification					
CFE = Contractor Furnished Equipment; GFE = Government Furnished Equipment; DI = Developmental Item; NDI = Non-developmental Item; OPR = Office of Primary Responsibility; HM = Hardness Maintenance (supporting system until decommissioning)					

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TABLE III. Typical NH&S task applicability (AVE/SE contractor).

Hardware Category \ Life-cycle Phase*			Technology Maturation and Risk Reduction		EMD		Production and Deployment (2)
			SRR/SFR (1)	PDR (1)	CDR	FCA	
Category independent			5.3.1.2 5.3.2.2 5.3.2.3 5.3.3.1.1 5.3.3.1.2	5.3.8.1 5.3.8.2 5.3.8.11	5.3.5.2 5.3.6.1	5.3.3.3 5.3.7.2 5.3.7.3 5.3.8.3 5.3.8.5 5.3.8.6 5.3.8.13	5.3.1.2 5.3.8.10
CFE	Developmental Items		5.3.1.2.1 5.3.3.2.2 5.3.4.1 5.3.4.1.1 5.3.8.2 5.3.4.2	5.3.4.1.2 5.3.5.1	5.3.4.1.3 5.3.7.2 5.3.8.8 5.3.8.9	5.3.4.1.4 5.3.8.4 5.3.8.7	
CFE	NON-DEVELOPMENTAL ITEMS (NDI)	Unmodified (Commercial NDI or Military NDI) (GFE also)					
CFE	NON-DEVELOPMENTAL ITEMS (NDI)	Modified (Commercial NDI or Military NDI (GFE also)	5.3.1.2.1 5.3.3.2.2 5.3.4.1 5.3.4.1.1 5.3.4.1.2 5.3.8.2 5.3.4.2	5.3.5.1	5.3.4.1.3 5.3.7.2 5.3.8.8 5.3.8.9	5.3.4.1.4 5.3.8.4 5.3.8.7	

*The column where a task first appears is where a) the task begins (although not listed again, it often continues for several phases thereafter), or b) the review milestone by which the task must complete. The text and Appendix B more fully discuss and illustrate the applicability, the time sequencing, and the continuation throughout the program. Where cells are grey, only the category independent tasks apply (i.e., there are not tasks specific to that contractor type and not applicable to others.

TABLE IV. Typical NH&S task applicability (Other contractors).

Contractor Category \ Life-Cycle Phase (3)(4)		Technology Maturation and Risk Reduction		EMD		Production and Deployment (2)	Operations and Support
		SRR/SFR (1)	PDR (1)	CDR	FCA		
System Support & Integration Contractor	Systems Integration Role	5.3.1.2 5.3.2.2 5.3.2.3 5.3.3.1.2 5.3.4.2		5.3.3.3 5.3.6.1	5.3.7.2 5.3.8.5	5.3.6.2 5.3.7.3	
	Facilities/RPIE Design Criteria Role	5.3.1.2 5.3.2.3 5.3.3.1.2 5.3.3.2.1 5.3.3.2.2 5.3.4.1 5.3.4.1.1 5.3.4.2	5.3.3.2.3 5.3.4.1.2 5.3.8.11	5.3.3.2.3 5.3.4.1.3 5.3.5.1 5.3.6.1 5.3.8.1 5.3.8.8	5.3.4.1.4 5.3.5.1 5.3.7.2 5.3.8.13 5.3.8.1.1	5.3.7.3	
Facilities A&E Contractor		5.3.4.1 5.3.4.1.1 5.3.4.2	5.3.4.1.2 5.3.8.2	5.3.4.1.3	5.3.4.1.4		
Facilities Construction Contractor					5.3.8.9 5.3.8.10	(Facility must be completed before deployment of WSE)	
A&CO Contractor					5.3.1.2 5.3.8.5.1		
Hardness Surveillance Support Contractor							5.3.1.2 5.3.8.15

(1) When no separate Technology Maturation and Risk Reduction phase occurs, SRR/SFR and PDR tasks are part of EMD and the associated tasks are to be completed in very early EMD.
(2) Perform all applicable EMD tasks to support design changes that occur during production and deployment phase.
(3) Facility contracting, development, and construction are not formally tied to Weapon System program reviews/audits. The flow in these figures provides a schedule that leads to timely incorporation of NH&S requirements into facility design and construction.
(4) The column where a task first appears is where a) the task begins (although not listed again, it often continues for several phases thereafter), or b) the review milestone by which the task must complete. The text and Appendix B more fully discuss and illustrate the applicability, the time sequencing, and the continuation throughout the program.

5.3 NH&S program tasks. The contractor shall implement the NH&S program tasks described below in accordance with the tasking defined by the applicable contract. The hardness trade studies, analyses, and tests performed in support of accomplishing these tasks shall be implemented in accordance with the requirements of 5.4. The task descriptions provided below constitute a complete menu of NH&S program tasks and do not explicitly identify individual contractor responsibilities. The particular tasks that typically apply to a specific category of contractor are indicated by Table I, Table III, and able IV in terms of the contractor's role in the program, the life cycle phase(s) under contract, and the hardware categories utilized. (For information on tailoring of this standard, see 6.4).

5.3.1 NH&S program definition.

5.3.1.1 SPO NH&S program planning. The SPO will prepare an NH&S program plan that provides an overview of the entire NH&S program for the weapon system under consideration, including the planned system hardness test and analysis activity. This plan will identify and summarize the approach and schedule by which the SPO will implement this NH&S program. It will also identify the organizational entities involved with accomplishing its implementation and the respective responsibilities of each organization and required interfaces.

5.3.1.2 Contractor NH&S program planning. The contractor shall define an NH&S program that provides for the cost-effective and timely accomplishment of all applicable NH&S tasks (see 6.3). The contractor shall ensure that the NH&S program is a recognized engineering discipline with authority to influence and when appropriate, dictate design solution choices needed to ensure compliance with program nuclear environment performance specifications. The NH&S program shall be supported within the contractor's overall program with management, technical, and coordination efforts necessary to achieve each applicable task.

5.3.1.2.1 WSE nuclear environment/effect hardware element matrix (NEEHEM). Contractor NH&S personnel shall compile and maintain a current WSE NEEHEM in support of the contractor's ongoing hardness design development activity. This NEEHEM shall be used to identify:

a. the particular nuclear environments and effects for which a given hardware element will undergo hardness evaluation;

b. the status of each evaluation; and

c. references to applicable documentation.

Other useful information lending itself to display in this matrix format by code reference may also be included. An example NEEHEM is provided in Section 6 data items associated with the NH&S Design Analysis Report.

5.3.2 WSS hardness requirements.

5.3.2.1 SPO development of WSS hardness requirements. The SPO will define the nuclear weapon effects/environments (NWE) and, as deemed appropriate by the SPO, selected WSE hardness performance requirements for inclusion in the WSS. Such definition will be based on current threat scenarios from the threat environment definition (TED), the system threat assessment report (STAR), or other approved threat definition documents, and the system concept design. This activity may require trade studies (5.4) to assess the impact of parametric nuclear weapon environment levels on the cost, schedule, and technical risks associated with the system concept designs. The NH&S content of the WSS will be coordinated among the SPO's contractors, the SPO organization responsible for survivability of the operational system, the CBRN Survivability Oversight Group Nuclear (CSOG-N), the defense threat reduction agency (DTRA), and other government agencies, as appropriate.

5.3.2.2 Contractor support to development of WSS hardness requirements. The contractor shall support the activity to develop WSS hardness requirements by:

a. conducting system level trade studies (5.4) in support of system concept design development;

b. conducting system level hardness analyses;

c. planning and conducting a system level hardness test program; and

d. incorporating and maintaining the SPO approved WSS hardness requirements within the appropriate operational requirements analysis (ORA) documentation.

5.3.2.3 WSS hardness requirements allocations. The contractor shall conduct hardness trade studies, hardness analyses, and hardness tests, as appropriate, at a level of detail consistent with the concept design (see 6.3). The objective of this activity shall be to identify any areas of the concept design that are driven by the WSS hardness requirements such that requirement compliance is not attainable within the cost objectives/constraints of the Air Force or due to limiting technology constraints. When such areas exist, the contractor shall make recommendations to the SPO regarding revisions to the WSS or revisions to the planned allocations which will be reviewed for acceptance by the Air Force based on validity and appropriateness.

5.3.3 WSE hardness requirements.

5.3.3.1 AVE/SE hardness requirements.

5.3.3.1.1 Development of AVE/SE hardness requirements. The contractor shall conduct hardness trade studies (5.4.1), hardness analyses (5.4.2), and hardness tests (5.4.3), as appropriate, to develop and allocate hardness requirements from the WSS for the AVE/SE under contract and begin to conceive a design that will meet them. The hardness requirements shall be documented in the ORA, and allocated to each CI PIDS, as appropriate. At PDR, the results of these efforts are reported in the NH&S Program Plan and NH&S DAR (see 6.3 and NEEHEM in A.3.105).

5.3.3.1.2 Hardness interface control requirements. The contractor shall identify hardness interface control requirements associated with the AVE/SE under contract and shall document these requirements in interface control documents (ICDs), as appropriate. The contractor shall provide NH&S support to the interface control working group (ICWG). When identifying and documenting hardness interface control requirements for specific nuclear environments, the following considerations shall apply.

5.3.3.1.2.1 Electromagnetic pulse (EMP). The identification and documentation of EMP interface control requirements shall include, as applicable, the following considerations:

a. electromagnetic field mitigation levels provided by shielded enclosures or equipment structures;

b. conducted transient mitigation provided by EMP protection devices and circuitry; and

c. EMP conducted transients in the form of a Thévenin/Norton equivalent source, complete with time waveform and source impedance.

5.3.3.1.2.2 Nuclear radiation. The identification and documentation of nuclear radiation interface control requirements shall include, as applicable, the following considerations:

a. circumvention and recovery (C&R) trigger levels and timelines;

b. C&R status signals that are generated to be sent to other hardware items and C&R status signals provided to the system central control function from other hardware items with appropriate signal protocol to allow for orderly recovery of system functions to known states that result in as-designed system function that lead to mission completion; and

c. attenuation of the free field environment provided by inherent or dedicated shielding.

5.3.3.1.2.3 Mechanical (x-ray, thermal radiation, blast, shock, and debris). The identification and documentation of x-ray, thermal radiation, blast, shock, and debris interface control requirements shall include, as applicable, the following considerations:

a. transmitted shock and vibration in the form of shock response spectra or shock-induced motion time histories;

b. static and dynamic air pressure loads;

c. temperature or heat flux transients;

d. dynamic stress or load transients;

e. x-ray transmittance; and

f. sound pressure level spectra of acoustic noise generated by blast.

5.3.3.2 Facilities hardness requirements.

5.3.3.2.1 Development of facilities design criteria hardness requirements. The contractor shall conduct hardness trade studies, hardness analyses, and hardness tests, as appropriate, to develop hardness requirements from the WSS for the facilities/RPIE under contract (see 6.3). These hardness requirements shall be documented in the facilities design criteria document such that:

a. hardness requirements are expressed in standard civil engineering terminology; and

b. all facility interfaces with other WSE that have hardness related requirements, as identified by WSE contractors through their facility criteria input reports, are identified.

5.3.3.2.2 Support to development of facilities design criteria hardness requirements. The contractor shall support the activity to develop facilities design criteria hardness requirements by:

a. identifying facilities/RPIE hardness requirements and design features associated with installation of the WSEs under contract;

b. performing hardness analysis to express the applicable hardness design constraints in standard civil engineering terminology;

c. identifying the design and hardness requirements for any additional A&CO hardware between the WSE and the facility, as identified in the contractor's A&CO technical analysis (TA) activity;

d. communicating additional A&CO hardware hardness requirements to the facilities design criteria contractor via facility criteria inputs;

e. supporting facilities design criteria technical interchange meetings (TIMs); and

f. reviewing the facilities design criteria documentation.

5.3.3.2.3 Review of facilities drawings. The contractor shall review the incremental drawing submittals for the facilities in conjunction with the development of the facility criteria hardness requirements (see 5.3.3.2.1) to ensure that:

a. the hardness requirements in the facilities design criteria documentation have been fully developed and implemented in a way that is consistent with the AVE/SE (A.3.2/A.3.131) hardening approach and which the SS&I contractor can show the Air Force at design reviews will result in an integrated system (combination of the AVE/SE hardware housed within the applicable facilities) which meets hardness criteria;

b. the design is mature enough prior to FCA that all the hardness critical features are identified; and

c. the drawings have been hardness annotated IAW contract requirements.

5.3.3.3 A&CO installation hardware hardness requirements. The contractor shall identify all hardness requirements associated with A&CO installation hardware related to the WSEs under contract and shall document them in the contractor's A&CO technical analysis.

5.3.4 WSE hardness design.

5.3.4.1 Hardness design development. The contractor shall incorporate nuclear hardness into the design of the WSEs under contract by implementing an iterative and interactive process of selecting and evaluating different design approaches and solutions to meet all applicable hardness requirements. The selection and evaluation process shall be accomplished through hardness trade studies, hardness analyses, and hardness tests, as appropriate (see 6.3). During the design process, the contractor shall:

a. ensure the hardened WSE design does not violate other non-NH&S requirements;

b. integrate the hardness design features of the WSE with other contractors' hardness design features, where appropriate;

c. select designs that minimize the cost and complexity of hardness verification and hardness qualification; and

d. make every effort to optimize the design with respect to cost-effective implementation of LCH, including the ease with which tests and inspections in support of hardness assurance, maintenance, and surveillance can be implemented.

5.3.4.1.1 Concept design. The contractor shall develop a concept design for the WSEs under contract that reflects hardness design concepts consistent with the draft WSS. This concept design shall be used during the SRR/SFR to verify that the WSS is complete and correct with respect to the WSEs under contract.

5.3.4.1.2 Preliminary design. The contractor shall develop a preliminary design for the WSEs under contract that incorporates hardness features in sufficient detail to support hardness allocation and to identify hardness critical interfaces.

5.3.4.1.3 Detail design. The contractor shall develop a detail design for the WSEs under contract that satisfies all applicable hardness requirements. The contractor shall use the detail design as the basis for accomplishing hardness verification.

5.3.4.1.4 Final design. The contractor shall develop a final design for the WSEs under contract that satisfies all applicable hardness requirements. For CIs, the contractor shall use the final design as the basis for hardness qualification of the WSEs under contract. This design is formally approved at CDR as the one to be used for qualification. The contractor's verification work is documented in the NH&S DAR (see 6.3) at CDR to provide the confidence that the design is likely to meet the hardness requirements at qualification. If qualification efforts reveal a need for design changes, the contractor shall update the final design and retest and/or analyze to ensure hardness qualification is complete.

After the CDR final NH&S DAR version is accepted by the government, the DAR shall be maintained under configuration control, similar to engineering drawings, and shall be assigned a document number. Changes after CDR shall be made only after coordination with the government's configuration control authority for the program and approval by the contractor's configuration control authority.

Any post CDR design updates are captured in an update of the NH&S DAR at PCA (See A.3.120) which also includes the details and results of the qualification efforts. Because in most system designs some items will become obsolete during production, the contractor shall update the final design during the production phase to address the obsolescence. Earlier NH&S tasks shall be repeated for the new additions/changes to design in order to verify and qualify the new items and demonstrate continued compliance with hardness requirements. The final design along with the hardness activities associated with it will be documented in an update to the NH&S DAR (see 6.3) near the end of the production phase.

5.3.4.2 Considerations for specific NH&S disciplines. For all NH&S disciplines, hardness design implementation shall include consideration of the feasibility, ease, and cost-effectiveness with which hardness verification of the design selected can be accomplished. When implementing hardness design for specific NH&S disciplines, the following considerations shall apply.

5.3.4.2.1 EMP. EMP hardness design shall incorporate the design features of a complete, well-defined system/subsystem, shielding topology. EMP hardness design implementation shall include, as applicable, the following considerations:

a. implementation of designs that are compatible with those of other contractors, including continuation of system shielding topologies;

b. implementation of box and structural electromagnetic shielding hardware, including conductive gaskets, cover fasteners, and compatible metal surface treatments;

c. implementation of cable shielding, including circumferential termination of cable shields through appropriate cable connector and backshell hardware;

d. implementation of electrical protection devices, including specified packaging and mounting parameters relating to protection device performance;

e. implementation of interface circuits impervious to EMP conducted transients, such as fiber optic technologies;

f. implementation of software communication protocols to reject EMP-generated conducted transient noise on digital interfaces;

g. implementation of exterior conductive coatings;

h. implementation of electrical bonding and grounding;

i. implementation of low response cabling (i.e., filled cables);

j. implementation of low atomic number dielectric coatings on interior surfaces; and

k. implementation of a segregated power distribution system (i.e., mission critical loads segregated from non-mission critical loads).

5.3.4.2.2 Nuclear radiation. Nuclear radiation design shall include, as applicable, the following considerations:

a. use of fully characterized and qualified semiconductor devices from the program's approved parts list;

b. the application of device derating factors in worst case circuit analyses to allow for radiation-induced degradation of performance parameters;

c. use of preferred circuit, wiring, and grounding procedures;

d. use of nuclear event protection, including C&R, photocurrent compensation and current limiting techniques, as appropriate;

e. design prohibitions based on the known inadequacy of certain semiconductor technologies;

f. use of dedicated radiation shielding at the local, box, or subsystem level with all line of sight apertures covered (i.e., baffle shields or high atomic number loaded elastomer boots);

g. use of low atomic number dielectric coatings on AVE hardware internal surfaces to minimize x-ray induced currents;

h. use of nitrogen filled pressurized volumes on AVE hardware to minimize x-ray induced currents; and

i. introduction of new materials after characterizing their radiation response, particularly of composites and shielding materials that historically have not been used in missile systems.

5.3.4.2.3 Mechanical. Mechanical/structural design implementation shall include, as applicable, the following considerations:

a. appropriate use of material properties with consideration of any thermal degradation;

b. specified factors of safety;

c. appropriate techniques for environment mitigation, such as shock isolation and shielding;

d. loading resultant from interactions of one or more NWE at a system or subsystem level; and

e. combinations of various nuclear and operational environments and loads.

5.3.5 WSE hardness evaluation.

5.3.5.1 WSE hardness verification. The contractor shall accomplish hardness verification of the detail design through hardness analyses (5.4.2) and hardness tests (5.4.3) that support the assertion that the detail design satisfies all applicable hardness requirements. The hardness verification activity shall include the determination of design margins (DMs) for each nuclear hardness environment and effect. It shall also include hardness trade studies (as appropriate, see Section 5.4.1). The verification is documented in the NH&S Design Analysis Report (DAR) (see 6.3 relative to contract inputs needed for the NH&S DAR).

5.3.5.2 WSE hardness qualification. The contractor shall accomplish hardness qualification of the approved final design through hardness analyses (5.4.2) or qualification tests (5.4.3) that support the assertion that hardness qualification has been accomplished (see 6.3). For CIs, hardness qualification shall be accomplished through implementation of the quality conformance methodology identified in Section 4 of the controlling PIDS. The qualification is documented in the NH&S Design Analysis Report (DAR) (see 6.3 relative to contract inputs needed for the NH&S DAR).

5.3.6 System level hardness evaluation.

5.3.6.1 System level hardness testing and analysis. The contractor shall participate in the implementation of system level tests (5.4.3) and analyses (5.4.2) as specified in the TEMP (A.3.148) and perform testing when required by contract. During initial program phases, this shall include component testing needed gain confidence to proceed towards a finished design and eventual system level testing.

5.3.6.2 System level hardness verification. The contractor shall perform a system level hardness verification activity to establish that the integrated weapon system meets or exceeds WSS NWE requirements. As part of this activity, the contractor shall review and evaluate relevant existing data and perform necessary test and analyses that enable a comprehensive statement and demonstration of system level hardness with respect to the NWE requirements stated in the WSS. The effort begins with planning near SRR/SFR and PDR and progressively becomes more complete and detailed until, at CDR and Qualification, the system's hardness is demonstrated to be in full compliance with the WSS. The data items to be reviewed and evaluated for this purpose shall include:

a. applicable requirement allocation documents referenced in the ORA (A.3.116); these data shall be reviewed and evaluated in the light of the final system configuration to identify and quantify any inconsistencies;

b. WSE hardness verification documentation, including all applicable NH&S design analysis reports (DARs); and

c. system level testing and analysis results.

The system level hardness verification is documented in the system level NH&S DAR (see 6.3).

5.3.7 System level assessment.

5.3.7.1 SPO system level assessment. The SPO will perform an assessment of the production configuration of the integrated system, using inputs from the WSE contractors and the SS&I contractor. This assessment will be limited in scope to the controlling failure mechanisms identified by the contractors. The analyses and their results will be documented and provided to the operating command for use during the operations and support phase. The operating command will use this information to support system use planning activities by USSTRATCOM. The SPO will use the information for periodic assessment updates which will allow for prioritizing potential modification, upgrade, or replacement actions.

5.3.7.2 WSE level support to system level assessment. The contractor shall provide support to the SPO's system level assessment activity (see 6.3). Such support shall include:

a. initial identification and prioritizing of the controlling hardness failure mechanisms for the WSE(s) under contract, as determined from the WSE hardness verification and qualification activities;

b. evaluation of the effects of selected nuclear environments on selected WSE constituent hardware elements at levels above and below specification levels, as well as those resulting from alternate threats or new environment prediction methodologies defined by the SPO; the selection of the specific nuclear environments and hardware elements to be included in this activity shall be based on the data provided under item (a);

c. fragility testing;

d. fragility analysis consisting of the calculation of transfer functions and fragility curves for the selected nuclear environments and hardware elements evaluated under items (b) and (c), including an estimate of associated random and systematic uncertainties; and

e. support to TIMs with the SPO and other contractors.

5.3.7.3 System level support to system level assessment. The contractor shall provide support to the SPO's system level assessment activity with respect to hardness failure mechanisms resulting from system level effects that involve multiple WSEs and are beyond the scope of one WSE contractor (see 6.3). Such support shall consist of the tasks defined in 5.3.7.2, as applicable.

5.3.8 Life cycle hardness (LCH) tasks

This section describes the life cycle hardness (A.3.99) tasks that are performed in TMRR, EMD, and Production & Deployment phases which result in the necessary equipment and documentation to support the system throughout its life cycle (i.e., tasks in phases prior the operations & support phases that are necessary to preserve hardness during the operations & support phase).

5.3.8.1 HCI/HCP identification. During all phases of the program (after part numbers of specific items begin to be available), the contractor NH&S personnel shall review the design of all of the contractor's WSEs and their constituent elements to identify the HCIs and hardness critical processes/procedures (HCPs) contained therein. The HCI identification activity shall apply to existing as well as to newly designed hardware, and shall include consideration of all levels of hardware down to the detailed part level. If a contractor proposes to limit the assembly level at which HCIs/HCPs are identified at a level above the detailed part level (usually if an assembly is designated as non-repairable), government System Chief Engineer approval is required before such a decision is accepted. The decision to approve will consider whether, at some future date, repairs will need to be made down to the detailed part level. If so, then HCIs/HCPs identification is needed down to that level regardless of whether the contractor intends for maintenance to initially occur at higher levels of assembly.

When a NH&S DAR is required by contract (see 6.3):

1). The contractor NH&S personnel shall compile and continuously update the HCIs identified for each deliverable WSE (usually a CI) containing HCIs. The results of this effort are documented in the HCI List within the NH&S DAR (see 6.3). This list shall serve as the sole authoritative listing to be used in all contractor NH&S input to activities such as drawing preparation (5.3.8.2), LSA document annotation (5.3.8.3), TO preparation (5.3.8.4), and A&CO TA (5.3.8.5).

2). The contractor shall release each WSE NH&S DAR as a configuration controlled document sometime after PDR, but well before CDR and shall maintain it to reflect the most current status of HCI identification throughout the entire duration of the contractor's program. The contractor shall ensure that any changes, additions, or deletions to the NH&S DAR HCI List are approved by the contractor's cognizant NH&S personnel for the program. All additions of parts shall be considered in the HCI evaluation process.

3). The contractor shall ensure that a one-to-one correspondence exists between the content of the HCI list for a given WSE and all other HCI annotations (A.3.59) associated with that WSE. No other HCI lists shall be prepared or distributed.

5.3.8.1.1 System master HCI list and NH&S DAR library index. To support the operational system, the SPO will compile all HCI lists from the NH&S DARs into a single master HCI list that will be maintained and updated throughout the system life. The SPO will also maintain a

NH&S DAR Library Index which is a listing of NH&S DARs for the system. All changes and additions to drawings and part numbers for the operational system need to be captured and updates made to both the master HCI List and the applicable NH&S DARs as part of life-cycle hardness once the DAR is baselined (i.e., becomes a configuration controlled document shortly after PDR). The government may contract for these tasks to be completed periodically or on a continuous basis or perform them internally.

5.3.8.1.2 HCI application identification. For each HCI identified, the contractor shall also identify all next higher assemblies (NHA) of the HCI and all uses of the HCI part number within each NHA and distinguish which of these applications is/are hardness critical and which is/are not. Applications which are HCI are designated HCI-A. The designations are to be annotated in parts list of engineering drawings (see C.5.2.3) and documented in the NH&S DAR HCI Index (see 6.3)

5.3.8.2 NH&S support to drawing preparation. Contractor NH&S personnel shall:

a. identify the hardness related test and inspection requirements associated with each WSE under contract for incorporation, as appropriate, in the contractor's engineering drawings. These shall include both requirements for use during the production phase (usually hardness assurance acceptance requirements) and for use during the operational phase (usually both qualification requirements and hardness assurance acceptance). Where decisions are made to eliminate testing performed prior to CDR as part of the design proof, the contractor shall ensure that drawings contain requirements for such testing as part of the operations and support phase in order to support new contractor selection and qualification long after the conditions which made the elimination of such testing acceptable are no longer applicable;

b. provide direct support to the contractor's configuration management (CM) activity to hardness annotate the drawings and parts lists, assist in ensuring that the NH&S DAR HCI List is the sole source used to annotate drawings, and update the list as necessary so that all documentation is consistent;

c. coordinate with CM to ensure that a review of all such hardness annotations (A.3.59) verifies their completeness and correctness; and

d. ensure that these hardness annotations are incorporated, as appropriate, into other relevant production related documentation, such as quality assurance plans where such annotations are important for quality personnel to evaluate the hardness compliance aspects of hardness testing and inspection.

e. ensure that the drawing content reflects requirements that support both the production phase (where design margins developed during EMD phase are still applicable) and the operations and support phase (where design margin development during EMD phase are no longer applicable and thus any tests eliminated or performed with less frequency or with smaller sample sizes based on those design margins need to be reinstated (if eliminated) or to have frequency and sample size increased).

5.3.8.3 NH&S support to LSA preparation. Contractor NH&S personnel shall:

a. identify applicable hardness related test and inspection requirements for incorporation in the contractor's LSA;

b. provide direct support to the hardness annotation of LSA documentation; and

c. coordinate with LSA personnel to ensure that a review of all such hardness annotations verifies their completeness and correctness.

5.3.8.4 NH&S support to TO preparation. Contractor NH&S personnel shall:

a. identify applicable hardness related test and inspection requirements and HCPs for incorporation in the contractor's TOs;

b. provide direct support to the hardness annotation of the TOs; and

c. coordinate with TO personnel to ensure that a review of all such hardness annotations verifies their completeness and correctness.

5.3.8.5 NH&S support to A&CO TA preparation. Contractor NH&S personnel shall:

a. identify applicable hardness related test and inspection requirements for incorporation in the contractor's A&CO TA;

b. provide direct support to the hardness annotation of A&CO TA documentation; and

c. coordinate with A&CO personnel to ensure that a review of all such hardness annotations verifies their completeness and correctness.

5.3.8.5.1 LCH during A&CO implementation. The contractor shall:

a. incorporate the hardness content of the A&CO TA into all applicable aspects of the A&CO implementation activity;

b. identify any additional HCIs and HCPs associated with A&CO installation hardware in the A&CO NH&S DAR;

c. hardness annotate A&CO implementation documentation, including drawings and procedural documentation (see 6.3);

d. define, plan, and implement a hardness assurance program (see 6.3); and

e. hardness annotate the as-built drawings that will be used by the operating command and the SPO for life-cycle hardness support.

5.3.8.6 Hardness maintenance planning & preparation. The contractor shall identify the hardness maintenance preparation activities that will result in the submittal to the SPO of the hardness information and documentation required during the operations and support phase to implement a hardness maintenance program throughout the system life cycle for the WSEs for which the contractor is responsible. The HM plan preparation is documented in the NH&S Program Plan (see 6.3). The hardness maintenance preparation support activity shall include:

a. HCI/HCP identification per 5.3.8.1 with the appropriate updates at CDR, FCA and near production finish;

b. the inclusion of hardness related test and inspection requirements in, and the hardness annotation of drawings and associated parts lists per 5.3.8.2, LSA and A&CO TA documentation per 5.3.8.3, and TOs per 5.3.8.4 in order to allow the SPO to procure spares and perform repairs and other maintenance during the operations and support phase; and

c. reporting the details of the hardness design (5.3.4.1) and the hardness evaluation, testing and analyses, verification, and qualification (5.3.5).

The contractor's responsibilities in the hardness maintenance plan shall be implemented by the contractor as the hardness maintenance preparation activity during the production phase.

5.3.8.7 Factory support equipment (FSE)/depot support equipment (DSE) hardness requirements. The contractor shall, to the maximum practical extent incorporate in the design of DSE and FSE a capability to evaluate hardness related characteristics of the WSEs under contract. Contractor NH&S personnel shall provide direct support to this activity and shall have the lead responsibility to:

a. identify the hardness related characteristics of the contractor's design that can be evaluated by means of FSE/DSE; and

b. maximize the extent to which the contractor's design originally provides for the opportunity to verify WSE hardness by means of FSE/DSE.

5.3.8.8 Hardness assurance planning. The contractor shall plan a hardness assurance program to assure the preservation of the hardness provided for in the design of the WSEs under contract throughout production, and as applicable, during system deployment (see 6.3). Planning shall include definition of all managerial, organizational, and technical elements of the program, including hardness assurance test and inspection requirements, and the identification of the procedural, documentation, and interface activities required of existing contractor control disciplines in support of hardness assurance. Planning for hardness assurance testing shall include, to the extent feasible and cost-effective, consideration of the possibilities for the acquisition of baseline data in support of hardness surveillance.

5.3.8.9 Hardness assurance resource definition and acquisition. The contractor shall identify and acquire all the hardware and software resources required to implement the approved hardness assurance program. In addition, all hardness assurance test procedures and equipment shall be validated prior to their initial use.

5.3.8.10 Hardness assurance implementation. The contractor shall implement the approved hardness assurance plan.

5.3.8.11 WSE hardness surveillance planning. The contractor shall plan for a hardness surveillance program that encompasses the hardness surveillance activities appropriate to the WSEs for which the contractor is responsible during design and development. During the activity to identify potential hardness degradation modes and candidate tests and inspections to detect such degradations, the contractor shall:

a. utilize all relevant information from the failure mode analysis (FMA) performed in accordance with ICBM-HDBK-01; and

b. consider the possibilities for incorporating or coordinating candidate hardness surveillance tests and inspections with routine repair and maintenance activities and planned or existing aging surveillance programs.

The planning and analysis are documented in the NH&S Program plan (HS planning section) and the findings of potential degrade modes and candidate tests and inspections as well as those from (a) and (b) above are reported in the NH&S DAR (see 6.3).

During design, the contractor shall envision methods and develop design concepts that will allow and/or facilitate testing without removing the system hardness protection (e.g., access points inside a drawer to measure EMP induced transients without having to open the drawer but also without adding a vulnerability)

5.3.8.12 SPO system hardness surveillance preparation planning. Subsequent to the receipt of all contractor hardness surveillance plans, the SPO will review the recommendations made and define a single, integrated hardness surveillance plan for the entire weapon system. This system level plan:

a. may or may not include specific recommendations submitted by a contractor; and

b. will be used to define system level hardness surveillance implementation activities during the operations and support phase.

5.3.8.13 Hardness surveillance preparation support. The contractor shall support the hardness surveillance preparation planning. Such support shall consist of the identification and acquisition of the resources necessary to implement those aspects of the integrated weapon system hardness surveillance program defined by the SPO that involve hardware elements for which the contractor is responsible.

The contractor shall identify and prepare to transition equipment (used during design proof testing or during production) which is also needed to perform surveillance to the government for implementation of hardness surveillance. Alternatively, if the equipment will be unavailable when needed for hardness surveillance, then the contractor shall build and provide another set of the equipment (when required by contract).

5.3.8.14 Hardness surveillance implementation. The SPO will implement the integrated weapon system hardness surveillance program at periodic intervals throughout the operations and support phase. The hardness surveillance program will begin within one year of initial system deployment.

5.3.8.15 Hardness surveillance implementation support. The contractor shall provide support to the implementation of the weapon system hardness surveillance program.

5.3.8.16 Hardness maintenance implementation. The SPO will implement a weapon system hardness maintenance program to continue throughout the remainder of the weapon system's life cycle.

5.4 Hardness trade study, analysis, and test requirements. The hardness trade studies, analyses, and tests performed in support of accomplishing the NH&S program tasks defined in 5.3 shall be implemented in accordance with the following requirements.

5.4.1 Hardness trade studies.

Hardness trade studies shall include, as applicable, the following considerations:

a. alternative allocations of hardness requirements among different levels of hardware assembly;

b. the possible reduction or elimination of selected hardness requirements through modification of operational requirements and procedures;

c. utilization of hardware items and technologies that are inherently hard to the specified NWE;

d. alternative approaches to accomplishing a hardened design;

e. associated cost-effectiveness of accomplishing the verification, by analysis and test, of the adequacy of the hardened design;

f. associated cost-effectiveness of LCH implementation;

g. the impact of the NH&S design on performance and operational requirements and other defined program constraints unrelated to hardness requirements (i.e., does NH&S cause a need for changes to other system requirements and constraints, even when those requirements/constraints are not specifically to harden the system, and if so, define those needed changes);

h. the impact of performance and operational requirements and other defined program constraints unrelated to hardness requirements on NH&S design (i.e., do other system requirements and constraints cause a need for changes to the hardness design, even when those requirements/constraints are not specifically to harden the system, and if so, define the needed changes); and

i. maximization of the use of common design solutions and hardware items.

When conducting hardness design trade studies for specific nuclear environments, the considerations for each nuclear environment listed in the following sections shall apply.

5.4.1.1 EMP. Electromagnetic pulse trade studies shall include, as applicable, the following considerations:

a. box, rack, structural, and cable electromagnetic shielding;

b. conductive coatings on exterior surfaces;

c. electrical bonding and grounding;

d. EMP protection devices and circuitry, including electrical surge arrestors (ESAs), circuit breakers, diodes, and filtering;

e. low response cabling;

f. low atomic number dielectric coatings;

g. utilization of hardware items and technologies that are inherently hard to the specified EMP requirements;

h. segregation of mission critical and non-mission critical power distribution;

i. interface compatibility with the designs of other contractors, including continuation of system shielding topologies; and

j. utilization of software communication protocols that reject EMP generated conducted transient noise on digital interface circuits.

5.4.1.2 Nuclear radiation. Nuclear radiation hardness trade studies shall include, as applicable, the following considerations:

a. use of dedicated radiation shielding at the local, box, or subsystem level with all line of sight apertures covered (i.e., baffle shields or high atomic number loaded elastomer boots);

b. C&R mechanization;

c. special design features for electronic parts and circuits;

d. inclusion of nuclear radiation-related design margin allowance in the design or specification of electronic parts and circuits;

e. use of low atomic number dielectric coatings on AVE hardware internal surfaces to minimize x-ray induced currents; and

f. use of nitrogen filled pressurized volumes on AVE hardware to minimize x-ray induced currents.

5.4.1.3 Thermal radiation. Thermal radiation hardness trade studies shall include, as applicable, the following considerations:

a. dependence on material ablation versus material heating for the absorption of thermal energy;

b. material property degradation versus heat loading;

c. environmental control system (ECS) sizing versus heat absorption requirements;

d. use of line-of-sight shielding for critical components; and

e. difficulty of external protection material (EPM) manufacture and application versus performance.

5.4.1.4 Blast. Blast hardness trade studies shall include, as applicable, the following considerations:

a. missile in-flight structural and shock loadings as a function of both local and whole missile response airblast loadings in combination with operational flight loads and consideration of thermal radiation induced heating and resultant material properties degradation and thermal stress;

b. effects of in-flight blast wave interaction on missile accuracy and controllability;

c. facility structural protection versus in-place blast and shock hardness;

d. rigid (linear) versus crushable or deformable elasto-plastic (nonlinear) components;

e. vulnerability of subsystems and components inside the protective structure to both the pressure loadings arising from leakage and the blast induced motion; and

f. effects of airblast induced acoustic noise on equipment and personnel.

5.4.1.5 Shock. Ground shock hardness trade studies shall include, as applicable, the following considerations:

a. sensitivity of design parameters to uncertainties in the ground motion and structure-media interaction (SMI) loading environments;

b. alternative basing locations to best utilize beneficial geology for shock mitigation;

c. alternative structure and shock isolation concepts with respect to such factors as rattlespace, missile equipment, structure and isolation performance requirements, constructibility, ease of maintenance and resistance to environmental degradation;

d. dual purpose (transportation and nuclear shock) isolation systems for mobile launchers; and

e. alternative designs to accommodate relative motions between supporting elements, such as antennas and communication lines, and main structures, such as a missile silo.

5.4.1.6 Debris. Debris hardness trade studies shall include, as applicable, the following considerations:

a. design parameters related to the mitigation of effects caused by impacting particles;

b. ability to operate through the debris environments;

c. ability of launch egress systems to perform missile egress and launch functions through the debris environments;

d. requirements for operation of command, control, and communication through the debris environments;

e. cost of AVE and equipment hardening versus debris fall-in prevention measures for silos;

f. rigid (linear) versus elasto-plastic (nonlinear) deformable components;

g. utilization of a single layer versus multilayer external protection material (EPM);

h. difficulty of EPM manufacture and application versus performance;

i. weight added due to use of EPM versus debris protection required; and

j. effects of dust/debris loading on environmental control systems, including radioactive effects.

5.4.2 Hardness analysis. Hardness analyses shall include, as applicable, the following considerations:

a. hardness allocation analysis shall utilize conservative NWE coupling assumptions in such a manner as to achieve a cost-effective compromise between minimizing the need for complex coupling models and precluding the circumstance that the resulting hardness requirements unreasonably drive hardware design;

b. hardness design analysis shall utilize the least complex analysis method available that accomplishes the goals of the analysis, and shall rely to the fullest extent possible on existing hardware performance data;

c. in cases where hardware performance data required in support of an analysis is not available, limited testing shall be performed to acquire the needed data;

d. implementation of system level hardness analysis may require progressively more complex analysis techniques to support the determination of fragility curves and transfer functions; and

e. during implementation of hardness analysis, consideration shall be given to the possibility of NWE synergistic effects that result in a given hardware element being more susceptible to other concurrent or subsequent NWE exposures as a consequence of some initial NWE exposure.

When defining hardness analyses for specific nuclear environments, the considerations for each nuclear environment listed in the following sections shall apply.

5.4.2.1 EMP. Electromagnetic pulse hardness analysis shall include, as applicable, the following considerations:

a. detailed shielding topology definition and incorporation of actual, verified EMP hardness design features;

b. utilization of hardness analysis approaches and techniques appropriate to the particular type of EMP environment and the WSE under consideration;

c. the need for coupling analysis to transform the specified EMP environments into EMP circuit drivers appropriate for circuit response analysis; and

d. awareness that EMP coupling is system design dependent, and the associated need to have EMP circuit drivers reflect overall system response, where appropriate.

5.4.2.2 Nuclear radiation. Nuclear radiation hardness analysis shall include, as applicable, the following considerations:

a. utilization of the analysis activity to support identification of piece part acceptance test requirements, including transient response and post-radiation acceptance criteria;

b. utilization of parts parameter data that have been derated (i.e., part application parameters have been adjusted to allow for radiation response/degrade and other relevant factors such as aging, temperature, etc.);

c. nuclear event protection (NEP), including C&R consistent with circuit recovery time requirements, photocurrent compensation, and current limiting;

d. the determination, for those WSEs employing C&R, of the existence and magnitude of any vulnerability resulting from detector shadowing by other elements of the system;

e. subsystem/system errors resulting from the specified single and multiple events, for both pre-flight and flight conditions;

f. shielding analyses to determine the radiation levels incident on internal components and materials;

g. evaluation of mechanical responses to the nuclear radiation environment, including bulk heating and thermomechanical effects and induced gross vehicle motion (vehicle motion refers to both the missile and re-entry vehicles in endo- and exo-atmospheric flight);

h. evaluation of radiological effects due to nuclear radiation-related energy deposition, particularly in personnel and ordnance; and

i. experimental activity to provide additional supporting data for the analysis activity, such as equation of state data, mechanical loading data, and component response data.

5.4.2.3 Thermal radiation. Thermal radiation hardness analysis shall include, as applicable, the following considerations:

a. material characteristics, such as thermal absorption and reflection, material ablation, conduction of heat, and thermally induced materials properties changes;

b. temperature time-histories at various locations, including bond lines, internal components, and structural attachments;

c. material recession time-histories caused by ablation, charring, and melting;

d. transmission of thermal radiation through transparent materials;

e. effects of aerodynamic flow, surface conditions, chemical reactions, and surface erosion on heat transfer at surfaces;

f. contact resistance in calculating heat transfer between materials;

g. appropriateness of two or three dimensional effects in complicated structures;

h. thermal studies to address temperature transients due to hot gas leakage;

i. prevention of sustained combustion during or after exposure to pre-flight or flight nuclear environments when combustible materials are used as missile skin materials; and

j. combined environment effects, such as blast and dynamic or static loading either preceding, during, or following exposure to the thermal environment.

5.4.2.4 Blast. Blast hardness analysis shall include, as applicable, the following considerations:

a. combining normal operation loads with blast-induced loads;

b. combining both the shock diffraction and drag loading associated with the passage of blast waves over a structure;

c. both side-on shocks and a traveling-wave loads due to blast wave interaction;

d. overpressure and acoustic environments of internal components;

e. response of a vehicle guidance system to blast-induced loads and accelerations;

f. interaction of shocks due to a blast and the shock produced by supersonic motion of the missile;

g. combined environment effects; and

h. structure-borne acoustic environments generated by flow field around structure.

5.4.2.5 Shock. Shock hardness analysis shall include, as applicable, the following considerations:

a. degraded or enhanced material properties caused by aging and environmental effects;

b. multi-degree of freedom rigid body finite element models that include coupling between translational, rotational and flexible modes, nonlinear constitutive relations for the isolators (including strain rate effects on isolator performance), isolator dead band friction, foam, liquid spring and hydro-pneumatic models of shock isolation systems;

c. nonlinear constitutive properties of the free-field, back-fill, structural material, and soil/structure interface behavior for representative siting geologies when performing SMI analysis;

d. material property degradation under multi-path loading; and

e. propagation of high frequency vibration environment through to critical electronic components.

5.4.2.6 Debris. Debris hardness analysis shall include, as applicable, the following considerations:

a. for impacting debris, material stress wave response and the overall structural response;

b. command, control and communication through the static debris, and debris removal during preparations for missile system launch;

c. effects of pebbles, dust, and ice on the in-flight system, including penetration, erosion, gouging, spall kinetic energy deposition, convective heating augmentation, chemical reactions of reactive surface materials, and surface roughening; and

d. command, control and communication through the airborne dust cloud.

5.4.3 Hardness testing. The purpose of hardness testing is to support requirements development, design development, hardness evaluation, and hardness assessment activities. In addition to pretest prediction analysis, planning for hardness testing shall include consideration of:

a. differences between the simulated environment and the specified nuclear environment, and, for multiple burst environments, pretest conditioning of the test article;

b. interactions between the item under test and the test fixture or test instrumentation;

c. instrumentation response to the test environment and means for eliminating spurious responses;

d. inaccuracies resulting from instrumentation limitations; and

e. combined nuclear environment testing, where feasible.

Analysis may be used to interpolate or extrapolate measured responses to compensate for lack of simulation fidelity. When establishing requirements for testing, full use shall be made of existing relevant data from other programs and tests, and careful consideration shall be given to the use of such data in lieu of conducting additional tests. When the modeling uncertainties associated with planned hardness analysis activities are large with respect to anticipated hardness DMs, hardness testing shall be considered for the purpose of either reducing the modeling uncertainties or replacing the hardness analysis activity, in whole or in part. When defining hardness testing for specific nuclear environments, the considerations for each nuclear environment listed in the following sections shall apply.

5.4.3.1 EMP. Electromagnetic pulse testing shall include, as applicable, the following considerations:

a. component failure level testing to determine the thermal and voltage breakdown characteristics of components identified in the EMP design analysis as being susceptible to EMP damage;

b. EMP protection device testing to verify the adequacy of the devices selected for their intended application in the design;

c. current injection testing to determine EMP upset and damage thresholds of circuit assemblies, boxes, and subsystems for specified wave forms;

d. electromagnetic shield testing to determine the shielding effectiveness and transfer impedance of grounding structures, electronic racks, boxes, cable shields, and connectors; of particular importance are the connector to connector backshell transfer impedance and the connector backshell to cable shield joints transfer impedance;

e. radiation testing to characterize the SGEMP response of circuit assemblies, boxes, subsystems, and system; it is particularly important to characterize the SGEMP response of electrical cables and connectors by this type of testing; radiation testing may include tests at pulsed radiation facilities and underground tests (UGT);

f. free-field testing to characterize the response of circuit assemblies, boxes, subsystems, and systems to specified electromagnetic radiation; and

g. logic upset testing to determine upset modes and thresholds of software systems to EMP-induced transients.

5.4.3.2 Nuclear radiation. Nuclear radiation testing shall include, as applicable, the following considerations:

a. selection of radiation test facilities that best simulate the specified radiation environment with respect to radiation level, spectrum, and the distribution of radiation over the test article volume;

b. electronic parts radiation effects testing to determine the radiation response of selected piece parts, such as semiconductor devices, capacitors, and crystals, to selected simulations of nuclear radiation environments; testing shall be conducted to obtain all relevant response characteristics;

c. circuit radiation effects testing to determine the responses of selected breadboard circuit designs to selected simulations of nuclear radiation environments; selection of circuits for testing should be based upon known or suspected criticalities, circuit analysis response predictions, and circuit complexity;

d. subsystem/WSE radiation effects testing to determine the responses of selected subsystems/WSEs to selected simulations of nuclear radiation environments; selection of subsystems/

WSEs for testing should be based on known or suspected criticalities, subsystem/WSE analysis response predictions, and design complexity;

e. mechanical radiation effects testing to provide additional supporting data for the analysis activity and to establish susceptible component response; and

f. radiation test levels shall be increased to compensate for uncertainties in dosimetry and parameter annealing.

The definition of nuclear radiation qualification and acceptance test frequency and sample size requirements for semiconductor devices shall include consideration of device DM (see A.3.27). Appendix E provides clarification on establishing adequate DM.

5.4.3.3 Thermal radiation. Thermal radiation testing shall include, as applicable, the following considerations:

a. incorporation of all significant phenomena, such as thermal radiation flux, fluence and spectrum, and external air flow conditions;

b. material properties such as density, specific heat, conductivity, emissivity, heats of phase change, and chemical reaction characteristics; and

c. instrumentation to measure all phenomena of interest, such as temperatures at various locations; depth of material ablated, charred, melted, or otherwise damaged; and transmission of radiation.

5.4.3.4 Blast. Blast testing shall include, as applicable, the following considerations:

a. incorporation of all significant phenomena, such as the magnitude, shape, duration, and impulse of the blast wave, as well as the capability to provide validated simulation of nuclear loads imposed on normal operating loads;

b. test configurations scaled to the actual system/subsystem configuration;

c. important material properties, such as stress-strain properties;

d. instrumentation to measure all phenomena of interest, such as pressures, accelerations, stresses, and strains, in addition to noting damage characteristics or failure levels; and

e. gravity enhancement mechanism in scale testing to simulate the inertial resistance to airblast loads.

5.4.3.5 Shock. Shock testing shall include, as applicable, the following considerations:

a. piece part, component, subsystem, and system testing to determine shock response and hardness levels;

b. component and transfer function inputs from connecting structure responses;

c. material stress wave propagation and failure levels;

d. time phasing between different components of the shock environment;

e. electromechanical/software-hardware response;

f. reinforced concrete mechanical properties;

g. structure/soil interface friction properties;

h. use of shock loops and features to address hydraulic surge effects in hoses when hoses are a part of the design;

i. facility penetration failures from structure/soil relative motion; and

j. subsystem/component failure from rattlespace depletion or other shock isolation system failures.

5.4.3.6 Debris. Debris testing shall include, as applicable, the following considerations:

a. impacting debris tests;

b. operational erection tests through static debris;

c. debris, pebble, dust, and ice testing to obtain response data for material erosion rates, particle penetration depths, impact response and ignition levels of combustible materials in erosive environments;

d. matching of test article material properties to system material properties; and

e. provision of instrumentation to measure all phenomena of interest.

5.5 System sustainment program for hardness assurance, maintenance, and surveillance (HAMS). The HAMS program is the effort to maintain the system in its fielded hardness state throughout its lifetime. This section provides a high-level overview of the program, which when combined with Appendix B, discusses and illustrates what needs to be done. The language in this section assumes that the government will perform these functions. However, the government may decide to contract for any or all of the tasks and if this is the case, then the phrase, "the SPO will," needs to be changed to "the contractor shall" in the appropriate contractual documents.

5.5.1 Maintain weapon system specification and lower level hardness requirements. For various reasons (e.g., threat changes, new mission needs) the WSS may need to be updated and the SPO will monitor such needs and update the WSS and the documents at lower levels, such as PIDS or engineering drawings, to reflect those changes in requirements. These changes are documented in Specification Change Notice documentation in accordance with SPO configuration management practices.

5.5.1.1 Evaluate NH&S impact(s) of changes in requirements. The SPO will evaluate any proposed changes and ensure that with those changes, the system will continue to meet its hardness requirements.

5.5.1.2 Allocate NH&S requirements. New or changed requirements must be imposed on the appropriate hardware and the SPO will ensure that the requirements are allocated to the appropriate hardware at the appropriate hardware assembly level by updating appropriate specifications (e.g., PIDS), lower tier requirements documents, and/or drawings. The SPO will ensure that such changes do not negatively impact the system's ability to perform its required mission.

5.5.1.3 Define new NH&S requirements. The SPO will define new hardness requirements in coordination with the system user stakeholders when driven by new technology needs, new or changed mission needs, and/or new or changed system threats.

5.5.2 Perform hardness assurance (HA) for system sustainment. All purchase of replacement spares or system modifications requires actions to ensure that system hardness is preserved. This section discusses the key tasks.

5.5.2.1 Review technical data packages for adequacy during spares procurement. The technical data package is the engineering drawings and other documentation assembled by the government and provided to a contractor which defines the item to be manufactured and/or purchased. It defines the tests and inspections needed to ensure that the item will meet its hardness requirements. Ideally drawings and other documentation would contain all the necessary requirements from the initial design, qualification, and acceptance. However, experience has shown that many technical data packages either become obsolete or outdated or otherwise inadequate for new procurement. The SPO performs a thorough technical review before each procurement to ensure the hardness requirements in the technical data package are complete. This includes review of the HCI design features and the details of how the item was originally demonstrated to meet its hardness requirements.

5.5.2.2 Perform hardness assurance (HA) test and/or inspections and/or analysis on spares. When testing or inspections are the means to achieving hardness, newly procured hardware are tested and/or inspected by the SPO or its designee with supplemental analysis that ensures hardness requirements are met.

5.5.2.3 Qualify new suppliers to meet hardness requirements. When the supplier of the original item no longer choses to supply the item (or for other government purposes new suppliers are deemed necessary), the SPO takes the necessary steps to qualify a new supplier and to update the documentation to show the supplier is approved for hardness critical items.

5.5.2.4 Perform HAMS efforts for system modifications. For modification programs, many or all of the tasks in section 5.3 and 5.4 are necessary and will be implemented by the SPO.

5.5.3 Perform hardness maintenance for system sustainment. Maintenance actions can degrade hardness either through inadvertent actions or through substitutions or replacement parts. Specific hardness actions necessary to avoid such degrades are discussed in this section. The SPO will implement a hardness maintenance program with the following elements:

5.5.3.1 NH&S review of technical order (TO) changes. The SPO reviews all updates and changes to TOs for impacts to hardness and for HCP identification consistent with the definition A.3.67 and the instructions of C.5.2.4). The emphasis is on no unauthorized parts substitutions, no actions that inadvertently degrade hardness, and on HCP identification.

5.5.3.2 Provide hardness awareness training. All personnel need awareness of how their actions can lead to hardness degradation. The SPO will provide training materials and present them (or designate presenters) to engineers, program managers, equipment specialists, item managers, and maintenance personnel, both within the SPO and in the various system support organizations that make decisions that can affect hardness.

5.5.3.3 Maintain master HCI list. The SPO will maintain a master HCI list that contains all HCI part numbers with the accompanying Figure A (A.3.43) or CI (A.3.20) number(s) along with other information related to supply (cataloging data) and configuration data that allow for item identification as HCI and cross-referencing to substitutes and other evaluations performed during operations and support phase.

5.5.3.4 NH&S review of shop maintenance procedures. When TO data do not address a particular repair need, special procedures and/or forms are prepared to address the repair. The SPO will review all such procedures to ensure they do not impact system hardness.

5.5.3.5 NH&S review of drawing changes (engineering orders, EOs). All changes to engineering drawings are accomplished by Engineering Orders (EOs). The SPO reviews all EOs for hardness impacts and ensure no degrades will be caused by the changes or suggests alternatives that will meet the need for change and preserve hardness.

5.5.3.6 Maintain NH&S DAR and HDM library. The SPO will maintain and continuously update the NH&S DAR and HDM library with changes to the system that occur through modification programs, updates requested by vendor(s), and engineering orders. All documents in the library will be maintained under configuration control and the updates shall be in accordance with SPO configuration management practices.

5.5.4 Perform hardness surveillance (HS) for system sustainment. The SPO will implement the hardness surveillance plan prepared during the EMD program phase, with additions, corrections, and other changes it deems appropriate to monitor the system for hardness degradations and prevent negative impacts if detected with enough lead time to allow for corrections. The SPO will perform periodic hardness surveillance throughout the weapon system's operational life.

The SPO will perform surveillance testing using well-documented testing requirements. This testing will be performed as dictated by the testing documents and/or as otherwise authorized by the SPO. All test data acquired are to be evaluated to verify on-going compliance with the specific part/assembly/system requirement(s). This may be done either through direct application of the environment or extrapolation/interpolation of test data. Surveillance testing frequency must be sufficient to allow for early detection (where possible) of decreased hardness margins, while not overwhelming normal missile operations and not requiring excessive use of system assets in destructive testing.

5.5.4.1 Detect degradation (monitor hardness margins). Hardness surveillance testing may identify system issues that are considered a degrade to hardness. The SPO will review all HS anomalies and findings and make a determination about their impact to hardness. The SPO will determine if any impacts cause an unacceptable degrade and reduce hardness margin to an unacceptable level.

5.5.5 Perform system survivability assessment. When hardness degrades occur, these may or may not result in an impact to system survivability. A survivability assessment determines the magnitude of the impact and thus provides decision makers with the information needed to accept the risk or direct that a correction be made and what that correction should be. The SPO will perform system level assessments as requested by the operating command responsible for survivability assessments of the operational system.

5.5.5.1 Survivability impact evaluation. When hardness degrades are determined to be unacceptable, the SPO will assess the survivability impact.

5.5.5.2 Perform trade studies of mitigation alternatives. If the survivability impact is found to be unacceptably large, then the SPO performs trade studies to identify alternatives to correct the impact.

5.5.5.3 Identify system hardness risks and plan mitigation (risk management). The SPO identifies areas where potential hardness degrades can occur and uses risk management to make plans of how the risk can be mitigated and assign priorities with respect to which risks will be allocated resources for mitigation.

5.5.6 Maintain test facilities and/or monitor test facilities at outside agencies. The SPO maintains the test facilities needed for hardness testing of replacement parts and equipment or monitors facilities maintained by other organizations to ensure that the necessary tests can be accomplished without unnecessary delay to allow for on-going system support. Without these facilities, spares could not be procured and new equipment could not be qualified.

6. NOTE. This section is not mandatory but contains information of a general or explanatory nature that may be helpful.

6.1 Intended use. This standard is to be used in the acquisition of ICBM weapon system hardware elements whose specifications include nuclear hardness performance requirements.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this standard or require compliance with the latest revision in effect on the date of contract award.

In addition, the contractor work statement (Statement of Work, Statement of Objectives, or other document that dictates contract required tasking) needs to call out compliance with the specific paragraphs that apply to that particular contract. All of this standard will never apply to a single contractor and several paragraphs define government tasking so it is incumbent upon the government to tailor the details of the contractor's requirements so they impose only the specific portions of this standard which apply to each contract.

6.3 Associated Data Item Descriptions (DIDs). This standard has been assigned an Acquisition Management Systems Control (AMSC) number authorizing it as the source document for the following DIDs. When it is necessary to obtain the data, the applicable DIDs must be listed on the Contract Data Requirements List (DD Form 1423).

DID Number	DID Title
DI-ENVR-80266A	Nuclear Hardness and Survivability Design Analysis Report
DI-ENVR-82096	Hardness Data Manual (HDM) Update
DI-ENVR-82097	Nuclear Hardness & Survivability (NH&S) Program Plan

These additional DIDs are to be used for ICBM programs:

DID Number	DID Title
DI-MISC-80508B	Technical Report - Studies/Services
DI-NDTI-80566A	Test Plan
DI-NDTI-80809B	Test/Inspection Reports

The above DIDs were current as of the date of this standard. The ASSIST database should be researched at http://quicksearch.dla.mil to ensure that only current and approved DIDs are cited on Form 1423.

6.4 Tailoring information for contractual application. Since the text of this standard provides a complete definition of the technical content of a comprehensive NH&S program for a major weapon system, the tailoring of this standard for application to a specific contract requires careful attention to the following particulars of program status and contractor involvement:

a. the program role performed by the contractor;

b. the system life cycle phase(s) under contract; and

c. the categories of hardware utilized by the contractor, as applicable.

In addition, other considerations related to specific NH&S tasks and program circumstances can affect both tailoring implementation and proposal evaluation. For these reasons, this paragraph provides information regarding these matters based on previous program experience. 6.4.1 addresses a variety of special circumstances that affect tailoring and proposal evaluation, while 6.4.2 contains explicit tailoring instructions with respect to the three parameters listed above. The format of 6.4.2 has been designed to facilitate insertion of applicable portions into the statement of work (SOW) under consideration.

6.4.1 Special considerations affecting tailoring and proposal evaluation.

6.4.1.1 Tailoring information for the System requirements review/system functional review (SRR/SFR). Paragraphs 5.3.1.2, 5.3.2.3, 5.3.3.2.2, and 5.3.4.1.1 are the AVE/SE contractor's tasks to accomplish the work needed to support SRR/SFR. For programs that conduct a formal technology maturation and risk reduction phase and thus an SRR/SFR, these tasks are not required in the engineering and manufacturing development (EMD) phase.

6.4.1.2 Hardness capability of GFE. It is important that the SPO recognize and understand that it is obligated to provide existing hardness capability information for any GFE that it imposes on a contractor (refer to Table II and A.3.51). Unless the contractor is specifically tasked by contract to modify the GFE to meet requirements, it is essential that the SPO ensure that all GFE meets the requirements it is imposing for the overall system hardness.

6.4.1.3 Facilities hardness design tasks. This standard tasks three categories of contractor to participate in the development of facilities hardness design:

a. the SS&I contractor (see 5.3.3.2.1 and 5.3.4.1);

b. the AVE/SE contractor (see 5.3.3.2.2); and

c. the facilities A&E contractor (see 5.3.4.1).

This overlap of tasks is such that tailoring/scoping of the above facilities hardness design tasks is required. The tailoring/scope of the activity assigned to each of these categories of contractor should be a function of each individual contractor's hardness engineering capability with respect to the applicable NWE.

6.4.1.4 Scope of hardness qualification analysis. The purpose of hardness qualification (see 5.3.5.2) is to establish that the actual hardware item (not just the detail design) satisfies its hardness requirements. If qualification is directed to be accomplished by means of analysis, the associated cost identified in the contractor's proposal should consist only of an addition to the cost of the existing hardness verification activity (see 5.3.5.1). Such an addition is intended to cover the cost of the hardness analysis of any design changes added to the final design subsequent to hardness verification.

6.4.1.5 Development testing data requirements. Paragraphs 5.3.3.1.1, 5.3.3.2.1, and 5.3.4.1 task the contractor to conduct hardness tests as appropriate. Test plans/reports are required. See section 6.3.

6.4.1.6 Tailoring for system level testing and analysis. Paragraph 5.3.6.1 requires a contractor to either conduct or support system level testing and analysis defined in the TEMP. The specific role of that contractor for a given test or analysis should be clearly defined in the TEMP. With respect to data requirements, a contractor acting as a test conductor or analysis lead should always submit the required data items shown in 6.3 above (i.e., test plan and report/system level analysis report). A contractor acting in a support role may not need to submit such data items depending on the scope or magnitude of the support. The SPO will evaluate this and identify the data requirements to the bidding contractor.

6.4.1.7 NH&S program plan requirements. In Table III and Table IV (and as depicted in the flow diagrams of Appendix B), paragraph 5.3.1.2 (contractor NH&S program planning) is shown for the AVE/SE and SS&I contractors as applying to all the phases in which they play a role. This could be interpreted to mean that under the associated data requirement for an NH&S program plan, a new and separate plan must be generated for each phase. Such an approach, however, would not be cost-effective and is not required. It is sufficient that the first release of a given plan be updated as each new system life cycle phase is placed on contract.

6.4.1.8 Hardness surveillance planning and preparation. Paragraphs 5.3.8.11 and 5.3.8.13 address hardness surveillance planning and preparation. Paragraph 5.3.8.11 tasks all WSE contractors to perform hardness surveillance planning for the WSE(s) under contract. However, 5.3.8.13 is intended to apply only to those contractors whose WSE(s) are included in the system level hardness surveillance plan generated by the SPO under 5.3.8.12.

6.4.1.9 Tailoring information for the NH&S Design Analysis Report (DAR). The following tailoring instructions are recommended for the NH&S DAR:

6.4.1.9.1 Tailoring the NH&S DAR for CI WSE. The NH&S DAR DID DI-ENVR-80266A provides the description of the data content and format appropriate for the AVE/SE contractor's NH&S DAR submitted for CDR (see Figure 2 and 5.3.5.1) and FCA (see Figure 2 and 5.3.5.2). The PDR version of the NH&S DAR (see 5.3.3.1.1) is intended as the appropriate place to document ORA allocation analysis not formally documented by trade studies or test reports. It is understood the PDR version of the NH&S DAR consists of a preliminary report reflecting the WSE preliminary design. The particular organization of the text in the NH&S DAR may change based on the complexity of the WSE design. The content of later DAR revision is covered in detail in the DID. Text organization issues to be mutually decided between the SPO and contractor are:

a. Whether the applicable NH&S nuclear weapon effects/environments are nested within discussions dedicated to hardware elements or vice-versa;

b. Whether single or multiple documents will be provided; and

c. Making the HCI list for each CI into a single list within the DAR or when a CI is comprised of multiple CIs (or major subassemblies), having an HCI List for each major subassembly.

6.4.1.9.2 Tailoring the contract data requirements for the NH&S DAR for non-CI WSE. Two versions of the NH&S DAR for non-CI WSE (i.e., RPIE, A&CO installation hardware) are needed. DI-ENVR-80266A calls for four versions and so tailoring is needed to eliminate two of them. These are:

a. A preliminary version to support the preliminary design for the WSE on contract. The preliminary version must contain the same type of information as the PDR version of the CI NH&S DAR; and

b. A final version to be released after the completion of all design, acquisition, fabrication, and installation activities associated with the WSEs on contract. The final version must contain the same type of information as the FCA version of the CI NH&S DAR.

6.4.2 Explicit tailoring information. Explicit tailoring instructions are provided below as a function of:

a. contractor role in the program;

b. system life cycle phase; and

c. hardware category, as applicable.

With knowledge of these three parameters as they apply to a particular SOW, the applicable paragraphs below can be readily identified. Their content can then be inserted into the SOW tailoring of this standard, subject only to the considerations discussed in 6.4.1. The information provided below is consistent with Table I, Table II, Table III and Table IV.

6.4.2.1 AVE/SE contractor.

6.4.2.1.1 Materiel solution analysis phase. N/A

6.4.2.1.2 Technology maturation and risk reduction (TMRR) phase.

6.4.2.1.2.1 Contractor furnished equipment.

6.4.2.1.2.1.1 Developmental items. All paragraphs in MIL-STD-1766 except: 5.1.1, 5.1.2.1, 5.1.2.3, 5.1.2.4, 5.1.3 through 5.1.5, 5.3.1.1, 5.3.1.2.1, 5.3.2.1, 5.3.2.2, 5.3.3.2.1, 5.3.3.2.3, 5.3.4.1.2 through 5.3.4.1.4, 5.3.5 through 5.3.8 .

6.4.2.1.2.1.2 Non developmental items/commercial.

6.4.2.1.2.1.2.1 Unmodified commercial NDI. All paragraphs in MIL-STD-1766 except: 5.1.1, 5.1.2.1, 5.1.2.2, 5.1.2.3, 5.1.2.4, 5.1.3 through 5.1.5, 5.3.1.1, 5.3.1.2.1, 5.3.2.1, 5.3.2.2, 5.3.3.2.1, 5.3.3.2.3, 5.3.3.3, 5.3.4 through 5.3.8.

6.4.2.1.2.1.2.2 Modified commercial NDI. All paragraphs in MIL-STD-1766 except: 5.1.1, 5.1.2.1, 5.1.2.2, 5.1.2.3, 5.1.2.4, 5.1.3 through 5.1.5, 5.3.1.1, 5.3.1.2.1, 5.3.2.1, 5.3.2.2, 5.3.3.2.1, 5.3.3.2.3, 5.3.3.3, 5.3.4.1.2 through 5.3.4.1.4, 5.3.5 through 5.3.8.

6.4.2.1.2.1.3 Non-developmental items/military.

6.4.2.1.2.1.3.1 Unmodified military NDI. All paragraphs in MIL-STD-1766 except: 5.1.1, 5.1.2.1, 5.1.2.2, 5.1.2.3, 5.1.2.4, 5.1.3 through 5.1.5, 5.3.1.1, 5.3.1.2.1, 5.3.2.1, 5.3.2.2, 5.3.3.2.1, 5.3.3.2.3, 5.3.3.3, 5.3.4 through 5.3.8.

6.4.2.1.2.1.3.2 Modified military NDI. All paragraphs in MIL-STD-1766 except: 5.1.1, 5.1.2.1, 5.1.2.2, 5.1.2.3, 5.1.2.4, 5.1.3 through 5.1.5, 5.3.1.1, 5.3.1.2.1, 5.3.2.1, 5.3.2.2, 5.3.3.2.1, 5.3.3.2.3, 5.3.3.3, 5.3.4.1.2 through 5.3.4.1.4, 5.3.5 through 5.3.8.

6.4.2.1.2.1.4 Government furnished equipment. All paragraphs in MIL-STD-1766 except: 5.1.1, 5.1.2.1, 5.1.2.2, 5.1.2.3, 5.1.2.4, 5.1.3 through 5.1.5, 5.3.1.1, 5.3.1.2.1, 5.3.2.1, 5.3.2.2, 5.3.3.1.1, 5.3.3.2.1, 5.3.3.2.3, 5.3.3.3, 5.3.45 through 5.3.8.

6.4.2.1.3 Engineering and manufacturing development phase.

6.4.2.1.3.1 Contractor furnished equipment.

6.4.2.1.3.1.1 Developmental items. All paragraphs in MIL-STD-1766 except: 5.1.1, 5.1.2, 5.1.3.1, 5.1.3.3 through 5.1.3.5, 5.1.4 through 5.1.5, 5.3.1.1, 5.3.2.1, 5.3.2.2, 5.3.3.2.1, 5.3.3.2.3, 5.3.6.2, 5.3.7.1, 5.3.7.3, 5.3.8.9, 5.3.8.10, 5.3.8.12, 5.3.8.14 through 5.3.8.16.

6.4.2.1.3.1.2 Non-developmental items/commercial.

6.4.2.1.3.1.2.1 Unmodified commercial NDI. All paragraphs in MIL-STD-1766 except: 5.1.1, 5.1.2, 5.1.3.1, 5.1.3.3 thru 5.1.3.5, 5.1.4 thru 5.1.5, 5.3.1.1, 5.3.2.1, 5.3.2.2, 5.3.3.2.1, 5.3.3.2.3, 5.3.4, 5.3.6.2, 5.3.7.1, 5.3.7.3, 5.3.8.9, 5.3.8.10, 5.3.8.12, 5.3.8.14 thru 5.3.8.16.

6.4.2.1.3.1.2.2 Modified commercial NDI. All paragraphs in MIL-STD-1766 except: 5.1.1, 5.1.2, 5.1.3.1, 5.1.3.3 through 5.1.3.5, 5.1.4 through 5.1.5, 5.3.1.1, 5.3.2.1, 5.3.2.2, 5.3.3.2.1, 5.3.3.2.3, 5.3.6.2, 5.3.7.1, 5.3.7.3, 5.3.8.9, 5.3.8.10, 5.3.8.12, 5.3.8.14 through 5.3.8.16.

6.4.2.1.3.1.3 Non developmental items/military.

6.4.2.1.3.1.3.1 Unmodified military NDI. All paragraphs in MIL-STD-1766 except: 5.1.1, 5.1.2, 5.1.3.1, 5.1.3.3 through 5.1.3.5, 5.1.4 through 5.1.5, 5.3.1.1, 5.3.2.1, 5.3.2.2, 5.3.3.2.1, 5.3.3.2.3, 5.3.4, 5.3.6.2, 5.3.7.1, 5.3.7.3, 5.3.8.9, 5.3.8.10, 5.3.8.12, 5.3.8.14 through 5.3.8.16.

6.4.2.1.3.1.3.2 Modified military NDI. All paragraphs in MIL-STD-1766 except: 5.1.1, 5.1.2, 5.1.3.1, 5.1.3.3 through 5.1.3.5, 5.1.4 through 5.1.5, 5.3.1.1, 5.3.2.1, 5.3.2.2, 5.3.3.2.1, 5.3.3.2.3, 5.3.6.2, 5.3.7.1, 5.3.7.3, 5.3.8.9, 5.3.8.10, 5.3.8.12, 5.3.8.14 through 5.3.8.16.

6.4.2.1.3.1.4 Government furnished equipment. All paragraphs in MIL-STD-1766 except: 5.1.1, 5.1.2, 5.1.3.1, 5.1.3.3 through 5.1.3.5, 5.1.4 through 5.1.5, 5.3.1.1, 5.3.2.1, 5.3.2.2, 5.3.3.1.1, 5.3.3.2.1, 5.3.3.2.3, 5.3.4, 5.3.6.2, 5.3.7.1, 5.3.7.3, 5.3.8.1, 5.3.8.2, 5.3.8.4, 5.3.8.6 through 5.3.8.10, 5.3.8.12, 5.3.8.14 through 5.3.8.16.

6.4.2.1.4 Production and deployment phase.

6.4.2.1.4.1 Contractor furnished equipment.

6.4.2.1.4.1.1 Developmental items. All paragraphs in MIL-STD-1766 except: 5.1.1 through 5.1.3, 5.1.4.1, 5.1.4.3 through 5.1.4.5, 5.1.5, 5.3.1.1, 5.3.1.2.1, 5.3.2 through 5.3.7, 5.3.8.1 through 5.3.8.8, 5.3.8.11 through 5.3.8.16; 5.4.

6.4.2.1.4.1.2 Non developmental items/commercial.

6.4.2.1.4.1.2.1 Unmodified commercial NDI. All paragraphs in MIL-STD-1766 except: 5.1.1 through 5.1.3, 5.1.4.1, 5.1.4.3 through 5.1.4.5, 5.1.5, 5.3.1.1, 5.3.1.2.1, 5.3.2 through 5.3.7, 5.3.8.1 through 5.3.8.8, 5.3.8.11 through 5.3.8.16, 5.4.

6.4.2.1.4.1.2.2 Modified commercial NDI. All paragraphs in MIL-STD-1766 except: 5.1.1 through 5.1.3, 5.1.4.1, 5.1.4.3 through 5.1.4.5, 5.1.5, 5.3.1.1, 5.3.1.2.1, 5.3.2 thru 5.3.7, 5.3.8.1 thru 5.3.8.8, 5.3.8.11 thru 5.3.8.16; 5.4.

6.4.2.1.4.1.3 Non developmental items/military.

6.4.2.1.4.1.3.1 Unmodified military NDI. All paragraphs in MIL-STD-1766 except: 5.1.1 through 5.1.3, 5.1.4.1, 5.1.4.3 through 5.1.4.5, 5.1.5, 5.3.1.1, 5.3.1.2.1, 5.3.2 through 5.3.7, 5.3.8.1 through 5.3.8.8, 5.3.8.11 through 5.3.8.16; 5.4.

6.4.2.1.4.1.3.2 Modified military NDI. All paragraphs in MIL-STD-1766 except: 5.1.1 through 5.1.3, 5.1.4.1, 5.1.4.3 through 5.1.4.5, 5.1.5, 5.3.1.1, 5.3.1.2.1, 5.3.2 through 5.3.7, 5.3.8.1 through 5.3.8.8, 5.3.11 through 5.3.8.16; 5.4.

6.4.2.1.4.1.4 Government furnished equipment. N/A.

6.4.2.1.5 Operations and support phase. N/A.

6.4.2.2 System support/integration contractor.

6.4.2.2.1 Materiel solution analysis phase. All paragraphs in MIL-STD-1766 except: 5.1.1.1, 5.1.2 through 5.1.5, 5.3.1.1, 5.3.1.2.1, 5.3.2.1, 5.3.2.3, 5.3.3 through 5.3.8.

6.4.2.2.2 Technology maturation and risk reduction phase. All paragraphs in MIL-STD-1766 except: 5.1.1, 5.1.2.1, 5.1.2.2, 5.1.2.4, 5.1.3 through 5.1.5, 5.3.1.1, 5.3.1.2.1, 5.3.2.1, 5.3.3.1, 5.3.3.2.2, 5.3.3.3, 5.3.4.1.3, 5.3.4.1.4, 5.3.5 through 5.3.8.

6.4.2.2.3 Engineering and manufacturing development (EMD) phase. All paragraphs in MIL-STD-1766 except: 5.1.1, 5.1.2, 5.1.3.1, 5.1.3.2, 5.1.3.4, 5.1.3.5, 5.1.4 through 5.1.5, 5.3.1.1, 5.3.2.1, 5.3.3.1, 5.3.3.2.2, 5.3.3.3, 5.3.5.2, 5.3.7.1, 5.3.8.2 through 5.3.8.7, 5.3.8.9, 5.3.8.10, 5.3.8.12, 5.3.8.14 through 5.3.8.16.

6.4.2.2.4 Production and deployment phase. All paragraphs in MIL-STD-1766 except: 5.1.1, 5.1.2, 5.1.3, 5.1.4.1, 5.1.4.2, 5.1.4.4, 5.1.4.5, 5.1.5, 5.3.1.1, 5.3.1.2.1, 5.3.2, 5.3.3, 5.3.4.1.1, 5.3.4.1.2, 5.3.5, 5.3.6.1, 5.3.7.1, 5.3.7.2, 5.3.8.

6.4.2.2.5 Operations and support phase. N/A.

6.4.2.3 Facilities A&E contractor.

6.4.2.3.1 Materiel solution analysis phase. N/A.

6.4.2.3.2 Technology maturation and risk reduction phase. All paragraphs in MIL-STD-1766 except: 5.1.1, 5.1.2.1 through 5.1.2.3, 5.1.3 through 5.1.5, 5.3.1 through 5.3.3, 5.3.4.1.3, 5.3.4.1.4, 5.3.5 through 5.3.8.

6.4.2.3.3 Engineering and manufacturing development phase. All paragraphs in MIL-STD-1766 except: 5.1.1, 5.1.2, 5.1.3.1 through 5.1.3.3, 5.1.3.5, 5.1.4 through 5.1.5, 5.3.1 through 5.3.3, 5.3.5 through 5.3.7, 5.3.8.1, 5.3.8.3 through 5.3.8.16.

6.4.2.3.4 Production and deployment phase. All paragraphs in MIL-STD-1766 except: 5.1.1 through 5.1.3, 5.1.4.1 through 5.1.4.3, 5.1.4.5, 5.1.5, 5.3.1 through 5.3.3, 5.3.4.1.1, 5.3.4.1.2, 5.3.5 through 5.3.7, 5.3.8.1, 5.3.8.3, through 5.3.8.16.

6.4.2.3.5 Operations and support phase. N/A.

6.4.2.4 Facilities construction contractor.

6.4.2.4.1 Materiel solution analysis phase. N/A.

6.4.2.4.2 Technology maturation and risk reduction phase. N/A.

6.4.2.4.3 Engineering and manufacturing development phase. All paragraphs in MIL-STD-1766 except: 5.1.1, 5.1.2, 5.1.3.1 through 5.1.3.4, 5.1.4 through 5.1.5; 5.3.1 through 5.3.7, 5.3.8.1 through 5.3.8.8, 5.3.8.11 through 5.3.8.16; 5.4.

6.4.2.4.4 Production and deployment phase. All paragraphs in MIL-STD-1766 except: 5.1.1 through 5.1.3, 5.1.4.1 through 5.1.4.4, 5.1.5, 5.3.1 through 5.3.7, 5.3.8.1 through 5.3.8.8, 5.3.8.11 through 5.3.8.16; 5.4.

6.4.2.4.5 Operations and support phase. N/A.

6.4.2.5 A&CO contractor.

6.4.2.5.1 Materiel solution analysis phase. N/A.

6.4.2.5.2 Technology maturation and risk reduction phase. N/A.

6.4.2.5.3 Engineering and manufacturing development phase. N/A.

6.4.2.5.4 Production and deployment phase. All paragraphs in MIL-STD-1766 except: 5.1.1 through 5.1.4, 5.1.5, 5.3.1.1, 5.3.1.2.1, 5.3.2 through 5.3.7, 5.3.8.1 through 5.3.8.4, 5.3.8.6 through 5.3.8.16; 5.4.

6.4.2.5.5 Operations and support phase. N/A.

6.4.2.6 Hardness surveillance support contractor.

6.4.2.6.1 Materiel solution analysis phase. N/A.

6.4.2.6.2 Technology maturation and risk reduction phase. N/A.

6.4.2.6.3 Engineering and manufacturing development phase. N/A.

6.4.2.6.4 Production and deployment phase. N/A.

6.4.2.6.5 Operations and supply phase. All paragraphs in MIL-STD-1766 except: 5.1.1 through 5.1.5, 5.2, 5.3.1.1, 5.3.1.2.1, 5.3.2 through 5.3.7, 5.3.8.1 through 5.3.8.14, 5.3.8.16; 5.4.

6.4.2.6.6 Subject term (key word) listing.

- Analysis
- Assessment
- Design
- Evaluation
- Hardness assurance
- Hardness maintenance
- Hardness surveillance

- Qualification
- Testing
- Verification
- Weapon effects

6.5 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

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ACRONYMS/ABBREVIATIONS & DEFINITIONS

A.1 SCOPE.

A.1.1 Purpose. This appendix contains a lists of acronyms/abbreviations used in the standard and then a list of definitions where each has a unique paragraph. The definitions are organized alphabetically based on their first letter and therefore are easier to locate. This appendix is a mandatory part of this standard. The definitions form a mandatory part of this standard and are therefore provided for compliance.

A.1.2 Application. The terms and their definitions contained in this appendix shall be controlling in all applications of this standard. During the implementation of the tasks directed by this standard, they shall take precedence over similar or corresponding terms and definitions that may exist in other documentation. The intent of this direction is to establish the basis for and to facilitate clear and unambiguous communication concerning the work covered by this standard between the government and its contractors and among all contractor internal organizations and personnel whose responsibilities are impacted by this standard. A large number of terms have been included to allow this standard to be as self-contained as possible. In addition to dictionary-like definitions of the terms addressed, additional background and tutorial comments are also frequently supplied. The purpose of including such information is also to facilitate clear communication among all concerned parties and to foster more cost-effective implementation of the tasks involved.

A.2 ACRONYMS/ABBREVIATIONS.

A&CO	Assembly and checkout
A&CO TA	Assembly and checkout technical analysis
A&E	Architectural and engineering
AoA	Analysis of Alternatives
AFI	Air Force Instruction
AFR	Air Force Regulation
AMSDL	Acquisition management systems and data list
ASSIST	Acquisition Streamlining and Standardization Information System
AVE	Aerospace vehicle equipment
C&R	Circumvention and recovery
CDR	Critical design review
CDRL	Contract data requirements list
CFE	Contractor furnished equipment

CI	Configuration item
COTS	Commercial-off-the-shelf
dB	Decibel
DID	Data item description
DM	Design Margin
DNA	Defense Nuclear Agency
DoD	Department of Defense
DoDD	Department of Defense Directive
DSE	Depot support equipment
ECP	Engineering change proposal
ECS	Environmental control system
EMD	Engineering and manufacturing development
EMP	Electromagnetic pulse
EPM	External protection material
ESA	Electrical surge arrestor
FAR	Federal Acquisition Regulation
FCA	Functional configuration audit
FMA	Failure mode analysis
FSE	Factory support equipment
GFE	Government furnished equipment
HALAT	Hardness assurance lot acceptance testing
HCI	Hardness critical item
HCP	Hardness critical process/procedure
HDM	Hardness data manual
HEMP	High-altitude electromagnetic pulse
IAW	In accordance with
ICBM	Intercontinental ballistic missile
ICD	Interface control drawing
ICWG	Interface control working group

IEMP	Internal electromagnetic pulse
KPP	Key performance parameter
KSA	Key system attribute
LCH	Life cycle hardness
LSA	Logistics support analysis
LSAR	Logistics support analysis record
MNS	Mission need statement
MSE	Maintenance support equipment
NCGS	Nuclear criteria group secretariat
NDI	Non developmental item
NEEHAM	Nuclear environment/effect hardness element matrix
NEP	Nuclear environment protection
NHA	Next higher assembly
NH&S	Nuclear hardness and survivability
NH&S DAR	Nuclear hardness and survivability design analysis report
NWE	Nuclear weapon effect/environment
ORA	Operational requirements analysis
OSE	Operational Support Equipment
PCA	Physical configuration audit
PDR	Preliminary design review
PIDS	Prime item development specification
RPIE	Real property installed equipment
SE	Support equipment
SE/TA	System engineering and technical assistance
SFR	System functional review
SGEMP	System-generated electromagnetic pulse
SHAR	System hardness analysis report
SIOP	Single integrated operating plan
SMI	Structure-media interaction

SOW	Statement of work
SPO	System program office
SRA	System requirements analysis
SREMP	Source-region electromagnetic pulse
SRR	System requirements review
STAR	System threat assessment report
STD	Standard
TED	Threat environment definition
TEMP	Test and evaluation master plan
TIM	Technical interchange meeting
TO	Technical Order
WSE	Weapon system element
WSS	Weapon system specification

A.3 DEFINITONS.

A.3.1 Acquisition Life Cycle. The acquisition life cycle, also referred to as the acquisition process, is a subset of the system life cycle (see A.3.139) and consists of the program phases through which a system passes from the time it is initially conceived and developed, until the time it is deployed and enters operational use. One or more of these program phases may also apply to major upgrade or system replacement actions. The acquisition life cycle is usually considered to consist of the following phases, although the precise terminology used tends to vary over time:

a. Materiel solution analysis (see A.3.103);

b. Technology maturation and risk reduction (see A.3.146);

c. Engineering and manufacturing development (see A.3.33);

d. Production and deployment (see A.3.124); and

e. Operations and support (see A.3.118).

Each acquisition life cycle phase has associated with it a particular set of hardness tasks.

A.3.2 Aerospace Vehicle Equipment (AVE). Aerospace vehicle equipment consists of the operational flight vehicle and all of its flight components. For purposes of configuration management, the SPO (see A.3.140) procures AVE in equipment groupings that are treated as individual CIs (see A.3.20), each with its own PIDS (see A.3.123). See also WSE, A.3.157.

A.3.3 Airblast. See blast, A.3.14.

A.3.4 Allocation. See hardness allocation, A.3.55.

A.3.5 Analysis. See hardness analysis, A.3.58.

A.3.6 Analysis of Alternatives (AoA). The AoA is the assessment of potential materiel solutions to satisfy the capability need documented in the approved Initial Capabilities Document (see A.3.92). It focuses on identification and analysis of alternatives, Measures of Effectiveness (MOE), cost, schedule, concepts of operations, and overall risk, including the sensitivity of each alternative to possible changes in key assumptions or variables. The AoA also assesses critical technologies associated with each proposed materiel solution, including technology maturity, integration risk, manufacturing feasibility, and where necessary, technology maturation and demonstration needs. The AoA is normally conducted during the Materiel Solution Analysis phase of the Defense Acquisition System, is a key input to the Capability Development Document (CDD) (see A.3.15), and supports the materiel solution decision at Milestone A. The AoA may be updated for the Development Request for Proposal Release Decision Point and Milestone C review if there are changes to the design that impact AoA assumptions (See https://dap.dau.mil/ glossary for any future updates of this definition).

A.3.7 Assembly and Checkout (A&CO). Assembly and checkout refers to the activity performed during the production and deployment phase (see A.3.124) of the acquisition life cycle (see A.3.1) during which the individual AVE (see A.3.2) and SE (see A.3.131), WSEs (see A.3.157) are assembled together and united with the associated facilities (see A.3.35) and RPIE (see A.3.127) to form a complete weapon system ready for operational use. Part of the A&CO activity is the checkout of the assembled system to verify that the system as assembled satisfies all performance requirements.

A.3.8 Assembly and Checkout (A&CO) Contractor. See contractor, A.3.21.

A.3.9 Assembly and Checkout (A&CO) Installation Hardware. Assembly and checkout installation hardware refers to hardware items necessary to complete installation of AVE (see A.3.2) and SE (see A.3.131) WSEs in the facilities (see A.3.35). Such hardware may be provided either by the AVE and SE contractors or by the A&CO contractor (see A.3.21). Assembly and checkout installation hardware sometimes have associated hardness requirements (see A.3.80), which must be identified for inclusion in the A&CO TA (see A.3.10).

A.3.10 Assembly and Checkout Technical Analysis (A&CO TA). The A&CO TA is one of the four elements of SRA (see A.3.142). Its primary objective is to perform the required detailed analyses and associated trade studies necessary to provide an approved A&CO program at lowest cost. The approved integrated A&CO TA becomes the baseline for the planning and conduct of the A&CO field effort, and it is provided by the SPO (see A.3.140) to the A&CO contractor (see A.3.21) for implementation. The A&CO TA must be hardness annotated (see A.3.59) to support the preservation of the system hardness during the A&CO activity (see A.3.7).

A.3.11 Assessment. In this standard, assessment refers to an analysis activity to estimate the as-built capability of a weapon system. The two categories of assessment pertinent to NH&S are hardness assessments and survivability assessments.

a. Survivability assessment. Survivability assessment. Survivability assessment is a type of assessment used to evaluate the nuclear survivability (see A.3.113) status of a system. Results typically take the form of probability of survival with respect to one or more hostile nuclear threats and attack scenarios.

b. Hardness assessment. Hardness assessment is a type of assessment used to evaluate the actual nuclear hardness capability of a deployed system. The results can take various forms depending on need (e.g., vulnerability number, probability of survival with respect to range or environmental level). As part of the procurement of an ICBM weapon system, the SPO will produce a hardness assessment of the system and provide results for use in on-going survivability assessment modeling during the operations and support phase.

Initial assessments are usually performed by the SPO (see A.3.140); with contractor (see A.3.21) support as required. Subsequent assessments are carried out by the SPO organization responsible for system survivability during the operations and support phase (A.3.118) under the direction of the operating command. Among the factors that may cause a reassessment of the system are changes in the threat, revisions to the operational scenario, major system upgrades, and degradation of hardness features.

A.3.12 Attenuation. In this standard, attenuation is used as a technical term to denote the reduction in magnitude of one or more of the applicable NWE (see A.3.114) by a hardware element. A common hardness design (see A.3.69) approach is to introduce various kinds of shields and mechanical isolators into the design to accomplish such attenuation. Often, an existing system hardware element is used to provide this shielding function. The NWE attenuation requirements assigned to a hardware element become one of that item's hardness performance requirements (see A.3.78). Correspondingly, the attenuated environment becomes the withstand (see A.3.160) requirement or hardness design constraint (see A.3.71) for the hardware element being shielded.

A.3.13 AVE/SE contractor. See contractor, see contractor A.3.21.

A.3.14 Blast. Blast or airblast is one of the NWE (see A.3.114). It consists of a shock wave of air propagated outward from a nuclear explosion, in which the static air pressure increases sharply at the shock front. This is accompanied by dynamic airflow or high winds behind the shock front. In addition, blast couples to the ground, contributing to the ground shock (see A.3.129) environment. Blast environments can inhibit mission critical performance by causing high stress loading and damage, inducing shock responses, and adversely affecting missile flight control.

A.3.15 Capability Development Document (CDD). A CDD specifies capability requirements in terms of developmental Key Performance Parameters (KPPs) (see A.3.97), Key System Attributes (KSAs) (see A.3.98), Additional Performance Attributes, and other related information necessary to support development of one or more increments of a materiel capability solution. A sponsor approved draft CDD is necessary for a Milestone A acquisition decision and each Request for Proposal release in support of the Technology Maturation and Risk Reduction (TMRR) phase (see A.3.146) of the Defense Acquisition System. A validated CDD is also necessary for each Development Request for Proposal Release Decision Point and Milestone B acquisition decision. The CDD format is in the Joint Capabilities Integration and Development System Manual, which is available online (https://acc.dau.mil/CommunityBrowser.aspx?id=530429) (See https://dap.dau.mil/glossary for any future updates of this definition).

A.3.16 Circumvention and Recovery (C&R). Circumvention and recovery (also called circumvention/reset) is one kind of nuclear event protection (see A.3.107) that consists of an electronic mechanism that makes use of specially hardened circuitry to:

a. detect the presence of ionizing radiation whose intensity exceeds an established set point;

b. protect stored data from alteration by erroneous writing;

c. provide resets for logic circuit upsets;

d. inhibit false inputs and outputs; and

e. provide a controlled resumption of operation after the radiation has decreased below the established set point by reconstruction of critical data and circuit logic states that were lost during circumvention.

A.3.17 Commercial-Off-The-Shelf (COTS). An item of COTS is a category of hardware or software that may be purchased for military use but has the following characteristics:

1). the design already exists (NDI - see Table II and A.3.104);

2). it is used by or available to the public;

3). it is bought without asking supplier to change the product; and

4). the manufacturer has his own specification.

It is a commercial product (see A.3.18) that has been produced and placed in stock by a manufacturer, or stocked by a distributor, before a government entity decides to use it for military purposes and thus places an order or releases a contract for its purchase. The design and possible future changes to the design or configuration are controlled solely by the manufacturer. Commercial-off-the-shelf hardware must be bought, used, and supported exactly as found in the civilian market. When the supplier makes changes to the item, those changes and updates instituted for the commercial market will flow to any system using the COTS item. Although the manufacturer's drawings for the item may be supplied to the government, they are not controlled by the government. Usually, the government neither controls the design of COTS hardware items nor exercises configuration control over them. This circumstance interferes with the SPO's ability to continue executing a hardness maintenance (see A.3.77) program and is a complicating factor in the use of COTS hardware in a hardened weapon system. In Section 5 of this standard, COTS items are discussed under the heading: already existing commercial/ unmodified items.

A.3.18 Commercial Product. Commercial product is a generic term referring to hardware or software that in the normal course of business is used by and is available to the public. Such products almost never have engineering data or alternative design documentation that complies with DoD specifications and the manufacturer retains all process and design authority. Among the categories of commercial product are:

a. COTS items (see A.3.17);

b. "commercial-type" items (commercially designed and built items) which may be selected for military use and then modified to meet some government-peculiar requirement or otherwise identified differently from their civilian counterparts) (see NDI, A.3.104); and

c. "best commercial practice" items (government-controlled design built and documented to widely accepted industrial standards).

A critical NH&S issue in the use of commercial products in ICBM weapon systems is the level of control the government has over the configuration. Hardness testing is often destructive and thus the number of items tested is often reduced to a single item or other very small number. However, such a reduction is based on the assumption that all items produced thereafter will be essentially identical. This is a good assumption for configuration controlled military items.

However, since the government generally does not (likely cannot) control a commercial item's configuration, before such items can be used in hardness critical functions, steps must be taken in the design phase to ensure that 1) the item has capability to meet the hardness requirements and 2) that tests and/or inspections or other design constraints are included in the system design and production process that ensure going forward that the uncontrolled hardness of the commercial item is still, and will remain, in compliance with system requirements. This often leads to much larger sample size and increased frequency of testing over military-design items.

There is often a perception that commercial items are less expensive than items designed for military use. But when the large number of tests required to accomplish item 2) above are imposed and when it is remembered that the lifetime of many commercial products is 3-5 years or less (thus requiring much more frequent replacement programs), the "cheap" nature of commercial items is often greatly diminished or inferior to an item specifically developed for hardened military use.

A.3.19 Concept Design. As used in this standard, the term concept design refers to the design the WSE contractor (see A.3.21) develops from the system concept design (also referred to as the baseline concept design). The AVE/SE WSE concept design will assist the contractor in identifying how the WSEs under contract will be partitioned into CIs (see A.3.20). Aspects of the concept design may change through EMD (see A.3.33). For the facilities (see A.3.35), concept design refers to the first incremental design, which consists of site location, gross facility features, accesses, utility hook-ups, required code compliance's, and incorporation of any additional information supplied by the AVE/SE contractors through the facility design criteria (see A.3.40).

A.3.20 Configuration Item (CI). A CI is an organized grouping of hardware, firmware, and software, separately or in some combination, that satisfies an end use function and is designated for configuration management. Configuration items are those items whose performance requirements (see A.3.119), design constraints (see A.3.26), and physical characteristics, both hardness and non-hardness related, must be separately specified and controlled. With respect to procurement considerations, CIs may consist of both CFE (see A.3.23) and GFE (see A.3.51). Contractor furnished equipment, in-turn, may consist of both developmental (see A.3.30) and non-developmental (see A.3.104) items. The latter may consist of both commercial and military items. See AVE, A.3.2 ; OSE, A.3.117; SE, A.3.131; WSE, A.3.157; and PIDS, A.3.123.

A.3.21 Contractor. As used in this standard, contractor refers to one of the organizations contracted with by the SPO (see A.3.140) in support of the acquisition, deployment, upgrade, or replacement of a hardened ICBM weapon system or subsystem thereof. The separate categories of contractor referred to in this standard are listed below. It should be noted that the same organization may serve more than one contracting role.

a. A&CO contractor. The organization responsible to implement the A&CO activity (see A.3.7).

b. AVE/SE contractor. The organization responsible to design, develop, and produce one or more of the items of AVE (see A.3.2) or SE (see A.3.131) utilized in an ICBM weapon system. The contractor that designs and develops a particular item of AVE or SE may not be the organization selected by the SPO (see A.3.140) to produce the item during the production and deployment phase. The SPO often contracts with a number of different AVE/SE contractors in support of the acquisition of a given ICBM weapon system.

c. Facilities architectural and engineering (A&E) contractor. The organization responsible to generate detailed plans and drawings for the construction of the facilities (see A.3.35) from the facilities design criteria (see A.3.40) document.

d. Facilities construction contractor. The organization responsible to construct the facilities (see A.3.35) and install the RPIE (see A.3.127).

e. Hardness surveillance support contractor. When the SPO decides to contract for such support, this is the organization responsible to support the implementation of hardness surveillance (see A.3.81) during the operations and support phase (see A.3.118). Often more than one organization is contracted with to provide this function for different subsystems.

f. System engineering and technical assistance (SE/TA) contractor. The organization responsible to provide system engineering and technical assistance services to the SPO (see A.3.140) throughout the system life cycle (see A.3.139). The responsibilities of the SE/TA contractor are not explicitly delineated in this standard. They generally support the government in all of its technical activities.

g. System support/integration (SS&I) contractor. The organization responsible to:

1). coordinate all nuclear hardness system level aspects of the design, including system level analysis and testing in support of the acquisition life cycle (see A.3.1); and

2). generate the design criteria (see A.3.40) for the weapon system facilities (see A.3.35) and RPIE (see A.3.127).

This contractor prepares the system-level NH&S DAR, the facilities/RPIE NH&S DAR, and nuclear hardness system test plans and reports for the same, as required.

h. WSE contractor. WSE contractor is used in this standard, as appropriate, to denote any one of the individual contractors responsible for a particular type of WSE (see A.3.157).

A.3.22 Critical Design Review (CDR). The CDR is a formal technical review that is conducted for each CI (see A.3.20) when the detail design (see A.3.29) has been completed. Its purpose is to ensure that there is high confidence that the design that will be submitted for qualification will pass qualification and that the design satisfies the system specification and is in every way in compliance with the contract. The hardness emphasis at CDR is to show that the detail design is expected to satisfy the hardness requirements of the applicable PIDS (see A.3.123) during qualification (see A.3.79). Of prime importance to the NH&S program is the satisfactory completion of all subcomponent or subsystem tests and analyses, whose purpose is hardness verification (see A.3.87), the documentation of these tests and analyses in the NH&S DAR (see A.3.70), and the documentation (HCI annotations as well as correct content) on the drawings of all the hardness critical items and hardness critical manufacturing/assembly processes required by the design. While drawings are not completed until FCA (see A.3.49) but a clear path to include the details of the testing and analyses that are needed for production phase must be evident at CDR.

A.3.23 Contractor Furnished Equipment (CFE). Contractor furnished equipment refers to equipment that is acquired, modified, or manufactured directly by a contractor (see A.3.21) for use in the system under contract. These may consist of both developmental (see A.3.30) and non-developmental (see A.3.104) items.

A.3.24 Debris. Debris is one of the NWE (see A.3.114). It is radioactive and consists of the material ejected from a crater or scoured from the earth's surface and deposited in such a manner as to possibly preclude launch or mobility or otherwise degrade mission capability. Debris also includes entrained material (pebbles, dust, ice, fission products) within the nuclear cloud that could damage AVE (see A.3.2).

A.3.25 Depot support equipment (DSE). Depot support equipment refers to the equipment necessary to repair, overhaul, and test weapon system CIs (see A.3.20) down to the lowest repairable level. It includes commercial equipment, as well as equipment specifically designed or built to fulfill a particular depot overhaul or repair function. Whenever possible and cost-effective, it is desirable to include in the design of applicable DSE the capability to test the hardness characteristics of the hardware items that will be evaluated by means of the DSE. Such a capability can contribute significantly to the cost-effective implementation of hardness maintenance (see A.3.77) and hardness surveillance (see A.3.81). See also support equipment, A.3.131.

A.3.26 Design constraints. See hardness design constraints, A.3.71.

A.3.27 Design margin (DM). The DM is a numerical measure of the extent to which a hardware item can withstand (see A.3.160) exposure to a particular NWE (see A.3.114) beyond the stress level associated with the applicable hardness design constraint (see A.3.71). Each nuclear environment that is sufficiently high to cause degradation or other effects in the system design will have a corresponding DM. Design margins are used to support:

a. hardness verification (see A.3.87) activities;

b. initial identification and prioritizing of the controlling hardness failure mechanisms for individual WSEs and the system as a whole; and

c. identification of hardness assurance (see A.3.61) and hardness surveillance (see A.3.81) test requirements.

The concept of design margin applies both to transient upset and permanent damage responses. When calculating values of DM, the numerical measure utilized to reflect the ability of a hardware item to withstand a particular NWE exposure may be based on one of the following:

a. a "no-fail NWE level" derived from a conservative derating of a performance characteristic based on accepted industry practice;

b. a "no-fail NWE level" traceable to a military or industrial standard to which the item is to be procured;

c. a conservative estimate of a "no-fail NWE level" based on published data for similar hardware, development tests (see A.3.31), or hardness analysis (see A.3.58), and having SPO concurrence; and

d. the actual failure level NWE, reduced to allow for performance characteristic variation as determined by fragility testing (see A.3.48).

The magnitude of DM calculated, along with an estimate of the conservatism associated with the methods and assumptions used to determine it, is a primary resource in identifying the hardware items that control the fragility of the weapon system and that are, therefore, candidates for fragility determination. The following formal definitions of DM for specific NH&S disciplines apply in this standard:

a. The DM (expressed as a dimensionless factor) for semiconductor devices in a nuclear radiation (see A.3.111) environment is defined by the following equation:

- $DM = (X_f - 3_s) / X_{spec}$

Where: X_f = Arithmetic mean of the radiation levels at which worst case functional failure (see A.3.50) occurs for the devices contained in the nuclear radiation characterization test sample (see A.3.112). When testing to failure is not performed, just use the highest exposure level that did not result in failure;

X_{spec} = Applicable specified or allocated radiation level;

s = Standard deviation of the distribution of worst-case functional failure radiation levels; a normal distribution is assumed, but a log-normal distribution may be used when the test data cannot be fitted with a normal distribution.

When the standard deviation of the test data cannot be determined, the highest radiation test level achieved without any observed upset or failure may be used as the numerator in the equation above. In order to demonstrate satisfactory compliance with applicable hardness requirements (see A.3.80), this value of DM must be shown to be greater than or equal to +1.

b. The DM for electronic circuits in a nuclear radiation environment is defined as the simple ratio of the radiation level at which functional failure (see A.3.50) of the circuit occurs with respect to the applicable specified or allocated radiation level. The circuit functional failure level shall be determined by worst-case circuit analysis (see A.3.161). In order to demonstrate satisfactory compliance with applicable hardness requirements (see A.3.80), this value of DM must be shown to be greater than or equal to +1.

c. The DM (expressed in decibels (dB)) for hardware elements in an EMP (see A.3.32) environment is defined in terms of the stresses associated with the applicable EMP related hardness design constraints (see A.3.71). It is expressed by the following equation:

- $DM = C \log_{10} (X_f / X_{spec})$

Where:	C	=	20 when the stress associated with the EMP hardness design constraint is defined in terms of voltage, current, electric field, or magnetic field; or
		=	10 when the stress associated with the EMP hardness design constraint is defined in terms of power, energy, or temperature;
	X_f	=	Magnitude of the stress associated with the EMP hardness design constraint at which hardware failure occurs; failure is to be interpreted as the loss of ability to perform a specified mission critical function;
	X_{spec}	=	Magnitude of the stress associated with the specification level EMP hardness design constraint.

In order to demonstrate satisfactory compliance with applicable hardness requirements (see A.3.80), this value of DM must be shown to be greater than or equal to 0.

d. The DM for hardware elements in one of the mechanical response environments (thermal radiation, see A.3.150; blast, see A.3.14; shock, see A.3.129; and debris, see A.3.24) is defined by the following equation:

- $DM = (X_f / X_{spec}) - 1$

Where:	X_f	=	Magnitude of applied environment at which either (a) the threshold of hard-failure has been determined by testing, or (b) highest level to which actual hardware performance has been measured (for cases where item has not been tested to failure, e.g., where test facility maximum is reached but item has not yet failed but test facility maximum is greater than X_{spec});
	X_{spec}	=	Magnitude of the specified or allocated environment.

In order to demonstrate satisfactory compliance with applicable hardness requirements (see A.3.80), this value of DM must be shown to be greater than or equal to 0.

A.3.28 <u>Design Reviews</u>. In this standard, design reviews refer to the set of three reviews that are held to formalize system requirements, preliminary design (see A.3.121), and detail design (see A.3.29). The three design reviews, in the order of their occurrence, are the SRR/SFR (see A.3.141, A.3.135), the PDR (see A.3.122), and the CDR (see A.3.22).

A.3.29 Detail Design. For AVE (see A.3.2) and SE (see A.3.131) hardware, the term detail design refers to the design embodied in the engineering drawings and associated design documentation for the CIs (see A.3.20) under contract that are reviewed by the SPO (see A.3.140) at CDR (see A.3.22). This design must satisfy all requirements of the applicable PIDS (see A.3.123); including hardness requirements (see A.3.80). For the facilities (see A.3.35), detail design refers to the design embodied in the drawings used for the facilities construction bid package (see A.3.37).

A.3.30 Developmental Item. Developmental items are items of either hardware or software that do not currently exist in full satisfaction of DoD requirements or existing items that require more than minor modification to satisfy DoD requirements. These items require government-sponsored research and development efforts to provide for their availability in support of DoD programs.

A.3.31 Development Tests. Development tests are a subset of hardness tests (see A.3.85). They are performed during the hardness design (see A.3.69) activity to generate engineering data, not readily available from other sources, on the hardness response characteristics of materials and selected items of hardware. These items are usually of a low level of hardware indenture such as piece parts, that are candidates for inclusion in the design of a WSE (see A.3.157). Among the uses made of these data are:

a. to directly support hardness allocation (see A.3.55) for WSE design development;

b. as input data in support of hardness verification analysis (see A.3.88); and

c. as inputs to procurement documentation for the items tested.

See also nuclear radiation characterization, A.3.112.

A.3.32 Electromagnetic Pulse (EMP). Electromagnetic pulse is one of the NWE (see A.3.114). It consists of transient electromagnetic energy generated by nuclear ionizing radiation interacting with the ambient environment. The electromagnetic energy produced by radiation interacting with the upper atmosphere is called high altitude EMP, or HEMP (see A.3.90). The electromagnetic energy produced by radiation interacting with the media surrounding or near a nuclear weapon detonation is called source region EMP, or SREMP (see A.3.130). The electromagnetic energy produced by radiation interacting with system hardware is called system generated EMP, or SGEMP (see A.3.136). A subset of SGEMP is referred to as internal electromagnetic pulse, or IEMP (see A.3.96).

A.3.33 Engineering and Manufacturing Development (EMD) Phase. The EMD phase is Phase II of the acquisition life cycle (see A.3.1). During this phase, the system is designed, fabricated, tested, and evaluated. The products of this phase are:

a. weapon system hardware to support EMD testing;

b. the documentation required to enter the production and deployment phase (see A.3.124); and

c. the documented analyses and tests that support the conclusion that the design that has been developed will satisfy all weapon system requirements.

Engineering and manufacturing development may be considered to consist of two parts. During the first part, the contractor (see A.3.21) allocates the hardness requirements of the WSS (see A.3.159) to the CIs (see A.3.20) under contract. This process concludes with a PDR (see A.3.122). During the second part, CI design is finalized and verified (see A.3.87). This process concludes with the FCA (see A.3.49).

A.3.34 Evaluation Tests. In this standard, evaluation tests are a subset of hardness tests (see A.3.85). They are conducted on selected items of hardware to evaluate compliance with applicable hardness requirements (see A.3.80). The test items are usually engineering models of hardware items that are complex enough to make the use of hardness analysis (see A.3.58) to evaluate hardness requirements compliance either infeasible or impractical. Even in cases where hardness analysis can be meaningfully implemented, evaluation tests are sometimes performed to provide additional confidence in the analytic results. Evaluation tests are used to support hardness verification (see A.3.87).

A.3.35 Facilities. As used in this standard, facilities refer to a building, structure, utility system, or other improvement to real property used in support of an ICBM weapon system.

A.3.36 Facilities A&E Contractor. See contractor, A.3.21.

A.3.37 Facilities Construction Bid Package. The facilities construction bid package refers to the engineering drawings and associated design documentation used for the procurement of a facility (see A.3.35). It is prepared by the facilities A&E contractor (see A.3.21) and is used in support of acquiring a facilities construction contractor (see A.3.21). All facilities hardness requirements must be expressed in the facilities construction bid package in terms of standard civil engineering terminology.

A.3.38 Facilities Construction Contractor. See contractor, A.3.21.

A.3.39 Facilities Criteria Input. The facilities criteria input is a document generated by AVE/SE contractors (see A.3.21) to identify to the facility design criteria contractor (see A.3.21) technical requirements associated with their AVE/SE that must be accommodated in the facility (see A.3.35) design. These requirements must be detailed enough to address all interfaces between the WSEs (see A.3.157) under consideration and the facility. If a particular interface involves A&CO installation hardware (see A.3.9), the facility criteria input will also address the requirements that must be imposed on facility design to enable it to accommodate this installation hardware.

A.3.40 Facilities Design Criteria. The facilities design criteria refer to the documentation prepared by the facility design criteria contractor (see A.3.21) that identifies the SPO's (see A.3.140) technical requirements, including hardness requirements (see A.3.80), for facility (see A.3.35) design. These requirements must be stated in the facility design criteria in such a way that they can be readily translated by the facilities A&E contractor (see A.3.21) into the facility construction bid package (see A.3.37) that will be used to acquire a facilities construction contractor (see A.3.38). In most cases, the nature of the facility hardness requirements will require the facility design criteria contractor to perform some hardness trade studies (see A.3.86), analyses (see A.3.58), and tests (see A.3.85) of facility hardware attenuation (see A.3.12), and withstand (see A.3.160) characteristics in order to be able to translate facility hardness requirements into standard civil engineering terminology.

A.3.41 Facilities Design Criteria Contractor. See contractor, A.3.21.

A.3.42 Factory Support Equipment (FSE). Factory support equipment refers to the equipment used in support of factory production operations. Whenever possible and cost-effective, it is desirable to include in the design of applicable FSE the capability to test the hardness characteristics of the CIs (see A.3.20) that will be evaluated by means of the FSE. Such a capability can contribute significantly to the cost-effective implementation of hardness assurance (see A.3.61). Since FSE is usually subsequently used as DSE (see A.3.25), it is particularly important to incorporate hardness considerations in the design of FSE. See also support equipment, A.3.131.

A.3.43 Figure A (Fig A). "Figure A" or "Fig A" is a legacy ICBM term. It refers to a hardware item and is the equivalent of a configuration item (CI) (A.3.20). The term was used by ICBM programs before the adoption of the modern common terminology (i.e., CI). The term, as applied to an item of hardware, arises from the fact that a "Figure A" is also a specification that is the equivalent of a modern Prime Item Development Specification (PIDS). The name for the original ICBM configuration item specification was "Figure A." Each specification had an identify number and that number became the simple reference designator for the hardware. It is believed that the specification document identified as "Figure A" existed first and the number assigned to it was then coined into the alternate reference to the hardware itself. For example, the end item known as the Programmer Group is Figure A 1201 has the specification whose number is S-133-001201 and a part of its title is similar to "Figure A 1201 - Programmer Group Model Specification".

A.3.44 Final Design. For AVE (see A.3.2) and SE (see A.3.131), the term final design refers to the design embodied in the engineering drawings for the CIs (see A.3.20) under contract that are reviewed by the SPO (see A.3.140) at FCA (see A.3.49) in support of accomplishing hardness qualification (see A.3.79). This design must satisfy all requirements of the applicable PIDS (see A.3.123), including hardness requirements (see A.3.80). With respect to the facilities (see A.3.35), the term final design refers to the design embodied in the as-built drawings.

A.3.45 Fragility. See hardness fragility, A.3.75.

A.3.46 Fragility Analysis. Fragility analysis refers to the calculation of transfer functions (see A.3.153) and fragility curves (see A.3.47) for selected nuclear environments and hardware elements, including an estimate of associated random and systematic uncertainties. Fragility analysis can include evaluation of the effects of selected nuclear environments on selected WSE constituent hardware elements at levels above and below specification levels. In addition, fragility analysis may also address alternate threats or new environment prediction methodologies defined by the SPO.

A.3.47 Fragility Curve. A fragility (see A.3.75) curve relates the probability of failure of a hardware item to the magnitude of applicable NWE (see A.3.114) to which the item is exposed. Fragility curves can be developed on the basis of fragility analysis (see A.3.46), fragility testing (see A.3.48), or the use of published data for the item's failure level. The presentation of these curves usually includes information on the associated random and systematic uncertainties.

A.3.48 Fragility Tests. Fragility tests are a subset of hardness tests (see A.3.85). They are conducted on selected items of hardware to determine the hardness fragility (see A.3.75), especially for the final design (see A.3.44). In general, the items of hardware selected to undergo fragility determination will be those identified as having the controlling hardness failure mechanisms. The objective of fragility tests is to generate hardware performance data resulting from NWE (see A.3.114) conditions above the specified hardness design constraint (see A.3.71). Fragility tests support system level assessment (see A.3.11).

A.3.49 Functional Configuration Audit (FCA). The FCA is a formal audit whose purpose is to validate that the development of a CI (see A.3.20) has been completed satisfactorily and that the CI has achieved the functional and performance characteristics required by the applicable specification. In addition, the completed operation and support documentation is reviewed.

A.3.50 Functional Failure. Functional failure refers to the inability of an item of hardware or software, at any level of assembly up to and including system level, to continue to function in the manner required by its intended application in the design.

A.3.51 Government Furnished Equipment (GFE). Government furnished equipment refers to items in the possession of or acquired directly by the government, and subsequently delivered or otherwise made available to a contractor (see A.3.21) for integration into a system or equipment.

A.3.52 Ground Shock. See shock, A.3.129.

A.3.53 Hardening. Hardening refers to the use of design techniques that increase the ability of a system or any of its constituent elements to withstand exposure to one or more effects of man-made hostile environments. The degree of hardening achieved in any specific instance for a particular hostile environment is designated by the maximum magnitude of the hostile environment at which the item hardened is still able to satisfactorily fulfill its design function. In this standard, hardening always refers to nuclear hardening (see A.3.108).

A.3.54 Hardness. Hardness is a measure of the ability of a system or any of its constituent elements to withstand exposure to one or more effects of man-made or natural hostile environments. In this standard, hardness always refers to nuclear hardness (see A.3.109).

A.3.55 Hardness Allocation. Hardness allocation refers to the process by which hardness requirements (see A.3.80) are distributed:

a. from the WSS (see A.3.159) to WSE (see A.3.157) specification documentation;

b. among the various WSEs that comprise a system; and

c. among and within the various hardware elements and levels of assembly that comprise a WSE.

It should be noted that the hardness allocation process narrows the choices of available design solutions.

A.3.56 Hardness Allocation Analysis. Hardness allocation analysis is a subset of hardness analysis (see A.3.58). It refers to the analytic activity performed by a WSE contractor (see A.3.21) to accomplish hardness allocations (see A.3.55) for the WSEs (see A.3.157) under contract. The AVE/SE contractor (see A.3.21) implements this activity not only for the CIs (see A.3.20) under contract, but also for any associated A&CO installation hardware (see A.3.9). It is important that all derived hardness requirements (see A.3.80) be consistent and traceable throughout all CI PIDS (see A.3.123), the ICDs (see A.3.94), the facility design criteria document (see A.3.40), and the A&CO TA (see A.3.10).

A.3.57 Hardness allocation trades. Hardness allocation trades are a subset of hardness trade studies (see A.3.86). They are performed by the WSE contractor (see A.3.21) to identify the most technically desirable and cost-effective distribution of specified attenuation (see A.3.12) and withstand (see A.3.160) requirements among the hardware elements that comprise a given WSE. Hardness allocation trades also include consideration by the WSE contractor of the possibilities for the attenuation of the NWE (see A.3.114) specified in the WSS (see A.3.159) by the WSEs of other contractors. Hardness allocation trades are conducted in support of SRR/SFR (see A.3.141, A.3.135) and support the identification of CIs (see A.3.20) by the AVE/SE contractor (see A.3.21).

A.3.58 Hardness Analysis. Hardness analysis refers to activities performed to determine by analytical means the propagation of NWE (see A.3.114) throughout a weapon system and the withstand (see A.3.160) capability of hardware elements to NWE. Hardness analyses are performed for various purposes during the system life cycle (see A.3.139) and may consist of varying degrees of complexity and sophistication. The categories of hardness analysis specifically addressed in this standard include:

a. system level analysis (see A.3.137);

b. hardness allocation analysis (see A.3.56);

c. hardness design analysis (see A.3.70);

d. hardness verification analysis (see A.3.88); and

e. fragility analysis (see A.3.46).

A.3.59 Hardness Annotations. Hardness annotations refer to the hardness dedicated symbols, notes, and other markings added to selected ICBM program data products to provide and highlight hardness related information. These data products consist of:

a. the engineering drawings (and associated parts lists) (see also HCI-A, A.3.66);

b. the LSAR (see A.3.101) for both system level and subsystem level LSA (see A.3.100);

c. the A&CO TA (see A.3.10); and

d. the TOs (see A.3.145).

The requirements for accomplishing these hardness annotations are contained in the contract documentation that controls the preparation of each of these data products (see the related tailoring in Appendix C). In addition to these hardness annotations, selected data products must also include, as appropriate, the documentation of hardness related test and inspection requirements associated with the purpose of the data product. The data products which need annotation are the engineering drawings, the LSAR, the A&CO TA, and the TOs.

A.3.60 Hardness Assessment. See assessment, A.3.11.

A.3.61 Hardness Assurance. Hardness assurance is a program element of LCH (see A.3.99). As applied to a given WSE (see A.3.157), it refers to those activities required to preserve the integrity of the hardness design (see A.3.69) contained in the approved final design (see A.3.44) throughout the production and deployment (see A.3.124) phase. The definition of a comprehensive hardness assurance program includes the following:

a. hardness assurance tests (see A.3.64), as required;

b. hardness assurance inspections (see A.3.62), as required;

c. the imposition of hardness assurance related requirements on existing contractor (see A.3.21) production control disciplines, including configuration control, parts/material control, production/manufacturing control, and quality assurance/quality control; and

d. the identification of a hardness assurance program management structure and associated procedures.

A.3.62 Hardness Assurance Inspections. Hardness assurance inspections refer to inspections (see A.3.76) performed in support of accomplishing hardness assurance (see A.3.61). Once a particular inspection activity is identified as required for the purposes of hardness assurance, the associated inspection requirements must be documented in the cognizant contractor's (see A.3.21) quality assurance planning and implementation documentation. During the production and deployment phase (see A.3.124), any hardness critical process (see A.3.67) identified on an engineering drawing must be verified by quality personnel that it was accomplished as specified during the manufacture and any hardness critical procedure (see A.3.67) identified in A&CO (see A.3.7) drawings or other A&CO documentation must undergo 100 percent inspection.

A.3.63 Hardness Assurance Lot Acceptance Testing (HALAT). Hardness assurance lot acceptance testing is a subset of hardness assurance testing (see A.3.64). It consists of the acceptance testing in one or more of the specified NWE (see A.3.114) of statistically based samples of hardware items selected from production, delivery, or other types of lots of such items procured in support of system production. The intent of this testing is to demonstrate statistically that the hardware items in the lot under evaluation are at least as hard in the environments of concern as the sample qualified prior to production and that the item manufacturing process has not changed to the detriment of the end product. Hardness assurance lot acceptance testing is performed most frequently to evaluate the response of semiconductor devices in nuclear radiation environments. The value of DM (see A.3.27) determined for a hardware element can affect decisions regarding the amount of HALAT required for that item. NOTE: This type of testing has historically also been called radiation lot acceptance testing (RLAT) or hardness assurance verification test (HAVT).

A.3.64 Hardness Assurance Tests. Hardness assurance tests are a subset of hardness tests (see A.3.85). Their primary purpose is to provide a direct measure, usually on a sample basis (see HALAT, A.3.63), of the hardness adequacy of production hardware. Decisions as to the nature and quantity of the hardness assurance testing to be performed for a particular WSE (see A.3.157) are based primarily on considerations of:

a. a review of the DM (see A.3.27) of all constituent HCIs (see A.3.65) of the WSE for all applicable NWE (see A.3.114); the lower the DM in a particular instance, the more likely that hardness assurance testing will be indicated;

b. the need to verify the adequacy of hardness design features (see A.3.72), such as C&R (see A.3.16), that are transparent, in whole or in part, to routine factory testing or inspection;

c. the need to obtain baseline data in support of planned hardness surveillance testing (see A.3.84); and

d. cost and schedule impacts and feasibility.

It is highly desirable to accomplish the goals of hardness assurance testing to the fullest extent possible through the inclusion in the design of FSE (see A.3.42) of the capability to evaluate hardness related characteristics of production hardware.

A.3.65 Hardness Critical Item (HCI). An HCI is defined to be an item of hardware or software that satisfies one or more of the following five rationales in any one or more of the applicable nuclear environments. More than one rationale may apply to a particular item, and, in such cases, different rationales may apply in different environments. Each candidate HCI must be reviewed separately for the applicability of each rationale in each applicable environment.

- HCI rationales:

1). Functionally required hardware (i.e., hardware that would continue to be included in the design even if all hardness requirements were removed) with the following characteristics:

a. the item is vulnerable to the applicable nuclear environment under consideration; and

b. the hardness design approach chosen for dealing with that vulnerability is to include additional provisions for hardness in some aspect of the item's procurement requirements, such as the item's specification, design, manufacture, or item selection process.

2). Functionally required hardware with the following characteristics:

a. the item does not satisfy rationale 1; and

b. its presence in the design is taken advantage of to also provide protection for the system or any of its elements against one or more of the applicable nuclear environments; for the purposes of providing this hardness protection function, the item may be used as-is, or it may be modified in some way to enhance its hardness protection capabilities.

3). Hardness dedicated hardware or software included in system design solely to help satisfy the specified hardness requirements. As contrasted with the non-hardness dedicated, functionally required hardware covered by rationales 1 and 2 above, hardness dedicated hardware and software would not be included in the design if hardness requirements had not been applied.

4). Hardware items to which a hardness critical process (see A.3.67) is applied during system fabrication, manufacture, or assembly, as identified in the applicable engineering drawings. The items selected to be identified as HCI in these cases shall be the highest level(s) of assembly directly involved with the hardness critical process that will enable clear traceability from the part number on the HCI list to the documentation of the hardness critical process in the applicable engineering drawings and the NH&S DAR (see A.3.110). The items identified as HCI to serve this traceability function may themselves have no special hardness characteristics.

5). A subassembly or higher level of assembly that contains one or more HCIs.

A.3.66 Hardness Critical Item - Application (concept and use). This term refers to a designator that distinguishes which uses (i.e., which locations within an assembly) are hardness critical and which are not. The designator is "HCI-A" and is used to identify HCI parts used in an application where the hardness matters (note that an HCI part can be used in locations where its hardness does not matter). The "HCI-A" is used in annotating flag notes on parts lists for drawings (see C.5.2.3), indentured parts lists or indentured bill of materials (when available and deliverable to the government), and in the HCI Index in the NH&S DAR (see 6.3, DI-ENVR-80266A).

HCIs are identified by a part number. Parts standardization efforts across a system may lead to use of a HCI in hardware with no requirement to survive or function during or after nuclear environments. Within hardware that does not need to survive, there can also be elements of the hardware to which the requirements do not apply (i.e., they need not survive and function). Applications of HCI part numbers in these locations are not hardness critical but without a designator to distinguish such applications from those that are hardness critical, the use of the HCI symbol identifier and including the part number in the HCI list provides no insight regarding hardness criticality in such locations. For long-term system sustainment during the operations and support phase, the use of substitutes in non-HCI-A applications need not be restricted to parts meeting the HCI requirements. Therefore, it is essential that this information be captured as part of the design process (i.e., the SPO must know which locations or use instances are important to hardness and where one need not conform to the hardness requirements..

A.3.67 Hardness Critical Process/Procedure (HCP). The terms "hardness critical process" and "hardness critical procedure" refer to two related but different concepts that are both represented by the same symbol "HCP". A hardness critical process is any fabrication, manufacturing, or assembly activity identified on an engineering drawing that supports the implementation of a hardness design feature (see A.3.72). Note that a hardness critical process results in the identification of additional HCIs (see A.3.65). In contrast, a hardness critical procedure is a particular task or activity performed to accomplish facility (see A.3.35) construction, A&CO (see A.3.7), or maintenance and repair (via TO) with the following characteristics:

a. it is noted in some type of procedural document, such as a TO (see A.3.145) or other procedural instructions;

b. it satisfies one or more of the following three conditions:

1). Its implementation impacts the initial establishment (as in facility construction or A&CO) or the restoration (as in maintenance and repair) of the hardened configuration provided for in the design;

2). Its implementation involves working on or near a HCI in a manner that could result in unacceptable, inadvertent damage to the HCI; and

3). its purpose is to accomplish implementation of a hardness specific test or inspection; and

c. it does not result in the identification of additional HCIs (see A.3.65).

A.3.68 Hardness Data Manual (HDM). A hardness data manual (HDM) is the precursor of the NH&S DAR. HDMs are organized into 5 sections. Section 1 provides the physical and functional description of the Figure A (A.3.43)/ CI (A.3.20). Section 2 provides the HCI Index and the references listing. Section 3 provides the design requirements, design verification, and design qualification details. Section 4 provides recommendations for the hardness maintenance during the operations and support phase. Section 5 addresses TO considerations for HCIs. HDMs are existing documents that need to be updated as the system is modified.

A.3.69 Hardness Design. Hardness design refers both to the process and end result of creating a design which satisfies specified or allocated hardness requirements (see A.3.80). Hardness design must be accomplished without violating any other specified design requirement or constraint.

A.3.70 Hardness Design Analysis. Hardness design analysis is a subset of hardness analysis (see A.3.58). It refers to the hardness analysis activities performed in support of the development of the hardness design (see A.3.69) of a WSE (see A.3.157) from its preliminary design (see A.3.121) through to its final design (see A.3.44). For AVE/SE, the hardness design analysis performed in support of CDR (see A.3.22) is considered to be its hardness verification (see A.3.87) analysis.

A.3.71 Hardness Design Constraints. Hardness design constraints are a subset of hardness requirements (see A.3.80). They are commonly referred to as withstand (see A.3.160) requirements. They refer to the specific NWE (see A.3.114) and their associated characteristics, such as magnitude, time duration, spectrum, and multiplicity, after, and sometimes during, exposure to which a given item of hardware must continue to function in such a way as to meet specified performance requirements in the applicable requirements documentation. Hardness design constraints are documented:

a. for the system, in the WSS (see A.3.159);

b. for CIs (see A.3.20) in the applicable PIDS (see A.3.123);

c. for facilities (see A.3.35) and RPIE (see A.3.127) in the facility design criteria (see A.3.40); and

d. for A&CO installation hardware (see A.3.9) in the A&CO TA (see A.3.10).

A.3.72 Hardness Design Feature. A hardness design feature is an implemented design approach that is used to accomplish hardness design (see A.3.69) and that therefore supports the satisfaction of system hardness requirements (see A.3.80).

A.3.73 Hardness Design Trades. Hardness design trades are a subset of hardness trade studies (see A.3.86). They are performed by the WSE contractor (see A.3.21) to determine the most desirable design solutions for satisfying the given WSEs (see A.3.157) hardness requirements (see A.3.80). Hardness design trades also include consideration, as appropriate, of the other requirements, in addition to hardness, imposed on the WSE design. For the AVE/SE contractor (see A.3.21), hardness design trade studies are performed in support of PDR (see A.3.122) and CDR (see A.3.22).

A.3.74 Hardness Evaluation. Hardness evaluation refers to the activities undertaken to determine if the detail and final designs meet all applicable hardness requirements. System level hardness evaluation is usually accomplished by some combination of analysis and test, as defined in the TEMP (see A.3.148) and as performed by the SS&I contractor (see A.3.21). The hardness evaluation of individual WSEs includes the following activities:

a. hardness verification (see A.3.87) in support of CDR (see A.3.22); and

b. hardness qualification (see A.3.79) in support of FCA (see A.3.49).

Although hardness evaluation activities occur primarily during EMD (see A.3.33), they may be performed at other points in the system life cycle (see A.3.139), as required. The concept of hardness evaluation applies both to developmental (see A.3.30) and non-developmental (see A.3.104) hardware. Hardness evaluation is a contractor (see A.3.21) activity, as contrasted with hardness assessment (see A.3.11), which is an Air Force activity supported by contractor inputs.

A.3.75 Hardness Fragility. Hardness fragility is the level of a nuclear environment that causes an item to fail. Individual items of hardware within a system population will typically fail over a range of environment levels resulting in a distribution of failures over that range. It is expressed as the cumulative probability that an item of hardware will fail to perform satisfactorily as a function of the magnitude of the applied nuclear environment or associated coupled stress that produces failure. Hardness fragility is determined by analysis or test or by some combination of these two activities. Hardness fragility data are used in support of system level assessments (see A.3.11). Failure to collect fragility data for each item in a system makes an accurate assessment of survivability difficult if not impossible. It is most cost-effective to collect the data as each item is acquired rather than waiting to perform the testing and analysis later in a life-cycle when assets are needed to sustain the system life and are generally unavailable for such destructive testing. When analysis is used to assess fragilities, the uncertainties may be so great that the analysis is ineffective. Therefore testing is most often required to determine fragility.

A.3.76 Hardness Inspections. Hardness inspections refer to inspections of hardness related characteristics of weapon system hardware elements at any level of assembly. Such hardness inspections may be performed in support of hardness qualification (see A.3.79), hardness assurance (see A.3.61), and hardness surveillance (see A.3.81). In the context of the qualification of CIs, which is performed in conformance with the quality conformance methodology identified in section 4 of the applicable PIDS, the term inspection is defined in a very broad manner that includes the activities of elimination, demonstration, test, and analysis. Such a broad definition does not apply to the concept of hardness inspection as it is implemented for hardness assurance and hardness surveillance. In these cases, hardness inspection is most similar to the qualification inspection activity called examination, which is defined as being nondestructive, and as including visual inspection, simple physical manipulation, gauging, and measurement.

A.3.77 Hardness Maintenance. Hardness maintenance is a program element of LCH (see A.3.99). It refers to those activities conducted by the SPO to maintain and preserve the hardness of a deployed weapon system throughout its operational life especially with respect to spares procurement and repair actions as well as activities such as corrosion prevention, etc. The acquisition organization with the SPO's (see A.3.140) role in hardness maintenance is to prepare a hardness maintenance capability for later use by the SPO organization responsible for survivability during the operations and support phase. Contractors (see A.3.21) support the SPO in this effort through HCI/HCP (see A.3.65 and A.3.67, respectively) identification; the hardness annotation (see A.3.59) of selected data products, including drawings (and associated parts lists), the portions of the SRA (see A.3.142), and TOs (see A.3.145); and preparation of the NH&S program plan and NH&S DAR.

A.3.78 Hardness Performance Requirements. Hardness performance requirements are a subset of hardness requirements (see A.3.80). They refer to the hardness related performance characteristics imposed on a WSE (see A.3.157) design. The majority of hardness performance requirements refer to the required amount a WSE has to attenuate or limit an NWE (see A.3.114). The purpose of attenuating an NWE is to protect more susceptible hardware items. The attenuated NWE becomes a hardness design constraint (see A.3.71) for the protected hardware items. Another type of hardness performance requirement is C&R (see A.3.16) requirements for nuclear radiation. Hardness performance requirements are documented:

a. for the system in the WSS (see A.3.159);

b. for CIs (see A.3.20) in the applicable PIDS (see A.3.123);

c. for facilities (see A.3.35) and RPIE (see A.3.127) in the facility design criteria (see A.3.40); and

d. for A&CO installation hardware (see A.3.9) in the A&CO TA (see A.3.10).

A.3.79 Hardness Qualification. Hardness qualification is the program activity in which the WSE contractor (see A.3.21) establishes that contractor hardware that is representative of the approved final design (see A.3.44) satisfies all specified hardness requirements (see A.3.80). For CIs, it is accomplished at FCA (see A.3.49) through implementation of the quality conformance methodology identified in section 4 of the controlling PIDS (see A.3.123). Hardness qualification is usually performed on prototype or preproduction hardware. However, when such hardware is not available, it is performed on a first production article.

A.3.80 Hardness Requirements. Hardness requirements consist of the hardness design constraints (see A.3.71) and hardness performance requirements (see A.3.78) imposed on a system and its constituent elements by virtue of the NH&S requirements contained in the applicable WSS (see A.3.159). Hardness requirements are documented:

a. for CIs (see A.3.20) in the applicable PIDS (see A.3.123) and ICDs (see A.3.94);

b. for facility (see A.3.35) hardware and RPIE (see A.3.127) in the facility design criteria (see A.3.40); and

c. for A&CO installation hardware (see A.3.9) in the A&CO TA (see A.3.10).

Quite often, the hardness performance requirement for one system element will constitute a hardness design constraint for another system element.

A.3.81 Hardness Surveillance. Hardness surveillance is a program element of LCH (see A.3.99). It consists of a program of periodic hardness tests (see A.3.85) and inspections (see

A.3.76) of a deployed weapon system with the purpose of identifying in a timely manner any degradations that reduce the hardness of the fielded system. Such degradations may be due to aging, the effects of the ambient environment and continuous operation, and maintenance actions.

A.3.82 Hardness Surveillance Inspections. Hardness surveillance inspections refer to those hardness inspections (see A.3.76) performed in support of accomplishing hardness surveillance (see A.3.81). Based on the recommendations of its WSE contractors (see A.3.21), as documented in their individual hardness surveillance plans submitted to the SPO (see A.3.140), the SPO will include in its system level hardness surveillance plan those hardness surveillance inspections that are considered to be high priority, feasible, and cost-effective. Hardness surveillance inspections will be implemented by the SPO (A.3.140) in cooperation with the operating command (see A.3.115) periodically during the operations and support phase (see A.3.118).

A.3.83 Hardness Surveillance Support Contractor. See contractor, A.3.21.

A.3.84 Hardness Surveillance Tests. Hardness surveillance tests refer to those hardness tests (see A.3.85) performed in support of accomplishing hardness surveillance (see A.3.81). Based on the recommendations of its WSE contractors (see A.3.21), as documented in their individual hardness surveillance plans submitted to the SPO (see A.3.140), the SPO will include in its system level hardness surveillance plan those hardness surveillance tests that are considered to be high priority, feasible, and cost-effective. Hardness surveillance test may be performed either at the operational facilities (see A.3.35) or in a laboratory setting. The latter are often similar to or identical with prior hardness assurance tests (see A.3.64). Hardness surveillance tests will be implemented by the SPO organization responsible for operational system survivability periodically during the operations and support phase (see A.3.118).

A.3.85 Hardness Tests. Hardness tests refer to tests performed to determine the response of weapon system hardware elements, at any level of assembly ranging from piece parts up through the system level, to exposure to either direct or simulated NWE (see A.3.114). Hardness tests are performed for various purposes throughout the system life cycle (see A.3.139). The categories of hardness testing specifically addressed in this standard include:

a. system level tests (see A.3.144);

b. development tests (see A.3.31);

c. evaluation tests (see A.3.34);

d. qualification tests (see A.3.126);

e. fragility tests (see A.3.48);

f. hardness assurance tests (see A.3.64), including HALAT (see A.3.63); and

g. hardness surveillance tests (see A.3.84).

A.3.86 Hardness Trade Studies. Hardness trade studies refer to studies, supported by hardness analysis (see A.3.58) and testing (see A.3.85), as required, to evaluate:

a. alternative system designs;

b. alternative allocations of hardness requirements (see A.3.80) among system elements; and

c. alternative WSE (see A.3.157) design approaches to satisfying these requirements.

The categories of hardness trade studies specifically addressed in this standard include:

a. system level trade studies (see A.3.138);

b. hardness allocation trades (see A.3.57); and

c. hardness design trades (see A.3.73).

A.3.87 Hardness Verification. Hardness verification refers to the activity during which it is established that the detail design (see A.3.29) satisfies all specified hardness requirements (see A.3.80). This activity is implemented on both an individual WSE (see A.3.157), as well as a system level. Hardness verification is accomplished by a review of existing hardness analysis (see A.3.58) and test (see A.3.85) data and the engineering drawings for the hardware element or system under consideration. This activity may be augmented, as required, by additional tests and analyses. For CIs, hardness verification is accomplished at the CDR (see A.3.22). Other terms that have sometimes been used to represent the hardness verification activity are "hardness demonstration" and "hardness validation". For purposes of standardization, these terms are not used in this standard.

A.3.88 Hardness Verification Analysis. See hardness design analysis, A.3.70.

A.3.89 Hardware Category. The term hardware category is used in this standard to distinguish between different kinds of hardware groupings that have some distinguishing characteristic relevant to the content of this standard. The following five types of hardware categories are referred to in this standard:

a. constituent ICBM WSEs (see A.3.157), consisting of AVE (see A.3.2), SE (see A.3.131), facilities (see A.3.35) and RPIE (see A.3.127), and A&CO installation hardware (see A.3.9); the latter is usually not considered to be a distinct weapon system element, but its separate identification is relevant to this standard;

b. CFE (see A.3.23) versus GFE (see A.3.51);

c. NDI (see A.3.104) versus developmental items (see A.3.30);

d. commercial versus military NDI and modified versus unmodified NDI; and

e. CIs (see A.3.20) versus items that are not CIs, such as facilities and RPIE.

A.3.90 High Altitude Electromagnetic Pulse (HEMP). High altitude electromagnetic pulse is a particular type of EMP (see A.3.32). It consists of transient electromagnetic energy generated by the interaction of nuclear ionizing radiation with the upper atmosphere and the earth's magnetic field, resulting in both an early-time transverse electromagnetic wave and a late-time quasi-static field.

A.3.91 Inherent Hardness. The inherent hardness of an item of hardware (at any assembly level up to system level) refers to the capability of the hardware item to withstand (see A.3.160) exposure to some designated set of NWE (see A.3.114) without the need for additional hardness design. Inherent hardness is a relative term and must always be referred to in terms of specific magnitudes of particular nuclear environments. No item has complete inherent hardness with respect to all magnitudes of all environments.

A.3.92 Initial Capabilities Document. The initial capabilities document states one or more new capability requirements and associated capability gaps. The initial capabilities document also documents the intent to partially or wholly address identified capability gap(s) with a non-materiel solution, materiel solution, or some combination of the two. An initial capabilities document may lead directly to a Capability Production Document, if capability requirements and associated and capability gaps can be satisfied though Commercial Off-the-Shelf (COTS) (see A.3.17), Government Off-the-Shelf (GOTS) (either as GFE or other existing military items - see Table II), or Non-Developmental Items (NDI) (see A.3.104), with no significant development or integration efforts.

A.3.93 Inspections. See hardness inspections, A.3.76.

A.3.94 Interface Control Drawing (ICD). An ICD depicts the physical and functional interface engineering requirements of an item that affects the design or operation of co-functioning items. These drawings are used as design control documents in order to:

a. establish and maintain compatibility between co-functioning items, including envelope and access compatibility;

b. control interface designs; and

c. communicate design decisions and changes to participating contractors (see A.3.21) and concerned government agencies.

Interface control drawings must include applicable hardness requirements and address hardness concerns in such a way that the two (or more) organizations involved in the interface will always continue to meet the hardness requirements.

A.3.95 Interface Control Working Group (ICWG). The ICWG serves as the official communications link between program participants to resolve interface problems, document interface agreements, and coordinate on engineering change proposals (ECPs). It consists of at least one member from each of the contractor (see A.3.21) and government agencies participating in system development.

A.3.96 Internal Electromagnetic Pulse (IEMP). See system generated electromagnetic pulse, A.3.136.

A.3.97 Key Performance Parameter (KPP). A KPP is a performance attribute of a system considered critical or essential to the development of an effective military capability. KPPs are contained in the Capability Development Document (CDD) and the Capability Production Document and are included verbatim in the Acquisition Program Baseline. KPPs are expressed in term of parameters which reflect Measures of Performance using a threshold/objective format. KPPs must be measurable, testable, and support efficient and effective Test and Evaluation. Mandatory KPPs are specified in the Joint Capabilities Integration and Development System Manual (see https://dap.dau.mil/glossary for any future updates of this definition).

A.3.98 Key System Attribute (KSA). Performance attribute of a system considered important to achieving a balanced solution/ approach to a system, but not critical enough to be designated as a Key Performance Parameter (KPP) (see A.3.97). KSAs must be measurable, testable, and support efficient and effective Test and Evaluation. KSAs are expressed in terms of Measures of Performance (see https://dap.dau.mil/glossary for any future updates of this definition).

A.3.99 Life Cycle Hardness (LCH). Life cycle hardness refers to that part of an overall system hardness program concerned with ensuring that a system that has been successfully designed to satisfy specified hardness requirements (see A.3.80) will continue to satisfy those requirements during the production and deployment, and operations and support phases. Thus, the key concept in LCH is the preservation throughout the remainder of the system life cycle (see A.3.139) of the hardness provided for in the design. By definition, LCH has been divided into three major program elements. During system production and the A&CO (see A.3.7) activity, the relevant LCH activity is referred to as hardness assurance (see A.3.61). Throughout the system's subsequent operational life, hardness assurance (HA) refers to activities dealing with spares procured to be used in system repairs and procurement of new or replacement hardware in system modifications. In addition to HA during the operations and support phase, the required LCH activities are provided by two additional program elements referred to as hardness maintenance (see A.3.77) and hardness surveillance (see A.3.81). There are several activities during EMD that prepare the necessary plans, reports, and other documentation needed to support the LCH activities. Section 5.5 of this standard addresses the implementation of these three efforts during the operations & support phase.

A.3.100 Logistic Support Analysis (LSA). Logistic support analysis is one of the four elements of SRA (see A.3.142). It is the systematic analytic methodology by which the logistics support requirements of the weapon system are identified, including hardness related logistics support requirements. The results of the LSA activity are documented on data forms referred to as LSA records (LSAR) (see A.3.101).

A.3.101 Logistic Support Analysis Record (LSAR). The LSAR consists of a set of seven data forms on which the results of the LSA (see A.3.100) activity are documented. Three of these forms, the B, D1, and H data sheets, require hardness annotation (see A.3.59).

A.3.102 Maintenance Support Equipment (MSE). Maintenance support equipment is that category of support equipment (see A.3.131) required to restore a system or any of its constituent elements to operating condition. As contrasted with OSE (see A.3.117), MSE is not an essential, functional part of the system or system element being supported. The operating procedures defined for a system may sometimes cause some elements of MSE to have hardness requirements (see A.3.80). See also DSE, A.3.25; and FSE, A.3.42.

A.3.103 Materiel Solution Analysis Phase. The materiel solution analysis phase is Phase 0 of the acquisition life cycle (see A.3.1). It extends from the determination of a needed operational capability major upgrade or system replacement to the program decision that authorizes the implementation of the technology maturation and risk reduction phase (see A.3.146). During the materiel solution analysis phase, the system concepts that warrant further development in response to the identified operational need are defined and selected.

A.3.104 Non-Developmental Item (NDI). An NDI is an item of existing, developed, and available hardware or software that may be capable of fulfilling DoD requirements, thereby minimizing or eliminating the need for costly government-sponsored research and development programs. Non-development items consist of the following categories of items:

a. any item of supply that is available in the commercial marketplace;

b. any previously developed item of supply that is in use by a department or agency of the United States, a state or local government, or a foreign government with which the United States has a mutual defense cooperation agreement; and

c. any item of supply described in (a) or (b) that requires only minor modification in order to meet the requirements of the SPO.

A.3.105 Nuclear Environment/Effect Hardness Element Matrix (NEEHEM). The NEEHEM is a program planning tool (viz., it is a table with rows and columns) prepared by a contractor (see A.3.21) to identify the planned hardness evaluation/verification methods of each constituent hardware element in the WSEs under contract impacted by the specified NWE (see A.3.114) and is used throughout the program to identify the status of hardness evaluation/verification and qualification in preparation for CDR and qualification. The NEEHEM is first used as a hardness evaluation management and tracking tool by both the SPO and the contractor in the NH&S program plan, and seconds, as an index to the hardness evaluation content of the NH&S DAR (see A.3.110). It must be completed by PDR in order to support completion of the NH&S program plan for EMD execution between PDR and CDR and as the starting content guide for the NH&S DAR. An example NEEHEM can be found in DID DI-ENVR-82097, NH&S Program Plan and in DID DI-ENVR-80266A because the NEEHEM is used in connection with both documents.

A.3.106 Nuclear Environments. See nuclear weapon effects/environments, A.3.114.

A.3.107 Nuclear Event Protection (NEP). Nuclear event protection refers to specific electronic design techniques implemented to protect mission critical hardware from nuclear radiation environments. These design techniques include circumvention and recovery (see A.3.16), photocurrent compensation, and current limiting.

A.3.108 Nuclear Hardening. Nuclear hardening refers to the employment of design techniques that increase the ability of a system to withstand (see A.3.160) exposure to one or more of the specified NWE (see A.3.114) without suffering an unacceptable change in performance characteristics. The nuclear hardening requirements associated with a given system can sometimes be reduced through modification of operational procedures.

A.3.109 Nuclear Hardness. Nuclear hardness is a measure, expressed in terms of applicable nuclear environment magnitude(s), of the ability of a system, or any of its constituent elements, to withstand (see A.3.160) exposure to one or more NWE (see A.3.114) without suffering an unacceptable change in performance characteristics.

A.3.110 Nuclear Hardness and Survivability Design Analysis Report (NH&S DAR). The NH&S DAR is a comprehensive report in which the AVE/SE contractor (see A.3.21) documents the approach, methodology, and results of the hardness design (see A.3.69) and evaluation (see A.3.74) activities performed for developmental items (see A.3.30) and the hardness evaluation activity performed for non-developmental items (see A.3.104). This report is used by the government during CDR, FCA, and near the end of production to evaluate the degree to which the contractor has demonstrated the satisfaction of all applicable hardness requirements (see A.3.80); and during the operations and support phase to aid in the evaluation of the hardness impact of redesign/modification/upgrade and other logistics support actions such as the evaluation of alternate parts or suppliers. The DAR is a configuration controlled drawing and is to be continuously updated during the program because it serves as the source for authoritative HCI information and many program tasks require that information. In addition, it must be kept up to date during the life of the system so that, whenever logistics actions are necessary to continue operation, the details of why an item is HCI, how it was qualified, what acceptance tests are needed, and how it is best purchased at a later date are contained in the DAR.

Access to information related to specific HCIs (see A.3.65) is provided by a comprehensive HCI list that, in addition to the NEEHEM, is the major focus for the organization of the NH&S DAR.

The HCI list in the NH&S DAR is a critical resource for weapon system life cycle hardness (see A.3.99), used by both the contractor and the SPO. It is used by the contractor as the authoritative source of HCI identification in all contract activities in which HCI identification and documentation plays a role, including the hardness annotation of engineering drawings (and associated parts lists), the A&CO TA, the LSA, and TOs. For this reason, it is critical that the contractor ensure that the NH&S DAR is maintained as a configuration controlled document that is reviewed and approved by the contractor's NH&S personnel. The contractor shall ensure that no additions, deletions, or other changes to the NH&S DAR are made unless the configuration management personnel have coordinated and received the explicit approval of the cognizant NH&S personnel for the program. The NH&S DAR HCI List is sometimes referred to as the HCI index. The NH&S DAR HCI List is used by the SPO as the basis for identifying and preserving the nuclear hardness in the design of each weapon system element that has hardness requirements applied to it.

When a hardness critical process (HCP) (A.3.67) is applied to or used to make a part, the part becomes HCI by Rationale 4 (see A.3.65 and D.4.3.2.1). The HCI list leads to DAR paragraphs that provide the explanation of what about the HCP is important to achieving the specified hardness level (A.3.80).

A.3.111 Nuclear Radiation. Nuclear radiation is one of the NWE (see A.3.114). It consists of atomic and nuclear particles and photons emanating directly from a nuclear detonation or from subsequent interactions of this radiation with the surrounding media. The important nuclear radiations from a weapon effects standpoint include prompt x-rays, prompt gammas, secondary gammas, fast neutrons, thermal neutrons, and fallout. An important nuclear radiation environment is a combined ionization pulse consisting of a prompt pulse followed immediately by a delayed pulse. Nuclear radiation produces both permanent and transient effects.

A.3.112 Nuclear Radiation Characterization. Nuclear radiation characterization refers to a category of development test (see A.3.31) that consists of the measurement of the electrical parameters of a semiconductor device as a function of increasing magnitudes of individual radiation environments. Testing is continued and device parameters are recorded until either parameter functional failure (see A.3.50) is observed or the limits of the particular simulator being used are reached. The data obtained are used:

a. as inputs to the device specification end-of-life table;

b. as input data in support of analysis activities; and

c. to determine the device's design margins (see A.3.27); these are subsequently utilized to determine the magnitude of HALAT (see A.3.63) required to assure the hardness of higher levels of assembly using the particular part. See Appendix E for further information and understanding.

A.3.113 Nuclear Survivability. Nuclear survivability is a measure of the capability of a system to withstand (see A.3.160) the environments and associated effects produced by a hostile nuclear attack without suffering an abortive impairment of its ability to accomplish its designated mission. Nuclear survivability of ICBM weapon system may be accomplished by a number of methods, including nuclear hardening (see A.3.108), concealment, avoidance, and proliferation. This standard addresses only the nuclear hardness aspects of accomplishing nuclear survivability.

A.3.114 Nuclear Weapon Effects/Environments (NWE). Nuclear weapon effects/environments refer to the primary nuclear weapon environments and all associated hardware stresses experienced by a weapon system as result of the detonation of a nuclear weapon. Primary nuclear environments, which may result directly from the weapon detonation or from subsequent interactions of weapon products with the air and earth, are usually grouped into the following six categories:

a. EMP (see A.3.32);

b. nuclear radiation (see A.3.111);

c. thermal radiation (see A.3.150);

d. blast (see A.3.14);

e. shock (see A.3.129); and

f. debris (see A.3.24).

Hardware stresses are caused by the interaction of primary environments with a weapon system, or with other hardware connected to a weapon system. Nuclear weapon effects/environments are identified as hardness design constraints (see A.3.71) in the applicable requirements documentation. The functions of attenuating and shielding NWEs are identified as hardness performance requirements (see A.3.78).

A.3.115 Operating Command. The operating command is the command assigned responsibility for operating a weapon system throughout its operational life.

A.3.116 Operational Requirements Analysis (ORA). Operational requirements analysis is one of the four elements of SRA (see A.3.142). It is the systematic analytic methodology by which the operational requirements of the weapon system, including those related to and impacted by NH&S considerations, are identified.

A.3.117 Operational Support Equipment (OSE). Operational support equipment refers to all items of support equipment (see A.3.131) that are a functional part of a system and are required in order for the system and its constituent elements to be operational in their intended environment. For purposes of configuration management, the SPO (see A.3.140) procures OSE in equipment groupings that are treated as individual CIs (see A.3.20), each with its own PIDS (see A.3.123). See also WSE, A.3.157.

A.3.118 Operations and Support Phase. The operations and support phase is part of Phase IV of the system life cycle (see A.3.139). During this phase, the system that was designed and produced in response to an identified operational need is maintained on full operational status until it is determined that the need no longer exists, and the system is deactivated and removed from the field. The key hardness tasks during this phase are implementation of hardness maintenance (see A.3.77) and hardness surveillance (see A.3.81).

A.3.119 Performance Requirements. See hardness performance requirements, A.3.78.

A.3.120 Physical Configuration Audit (PCA). The PCA is the formal examination of the as-built version of a CI (see A.3.20) against its design documentation in order to verify that the CI as-built conforms to the technical documentation that defines the CI, and to thereby establish the product baseline. The PCA includes a detailed audit of engineering drawings including the completeness and correctness of hardness annotations (see A.3.59).

A.3.121 Preliminary Design. For AVE (see A.3.2) and SE (see A.3.131) hardware, the term preliminary design refers to the design used to support the development of PIDS (see A.3.123) for the CIs (see A.3.20) under contract. This level of design must be developed enough to support a meaningful allocation of WSS (see A.3.159) requirements to CI PIDS requirements, including the allocation of hardness requirements (see A.3.80). Aspects of the preliminary design may change with the design process through EMD (see A.3.33). For the facilities (see A.3.35), the term preliminary design refers to the design that has evolved subsequent to the concept design (see A.3.19) but prior to the detail design (see A.3.29) that will be used as the basis for the facilities construction bid package (see A.3.37).

A.3.122 Preliminary Design Review (PDR). The PDR is a formal technical review of the CI PIDS and the adequacy of the design approach for a CI (see A.3.20) as represented by the preliminary design (see A.3.121). Among the items presented for review are trade study (see A.3.86) results. Of prime concern to the NH&S program are:

a. the traceability of CI hardness requirements to the WSS (see A.3.159) hardness requirements;

b. the compatibility of CI hardness requirements with other CI requirements;

c. the consistency of hardness requirements between CIs;

d. the identification of the verification (see A.3.87) approach to be used for each CI hardness requirement; and

e. the identification of interface hardness requirements (see A.3.94) with other WSEs (see A.3.157).

A.3.123 Prime Item Development Specification (PIDS). The PIDS establishes the performance, design, development, and test requirements for those elements of a system that the government decides will be procured as separate CIs (see A.3.20). The hardness performance requirements (see A.3.78) associated with a CI are identified in the main body of the PIDS. The details of the applicable hardness design constraints (see A.3.71) are usually provided in a classified appendix.

A.3.124 Production and Deployment Phase. The production and deployment phase is Phase III of the acquisition life cycle (see A.3.1). During this phase, all elements of the system are united, culminating in the delivery of an acceptable integrated system from the SPO (A.3.140) to the operating command (A.3.115). The phase extends from production approval until the last system is deployed.

A.3.125 Qualification. See hardness qualification, A.3.79.

A.3.126 Qualification Tests. Qualification tests are a subset of hardness tests (see A.3.85). They are conducted, as required by Section 4 of the applicable PIDS (see A.3.123), on hardware representative of the production hardware to support WSE (see A.3.157) hardness qualification (see A.3.79). The objective of qualification tests is to establish by direct measurement that production configuration hardware satisfies specified hardness requirements.

A.3.127 Real Property Installed Equipment (RPIE). Real property installed equipment are those items of government-owned or -leased accessory equipment, apparatus, and fixtures that aid in the function of a facility (see A.3.35) and are permanently attached to, integrated into, built in, or on the facility.

A.3.128 Shielding Topology. Shielding topology is a term used to describe the various layers of electromagnetic shielding and protection features used to attenuate and mitigate EMP (see A.3.32) effects. The shielding topology is documented in a shielding topology diagram included in NH&S DAR(s) (see A.3.110), as applicable. These shielding topology diagrams support:

a. the hardness allocation process (see A.3.55);

b. the hardness design development process; and

c. the hardness verification (see A.3.87) and qualification (see A.3.79) processes.

A.3.129 Shock. Shock, or ground shock, is one of the NWE (see A.3.114). It consists of the stress waves propagated through the earth or water medium surrounding ground zero. It results in structural or equipment shock-induced response of facilities (see A.3.35), SE (see A.3.131), and AVE (see A.3.2). Shock can produce transient responses, which include large material deflections, relative motions, high accelerations, and resulting stresses. Additionally, permanent material deformations and displacements are possible.

A.3.130 Source Region Electromagnetic Pulse (SREMP). Source region electromagnetic pulse is a particular type of EMP (see A.3.32). It refers to the electromagnetic energy near a nuclear weapon detonation that is generated by interaction of nuclear ionizing radiation with the surrounding media.

A.3.131 Support Equipment (SE). Support equipment refers to all equipment required to make or to keep a system and all of its constituent elements operational in their intended environment. Support equipment may be functionally sub-classified as OSE (see A.3.117) and MSE (see A.3.102). Maintenance support equipment includes DSE (see A.3.25) and FSE (see A.3.42). Support equipment is usually procured as CIs (see A.3.20), each with its own PIDS (see A.3.123).

A.3.132 Survivability. Survivability is the capability of a system to withstand (see A.3.160) a hostile attack without suffering an abortive impairment of its ability to accomplish its designated mission. In this standard, survivability always refers to nuclear survivability (see

A.3.113) and is a probability between zero and one. It is dependent upon threat, scenario of threat employment, and the design and concept of operations of the system.

A.3.133 Survivability Assessment. See assessment, A.3.11.

A.3.134 System Engineering and Technical Assistance (SE/TA) Contractor. See contractor, A.3.21.

A.3.135 System Functional Review (SFR). The SFR is a multi-disciplined technical review to ensure that the system's functional baseline is established and has a reasonable expectation of satisfying the requirements of the Initial Capabilities Document or draft Capability Development Document (CDD) within the currently allocated budget and schedule. It completes the process of defining the items or elements below system level (See https://dap.dau.mil/glossary for any future updates of this definition).

A.3.136 System Generated Electromagnetic Pulse (SGEMP). System generated electromagnetic pulse is a particular type of EMP (see A.3.32). It consists of the electromagnetic energy generated by the interaction of nuclear ionizing radiation with system hardware. A subset of SGEMP is referred to as internal electromagnetic pulse (IEMP). This consists of the electromagnetic field generated inside an enclosure as a result of the interaction of ionizing radiation with the material of the enclosure.

A.3.137 System Level Analysis. As used in this standard, the term system level analysis refers to the activity conducted to evaluate aspects of the system related to nuclear hardness. System level analyses can be conducted by:

a. the SPO (see A.3.140);

b. a contractor (see A.3.21) under SPO direction IAW the TEMP (see A.3.148) or other approved test plan; or

c. the operating command (see A.3.115)

A.3.138 System Level Trade Study. System level trade studies are conducted by the SPO (see A.3.140), or by the contractor (see A.3.21) under SPO direction, to support the development of a system concept design.

A.3.139 System Life Cycle. The system life cycle refers to the total set of program phases a system passes through from the time it is initially conceived and developed until the time it is deactivated and removed from operational use. Phase 0 through Phase IV of the system life cycle are referred to as the acquisition life cycle (see A.3.1). One or more of the phases in the acquisition life cycle may also apply to major upgrade or system replacement actions.

A.3.140 System Program Office (SPO). The SPO is the organization consisting of technical, administrative, and management personnel assigned full time to the system program manager. It is the organization responsible for a system during its acquisition life cycle (see A.3.1) and throughout its life in the operations and support phase.

A.3.141 System Readiness Review (SRR). The SRR is a multi-disciplined technical review to ensure that the system under review can proceed into initial systems development, and that all system requirements and performance requirements derived from the Initial Capabilities Document or draft Capability Development Document are defined and testable, and are consistent with cost, schedule, risk, technology readiness, and other system constraints. Generally this review assesses the system requirements as captured in the system specification, and ensures that the system requirements are consistent with the approved materiel solution (including its support concept) as well as available technologies resulting from the prototyping effort. It is held normally during the Technology Maturation and Risk Reduction (TMRR) phase (See https://dap.dau.mil/glossary for any future updates of this definition).

A.3.142 System Requirements Analysis (SRA). System requirements analysis is the systematic analytic methodology used to define and optimize the requirements associated with the acquisition and support of a weapon system. It consists of the following four major analysis activities:

a. operational requirements analysis (see A.3.116);

b. test planning analysis (see A.3.149);

c. logistic support analysis (see A.3.100); and

d. the A&CO technical analysis (see A.3.10).

Hardness inputs to the SRA are of two kinds:

a. hardness related requirements; and

b. special hardness annotations (see A.3.59); these apply only to the A&CO TA (see A.3.10) and the LSA (see A.3.100).

A.3.143 System Support/Integration (SS&I) Contractor. See contractor, A.3.21.

A.3.144 System Level Tests. System level tests are conducted to support:

a. development of a system concept design during the technology maturation and risk reduction phase (see A.3.146);

b. development of WSS (see A.3.159) requirements during initial development or during system upgrades and modifications where the hardness level of an achievable requirement is unknown; and

c. the system level hardness evaluation activity.

Participation in system level tests require coordination with system test organizations to develop and acquire hardware. The respective responsibilities of the different contractors that may be involved in a particular system test are defined in the TEMP (A.3.148) for EMD (see A.3.33) system level tests.

A.3.145 Technical Order (TO). The TO is a document prepared in support of the repair and maintenance of WSEs (see A.3.157). Of the various categories of TOs, the following require hardness annotation (see A.3.59) in support of hardness maintenance (see A.3.77) implementation:

a. organizational and intermediate level TOs;

b. depot control manuals; and

c. illustrated parts breakdowns.

A.3.146 Technology Maturation and Risk Reduction (TMRR) Phase. The technology maturation and risk reduction phase is Phase I of the acquisition life cycle (see A.3.1). During this phase, selected candidate solutions to the identified operational need derived from the materiel solution analysis phase (see A.3.103) are validated and refined through extensive evaluations. The objective is to validate one or more of the selected solutions and thereby provide a basis for deciding whether to proceed into engineering and manufacturing development (see A.3.33). The TMRR phase culminates with the PDR (see A.3.122).

A.3.147 Testing. See hardness testing, A.3.85.

A.3.148 Test and Evaluation Master Plan (TEMP). The TEMP is a SPO-generated (see A.3.137) document that defines the system level testing and associated contractor (see A.3.19) support activities required to verify that selected system functions comply with the requirements of the WSS (see A.3.155). The SPO may identify system level analyses (see A.3.134), in lieu of or in addition to system level tests, to verify WSS compliance, and in these instances, it will also document these analysis requirements in the TEMP. The TEMP forms the basis for the TPA (see A.3.149). Certain of the system level tests and analyses can be hardness related.

The test and evaluation master plan is the overarching document for managing a test and evaluation program. The plan is developed prior to EMD (A.3.33) and a formal submittal is to be completed for Milestone B, i.e., completion of the TMRR (A.3.146) phase and transition to EMD. It should be updated at each major milestone (if applicable). It provides the framework for estimating test resources needed to execute the plan. It describes the links between key program objectives and user decisions to move forward with development of the system. The TEMP discusses how the testing and evaluation will demonstrate maturation of the system's key technologies relative to mission objectives and desired capabilties of the system. The document evolves with the system and in its later stages will also address production readiness, acceptance testing, and sustainment testing of the system. The test planning analysis (A.3.149) of the SRA (A.3.142) is important to developing the TEMP.

A.3.149 Test Planning Analysis (TPA). Test planning analysis is one of the four elements of SRA (see A.3.142). The TPA develops detailed test objectives, success criteria, and special test equipment, instrumentation, and documentation requirements for each system test identified in the TEMP (see A.3.148), including system level hardness tests.

A.3.150 Thermal Radiation. Thermal radiation is one of the NWE (see A.3.114) and consists of ultraviolet, visible, and infrared radiation, emitted from the fireball (or other heated regions) as a result of its very high blackbody temperature. Thermal radiation can cause material heating and ablation, resulting in changes in material properties, including mass and surface characteristics. Thermal radiation heating can be particularly critical when combined with airblast (see A.3.14) loadings.

A.3.151 Thermomechanical Response. Thermomechanical response refers to the mechanical responses that result from the deposition of x-ray energy in materials, which produces local and gradational temperature increases. In many cases, loading is experienced both at local and global levels. Thermomechanical responses include:

a. stress resultant from bulk heating;

b. stress, stress waves, and shock resultant from surface heating induced blowoff impulse; and

c. gradational heating induced thermal line load.

A.3.152 Trade Studies. See hardness trade studies, A.3.86 and Section 5.4.

A.3.153 Transfer Function. A transfer function is a mathematical function or algorithm that permits calculation of the nuclear environment or coupled stress at the output of some element of hardware of a system, given the nuclear environment or associated coupled stress applied at its input.

A.3.154 Validation/Validate. As used in this standard, the terms "validation" and "validate" are used in their usual dictionary sense of confirming the validity or correctness of something, and do not refer to a special hardness activity or program element.

A.3.155 Verification. See hardness verification, A.3.87.

A.3.156 Vulnerability. As used in this standard, a system or any of its constituent elements is said to have a vulnerability or to be vulnerable to a particular nuclear environment when one or more of its characteristics necessary for acceptable system performance are capable of being damaged or degraded upon exposure to that environment. When discussing vulnerabilities, it is important to identify the nuclear environment of concern and the magnitude above which the degradation is likely to occur. However, if the magnitude at which degradation begins is orders of magnitude above the requirement level, then no vulnerability exists for the particular hardware in the particular application.

A.3.157 Weapon System Element (WSE). As used in this standard, WSE is a generic term that refers to any top level unit of hardware, firmware, or software below the system level. In the case of AVE (see A.3.2) and SE (see A.3.131), a WSE is composed of one or more configuration items (see A.3.20). When dealing with facilities (see A.3.35), RPIE (see A.3.127), and A&CO installation hardware (see A.3.9), the concept of configuration item does not apply and so WSE is the term used to identify all such entities regardless of equipment type. The discussion of requirements in this standard for NH&S program tasks and NH&S program task support activities is presented in terms of the general designation WSE.

A.3.158 Weapon System Element Contractor. See contractor, A.3.21.

A.3.159 Weapon System Specification (WSS). The WSS states the technical and mission requirements for a system and documents design constraints. From an NH&S perspective, it identifies the design constraints (see A.3.71) and hardness performance requirements (see A.3.78) imposed on the system.

A.3.160 Withstand. In this standard, withstand is used as a technical term to denote the inherent capability of an item of hardware, at any level of assembly, to withstand exposure to one or more NWE (see A.3.114) without suffering any unacceptable degradation of performance capability of concern to the system design. Withstand requirements are included in the specification of hardness requirements (see A.3.80) as hardness design constraints (see A.3.71). See also inherent hardness, A.3.91, and attenuation, A.3.12.

A.3.161 Worst-Case Circuit Analysis (WCCA). Worst-case circuit analysis refers to a type of circuit analysis that evaluates circuit performance under extreme conditions by accounting for component variability, particularly semiconductor devices. Sources of component variability drift due to component aging (end-of-life limits) and the stress applied to each circuit component (including humidity, temperature, and radiation). Even with these degraded parameters, the circuit must be shown to continue operating as required. Worst-case circuit radiation analysis is a variant of WCCA in which current generators are added to the circuit model to simulate the magnitudes and durations of photocurrents generated by the specified prompt and secondary ionizing radiation. Worst case circuit EMP (see A.3.32) analysis is a variant of WCCA in which current/voltage generators are added to the circuit model, as appropriate, to simulate the coupled EMP transients generated by the specified EMP environments. In addition, circuit component and operational power supply parameters are varied throughout their specification range in such a manner that the most severe transients are coupled into the system.

NH&S PROGRAM OVERVIEW IN FLOW DIAGRAM FORMATSCOPE

B.1 SCOPE.

B.1.1 Scope. This appendix contains flow diagrams that depict the program phasing and interrelationships of the NH&S program tasks defined in Section 5.3 of this standard as a function of:

a. system life cycle phase;

b. contractor program role;

c. individual military command responsibilities; and

d. the relationship of program tasks and accomplishments to mandated design reviews and audits (when such are applicable to the task).

The diagrams are located at the end of this appendix due to their size and fold-out nature of the pages.

The intent of these diagrams is to provide additional insight into how all the individual tasks that comprise a comprehensive NH&S program interrelate and work together to result in the design, production, deployment, and operation of a hardened weapon system that satisfies all specified hardness requirements and preserves that hardness throughout the weapon system life cycle. These diagrams are considered to be self-explanatory, once the nature of their content and layout are understood, as explained below. They will be most useful when studied in conjunction with a careful reading of Section 5 of this standard, especially Section 5.3.

This appendix is a mandatory part of this standard (i.e., the figures tie various aspects of the tasks together so that they are better understood in their time phasing and context with other tasks), and the figures are to be used to plan and execute the program.

B.2 APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

B.3 DEFINITIONS.

B.3.1 Definitions. For purposes of this appendix, the definitions contained in Appendix A of this standard shall apply.

B.4 FLOW DIAGRAM CONTENT.

B.4.1 Flow diagram content considerations. A flow diagram is presented for each of the following system life cycle phases:

a. Materiel solution analysis phase;

b. Technology maturation and risk reduction (TMRR) phase;

c. Engineering and manufacturing development (EMD) phase;

d. Production and deployment phase; and

e. Operations and support phase.

The diagrams for the materiel solution analysis and TMRR are contained on Figure 1. The EMD phase is delineated separately on Figure 2. The remaining phases are all depicted on Figure 3.

It should be noted that only the TMRR phase specifically shows the conduct of a system requirements review/system functional review (SRR/SFR). A note and a few blocks for SRR/SFR are shown in the EMD diagram to allow for the possibility that a formal TMRR phase may not be implemented during the course of a particular program but to also ensure that, when necessary, the tasks needed and associated with SRR/SFR will be performed. The elimination of TMRR usually arises when a procurement does not involve significant new design concepts or technologies that must be developed to mitigate program risks relative to immature technology. In instances where no TMRR applies, but SRR/SFR is deemed necessary, the system program office (SPO) will:

a. conduct the SRR/SFR during the first part of the EMD phase as depicted on Figure 2; and

b. will either generate (prior to contracting for EMD) the documentation needed to conduct EMD so that the documentation can be provided to the contractor at contract start, or task the contractor to perform the necessary tasks (including documentation) for SRR/SFR.

When a formal TMRR phase is held, the SRR/SFR will be part of that phase, as shown on Figure 1.

It should be further noted that the tasks for procurement of weapon system facilities are:

a. implemented separately from the acquisition of other weapon system elements (WSEs); and

b. not implemented in terms of the formal phases discussed above.

For facilities that have significant NH&S requirements, the facility related flows depicted on Figure 1 through 3 indicate a facility procurement time sequencing in relation to the procurement of other WSEs and their design reviews and audits that supports timely incorporation of NH&S requirements into the facility design.

B.5 FLOW DIAGRAM FORMAT.

B.5.1 Flow diagram format considerations. The following notation and layout considerations apply to Figures 1 through 3. The diagrams use shapes, shading/patterns, and border patterns (variations of dashed line borders) to tie tasking to the mandated design reviews and audits. For the facilities, these are general time periods rather than specific tasking that must be completed as part of the design review (see B.4.1).

B.5.1.1 Contractor categories. The tasks associated with each category of contractor (see A.3.21 for a discussion of contractor categories) are identified within a separate shaded area in each of the flow diagrams. The tasks for each contractor are shown as blocks within that contractor's shaded area. It will be noted, however, that in the diagrams for the TMRR, EMD, and production and deployment phases, the AVE/SE contractor's shaded area lies within the shaded area depicting the SS&I contractor. This overlay is not intended to imply that the AVE/SE contractor is part of or subordinate to the SS&I contractor. Each contractor has independent contractual commitments to the SPO but one of those commitments is to work together and cooperate so that the SS&I contractor can complete the NH&S Design Analysis Report and associated testing and analysis. The overlay was introduced solely to facilitate clarity of presentation. During the production and deployment phase, the interaction is somewhat lessened due to the fact that the AVE/SE contractor is producing hardware and the only interaction needed is 1) where design changes occur during production (usually due to obsolescence or a design flaw discovered in hardness assurance that was not detected in EMD) and 2) where interaction continues in order to complete the system level assessment tasks.

B.5.1.2 Task designation. The tasks for each contractor are depicted by blocks of various shapes and shades and borders. The format for tasks matches the shape, shade, and border for the program review with which each is associated. Associated with each task box is the corresponding Section 5.3 paragraph number and title. Only items from tasks with an indent level of four or less are shown. In some instances, for purposes of simplicity and clarity, only the highest indenture paragraph associated with a particular task is identified. In these cases, the corresponding lower indenture paragraphs are also included in the task.

B.5.1.3 Documentation categories. The items of documentation generated are depicted by the flowchart "document" symbol with a solid border for items that are dedicated to NH&S. An example is the NH&S design analysis report. A documentation symbol with a round dotted border indicates program documentation that is not NH&S dedicated but that does contain NH&S related information. An example is the LSAR. The four EMD design review and audit milestones shown (SRR/SFR, PDR, CDR, and FCA) are depicted with very specific shapes, shading, and borders so that tasks may be more clearly associated with them by using the same shapes, shading, and borders. The contractor's NH&S briefing material prepared in support of these EMD design reviews and audit milestones form a significant part of the NH&S documentation trail throughout the EMD phase. Each task shown in the flows is either directly documented or supplies inputs to another task that will eventually result in some item of documentation. Documentation that supports the performance of a task is indicated with an arrow from that item of documentation to the task that uses it as an input. In the case of the operations & support phase the flow diagram is slightly different in nature. It does not have major review or audit milestones but most tasks begin as a result of four broad areas which are shown in the upper right corner. The flowchart connector symbol for A and B are shown leading to the major program efforts of requirements, hardness assurance, and hardness maintenance. Connector symbol for C shows the input of EMD Phase documents into the assurance and maintenance areas. Connector symbol D shows the options that come from the results of survivability impact analysis and the subsequent trade study efforts (See 5.5.5.2). It is important to understand that several of the tasks in the operations & support phase are part of bigger overall processes but since this standard is NH&S specific that tasks are shown without connections to follow-on NH&S tasking. See Section 5.5 for further explanation of each of the tasks and how they relate to other tasks.

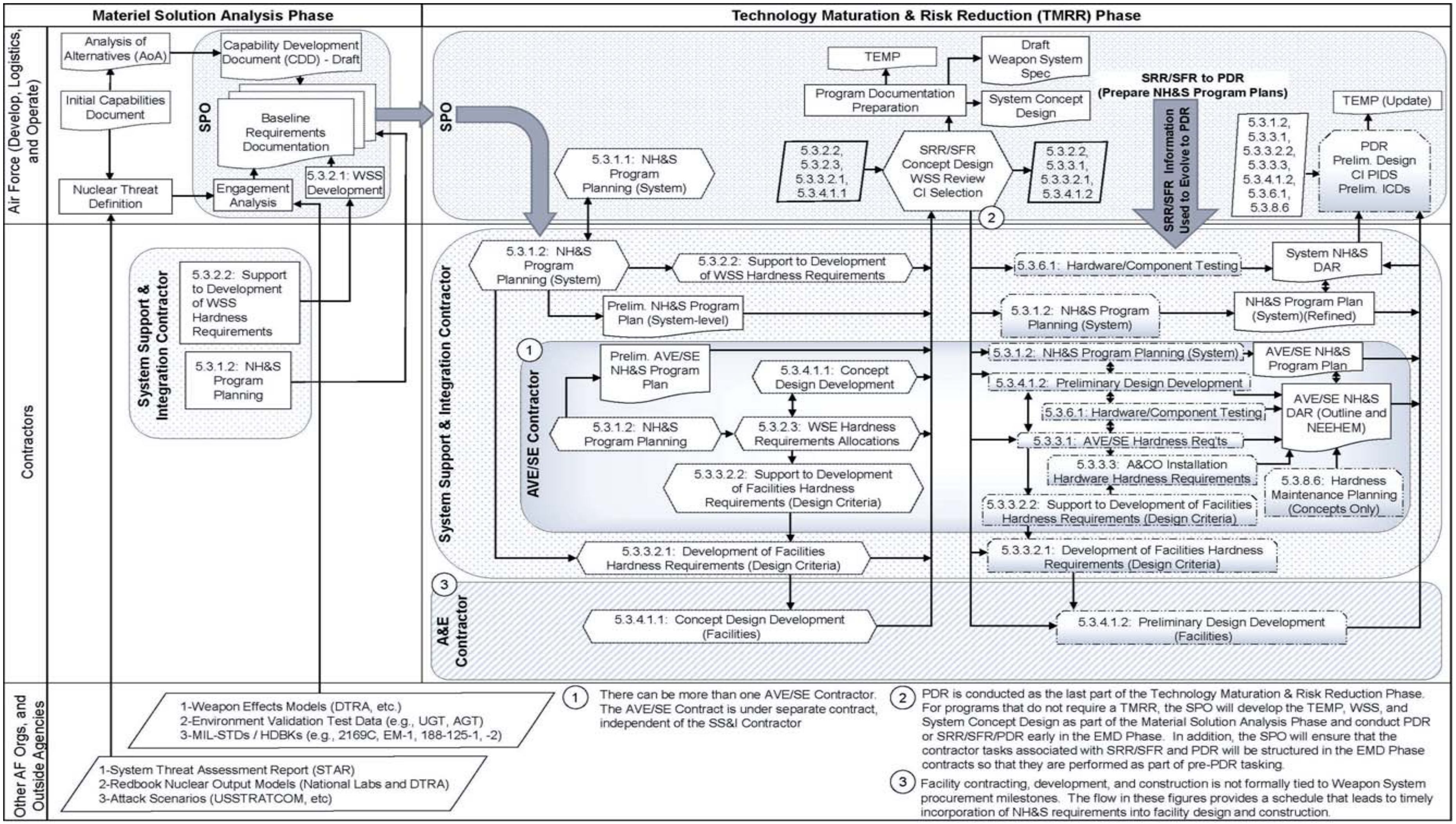

FIGURE 1. Materiel Solution Analysis Flow and Technology Maturation and Risk Reduction Process Flow

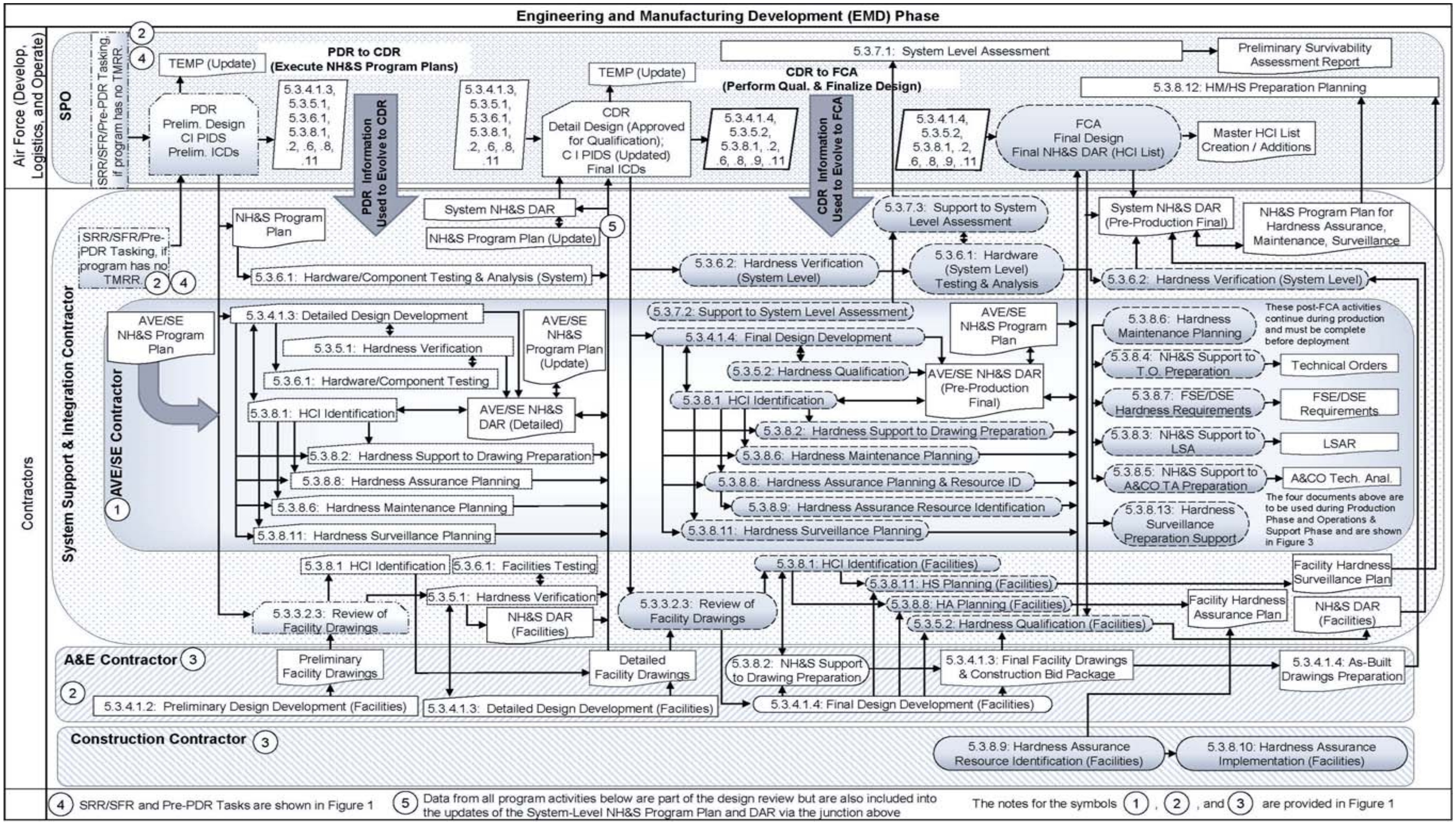

FIGURE 2. Engineering and Manufacturing Development Process Flow

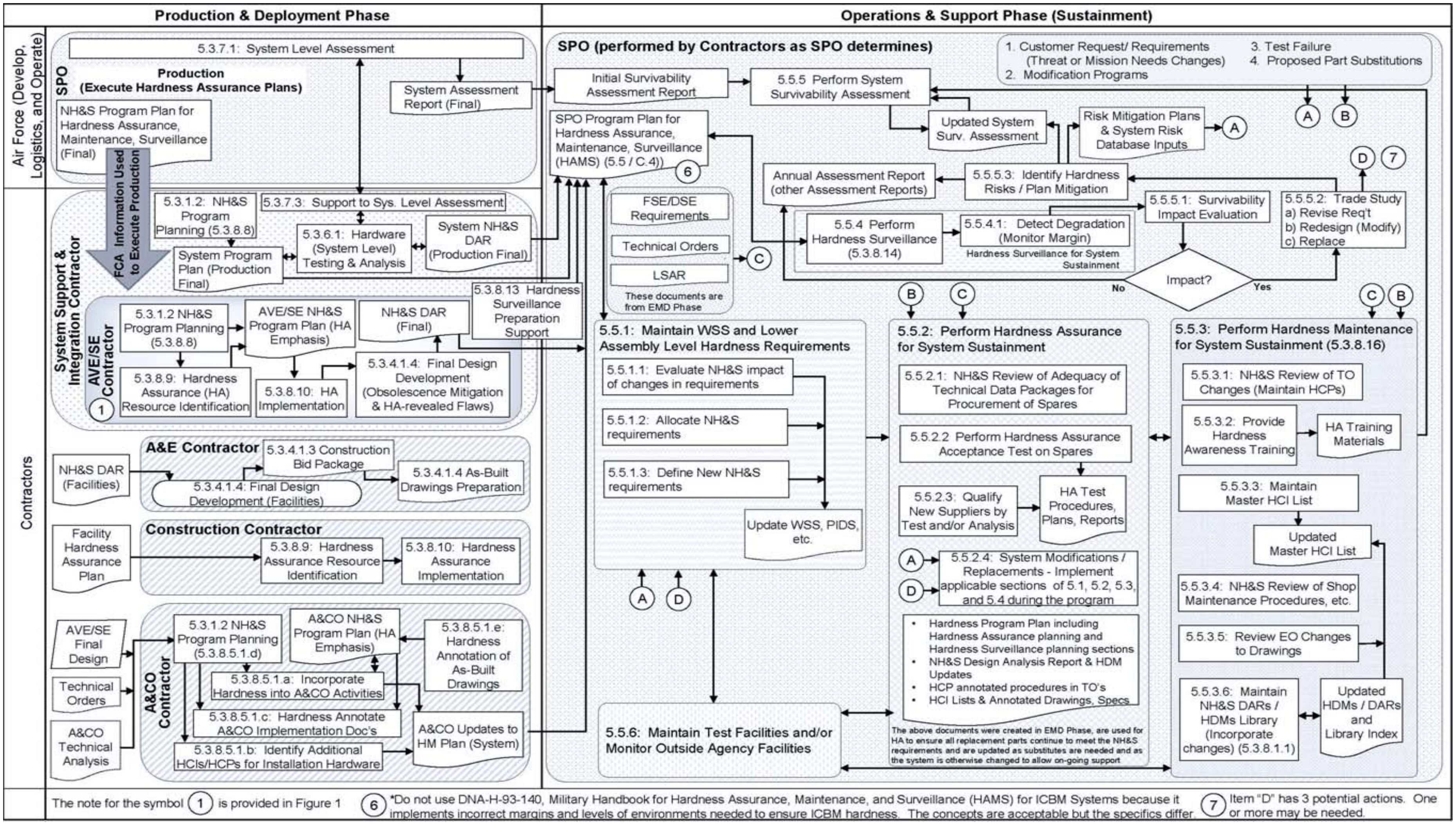

FIGURE 3. Production & Deployment, and Operations & Support Process Flow

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NH&S PROGRAM OVERVIEW IN FLOW DIAGRAM FORMATSCOPE

C.1 SCOPE.

C.1.1 Scope. This appendix contains instructions for ICBM personnel regarding the preparation of weapon system-level NH&S related program plans, including an NH&S program plan that includes the system-level hardness maintenance planning and the system-level hardness surveillance planning. The SS&I contractor, teaming with the SPO, prepares the weapon system-level program plan. The SPO prepares the HAMS (see 5.5) plans. The instructions for tailoring engineering drawings annotations are to be applied to appropriate contractors through tailoring and contract data requirements as well as to any SPO generated engineering drawings. These instructions are not a mandatory part of this standard; however, application of these instructions to ICBM programs will result in consistent and complete plan content and engineering drawing markings that are necessary to life-cycle hardness maintenance.

C.2 APPLICABLE DOCUMENTS.

C.2.1 General. The documents listed herein are used by the ICBM SPO to obtain uniform hardness annotations (A.3.59) of engineering drawings.

C.2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME Y14.100	Engineering Drawing Practices
ASME Y14.24	Types and Applications of Engineering Drawings

(Copies of this document are available online at http://www.asme.org.)

C.3 DEFINITIONS.

C.3.1 Definitions. For purposes of this appendix, the definitions contained in Appendix A of this standard apply.

C.4 SPO GENERATED NH&S RELATED PROGRAM PLANS.

C.4.1 System level NH&S program plan. The system-level NH&S program plan is for a particular weapon system acquisition has a three-fold purpose:

a. to provide an overview of all aspects of the weapon system NH&S program;

b. to identify and summarize the approach and schedule by which the SPO will implement this NH&S program; and

c. to identify the organizational entities, both within and without the SPO, involved with accomplishing the implementation of this NH&S program, and their respective responsibilities and required interfaces.

The primary objective of this program plan is to provide a program tool that will aid the SPO in accomplishing NH&S program requirements in a timely and cost-effective manner. The plan may also serve the subsidiary purpose of providing a comprehensive road map to the entire process by which the NH&S aspects of a major weapon system acquisition program are defined and implemented. Such a roadmap can be a significant aid in orienting new SPO personnel assigned to support the implementation of NH&S program requirements.

A separate NH&S program plan may be prepared for each individual phase of the acquisition life cycle, or a single comprehensive plan encompassing multiple phases may be prepared. The comprehensive approach is recommended for any system expected to proceed to engineering and manufacturing development (EMD). For system investigations during the materiel solution analysis phase, where several systems will be evaluated, a single plan is probably appropriate. This decision must be made by the cognizant SPO and project officer well prior to entry into the first phase of any program in order to support timely plan development.

C.4.1.1 Model outline. A model outline for the system level NH&S program plan is provided on Figure 4. The initial draft will normally not include all or even detailed aspects of the weapon system NH&S program. As system acquisition progresses, the plan should be updated to include program changes and more detailed planning. These updates should continue, at a minimum, into CDR. At this point, most planning to complete the EMD phase and the remaining acquisition phases should be included within the NH&S program plans prepared and maintained by the weapon system element (WSE) and system support and integration (SS&I) contractors.

1.0	INTRODUCTION
1.1	Purpose
1.2	Objective
1.3	Scope
1.4	Weapon system program overview
1.4.1	Weapon system description
1.4.2	System acquisition approach
1.5	Weapon system NH&S requirements
1.6	Weapon system NH&S program approach
1.6.1	Hardness design
1.6.1.1	Weapon system hard parts program
1.6.2	System level hardness evaluation
1.6.3	System level assessment
1.6.4	Life cycle hardness
1.7	NH&S authority/compliance documents
2.0	ORGANIZATIONAL RESPONSIBILITIES AND INTERFACES
2.1	Overview
2.2	Role of SPO and organizations under direct contract to SPO
2.2.1	SPO
2.2.2	SE/TA contractor
2.2.3	System support and integration (SS&I) contractor
2.2.4	Weapon system element (WSE) contractors
2.3	Role of Air Force/DoD organizations outside SPO
3.0	WSE HARDNESS EVALUATION
3.1	WSE hardness evaluation approach
3.2	Hardness development evaluation
3.3	Hardness verification
3.4	Hardness qualification
4.0	SYSTEM LEVEL HARDNESS EVALUATION
4.1	System level hardness evaluation approach
4.2	Hardness analysis
4.3	Hardness testing
4.3.1	Nuclear above-ground (simulation) testing
4.3.2	Hardness verification
5.0	SYSTEM LEVEL ASSESSMENT
5.1	System level assessment approach
5.2	WSE level support
5.3	System level support
6.0	LIFE CYCLE HARDNESS
6.1	Life cycle hardness approach
6.2	HCI identification and documentation
6.3	Role and responsibilities of contractor NH&S personnel
6.4	Hardness assurance planning, preparation, and implementation
6.5	Hardness maintenance planning, preparation, and implementation
6.6	Hardness surveillance planning, preparation, and implementation
7.0	NH&S PROGRAM SCHEDULE
8.0	DEFINITIONS AND ACRONYMS/ABBREVIATIONS

FIGURE 4. Model Format for SPO NH&S Program Plan

C.4.2 System level hardness maintenance plan. The purpose of the SPO-generated system level maintenance hardness plan is to provide the comprehensive overview of the hardness maintenance capability that the SPO will need to support their responsibility to preserve system hardness throughout the deployment and operations and support phase of the weapon system life cycle. This hardness maintenance capability will consist primarily of data products containing both hardness related information required to preserve system hardness and hardness annotations that flag the presence of such information. In addition, certain types of hardware capability that will support hardness maintenance implementation, such as the capability of particular items of depot support equipment to evaluate the adequacy of selected system hardware hardness characteristics, may also be provided. The following items of information shall be included in the plan, as applicable:

a. Identify the specific items of hardness related data that will be supplied in support of the hardness maintenance responsibilities of each of the following areas of maintenance activity and maintenance support responsibility:

1). organizational maintenance;

2). intermediate maintenance;

3). depot maintenance;

4). SPO LCH redesign activities;

5). SPO spares procurement activities;

6). Defense Logistics Agency (DLA)/Defense Supply Center Columbus (DSCC) activities; and

7). 20AF/MES activities.

b. For each category of maintenance activity and responsibility and each associated data item identified in paragraph (a) above, identify:

1). the nature of the hardness related information provided;

2). the manner in which hardness related information is flagged;

3). how the hardness related information is intended to be used; and

4). where hardness requirements meant to facilitate competitive procurement are located.

c. Identify in detail any differences among the SPO's contractors in the nature and content of the hardness related data that will be supplied to the organization within the SPO responsible for the logistics support and operating management.

d. Identify the library and associated index of hardness related data items that will be provided to the organization within the SPO performing the logistics and operating functions. Identify also the manner and timing for the delivery of these items and the steps to be taken by the SPO to ensure their completeness and accuracy at the time of transfer.

e. Identify the means by which the completeness and accuracy of the hardness related information supplied to the SPO's organization responsible for the logistics and operating functions can be verified.

f. Identify any non-data resources or capability that will be provided to the SPO's organization responsible for logistics and operating functions (in support of hardness maintenance implementation). These may consist of test equipment, such as depot support equipment, capability to evaluate hardness related characteristics of selected items of weapon system hardware.

C.4.3 System level hardness surveillance plan. During the EMD phase, the SPO usually directs all end-item contractors to prepare separate hardness surveillance program (HSP) plans in which they identify the prioritized hardness surveillance activities they consider to be appropriate for the particular end-items under contract. On the basis of these contractor recommendations, the SPO program organization undertakes, in consultation with the SPO organization responsible for logistics and operating functions, to define the most cost-effective, single, integrated HSP plan for the entire weapon system. This activity is referred to as the HSP definition phase. Subsequent to the completion of this phase, the SPO undertakes to acquire and validate all the resources, including test plans and procedures, necessary to implement the program defined. This activity, implemented with the aid of selected contractors, is referred to as the HSP preparation phase. After this phase has been completed, the SPO is in a position to transfer essentially a turn-key HSP capability to the operating command. Given this background, the weapon system hardness surveillance plan prepared by the SPO may be said to have the following two-fold purpose:

a. to communicate to all cognizant parties the content of the weapon system HSP defined by the program office during the program, and the means and schedule by which the program will validate and transfer to the SPO organization responsible for implementing system HSP, the resources required to implement the program defined; and

b. to serve as a coordination tool in support of the accomplishment of the weapon system HSP preparation phase.

A model outline for the system level HSP plan is provided on Figure 5.

1.0	INTRODUCTION
1.1	Purpose
1.2	Objectives
1.3	Scope
1.4	Ground rules and assumptions (as applicable)
2.0	DEFINITION PHASE
2.1	Definition phase approach
2.2	Definition phase outcome
3.0	PREPARATION PHASE
3.1	Definition of required resources
3.2	Acquisition of required resources
3.2.1	Resource acquisition schedule
3.3	Validation of HSP capability
3.3.1	Field validation
3.3.2	Laboratory activity validation
3.3.3	Validation schedule

FIGURE 5. Model Outline for System Level HSP Plan

C.5 ANNOTATIONS TO ENGINEERING DRAWINGS AND PARTS LISTS.

C.5.1 Description/purpose. The purpose of this section is to provide the tailoring to be used to ensure that hardness annotations for HCIs is made to engineering drawings and to institute a uniform manner of implementing such.

C.5.2 Preparation instructions for tailoring of ASME Y14.100 and ASME Y14.24 in contracts where applicable. The specific wording provide here cannot be invoked merely by reference. It must be placed in the contracts where it is needed as tailoring to ASME Y14.100 and ASME Y14.24. The convention used in this tailoring is: Where specific word changes are made, bold, underlined text is used to indicate insertions and bold text with single strikethrough is used for deletions.

C.5.2.1 Tailoring of ASME Y14.100.

C.5.2.1.1 Tailoring to definitions of ASME Y14.100. The definitions of HCI and HCP in Section 3 of ASME Y14.100 shall be replaced by the definitions in MIL-STD-1766.

C.5.2.1.2 Tailoring to paragraph 7.6.1 of ASME Y14.100. Exceptions to Boxed Symbols. For systems that cannot produce the boxed symbols, and for standard text, **the** alternate symbols **of the form** ~~**such as**~~ *HCI*, ~~-~~*CSI*~~-~~, *ODC*, or *INT*, in applicable note and text size, ~~**may**~~ **shall** be used. The same symbology structure shall be used throughout the drawing or list. However, for the ESD symbols shown in Fig. 1, those symbols shall be used in non-text applications.

C.5.2.1.3 Tailoring to Section 7, Figure 1, Symbology of ASME Y14.100. The symbol shown for HCI/HCP shall not be used in ICBM drawings. HCPs in drawings are at least one of the reasons an item is hardness critical and shall be marked only by the HCP symbol, when applicable. The drawing shall be marked with the HCI symbol in the title block of the drawing and in the applicable column of the associated parts list for each HCI item in the list. If no column is provided, the symbol shall be placed as near the part number in the list as is practical. (see C.5.2.1.4 of MIL-STD-1766)

C.5.2.1.4 Tailoring to paragraph E5.1 Hardness Critical Note in ASME Y14.100. The following note shall be ~~used~~ **placed on sheet 1 of drawings (or the coversheet, whichever comes first)** for nuclear hardness critical items**:** ~~and processes~~

a. **When source control is not a part of the HCI controls for the item**: THIS ~~(enter the word~~ DRAWING ~~or PARTS LIST, as appropriate)~~ DEPICTS HARDNESS CRITICAL ITEMS (HCIs) AND/(OR) HARDNESS CRITICAL PROCESSES (HCPs). ALL CHANGES TO, OR PROPOSED SUBSTITUTIONS OF THESE HCIs OR HCPs SHALL BE EVALUATED BY **THE ICBM SYSTEM ENGINEERING ACTIVITY RESPONSIBLE FOR NUCLEAR SURVIVABILITY** ~~(enter the engineering activity responsible for nuclear survivability)~~.

b. **When source control is a part of the HCI controls used to ensure the hardness of the item: THIS DRAWING DEPICTS ITEMS WHICH, WHEN PROCURED FROM THE SOURCES SHOWN IN THE DRAWING, ARE HARDNESS CRITICAL ITEMS (HCIs) AND/OR HARDNESS CRITICAL PROCESSES (HCPs). ALL CHANGES TO THIS DRAWING INCLUDING SOURCES OF SUPPLY AND PROPOSED SUBSTITUTIONS SHALL BE EVALUATED BY THE ICBM SYSTEM ENGINEERING ACTIVITY RESPONSIBLE FOR NUCLEAR SURVIVABILITY.**

c. **When a drawing contains no requirements for HCIs but simply has HCIs in its parts list (i.e., it corresponds to HCI rationale 5 of MIL-STD-1766), the note shall read as follows: Hardness Critical Item. For Hardness Design/Test/Inspection Requirements, See Applicable Detail and/or Lower Assembly Drawings.**

Tailoring addition to ASME Y14.100, para. 7.3: **All HCIs and hardness critical processes (HCPs), as defined in MIL-STD-1766 shall be identified in drawings that depict HCIs and/or HCPs using part numbers to identify the HCIs. HCIs shall be identified as follows (with allowed variation per 7.6.1 of ASME Y14.100, as tailored):**

a. **The HCI symbol (see Figure 1 of ASME Y14.100) shall be placed in the following locations:**

1). **Within, above, or next to the drawing title block,**

2). **On the parts list/material list next to each HCI part number,**

3). **Next to the hardened part number, wherever it occurs in the drawing,**

b. **Notes -**

1). **Each item identified with an HCI symbol shall have a corresponding note that begins with the words, "Hardness Critical Item" and provides the reference to the nuclear hardness and survivability design analysis report (NH&S DAR) by identifying document number, title, originating contractor's name and CAGE, date of latest revision, and document control number (for classified documents),**

c. **The HCP symbol (see Figure 1 of ASME Y14.100) shall be placed at the beginning of any paragraphs that describe hardness critical processes (with allowed variation per 7.6.1 of ASME Y14.100, as tailored).**

C.5.2.1.5 Tailoring to Table E1 ACRONYMS FOR SPECIAL ITEMS AND PROCESSES. In the reference column, MIL-STD-1766 shall apply for HCI and HCP rows in the table.

C.5.2.2 Tailoring of ASME Y14.24.

C.5.2.2.1 Tailoring of ASME Y14.24, paragraph 8, CONTROL DRAWINGS. A control drawing is a ... without disclosing details of designs or divulging proprietary vendor data. **However, for HCIs, limitations on disclosing design details shall be overridden by the contract requirements to perform detailed design analysis and to perform testing necessary to ensure compliance with the system hardness requirements. Design details (including proprietary data) are required to be divulged if they are necessary to the hardness design analysis. If a contractor has concerns in this area, then agreement must be reached during contract negotiations relative to what details may be kept from the government on HCIs.**

C.5.2.2.2 Prohibited drawing type. HCIs shall not be depicted on Vendor Item Drawings unless the item meets all the criteria of MIL-STD-1766 relative to a Non-Developmental Item (NDI).

C.5.2.3 Parts List Format for HCI identification. When the exception to boxed symbols described in C.5.2.1.2 occurs such that the boxed HCI symbol cannot be placed next to the part number in the parts list, then the format of the drawing parts list shall be similar to Figure 37 of ASME Y14.24 with respect to including a column for HCI. Regardless of the exception in C.5.2.1.2, a HCI flag note shall also be included in the parts list for HCI application (see A.3.66) and it shall be labeled, "HCI-A" and identify the specific locations/applications within the assembly where the HCI part number is used in a hardness critical function. For example: If an integrated circuit with part number 832-91527-01 were used on a circuit card assembly in five locations designated as U1, U2, U3, U4, and U5 and location 5 is part of a test circuit that is not used operationally and can fail due to nuclear environments without affecting the system, if the flag note on the parts list by part number 832-9527-01 is numbered "17", it would appear as, "17/ HCI-A: U1 thru U4 only.

C.5.2.4 Tailoring to paragraph E5.1 Hardness Critical Note in ASME Y14.100 for use in TO preparation.

Note that the following tailoring is to be included in the section of the contract which addresses TO preparation and not in the section addressing engineering drawing preparation.

The HCP symbol (see Figure 1 of ASME Y14.100) shall be placed at the beginning of any paragraphs that describe hardness critical processes (with allowed variation per 7.6.1 of ASME Y14.100, as tailored).

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INSTRUCTIONS REGARDING HCI IDENTIFICATION AND DOCUMENTATION

D.1 SCOPE.

D.1.1 Scope. This appendix contains instructions for SPO and contractor personnel regarding:

a. hardness critical item (HCI) identification; and

b. the correct application of such identification to life cycle hardness documentation and implementation, particularly with respect to hardness maintenance.

This appendix provides information critical to a correct understanding of the principles involved and is needed to implement uniform application of HCI identification practices across the multi-contractor and multi-discipline ICBM program. Knowledge and understanding of the information in this appendix are necessary for correct performance of contract tasking. It is strongly encouraged that all contractor and SPO personnel be briefed on these principles as part of the hardness assurance plan implementation and that NH&S personnel be trained on these principles from their first involvement in ICBMs.

D.1.2 Purpose. The purpose of this appendix is to provide instructions that facilitate the correct and complete identification and documentation of the HCIs and the HCPs (A.3.67) associated with the design of a hardened weapon system. Since this identification and documentation activity forms the foundation for the subsequent implementation of weapon system life cycle hardness (LCH), a correct and relatively uniform understanding of this activity is critical to accomplishing the required preservation of weapon system hardness throughout the weapon system life cycle.

D.2 APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

D.3 DEFINITIONS.

D.3.1 Definitions. For purposes of this appendix, the definitions contained in Appendix A of this standard shall apply.

D.4 HCI IDENTIFICATION.

D.4.1 Clarification of the HCI identification process. The definition of hardness critical item employed for ICBM weapon systems is contained in paragraph A.3.65 of Appendix A. It is reproduced on Figure 6 for ease of reference. This definition consists of five explicit and independent rationales. Any item of hardware or software within an ICBM weapon system that satisfies one or more of these rationales is defined to be an HCI. This approach applies even in instances where the provision of such hardness was not part of the original design intent. With such a definition, the task of identifying the HCIs contained within a given system is reduced to a systematic and unambiguous process. One simply turns the five HCI rationales into five questions by asking, rationale by rationale, whether a given system element satisfies the conditions stated in the rationale for any of the applicable nuclear weapon environments and effects (NWE). If the answer is affirmative for one or more of the rationales, the item under evaluation is called an HCI. This questioning review process is implemented for each and every system element in those portions of the system to which NH&S requirements apply, at every level of assembly down to the piece part level. The result is a complete HCI list for the weapon system.

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An HCI is defined to be an item of hardware or software that satisfies one or more of the following five rationales in any one or more of the applicable nuclear environments. More than one rationale may apply to a particular item, and, in such cases, different rationales may apply in different environments. Each candidate HCI must be reviewed separately for the applicability of each rationale in each applicable environment.

HCI rationales:

1. Functionally required hardware (i.e., hardware that would continue to be included in the design even if all hardness requirements were removed) with the following characteristics:

(a) The item is vulnerable to the applicable nuclear environment under consideration; and

(b) The hardness design approach for dealing with that vulnerability is to include additional provisions for hardness in some aspect of the item's procurement requirements, such as the item's specification, design, manufacture, or item selection process.

2. Functionally required hardware with the following characteristics:

(a) The item does not satisfy rationale 1; and

(b) Its presence in the design is taken advantage of to also provide protection for the system or any of its elements against one or more of the applicable nuclear environments; for the purposes of providing this hardness protection function, the item may be used as-is, or it may be modified in some way to enhance its hardness protection capabilities.

3. Hardness dedicated hardware or software included in system design solely to help satisfy the specified hardness requirements. As contrasted with the non-hardness dedicated, functionally required hardware covered by rationales 1 and 2 above, hardness dedicated hardware and software would not be included in the design if hardness requirements had not been applied.

4. Hardware items to which a hardness critical process is applied during system fabrication, manufacture, or assembly, as identified in the applicable engineering drawings. The items selected to be identified as HCI in these cases shall be the highest level(s) of assembly directly involved with the hardness critical process that will enable clear traceability via the HCI list to the documentation of the hardness critical process in the applicable engineering drawings and the NH&S DAR. The items identified as HCI to serve this traceability function may themselves have no special hardness characteristics.

5. A subassembly or higher level of assembly that contains one or more HCIs.

FIGURE 6. ICBM Weapon System Definition of HCI

D.4.1.1 HCI identification for hardware not originally designed to be hard. The design of a weapon system with nuclear hardness requirements may include the use of hardware items that were not originally designed to satisfy the specified hardness requirements but were evaluated to be satisfactorily hard for the intended use after the design had been completed. This circumstance may apply both to developmental and non-developmental hardware items. In either case, HCI identification must be fully implemented in the same manner as would be done when hardness is intentionally incorporated in the design from its inception. Such identification will be a product of the hardness evaluation activity that will be performed for all hardware elements with hardness requirements.

D.4.1.2 Relationship of potential vulnerabilities to HCI identification. In addition to the use of HCI identification to flag the specific hardware and software elements that contribute to the present hardness capability of a system, such identification has also sometimes been utilized to identify ways in which new vulnerabilities (see A.3.156 of Appendix A) could possibly be introduced into the design at some later time because of conceivable changes in the characteristics, such as material properties, of replacements for existing system elements. This concern is not included in the approach to HCI identification followed in this standard. It is considered too open-ended and impractical to identify every way in which the present hardness of a system could conceivably be compromised at a future time. Therefore, the ICBM approach to HCI identification addresses only the hardness features actually contained in the present design. To preclude the introduction of new vulnerabilities into a system, it is vital that every proposed design change or item substitution, however seemingly minor, be reviewed for hardness impact by appropriate personnel. The need for this NH&S review function applies not only to design changes or modifications that explicitly involve currently identified HCIs but also to proposed changes that do not appear to address HCIs. Indeed, it is by means of the latter that the greatest threat exists of inadvertently introducing new vulnerabilities.

D.4.1.3 Responsibility for HCI identification. The activity to identify HCIs is a technical task that requires both specialized knowledge of the various NH&S disciplines and a detailed knowledge of the weapon system design undergoing an HCI evaluation. This consideration applies most strictly to rationales 1 through 4. No personnel other than experienced NH&S experts should make judgments regarding the application of these four rationales. Once the HCIs resulting from the first four rationales are identified, it is acceptable that personnel with thorough knowledge of the system design and the associated drawing trees apply rationale 5. However, it is vital that within the contractor's organization, the NH&S personnel be empowered as the final authority regarding HCI identification and documentation. All other contractor organizations should follow their direction and guidance on HCI matters. A failure to do so can result in serious technical errors and significant added program costs. The government NH&S personnel are the ultimate authority but rely heavily on contractor personnel to provide the rationale and justification for each HCI part number. If the contractor deems necessary, a dispute can be referred to the government's NH&S personnel for adjudication.

D.4.2 Significance of the HCI identification process. The compilation of a complete HCI list for a given hardened weapon system is critical for the implementation of a comprehensive and effective LCH program for the system. As stated in paragraph A.3.99 of Appendix A, the key concern of LCH is the preservation, throughout the production and deployment, and operations and support phases, of the hardness that was verified prior to system production to be contained in the original system design. To ensure preservation of this hardness throughout the remainder of the system life cycle, we must know the specific aspects of system design that contribute to the achievement of this required level of hardness. It is this knowledge that the complete HCI list provides. It is able to do this because the HCI rationales (at least, the first four; as will be discussed subsequently, the fifth rationale serves an important configuration management purpose) were carefully chosen to encompass in broad terms every means by which hardness can be accomplished in the design. Thus, a complete HCI list tells us where the hardness in the system resides. When we know this, we are then in a position to take the actions necessary to preserve that hardness throughout the weapon system life cycle. This, in essence, is the mandate of the program activity referred to as life cycle hardness.

D.4.3 Clarification of HCI rationales. As noted in D.4.1 and as exhibited on Figure 6, the ICBM HCI definition consists of five explicit and independent rationales. These rationales are essentially identical with those contained in prior versions of MIL-STD-1766, except that the wording has been changed in most instances with the intent of enhancing clarity and understanding. The specific changes made in wording were chosen to address particular misunderstandings regarding HCI identification that sometimes arose during the initial implementation of MIL-STD-1766 on prior programs. It is believed that the present text resolves all the ambiguities reported. However, in the interest of providing additional insight and background not appropriate for inclusion in the text of a definition, further comments regarding each rationale are provided below.

D.4.3.1 Clarification of rationales 1-3. One immediate distinction to be made between rationales 1 and 2 as contrasted with rationale 3 is that rationales 1 and 2 both concern hardware defined as being "functionally required", whereas rationale 3 deals only with "hardness dedicated" design elements. The text of rationale 1 defines "functionally required" hardware as hardware that would continue to be included in the design even if all hardness requirements were removed. It is a phrase introduced into the HCI definition to distinguish those hardware or software elements incorporated in the design solely to serve a hardness design purpose (such elements are referred as "hardness dedicated", and are addressed in rationale 3) from those that are used to accomplish any design purpose other than NH&S.

D.4.3.1.1 Clarification of rationale 1. Given that rationales 1 and 2 both concern functionally required hardware, the issue now is to identify what the difference is between them. A hardware item identified as HCI by virtue of rationale 1 must satisfy the following criteria:

a. The item is vulnerable to the applicable nuclear environment under consideration; in other words, at the required level for the nuclear environment, the item must be vulnerable in some way that requires extra attention; and

b. The hardness design approach chosen for dealing with that vulnerability is to include additional provisions for hardness in some aspect of the item's procurement requirements, such as the item's specification, design, manufacture, or item selection process.

Thus, the two key ideas in rationale 1 are "item vulnerability" and "additional provisions for hardness". For every item identified as a rationale 1 HCI, the following two questions must be able to be answered:

a. What is the vulnerability that the item exhibits in the applicable nuclear environment under consideration?

b. What additional provisions for hardness have been included in the item's procurement requirements, such as the item's specification, design, manufacture, or item selection process, to address that vulnerability?

A simple example of a rationale 1 HCI is a transistor that has a requirement to continue to function after exposure to neutrons of sufficient magnitude to produce observable damage. The answer to the first question above in this instance is that the vulnerability involved is a decrease in device gain caused by neutron induced damage to the semiconductor material of the device. The answer to the second question for this example typically involves additional requirements on both device specification and the item selection process. The former usually consists of a requirement for a higher magnitude of initial gain to offset the decrease in gain caused by the neutron exposure, while the latter typically involves a neutron test lot sampling requirement. It is vital that the content of the answer to the second question be appropriately and thoroughly documented in both the applicable NH&S DAR and the engineering drawings that support the procurement of the item.

D.4.3.1.2 Clarification of rationale 2. In contrast to rationale 1, the key idea in rationale 2 is that of the utilization of an item of hardware already existing in system design to provide hardness protection to another item or items of functionally required hardware needing such protection. Thus, items identified as HCI by virtue of rationale 2 with respect to a particular nuclear environment are:

a. Not vulnerable to that environment; and

b. Are used to provide protection to other system elements that are vulnerable to the environment under consideration.

Functionally required hardware designated HCI under rationale 2 may be utilized to provide this hardness protection role either "as-is" or after some modification to enhance its hardness protection capability. An example of the former is the use without modification of existing hardware elements to serve as x-ray shields for buried electronics. An example of the latter is the modification of existing electrical cables to include special fill material for the purpose of reducing the magnitude of x-ray induced system generated electromagnetic pulse (SGEMP) currents that may damage sensitive electronic components downstream from the cable. Thus, for every item identified as a rationale 2 HCI, the following two questions must be able to be answered:

a. What is the nature of the protection that the item is being used to provide? The answer to this question must include identification of the nuclear environment involved and the system elements being protected.

b. What are the characteristics of the item, either "as-is" or modified, that allow it to provide this protection function?

In the first example given above, the answer to the first question is that the identified system elements are being shielded against x-rays. The answer to the second question will involve identification of the thickness and atomic number of the material or materials of which the item is composed. For the second example, the answer to the first question is that some sensitive identified electronics are being protected against high currents resulting from SGEMP induced current flow in the cables. The answer to the second question is that the addition of special fill material within the body of the cable reduces air voids and thereby reduces the SGEMP induced space charge effects that cause additional unwanted currents to flow. It is vital that the content of the answer to the second question be thoroughly documented in the applicable NH&S DAR.

D.4.3.1.3 Clarification of rationale 3. Rationale 3 is probably the easiest of the first three rationales to understand and to apply. This rationale concerns the fact that sometimes-special hardware or software elements are introduced into the design of a weapon system solely for the purpose of increasing the nuclear hardness of the design. They serve no other design purpose, and if the hardness requirements associated with the weapon system were to be deleted or voided for some reason, such hardware and software could be removed from the design without affecting any other performance characteristic or capability. Such items are referred to as "hardness dedicated" and are to be identified as HCI by virtue of rationale 3. Examples of hardness dedicated hardware are electrical surge arrestors (ESAs), shielded enclosures to protect against either x-rays or electromagnetic fields, and shock isolators. It should be noted that some of the items that are typically used for hardness dedicated protection purposes are also used to protect against other environmental concerns, such as electromagnetic interference (EMI) or lightning. In those cases where a given hardware element serves multiple purposes or concerns, including NH&S, that item shall not be identified as a rationale 3 HCI, but rather as a rationale 2 HCI.

D.4.3.2 Clarification of rationale 4. Rationale 4 differs from the first three rationales in that it is concerned with fabrication, manufacturing, or assembly processes that contribute to achieving hardness in the design, rather than with the contribution of hardware elements per se. Such processes are referred to as "hardness critical processes (HCPs)". The concept of HCP is included within the definition of HCI to provide a means to identify, track, and preserve those aspects of the hardened design whose implementation involve hardness related processes. This approach is necessary because, once an ICBM weapon system is fielded, the hardened configuration is tracked and maintained only in terms of constituent hardware elements. This activity is based on the HCI list. Therefore, the only way to ensure the preservation of the integrity of hardness critical processes throughout the system life cycle is to include them in the HCI list. The means by which this is accomplished is identified in the text of rationale 4 contained on Figure 6. Once a particular process contained in a design is identified as being hardness critical (i.e., it serves to implement a hardness design feature), the approach taken is to identify as HCI those hardware items to which the HCP is applied. As noted in the text of rationale 4, the items selected to be identified as HCI in these cases are to be the highest level(s) of assembly directly involved with the hardness critical process that will enable clear traceability via the HCI list to the documentation of the hardness critical process in the applicable engineering drawings and the NH&S DAR (see A.3.110). In other words, the goal here is to "tag" the HCP for inclusion in the HCI list by identifying some associated item or items of hardware as HCI. To avoid unnecessarily increasing the size of the HCI list, only the "highest level(s) of assembly directly involved with the hardness critical process" need be labeled as HCI. It is important to note that the item(s) identified as HCI to serve this traceability function may themselves have no special hardness characteristics. On the other hand, they may never have been identified as HCI if not for their association with an HCP. Examples of processes that may be identified as being hardness critical are surface preparation requirements, bonding and welding requirements, torquing requirements, and the application of suppression coatings.

D.4.3.2.1 Relationship to HCI identification of distinction between hardness critical process and hardness critical procedure. In applying rationale 4 during the HCI identification activity, it is important to be aware of the distinction made in A.3.67 of Appendix A between the terms “hardness critical process” and “hardness critical procedure”. These are two related but different concepts that are both represented by the symbol HCP. The following quote from A.3.67 of Appendix A explains the difference:

> "A hardness critical process is any fabrication, manufacturing, or assembly activity identified on an engineering drawing that supports the implementation of a hardness design feature (see A.3.72 of Appendix A). If not performed correctly, the hardness design feature will be compromised."
>
> "A hardness critical procedure is any facility (see A.3.35 of Appendix A) construction, A&CO (see A.3.7 of Appendix A), or maintenance and repair task which, if not performed correctly, will have an adverse effect on system hardness."

In any specific instance, the meaning of the symbol "HCP" (whether "hardness critical process" or "hardness critical procedure") is determined from the type of documentation in which it appears. Rationale 4 is intended to apply only to the concept of "hardness critical process".

Even though a hardness critical procedure, as defined above, is also represented by the symbol "HCP", hardware elements involved with such a procedure must not be identified as HCI by virtue of rationale 4. Hardness critical procedures are applied to HCIs and other associated items as directed by Technical Order (or equivalent documentation). The reason for this is that, whatever hardness concern may be associated with the hardness critical procedure, no new information regarding the implementation of a hardness design feature will be involved that is not already identified on an engineering drawing. Therefore, no new information about how hardness is provided for in the design will be supplied. Unnecessary HCI identification can lead to extra cost. Therefore, care must be taken not to unnecessarily identify items as being HCI when such actions do not serve the purposes for which such identification is performed in the first place.

The purpose of HCP (process) markings in drawings is to identify the specifics of which process led to designation of the parts as HCI using Rationale 4 so that any needed substitutions or new suppliers can be qualified and conform to those processes. HCP (procedure) markings in TOs (and related) are for the purpose of ensuring that care is used while executing the procedure in order to avoid hardness degradation and while working with parts that are not HCI but which could cause damage or degradation to the HCI involved in (or nearby) the procedure being performed.

D.4.3.3 Clarification of rationale 5. Rationale 5 differs from the first four rationales in that it is intended to serve the purposes of configuration management rather than the identification of how hardness is provided for in the design. The inclusion of rationale 5 in the HCI definition allows the tracking of system hardness from the "top down" as well as from the "bottom up"; i.e., one is then able to readily identify all locations within the weapon system where a particular part, component, or assembly that is HCI is utilized. This capability is of great value in supporting cost-effective system hardness management throughout the operations and support phase. The implementation of rationale 5 does not involve any technical challenge or uncertainty. One simply applies the direction that any assembly or subassembly that contains an HCI will also be identified as an HCI. It should be noted, however, that as a result of applying this rationale many assemblies may be identified as HCI, not necessarily because there is an inherent "hardness story" associated with those particular assemblies per se, but only because somewhere within these assemblies there is an item that satisfies one or more of rationales 1 through 4.

D.5 HCI DOCUMENTATION AND APPLICATION.

D.5.1 HCI listings and annotations. Once an HCI index in the NH&S DAR is prepared and validated as accurate by the program's NH&S and Configuration Management personnel for a given WSE is available, the information contained in it is used to support the preparation and implementation of various HCI annotations in other documentation and by the SPO to update the system master HCI list. Explicit direction for the content and format of this listing is contained in DID DI-ENVR-80266B. Contractor NH&S personnel have the lead responsibility for the preparation of this HCI index in the DAR. The other program documentation that must also be annotated with respect to HCI identification include:

a. Drawings (and associated parts lists);

b. The assembly and checkout technical analysis (A&CO TA);

c. The logistics support analysis (LSA); and

d. Technical Orders (TOs) and other applicable procedural documentation (see C.5.2.4 and D.4.3.2.1).

Such annotations must be accomplished in accordance with the direction contained in the applicable contract compliance documentation that controls the preparation of each of these data products. Lead responsibility for accomplishing these HCI annotations rests with the separate organizations within the contractor that prepare these data products, but contractor NH&S personnel have significant support and review responsibilities, as identified in paragraphs 5.3.8.2 through 5.3.8.5 of this standard. All parties involved have the overriding responsibility to utilize the applicable DAR HCI index as the only authoritative source of information for accomplishing these annotations.

D.5.2 Other HCI related documentation. In addition to HCI listings and annotations (which consist primarily of the inclusion of HCI flags and other symbolic notations in different types of documentation, as required), various other kinds of substantive HCI documentation must also be implemented. These range from the detailed technical discussion of HCIs that must be included in NH&S DARs to the identification for each HCI included in the HCI index of hardness related test and inspection requirements. The rationale for each of these kinds of HCI documentation can best be both understood and implemented from an understanding of the hardness purpose of each type of documentation. Once a system has been deployed, there are three main categories of activity that can impact system hardness. These are:

a. reprocurement;

b. repair and maintenance; and

c. redesign.

The identification of hardness related test and inspection requirements in engineering drawings and the associated HCI list drawing clearly supports reprocurement. If system hardness is to be preserved throughout operational life, any HCIs that are later purchased as spares must exhibit the same or better hardness capability as the original items. This can be ensured only if the documentation used in support of spares procurement identifies required hardness related characteristics and any associated tests and inspections necessary to determine that those characteristics are, in fact, still present in the items being procured at a later date. Likewise, the inclusion of hardness related cautions and hardness related test and inspection requirements in TOs provides the means to ensure that the hardness properties of HCIs will not be compromised during repair and maintenance activities. Finally, the detailed technical discussion required to be included in the NH&S DARs provides cognizant NH&S personnel the insight necessary to support redesign or modification activities and to provide a necessary review and consultation capability with respect to reprocurement and repair and maintenance actions. Thus, it is seen that every aspect of HCI identification and documentation requirements supports in some way the preservation of system hardness throughout weapon system operational life. Each aspect is necessary, and each must be accomplished carefully, thoroughly, and in full accordance with contractual requirements.

D.5.2.1 Utilization of HCI documentation. It is clear from the above discussion that HCI identification and documentation serve many diverse program needs and that many communities (e.g., reprocurement, repair, TO preparation), in addition to NH&S, make use of this information, each for its own purposes. Because each such community is focused primarily on the HCI needs of its own specific area of concern, awareness of the totality of NH&S technical concerns and the ways in which other communities utilize HCI identification and documentation is sometimes lost sight of. This circumstance has occasionally resulted in attempts by members of non-NH&S communities to make independent judgments about matters relating to HCIs not fully consistent with the body of data established, reviewed, and approved by cognizant NH&S personnel. This situation must be avoided. Although each separate program community is, of course, the established authority for the responsibilities assigned to that community, the NH&S community is the only entity with the depth of understanding of hardness matters and the overview of the program wide utilization of hardness information to make appropriate judgments about the correctness and completeness of all issues related to HCIs.

SEMICONDUCTOR PARTS RADIATION TEST MANAGEMENT PLANSCOPE

CONTENTS

E.1	INTRODUCTION
E.1.1	Purpose
E.1.2	Scope
E.2	PARTS CONTROL FOR WEAPON SYSTEM EQUIPMENT
E.2.1	Background
E.2.2	Equipment categories
E.2.2.1	Contractor Furnished Equipment (CFE)
E.2.2.2	Government Furnished Equipment (GFE)
E.2.2.3	Commercial equipment (COMM or COTS)
E.2.2.4	Military equipment (MIL)
E.3	RADIATION TEST PROGRAM STRUCTURE
E.3.1	Radiation characterization testing
E.3.2	Radiation qualification testing
E.3.3	Hardness assurance/lot acceptance testing (HALAT)
E.3.4	Options for semiconductor parts radiation testing
E.4	RADIATION TESTING BASED ON DESIGN MARGIN (DM)
E.4.1	Guidelines for HALAT
E.4.2	DM tracking
E.5	GUIDELINES FOR THE USE OF EXISTING TEST DATA
E.5.1	Considerations for acceptability of similar data
E.5.1.1	Options relative to age of the data
E.5.1.2	Options relative to device and manufacturer similarity tradeoffs
E.5.2	Qualification of advanced technology parts
E.6	CATEGORIES AND HARDNESS CRITICAL ITEMS (HCIs)
E.7	ACRONYM LIST

TABLES

Table V Radiation Test and Parts Control Requirements for Semiconductor Parts

E.1 INTRODUCTION.

E.1.1 Purpose. This Semiconductor Parts Radiation Test Management Plan provides an integrated reference of the radiation testing requirements for semiconductors. Government Contractors, Project Officers, Program Managers, Project Engineers, and Item Managers need to use this plan to avoid ambiguity regarding radiation testing required of semiconductors during engineering & manufacturing development (EMD), production, and procurement of spares for life-cycle support during the operational phase of the system. While not a mandatory compliance portion of MIL-STD-1766, the methods outlined here need to be followed closely because they are based on sound technical principles and experience with semiconductor radiation performance. Several other MIL-STDs use the general concepts discussed here but they establish too small a design margin and remove controls too early relative to the high probability and confidence required of sampling plans for ICBM parts. Acronyms/abbreviations which have been previously defined in the body of the MIL-STD will often not be spelled out again in this appendix.

E.1.2 Scope. This plan discusses the radiation characterization testing (CHAR), qualification testing (QUAL), and hardness assurance/lot acceptance testing (HALAT) for semiconductor parts in all phases of the life cycle for ICBM weapon system from technology maturation and risk reduction through EMD and production. The goal of this plan is to reduce semiconductor testing as much as possible while continuing to meet all radiation requirements and maintain a very high level of probability and confidence. Ultimately, the goal is to make the procurement of radiation hard parts for the program as cost-effective as possible.

One component of this plan is to allow the use of previous test data to establish the design margin (DM) of parts with respect to the radiation requirement. However, this practice is only acceptable under the specific terms outlined in this plan. Contractors and SPOs are cautioned to avoid using data that is unreliable or not of sufficient technical integrity to assure that adequate margins are established. Therefore, users of this document must be attentive to limits placed on the use of old data.

E.2 PARTS CONTROL FOR WEAPON SYSTEM EQUIPMENT.

E.2.1 Background. All semiconductors used in the ICBM weapon systems need to be characterized early in the program in the specified nuclear radiation environments. The characterization provides the data necessary to establish margins and then determine what tests are appropriate for qualification and for later in the production phase so that the definition of a complete Hardness assurance/lot acceptance test program has a firm technical basis.

Aerospace vehicle equipment (AVE) parts often have small DMs resulting from the extreme nuclear radiation environments experienced during flight. Operational support equipment parts typically have large DMs resulting from the lower radiation levels that occurred in shielded, buried structures. The small DM of AVE parts requires more tightly controlled manufacturing processes to ensure that adequate design hardness is implemented during EMD, production, and spares procurement. The MIL-STDs, such a MIL-M-38510 and MIL-S-19500, historically established levels identified as Class S (for AVE or space vehicles including JAN-S) and Class B (for ground equipment including JAN, JANTX, or JANTXV). Much later, the MIL-STDs were converted to performance documents (PRF) and made use of Class V (AVE) and Class Q (ground equipment). The use of Class S or Class V for AVE typically led to less variation within a given lot since the definitions for lots included a smaller group of parts made over a smaller time period. Thus, QUAL and HALAT requirements based on margin are expected to inherently lead to tighter distributions for AVE parts when these classes of parts are used. For similar reasons and more, they are also expected to have somewhat higher reliability.

E.2.2 Equipment categories. All equipment is either contractor furnished equipment (CFE) or government furnished equipment (GFE). Contractor furnished equipment is either developmental or non-developmental. Developmental and non-developmental categories may be designated as commercial (COMM) or military (MIL) and as modified (M) or unmodified (U) (i.e., there are four combinations, COMM-M, COMM-U, MIL-M, and MIL-U).

E.2.2.1 Contractor Furnished Equipment (CFE). This is equipment that has been specifically designed or chosen by the contractor for use on the program. Developmental items (DI) are newly designed or extensively modified to meet ICBM requirements (CFE-DI). Non-developmental items (CFE-NDI) may or may not meet applicable ICBM nuclear radiation requirements.

For CFE, the contractor is responsible for the semiconductor parts characterization testing, QUAL testing, and HALAT. Contractor furnished equipment used for AVE, typically used tightly controlled MIL-PRF-38535 Class V and S parts for reliability. The strict reliability controls help minimize the variation in radiation induced parameter shifts. The class of parts used for OSE (mostly MIL-PRF-38535, Class Q or B) can exhibit wide vendor-to-vendor and lot-to-lot variations, limited process controls, and a requirement only to report process changes to the Defense Supply Center Columbus (DSCC) annually. Hardness assurance/lot acceptance testing for Class Q or B parts can be more significant than Class V or S parts.

The DSCC has been trying to include limited radiation hardness screening in standard military drawings (SMDs). The use of DSCC screened parts has the potential of significant cost savings. Intercontinental ballistic missile contractors and SPOs must work with DSCC to include their programs nuclear radiation requirements in DSCC SMDs. When the DSCC SMD nuclear environments do not completely cover the program requirements, additional nuclear hardness test requirements are documented using a selected item drawing (SID).

E.2.2.2 Government Furnished Equipment (GFE). This is equipment which is supplied by the government directly to the contractor. It is equipment developed for other government programs. The problems encountered with the use of non-hardened GFE are more complicated than the use of COMM because the government directs the use of this hardware. Usually, this equipment is used "just as it is", i.e., unmodified (GFE-U). However, it may be necessary to implement modifications for hardness reasons. When GFE is modified, this equipment must be re-identified with a new part number and may not be freely interchangeable among programs unless the manner in which it is modified basically "wraps" it in a protective layer so that it remains as GFE-U.

If the equipment was hardened to hardness requirements different from the current program, a review of its NH&S Design Analysis Report (DAR) is performed to determine whether the equipment meets the nuclear hardness requirements of the current program. This is accomplished by reviewing the NH&S DAR data to determine DMs and verifying that the parts control and testing which would be required to demonstrate compliance has occurred. If the GFE-U does not meet the current nuclear radiation requirements, even after use of system shielding or other protection, the contractor must notify the SPO and recommend alternate design solutions. The SPO will decide whether to modify the GFE, substitute other GFE, or implement an alternate design solution. If the original hardening effort did not implement the correct and necessary hardening controls, the contractor must augment the existing hardness assurance program to comply with current program requirements.

E.2.2.3 Commercial equipment (COMM or COTS). This is equipment that may be procured commercially for use in the weapon system. Parts in COMM equipment require characterization by the contractor because there was no need to consider radiation environments when the equipment was originally designed for commercial use. The class of parts used for commercial applications have exhibited wider vendor-to-vendor and lot-to-lot variations than MIL-PRF-38535 Class Q or B parts resulting from nonexistent process controls and no requirement to report process changes. The choice of COMM is attractive only if the radiation levels are low enough to ensure a large DM.

E.2.2.4 Military equipment (MIL). Military equipment usually has an existing hardness baseline of testing and controls. Military equipment typically requires the least effort to demonstrate hardness. If the equipment was hardened to radiation requirements different from the current program, a review of its NH&S DAR (or equivalent report) is performed to determine whether the equipment meets the nuclear radiation requirements of the current program. This is accomplished by reviewing the NH&S DAR data to determine semiconductor parts DM and verifying that the parts control and testing specified in this plan have been implemented. If the MIL-U does not meet the current radiation requirements, even after use of system shielding, the contractor must modify the equipment. If the original hardening effort did not implement the correct and necessary HALAT controls, the contractor must augment the existing hardness assurance program to comply with current requirements.

E.3 RADIATION TEST PROGRAM STRUCTURE. The test program for semiconductors is comprised of three activities. These are:

a. Characterization testing;

b. Qualification testing (QUAL); and

c. Hardness assurance/lot acceptance testing (HALAT).

The radiation environments of interest to ICBMs are gamma dose rate [short & long pulse], total ionizing dose, and neutron fluence [1 MeV D.E.S.]. Single event upset (SEU) phenomena are also important for many modern part process and design technologies.

Characterization testing provides data needed to decide if a part can meet specified nuclear radiation requirements. Because it is the basis for the scope of the whole nuclear radiation test program, it must happen early in the program. Characterization testing is almost exclusively conducted during the early part of EMD. On occasion, when a qualified supplier is no longer available, such testing is performed during spares procurement.

Qualification testing is an EMD activity conducted before production and proves that the parts used in the design are ready for production. Qualification testing is also required during the operational phase for spares procurement. This later life cycle testing is needed for the same reasons as noted for characterization testing above and is necessary when sufficient time has passed that confidence in the DMs established by the EMD phase characterization are no longer valid. The validity of DMs become questionable due to process and design changes that are not being monitored continuously by either the contractor or the government. For most semiconductor parts a period of 18 months is considered sufficient time for DMs to become questionable unless the process is continuously monitored (with approval authority) for manufacturer-desired changes. A period longer than three years without monitoring requires either re-characterization or, when re-establishing DMs is not deemed necessary, re-qualification.

HALAT is performed during production and on any procurement of spares.

E.3.1 Radiation characterization testing. The goal of radiation characterization testing is to determine the behavior of all critical parameters when exposed to increasing levels of nuclear radiation. The less variation and larger the DM observed, the less testing is required during production. Sample size for radiation characterization testing is often fifteen (15). Typically, five (5) samples are tested in each of three environments (dose rate, total dose, and neutron). The samples tested must represent the part used in production (i.e., same process, same configuration, etc.). Refer to Section E.5 for additional information on similarity and constraints associated with its use.

Characterization testing measures the semiconductor's electrical parameters or functional performance as they vary with radiation to determine its behavior in each of the applicable environments. Parts are exposed to increasing radiation levels until parametric or functional failure occurs or the limits of the simulation facility are reached. It is essential that the radiation simulator be capable of reaching or exceeding the specified radiation levels. However, the testing does not need to continue to facility maximum if the level achieved is high enough to show that sufficient margins exist in each environment.

It is important to distinguish between parametric and functional failures. As the radiation levels are increased, the electrical parameters for a device will begin to change. Eventually, the parameters fall outside the specified limits for that part. Each parameter will seldom change at the same rate. Therefore, a single parameter may be first to fail. Such an out-of-tolerance condition is a parametric failure. The parameter which fails may be different for different radiation environments. Despite the number of out-of-tolerance parameters, the first such event is a failure. However, in setting the value at which failure is defined to occur, it is important to note that circuit design may be used to allow for variations significantly beyond the values considered by the manufacturer for non-military application of the part in the absence of radiation environments. Such limits are often called post-radiation end point limits.

Even when a parameter failure has occurred, the part may continue to function and it will continue to respond to changes in input conditions. As the radiation level increases higher than the parametric failure level, the device will eventually fail to respond. This is a functional failure.

During characterization, many electrical parameters must be measured (not just a chosen few). Parameters to be monitored are a function of:

a. The complexity of the device;

b. Previous radiation test data on the device; and

c. The criticality of the part application to weapon system performance.

As a minimum, devices must be monitored for input and output voltages and currents. New devices may require tens of parametric tests at many radiation levels while a diode or transistor may only need limited testing or analysis using existing data.

Because many semiconductor parts have large lead times for procurement, it is often necessary to perform characterization using "generic" type devices. These devices must be from the same vendor(s) as the parts to be used in production. Such parts are usually a commercial version of the actual part or a version of the actual part which has received electrical screening tests but has not been subjected to all reliability testing required for the production parts to meet reliability requirements at the system level. These characterization samples are adequate for characterization in the sense that they give some idea about the margins that exist and some confidence in meeting the hardness requirements but do not prove that actual devices will meet the requirements for production parts (either in nuclear environments or for reliability).

Characterization test data serve two purposes. First, the data will determine which parameters will be monitored for qualification and HALAT and establish design limits for each of those parameters which will eventually be incorporated into an End of Life (EOL) parameters table in the engineering drawing or other design document. The EOL limits set the capability of the part for use by circuit designers and may be known by other names such as worst case design limits or parts derating limits. Such limits include allowances for temperature variation, aging drift of semiconductors, and radiation-induced changes. Second, the data will establish the DM. This DM will determine the frequency of the qualification testing and HALAT required (see Table V). When "generic" devices are used for characterization, the DM established by the characterization testing is subject to review when qualification of actual production parts is performed. The guidelines of Table V must not be used to eliminate QUAL or HALAT completely when "generic" devices are used in characterization.

Before characterization testing begins, an approved test plan is required. The test plan must include test configurations which represent the worst-case expected usage for each part (see Section E.5 regarding similarity and constraints on its use. A test report is required upon completion of the characterization test. The test report includes the reduced data (with raw data appended), conclusions, recommendations, and discussions of anomalous behavior and plans for action to resolve problems.

E.3.2 Radiation qualification testing. Radiation qualification (QUAL) testing proves the semiconductor part meets radiation requirements during and after exposure to the specified nuclear radiation environments and serves as proof that the manufacturer's production parts are acceptable for system use. The number of parameters and the complexity of the test (i.e., amount and degree of monitoring of parameters during and/or after the nuclear environment) is determined by the DM identified during characterization (see Table V).

TABLE V. Radiation test and parts control requirements vs design margin

Design Margin Break Points (BPs)	Characterization Testing 1/	Qualification Testing 2/	Hardness Assurance/ Lot Acceptance Testing (HALAT) 3/
3 < DM ≤ 10	Testing or analysis to: 1. Failure ≤ 10X 2. Facility maximum ≤ 10X 3. 10X requirement	Qualification by test required	Testing required for all lots 4/
10 < DM ≤ 50	Testing or analysis to: 1. 10X < Failure ≤ 50X 2. 10X < Facility maximum ≤ 50X 3. 50X requirement	Qualification by test required	Test first production lot, then every other lot
50 < DM ≤ 100 (for Total dose & neutron) 50 < DM ≤ 200 (for Dose rate)	Testing or analysis to: 1. BPL < Failure ≤ BPH 2. BPL < Facility maximum ≤ BPH 5/ 3. BPH times requirement	Qualification by analysis 6/	Test first production lot, then one lot year 7/
100 < DM ≤ 200 (for Total dose & neutron) 200 < DM ≤ 500 (for Dose rate)	Testing or analysis to: 5/ 1. BPL < Failure ≤ BPH 2. BPL < Facility maximum ≤ BPH 3. = BPH times requirement	Qualification by analysis 8/	No testing required

TABLE V. Radiation test and parts control requirements vs design margin (Continued)

Design Margin Break Points (BPs)	Characterization Testing 1/	Qualification Testing 2/	Hardness Assurance/ Lot Acceptance Testing (HALAT) 3/
200 < DM ≤ 500 (for Total dose & neutron) 500 < DM ≤ 1000 (for Dose rate)	Testing or analysis to: 5/ 9/ 1. BPL < Failure ≤ BPH 2. BPL < Facility maximum ≤ BPH 3. = BPH times requirement	No testing required	No testing required
DM > 500 (for Total dose & neutron) DM > 1000 (for Dose rate)	Testing or analysis to: 5/ 9/ 1. Failure > BPH 2. Facility maximum > BPH 3. > BPH times requirement	NO TESTING REQUIRED	

1/ Characterization by analysis means the demonstration of radiation capability by using previous test data for the same or similar part. Use of data for similar part is subject to government approval. Data used for characterization must be for all vendors being considered for use. See Section E.5.
2/ Requalification required after major changes affecting hardness (see MIL-STD-1546).
3/ Qualification testing on the first production lot buy can serve as the first hardness assurance lot acceptance test (HALAT).
4/ If lot-to-lot or vendor-to-vendor variability (3s) is larger than 10X or if DM?2X, then test and traceability shall be at the wafer level than at the lot level (i.e., test samples from each wafer).
5/ BPH = the Higher Break Point and BPL = the Lower Break Point.
6/ Qualification by analysis consists of verifying that no major changes in processing or design have occurred since characterization was completed.
7/ The time between tests shall not exceed more than one year unless no lots have been purchased during that time. If date codes for any lot are separated by more than one year, then test a sample from each date code which is so separated.
8/ Qualification must be by test if characterization is by analysis.
9/ If characterization is by analysis, data must be no more than three years old.

Radiation qualification testing is the design proof for CDR which shows that the actual parts used in production meet the requirements of the design. These requirements must be documented in the appropriate engineering drawings, other associated documents that will be used in production phase and during the operations and support phase, and in the NH&S DAR.

It is possible to combine characterization and QUAL testing into a single test. If the characterization test parts are from the same manufacturer as the production part, have large DMs, and are the actual device to be used for production, then characterization test data may serve as qualification for the part.

The sample size for QUAL is usually twenty-two (22) parts with all devices being exposed to all the radiation environments in the order of dose rate, total dose, and neutron. Therefore, if characterization is to serve also as QUAL, then sample size must be increased. This better detects variations that may be missed by small sample sizes. In order to ensure that if a performance parameter changes during test, the change is due to radiation, control devices are used which are not exposed to radiation but only to the non-radiation tests such as electrical measurements.

In contrast to characterization, QUAL usually includes testing at specific, but limited radiation levels (usually three levels for photocurrent response/surge current, at least one level for burnout and/or latch up testing, and neutron exposure at one or more levels). Characterization provides information needed to decide which parameters are measured during QUAL. These will usually be a small subset of those tested in characterization and represent those parameters, which vary most severely with radiation.

E.3.3 Hardness assurance/lot acceptance testing (HALAT). Hardness assurance/lot acceptance testing of semiconductor parts in the specified radiation environments shows statistically that the parts bought for production meet radiation requirements. Table V shows that this testing may be on every lot, every other lot, or on one lot per year depending on DM. When the DM is very large, HALAT may be eliminated. HALAT is sometimes called radiation lot acceptance testing (RLAT) or simply hardness assurance testing (HAT).

As with QUAL, HALAT is usually comprised of testing at specific radiation levels (usually three levels for photocurrent response/surge current, and at least one level for burnout and/or latch up testing along with neutron exposure at one or more levels). HALAT often uses only a subset of parameters tested at QUAL. HALAT provides assurance that production parts continue to meet requirements and that design requirements are being maintained throughout production. As noted earlier in this appendix, during the operations and support phase it is important to distinguish when HALAT conditions used in a production phase are still applicable (especially when testing frequency is limited or eliminated and when very few parameters are monitored in HALAT). In the operations and support phase, the program must first evaluate whether the DMs established in EMD are still valid and invoke a re-qualification if significant time has passed since EMD and production testing have been completed.

The sample size for HALAT is based on lot tolerance percent defective (LTPD) sampling. Requirements for QUAL are based on 90 percent probability (P) with 90 percent confidence (C) (22 samples with no failures). This is a compromise between high P/C and a reasonable sample size. Sometimes HALAT sample size is further reduced based on 85 percent probability with 90 percent confidence (15 samples with no failures). Although LTPD sampling in historical documents may allow larger sample sizes when failures occur, such sampling must be avoided in ICBM hardware. The reason for this is that even when parts are tested at 90/90 or 85/90 (P/C), such testing does not necessarily guarantee a high probability and confidence of hardness at the system level. It is the combination of high DM and reasonable sample size P/C that provides assurance that system requirements are met. A single HALAT failure can lower system hardness if the parts are used in the weapon system. Only when there is confidence that any such defects can be screened out of the lot should parts from a lot with failures be used.

It is possible that the first HALAT in a production program can be accomplished during characterization testing and QUAL. If the characterization test parts are from the same vendor and lot and are the actual device types used for production, then characterization and the determination of DMs and EOL limits will provide enough confidence in the first production buy of the particular semiconductor part in question.

E.3.4 Options for semiconductor parts radiation testing. The contractor must evaluate the semiconductor parts radiation testing to be conducted in each of the program phases. It may be more cost-effective to have minimal parts control combined with a large amount of HALAT testing. In such a case, characterization is minimized or eliminated using previous test data. In another case, the least costly approach may be to do extensive characterization testing during EMD to show that large DMs exist and implement a production phase which has little or no HALAT. The most likely program is somewhere between these two extremes using CHAR, QUAL, and HALAT requirements based on DM.

The example in Table V assumes that the contractor has design control and therefore can perform testing at the piece part level and that the contractor is the same for both EMD and Production. If the contractor does not control the parts source process, then margin established during EMD can vanish during production. Therefore, without parts controls it is often necessary to test enough in EMD to establish confidence that the design will meet the requirements (i.e., for CDR/Qualification) and then perform HALAT and/or higher assembly testing during production with relatively large sample size (HALAT) and/or increased frequency (HALAT and/or higher assembly) to ensure the margin still exists throughout the program. This is especially the case for COTS. The general approach must be agreed upon at PDR so that, by CDR, the DM is obtained which is necessary for the production phase plans for testing. In other words, EMD phase affects production and vice versa; thus,the planning for this comes relatively early in the program EMD, but the HALAT plan is executed in the production phase

E.4 RADIATION TESTING BASED ON DESIGN MARGIN (DM). The concept of radiation DM is of fundamental importance in this plan. Generally, radiation DMs of semiconductor parts are measured by characterization testing of samples of each part type, from each vendor, in each specified nuclear environment.

The radiation DM is the arithmetic mean minus three sigma of the parametric or functional failure level (whichever occurs at the lowest radiation level) of the test sample divided by the specification environment (free-field or local as specified). It is the ratio of two radiation levels. The numerator is the radiation level at which failure occurs and the denominator is the requirement level. Unless test data shows a more appropriate distribution, a normal distribution is assumed when calculating the three sigma deviation from the mean.

$$DM = \frac{\text{Mean Radiation Failure Level - 3 Sigma}}{\text{Specified Radiation Level}}$$

The correct definition of a failure level is essential to the determination of DM. The parametric failure level is the lowest radiation level at which any parameter specified for the device under test (DUT) is out-of-tolerance to the extent that the circuit may no longer work and a functional failure level is the lowest radiation level at which the device does not respond correctly at its outputs based on known inputs. Because there are several radiation environments (dose rate [prompt and delayed], total dose, and neutron), several parameters affected by radiation, and several failure modes must be explored (parametric, burnout, latch-up, excessive photocurrent, upset, and other incorrect functions) for each device because each may have a different DM. The lowest DM for each environment is the one that determines testing required for that environment.

Table V provides the HALAT and QUAL test requirements as a function of DM for parts without specifically controlling the manufacturer's process. Even MIL-STD parts, while under some change control by the Defense Logistics Agency, are not controlled with respect to hardness or the parameters that affect it and ICBM programs are typically not privy to DLA's information. Therefore, Table V applies to all parts not having process control maintained by the program (or otherwise controlled in a way that gives the program full knowledge of all process changes). If the contractor intending to use the parts has a long history with the vendor and its parts, the break points used in Table V can be lowered somewhat.

Contractors shall consider the following as they develop hardness assurance plans based on the HALAT and QUAL requirements in Table V (or an adapted version of it):

a. The statistical variation within each given lot;

b. The variation of radiation response over the period procurement;

c. The variation of the radiation response between vendors and between lots from the same vendor (they should be no wider than the DM windows; i.e., the ranges over which a set of controls applies in Table V must encompass variation between lots from the same vendor or between vendors depending on whether procurement will be from a single supplier or will be allowed to come from more than one);

d. Use of worst case source and load conditions during active total dose and dose rate testing; and

e. Over-testing by a factor of 3-10X during passive neutron tests to account for parameter annealing (characterization with transient response monitoring may also be used to have better knowledge of the neutron annealing effects and thus allow for minimal over-test). Passive neutron testing is performed without bias voltage and the post radiation parameters are measured several days after the radiation exposure but these will be almost fully annealed and thus require over-testing.

E.4.1 Guidelines for HALAT. Once margins are measured using radiation characterization data, the frequency and amount of HALAT for each part can be determined using Table V.

Generally, for any device which is permitted to upset and for which recovery time is not an issue, dose rate HALAT is not required to address upset or recovery time. However, dose rate HALAT should address burnout and latchup. Unless these failure modes have adequate DM, HALAT is required by Table V.

As stated in Note 3 of Table V, if delivery schedule or cost is a controlling factor, qualification testing may be performed as part of HALAT on the first production lot. This option should be used with extreme caution because it increases the risk of program delays and costs incurred resulting from a failure during HALAT/QUAL. Production cannot proceed without qualified parts. The option to QUAL at first HALAT should be used only when characterization has been by test or with very reliable data and the program has detailed knowledge that no manufacturing process changes have occurred between characterization and the first HALAT.

Caution is required when eliminating HALAT. It is essential that any elimination of HALAT or QUAL is justified with large DMs and those DMs are supported with technically sound data. The parts used to establish DMs during characterization testing must truly represent the actual parts used for production. Further, characterization test methods must also represent the actual radiation environments.

E.4.2 DM tracking. It is essential that DMs be established early in the program and that sufficient parts control and testing be implemented in order to assure that it does not drop to unacceptable levels as the weapon system program progresses. Experience has shown that DMs tend to decrease for some parts as a weapon system progresses through its development, deployment, and operational phases. In many programs, at least one part has a precipitous drop such that a process change is needed to reestablish the DM or a new supplier must be found.

It is also best to establish DMs during characterization based on data from several different lots instead of from a single lot. Concern about "slipping" DMs is low when the DM is large and has a statistically significant track record. Therefore, the contractor must evaluate how many radiation levels and parameters to test during characterization, and how many lots over what time period. Many programs use just one sample but insist on a minimum DM of 10 for a part selected as a risk reduction hedge.

Throughout the development and production, the contractor needs to implement a tracking effort to monitor the DM. Each time new test data is taken, the data shall be compared to previous data to ensure that a negative trend is not developing. This type of tracking requires that parts be tested at or near their capability level (or at least to the breakpoint for a given DM window). The start of the tracking chart is based on characterization data. At QUAL, additional data will be available and plotted. Each HALAT test will provide more points for trend tracking.

E.5 GUIDELINES FOR THE USE OF EXISTING TEST DATA. The use of previous data must be approached with extreme caution. Generally, the best data is from the same device, from the same manufacturer, and is not old (less than one year to reduce the risk of manufacturing process changes). Also, it is necessary to have details of how the part was tested to assure that the correct and necessary procedures were implemented. Knowledge about dose rates, fluences, doses, dosimetry, length of test, length of time between irradiation and electrical tests, bias conditions, are each important.

E.5.1 Considerations for acceptability of similar data. Design margins based on data which do not comply to the guidelines in the previous paragraph (i.e., the same part, same vendor, one year, with adequate test condition information) are not really firm DMs but indications of what the correct DM may be. The higher the margin, the less important it is that every "rule" noted in E.5 be strictly followed.

Old data can be unreliable for three reasons:

a. a.Manufacturer process changes can have subtle and poorly understood effects on hardness;

b. Old data documentation does not include enough information for the data to be evaluated for applicability; and

c. Radiation test methods are constantly under review and periodically changed.

Any options used are based on engineering judgment but ultimately must have a sound technical basis that addresses the issues of non-uniformity that come into play due to a, b, and c above, as well as other aspects of manufacturing that induce variability in product. Since the starting basis for hardness judgments and decisions is that configuration is uniform, anything that introduces non-uniformity within a lot or between lots can affect hardness and must be considered in the sample size, the frequency of testing, and in any decisions to eliminate testing. Especially when dealing with COTS items, one must assume that variations will occur and thus strictly follow the guidelines herein to be conservative (this usually results in decisions to test more when dealing with COTS assemblies than would be necessary if the production were controlled directly by the government's contractor from the piece part level upward in assembly level).

E.5.1.1 Options relative to age of the data. If data is older than 1 year, a quantity of data over several years can compensate for the age of the data. Specifically, if the data is from a several year period and the DM is stable over that period, then it may be safe to assume that it will remain constant in the future. If data for several years is not available, then data from several vendors over some reasonable time period may show that the device has a stable DM.

E.5.1.2 Options relative to device and manufacturer similarity tradeoffs. The rule regarding same device for data can be relaxed for discrete and less complex digital devices. The same device rule is more important for dose rate and much less so for neutron and total dose. The reason for this is that neutron and total dose performance is more a function of the manufacturing process and device technology while dose rate response is still very much circuit design dependent. In a case where data for the same device is not available and the part is a discrete semiconductor or a simple digital device, then data for a similar device may be substituted.

The term similar, in the context of a similar device, means that the data is for a device from the same process technology at the same vendor but with a slightly different electrical function or set of parameters. Such data is sometimes also called family data. If the data is for the sample part type/function but from different vendors, then it is referred to as generic data.

Another way to compensate for similar data, but different vendor, is to get data from several vendors. If large DMs exist for several vendors, then there is enough confidence that no matter who makes the part, it will meet the nuclear radiation requirements.

E.5.2 Qualification of advanced technology parts. Advanced technology parts include hybrids, multi-chip modules, gate arrays including field-programmable versions, and application specific integrated circuit (ASIC) technologies. The high cost of these advanced technology parts requires consideration of qualification using reduced sample size or by similarity due to the high cost per part and the desire to limit destructive radiation testing on these expensive parts. Qualification by similarity is allowed with the approval of the contracting activity who must accept the risk to program. Therefore, the following requirements are provided for qualification by similarity of advanced technology parts.

a. Parts must be selected to represent all of the standard cells, logic array blocks, functional blocks, etc. The selected parts must be subjected to full hardness characterization/qualification testing at the part or sub-part level. Radiation prediction models must be validated using the characterization test data. The radiation prediction models must be used to analyze the performance of all other parts of similar technology. This analysis must show that all parts meet performance requirements during and after exposure to the specified nuclear radiation environments. The analysis must be based on standard vector test patterns. The analysis must include prediction of prompt ionization and long pulse upset, total dose, and neutron degradation, transient recovery time, and propagation delay time. If the model is inadequate to address all of these, radiation testing must occur where modeling deficiencies exist.

b. A part may be "qualified by similarity" if it has:

1). the same packaging and die size(s);

2). the same electrical and layout design rules;

3). the same standard cells, logic array blocks, etc.;

4). the same (or lower) level of logic complexity (gate count, latches, macros, timing loops, etc.);

5). the same processing steps;

6). the same process monitor chip; and

7). is manufactured by the same vendor as the parts that received the full radiation characterization/qualification testing.

In addition, the overall manufacturing process must be shown to be controlled by a quality manufacturing plan similar to the qualified manufacturers list (QML) described in MIL-PRF-38535.

E.6 CATEGORIES AND HARDNESS CRITICAL ITEMS (HCIs). The use of Table V does not imply different categories of HCI based on different margins. Some handbooks and other documents attempt to make classes or categories of HCIs. While this standard does keep track of HCI rationale, all HCIs are treated equally and it is their engineering drawings which contain the necessary content for them to meet requirements. The placing of HCIs into different categories is an unnecessary management tool and must not be used for ICBM NH&S DARs or drawings. If a contractor desires (for internal reasons) to use such categories, they must occur only the contractor's internal documentation and not the documentation delivered to the government.

Whenever HALAT or source control requirements are imposed, the SMDs or SIDs are marked HCI. The drawings must address the testing and controls that the instructions herein dictate are to be implemented. Once it is documented, the drawings will control the procurement of the part without additional HCI categories.

E.7 ACRONYM LIST.

ASIC	Application Specific Integrated Circuit
AVE	Aerospace Vehicle Equipment
CFE	Contractor Furnished Equipment
COMM	Commercial Equipment
COTS	Commercial Off-The-Shelf Equipment
DAR	Design Analysis Report
DES	Damage Equivalent Silicon
DESC	Defense Electronics Supply Center
DI	Developmental Item
DoD	Department of Defense
DUT	Device Under Test
EMD	Engineering and Manufacturing Development
EOL	End of Life
GFE	Government Furnished Equipment
HALAT	Hardness Assurance Lot Acceptance Test
HCI	Hardness Critical Item
LINAC	Linear Accelerator
LTPD	Lot Tolerance Percent Defective
MeV	Million Electron Volt
MIL	Military
NDI	Non-Developmental Item
NH&S	Nuclear Hardness and Survivability
OSE	Operational Support Equipment
QUAL	Qualification
QML	Qualified Manufacturers List

SID	Selected Item Drawing
SPO	System Program Office
SMD	Standard Military Drawing

Index

Definitions of the following terms are provided in appendix A.

Term	Paragraph	Page
Acronyms/Abbreviations	A.2	65
Definitions	A.3	68
Acquisition Life Cycle	A.3.1	68
Aerospace Vehicle Equipment (AVE)	A.3.2	68
Airblast	A.3.3	69
Allocation	A.3.4	69
Analysis	A.3.5	69
Analysis of Alternatives (AoA)	A.3.6	69
Assembly and Checkout (A&CO)	A.3.7	69
Assembly and Checkout (A&CO) Contractor	A.3.8	69
Assembly and Checkout (A&CO) Installation Hardware	A.3.9	69
Assembly and Checkout Technical Analysis (A&CO TA)	A.3.10	69
Assessment	A.3.11	70
Attenuation	A.3.12	70
AVE/SE contractor	A.3.13	70
Blast	A.3.14	70
Capability Development Document (CDD)	A.3.15	70
Circumvention and recovery (C&R)	A.3.16	71
Commercial-off-the-shelf (COTS)	A.3.17	71
Commercial product	A.3.18	72
Concept design	A.3.19	72
Configuration item (CI)	A.3.20	73
Contractor	A.3.21	73
Critical design review (CDR)	A.3.22	74
Contractor furnished equipment (CFE)	A.3.23	74

Term	Paragraph	Page
Debris	A.3.24	74
Depot support equipment (DSE)	A.3.25	74
Design constraints	A.3.26	75
Design margin (DM)	A.3.27	75
Design reviews	A.3.28	77
Detail design	A.3.29	78
Developmental item	A.3.30	78
Development tests	A.3.31	78
Electromagnetic pulse (EMP)	A.3.32	78
Engineering and manufacturing development (EMD) phase	A.3.33	78
Evaluation tests	A.3.34	79
Facilities	A.3.35	79
Facilities A&E contractor	A.3.36	79
Facilities construction bid package	A.3.37	79
Facilities construction contractor	A.3.38	79
Facilities criteria input	A.3.39	79
Facilities design criteria	A.3.40	80
Facilities design criteria contractor	A.3.41	80
Factory support equipment (FSE)	A.3.42	80
Figure A (Fig A)	A.3.43	80
Final design	A.3.44	80
Fragility	A.3.45	80
Fragility analysis	A.3.46	81
Fragility curve	A.3.47	81
Fragility tests	A.3.48	81
Functional configuration audit (FCA)	A.3.49	81
Functional failure	A.3.50	81
Government furnished equipment (GFE)	A.3.51	81

Term	Paragraph	Page
Ground shock	A.3.52	81
Hardening	A.3.53	81
Hardness	A.3.54	82
Hardness allocation	A.3.55	82
Hardness allocation analysis	A.3.56	82
Hardness allocation trades	A.3.57	82
Hardness analysis	A.3.58	82
Hardness annotations	A.3.59	83
Hardness assessment	A.3.60	83
Hardness assurance	A.3.61	83
Hardness assurance inspections	A.3.62	83
Hardness assurance lot acceptance testing (HALAT)	A.3.63	84
Hardness assurance tests	A.3.64	84
Hardness critical item (HCI)	A.3.65	84
Hardness critical item - application (concept and use)	A.3.66	85
Hardness critical process/procedure (HCP)	A.3.67	86
Hardness data manual (HDM)	A.3.68	86
Hardness design	A.3.69	87
Hardness design analysis	A.3.70	87
Hardness design constraints	A.3.71	87
Hardness design feature	A.3.72	87
Hardness design trades	A.3.73	87
Hardness evaluation	A.3.74	87
Hardness fragility	A.3.75	88
Hardness inspections	A.3.76	88
Hardness maintenance	A.3.77	88
Hardness performance requirements	A.3.78	89
Hardness qualification	A.3.79	89

Term	Paragraph	Page
Hardness requirements	A.3.80	89
Hardness surveillance	A.3.81	89
Hardness surveillance inspections	A.3.82	90
Hardness surveillance support contractor	A.3.83	90
Hardness surveillance tests	A.3.84	90
Hardness tests	A.3.85	90
Hardness trade studies	A.3.86	91
Hardness verification	A.3.87	91
Hardness verification analysis	A.3.88	91
Hardware category	A.3.89	91
High altitude electromagnetic pulse (HEMP)	A.3.90	92
Inherent hardness	A.3.91	92
Initial Capabilities Document	A.3.92	92
Inspections	A.3.93	92
Interface control drawing (ICD)	A.3.94	92
Interface control working group (ICWG)	A.3.95	92
Internal electromagnetic pulse (IEMP)	A.3.96	93
Key performance parameter (KPP)	A.3.97	93
Key system attribute (KSA)	A.3.98	93
Life cycle hardness (LCH)	A.3.99	93
Logistic support analysis (LSA)	A.3.100	93
Logistic support analysis record (LSAR)	A.3.101	94
Maintenance support equipment (MSE)	A.3.102	94
Materiel solution analysis phase	A.3.103	94
Non-developmental item (NDI)	A.3.104	94
Nuclear environment/effect hardness element matrix (NEE-HEM)	A.3.105	94
Nuclear environments	A.3.106	95

Term	Paragraph	Page
Nuclear event protection (NEP)	A.3.107	95
Nuclear hardening	A.3.108	95
Nuclear hardness	A.3.109	95
Nuclear hardness and survivability design analysis report (NH&S DAR)	A.3.110	95
Nuclear radiation	A.3.111	96
Nuclear radiation characterization	A.3.112	96
Nuclear survivability	A.3.113	96
Nuclear weapon effects/environments (NWE)	A.3.114	96
Operating command	A.3.115	97
Operational requirements analysis (ORA)	A.3.116	97
Operational support equipment (OSE)	A.3.117	97
Operations and support phase	A.3.118	97
Performance requirements	A.3.119	97
Physical configuration audit (PCA)	A.3.120	98
Preliminary design	A.3.121	98
Preliminary design review (PDR)	A.3.122	98
Prime item development specification (PIDS)	A.3.123	98
Production and deployment phase	A.3.124	98
Qualification	A.3.125	99
Qualification tests	A.3.126	99
Real property installed equipment (RPIE)	A.3.127	99
Shielding topology	A.3.128	99
Shock	A.3.129	99
Source region electromagnetic pulse (SREMP)	A.3.130	99
Support equipment (SE)	A.3.131	99
Survivability	A.3.132	99
Survivability assessment	A.3.133	100

Term	Paragraph	Page
System engineering and technical assistance (SE/TA) contractor	A.3.134	100
System functional review (SFR)	A.3.135	100
System generated electromagnetic pulse (SGEMP)	A.3.136	100
System level analysis	A.3.137	100
System level trade study	A.3.138	100
System life cycle	A.3.139	100
System program office (SPO)	A.3.140	100
System readiness review (SRR)	A.3.141	101
System requirements analysis (SRA)	A.3.142	101
System support/integration (SS&I) contractor	A.3.143	101
System level tests	A.3.144	101
Technical order (TO)	A.3.145	102
Technology maturation and risk reduction (TMRR) phase	A.3.146	102
Testing	A.3.147	102
Test and Evaluation Master Plan (TEMP)	A.3.148	102
Test planning analysis (TPA)	A.3.149	103
Thermal radiation	A.3.150	103
Thermomechanical response	A.3.151	103
Trade studies	A.3.152	103
Transfer function	A.3.153	103
Validation/validate	A.3.154	103
Verification	A.3.155	103
Vulnerability	A.3.156	103
Weapon system element (WSE)	A.3.157	104
Weapon system element contractor	A.3.158	104
Weapon system specification (WSS)	A.3.159	104
Withstand	A.3.160	104
Worst-case circuit analysis (WCCA)	A.3.161	104

CONCLUDING MATERIAL

Custodians:	Preparing Activity:
Air Force - 27	Air Force - 27 (Project ENVR-2014-001)

Review Activities:
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Navy - OS
Air Force - 11, 19

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