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Safety

SAFETY DESIGN AND EVALUATION CRITERIA FOR NUCLEAR WEAPON SYSTEMS

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This manual implements Air Force Instruction (AFI) 91-101, A*ir 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 all civilian employees and uniformed members of the Regular Air Force, Air Force Reserve, and Air National Guard. Ensure all records created as a result of processes prescribed in this publication are maintained in accordance with Air Force Manual (AFMAN) 33-363, *Management of Records*, and disposed of in accordance with the Air Force Records Disposition Schedule located 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 AF Form 847, *Recommendation for Change of Publication*; route AF 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 level requirements in this publication are identified with a Tier ("T-0, T-1, T-2, T-3") number following the compliance statement. See AFI 33-360, *Publications and Forms Management*, 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. Commanders or equivalent must send a copy of the approved waiver to the OPR within 30 days of approval, for situational awareness and process improvement considerations. For Tier waiver items, send an email to the publication OPR that includes a completed AF Form 679, *Air Force Publication Compliance Item Waiver Request/Approval*, or other format with equivalent information content.

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SUMMARY OF CHANGES

This document has been substantially revised and needs to be completely reviewed. Major changes include replacement of requirements language, addition of individual chapters for each section, increased traceability, and removal of prescriptive requirements.

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Chapter 1

GENERAL INFORMATION

1.1. Responsibility and Scope.

1.1.1. Air Force activities shall apply Department of Defense (DoD) and Air Force 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. **(T-1)**.

1.1.2. Design agencies (e.g. Lockheed Martin, Northrop Grumman, Boeing, etc.) implement safety criteria from the start of weapon system development by including them in appropriate formal source documents. These documents include, but are not limited to, the program management directive, Stockpile-to-Target Sequence (STS), military characteristics, weapon system specifications, interface control document, 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 Air Force nuclear weapon systems. The Surety Standards state that:

1.1.3.1. There shall be positive measures to prevent nuclear weapons involved in accidents or incidents, or jettisoned weapons, from producing a nuclear yield (equivalent to four pounds of TNT). **(T-0)**.

1.1.3.2. There shall be positive measures to prevent *deliberate* prearming, 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. There shall be positive measures to prevent *inadvertent* prearming, arming, launching, or releasing of nuclear weapons in all normal and credible abnormal environments. **(T-0)**.

1.1.3.4. There shall be positive measures to ensure adequate security of nuclear weapons, as governed by DoD Manual (DoDM) S-5210.41, *Nuclear Weapon Security Manual*. **(T-0)**.

1.1.4. To comply with the DoD Nuclear Surety Standards, the Air Force has implemented a set of minimum design criteria for their nuclear weapon systems. Criteria contained in this manual is consistent with AFI 91-101 and the DoD Nuclear Surety Standards. These criteria do not invalidate the safety requirements in other DoD publications. Air Force nuclear safety design certification activities shall apply the most stringent requirements, as applicable, from all requirements that apply to a given nuclear surety issue (final applicability of requirements for a given certification action is documented in the signed Certification Requirements Plan in accordance with AFI 63-125, *Nuclear Certification Program*). **(T-1)**. Since the design surety 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. Air Force nuclear weapon system designers may add feasible and reasonable safety features as needed while meeting operational requirements because the Air Force goal is to incorporate maximum nuclear surety, consistent with operational requirements, from weapon system development to dismantlement. Refer to AFI 63-125 for details on the nuclear certification procedures. AFI 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. Safety Design Certification only covers weapon system designs or modifications that have an impact to nuclear surety. This means that all of the designs (hand calculations, models, simulations, analysis) are evaluated according to the four DoD Surety Standards before any fabrication of components. Air Force Safety Center, Nuclear Weapons 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, only that the design of the weapon and weapon system does not exceed the limitations of the STS. Test equipment used to perform Operational Certification and identified as requiring Nuclear Safety Design Certification per AFI 91-101 shall comply with all applicable General, Electrical, Hazard Prevention, and Test Equipment requirements of this manual. **(T-1)**.

1.2. Non-Compliance with Criteria. If the design of an Air Force nuclear weapon system does not meet the requirements contained in this manual, a deviation shall be requested according to the requirements of AFI 91-101. **(T-1)**. Exceptions to this manual, as evidenced by current and older designs, do not constitute a precedent to deviate from the criteria. However, if the design does not meet requirements of this manual and the risk acceptance authority accepts the risk, in accordance with AFI 91-101 paragraph 1.5, designers are exempt from meeting the respective requirement(s).

1.3. Standards and Guidance. All documents cited within this AFMAN must 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.

1.3.1. Existing operational systems are not required to be modified solely to meet enhanced safety criteria implemented after the system became operational. However, if an existing system is modified, the system shall meet new requirements as necessary per this AFMAN and applicable 91-series instructions. **(T-1)**. If the design of a modified system is not expected to meet the requirements in this manual, a deviation shall be obtained per Chapter 8 of AFI 91-101. **(T-1).**

1.3.2. The Air Force or the DoD may prohibit or restrict operational use of a nuclear weapon system if the minimum safety criteria are not satisfied.

1.4. Criteria Administratively Certified Non-Specialized Commercial-Off-The-Shelf Equipment and other Agency Items. The following are considered to be nuclear safety design certified, and therefore do not require separate Air Force Nuclear Safety Design Certification actions provided the item is in its original unmodified condition and is used in its intended operating environment in accordance with approved technical data. Modifications to non-specialized equipment that could impact the item's primary structure, electrical and hydraulic power systems, load-bearing capacity, steering and braking capability, software, or positive control features, as well as any changes resulting in noncompliance with specific design criteria in this manual must be approved by AFSEC/SEW. **(T-1)**.

1.4.1. Restraints. Tiedown chains and cables, straps, and adjusters used for restraint during transportation so long as they comply with other Air Force transportation restraint standards.

1.4.2. Commercial Vehicles.

1.4.2.1. Outside the Continental United States commercial vehicles that comply with all relevant and current European community standards. The vehicle must be compatible with nuclear certified semi-trailers. N1 and N2, per European Community Directive 70/156/EEC Annex II, are examples of European Community standards.

1.4.2.2. Truck Tractor.

1.4.2.2.1. Truck tractors (Class 3 or above) that comply with all relevant and current industry standards.

1.4.2.2.2. Vehicles modified for alternative fuels, in accordance with Technical Order 36A-1-1341, *Compressed Natural Gas And Alternative Fuel For Vehicular (Engine Combusted) Propulsion*, and Technical Order 36A-1-1331, *Propane Gas Conversion Guide for Vehicular Equipment*, if they were certified in their unmodified state.

1.4.2.3. Semi-trailers. Non-specialized semi-trailers with fixed axles, fixed gooseneck, and single deck surface (no protrusions) when they are in original unmodified condition and meet all relevant and current industry standards. **Note:** The addition of a certified item to an uncertified trailer does not certify that trailer. To have a certified unit, both the trailer and the modification kit are required to be separately certified.

1.4.3. Items that Do Not Require Nuclear Safety Design Certification.

1.4.3.1. General purpose hand tools, such as pliers, wrenches, and screwdrivers.

1.4.3.2. Depot and intermediate-level test equipment, if the critical circuits of the tested items are verified at the organizational level before use with nuclear weapons.

1.4.3.3. Common, multipurpose, and non-specialized test equipment, such as multimeters, decade resistance boxes, and impedance bridges unless the equipment directly interfaces with nuclear weapons or end items that are nuclear safety design certified.

1.4.3.4. All Air Force equipment designed and used for proficiency training, such as full-scale and miniature practice delivery bombs and bomb dispensers, practice loading bombs and warheads, training re-entry vehicles and payload sections, explosive ordnance disposal disassembly/reassembly training equipment.

1.4.3.5. Items listed in the General Guidance section of the *Master Nuclear Certification List* (MNCL) as having blanket certification, provided they are in original, unmodified condition and used for their intended purpose. The MNCL can be found by contacting the Air Force Nuclear Weapon Center, Certification Management Division (AFNWC/NTS).

1.4.3.6. Any equipment used with nuclear weapons, but not specifically designed for that purpose, is considered non-specialized equipment, specifically, items listed in **paragraph 1.4.1** through **1.4.3**. Certain modifications to non-specialized equipment do not require formal Nuclear Safety Design Certification. These modifications include common add-on equipment such as fire extinguishers, radios, lights, bedliners, camper shells, sirens, or foreign object damage magnets or containers.

1.4.3.7. The following process should be used by the field unit to determine the appropriate course of action for evaluation and local approval of minor field-level modifications:

1.4.3.7.1. Identify item(s) to be modified, and provide a complete description of the proposed changes to the item maintenance supervisor/superintendent (or equivalent)

and the wing safety office (or any geographically separated units that function as a wing. These offices will jointly review the proposed modification to determine if approval can be granted at the unit level or if further evaluation of the nuclear safety impact is necessary. **(T-1)**.

1.4.3.7.1.1. If there is no impact to nuclear surety, approve the modification locally.

1.4.3.7.1.2. If further evaluation is required, submit a formal request for evaluation/approval from the using MAJCOM safety office.

1.4.3.7.2. If formal Nuclear Safety Design Certification is not required, the using MAJCOM will:

1.4.3.7.2.1. Provide formal approval to the field unit.

1.4.3.7.2.2. Inform the Program Manager (PM) and AFSEC/SEW of the approved modification.

1.4.3.7.3. If the modification requires formal Nuclear Safety Design Certification, the using MAJCOM will:

1.4.3.7.3.1. Notify the submitter that further evaluation is necessary.

1.4.3.7.3.2. Follow the process specified in AFI 91-101.

1.4.3.8. For all non-specialized equipment (including foreign manufactured, United States, or host nation owned), the host nation as PM shall submit certification documentation through Air Force Nuclear Weapons Center Engineering Liaison Office, which will serve as the interface between the host nation and the United States on all nuclear safety certification processes and issues. **(T-1)**.

1.4.4. Department of Energy Qualified Equipment. Department of Energy-qualified test, handling, and support equipment provided by Department of Energy to the Air Force for use with nuclear weapons or nuclear weapons systems, provided the equipment is used on other Department of Energy qualified equipment, as outlined in approved Joint Nuclear Weapons Publication System publications, special procedures, or authorized unsatisfactory reports responses.

1.5. Weapon Design. Any weapon system shall be designed to enable verification of all applicable design requirements. **(T-1)**. An evaluator should be able to verify compliance with all requirements.

1.6. Terms and Definitions. All relevant terms and definitions for the 91-series Air Force publications are located in the Glossary of AFI 91-101.

1.7. Roles and Responsibilities.

1.7.1. Assistant Secretary of the Air Force for Acquisition, Technology and Logistics (SAF/AQ) shall assign a PM for nuclear certified items. **(T-0)**.

1.7.2. PMs through the System Program Office shall be ultimately responsible for meeting all applicable requirements in this manual, as determined by AFSEC/SEWN. **(T-1)**.

1.7.3. Development Organizations shall:

1.7.3.1. Comply with the requirements in this manual when developing new hardware for nuclear certified items. **(T-1)**.

1.7.3.2. Provide documentation of compliance with the requirements in this manual to the PM. **(T-1)**.

1.7.4. AFSEC/SEWN shall:

1.7.4.1. Determine applicability of requirements in this manual. **(T-1)**.

1.7.4.2. Approve documents provided by the PM, as required by this manual. **(T-1)**.

Chapter 2

GENERAL DESIGN PHILOSOPHY

2.1. Nuclear Weapons System Safety Design Philosophy. Air Force nuclear weapons designers and evaluators implement nuclear critical function controls, providing positive measures to uphold the DoD Surety Standards.

2.2. Nuclear Critical Function Control Concepts. Criteria for adequately controlling critical functions depend on the specific nuclear safety design concept of the weapon system. Older nuclear weapons and weapon systems use either the Energy Control Concept or the Information Control Concept. Many currently deployed systems use the Information Control Concept or a combination of both concepts.

2.2.1. The Energy Control Concept involves limiting the entry of threat energy into the weapon system devices that control the operation of the critical functions. Critical functions are designed to require functional energy signal(s) for operation. Reliability requires that the weapon system respond as intended when the functional energy signal(s) are present at the weapon interface. Therefore, safety levels of weapon systems using this design concept depend on the safety controls that block application of those functional energy signal(s) to the weapon interface until the controls are properly removed.

2.2.2. Critical prearm functions are commanded by a unique signal that provides indication of an unambiguous human intent to detonate the weapon. Safety levels depend upon the uniqueness of a carefully designed sequence of bi-valued events and are evaluated based on the assumptions of worst-case power levels. Worst-case power levels involve temporal patterns of energy type(s) and level(s) needed to transmit bi-valued events which can be discriminated by the strong link and can lead to an unintended establishment of the transmission path through the strong link barrier that allows passage of either functional or threat energy.

Chapter 3

GENERAL DESIGN

3.1. Physical and Internal Security.

3.1.1. The weapon system fixed infrastructure shall incorporate a physical security system that prevents access to nuclear weapons and protects nuclear weapons system equipment and secure data. **(T-1)**.

3.1.2. The weapon system design shall incorporate internal security features to prevent unauthorized use. **(T-1)**.

3.2. Reversible Operations. The operation of devices for authorization, bomb prearming, rocket motor propulsion system ignition arming, and weapon release system unlocking functions shall be reversible. **(T-1)**.

3.3. Material Compatibility. The weapon system shall incorporate chemical compatibility with its operational environment as specified in the STS (e.g. fire-fighting chemicals, safety subsystems, electrochemical corrosion, internal compatibility). **(T-1)**.

3.4. Nuclear Critical Function Design.

3.4.1. The weapon system design shall prevent a failure or accidental operation of a single component resulting in the authorization of a nuclear weapons system or prearming, launching, releasing, or arming of a nuclear weapon as outlined in **Table 3.1**. **(T-1)**.

3.4.2. Prior to the initiation of authorized nuclear actions, the weapon system design shall ensure that no two independent human errors or unauthorized acts will result in the authorization of a nuclear weapons system or prearming, launching, releasing, or arming of a nuclear weapon. **(T-1)**.

3.5. Nuclear Critical Functions.

3.5.1. Authorization.

3.5.1.1. The weapon system shall incorporate one or more features to control authorization to use the weapon. **(T-1).** Examples of these controls are the enable device in the Minuteman weapon system and the permissive action link in many nuclear bombs.

3.5.1.2. The feature(s) shall prevent attempts to prearm and/or arm a nuclear bomb or warhead in aircraft-carried weapons and launch of a ground-launched missile until the weapon system receives authorization to employ the weapon through the command and control system. **(T-1)**.

3.5.1.3. Operate on the Information Control Concept.

3.5.1.3.1. The feature(s) shall operate on the Information Control Concept with the information provided, securely, through command and control channels. **(T-1)**.

3.5.1.3.2. The feature(s) shall meet the numerical requirements specified in **Table 3.1**. **(T-1)**.

3.5.1.4. The feature(s) shall protect against unauthorized use or bypass of, the device(s). **(T-1)**.

3.5.1.5. The feature(s) shall allow a safing or relocking function, regardless of the state of the device(s), as long as the weapon has not been released or launched. **(T-1)**.

3.5.1.6. The feature(s) shall prevent inadvertent data entry into the device(s). **(T-1)**.

3.5.1.7. The feature(s) shall reveal any attack on or bypass of the device(s), for local and/or remote monitoring, with an indicator. **(T-1)**.

3.5.1.8. The indication shall be latching (remain actuated until reset by authorized personnel). This will prevent an attacker from attempting to reset the latch. **(T-1)**.

3.5.2. Prearming.

3.5.2.1. Access to the prearming function shall require unambiguous human intent through nuclear consent. **(T-1)**.

3.5.2.2. The weapon system design shall exclusively utilize a unique prearming signal. **(T-1)**.

3.5.2.3. The weapon system design shall send a prearm command signal that provides an unambiguous indication of human intent. **(T-1)**.

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

3.5.2.5. The weapon system design shall prevent circumvention of prearming. **(T-1)**.

3.5.2.6. For weapons whose design is based on the Information Control Concept:

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

3.5.2.6.2. Unique Signal Generator.

3.5.2.6.2.1. The information needed to generate the unique signal shall be physically unavailable (e.g. not stored in memory prior to prearming) to the unique signal generator until required for use. **(T-1)**.

3.5.2.6.2.2. The information from the unique signal shall be erased following the completion of the signal transmission. **(T-1)**.

3.5.3. Launching (Weapon Systems Incorporating Rocket Motors).

3.5.3.1. The missile weapon system shall operate control of launch of a rocket motor propulsion system through two independent functions, either the ignition system arm or safe command: **(T-1)**.

3.5.3.2. The weapon system shall prevent unintended (including failures) ignition. **(T-1)**.

3.5.3.3. For the rocket motor arm command, the propulsion system ignition shall not occur without the arm command signal even if the system sends the ignition command signal. **(T-1)**.

3.5.4. Releasing.

3.5.4.1. Access to the release function shall require unambiguous human intent through nuclear consent. **(T-1)**.

3.5.4.2. The release system for aircraft-carried weapons shall operate through two independent functions, the unlock command and the release command: **(T-1)**.

3.5.4.3. The weapon system shall not separate the weapon from the combat delivery aircraft without the unlock command signal, even if the system sends (including accidentally) the release command signal. See Rule 5 of **Table 3.1**. **(T-1)**.

3.5.4.4. For aircraft-delivered guided weapons, the weapon system shall prevent employment of a nuclear weapon against anything other than authorized targets. **(T-1)**.

3.5.4.5. The release system unlock function shall be separate and independent from the release function and other Aircraft Monitor and Control (AMAC) signals. **(T-1)**.

3.5.5. Arming.

3.5.5.1. The weapon shall prevent unauthorized bypass of the arming system. **(T-1)**.

3.5.5.2. If the weapon is an aircraft-carried missile or a guided bomb, the weapon system design shall include a proper transfer alignment signal as a verification of the proper release environment. **(T-1)**.

3.5.5.3. The weapon system shall require a positive indication of complete weapon separation from the aircraft or the Launch facility. **(T-1)**.

3.5.5.4. The weapon system design shall prevent erroneous transmission of the good transfer alignment signal. **(T-1)**.

3.5.6. Navigation Validation.

3.5.6.1. Prior to termination of guided flight or initiation of detonation, the navigation solution shall be validated to ensure that weapon kinematics will deliver the weapon to an authorized target. **(T-1)**.

3.5.6.2. If the navigation cannot be validated, the weapon shall inhibit a nuclear yield. **(T-1)**.

3.5.6.3. Guided bombs shall receive the navigation validation signal from the guidance and control unit after release occurs but before arming can occur. **(T-1)**.

3.5.6.4. The signal shall be withheld if the bomb cannot be guided to detonate within specified target boundaries. **(T-1)**.

3.6. Nuclear Critical Function Numerical Requirements. The weapons system design shall comply with Rule 6 of **Table 3.1**. **(T-1)**.

3.6.1. Every piece of nuclear certified equipment that interfaces with a critical function shall demonstrate compliance with the numerical probability requirements located in **Table 3.1**. **(T-1)**.

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

3.6.3. For credible abnormal environments listed in the STS, the weapon system design shall incorporate positive safety features into the design of combat delivery vehicles to protect against inadvertent nuclear critical function activation. **(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 weapons 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 Arming and Fuzing 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 good transfer alignment signal/navigation validation signal	1×10^{-3} per missile
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 safety features 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, but before release of reentry vehicles.

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

RULE	A	B
	The probability of obtaining a nuclear yield is less than…	in the absence of…
1	1×10^{-9} per weapon over the stockpile lifetime.	bomb or warhead-unique prearming, environment or trajectory 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 environmental stimuli.
Note: The Air Force defines an "event" as the application of a prearm command and deliberate deployment (weapon launch or release).		

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

3.6.5. Safe and Arm and Arm/Disarm Devices.

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

3.6.5.2. The safing signal shall differ from the arming signal. **(T-1)**.

3.6.6. Monitor Signal.

3.6.6.1. If a monitor signal is used, it shall be different from the arming signal. **(T-1)**.

3.6.6.2. The weapon state status shall have the capability to be monitored at any point in the STS up to release or launch. **(T-1)**.

3.6.6.3. The weapon system shall provide a notification of the state of the weapon and any change in state of any safety system activation of any critical signal to the operator and maintainer, as applicable. **(T-1)**. This requirement applies when the weapon is powered.

3.6.7. Specialized commercial-off-the-shelf items that are used or integrated as part of a higher level assembly shall meet the same certification requirements as the higher assembly. **(T-1)**.

Chapter 4

ELECTRICAL DESIGN

4.1. Isolation.

4.1.1. Any 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 or cable shields shall not be used as current-carrying conductors. **(T-1)**.

4.1.3. Wire and cable shields shall be covered with an insulation layer. **(T-1)**.

4.1.4. Electro-explosive circuitry that interfaces with nuclear critical functions shall be hazards of electromagnetic radiation to ordnance safe in accordance with **paragraph 5.2**. **(T-1)**.

4.1.5. Both the AMAC and release systems utilizing the Energy Control Concept shall not share an electrical connector with non-nuclear functions. **(T-1)**.

4.1.6. For circuits that use the Energy Control Concept, the electrical design shall provide engineered solution(s) to prevent unintentional application of compatible energy in normal and credible abnormal environments. **(T-1)**.

4.2. Switching.

4.2.1. The electrical design shall switch the supply side of switchable circuits. **(T-1)**.

4.2.2. For critical circuits, the electrical design shall switch both the supply and return sides of switchable circuits. **(T-1)**.

4.3. Wiring and Cabling.

4.3.1. Electrical wiring shall be installed and secured in accordance with applicable standards to prevent vibration and chafing. **(T-1)**.

4.3.2. Shields.

4.3.2.1. Cable shields shall terminate at a connector backshell that provides for 360 degree peripheral bonding. **(T-1)**.

4.3.2.2. Connector backshells shall have conductive finishes in order to minimize shield termination impedance. **(T-1)**.

4.3.2.3. When shielded wires and cables are contained within an overall cable shield and terminate with pigtails, cable shield pigtails shall not exceed 6 inches. **(T-1)**.

4.3.3. Grounds.

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

4.3.3.2. Ground wire gauge or shield braid gauge shall allow the largest current expected during system operation or credible failure. **(T-1)**.

4.3.4. Except for weapon and warhead interface connectors, electrical power wiring shall end in female connectors at the power source side. **(T-1)**.

4.3.5. Nuclear critical circuit wiring shall have a mechanical support, to act as a strain relief, at the entry point into the electrical connector. **(T-1)**.

4.4. Electrical Connector. For nuclear weapon circuits, the connector design shall conform to Military Detail Specification 38999-XX series connectors. This requirement does not apply to electrical connectors used within a Line Replaceable Unit. **(T-1)**.

4.5. Alignment and Mating.

4.5.1. Connectors shall prevent misalignment of connector components and bent pins during mating. **(T-1)**.

4.5.2. Connectors shall be compatible with their intended connection only and incompatible with other accessible connectors. **(T-1)**.

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

4.5.4. Connectors shall only use one wire for each pin. **(T-1).**

4.5.5. Connector pin mapping shall prevent any bent pin(s) from resulting in the inadvertent activation of a critical function. **(T-1)**.

4.6. Sealing.

4.6.1. Connectors shall be sealed from the operational environment. **(T-1)**.

4.6.2. If used, potting compounds shall not revert over the life of the system in its intended environment. **(T-1)**.

4.7. Mandated Use Isolation Exception. Multiple circuits within a single connector shall meet the isolation requirements in **paragraph 4.1**. **(T-1)**.

4.8. Critical Electrical Circuit Isolation. Nuclear critical circuits shall be isolated from lines carrying liquids such as coolant solutions, fuels, or hydraulic fluids. **(T-1)**.

4.9. Electrical Current Considerations.

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

4.9.2. For any system using the Information Control Concept, the weapon 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. Electromagnetic Environmental Effects. Each system shall be electromagnetically compatible among all subsystems and equipment within the system and with environments caused by emitters and other electromagnetic sources external to the system. **(T-1)**. Electromagnetic environmental effects encompasses hazards of electromagnetic radiation to ordnance, electromagnetic interference/electromagnetic vulnerability, electrostatic discharge, electromagnetic pulse, and lightning. See Military Standard (MIL-STD)-464C, *Electromagnetic Environmental Effects Requirements for Systems,* for specific requirements.

5.2. Hazards of Electromagnetic Radiation to Ordnance.

5.2.1. The design shall provide hazards of electromagnetic radiation to ordnance margins as defined in MIL-STD-464C and AFI 91-208, *Hazards of Electromagnetic Radiation to Ordinance Certification and Management*, to potentially sensitive components, including electrically-initiated devices, e.g., electro-explosive devices; firing circuit components, such as semiconductors and integrated circuits, and Safe and Arm circuits, in both powered-on and powered-off states throughout the STS. **(T-1)**.

5.2.2. For intercontinental ballistic missile systems exposed to the electromagnetic radiation levels specified in the applicable Hazards of Electromagnetic Radiation to Ordnance table in MIL-STD-464C, 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. Electromagnetic Interference. Active (powered) ordnance circuits, firing circuits, and other circuits controlling or otherwise impacting critical signals or safety subsystems shall be protected against inadvertent upset/degradation from external electromagnetic environments and emissions from circuits contained within the ordnance in accordance with MIL-STD-461G, *Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment*. **(T-1)**.

5.4. Electrostatic Discharge.

5.4.1. The 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 to avoid inadvertent detonation and to prevent damage to electronics. Use MIL-STD-1686C, *Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment (Excluding Electrically Explosive Devices),* for reference. **(T-1)**.

5.4.2. For weapon systems capable of in-flight refueling, the 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)**.

5.5. Electromagnetic Pulse.

5.5.1. Critical signals and safety subsystems shall function as designed after they are subjected to the electromagnetic pulse environment specific to the weapon system. In the absence of a

system-specific electromagnetic pulse environment, use the environment as defined in MIL-STD-2169B, *High-Altitude Electromagnetic Pulse Environment*. **(T-1)**.

5.5.2. The weapon system shall remain safe during and after experiencing both direct and near strikes. See MIL-STD-464C for applicable direct and near strike lightning environments. **(T-1)**.

Chapter 6

ARMING AND FUZING SYSTEMS

6.1. System Devices.

6.1.1. The Arming and Fuzing system shall provide a unique prearming signal to activate the strong link prearm device in the warhead or nuclear bomb. **(T-1)**.

6.1.2. The prearm signal shall be initiated only from human intent. **(T-1)**.

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

6.1.4. The Arming and Fuzing system design shall include an Environmental or Trajectory Sensing Device. **(T-1)**.

6.1.5. Include a launch or release sensing device that shall prevent power from being applied to the Arming and Fuzing system or applicable components within the system until a weapon launch or release is detected. **(T-1)**.

6.2. System Design Features.

6.2.1. Include protective features in the Arming and Fuzing system that shall prevent prearming and arming in all credible abnormal environments specified in the STS and in the applicable weapon system specifications. **(T-1)**.

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

6.2.3. A nondestructive test environment such as x-ray, ultrasonic, and magnetic shall not degrade the nuclear safety of the device. **(T-1)**.

Chapter 7

GROUND-LAUNCHED MISSILE SYSTEMS

7.1. Launch Control System.

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

7.1.2. No other system or subsystem shall: **(T-1)**.

7.1.2.1. Authorize a missile launch.

7.1.2.2. Start a launch sequence.

7.1.2.3. Launch a missile.

7.1.2.4. Initiate the propulsion system.

7.1.3. The missile system shall provide the capability to detect and resist tampering with the launch control functions. **(T-1)**.

7.1.3.1. All Launch Control Points (LCP) shall receive a continuous indication, both visually and audibly, when an attempt is made to operate the Launch Control system. This requirement does not apply to the Airborne Launch Control System. **(T-1)**.

7.1.3.2. The indications shall remain until the system operators reset them. **(T-1)**.

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

7.1.5. The arm (operate) and safe (off) critical command signal functions shall not be complementary functions. In other words, the absence of the "arm" signal shall not be construed as the "safe" signal or vice versa. **(T-1)**.

7.2. Propulsion System Ignition Protection.

7.2.1. The ignition system design shall include a Safe and Arm or Arm/Disarm device (or equivalent device) to prevent unintended ignition. **(T-1)**.

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

7.2.3. The unique arming signal shall not be generated within the missile. **(T-1)**.

7.2.4. The ignition protection device shall have electrical and mechanical means for safing. **(T-1)**.

7.2.5. The ignition system shall require the generated unique arming signal to perform a physical or electrical action that is compliant with Rule 3 in **Table 3.1**. **(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 processing of critical signals in the warhead 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, the weapon system design shall: **(T-1).**

7.4.1. Automatically attempt to safe the weapon.

7.4.2. Automatically remove power to the weapon.

7.5. Command and Control Communications.

7.5.1. LCPs.

7.5.1.1. Prior to receipt of an Emergency Action Message, the weapon system shall not contain the information provided by the Emergency Action Message. **(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 Air Force or other branches of the military. **(T-1)**.

7.5.2. LCPs to Launch Point Communications.

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

7.5.2.2. The primary LCPs and at least one other location shall monitor the critical launch point status. **(T-1)**.

7.5.2.3. Each LCP shall be able to inhibit action in the event an unauthorized critical signal is issued. **(T-1)**.

7.5.2.4. The system shall be designed to preclude transmission of the authorization or 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 cryptographic codes. **(T-1)**.

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

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

7.5.3.4. The weapon system shall not store the prearm/authorization and launch signals in a directly usable form within the weapon system. **(T-1)**.

7.5.3.5. For any device operated by the secure code, the design shall comply with the following: **(T-1).**

7.5.3.5.1. Allow only a limited number of attempts at operation using incorrect codes.

7.5.3.5.2. The system design shall include a means to detect tampering.

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 weapon and lock the release system. **(T-1)**.

8.2. Nuclear Weapon Suspension and Release Systems.

8.2.1. The suspension and release systems designs shall comply with Rules 4 and 5 from **Table 3.1**. **(T-1)**.

8.2.2. Suspension Lock Monitor. The locked condition shall be determined electrically while the aircraft is on the ground or during flight. **(T-1)**.

8.2.3. The aircraft system shall include a Reversible In-Flight Lock (RIFL) that incorporates the following requirements: **(T-1)**.

8.2.3.1. The RIFL shall mechanically prevent weapon release, when locked, even if the maximum releasing force is generated and transmitted to the release system.

8.2.3.2. The RIFL and its control shall be independent of the release system and the electrical connections to the weapon.

8.2.3.3. Mechanically restrain the releasing device.

8.2.3.4. The outcome of the primary failure mode of the RIFL is to revert to the locked state.

8.2.3.5. The RIFL shall be observable, visually, to ground personnel via an unmistakable indication of the locked state.

8.2.3.6. Unlocking of the RIFL shall require two separate and independent human actions.

8.2.3.7. The aircrew RIFL controls shall incorporate a means for tamper indication.

8.2.3.8. The Stores Management System shall notify the aircrew with a remote indication, visually and/or audibly, of unknown or uncommanded RIFL states.

8.2.3.9. Indications shall only be given if the position is completely locked or completely unlocked.

8.2.3.10. If the release system utilized independently actuated retention hooks, each hook shall require a RIFL.

8.2.3.11. The RIFL shall relock if unlock power is removed while the RIFL is unlocked.

8.2.3.12. A RIFL fault shall be unable to cause a release.

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

8.2.5. Energy control signals for the RIFL and release system shall be isolated both physically and electrically. **(T-1).**

8.2.6. The aircraft shall provide the aircrew with a positive confirmation that the weapon has completely separated from the aircraft. **(T-1)**.

8.3. Nuclear System Controls and Displays.

8.3.1. Each weapon shall be addressable 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 and inhibit release until prearm consent is reestablished through aircraft and aircrew procedures. **(T-1)**.

8.3.4. The prearm consent control shall provide indication of unauthorized operation or tampering. **(T-1)**.

8.3.5. For System 1 weapons (Non MIL-STD-1760E, *Aircraft/Store Electrical Interconnection System*), the prearm consent function shall be a hardwired control that interrupts power to the prearm circuit controlling the intent strong link. **(T-1)**.

8.3.6. Release and Launch Controls.

8.3.6.1. The aircraft shall unlock the RIFL only when nuclear consent is active. **(T-1)**.

8.3.6.2. At the time of release, nuclear consent shall be present. **(T-1)**.

8.3.6.3. The RIFL shall relock upon removal of nuclear consent. **(T-1)**.

8.3.6.4. Aircraft designed to release multiple nuclear weapons shall require an unambiguous, non-latching human intent at the time of release per target. If the human intent is provided after reaching a control point or region, the intent may be latched. **(T-1)**.

8.3.6.5. The jettison sequence for a nuclear weapon shall attempt to automatically safe the weapon before jettison. **(T-1)**.

8.4. Multi-Crew Aircraft Consent Functions.

8.4.1. Multi-crew aircraft AMAC and release systems shall require separate controls for nuclear consent. **(T-1)**.

8.4.2. Each consent control shall require physical separation and independent action of individual aircrew members for activation. **(T-1)**.

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 Cautions. The aircraft shall send an alert and/or indication to the aircrew for the following events (when power is applied): **(T-1)**.

8.5.1. Unlocking of, or an unlock signal going to, the RIFL when normal operation of controls has not commanded unlocking.

8.5.2. Prearming of a weapon when normal operation of controls has not commanded prearming.

8.5.3. When the safe state of the weapon cannot be positively determined. The weapon system is not required to provide a caution during normal transition through an intermediate state from a known state to a commanded state.

8.5.4. Release of, or a release signal being sent to, the release system when normal operation of controls has not commanded release.

8.6. Interface Unit and Weapon Power Control. Control of power to interface units and weapon interfaces shall require these actions and controls: **(T-1)**.

8.6.1. For systems that utilize the Energy Control Concept:

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

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

8.6.2. For systems that utilize the Energy Control or Information Control Concept:

8.6.2.1. Positive action to supply power at the weapon interface.

8.6.2.2. Separate control that removes power from the weapon interface.

8.7. Multiplexed Systems.

8.7.1. All hardwired discrete signals in the multiplexed AMAC system shall meet the requirements of a system built entirely with discretes. **(T-1)**.

8.7.2. Unauthorized weapon stations transmitting or receiving data shall be ignored by the weapon. **(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 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-tenth 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 protection, electrical subsystems, and Arming and Fuzing systems shall apply to the missile or Air Force-owned guided bomb components. The following criteria also apply: **(T-1)**.

9.2. Safe and Arm and Arm/Disarm Devices.

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

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

Chapter 10

TEST EQUIPMENT

10.1. General Criteria. Apply the design criteria in this section to test equipment used to verify the proper operation, safe state, and control of nuclear critical functions.

10.2. Fail-Safe.

10.2.1. The test equipment design shall prevent faults within the test equipment or test circuits that could operate nuclear critical functions. **(T-1)**.

10.2.2. The test equipment design shall not present voltages or currents to the unit under test that are in excess of the interface specifications. **(T-1)**.

10.2.3. The test equipment design shall not operate or fire 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 weapon system component that was operated during testing shall be in a safe state. **(T-1)**.

10.3.2. The test system 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 design and safety requirements that apply to nuclear weapon systems. **(T-1).**

10.4.2. With nuclear weapons attached, built-in test equipment shall not operate any nuclear critical function nor energize any nuclear critical circuit such as the RIFL. **(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 is capable of properly verifying systems that handle critical functions. **(T-1)**.

10.5.2. Test equipment shall not generate radiated emissions that exceed the applicable weapon STS when weapons are present as outlined in AFI 91-208 and MIL-STD-461G. **(T-1)**.

Chapter 11

MAINTENANCE AND STORAGE FACILITIES

11.1. Criteria Applicability. Apply the criteria in this section to new and existing United States-owned facilities or other associated nuclear weapon system infrastructure with facility-like characteristics where nuclear weapons are maintained, stored, or placed on alert at times other than during heightened states of readiness. Applicable criteria from this chapter must be tailored to the specific application as documented in the Certification Requirements Plan. Design criteria need not be applied to weapon transient areas or areas the weapon will not reside (for example loading docks and administrative areas). The following design criteria shall be used to nuclear safety design certify nuclear weapons maintenance and/or storage facilities and other nuclear weapon system infrastructure to include existing facilities where the mission has changed to include nuclear weapons. **(T-1)**.

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

11.3. New Facilities and Facility Modifications. Any new facility or any proposed, planned, required, or upgrade modification to an existing facility, essential facility system, or other associated infrastructure, as defined by AFSEC/SEWN, shall require Nuclear Safety Design Certification in accordance with AFI 91-101 and AFI 63-125. **(T-1)**.

11.4. Hazards Analyses.

11.4.1. Documented hazards analyses shall be used to determine the underlying design basis for facility and essential facility system designs. **(T-1)**.

11.4.2. At a minimum, a hazards analysis shall be performed for the following systems: **(T-1)**.

11.4.2.1. The fire protection system.

11.4.2.2. Nuclear criticality safety.

11.4.2.3. Radiation safety.

11.4.2.4. Explosives Safety.

11.4.2.5. Chemical safety.

11.4.2.6. Natural phenomena hazards mitigation.

11.4.3. Where Essential Facility Systems or Systems Important to Nuclear Safety require operation of a component to perform an intended safety design function, that function shall be designed to operate automatically (without manual intervention), to include the transfer from normal (offsite) power supply to emergency power supply. **(T-1)**.

11.5. Essential Facility Systems. Facility systems and sub-systems that are determined to affect the four DoD Surety Standards directly are "Essential Facility Systems."

11.5.1. Lightning Protection Systems. A lightning protection system shall be provided. **(T-1)**.

11.5.2. The design of the lightning protection system shall prevent or significantly mitigate the introduction of uncontrolled electrical energy to any nuclear weapon or nuclear weapons system. **(T-1)**.

11.5.3. Electrical Power Systems.

11.5.3.1. An electrical power system shall be provided for all surety related systems and subsystems that require electrical power. **(T-1)**.

11.5.3.2. The design of the electrical power system shall include permanently installed backup power generation. **(T-1)**.

11.5.4. Fire Protection Systems.

11.5.4.1. A National Fire Protection Agency-compliant fire protection system shall be provided. **(T-1)**.

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

11.5.5. Security Systems.

11.5.5.1. The design of security systems shall ensure unauthorized or unintended access to a nuclear weapons system is prevented. **(T-1)**.

11.5.5.2. The design of security systems shall also be compatible with nuclear weapon systems (e.g., electromagnetic environment). **(T-1)**.

11.5.6. Blast Containment Systems.

11.5.6.1. A blast containment system shall be provided for the weapon maintenance and storage areas. **(T-1)**.

11.5.6.2. The design of blast containment systems shall significantly minimize the potential for a sympathetic detonation of another energy source (e.g., another nuclear weapons system, conventional weapon system, fuel) or breach of a designated blast area. **(T-1)**.

11.5.7. Facility Structures.

11.5.7.1. The design of facility structures shall ensure that security plan requirements are met (e.g., outer wall thickness). **(T-1)**.

11.5.7.2. The design of facility structural supports for lifting devices shall be considered part of the lifting devices for certification. **(T-1)**.

11.6. Systems Important to Nuclear Safety. Facility systems and sub-systems that are determined to be impacted by the requirements of AFPD 91-1, *Nuclear Weapons and Systems Surety*, concerning the ability to prevent or mitigate the spread of radiological material, are "Systems Important to Nuclear Safety."

11.6.1. Radiological Contaminant Isolation System.

11.6.1.1. A radiological contaminant isolation system shall be provided. **(T-1)**.

11.6.1.2. The radiological contaminant isolation system shall provide positive measures to control the spread of radiological contamination to facility areas outside of the event area and to the public. **(T-1)**.

11.6.2. Radiological Monitoring System.

11.6.2.1. A radiological monitoring system shall be provided. **(T-1)**.

11.6.2.2. The radiological monitoring systems shall provide input to other facility systems (e.g., isolation, ventilation) and base emergency response personnel to prevent the spread of radiological contamination to facility areas outside of an event area and to the public. **(T-1)**.

11.6.3. Ventilation System

11.6.3.1. A facility ventilation system(s) shall be provided. **(T-1)**.

11.6.3.2. The ventilation system(s) shall support radiological contaminant isolation system design. **(T-1)**.

11.7. Nuclear Weapons Maintenance and Storage Facilities Design Features/Programs.

11.7.1. The design of a facility shall ensure compliance with AFI 91-208. **(T-1)**.

11.7.2. Facility areas designated for nuclear weapons system maintenance activities shall be designed to accommodate side flash protection policy as directed in AFMAN 91-201, *Explosives Safety Standards*. **(T-1)**.

11.7.3. Programs that are determined to be impacted by the four surety standards or requirements of AFPD 91-1, concerning the ability to prevent or mitigate the spread of radiological material not currently identified in this manual, shall be reviewed to determine if surety certification is required. **(T-1)**.

Chapter 12

NONCOMBAT DELIVERY VEHICLES AND SUPPORT EQUIPMENT

12.1. Criteria Applicability. Apply the criteria in this section to noncombat delivery vehicles and equipment used to transport, store, structurally support, and load/unload nuclear weapons and nuclear weapon systems. **(T-1)**.

12.2. General Design.

12.2.1. Commercial United States design standards (e.g. American National Standards Institute standards 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. Any updates to United States or European standards used for certification shall require review by the process owners to ensure there are no significant changes that would invalidate their nuclear certification. **(T-0)**.

12.2.2. Where commercial equipment is not specifically designed to accommodate a safety factor of three (3) against plastic deformation (i.e., yield strength) for load lifting, it is acceptable to procure equipment with a higher designed capacity and then de-rate the equipment such that there is an inherent safety factor of three (3); this shall be documented and noted in the MNCL. **(T-1)**.

12.3. Handling Equipment General Requirements.

12.3.1. All equipment designs shall use industrial standards that apply to the equipment and the application for which the equipment is being designed. **(T-1)**.

12.3.2. The industry standard shall be presented in the Certification Requirements Plan with justification. **(T-1)**.

12.3.3. As an alternative, the equipment may be designed using the following probability criteria: The requirement for the probability of failure of the design is less than 1×10^{-6}. This applies to the entire lifetime of the proposed equipment.

12.4. Structural Load Design Requirements. The rated load shall be based on the combination of load forces the basic equipment must support or resist in a static state and the planned operational use. **(T-1)**.

12.5. Stress Levels. 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. In cases where the standards specify both an average and a minimum stress, use the minimum stress. **(T-1)**.

12.6. Primary Failure Mode. The design materials, whether solid or composite, shall not be subjected to any material failure that degrades support or control of a nuclear weapon(s) and could result in weapon damage. The following are typical failure mode classifications: **(T-1)**.

12.6.1. The tensile stresses applied to the equipment shall not exceed the material yield strength.

12.6.2. The stresses, induced by a compressive load, applied to the equipment shall not exceed half (0.5 times) the yield strength of the material.

12.6.3. The stresses applied to the equipment shall not result in a failure of the component.

12.6.4. The equipment shall not exceed the calculated endurance limit of the material within the life of the equipment.

12.6.5. Composite material shall not delaminate under a compressive load.

12.6.6. The equipment shall not fail by fracture as the result of tension/compression overloads and fast/slow crack growth within the component.

12.7. Ground Transportation Equipment.

12.7.1. In addition to the general design requirements, the following specific design criteria shall be used for ground transportation equipment that carry nuclear weapons or nuclear weapon systems. **(T-1)**.

12.7.2. The equipment shall be designed to support nuclear loads on the basic frame of the equipment rather than by lift arms, cables or hydraulic systems. This requirement does not apply to equipment used only to position or transfer nuclear weapons within a designated area (such as a weapons storage area). Hydraulic or pneumatic suspension systems are acceptable. **(T-1)**.

12.7.3. The equipment shall be designed with grounding provisions to accommodate grounding requirements of the weapon system. **(T-1)**.

12.7.4. The equipment shall be designed so that the engine start circuitry will only operate when the clutch is disengaged or when the automatic transmission is in the "neutral" or "park" position. **(T-1)**.

12.7.5. Equipment capable of freewheeling shall be designed with parking brakes designed to hold the maximum operational load on an 11.5-degree incline when headed both up and down, for a minimum of 15 minutes each. **(T-1)**.

12.7.6. Equipment shall be designed such that it does not have an unsafe tendency to tip, tilt, yaw, sway, skid or jackknife while loaded in the maximum operational configuration or while undergoing maximum performance maneuvers such as emergency braking and obstacle avoidance. **(T-1)**.

12.7.7. The equipment shall meet the minimum roadability requirements in the applicable sections in the STS and weapon system specifications. **(T-1)**.

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

12.8. Tow Vehicles.

12.8.1. The brake system shall be functionally compatible with the towed vehicle brake system. **(T-1)**.

12.8.2. The combination of tow vehicle and trailer shall meet the braking requirement listed in 12.7.5. **(T-1)**.

12.8.3. 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)**.

12.8.4. The tow vehicle structure shall be designed to accept loads induced by the equipment in tow and the tow bar. **(T-1)**.

12.9. Lifting Vehicles.

12.9.1. Lift systems shall be designed to maintain, or capable of allowing, a controlled drop of the rated load, in the event of an electrical, hydraulic or pneumatic failure, not to exceed 2.5 feet per second. **(T-1)**.

12.9.2. The design shall include pressure relief valves or regulators in hydraulic and pneumatic systems to prevent overpressure. **(T-1)**.

12.10. Movement and Positioning Controls.

12.10.1. The design of all movement controls shall be self-centering (except for such devices as the parking brake, steering control, transmission selectors, power takeoff and hydraulic pump). **(T-1).**

12.10.2. The design of mechanical stops and/ or electrical switches shall prevent over-travel in all directions of the lift control. **(T-1)**.

12.10.3. The design shall include the capability for small increments of movement (inching) in both reverse and forward directions. **(T-1)**.

12.10.4. If more than one power-operating component in a mechanically parallel system is used to lift the weapon, then the design shall uniformly control lifting attitude. **(T-1)**.

12.11. Hoists, Cranes, and Other Lifting Devices.

12.11.1. Hoist system controls shall incorporate automatic stops and mechanical stops or fail-safe limit switches that prevent over travel of a hoist, chain, wire rope or hook. **(T-1)**.

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

12.12. Handling and Support Fixtures. Handling and support structures design shall ensure stability (no excessive movement or tendency to tip or buckle) while laterally loaded to a minimum of half of the acceleration of gravity (0.5g). **(T-1)**.

12.13. Air or Ground Transport Design Criteria.

12.13.1. Pallet lock systems on cargo shall be designed to fail-safe (i.e., a single point failure of an active component shall not result in an un-commanded release of the pallet). **(T-1)**.

12.13.2. Cargo restraint systems (including tie-down restraint designs), on either ground or air transport vehicles, shall be designed to ensure that tie-down configurations prevent nuclear weapons or nuclear weapon systems from exceeding the envelopes described in **Table 12.1** and **Table 12.2**. **(T-1)**.

Table 12.1. Ground Transport Envelope.

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

Table 12.2. Air Transport Envelope.

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

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Attachment 1

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

References

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Master Nuclear Certification List

AFPD 13-5, *Air Force Nuclear Mission*, 17 July 2018

AFPD 91-1, *Nuclear Weapons and Systems Surety*, 24 October 2019

Adopted Forms

Air Force Form 679, *Air Force Publication Compliance Item Waiver Request/Approval*

Air Force Form 847, *Recommendations for Change of Publication*

Abbreviations and Acronyms

AFI—Air Force Instruction

AFPD—Air Force Policy Directive

AFMAN—Air Force Manual

AFNWC/NTS—Air Force Nuclear Weapon Center, Certification Management Division

AFSEC—Air Force Safety Center

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

AMAC—Aircraft Monitor and Control

DoD—Department of Defense

DoDM—Department of Defense Manual

g—Gravity

LCP—Launch Control Point

MAJCOM—Major Command

MIL-STD—Military Standard

OPR—Office of Primary Responsibility

PM—Program Manager

RIFL—Reversible In-Flight Lock

STS—Stockpile-to-Target Sequence

Terms

Terms not found below can be found in—AFI 91-101.

Class 3—A category of commercial vehicles with gross vehicle weight rating of 10,001 to 14,000 pounds.