NEW DESIGN SAFETY REQUIREMENTS OF MIL-STD-1316F

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MIL-STD-1316F REQUIREMENTS

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Use of NATO AOP-52 for Evaluating Safety Critical Software
Use of NATO STANAG 4170/AOP-7 for Explosives Qual
Use of NATO AECTPs for E^3 Testing

MIL-STD-1316F REQUIREMENTS

US Fuze Standards like MIL-STD-1316 are conceived and written by the DOD Fuze Engineering Standardization Working Group (FESWG).

NATO Fuze Standards like STANAG 4187 are conceived and written by the NATO Council Of National Armament Director's Ammunition Safety Group, AC/326 Subgroup "A" (Explosives and Initiation Systems).

The Safety Authorities get to review final drafts. If they have comments, these are adjudicated by the above listed Standardization Committees.

MIL-STD-1316F REQUIREMENTS

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Originally, MIL-STD-1316F was to be a supplement to NATO STANAG 4187, Ed 4.

Change in direction:
Now, MIL-STD-1316F will be a complete, stand alone document.

Most comprehensive changes to 1316 since the "D" revision introduced guidelines for ESAs (1991)

MIL-STD-1316F REQUIREMENTS

Currently:
In order to meet all requirements it is necessary to comply with both MIL-STD-1316E and STANAG 4187, Edition 4.

MIL-STD-1316F will incorporate the new requirements of STANAG 4187, Edition 4 plus additional new requirements.

NEW DEFINITIONS

MIL-STD-1316F REQUIREMENTS

<u>Initiator:</u>

MIL-STD-1316E:
"A device capable of directly causing functioning of the fuze explosive train."

MIL-STD-1316F:
"The component or components which convert the firing energy resulting in initiation of the first explosive or pyrotechnic element, even in the case of a distributed system where the energy conversion may occur at some distance and in a physically different module from the explosive or pyrotechnic element. The first explosive or pyrotechnic element of the explosive train will always be considered as part of the initiator."

MIL-STD-1316F REQUIREMENTS

Initiator - Continued

Examples:

a. Exploding Bridgewire (EBW) devices
b. Semi-Conductor Bridge (SCB) Initiators
c. Laser diodes, the first component of the explosive or pyrotechnic train, and the in between (transfer) components.
d. Exploding Foil Initiators (EFI), including the bridge and explosive component.
e. Stab detonators

MIL-STD-1316F REQUIREMENTS

New Definitions

Common Cause Failure:

"The failure of two or more components due to a single cause. For example, two or more components may fail due to the single cause of heating. The mode of failure may or may not be the same. "

Common Mode Failure:

"The failure of two or more components in the same mode. For example, two or more components such as switches may fail as an open circuit. The cause of failure may or may not be the same.

MIL-STD-1316F REQUIREMENTS

Maximum Non-Initiation Threshold (MNIT) Stimulus for Arming:
"The energy stimulus at which the probability of functioning the initiator is 0.005 at the 95% single sided lower level of confidence. Stimulus refers to the characteristic(s) such as current, rate of change of current (di/dt), power, voltage, or energy which is (are) most critical in defining the no-fire performance of the initiator."

No-Fire Threshold (NFT) Stimulus:
"The energy stimulus at which the probability of functioning the initiator is 0.001 at 95% single sided lower level of confidence."

NEW REQUIREMENTS

MIL-STD-1316F REQUIREMENTS

Safety Features:

- **The control and operation of safety features are to be functionally isolated from other processes within the munition system.**

- **Where it is not technically possible to functionally isolate the safety features, those non-isolated components, including software, used to enable the safety features shall be considered part of the fuzing system and must meet the requirements of this standard.**

- **The reason for not complying with the paragraph above and mitigation must be provided to the review authority to prove that the safety requirements have still been met.**

MIL-STD-1316F REQUIREMENTS

Safety Features:

- At least two of the safety features shall be independent and designed to minimize the potential for common cause failures.

- **The design of each safety feature shall be robust enough to permit exposure of the fuze system to the environments and handling stresses anticipated in its life cycle with no deterioration or degradation of the fuze safety system.**

- **The robustness of each safety feature and its contribution to the overall safety of the fuzing system shall be assessed through analysis and testing and its acceptance shall be determined by the appropriate review authority.**

  - Requires fault tree analysis

  - Requires subverted safety testing

MIL-STD-1316F REQUIREMENTS

Fuze Arming:

- **Fuzing systems shall not be capable of arming except as a consequence of a sequence of actions resulting from the sensing of environments that occur during and after launch or deployment.** ***(Environments vs. events)***

- **Fuzing system features which control arming, including safety logic devices and safety logic shall be dedicated to the control of arming.**

Single Device:

- **The elements of the fuzing system that prevent arming until valid launch environments have been sensed and the arming delay has been achieved should be located in a single safety and arming device.**

MIL-STD-1316F REQUIREMENTS

Non-Interrupted Explosive Train Control:

- **For fuzing systems using techniques that do not accumulate all functioning energy from the post-launch environment:**

- **At least 2 safety features shall enable at least 3 energy breaks.**

- **At least one energy break shall function in a static mode.**

- **At least one energy break shall function in a dynamic mode.**

- **Independent control of energy breaks shall be exercised to the maximum extent possible; a minimum of two separate logic devices shall be employed.**

MIL-STD-1316F REQUIREMENTS

Fuze Qualification:

Qualification of fuzes shall be based on:

- **STANAG 4157, and**

- **New FESWG document:**
- **Joint Ordnance Test Procedure JOTP-052, Guideline for Qualification of Fuzes, Safe and Arm (S&A) Devices, and Ignition Safety Devices (ISD), 17 March 2012**

Testing shall be conducted IAW:
- **MIL-STD-331 or AOP-20**

MIL-STD-1316F REQUIREMENTS

Logic Device Control of Safety Features:

Logic Devices used in the control or operation of safety features shall be implemented IAW:

New FESWG document:

Joint Ordnance Test Procedure JOTP-051, Technical Manual for the Use of Logic Devices in Safety Features, 10 Feb 2012

MIL-STD-1316F REQUIREMENTS

Safety Critical Software:

Where electronic logic (software) is shown to directly control or enable one or more safety features:

- A detailed analysis and testing of the software, using AOP-52, shall be performed to ensure that no design weaknesses, credible software failures, or credible hardware failures propagating through the software can result in compromise of the safety features.

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MIL-STD-1316F REQUIREMENTS

<u>Revised Stored Energy Requirement:</u>

- **Fuzing systems shall use environmentally derived energy generated after initiation of the launch or deployment cycle in preference to pre-launch stored energy to enable or arm the system.**

- **If this cannot be practically achieved and stored energy is used, then the system safety hazard analyses shall demonstrate that no failure mode for that source of energy will compromise the specified failure probabilities for that system.**

- **Where practical, the same stored energy source shall not be used to remove a lock and arm the S&A.**

MIL-STD-1316F REQUIREMENTS

Electrical Firing Energy Dissipation:

- For electrically initiated fuzing systems, the fuzing design shall include a provision to deplete the firing energy after the expiration of the operating lifetime of the fuze, or a fuze failure. The timeframe associated with the dissipation should be as short as practical based on operational requirements. The dissipation means shall be designed to prevent single point and common cause failures.

- *Eliminated the 30 minute requirement of MIL-STD-1316E*

MIL-STD-1316F REQUIREMENTS

Assessment and Qualification of Explosives:

Explosives and explosive compositions shall be assessed and qualified IAW:

- STANAG 4170, Principles and Methodology for the Qualification of Explosive Materials for Military Use
- AOP-7, Manual of Data Requirements and Tests for the Qualification of Explosive Materials for Military Use (US Annex)

No longer used:

- OD 44811, Safety and Performance Tests for Qualification of Explosives
- MIL-STD-1751, Safety and Performance Tests for Qualification of Explosives

MIL-STD-1316F REQUIREMENTS

New Approved In-Line Explosives:

The following explosives have been added to Table 1, and can be used in non-interrupted explosive trains:

- **LX-14**	**MIL-H-48358**	
- **PBXN-7**	**MIL-DTL-82874**	
- **PBXN-9**	**MIL-E-82875**	
- **PBXN-11**	**MIL-DTL-32064**	
- **PBXN-301**	**MIL-E-82740**	
- **RSI-007**	**WS 35173**	**(limitation of 3 Grams maximum)**
- **EDF-11**	**MIL-DTL-32387**	

MIL-STD-1316F REQUIREMENTS

Compliance With the 500 Volt Requirement:

- **The Electric Cook-Off test, the Maximum Allowable Electrical Sensitivity (MAES), and the computation of the Maximum Allowable Safe Stimulus (MASS), provided in STANAG 4560 can be conducted to show compliance with the 500V requirements.**

- **When voltages greater than 500 volts are present in the munition, evidence shall be presented to the review authority that demonstrates the S&A and the in-line initiator are insensitive to voltages up to and including the highest voltage present in the munition, excluding the firing voltage.**

MIL-STD-1316F REQUIREMENTS

EED No-Fire Threshold Safety Margins:

If safety of an S&A is dependent on preventing the unintentional functioning of an EED;

- A minimum safety margin between the NFT stimulus and any stimulus that could be induced by electrical or electromagnetic interference must be demonstrated to and accepted by the proper review authority.

MIL-STD-1316F REQUIREMENTS

Electrical Initiator Qualification:

Initiators for electrically fired non-interrupted explosive trains shall be qualified IAW MIL-DTL-23659, Appendix A

Remote Firesets:

For firesets that are not physically located within the Single Device, the 500V no fire requirements of MIL-DTL-23659 Appendix A, shall not be compromised.

MIL-STD-1316F REQUIREMENTS

E^3 Testing:

- **Testing will now be performed against NATO AECTP 500, Electromagnetic Environmental Effects Test and Verification**

- **EMV: AECTP 500, Category 508, Leaflet 1, Ordnance Electromagnetic Vulnerability of a complete munitions system containing electronics**

- **ESD: AECTP 500, Category 508, Leaflet 2, Electrostatic Discharge**

- **EMR: AECTP 500, Category 508 Leaflet 3, Electromagnetic Radiation**

- **LE: AECTP 500, Category 508 Leaflet 4, Lightning**

- **EMP: AECTP 500, Category 508, Leaflet 5, Nuclear Electromagnetic Pulse**

- **PST: By new Electrical Stress Test of MIL-STD-331**

MIL-STD-1316F REQUIREMENTS

New Appendices and Annexes:

- **Sensor/Fuze Terms and Definitions**
  - **Unarmed, Partially Armed, Armed (based on MNIT), Partially De-Armed, De-Armed, Sterilized, Self-Functioned, Self-Disrupted, Destroyed**

- **Definitions of Terms Related to Sensors**
  - **Inactive, Active, Deactivated, Permanently Deactivated, Destroyed**

- **Additional Safety Design Requirements for Mine Fuzing Systems**
  - **Deployment**
  - **Passage of Friendly Forces**
  - **Approaching a Mine**
  - **Recovery**
  - **Re-deployment**

MIL-STD-1316F REQUIREMENTS

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Summary:

- **All referenced documents are available on ASSIST**
- **MIL-STD-1316F will replace MIL-STD-1316E + STANAG 4187, Ed 4**
- **New requirements address:**
  - **Architecture related to control of safety features**
  - **Implementation of safety logic**
  - **Test methods and requirements for fuze, S&A, and explosives qualification**
  - **Compliance with 500V requirement**
  - **Safety critical software evaluation per AOP-52**
  - **EEE testing per revised NATO AECTPs**
- **It is intended that eventually, STANAG 4187, Edition 5 will supersede MIL-STD-1316F**