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Safety

SAFETY DESIGN CRITERIA FOR NUCLEAR WEAPON SYSTEMS

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This manual implements Department of the Air Force Instruction (DAFI) 91-101, *Air Force Nuclear Weapons Surety Program*. It applies to all organizations that design, develop, modify, evaluate, operate or acquire a nuclear weapon system. This manual applies to the entire Department of the Air Force (DAF), including DAF civilian employees and uniformed members of the United States Air Force and the United States Space Force, the Air Force Reserve, and Air National Guard, as well as those with a contractual obligation to abide by the terms of DAF issuances, except where noted otherwise. Ensure all records generated as a result of processes prescribed in this publication adhere to Air Force Instruction (AFI) 33-322, *Records Management and Information Governance Program*, and are disposed in accordance with the Air Force Records Disposition Schedule, which is in the Air Force Records Information Management System. Refer recommended changes and questions about this publication to the Office of Primary Responsibility (OPR) using the DAF Form 847, *Recommendation for Change of Publication*; route DAF Forms 847 from the field through the appropriate functional chain of command. This publication may be supplemented at any level, but all supplements must be routed to the OPR of this publication for coordination prior to certification and approval. The authorities to waive wing, unit, or delta level requirements in this publication are identified with a Tier ("T-0, T-1, T-2, T-3") number following the compliance statement. See Department of the Air Force Manual (DAFMAN) 90-161, *Publishing Processes and Procedures*, for a description of the authorities associated with the Tier numbers. Submit requests for waivers through the chain of command to the appropriate Tier waiver approval authority, or alternately, to the requestor's commander for non-tiered compliance items. If there is conflicting guidance between this DAFI and any DoD series or published higher-level guidance, the DoD series or published higher-level guidance takes precedence. The use of the name or mark

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SUMMARY OF CHANGES

Tiering authority for the surety standards has changed from (T-1) to (T-0) to follow DoD authority. A "Legend" paragraph was added to **Chapter 1** to describe the differences between safety design criteria requirements language and contextual information. Significant requirements content, format, and arrangement changes have been made since last publication.

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Chapter 1

GENERAL INFORMATION

1.1. Responsibility and Scope.

1.1.1. DAF activities apply Department of Defense (DoD) and DAF safety criteria to design, develop, evaluate, troubleshoot, certify, and maintain nuclear weapon systems. Weapon system designers should constantly seek to design systems that significantly exceed minimum safety standards.

1.1.2. Organic service development organizations (e.g., defense contractors, DoD organizations, Department of Energy organizations) implement safety criteria from the start of weapon system development by including them in appropriate formal source criteria. These criteria include but are not limited to: the program management directive, Stockpile-to-Target Sequence (STS), military characteristics, weapon system specifications, interface control documents, systems engineering plan, and test and evaluation master plan.

1.1.3. The DoD Nuclear Surety Standards form the basis for the safety design criteria for DAF nuclear weapon systems. The surety standards from Department of Defense Instruction (DoDI) 3150.02, *DoD Nuclear Weapons Surety Program* state the four DoD nuclear weapon surety standards provide positive measures to:

1.1.3.1. Prevent nuclear weapons involved in accidents or incidents, or jettisoned weapons, from producing a nuclear yield. **(T-0)**

1.1.3.2. Prevent deliberate pre-arming, arming, launching, or releasing of nuclear weapons, except upon execution of emergency war orders or when directed by competent authority. **(T-0)**

1.1.3.3. Prevent inadvertent pre-arming, arming, launching, or releasing of nuclear weapons in all normal and credible abnormal environments. **(T-0)**

1.1.3.4. Prevent unauthorized access or unauthorized actions, by physical or digital means, that may result in loss or unauthorized pre-arming, arming, launching, or releasing of a nuclear weapon. **(T-0)**

1.1.4. To comply with the DoD Nuclear Surety Standards, the DAF has implemented a set of minimum design criteria for Nuclear Safety Design Certification of nuclear weapon systems. Criteria contained in this manual are consistent with DAFI 91-101 and the DoD Nuclear Surety Standards. These criteria do not invalidate the safety requirements in other DoD publications. DAF nuclear safety design certification activities shall apply the most appropriate design criteria, as applicable, from all that apply to a given nuclear surety issue. **(T-1) Note:** Final applicability of design criteria for a given certification action is documented in the signed Certification Requirements Plan (CRP). Since the design criteria in this manual are not design solutions and are not intended to restrict the designer in the methods and techniques used to meet operational design requirements, they are not all-inclusive. DAF nuclear weapon system designers may add feasible and reasonable safety features as needed while meeting operational requirements because the DAF goal is to incorporate maximum nuclear surety, consistent with operational requirements, from weapon system development to dismantlement. DAFI 91-101

provides details on what is required to be nuclear safety design certified, while this document provides the design criteria for those items requiring nuclear safety design certification.

1.1.5. Nuclear safety design certification only covers nuclear weapon system designs or modifications that have an impact to nuclear surety. This means all the nuclear surety related designs (hand calculations, models, simulations, analysis, etc.) are evaluated according to the DoD Nuclear Surety Standards. Air Force Safety Center, Nuclear Weapons Safety Branch (AFSEC/SEWN) does not have an obligation to validate that the components were fabricated and manufactured to the exact specifications agreed to in the design, but will certify the system through verification as necessary and as specified in the CRP.

1.2. Non-Compliance with Criteria. If the design of a DAF nuclear weapon system does not meet the design criteria contained in this manual, a deviation shall be obtained per DAFI 91-101. **(T-1)**

1.3. Standards and Guidance. All documents cited within this DAFMAN should be verified as current before being used as a resource for nuclear safety design certification actions. In the event of cancellation or modification of the referenced standards or guidance, contact AFSEC/SEWN for requirements.

1.4. Existing Nuclear Certified Operational Systems.

1.4.1. Existing nuclear certified operational systems are not required to be modified solely to meet enhanced safety criteria implemented after the system completed nuclear certification.

1.4.2. If an existing system is modified, the system shall conform to current design criteria per this DAFMAN and applicable 91-series DAFIs. **(T-1)** The CRP process will capture the necessary requirements.

1.5. Nuclear Weapon System Design. Any nuclear weapon system should be designed to allow verification of all applicable design criteria through analysis, test, demonstration, and/or inspection as proof of compliance with the requirements in the CRP.

1.6. Roles and Responsibilities.

1.6.1. Assistant Secretary of the Air Force for Acquisition, Technology and Logistics (SAF/AQ) assigns a Program Manager (PM) for nuclear certified items.

1.6.2. PMs through the Program Office (PO) are ultimately responsible for meeting all applicable design criteria and providing their Development Organizations' documentation of compliance to AFSEC/SEWN as required in the Certification Requirements Plan.

1.6.3. AFSEC/SEWN will:

1.6.3.1. Determine applicability of design criteria in this manual.

1.6.3.2. Approve documents provided by the PM, as required to show proof of compliance of nuclear safety design criteria.

1.6.4. For Space related nuclear weapon systems the Assistant Secretary for Space Acquisition and Integration (SAF/SQ) is responsible for providing space-focused input and coordination to SAF/AQ, to maximize efficiencies in activities common to both organizations, consistent with this mission directive and Headquarters Air Force Mission Directive 1-17, *Assistant Secretary of the Air Force (Space Acquisition and Integration),* 30 September 2022.

1.7. Legend. In this document, text with requirements use the word ‘shall.” The format for requirements is written with a shall statement followed by tiering and then an explanatory portion if applicable. The explanatory portion is not a requirement and will not include the words ‘shall,’ ‘will,’ or ‘must.’

Chapter 2

GENERAL DESIGN PHILOSOPHY

2.1. Nuclear Weapons System Safety Design Philosophy. The DAF upholds the DoD Nuclear Surety Standards for DAF weapon systems.

2.2. Energy and Information Control Systems. Criteria for controlling critical functions depend on the specific nuclear safety design concept of the nuclear weapon system.

2.2.1. The Energy Control Concept is the design concept which isolates compatible energy from components which activate critical functions and ultimately result in nuclear detonations. Properly employed, the energy control concept prevents the exposure of these components to energies outside the usable range of the critical function activation energy to reduce risk of inadvertent activation.

2.2.1.1. Energy control concept systems are those systems that rely strictly on the absence or presence of power to control an action.

2.2.1.2. The safety of nuclear weapon systems using the energy control concept depends on the safety controls that block the application of these energies to the devices that activate critical functions.

2.2.2. Information Control Concept utilizes the mathematical principles from information theory to unambiguously communicate human intent to detonate and prevent inadvertent communication of such information to the components which activate critical functions or result in nuclear detonation.

2.2.2.1. Information control systems are those systems that use data to control access to and operation of critical functions.

2.2.2.2. The safety of nuclear weapon systems using the information control concept depends on a unique signal that provides an indication of unambiguous human intent, without which the critical functions cannot be activated.

Chapter 3

GENERAL DESIGN

3.1. Security.

3.1.1. A physical and digital security system, along with operational security restrictions, shall prevent unauthorized access to nuclear weapons in accordance with DoDM S-5210.41 (U) *Nuclear Weapon Security Manual*. **(T-0)**

3.1.2. The nuclear weapon system design shall incorporate internal security features to prevent unauthorized use. **(T-0)**

3.2. Reversible Operations. The critical functions of authorization and prearming, as well as the arming of launch and release systems, shall be reversible. **(T-1)** The intent of this requirement is to provide the capability of withdrawing the deployment of a nuclear weapon after the above functions have activated (i.e., ensuring all actions preparing a weapon for use are reversible up to the point of final release or launch). The Reversible In-Flight Lock (RIFL) is an example of a device with reversible operation.

3.3. Nuclear Critical Function Design.

3.3.1. The nuclear weapon system design shall prevent inadvertent activation of a critical function due to failure or accidental operation of a single component. **(T-1)**

3.3.2. Prior to the initiation of nuclear weapon system actions, the nuclear weapon system shall require that no two independent human errors, unauthorized acts, or combination of both, will result in the activation of a critical function. **(T-1)** This requirement ensures nuclear weapon system designers consider the human engineering point of view where the system will, by design, inhibit human error from initiating a critical function. It also encourages a design agency to consider human factor error possibilities during the design phase of weapon system deployment, rather than trying to account for human factor errors with procedures.

3.4. Nuclear Critical Functions.

3.4.1. Authorization.

3.4.1.1. The nuclear weapon system shall incorporate one or more features to control authorization. **(T-1)** Examples of these controls are the enable device in the Minuteman weapon system and the entry of the Permissive Action Link (PAL).

3.4.1.2. The authorization feature(s) shall prevent prearming and/or arming of a nuclear bomb or warhead in aircraft-carried weapons and launch of a ground-launched missile before the nuclear weapon system receives authorization. **(T-1)**

3.4.1.3. The authorization feature(s) shall operate on the Information Control Concept. **(T-1)** The PAL code is provided through command and control channels. Programs ensure the interface specifications are incorporated.

3.4.1.4. The authorization feature(s) shall protect against unauthorized use, to include bypass, of the authorization device(s). **(T-1)** An example of this is the F-35 pilot password that is required to be entered to access the control panel.

3.4.1.5. The authorization feature(s) shall allow a state transition to a safe state (enable/ disenable), regardless of the state of the authorization device(s), before release or launch. **(T-1)** The intent is to ensure that the authorization device does not interfere with the operation of safety features of the nuclear weapon system.

3.4.1.6. The authorization feature(s) shall prevent inadvertent data entry into the authorization device(s) from actuating the authorization device(s). **(T-1)**

3.4.1.7. The nuclear weapon system shall reveal any attempted bypass of the authorization device(s) with an indicator that remains active until reset by authorized personnel. **(T-1)**

3.4.2. Prearming. The prearm command begins with operator action indicating that the operator wants the nuclear weapon to function and results in a unique electrical signal pattern being sent to the nuclear weapon prior to release or launch; this is the implementation of unambiguous human intent.

3.4.2.1. Activation of the prearming critical function shall require unambiguous human intent. **(T-1)**

3.4.2.2. The nuclear weapon system design shall prevent unintentional prearming as set forth in **Rule 2** of **Table 3.1**. **(T-1)**

3.4.2.3. The nuclear weapon system design shall prevent circumvention of the prearming function. **(T-1)**

3.4.2.4. For nuclear weapon system design based on the Information Control Concept:

3.4.2.4.1. The nuclear weapon system design shall use uniquely coded prearm command signals. **(T-1)** Reference **Rule 2** in **Table 3.1** for probability.

3.4.2.4.2. Unique Signal Generator.

3.4.2.4.2.1. The information needed to generate the prearming unique signal shall be unavailable to the unique signal generator until required for use. **(T-1)** This paragraph ensures the weapon system will not have the capability to access the unique signal in the event of a failure or accident (i.e., the unique signal should not be stored in memory prior to prearming).

3.4.2.4.2.2. The prearming unique signal shall be erased following the completion of the signal transmission. **(T-1)** This paragraph ensures that, once the authorized unique signal transmits, it cannot be used later without the proper authorization.

3.4.2.5. The nuclear weapon system design shall keep the prearming function separate and independent from the authorization function. **(T-1)**

3.4.3. Launching. This section applies to the ignition of the propulsion system on a ground-launched missile system.

3.4.3.1. The nuclear weapon system shall control rocket motor propulsion system ignition through the following independent commands: the ignition system arm command, the ignition system safe command, and the ignition command. **(T-1)**

3.4.3.2. The weapon system shall prevent unintended rocket motor propulsion system ignition in accordance with **Rule 4** of **Table 3.1**. **(T-1)** This paragraph includes failures of the propulsion system that would permit ignition when the ignition system is safed.

3.4.3.3. The propulsion system ignition shall not occur without the arm command signal even if the system sends the ignition command signal. **(T-1)** For example: the Minuteman III ignition safing device is a mechanical interlock that prevents any form of compatible energy from reaching the propulsion system igniters.

3.4.3.4. The nuclear weapon system shall require a positive indication of successful launch. **(T-1)**

3.4.4. Releasing. This section applies to aircraft-carried nuclear weapons and aircraft-carried nuclear weapon delivery vehicles. Releasing requirements ensure the design of the nuclear weapon system prevent unauthorized or inadvertent release.

3.4.4.1. Access to the release function shall require unambiguous human intent. **(T-1)**

3.4.4.2. The release system for aircraft-carried nuclear weapons or nuclear weapon delivery vehicles shall operate through two independent functions, the release system unlock command and the release command. **(T-1)** This paragraph helps ensure the combination of unlock and release commands adheres to the weapon separation numerical requirements as well as prevents an inadvertent release. Reference **Rule 5** of **Table 3.1**.

3.4.4.3. The nuclear weapon system shall only release the nuclear weapon or nuclear weapon delivery vehicle from the combat delivery aircraft after receiving the unique unlock signal prior to the unique release command signals. **(T-1)** This paragraph helps ensure the combination of unlock and release commands adhere to the weapon separation numerical requirements and prevents an inadvertent release even if the system accidentally sends the release command signal early.

3.4.4.4. For aircraft-delivered guided nuclear weapons and nuclear weapon delivery vehicles, the nuclear weapon system shall prevent release against anything other than authorized targets. **(T-1)** This paragraph ensures a nuclear detonation occurs only within the desired authorized target location.

3.4.4.5. The release system unlock function shall be separate and independent from the release function and Aircraft Monitor and Control (AMAC) signals. **(T-1)** This paragraph ensures the failure or inadvertent activation of one of these functions does not contribute to inadvertent release.

3.4.4.6. If the nuclear weapon is part of a nuclear weapon delivery system (missile) or a guided bomb, the nuclear weapon system design shall include a good transfer alignment signal as a verification of the proper release environment. **(T-1)** This paragraph ensures the nuclear weapon can reach an authorized target.

3.4.4.7. The nuclear weapon system design shall ensure that the aircraft receives positive indication that the nuclear weapon delivery vehicle has received an acceptable transfer alignment signal before commanding release. **(T-1)**

3.4.4.8. The nuclear weapon system shall require a positive indication of complete weapon separation from the aircraft. **(T-1)** This paragraph ensures the aircraft relays an unambiguous indication back to the operators.

3.4.5. Arming. The nuclear weapon system shall prevent unauthorized bypass of the arming system. **(T-1)** If the nuclear weapon is prearmed, arming is the design response of the nuclear

weapon sensing the environment is within the limits defined for operational use after launch or release. The armed condition allows the selected fuze signal to detonate the warhead.

3.4.6. Navigation Validation. Navigation validation is the process that confirms the nuclear weapon's calculated state vector and allows detonation at the authorized target. It includes the authorized target data and the processing done to validate the nuclear weapon will reach its authorized target.

3.4.6.1. Navigation shall be validated prior to arming of a guided nuclear weapon. **(T-1)**

3.4.6.2. If the navigation of the guided nuclear weapon delivery vehicle cannot be validated, the nuclear weapon system shall inhibit the arming signal. **(T-1)**

3.4.6.3. Guided nuclear weapon delivery vehicles shall perform navigation validation after release occurs but before arming can occur. **(T-1)** This paragraph ensures the authorized target is achievable.

3.4.6.4. The arming signal shall be withheld if the nuclear weapon cannot be guided to detonate within authorized target boundaries. **(T-1)** This paragraph ensures a nuclear yield only occurs at the desired authorized target.

3.5. Nuclear Critical Function and Unintended Nuclear Yield Numerical Requirements. Numerical requirements ensure the nuclear weapon system design achieves nuclear safety to the greatest extent possible. These paragraphs ensure nuclear safety is sufficient for the lifetime of the weapon system. The nuclear safety features designed into the nuclear weapon system eliminate or minimize the dependence of safety and security on administrative procedures.

3.5.1. The nuclear weapon system design shall comply with **Table 3.1**. **(T-1)**

3.5.2. The nuclear weapon system shall prevent an unintentional significant nuclear yield (greater than 4 pounds Trinitrotoluene (TNT) equivalent) from nuclear bombs, warheads, and other nuclear devices due to faults or failures in the nuclear weapon system within the probabilities defined in **Table 3.2**. **(T-1)**

3.5.3. For credible abnormal environments listed in the STS, the nuclear weapon system design shall show, within the calculated probability of occurrence, that the DAF contributions to preventing inadvertent prearming, launching, releasing, jettisoning, arming, or erroneous targeting will not occur during the system's lifetime. **(T-1)**

Table 3.1. Inadvertent Nuclear Critical Function Activation Numerical Requirements.

RULE	A	B	C
	For the critical function of…	The probability of faults and failures in the nuclear weapon system resulting in…	will be less than…
1	Authorization	Not applicable	(See **note 1**)
2	Prearming	Inadvertent transmission of the prearm command signals.	1×10^{-6} per combat delivery vehicle over the system's lifetime in normal environments. (See **note 2**)

3	Arming	Arming and Fuzing system failure in a normal environment after the nuclear weapon system has been prearmed but before launch or release.	1×10^{-4} per prearmed weapon. (For intercontinental ballistic missile systems see **note 6**)
4	Launching	Accidental propulsion system ignition.	1×10^{-7} per missile over the system's lifetime in normal environments. (see **note 3**)
		Inadvertent programmed launch of a ground-launched missile during a fully assembled weapon system operation.	1×10^{-12} per missile over the system's lifetime in normal environments.
5	Releasing	Inadvertent release or jettison of a bomb or missile when the release system is locked.	1×10^{-6} per weapon station over the system's lifetime in normal environments. (See **note 4**)
		Inadvertent release or jettison of a bomb or missile when the release system is unlocked.	1×10^{-3} per unlocking event normal environments. (See **note 4**)
6	Navigation Validation	Erroneous issuance of the navigation validation signal.	1×10^{-3} per nuclear weapon.
7	(See **note 5**)	Inadvertent application of power signals or message signals (other than the prearm command) to the warhead/bomb interface.	1×10^{-4} per combat delivery vehicle over the system's lifetime in normal environments.

Notes:

1. Safety evaluations of combat delivery aircraft systems shall consider the authorization device as part of the command and control function and assume the authorization device has been activated. Safety criteria shall be met with the authorization device activated. For ground-launched missile systems (for which the user accepts the restriction that the authorization device will not be activated until immediately before intended use of the missile), safety studies and calculations may recognize and take credit for any safety enhancements the authorization device provides.

2. Designers shall include positive measures to prevent inadvertent prearming in credible abnormal environments.

3. "Accidental ignition" does not include non-propulsive burning or explosion in the propulsion system.

4. “Inadvertent release or jettison” does not include cases when weapons separate from the aircraft because of catastrophic structural failure of the aircraft rather than operation of the release system.

5. Although not a critical function, weapon system designers shall apply this numerical requirement as an additional positive safety measure.

6. For intercontinental ballistic missile systems, this requirement applies after launch.

Table 3.2. Unintentional Significant Nuclear Yield Numerical Requirements for Nuclear Bombs, Warheads, and Other Nuclear Devices.

RULE	A The probability of obtaining a nuclear yield is less than…	B in the absence of…
1	1×10^{-9} per weapon over the stockpile lifetime in normal environments.	bomb or warhead-unique prearming, environment or enabling stimuli.
2	1×10^{-4} per event. (see **note**)	the arming signal.
3	1×10^{-6} per weapon during exposure to abnormal environments.	unique prearming or trajectory stimuli.
Note: The Department of the Air Force defines an "event" as the application of a prearm command and deliberate deployment (weapon launch or release).		

3.5.4. The nuclear weapon system design shall incorporate emergency access to those components and circuits required to carry out render-safe procedures. **(T-1)**

3.5.5. Safe and Arm and Arm/Disarm Devices.

3.5.5.1. Nuclear weapon system design shall implement a device that prevents inadvertent initiation of ordnance devices that are directly attributed to nuclear critical function activation. **(T-1)**

3.5.5.2. If the device actuates electrically, it shall arm only in response to an externally generated unique signal. **(T-1)**

3.5.5.3. The safing signal shall differ from the arming signal. **(T-1)** This requirement reduces the risk of arming during attempted safing.

3.5.5.4. If a monitor signal is used within the Safe and Arm and Arm/Disarm device, the monitor signal shall differ from the arming signal. **(T-1)** This requirement aids in preventing inadvertent arming of ordnance devices.

3.5.6. Monitoring.

3.5.6.1. The nuclear weapon state status shall be monitored until release or launch. **(T-1)** Monitoring may not be possible during short periods because of system start-up or latency between digital messages.

3.5.6.2. The nuclear weapon system shall provide a notification of the state change of any critical function to the operator or maintainer, as applicable. **(T-1)** This paragraph ensures the operator can continuously monitor the safe status of the missile propulsion system, the warhead or warheads, the reentry system, reentry vehicle, or payload section Arm/Disarm device, and the launch control system.

3.5.7. Systems that integrate commercial off-the-shelf (COTS) items into the design shall be evaluated in accordance with this manual. **(T-1)** This paragraph ensures COTS items do not degrade the overall assembly.

3.6. Software Verification. Programmable Logic Devices that require Nuclear Safety Design Certification shall require software verification on production-equivalent hardware in accordance with DAFMAN 91-119, *Safety Design Criteria for Nuclear Weapon Systems Software*. **(T-1)** Examples of Programmable Logic Devices include, but are not limited to, Field Programable Gate Arrays, Complex Programmable Logic Devices, and Application Specific Integrated Circuits.

Chapter 4

ELECTRICAL DESIGN

4.1. Isolation. Isolation ensures faults or common mode malfunctions do not operate critical circuits or explosive components in all normal and credible abnormal environments.

4.1.1. Any nuclear weapon system critical circuit that relies on the Energy Control Concept, either power or control, shall be isolated physically and electrically, from all other circuits. **(T-1)**

4.1.2. Wire shielding or cable shielding shall not be used as current-carrying conductors. **(T-1)**

4.1.3. Nuclear weapon system wire and cable shields shall be covered with an insulation layer. **(T-1)**

4.1.4. Electro-explosive circuitry within a nuclear weapon system that interfaces with nuclear critical functions shall be Hazards of Electromagnetic Radiation to Ordnance (HERO) safe in accordance with DAFI 91-208, *Hazards of Electromagnetic Radiation to Ordnance (HERO) Certification and Management*. **(T-1)**

4.1.5. The design of nuclear weapon system circuits that use the Energy Control Concept shall provide engineered solution(s) to prevent inadvertent activation of a critical function. **(T-1)**

4.1.6. Nuclear weapon system critical circuits shall be isolated from lines carrying liquids such as coolant solutions, fuels, or hydraulic fluids. **(T-1)** This paragraph ensures critical circuits do not experience unnecessary hazards and cause shorts or inadvertent critical function activation.

4.2. Switching. Switching achieves protection against faults and failures. A switch is an electrical component that can disconnect or connect the conducting path in an electrical circuit.

4.2.1. The design of nuclear weapon system circuits shall implement a switch on the supply side of switchable circuits. **(T-1)**

4.2.2. The design of nuclear weapon system critical circuits shall implement a switch on both the supply and return sides of switchable circuits. **(T-1)**

4.3. Wiring and Cabling.

4.3.1. Routing and Installation. Electrical wiring, within nuclear weapon systems, shall be installed and secured in accordance with applicable industry standards to prevent mechanical failure of the wiring. **(T-1)** Examples of this include, but are not limited to, chafing, abrasion, insulation degradation, and broken wiring.

4.3.2. Shields. Shields protect inner signal or power-carrying conductors by reflecting and/or conducting external energy to ground preventing inadvertent signals and function activation caused by Electromagnetic Interference.

4.3.2.1. Nuclear weapon system cable shields shall terminate at a connector backshell that provides for 360-degree peripheral bonding. **(T-1)** Reference Military Standard (MIL-STD)-461, *Requirements for The Control of Electromagnetic Interference Characteristics of Subsystems and Equipment*.

4.3.2.2. Nuclear weapon system connector backshells shall have conductive finishes to minimize shield termination impedance. **(T-1)**

4.3.2.3. When shielded wires and cables within a nuclear weapon system are contained within an overall cable shield and terminate with pigtails, cable shield pigtails shall not exceed 6 inches. **(T-1)** This paragraph addresses the problem of cable shields possibly carrying a current. The designer should build or choose a shield design which minimizes the chances for current.

4.3.3. Grounds. Grounds provide a path for spurious energy to dissipate safely. Grounding ensures the developer considers possibilities of ground loops and designs a system that will eliminate or minimize ground loops. Ground loops can cause noise that may activate signals or can cause dangerous currents.

4.3.3.1. A common ground reference connection within the nuclear weapon system shall be used for signal returns common to two or more circuits. **(T-1)**

4.3.3.2. Nuclear weapon system ground wire gauge shall allow the largest current expected during nuclear weapon system operation or credible failure. **(T-1)**

4.3.3.3. Nuclear weapon system shield braid gauge shall allow the largest current expected during nuclear weapon system operation or credible failure. **(T-1)**

4.3.4. Power Cable Terminations. Nuclear weapon system electrical power wiring shall end in female connectors at the power source side. **(T-1)** This paragraph does not supersede nuclear weapon and warhead interface connector requirements.

4.3.5. Mechanical Support. Nuclear weapon system critical circuit wiring shall implement a mechanical support strain relief at the entry point into the electrical connector. **(T-1)**

4.4. Electrical Connectors. Nuclear weapon system critical circuits shall have a robust design for electrical connectors. **(T-1)** References for robust design can be found in Military Detail Specification (MIL-DTL) 38999 series, *Specification Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect (Bayonet, Threaded or Breech Coupling), Environment Resistant With Crimp Removable Contacts or Hermetically Sealed With Fixed, Solderable Contacts, General Specification* or the Department of Energy interface specification.

4.4.1. Alignment and Mating. These requirements ensure that personnel cannot mate connectors incorrectly. They also ensure the developer not only consider isolation from one cable/connector to the next, but the isolation of the signals within a connector as well.

4.4.1.1. All nuclear weapon system circuits within a single connector shall meet the isolation design criteria in **paragraph 4.1**. **(T-1)**

4.4.1.2. Nuclear weapon system connectors shall prevent misalignment of connector components and bent pins during mating. **(T-1)**

4.4.1.3. Nuclear weapon system connectors shall be compatible with their intended connection only and incompatible with other accessible connectors. **(T-1)**

4.4.1.4. When nuclear weapon system cable assemblies with connectors do not have a pin-to-pin correspondence, the connectors shall be mutually incompatible. **(T-1)**

4.4.1.5. Nuclear weapon system connectors shall only use one wire for each pin. **(T-1)**

4.4.1.6. Nuclear weapon system connector pin mapping shall prevent any bent pin(s) from resulting in the inadvertent activation of a critical function. **(T-1)**

4.4.2. Sealing. Sealing improves the integrity of the connector and ensures the connector provides the type and number of electrical connections that the developer intends.

4.4.2.1. Nuclear weapon system connectors shall be sealed from the operational environment. **(T-1)**

4.4.2.2. If used in a nuclear weapon system, potting compounds shall not revert over the life of the system in its intended environment. **(T-1)** This paragraph prevents liquid or other contaminant infiltration which can degrade connector functionality and result in shorts (i.e., unintended operation) or opens (i.e., inability to monitor or command safe).

4.5. Electrical Current Considerations. These paragraphs ensure the system cannot mistake monitoring and testing currents as critical function activation signals.

4.5.1. For any nuclear weapon system using the Energy Control Concept, the maximum no fire stimuli to ordnance devices shall be limited to a value at least one order of magnitude below the maximum no-fire stimuli of the most sensitive ordnance device or firing circuit component. **(T-1)**

4.5.2. Any nuclear weapon system using the Information Control Concept shall incorporate features to prevent activation of any ordnance device(s) or firing circuit(s) as the result of a single-point failure. **(T-1)**

Chapter 5

HAZARD PREVENTION

5.1. General Hazards. The PO shall provide a comprehensive Hazard Analysis focused on the safety of the nuclear weapon. **(T-1)** Hazard analysis is an iterative process that should inform the design and will be a resource document for nuclear safety design certification and safety studies. Reference MIL-STD-882, *Department of Defense Standard Practice System Safety*, as it describes processes proven effective in the preparation of required hazard analyses.

5.1.1. Hazards Analyses. The hazard analysis is a tool that can aid in the design of a nuclear weapon system to ensure adequate protective measures and thus, the four standards outlined in **paragraph 1.1.3**. A comprehensive hazard analysis shall identify and estimate the hazards that are added during the design and operations to include the following:

5.1.1.1. Fire hazards. **(T-1)**

5.1.1.2. Nuclear criticality safety. **(T-1)**

5.1.1.3. Radiation and radioactive material that are integrated into the design and may cause an exposure to the weapon. **(T-1)**

5.1.1.4. Explosives. **(T-1)**

5.1.1.5. Chemicals. **(T-1)**

5.1.1.6. Natural phenomena such as lightning, earthquake, flood, tornado, etc. **(T-1)**

5.1.1.7. Site/facility specific hazards. **(T-1)**

5.1.2. The PO shall qualitatively ascertain the potential impact of the hazard upon the nuclear weapon and identify positive measures used to mitigate those impacts. **(T-1)** If evaluation indicates no impact to the design or that the impact is within the STS, this should be documented in the hazard analysis. Coordination with the weapons laboratories may be needed.

5.2. Material Compatibility. The nuclear weapon system design shall incorporate material compatibility with its operational environment as specified in the STS. **(T-1)** This includes, but is not limited to fire-fighting chemicals, safety subsystems, electrochemical corrosion, and internal compatibility. This is to ensure the developer: (1) adheres to the STS when selecting materials the entire weapon system will use, and (2) does not use materials that could increase the high explosive sensitivity, generate an explosive gas, cause an electrical short, or create similar results.

5.3. Electromagnetic Environments (EME).

5.3.1. Electromagnetic Environmental Effects. Each nuclear weapon system design shall be electromagnetically safe among all its subsystems and equipment and with environments caused by emitters and other electromagnetic sources external to the nuclear weapon system IAW MIL-STD-464, *Interface Electromagnetic Environmental Effects Requirements for Systems*. **(T-1)**

5.3.2. HERO.

5.3.2.1. The nuclear weapon system design shall provide hazards of electromagnetic radiation to ordnance margins as defined in MIL-STD-464 and DAFI 91-208, in both powered-on and powered-off states throughout the STS. **(T-1)**

5.3.2.2. For intercontinental ballistic missile (ICBM) systems exposed to the electromagnetic radiation levels specified in the applicable Hazards of Electromagnetic Radiation to Ordnance table in MIL-STD-464, the electrically initiated devices shall maintain the maximum root mean square current in its bridge wire at 20 decibels below the maximum no-fire current of the electrically initiated device. **(T-1)**

5.3.2.3. For nuclear weapon systems, other than ICBM, exposed to the electromagnetic radiation levels specified in the applicable HERO table in MIL-STD-464, the electrically initiated devices shall maintain the maximum root mean square current in its bridge wire at 16.5 decibels below the maximum no-fire current of the electrically initiated device. **(T-1)**

5.3.3. Electromagnetic Interference. Active (powered) ordnance circuits, firing circuits, and other circuits controlling or otherwise impacting critical functions or safety subsystems of the nuclear weapon system shall be protected against inadvertent upset/degradation from external electromagnetic environments and emissions from circuits contained within the ordnance in accordance with MIL-STD-461. **(T-1)**

5.3.4. Electrostatic Discharge.

5.3.4.1. The nuclear weapon system shall safely control and dissipate the build-up of electrostatic charges caused by precipitation static effects, fluid flow, air flow, exhaust gas flow, personnel charging, charging of launch vehicles (including pre-launch conditions) and space vehicles (post deployment), and other charge-generating mechanisms. **(T-1)**

5.3.4.2. For nuclear weapon systems capable of in-flight refueling, the nuclear weapon system shall protect against inadvertent activation of critical signals and damage to safety subsystems when the platform is subjected to a 300-kilovolt electrostatic discharge. **(T-1)** Reference MIL-STD-331, *Environmental and Performance Tests for Fuzes, Ignition Safety Devices and Other Related Components*.

5.3.5. Electromagnetic Pulse.

5.3.5.1. Nuclear weapon systems shall remain safe after they are subjected to the electromagnetic pulse environment. **(T-1)** In the absence of a system-specific electromagnetic pulse environment, use the environment as defined in MIL-STD-2169, *High-Altitude Electromagnetic Pulse (HEMP) Environment*.

5.3.5.2. The weapon system shall remain safe during and after experiencing both direct and near lightning strikes in accordance with MIL-STD-464. **(T-1)**

Chapter 6

ARMING AND FUZING (A&F) SYSTEMS

6.1. System Devices. An A&F system is the sum of components, devices, and design features that cause weapon prearming, arming, fuzing, and firing as well as those components and features that protect against deliberate unauthorized or accidental prearming, arming, fuzing, and firing. Both DoD and DOE subsystems are normally a part of the total nuclear weapon system A&F design.

6.1.1. The nuclear weapon arming and fuzing system(s) signal shall be initiated only by deliberate human intent and action. **(T-1)**

6.1.2. The nuclear weapon system prearm function shall be reversible up to the time of release for aircraft systems or launch for ground-launched missiles. **(T-1)**

6.1.3. The nuclear weapon arming and fuzing system(s) design shall prevent arming until the intended use (delivery) environment is sensed. **(T-1)**

6.1.4. The nuclear weapon arming and fuzing system(s) design shall prevent application of power until the intended use environment is sensed. **(T-1)**

6.2. System Design Features.

6.2.1. The nuclear weapon arming and fuzing system(s) shall prevent inadvertent prearming and arming in credible abnormal environments specified in the STS. **(T-1)** An example of this is implementing at least two separate and independently derived signals, which cannot be generated by a single signal at any point, to arm the weapon.

6.2.2. If nuclear weapon arming power is interrupted, any storage devices shall discharge stored energy automatically. **(T-1)**

6.2.3. Safety features shall be designed to withstand nondestructive test environments such as x-ray, ultrasonic, and electromagnetic as specified in USAF-approved technical procedures. **(T-1)**

6.3. Safe and Arm and Arm/Disarm Devices.

6.3.1. The A&F system shall implement a Safe & Arm and Arm/Disarm device that will prevent inadvertent power from being applied to the A&F system or applicable components within the system. **(T-1)**

6.3.2. The A&F system shall implement an Environmental or Trajectory Sensing Device (E/TSD) that will prevent arming of the nuclear weapon until the proper environment is sensed. **(T-1)** The E/TSD stimulus should only be activated after the flight profile of the nuclear weapon delivery vehicle is achieved.

Chapter 7

GROUND LAUNCHED MISSILE SYSTEMS

7.1. Launch Control System. The launch control system of a ground-launched missile system includes the Launch Control Point (LCP) (e.g., manned by operators) and Launch Point (LP) (e.g., contains delivery platform), consisting of independent authorization and launch actions. Additionally, this system includes features to monitor and allow for timely compensatory actions (e.g., Inhibit, Remote Data Halt).

7.1.1. The launch of a missile shall only occur through intentional operation of the authorization and launch systems. **(T-1)**

7.1.1.1. The authorization system shall:

7.1.1.1.1. Authorize a missile launch. **(T-1)**

7.1.1.1.2. Protect the propulsion system from inadvertent and unauthorized ignition. **(T-1)** Reference energy control concept and information control concept in the General Design Philosophy section of this DAFMAN.

7.1.1.2. The launch system shall:

7.1.1.2.1. Validate unambiguous human intent prior to critical function activation. **(T-1)**

7.1.1.2.2. Prevent launch from a single LCP until adequate time to perform compensatory actions has elapsed. (**T-1)** An example of this is the expiration of the single vote launch timer.

7.1.1.2.3. Start a launch sequence upon successful validation of unambiguous human intent for launching. **(T-1)**

7.1.1.2.4. Launch a missile. **(T-1)**

7.1.2. The nuclear weapon system shall detect and resist tampering with the launch control functions. **(T-1)** Examples of launch control functions include nuclear critical functions identified earlier in this DAFMAN, functions that monitor the nuclear weapon (e.g., nuclear weapon monitor loop or arm/disarm devices), or compensatory actions to mitigate unauthorized actions.

7.1.2.1. All LCPs shall receive a continuous indication, both visually and audibly, when an attempt is made to operate the Launch Control System. **(T-1) Note:** This requirement does not apply to secondary launch systems that have a transmit-only capability.

7.1.2.2. The indications shall remain until they are reset by system operator(s). **(T-1)**

7.1.3. The nuclear weapon system shall remain in, or return to, a known safe state when any component in a critical signal path fails. **(T-1)**

7.1.4. The arm (operate) and safe (off) critical command signal functions shall not be complementary functions. **(T-1) Note:** The absence of the "arm" signal shall not be construed as the "safe" signal.

7.1.5. The nuclear weapon system shall not store the authorization, launch, or prearm signals in a directly usable form until required for authorized use. **(T-1)**

7.1.6. The nuclear weapon system design shall utilize separate unique signals for the authorization, launch, and prearm commands. **(T-1)**

7.2. Propulsion System Ignition Protection.

7.2.1. The propulsion ignition system design shall include protections to prevent unintended ignition in compliance with **Rule 4** of **Table 3.1**. **(T-1)** American Institute of Aeronautics and Astronautics (AIAA) S-113, *Criteria for Explosive Systems and Device on Space and Lauch Vehicles* provides modern safety design guidance which supports satisfaction of this requirement.

7.2.2. The ignition protection device shall require a unique signal to transition to the armed state. **(T-1)**

7.2.3. The unique signal used for arming the ignition protection device shall be generated external to the missile. **(T-1)** This requirement ensures the information needed to generate a launch is not stored on the missile.

7.2.4. The ignition protection device shall have electrical safing means to prevent launch. **(T-1)**

7.2.5. The ignition protection device shall have mechanical safing means to prevent launch. **(T-1)**

7.2.6. The unique signal used for arming the ignition protection device shall perform a physical and electrical action that contributes to preventing inadvertent propulsion system ignition in accordance with **Rule 3** in **Table 3.1**. **(T-1)**

7.2.7. The ignition protection device shall be collocated with the propulsion activation device to ensure that compatible energy will only pass through the ignition safety device. **(T-1)**

7.3. Arm/Disarm Device for Reentry System, Reentry Vehicle, or Payload.

7.3.1. The device shall provide positive measures to prevent inadvertent application of energy to the warhead interface in accordance with **Rule 7** of **Table 3.1**. **(T-1)**

7.3.2. The device shall provide positive measures to prevent inadvertent application of critical signals through the warhead interface in accordance with **Rule 7** of **Table 3.1**. **(T-1)**

7.3.3. The device shall provide unambiguous indications to system operators and maintainers of the status of these positive measures. **(T-1)**

7.4. Power Removal. When an unsafe condition is indicated IAW **Table 3.1**, the nuclear weapon system shall:

7.4.1. Automatically attempt to safe the nuclear weapon. **(T-1)**

7.4.2. Automatically remove power to the nuclear weapon. **(T-1)**

7.4.3. Automatically remove power to the propulsion ignition system. **(T-1)**

7.5. Command and Control Communications. This section addresses communications and communication paths between the LCPs and launch points.

7.5.1. LCPs.

7.5.1.1. Prior to receipt of an Emergency Action Message, the nuclear weapon system shall not contain sufficient information to launch a missile. **(T-1)**

7.5.1.2. The secure information and commands that authorize and launch a missile shall be separate and independent. **(T-1)**

7.5.1.3. For systems with a selective launch capability, the launch control system shall allow one or more missiles to launch without revealing or compromising any secure information for the other missiles within the Department of the Air Force or other branches of the military. **(T-1)**

7.5.2. LCPs to LP Communications. An LP contains the delivery platform that will deliver a nuclear weapon to its authorized target.

7.5.2.1. Any launch or authorization actions shall be protected to the numerical standards for Unauthorized Launch actions. **(T-1)** Contact AFSEC/SEWN staff for these standards.

7.5.2.2. At least two LCPs shall monitor an LPat all times. **(T-1)**

7.5.2.3. Each LCP shall be able to accomplish compensatory actions in the event an unauthorized critical signal is detected. **(T-1)**

7.5.2.4. The nuclear weapon system shall be designed to preclude transmission of the authorization command signal by any one system operator. **(T-1)**

7.5.2.5. The nuclear weapon system shall be designed to preclude transmission of the launch command signal by any one system operator. **(T-1)**

7.5.3. LCPs to Code Devices.

7.5.3.1. The system shall prevent unauthorized access to any stored secure codes. **(T-1)**

7.5.3.2. The system shall prevent unauthorized code changes. **(T-1)**

7.5.3.3. For any device operated by a secure code, the design shall comply with the following:

7.5.3.3.1. Allow only a limited number of attempts at operation using incorrect codes. **(T-1)** Reference DoDI S-5200.16, *(U) Objectives and Minimum Standards for Communications Security (COMSEC) Measures Used in Nuclear Command and Control (NC2) Communications*.

7.5.3.3.2. The nuclear weapon system design shall include a means to detect tampering. **(T-1)**

7.5.3.3.3. The nuclear weapon system design shall include a means to resist tampering. **(T-1)**

7.6. Ground Launched Missile Systems Facility Design.

7.6.1. Lightning protection shall be provided for launch points per AFMAN 32-1065, *Grounding & Electrical Systems*. **(T-1)**

7.6.2. Electrical power systems and subsystems shall comply with Defense Explosives Safety Regulation (DESR) 6055.09_DAFMAN 91-201, *Explosives Safety Standards*. **(T-1)**

7.6.3. The LCP system shall include permanently installed backup power generation designed in accordance with DAFMAN 32-1062, *Electrical Systems, Power Plants and Generators*. **(T-1)**

7.6.4. LPs shall be equipped with fire detection systems. **(T-1)**

7.6.5. Structural Requirements.

7.6.5.1. Equipment that supports the nuclear weapon and nuclear weapon delivery vehicle within the launch point shall be designed to a Safety Factor of 3 (ultimate). **(T-1)**

7.6.5.2. The launch point structure that the lift or support is connected to shall also be designed to a Safety Factor of 3 (yield). **(T-1)**

Chapter 8

COMBAT DELIVERY AIRCRAFT SYSTEMS

8.1. AMAC and Release System Electrical Power.

8.1.1. Nuclear critical functions shall not activate in the event of a circuit breaker or other circuit protective device actuation. **(T-1)**

8.1.2. If the primary power source fails, a secondary or backup power source shall automatically provide a means to safe the nuclear weapon. **(T-1)**

8.1.3. The nuclear weapon system shall prevent application of unintended power to the nuclear weapon interface. **(T-1)**

8.2. Suspension and Release Systems. Suspension and release systems are mechanisms to carry, jettison, and release weapons.

8.2.1. The suspension and release systems designs shall comply with **Rule 5** from **Table 3.1**. **(T-1)**

8.2.2. Lock/Unlock Mechanism. The aircraft system shall provide a lock/unlock mechanism. **(T-1)** The RIFL is an example of a lock/unlock mechanism.

8.2.2.1. The lock/unlock mechanism shall mechanically prevent weapon release when locked, even if the maximum releasing force is generated and transmitted to the release system. **(T-1)**

8.2.2.2. The lock/unlock mechanism shall have a mechanical restraint on the releasing device. **(T-1)** This requirement prevents release in the event a failure initiates the release system.

8.2.2.3. The lock/unlock mechanism and its controls shall be independent of the release controls. **(T-1)**

8.2.2.4. The lock/unlock mechanism and its controls shall be independent of the electrical connections between the aircraft and the nuclear weapon. **(T-1)**

8.2.2.5. The lock/unlock mechanism shall revert to the locked state in the event of failure. **(T-1)**

8.2.2.6. The nuclear weapon system shall provide an indication of any state of the lock/unlock mechanism to the cockpit. **(T-1)**

8.2.2.7. The lock/unlock mechanism shall be visually observable to ground personnel via an unmistakable indication of the locked state. **(T-1)**

8.2.2.8. Unlocking of the lock/unlock mechanism shall require two separate and independent human actions. **(T-1)**

8.2.2.9. The aircrew lock/unlock mechanism controls shall incorporate a means for tamper detection in accordance with DAFI 91-101. **(T-1)** See DAFI 91-101 for further guidance.

8.2.2.10. The Stores Management System shall notify the aircrew of uncommanded lock/unlock mechanism states with a visual and/or audible indication. **(T-1)**

8.2.2.11. The release system retention hooks shall operate on the same lock/unlock mechanism. **(T-1)**

8.2.2.12. The lock/unlock mechanism shall relock if unlock power is removed, inadvertently or intentionally, while the lock/unlock mechanism is unlocked. **(T-1)**

8.2.2.13. A single lock/unlock mechanism fault shall be unable to cause a release. **(T-1)**

8.2.3. The release system retention hooks shall operate on the same lock/unlock mechanism. **(T-1)**

8.2.4. Pylons carrying nuclear weapons shall either include a pylon jettison lock that meets the criteria for the lock/unlock mechanism or be unable to jettison. **(T-1)**

8.2.5. Energy control signals for the lock/unlock mechanism and release system shall be isolated both physically and electrically. **(T-1)** This requirement is to protect against an electrical fault resulting in an inadvertent release.

8.2.6. The aircraft shall provide the aircrew with a positive indication the nuclear weapon or nuclear weapon delivery vehicle has completely separated from the aircraft. **(T-1)**

8.3. Nuclear System Controls and Displays. This section is applicable to prearm and safe controls, prearm command, prearm consent, and release controls, AMAC interfaces, release consent, lock/unlock mechanism, aircrew member release input, and jettison. These are addressed in their respective sections to avoid duplicating their control requirements here on a case-by-case basis.

8.3.1. The aircraft shall control each nuclear weapon or nuclear weapon delivery vehicle individually. **(T-1)**

8.3.2. The prearm consent control shall require human intent. **(T-1)**

8.3.3. Loss of prearm consent shall pause any prearm or release functions in process. **(T-1)**

8.3.4. Loss of prearm consent shall inhibit release until prearm consent is reestablished through aircraft and aircrew procedures. **(T-1)**

8.3.5. The prearm consent control shall provide indication of tampering. **(T-1)**

8.3.6. For System 1 nuclear weapons, the prearm consent function shall be a hardwired control that interrupts power to the prearm circuit controlling the intent strong link. **(T-1)**

8.3.7. Release Controls.

8.3.7.1. The aircraft shall unlock the lock/unlock mechanism for release only when nuclear consent is active. **(T-1)** This requirement is to inhibit unlocking the release system unless consent is given, without the nuclear consent the lock/unlock mechanism will not unlock to prevent an unauthorized release.

8.3.7.2. The aircraft shall inhibit release of the nuclear weapon or nuclear weapon delivery vehicle if nuclear consent is not present. **(T-1)**

8.3.7.3. The aircraft shall relock the lock/unlock mechanism upon removal of nuclear consent. **(T-1)**

8.3.7.4. Aircrew Member Release Input. Aircraft designed to release multiple nuclear weapons shall require an unambiguous, non-latching human intent at the time of release

per authorized target. **(T-1)** For a multiple weapon release, if the human intent is provided after reaching a control point or region, the intent may be latched.

8.3.7.5. The implementation of the selective jettison sequence shall transition the nuclear weapon to the safest state possible. **(T-1)** This requirement can be met procedurally.

8.3.7.6. The implementation of the emergency jettison sequence shall attempt to place the nuclear weapon in the safest state possible. **(T-1)**

8.3.7.7. Release systems shall comply with the requirements in **paragraph 3.4.4**. **(T-1)**

8.4. Multi-Crew Aircraft Consent Functions.

8.4.1. Multi-crew aircraft shall require separate controls for nuclear consent. **(T-1)** This requirement is to prevent inadvertent release of the nuclear weapon.

8.4.2. Each nuclear consent control shall require physical separation and independent action of individual aircrew members for activation. **(T-1)** This requirement has Two-Person Concept consent control to ensure one (1) individual cannot provide nuclear consent.

8.4.3. If a multi-crew aircraft is intended to be used in combat by one person and a bypass is done before flight, the aircraft shall have provisions for nuclear consent by a single person. **(T-1)**

8.4.4. This bypass shall be unable to commence while in flight. **(T-1)**

8.5. Aircrew Indications. The aircraft shall send an alert and/or indication to the aircrew for the following events:

8.5.1. Uncommanded Unlock. Unlocking of, or an unlock signal going to, the lock/unlock mechanism when normal operation of controls has not commanded unlocking. **(T-1)**

8.5.2. Uncommanded Prearm. Prearming of a nuclear weapon when normal operation of controls has not commanded prearming. **(T-1)**

8.5.3. Indeterminate Weapon State. When the safe state of the nuclear weapon cannot be positively determined. The nuclear weapon system is not required to provide an indication during normal transition through an intermediate state from a known state to a commanded state. **(T-1)**

8.5.4. Uncommanded Release. Release of, or a release signal being sent to, the release system when normal operation of controls has not commanded release. **(T-1)**

8.6. Interface Unit and Nuclear Weapon Power Control.

8.6.1. Systems that utilize the Energy Control Concept shall require control of power to interface units by means of:

8.6.1.1. Positive action to supply power to the interface unit (logic and power switching assemblies). **(T-1)**

8.6.1.2. Separate control that removes power from the interface unit (logic and power switching assemblies). **(T-1)**

8.6.2. Systems that utilize the Energy Control or Information Control Concept shall require control of power to nuclear weapon interface by means of:

8.6.2.1. Positive action to supply power at the nuclear weapon interface. **(T-1)**

8.6.2.2. Separate control that removes power from the nuclear weapon interface. **(T-1)**

8.7. Multiplexed Systems.

8.7.1. All hardwired discrete signals in the multiplexed AMAC system shall meet the design criteria of a system built entirely with discrete signals. **(T-1)** MIL-STD-1760 provides guidance to fulfill this requirement.

8.7.2. Weapon stations that are not certified to carry nuclear weapons transmitting or receiving data shall be ignored by the nuclear weapon system. **(T-1)**

8.7.3. Abnormal Environment Protection.

8.7.3.1. For systems that utilize the Energy Control Concept, multiplexed units shall provide break-before-make action between changes of state of all nuclear critical signals applied to the nuclear weapon interface. **(T-1)**

8.7.3.2. For nuclear weapon systems that utilize the Energy Control Concept, if the voltages and currents that operate the multiplexed system station logic are inadvertently applied to the nuclear weapon interface, they shall be below one order of magnitude of the nuclear critical function activation levels. **(T-1)**

Chapter 9

AIR LAUNCHED MISSILES AND AIR RELEASED BOMB SYSTEMS

9.1. General Criteria. The same criteria applicable to combat delivery aircraft, such as connector design, electromagnetic radiation protections, electrical subsystems, and Arming and Fuzing systems shall apply to the missile or Air Force-owned guided bomb components. **(T-1)** These criteria are in addition to **Chapter 8** because an air-launched missile or air-released bomb is generally considered an extension of the aircraft until it is released.

9.2. Safe and Arm and Arm/Disarm Devices.

9.2.1. Each nuclear weapon system shall require a nuclear weapon system operator to apply safing power. **(T-1)**

9.2.2. If the nuclear weapon system uses a subsystem that can automatically control a Safe and Arm device or automatically control the ability to apply safing power to the nuclear weapon, that subsystem shall comply with applicable criteria within DAFMAN 91-119. **(T-1)**

9.2.3. The nuclear weapon system monitor system shall monitor the device(s) for the safe/arm condition, either continuously or on demand. **(T-1)**

9.2.4. The nuclear weapon delivery vehicle shall implement a release sensing device that ensures electrical and mechanical “make-before-break” isolation of A&F system. **(T-1)**

Chapter 10

TEST EQUIPMENT

10.1. General Criteria. Apply design criteria in this chapter to test equipment used to verify the proper operation, safe state, and control of nuclear critical functions. Reference DAFI 91-101 for applicability guidance.

10.2. Fail-Safe.

10.2.1. The test equipment design shall ensure faults within the test equipment or test circuits do not operate nuclear critical functions. **(T-1)**

10.2.2. The test equipment shall meet the interface limits of all components that tester-induced signals, voltages, and currents pass through and/or interact with. **(T-1)**

10.2.3. The test equipment design shall prevent operation or firing of an item under test, except when specifically designed for that purpose. **(T-1)**

10.3. End-of-Test Safe State.

10.3.1. When a successful test ends, the nuclear weapon system component that was operated during testing shall be in a safe state. **(T-1)**

10.3.2. The test equipment shall verify and display the safe state of such components. **(T-1)**

10.4. Built-In Test Equipment.

10.4.1. Built-in test equipment for nuclear weapon systems shall comply with all safety design criteria that apply to nuclear weapon systems. **(T-1)**

10.4.2. Built-in test equipment shall be incapable of operating any critical function on a loaded nuclear weapon system. **(T-1)**

10.4.3. Built-in test equipment shall not energize any critical circuit within a loaded nuclear weapon system. **(T-1)**

10.5. Functionality and Safety Checks.

10.5.1. The test equipment shall conduct a self-test that verifies the equipment complies with **paragraph 10.2** and that the test equipment can successfully verify the safe state of the systems under test that control critical functions. **(T-1)**

10.5.2. Test equipment generated electromagnetic emissions shall be equal to or less than the applicable weapon STS levels when weapons are present as outlined in DAFI 91-208 and MIL-STD-461. **(T-1)**

10.6. Reprogramming Functionality. Any test equipment that can manipulate critical function activation in accordance with DAFMAN 91-119 shall require compliance with all criteria within this chapter, even if depot-level-test equipment. **(T-1)**

10.7. Operational Certification/Decertification of Critical Components (OPCERT) Equipment. The OPCERT equipment shall perform testing of a critical component to verify that it is functioning as designed and detects tampering/malicious injects, IAW AFI 91-106, *Unauthorized Launch, Threat Mitigation, and Launch Action Studies*. **(T-1)** See General,

Electrical, Hazard, and Test Equipment design criteria for design requirements. **Note:** "Operational Certification" and "OPCERT" are different terms; see the glossary for clarification.

Chapter 11

FACILITIES

11.1. Criteria Applicability. Apply the criteria in this chapter to new and existing facilities or other associated nuclear weapon system infrastructure with facility-like characteristics where nuclear weapons are maintained and stored. These criteria may also be applied to Weapon Storage and Security Systems and support equipment as applicable. Applicable criteria from this chapter must be tailored to the specific application as documented in the CRP. Design criteria need not be applied to areas where the nuclear weapon will not reside (for example, administrative areas and loading docks).

11.2. Existing Facilities. Existing nuclear weapons maintenance and storage facilities and facility systems are not required to be modified solely to meet the design criteria of this chapter.

11.3. New Facilities and Facility Modifications. Any new facility or modification to an existing facility, essential facility system, or other systems, as defined by AFSEC/SEWN, shall require nuclear safety design certification in accordance with DAFI 91-101. **(T-1)**

11.4. Hazards Mitigation.

11.4.1. For a facility capable of storing or maintaining nuclear weapons, a comprehensive, coordinated maximum credible event (MCE) determination shall be derived by the using Major Command/Field Command weapon safety office and verified by AFSEC. **(T-1)**

11.4.2. The verified MCE shall be addressed in the underlying design basis for facility and essential facility system designs. **(T-1)**

11.4.3. A Fire Hazards Analysis (FHA) shall be performed during design of new facilities and for modifications to existing facilities, if required by the CRP. **(T-1)** The FHA is a tool used to ascertain if the following objectives are met: minimizing potential for occurrence of a fire, ensuring that fire does not cause release of radiological or other hazardous material, and ensuring weapon design, weapon system responses, and weapon safety limits will withstand a fire and its effects.

11.4.3.1. The FHA is concerned with the risk to weapons only and shall be used to ascertain if Air Force nuclear safety design criteria is met. **(T-1)**

11.4.3.2. The FHA shall include a fire model analysis and evaluation. **(T-1)** Tabletop analyses may also be used as a tool to analyze effects of fires in adjacent rooms.

11.4.3.3. The FHA includes an assessment of the following:

11.4.3.3.1. The FHA shall assess the probability of fires within each new or modified fire area within a facility that could potentially impact the weapons. **(T-1)**

11.4.3.3.2. The FHA shall assess the effects of possible fires and related perils in relation to the fire safety features' capabilities to control the effects of fire events. **(T-1)**

11.4.3.3.3. The FHA shall assess the effects of mission operations on the fire. **(T-1)** This requirement is intended to analyze equipment and operational programs that were not evaluated during design to ensure no new fire hazards were introduced to facility areas where weapons may be located.

11.4.3.3.4. The FHA shall include a comparison of thermal results to the weapon screening values. **(T-1)** The Air Force will provide appropriate screening values.

11.4.3.3.5. When performing an evaluation, the assessor shall assume all potentially vulnerable systems will be damaged within fire areas except water-filled steel pipes, tanks, and similar components of superior structural integrity with welded fittings and adequate pressure relief. **(T-1)** Passive fire protection features, such as blank fire-rated walls, floors, ceilings, and continuous fire-rated cable wraps, are assumed to remain viable. If redundant automatic fire protection systems are provided in an area, only the one system or component that causes the most vulnerable condition need be assumed unavailable.

11.4.3.4. Fire modeling includes the following, at a minimum:

11.4.3.4.1. Fire models shall be based on fire scenarios determined by relevant stakeholders, including AFSEC/SEWN. **(T-1)**

11.4.3.4.2. Fire models shall be based on combustible loading established by agreement between relevant stakeholders, including AFSEC/SEWN. **(T-1)**

11.4.3.4.3. Fire models shall be based on dimensions established by agreement between relevant stakeholders, including AFSEC/SEWN. **(T-1)**

11.4.3.4.4. Model assumptions shall match the performance of components as designed (e.g., Sprinklers don't start immediately, fire walls, changes in air flow from ventilation system, dampers, etc.). **(T-1)** The performance of fire protection systems, building features, and emergency procedures should reflect the documented performance and reliability of the components of those systems or features, unless design specifications are incorporated to modify the expected performance.

11.4.3.4.5. Models shall run until the fire is well into the decay phase without a remote chance of reentering the growth phase. **(T-1)** Models should not assume the fire suppression is assisted by any manual means, such as fire department response.

11.4.3.5. The FHA shall assess the impact of the facility fire protection system on nuclear criticality following a fire event and blast event (if applicable) for each new or modified area. **(T-1)**

11.4.3.6. Qualifications. The FHA shall be prepared by a design professional who has passed the National Council of Examiners for Engineering and Surveying Fire Protection Professional Engineering exam. **(T-1)**

11.4.4. Sideflash. Facility areas designated for nuclear weapon maintenance activities shall be designed to accommodate nuclear sideflash protection policy as directed in DAFI 91-101. **(T-1)**

11.4.5. EME. For new facilities or modifications to existing facilities, the design of a facility or essential facility system should document electromagnetic radiation contributions derived from facility installed equipment.

11.4.5.1. Prior to construction of a new facility, the PM shall provide an ambient electromagnetic radiation survey of the site. **(T-1)**

11.4.5.2. During design, the PM shall provide an analysis that documents the contribution of installed equipment to the electromagnetic environment to ensure compliance with MIL-STD-464. **(T-1)** This strawman analysis lists the built-in equipment and the expected contribution to EME to ensure no large emitters are used in the construction.

11.4.5.3. The PM shall provide a final electromagnetic radiation survey after construction, with all user equipment present to prove compliance with MIL-STD-464. **(T-1)**

11.5. Essential Facility Systems. Facility systems and sub-systems that are determined to affect the DoD Surety Standards directly are "Essential Facility Systems." This includes, but is not limited to, lightning protection systems, electrical power systems, fire protection systems, security systems, and blast containment systems.

11.5.1. Where Essential Facility Systems require operation of a component to perform an intended safety design function, that function shall be designed to operate automatically without manual intervention (including but not limited to mechanical, electrical, monitoring systems, etc.). **(T-1)**

11.5.2. Lightning Protection Systems.

11.5.2.1. The facility design shall include a lightning protection system. shall be provided in accordance with DESR 6055.09_DAFMAN 91-201. **(T-1)**

11.5.2.2. The installation of the lightning protection and grounding systems shall be documented during construction and tested. in accordance with DAFMAN 32-1065. **(T-1)**

11.5.2.3. The facility shall include surge protection in accordance with DAFMAN 32-1065. **(T-1)**

11.5.3. Electrical Power Systems.

11.5.3.1. All essential facility systems that require power shall have electrical power systems and subsystems in compliance with DESR 6055.09_DAFMAN 91-201. **(T-1)**

11.5.3.2. The design of the facility electrical power system shall include permanently installed backup power generation designed in accordance with DAFMAN 32-1062. **(T-1)**

11.5.3.3. The design of the facility electrical power system shall include a tertiary connection for a mobile backup generator. **(T-1)**

11.5.4. Fire Protection Systems.

11.5.4.1. The design of fire protection systems shall prevent exposure of the nuclear weapon to thermal environments in excess of STS/military characteristics of the weapon. **(T-1)**

11.5.4.2. Heating Ventilation and Air Conditioning (HVAC) zones shall be arranged to coincide with fire zones. **(T-1)**

11.5.4.3. Fire suppression systems shall have two sources of water. **(T-1)** Looped systems meet this requirement if each main is large enough to independently supply the maximum fire water demand.

11.5.4.4. Fire suppression systems requiring fire pump(s) must have one or more redundant fire pump(s) able to provide adequate fire line pressure during a pump malfunction. **(T-1)**

11.5.4.5. Maintenance and storage areas shall be equipped with very early warning smoke detection systems. **(T-1)** Laser-based air sampling is an example of a "very early warning smoke detection system."

11.5.5. Facility Security Systems.

11.5.5.1. The design of security systems shall prevent unauthorized or unintended access to a nuclear weapon system per DoDM S-5210.41_AFMAN 31-108, *The Nuclear Weapon Security Manual*. **(T-1)**

11.5.5.2. The design of security systems shall operate within the normal and or credible abnormal environment of the nuclear weapon types that they are being employed to protect. **(T-1)** This requirement addresses new technologies for security such as using loud noises, exploding small amounts of combustibles, or other technology.

11.5.5.3. The facility design shall ensure that security plan requirements are met. **(T-1)** Examples of these are outer wall thickness and vehicle barriers.

11.5.5.3.1. Fire detection shall be installed in buildings and/or rooms with equipment or personnel that control security access. **(T-1)**

11.5.5.3.2. HVAC systems in weapons maintenance and storage facilities shall have the ability to activate (within the room and remotely) the exhaust through the ventilation system from areas where a fire has occurred to remove smoke. **(T-1)** The smoke purge supports the capability to expedite an inventory assessment after a fire and should use the same HVAC system design necessary to meet all other requirements.

11.5.6. Blast Containment Systems.

11.5.6.1. A blast containment system shall be provided for weapon maintenance and storage areas used to store and maintain Hazard Division 1.1 weapon systems. **(T-1)** Guidance on hazard divisions is provided in DESR 6055.09_DAFMAN 91-201.

11.5.6.2. The blast containment system shall be designed to withstand the MCE, including the worst-case fragment. **(T-1)** The blast load should be derived from the MCE through analysis. Blast loads need to be accurate to ensure the validity of the blast system.

11.5.6.3. The design of the blast containment system shall provide a barrier and containment structure protective system, protection category 3, that is fully confined with blast doors and blast valves to contain all contaminants per UFC 3-340-02, *Structures to Resist the Effects of Accidental Explosions*. **(T-1)**

11.5.6.3.1. Blast zones for weapon maintenance areas shall be separate from blast zones for weapon storage areas. **(T-1)** Storage and maintenance areas are designated as separate blast zones per DESR 6055.09_DAFMAN 91-201.

11.5.6.3.2. Penetrations of the blast-resistant barriers shall be limited to only those services necessary to serve the blast zone. **(T-1)**

11.5.6.3.3. Wires and cables shall be placed in conduit to run across the boundary of a blast containment zone. **(T-1)** Wireways and cable trays are not allowed as they will compromise the integrity of the blast zone.

11.5.6.3.4. Ventilation ducts from the blast valve through the blast wall shall be constructed from Schedule 80 steel. **(T-1)** Ducts that remain entirely within a blast zone are not required to be a hardened duct.

11.5.6.3.5. Conduit through blast walls shall be provided with an explosion-proof conduit seal meeting the requirements of National Fire Protection Agency 70 for a Class I, Division 1 boundary. **(T-1)** Proper seals are necessary to ensure the integrity of the blast zone. Conduit through blast walls can degrade the effectiveness of the blast wall therefore robust explosion-proof seal is required.

11.5.6.3.6. Blast containment zones shall be arranged to coincide with HVAC and fire zones. **(T-1)** Systems must function together as an effective whole. It is recommended that an HVAC zone serves only one blast zone.

11.5.6.4. Doors to blast zones shall be designed to provide the same protection and blast containment as the walls. **(T-1)** Specific test data or modeling is required to demonstrate the capability of the doors to meet the required blast resistance.

11.5.6.4.1. Upon loss of power, the door operating system shall automatically cycle the doors to a failsafe position. **(T-1)**

11.5.6.4.2. Blast doors shall be designed with a gasket to fully contain the pressure of the MCE. **(T-1)**

11.5.6.4.2.1. The gasket shall be capable of overcoming a force of 125 pounds per linear inch of the gasket. **(T-1)**

11.5.6.4.2.2. Blast door deflections shall be limited to ensure satisfactory performance of the gasket. **(T-1)** This can be proven through structural analysis.

11.5.6.4.3. Blast door systems shall be designed with the capability to test leakage around the seals with the door and seals in place without separate equipment and special procedures. **(T-1)**

11.5.6.4.4. The hinge design capacity shall be at least 150 percent of the calculated load to which the hinge will be subjected, including each component and mounting hardware. **(T-1)**

11.5.6.4.5. In cases where a blast door is within a fire barrier wall, a fire protection engineer shall evaluate the door and determine if it meets the intent and function of a fire-rated door. **(T-1)** Blast doors are not listed by nationally recognized testing laboratories as fire doors; however, based on their massive construction, they likely meet most of the listing agencies' criteria for a fire door. FHA results may be used in this evaluation.

11.5.6.4.6. Blast doors shall be capable of being manually operated from the exterior of the room. **(T-1)** Following an explosion, or in the event of a power outage, the blast doors must be capable of emergency operation to ensure unsafe conditions can be remedied as soon as possible.

11.5.6.5. Blast valves.

11.5.6.5.1. Blast valves shall be installed on HVAC hardened ducts that penetrate blast-resistant barriers. **(T-1)**

11.5.6.5.2. Blast valves shall prevent over- and under-pressure blast waves from reaching the supply and exhaust airstreams. **(T-1)** This requirement is consistent with non-latching mechanical blast valves per UFC 3-340-02.

11.5.6.5.3. Blast valves shall be self-contained and capable of automatically closing upon an explosive event. **(T-1)**

11.5.6.6. Containment valves.

11.5.6.6.1. Quick-acting, gas-tight containment valves shall be installed on all penetrations of a blast zone to isolate a zone after an internal blast. **(T-1)** This requirement applies to HVAC and plumbing to include fire suppression lines.

11.5.6.6.2. Containment valves shall be specified to handle the pressure and temperature for the blast load derived from the MCE. **(T-1)**

11.5.6.6.3. Containment valves shall close automatically upon an explosive event when the pressure differential is one (1) pound per square inch. **(T-1)**

11.5.6.6.4. Containment valves shall be monitored remotely. **(T-1)**

11.5.6.6.5. Containment valves shall be controlled remotely. **(T-1)**

11.5.6.7. Ventilation System Requirements.

11.5.6.7.1. The ventilation system(s) shall support blast isolation and radiological contaminant containment system design. **(T-1)**

11.5.6.7.2. A radiological contaminant isolation system shall be provided in facilities with blast isolation systems. **(T-1)** This is met with High Efficiency Particulate Air filtration on exhaust.

11.5.7. Facility systems that are determined to be impacted by the DoD surety standards or requirements of Air Force Policy Directive (AFPD) 91-1, *Nuclear Weapons and Systems Surety*, that are not covered in this manual shall be reviewed to determine if safety design certification is required. **(T-1)**

11.5.8. The design of essential facility systems shall not create an environment that negatively affects the nuclear weapon or other essential facility systems. **(T-1)** For example, innovative solutions to fire protection such as ignitable liquid drainage floor assembly and water mist were deemed inappropriate for use in nuclear capable facilities and standpipes in blast zones conflict with the ability to isolate the room.

Chapter 12

NONCOMBAT DELIVERY VEHICLES AND SUPPORT EQUIPMENT

12.1. Design Philosophy. Noncombat delivery vehicles and support equipment should incorporate positive measures and meet appropriate structural, environmental, stability and mobility requirements.

12.2. Criteria Applicability. Apply the criteria in this chapter to systems used to maintain, transport, store, structurally support, restrain, and load/unload nuclear weapons. Secure Transportable Maintenance System is included in this.

12.3. Standards. Commercial United States design standards (e.g., American National Standards Institute) or military design standards, if applicable, can be used to substantiate nuclear safety design certification of any commercially designed, non-specialized equipment. For locations outside the United States and territories, non-United States design standards (i.e., European Specifications and Approvals) may be used in lieu of United States standards. The industry/military standard applicable sections should be listed in the Certification Requirements Plan with justification.

12.4. Structural Load Design Criteria.

12.4.1. Rated Load. The rated load shall be calculated using the heaviest configuration approved for operational use. **(T-1)**

12.4.2. Design Load. The design load used to initiate the design or modification of structural components of equipment shall be based on the rated load multiplied by an applicable factor of safety as outlined in **Table 12.1**. **(T-1)**

Table 12.1. Safety Factors for Nuclear Weapon System Support Equipment.

System	Safety Factor
Metallic Devices (i.e., Loaders, stands, cradles, adapters, trailers, positioners, other transporting, lifting, non-lifting equipment)	3:1 (yield)
Nonmetallic Lifting Devices (i.e., loaders, trailers, positioning equipment)	5:1 (no failure)
Nonmetallic Non-lifting Devices (i.e., stands, cradles, adapters, other non-lifting, non-transporting equipment)	4:1 (ultimate)
Hoists	3:1 (yield)
Metallic Wire Rope, Chain and Associated Fittings	5:1 (ultimate)
Nonmetallic Rope	10:1 (ultimate)

12.4.3. Dynamic Loading. Where dynamic factors induce loads that exceed 1.5 times the rated load, the stress level at any point in the structure shall be limited to a level that provides a safety factor of two (2) against plastic deformation. **(T-1)** In cases where standards specify both an average and a minimum stress, use the minimum stress.

12.5. Primary Failure Mode. Equipment materials, whether solid or composite, shall be designed such that material failure does not occur due to one or more of the following:

12.5.1. Tensile Strength. Material tensile strength shall exceed the stresses applied to the equipment. **(T-1)**

12.5.2. Compressive Loading. The equipment shall be designed such that the stresses induced by a compressive design load applied to the equipment do not exceed half (0.5 times) the yield strength of the material. **(T-1)**

12.5.3. Fatigue Loading. The equipment shall be designed such that fatigue failure does not occur within its lifetime. **(T-1)** Design for either Endurance Limit or Fatigue Strength.

12.5.4. Composite Loading. Composite material within the equipment shall be designed such that delamination of the layers or breakage of fibers does not occur. **(T-1)**

12.5.5. Excessive Deflection. The deflection in any structural load path member shall remain within the operable range for the system operating intent. **(T-1)** This is intended to capture the fact that some components could be designed to meet a safety factor but, in so doing, still deflect sufficiently to prevent the system from operating as intended.

12.6. General Safety.

12.6.1. Static Grounding. The equipment shall be designed with grounding IAW AFMAN 32-1065. **(T-1)** This requirement is to prevent static electrical discharge passing through the equipment to the nuclear weapon.

12.6.2. Fire Propagation. The equipment shall be designed to mitigate fire propagation due to system failure. **(T-1)**

12.6.3. Environmental Considerations. The system shall be designed to adhere to all environmental considerations within its operational envelope and adhere to applicable STS requirements in accordance with MIL-STD-810, *Environmental Engineering Considerations and Laboratory Tests*. **(T-1)**

12.6.3.1. The system shall be designed to adhere to shock requirements in accordance with MIL-STD-810. **(T-1)**

12.6.3.2. The system shall be designed to adhere to vibration requirements in accordance with MIL-STD-810. **(T-1)**

12.6.4. Systems shall not allow for Bluetooth or wireless connection. **(T-1)**

12.6.5. Software verification shall be conducted in accordance with DAFMAN 91-119. **(T-1)**

12.7. Roadability.

12.7.1. Engine and Motor.

12.7.1.1. Internal Combustion Engine Start Switch. For self-propelled ground transport equipment that has a mechanical drive train, the engine start circuitry shall only operate when the clutch is disengaged or when the automatic transmission is in the “neutral” or “park” position. **(T-1)**

12.7.1.2. Electric Start Switch. For self-propelled ground transport equipment that has an electrical drive train, the drive system startup shall only occur when the system is in a "neutral" or "park" drive setting. **(T-1)**

12.7.1.3. Equipment shall be designed to allow for manual operation in the event of power failure in accordance with its operational envelope. **(T-1)**

12.7.2. Self-propelled and towed equipment shall comply with applicable mobility requirements at Gross Vehicle Weight Rating in accordance with its operational envelope and adhere to applicable STS requirements. **(T-1)**

12.7.2.1. Self-propelled and towed equipment shall be designed in accordance with Society of Automotive Engineers (SAE) AS8090, *General Requirements for Mobility, Towed Aerospace Ground Equipment*. **(T-1)** Tier waiver authority of this DAFMAN requirement supersedes reference waiver authority as stated in the Purpose of this DAFMAN.

12.7.2.2. Equipment shall be designed such that it does not tip, tilt, yaw, sway, skid, or jackknife while configured with the rated load and while undergoing maximum performance maneuvers. **(T-1)** Some examples of maximum performance maneuvers are emergency braking and obstacle avoidance.

12.7.3. Casters. Handling equipment with casters shall be designed on individual equipment specifications for weight and service in accordance with SAE AS8090. **(T-1)** Tier waiver authority of this DAFMAN requirement supersedes reference waiver authority as stated in the Purpose of this DAFMAN.

12.7.4. Towing.

12.7.4.1. Tow Vehicle Brake System Compatibility. The tow vehicle service brake system shall be functionally compatible with the towed vehicle service brake system. **(T-1)**

12.7.4.2. Trailer Emergency Brakes. Trailers using tow bars shall be designed with an emergency brake system that activates automatically and brings the trailer to a controlled stop in case of inadvertent tow bar disconnect. **(T-1)**

12.7.4.3. Tow Vehicle Parking Brakes. The combination of tow vehicle and item being towed (e.g., trailer) shall meet the parking brake requirement in **paragraph 12.7.5.2**. **(T-1)**

12.7.4.4. Tow System Interconnect Device. The interconnect equipment used for combining tow vehicles and items being towed shall comply with the structural criteria in paragraphs **12.4** and **12.5**. **(T-1)**

12.7.4.5. Trailer Hitch. Equipment designed with a trailer hitch (including fifth wheels) shall include a safety latch that allows for a visual check of the locked condition. **(T-1)**

12.7.4.6. Towed vehicles shall have a parking brake that secures the trailer with the rated load without the tow vehicle being connected. **(T-1)**

12.7.5. Braking.

12.7.5.1. Service Brakes. Equipment shall be capable of holding the rated load stationary on an incline of 11.5 degrees. **(T-1)**

12.7.5.2. Parking Brakes. Equipment shall be capable of holding the rated load stationary on an incline of 11.5 degrees, in the up and down direction, without rolling or skidding. **(T-1)**

12.7.5.3. Emergency Brakes. Equipment, at its maximum speed and rated load, shall be capable of stopping in a safe distance based on its operational environment. **(T-1)**

12.8. Lift Systems.

12.8.1. Lift Systems Drop Rate. Lift systems shall be designed to maintain a controlled drop of the rated load in the event of an electrical, hydraulic, or pneumatic failure, not to exceed 0.5 inches per hour. **(T-1)**

12.8.2. Lift Systems Overpressure. Lift system design shall include pressure relief valves or regulators in hydraulic and pneumatic systems to prevent overpressure. **(T-1)**

12.8.3. Auxiliary System. Lift system design shall include an auxiliary mechanism capable of manually lifting and lowering the maximum load. **(T-1)**

12.8.4. Emergency Stop. Lift systems shall include a manually or automatically operated electric switch to cut off electric power independently of the regular operating controls. **(T-1)**

12.9. Movement and Positioning Controls.

12.9.1. Controllers. Controllers shall require a hardwired connection to the system during operation. **(T-1)**

12.9.2. Positive Measures. Movement and positioning controls shall incorporate positive measures to control the lifting and handling of nuclear weapons. **(T-1)**

12.9.2.1. Autonomous systems shall be designed with the “human-in-the-loop” concept to allow for semi-autonomous functionality. **(T-1)**

12.9.2.2. Dead-Man Control. All movement and positioning controls shall be designed on the dead-man principle, ensuring handles, switches, and other manual controls automatically neutralize in the absence of manual force. **(T-1)**

12.9.3. The design of all movement and positioning controls shall be self-centering. **(T-1)**

12.9.4. Movement and positioning controls shall incorporate mechanisms to prevent over-travel in all directions of the lift control, to include automatic stops, mechanical stops, electrical switches, software defined limits, or fail-safe limit switches. **(T-1)**

12.9.5. Movement and positioning controls shall include the capability for small increments of movement in all directions. **(T-1)**

12.9.6. If more than one power-operating component in a mechanically parallel system is used to lift the weapon, the design shall uniformly control lifting attitude. **(T-1**) The components may be individually controlled to provide weapon attitude adjustments but should be capable of synchronization.

12.10. Stability.

12.10.1. Lifting equipment shall have a minimum tipping load of 110% of the rated load in all operational configurations. **(T-1)**

12.10.2. Mounted and free-standing handling and support structures shall remain stable at a tipping angle of 11 degrees or less. **(T-1)**

12.10.3. Mounted and free-standing handling and support structures shall remain stable while laterally loaded with 0.5g acceleration at their loaded center of gravity on level ground. **(T-1)**

12.11. Hoists, Cranes, Winches, and Other Lifting Devices. The criteria in this section apply to hoists, cranes, winches, and similar devices. These are not to be assumed to only apply in facilities but to any such device used in a nuclear weapons operation.

12.11.1. Hooks. Hooks shall be designed with throat-opening safety devices. **(T-1)**

12.11.2. The design of facility structural supports for lifting devices shall be considered part of the lifting devices for certification. **(T-1)** This is applicable to systems like the Suspended Load Frame and the Missile Suspension System.

12.11.3. Mechanical locking capabilities shall be provided on any hydraulic lifting or hoisting mechanism that is intended (or might be used) to hold the load in the raised or extended position for more than 2 minutes. **(T-1)**

12.11.4. Where a load must be lifted into close quarters or onto precise mating, provisions shall be made for final adjustment in aligning, mounting, and stabilizing the load. **(T-1)**

12.11.5. Hand operated hoist(s) shall be designed such that, when the actuating force is removed, it will automatically stop and hold the load in the raised position. **(T-1)**

12.11.6. The lifting device shall not malfunction, such as skipping or jumping of the cable from the cable grooves or uncontrolled lowering, during operations. **(T-1)**

12.12. Air or Ground Transport Design Criteria. This covers transportation of nuclear weapon cargo for whatever means of conveyance is chosen.

12.12.1. Air transportable delivery vehicles and support equipment shall meet the general specifications of MIL-STD-1791, *Designing for Internal Aerial Delivery in Fixed Wing Aircraft*. **(T-1)**

12.12.2. Ground transport shall conform to MIL-STD-1366, *Transportability Criteria*. **(T-1)**

12.12.3. Pallet Lock Systems. Pallet lock systems on cargo shall be designed to fail-safe. **(T-1)**

12.12.4. Restraints.

12.12.4.1. Cargo restraint systems (including tie-down restraint designs) on ground and air transport vehicles shall be designed to ensure tie-down configurations prevent nuclear weapons from exceeding the envelopes described in **Table 12.2** and **Table 12.3**. **(T-1)**

Table 12.2. Ground Transport Envelope.

Vertical Upwards	0.2g
Vertical Down	Not Considered
Forward	0.8g
Aft	0.5g
Lateral	0.5g

Table 12.3. Air Transport Envelope.

Vertical Upwards	3.7g **Note:** This includes standard gravity of 1g, otherwise 2.7g
Vertical Down	4.5g **Note:** This includes standard gravity of 1g, otherwise 3.5g
Forward	3.0g
Aft	1.5g
Lateral	1.5g

12.12.4.2. Restraints for attaching nuclear weapons to their mode of conveyance shall not damage any part of a nuclear weapon. **(T-1)**

12.12.4.3. Restraint design shall comply with MIL-STD-209, *Lifting and Tiedown Provisions,* for designing tiedown provisions. **(T-1)**

MICHAEL A. THOMAS
Colonel, USAF
Acting Air Force Chief of Safety

Attachment 1

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

References

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MIL-STD-209, *Lifting and Tiedown Provisions*, 22 February 2005

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Abbreviations and Acronyms

A&F—Arming and Fuzing

AFI—Air Force Instruction

AIAA—American Institute of Aeronautics and Astronautics

AFMAN—Air Force Manual

AMAC—Aircraft Monitor and Control

COMSEC—Communications Security

COTS—Commercial Off-The-Shelf

CRP—Certification Requirements Plan

DAF—Department of the Air Force

DAFI—Department of the Air Force Instruction

DAFMAN—Department of the Air Force Manual

DAFPD—Department of the Air Force Policy Directive

DESR—Defense Explosives Safety Regulation

DoD—Department of Defense

DoDI—Department of Defense Instruction

DoDM—Department of Defense Manual

E/TSD—Environmental or Trajectory Sensing Device

EME—Electromagnetic Environments

FHA—Fire Hazards Analysis

g—Gravity—HERO—Hazards of Electromagnetic Radiation to Ordnance

HVAC—Heating Ventilation and Air Conditioning

ICBM—Intercontinental Ballistic Missile

IUSI—Intent Unique Signal Information

LCP—Launch Control Point

LP—Launch Point

MCE—Maximum Credible Event

MIL-DTL—Military Detail

MIL-STD—Military Standard

OPCERT—Operational Certification/Decertification Procedures for Critical Components

OPR—Office of Primary Responsibility

PAL—Permissive Action Link

PM—Program Manager

PO—Program Office

RIFL—Reversible In-Flight Lock

SAE—Society of Automotive Engineers

STS—Stockpile-to-Target Sequence

TNT—Trinitrotoluene

UFC—Unified Facilities Criteria

USAF—United States Air Force

USG—Unique Signal Generator

Office Symbols

AF/SE—Air Force Chief of Safety

AFSEC/SEW—Air Force Safety Center, Weapons Safety Branch

AFSEC/SEWN—Air Force Safety Center, Nuclear Weapons Safety Branch

SAF/AQ—Secretary of the Air Force for Acquisition, Technology and Logistics

SAF/SQ—Assistant Secretary for Space Acquisition and Integration

Terms

Abnormal Environment—Environments as defined in a weapon's Stockpile-to-Target Sequence and Military Characteristics in which a nuclear weapon or a nuclear weapon system is not expected to retain full operational reliability.

Air Force Nuclear Weapons Surety Program—Air Force policies, procedures, and safeguards used to comply with DoD nuclear weapon system surety standards.

Aircraft Monitoring and Control—Equipment installed in aircraft to permit monitoring and control of safing, prearming, and fuzing functions on nuclear weapons and nuclear weapon systems.

Arm/Disarm Device—A mechanical or electromechanical device providing a positive interruption of the firing circuit to prevent initiation of an explosive or pyrotechnic train before the device's commanded closure.

Arming—Readying a nuclear weapon so that a fuzing signal will operate the firing system, includes operation or reversal of safing items.

Authorization—Critical function representing Presidential consent allowing the use of a nuclear weapon.

Command and Control—The exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of the mission.

Credible Abnormal Environment—An Abnormal Environment that has a plausible and reasonable probability of occurrence under a given set of circumstances.

Critical Component—A component of a nuclear weapon system that if bypassed, activated, or tampered with could result in, or contribute to, deliberate or inadvertent authorizing, prearming, arming, releasing, or launch of a combat delivery platform carrying a nuclear weapon, or the employment of a nuclear weapon against anything other than an authorized target.

Critical Function—A function that readies a nuclear weapon system for use by controlling the authorization, prearming, arming, or launching/releasing of a nuclear weapon, or the navigation validation of a nuclear weapon.

Critical Signal—Critical Signals are any signals or data, either analog or digital, which logically represent human intent to activate or deactivate critical functions. If Critical Signals are not properly protected, human intent could be lost and cause an inadvertent or unauthorized activation of a Critical Function.

Delivery Platform—A platform, with its installed equipment and components, used to deliver a nuclear weapon to a target. For ICBM, delivery platform is the missile.

Design Certification—Occurs when each of four components is accomplished for the weapon system: Compatibility Certification, Nuclear Safety Design Certification, Weapon System Safety Rules Approval, and Technical Orders Approval.

Development Organization—A group of persons independent of the Verification Organization, including subcontractors and other entities performing auxiliary activities such as configuration management or quality assurance, that is responsible for designing, implementing, modifying, testing, or maintaining software in a nuclear weapon system.

Essential Facility Systems—Systems and sub-systems within a facility that are determined to affect the four DoD Surety Standards directly.

Facility Lifting and Suspension Systems—Equipment (i.e., a hoist, crane, or suspended load frame) installed in a facility that is used to lift or support nuclear weapons.

Fuzing—Generating a signal that, in an armed nuclear weapon, will operate the firing system.

Inadvertent Programmed Launch—The unintentional entry into terminal countdown or launch countdown and the resultant launch of a missile.

Incident—An unexpected event that presents the potential for negative consequences that may be caused by accidental or intentional acts, acts of God, unfavorable environmental conditions, or other factors.

Jettison—The intentional separation of an unarmed weapon from its delivery platform or transport carrier in response to an emergency.

Latch—A mechanism that cannot be undone without acknowledgment and action.

Launch Control Point—The control center from which system operators control, monitor, and launch a ground-launched missile. Also known as the Launch Control Center.

Launch Point—The geographical area or facility from which a ground-launched missile is launched.

Launching—Propulsion of a missile with a nuclear warhead into flight, through the ignition of any rocket motor or propulsion system, beyond the immediate area of the launching site.

Master Nuclear Certification List—Identifies equipment, hardware, facilities and software that are certified in accordance with DAFI 63-125. The Master Nuclear Certification List is the sole source for verifying the nuclear certification status of nuclear certified equipment (system, hardware, software).

Military Characteristics—A DoD document submitted to Department of Energy that specifies performance requirements and physical characteristics for a nuclear warhead, bomb, or basic assembly to be compatible with a specific weapon system or systems.

Multiplexed System—A signal transmission system in which two or more signals share one transmission path.

Navigation Validation—The process that compares the authorized targeting data with the navigation solution to confirm that nuclear weapon kinematics will deliver a nuclear weapon to an authorized target.

Non-specialized Equipment—Equipment used with nuclear weapons but not specifically designed for that purpose.

Normal Environment—The expected logistical, storage, and operational environments defined in the Stockpile-to-Target Sequence document and the Military Characteristics that the weapon system is required to survive without degradation in operational reliability.

Nuclear Certified Item—Procedures, equipment, software, facilities, systems, subsystems or components which are nuclear certified in accordance with the nuclear certification process outlined in DAFI 63-125.

Nuclear Consent—A function implemented by a deliberate human action that is a necessary, reversible step in the process of using a nuclear weapon.

Nuclear Criticality Safety—A safety discipline with the objective to protect against an uncontrolled nuclear chain reaction and its consequences during all normal and credible abnormal conditions.

Nuclear Safety Design Certification—A component of design certification that evaluates facilities, hardware, and/or software associated with nuclear weapon systems for compliance with nuclear safety design and evaluation criteria.

Nuclear Weapon—A complete assembly (i.e., implosion type, gun type, or thermonuclear type), in its intended ultimate configuration which, upon completion of the prescribed arming, fusing, and firing sequence, is capable of producing the intended nuclear reaction and release of energy.

Nuclear Weapon Delivery Vehicle—The nuclear, Department of Energy-provided component(s) coupled with the non-retrievable hardware that leaves a delivery platform intended for authorized targets.

Nuclear Weapon System—A nuclear weapon and a means for delivering it to the authorized target, with associated specialized support equipment, facilities, procedures, personnel, and any vehicles peculiar to the system used for weapon transport.

Nuclear Weapons Surety—Policies, procedures, controls, and actions that encompass safety, security, and control measures, which ensure there will be no nuclear weapons accidents, incidents, unauthorized detonation, hazardous exposure of radioactive materials to the environment, or degradation of weapon effectiveness during its Stockpile-to-Target Sequence.

OPCERT—The process of verifying a system or critical component is functioning as design certified and all credible threats and scenarios are mitigated. OPCERT procedures are accomplished on all critical components prior to installation in the operational weapon system or whenever two-person control has been lost, the component has been removed from the Master Nuclear Certification List IAW DAFI 91-101, or when directed by higher authority. **Note:** This abbreviated term is uniquely distinct from the Operational Certification term without this abbreviation.

Operational Certification—This occurs when the lead/using command qualifies its personnel to perform the mission, certifies them in the Personnel Reliability Assurance Program, trains them in nuclear weapons surety, and assigns a “Ready” rating on an Initial Nuclear Surety Inspection.

Permissive Action Link—A device included in or attached to a nuclear weapon system in order to preclude arming and/or launching until the insertion of a prescribed, discrete code or combination. It may include equipment and cabling external to the weapon or weapon system that can activate components within the weapon or weapon system.

Positive Measure—The combination of procedural and administrative actions, physical safeguards, and design features expressly for the purpose of ensuring security, safety, and control of nuclear weapons and systems, including associated personnel.

Prearming—Nuclear weapon system operations that configure a nuclear weapon so that arming, launching, or releasing will start the sequence necessary to produce a nuclear detonation.

Release—The separation of a missile or gravity bomb with a nuclear warhead, for use in its intended mode of operation, from a delivery platform.

RIFL—The RIFL is a safety device that mechanically and electrically safes the "bomb" from release.

Safe/Safing—The act of placing a nuclear weapon in a state such that the receipt of the final irreversible action does not cause a nuclear detonation.

Security—Protection against loss of control, theft, or diversion of a nuclear weapon system; protection against unauthorized access; or protection against unauthorized actions, vandalism, sabotage, and malevolent damage.

Significant Nuclear Yield—The energy released through nuclear fission or fusion that is equivalent to or greater than the energy released by detonation of four pounds of TNT.

Software—Sequential instructions used to control a digital processor, or reconfigurable logic implementations.

Stockpile-To-Target Sequence—The order of events involved in removing a nuclear weapon from storage and assembling, testing, transporting, and delivering it on the authorized target. Alternatively, a document that defines the logistic and employment concepts and related physical environments involved in the delivery of a nuclear weapon from the stockpile to the authorized target. It may also define the logistic flow involved in moving nuclear weapons to and from the stockpile for quality assurance testing, modification and retrofit, and the recycling of limited life components.

Stores Management System—The portion of the aircraft system that provides weapon control, release, and monitor functions.

Support Equipment—Includes all equipment required to perform the support function, except that which is an integral part of the mission equipment. It does not include any of the equipment required to perform mission operation functions. Support equipment should be interpreted as tools, test equipment, automatic test equipment (when used in a support function), organizational, field, and depot support equipment, and related computer programs and software.

Tamper—To knowingly perform an incorrect act or unauthorized procedure involving a nuclear weapon, nuclear weapon system, or critical component.

Targeting—The process of selecting authorized targets and matching the appropriate weapon to them by taking account of operational requirements and capabilities.

Troubleshooting—The tracing and correction of faults in a mechanical or electronic system.

Two-Person Concept—Designed to ensure that a lone individual is denied access to nuclear weapons, nuclear weapon systems or critical components, never allowing the opportunity for tampering, damage, or an unauthorized act to go undetected. The two-person concept requires the presence at all times of at least two authorized persons, each certified under Personnel Reliability Assurance Program, knowledgeable in the task to be performed, familiar with applicable safety and security requirements and each capable of promptly detecting an incorrect act or improper procedure with respect to the task to be performed. Both members must have completed required nuclear weapons surety and Personnel Reliability Assurance Program training.

Two-Person Control—The close surveillance of control of materials at all times by at least two authorized persons, each capable of detecting incorrect or unauthorized procedures with respect to the task to be performed and each familiar with established security requirements

Unauthorized Launch—A deliberate launching or releasing of a nuclear missile or bomb (except jettisoning) before execution of a valid and authentic emergency war order.

Unique Signal—A digital or analog signal that operates only one specific and corresponding critical function by allowing the receiver to discriminate this signal from all other signals in the

nuclear weapon system and from those signals that may be generated accidentally or applied from outside the nuclear weapon system.

Vulnerability—The characteristics of a system that cause it to suffer a definite degradation (incapability to perform the designated mission) as a result of having been subjected to a certain level of effects in an unnatural (man-made) hostile environment.