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NSA

1 August 2011 NSA/0781(2011)-JAIS/4368

See CNAD AC/326 STANAG distribution

STANAG 4368, JAIS (Edition 3) - IGNITION SYSTEMS FOR ROCKETS AND GUIDED MISSILE MOTORS - SAFETY DESIGN REQUIREMENTS

References:

a. NSA/0189-PPS/4368 dated 25.02.2002 (Edition 2)
b. PFP(AC/326)D(2009)0004 dated 11.05.2009 (Edition 3)(Ratification Draft)

1. The enclosed NATO Standardization Agreement, which has been ratified by nations as reflected in the NATO Standardization Document Database (NSDD), is promulgated herewith.

2. The references listed above are to be destroyed in accordance with local document destruction procedures.

ACTION BY NATIONAL STAFFS

3. National staffs are requested to examine their ratification status of the STANAG and, if they have not already done so, advise the Defence Investment Division through their national delegation as appropriate of their intention regarding its ratification and implementation.

for Cihangir AKSIT, TUR Civ
Director, NATO Standardization Agency

Enclosure:
STANAG 4368 (Edition 3)

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STANAG 4368
(Edition 3)

NORTH ATLANTIC TREATY ORGANIZATION
(NATO)

NATO STANDARDIZATION AGENCY
(NSA)

STANDARDIZATION AGREEMENT
(STANAG)

SUBJECT: IGNITION SYSTEMS FOR ROCKET AND GUIDED MISSILE MOTORS, SAFETY DESIGN REQUIREMENTS

Promulgated on 1 August 2011

Cihangir AKSIT, TUR Civ
Director, NATO Standardization Agency

RECORD OF AMENDMENTS

No.	Reference/Date of amendment	Date entered	Signature

EXPLANATORY NOTES

AGREEMENT

1. This STANAG is promulgated by the Director NATO Standardization Agency under the authority vested in him by the NATO Standardization Organisation Charter.

2. No departure may be made from the agreement without informing the tasking authority in the form of a reservation. Nations may propose changes at any time to the tasking authority where they will be processed in the same manner as the original agreement.

3. Ratifying nations have agreed that national orders, manuals and instructions implementing this STANAG will include a reference to the STANAG number for purposes of identification.

RATIFICATION, IMPLEMENTATION AND RESERVATIONS

4. Ratification, implementation and reservation details are available on request or through the NSAwebsites (internet http://nsa.nato.int; NATO Secure WAN http://nsa.hq.nato.int).

FEEDBACK

5. Any comments concerning this publication should be directed to NATO/NSA – Bvd Leopold III - 1110 Brussels - Belgium.

STANAG 4368
(Edition 3)

NAVY/ARMY/AIR

NATO STANDARDIZATION AGREEMENT
(STANAG)

IGNITION SYSTEMS FOR ROCKET AND GUIDED MISSLE MOTORS, SAFETY DESIGN REQUIREMENTS

Annexes:

A. National Safety Approving Authorities.
B Example Architectures for Ignition Systems (IS) and Ignition System Devices (ISD)

RELATED DOCUMENTS:

Stanag 4145 - Nuclear Survivability Criteria For Armed Forces Materiel And Installations.

Stanag 4187 - Fuzing Systems - Design Safety Requirements.

Stanag 4370 - Environmental Testing.

Stanag 4439 - Policy For Introduction, Assessment, And Testing For Insensitive Munitions (Im).

Stanag 4432 Air-Launch Guided Munitions, Principles For Safe Design.

Stanag 4518 Safe Disposal Of Munitions, Design Principles And Requirements And Safety Assessment.

AECTP-250 - Electrical And Electromagnetic Environmental Conditions

AECTP -500 - Electrical/Electromagnetic Environmental Tests

AEP-4 Nuclear Survivability Criteria For Armed Forces Material And Installations

AOP-15 Guidance On The Assessment Of Safety And Suitability For Service Of Non-Nuclear Munitions For Nato Armed Forces.

AOP-16 Fuzing Systems: Guidelines For Stanag 4187.

AOP-24 Electrostatic Discharge, Munition Assessment And Test Procedures.

REFERENCED DOCUMENTS:

STANAG 4147 Chemical Compatibility Of Ammunition Components With Explosives (Non-Nuclear Applications).

STANAG 4157 Fuzing Systems: Test Requirements For The Assessment Of Safety And Suitability For Service.

STANAG 4170 Principles And Methodology For The Qualification Of Explosive Materials For Military Use.

STANAG 4560 Electro-Explosive Device, Assessment And Test Methods For Characterization.

AOP-7 Manual Of Data Requirements And Tests For The Qualification Of Explosives Materials For Military Use

AOP-20 Manual Of Tests For The Qualification Of Fuzing Systems

AOP-38 Glossary Of Terms And Definitions Concerning The Safety And Suitability For Service Of Munitions, Explosives, And Related Products.

AOP-42 Integrated Design Analysis For Fuzing And Other Safety Critical Systems.

AOP- 43 Electro-Explosive Devices Assessment And Test Methods For Characterization Guidelines For STANAG 4560.

AOP-52 Guidance On Software Safety Design And Assessment Of Munition-Related Computing Systems

AIM

1. The aim of this agreement is to standardize the safety design requirements for ignition systems for rocket and guided missile solid propellant motors used in non-nuclear systems. These safety requirements may be applied to ignition systems of other types of motors, as deemed applicable by the National Safety Approving Authorities (NSAA).

AGREEMENT

2. Those Nations ratifying the STANAG agree to design ignition systems for rocket and guided missile solid propellant motors in accordance with the requirements of this STANAG. This agreement is applicable to new developments initiated after ratification. This agreement shall be applied by the National Safety Approving Authorities (NSAA) listed in Annex A.

EXCLUSIONS

3. The following are excluded from this agreement:

   a. Nuclear weapon systems;

   b. Flares and signals dispensed by hand;

   c. Devices containing thrusters and gas generators which the NSAA agrees do not present sufficient hazard;

   d. Rocket-assisted projectiles and rocket-propelled grenades which the NSAA agrees do not present sufficient hazard; and

   e. Pyrotechnic countermeasure devices which the NSAA agrees do not present sufficient hazard.

DEFINITIONS

4. The following terms and definitions are used for the purpose of this agreement. AOP-38 provides additional guidance on terminology.

4.1 Armed. An ignition system is armed when the output of a primary explosive, a sensitive pyrotechnic, the application of a firing stimulus, or the delivery of the accumulated arming energy can produce ignition of the munition propulsion system.

   a. An ignition system employing an ignition safety device with pyrotechnic train interruption is considered armed when the interrupter(s) position (or condition) is such that the probability of propagation through the pyrotechnic train, given initiation of the sensitive elements of the train is equal to or exceeding 0.005 at the 95 percent single-sided lower level of confidence. If the implementation prevents the use of normally accepted statistical techniques and methods (see AOP 43), then other methods of assurance may be used with the approval of the NSAA.

b. An ignition system employing firing energy path interruption is considered armed when the interrupters' position or condition is such that the probability of initiation of the first element of the pyrotechnic train, given application of the firing energy, is equal to or exceeding 0.005 at the 95 percent single-sided lower level of confidence. If the implementation prevents the use of normally accepted statistical techniques and methods (see AOP 43), then other methods of assurance may be used with the approval of the NSAA.

c. An ignition system employing a arming energy accumulation control is considered armed when the accumulated arming energy available for delivery to the initiator equals or exceeds the initiator's maximum non-initiation threshold.

4.2. Commit to Launch. Actions carried out upon a munition, following which the Ignition System (IS) will irreversibly function.

4.3. Common Cause Failure. 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 not be the same. Common causes may be conditions or events internal within the system or external, from its environment.

4.4. Enabling. The act of removing or deactivating any safety feature which prevents arming.

4.5. Energy Break. A component, e.g., a switch, which prevents the accumulation of arming energy on the firing capacitor in a non-interrupted pyrotechnic train with arming energy accumulation control.

4.6. Firing Energy Path. The path of all non-chemical energy leading to the first pyrotechnic element of a non-interrupted pyrotechnic train.

4.7. Firmware. Instructions fixed in the computer in the “Read only” memory. The combination of a hardware device and computer instructions or computer data that reside as “read only” software on the hardware device. 4.8. In-line Initiator. In-line initiation devices are defined as those initiators with electrical and pyrotechnic characteristics that are insensitive enough to be approved for non-interrupted use.

4.8. In-line Initiator. In-line initiation devices are defined as those initiators with electrical and pyrotechnic characteristics that are insensitive enough to be approved for non-interrupted use.

4.9. Ignition Safety Device (ISD). A device whose purpose is to prevent an unintended functioning of the rocket or missile motor through interruption of the pyrotechnic train, interruption of the firing energy path, or control of the energy required to arm the ISD and function the initiator.

4.10. Ignition System (IS). The aggregate of devices in a weapon system, including those in the munition, launcher and munition launch platform (e.g., fire control system, armament control unit), which control the arming and firing signals to cause the rocket or missile motor to function.

4.11. Independent Safety Feature. A safety feature which is not affected by the function or malfunction of any other safety feature.

4.12. Initiator. The component or components which convert the arming or 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. Initiators can be designed to be functioned by a firing pin striking the energetic material or through heating of it by electrical current or by laser. Examples of Electric Initiators (which are defined in STANAG 4560) include but are not limited to:

a. Bridge-wire (BW) Electro-Explosive Devices (EED);

b. Exploding Bridgewire (EBW) devices;

c. Semi-Conductor Bridge (SCB) initiators;

d. Laser diodes, the first component of the explosive or pyrotechnic train, and the in-between (transfer) components; and

e. Exploding Foil Initiators (EFI) including the bridge and explosive components.

4.13. Interrupted Firing Energy Path. A firing energy path with its elements physically and functionally separated until arming to interrupt the firing energy path and thus prevent ignition of the first element of a non-interrupted pyrotechnic train in the event of unintended activation of any sensitive element in the firing energy path (e.g., low voltage laser diodes).

4.14. Interrupted Pyrotechnic Train. A pyrotechnic train with elements of the train physically and functionally separated until arming to interrupt the firing path and thus prevent ignition of the motor propellant in the event of unintended ignition of any sensitive element of the train.

4.15. Out-of-line Initiators. Out-of-line initiation devices are defined as those initiators whose electrical and pyrotechnic characteristics are too sensitive to be approved for non-interrupted use.

4.16. Maximum Non-Initiation Threshold (MNIT). 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. MNIT is used when it is required to define the arming threshold for an IS or an ISD.

4.17. National Safety Approving Authority (NSAA). The national authority responsible for approving service use of an ammunition item or component.

4.18. Non-Armed.

a. Interrupted pyrotechnic train – Interrupter restrained, but not locked, in the original position designed to prevent ignition of the rocket motor by the initiator.

b. Interrupted Firing Energy Path - Interrupter restrained, but not locked, in the original position designed to prevent ignition of the rocket motor by the out-of-line energy conversion device.

4.19. Pyrotechnic Materials. Those energetic materials or compounds which do not ordinarily detonate in their intended function but rather burn or deflagrate. Typical examples include boron potassium nitrate ($BKNO_3$), black powder, and many metal/oxidant combinations.

4.20. Pyrotechnic Train. The deflagration train beginning with the first pyrotechnic element and terminating in the munition propellant. For the purposes of this standard, the term pyrotechnic train refers also to those trains incorporating one or more detonating components.

4.21. Safety Feature. An element or combination of elements that prevents unintentional arming or functioning.

4.22. Safety Critical. Characterization of a condition, event, function, operation, process, or item of a system whose proper recognition, control, performance, or tolerance is essential to system safety during any phase of its life cycle.

4.23. Sensitive Pyrotechnics. Sensitive pyrotechnics are used to initiate or ignite other, less sensitive, materials in the pyrotechnic train. They are used in primers or squibs of ignition systems and are sensitive to electrostatic discharge, heat, impact, or friction and undergo a rapid exothermic reaction upon initiation. Sensitivity limits are established by the NSAA.

4.24. Sensor, Environmental. A component or series of components designed to detect and respond to a specific environment.

4.25.1. Sponsor - The sponsor is the government entity responsible for the development and/or acquisition of the material, component, munition or weapon system.

4.26. Unarmed

a. Interrupted Pyrotechnic Train –An ISD with interrupted pyrotechnic trains is considered unarmed if the interrupter is locked and restrained by all safety features, in the original position which is designed to prevent ignition of the rocket motor.

b. Interrupted Firing Energy Path – An ISD with interrupted firing energy path is considered unarmed if the interrupter is locked and restrained, by all safety features, in the original position which is designed to prevent ignition of the rocket motor.

c. Arming Energy Accumulation Control – An ISD with non-interrupted pyrotechnic train and arming energy accumulation control is considered unarmed if the Arming Capacitor Energy (ACE) is not present and all safety features are in their original unpowered condition to prevent accumulation of ACE.

4.27. Unexploded Ordnance (UXO). A launched or emplaced munition that has been operationally deployed but where its propulsive, pyrotechnic and/or explosive content failed to function as intended.

GENERAL

5. General Requirements.

The need for Safety Design Requirements. Rocket and guided missile motor ignition systems perform safety critical functions for many weapon systems as their inadvertent operation can result in serious risk to personnel and significant material damage. Inadvertent operation can be the result of direct initiation of the igniter by external stimuli, failure of ignition system control circuitry or human error and can occur in all configurations and conditions found during storage, handling, operational use, tests, maintenance and disposal. The increasing use of complex, software-controlled, fire control systems and the trend towards more "in-depth" testing of guided weapons adds a further need for design safety requirements.

5.1. Design Review. Designs shall be certified by the NSAA for compliance with this STANAG. New designs, modifications to approved designs which affect safety, and new applications of previously approved designs shall be presented with supporting evidence to the NSAA for safety evaluation and certification of compliance.

5.2. Ignition System Design. The ignition system shall include an Ignition Safety Device (ISD). The design of the ignition system shall take into account the aggregate of sub-systems and devices in the weapon system (munition, launcher, and munition launch platform including software and firmware) which generate and control the operating signal to cause the motor to function.

5.3. Non-Compliance. If a design does not comply with one or more requirements of this STANAG but is certified as safe and suitable for service by a National Safety Approving Authorities (NSAA), a detailed description of the non-compliance and the rationale upon which the safe and suitable certification is based on shall be recorded as part of the NSAA decision. This document shall be made available to other NATO nations justifiably requiring this information.

DETAILS OF THE AGREEMENT

6. Fundamental Safety Design Requirements.

6.1. Ignition Components.

6.1.1. Explosives. All explosives used in the ignition system shall be qualified in accordance with STANAG 4170 and be approved for their intended use by the National Safety Approving Authorities (NSAA).

6.1.2. Initiator. The initiator shall be characterised in accordance with STANAG 4560 and that information shall be made available to the NSAA. The NSAA shall establish the pass/fail criteria for qualification, and approve the test plan, and procedures.

6.1.3. Compatibility of Components. All components used in the ISD shall be chosen to be compatible and stable so that under all specified natural and induced environmental conditions in its life cycle, none of the following can occur in an unarmed ISD:

a. Premature arming or functioning;

b. Dangerous ejection or exudation of material;

c. Deflagration of any of the non-interrupted pyrotechnics;

d. The formation of dangerous or incompatible compounds. Material which could contribute to the formation of more volatile or more sensitive compounds should not be used. If used, then the material shall be treated, located or contained to prevent the formation of a hazardous compound (see STANAG 4147);

e. Production of unacceptable levels of toxic or other hazardous materials; and

f. A compromise of the safety features. (e.g., by electro-chemical reaction or plastic embrittlement).

6.2. Safety Analyses. The following safety analyses shall be performed on the IS to identify hazardous conditions for the purpose of their elimination or control.

a. A preliminary hazard analysis (PHA) shall be conducted to identify and classify hazards of normal and credible accidental and/or unintended environments as determined by an assessment of the life cycle. In addition, conditions and personnel actions that may occur from delivery through the remaining life cycle, including demilitarization and mitigation of Unexploded Ordnance (UXO) must be considered. This analysis shall form the basis for preparation of system design, test, and evaluation requirements.

b. System hazard analyses and detailed analyses, such as fault tree analyses (FTA) and failure mode effects and criticality analyses (FMECA), or an Integrated Design Analysis (AOP-42) shall be conducted for all phases of the life cycle to arrive at an estimate of the safety system failure rate (see 6.9) and to identify any single point, common cause, or other credible failure modes that could result in inadvertent or premature arming or firing of the motor. These analyses shall include an assessment of the relative sensitivity of each component in the pyrotechnic train and shall include potential failure modes that could occur due to the manufacturing process to assess their consequences to the functional and safety characteristics of the munition.

c. For the IS or ISD containing an embedded computer, microprocessor, micro-controller or other computing device, the analyses shall include a determination of the contribution of the software or firmware to the enabling of a safety feature.

d. Where electronic logic (software) is shown to directly control or enable one or more safety features, a detailed analysis and testing of the applicable software, following the appropriate guidelines (such as AOP-15 or 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.

e. For an IS or ISD containing Application Specific Integrated Circuits, Programmable Gate Arrays, or similar devices, the analyses shall include a determination of the safety criticality of these devices to the arming and functioning of the system. Detailed safety analyses and tests shall be performed on those devices shown to be safety critical or directly influence safety critical functions to determine their contribution to the safety failure rate.

6.3. Environments. In their normal life cycle configurations, ISs and ISDs shall be designed so that they will not inadvertently arm, function, or exhibit unsafe degradation during and after exposure to all expected mechanical, thermal, and other service environments, including electromagnetic radiation (EMR), electrostatic discharge (ESD), electromagnetic pulse (EMP), electromagnetic interference (EMI), lightning effects (LE) or power supply transients (PST) environments.

6.4. Electronic Logic Functions. Any electronic logic related to safety functions performed by the IS or ISD shall be embedded as non-reconfigurable firmware or hardware. Firmware devices shall not be erasable or alterable by credible environments which the IS or ISD would otherwise survive.

6.5. Fail-Safe Features. Fail-safe designs shall be considered for IS and ISD.

6.6. Ignition System. In order to preclude unintended or premature ignition system arming or initiation, the ignition system shall:

a. Inhibit the initiation of the arming sequence except as a consequence of a valid launch intent;

b. Not be susceptible to common-cause failures;

c. Not contain any single point failure modes prior to or at the start of the arming sequence;

d. Delay arming as long as possible within operational constraints;

e. Utilize environmental forces (such as air pressure for air-launched rockets or missiles), if practical, to enable safety features;

f. Functionally isolate the control and operation of IS safety feature(s) from other processes within the weapon system and shall prevent unintentional launch. Where it is not technically possible to functionally isolate the safety feature(s), those non-isolated components, including software, used to enable the safety feature(s) shall be considered part of the IS and must meet the requirements of this STANAG; and

g. Ensure Built-in test (BIT) and In-service test or maintenance do not degrade safety.

6.6.1. Ignition Safety Device (ISD). As an element of the ignition system, the ignition safety device shall:

a. Prevent arming or initiation of the propulsion system except in response to valid arming and launching signals from the ignition system. These safety functions should be located in a single safety device and not distributed throughout the munition.

b. Not be susceptible to common-cause failures;

c. Not contain any single point failure modes that could result in inadvertent or premature arming or firing prior to or at the start of the arming sequence;

d. Utilize environmental forces, if practical, to enable safety features. When the ISD uses stored energy to enable the safety feature(s), the stored energy source shall not be integral to the ISD unless it can be demonstrated that it is impractical to do otherwise and that the required safety failure rate (see 6.9) can be achieved. In addition, if the ISD uses stored energy to enable safety features, it shall be as unique, in terms of level and type, as allowed by system requirements; and

e. The safety features which prevent arming should require ordered sequential removal.

6.7. Manual Arming. The IS and, assessed separately, the ISD shall not be capable of being armed manually unless such capability is required by operational conditions and is specifically approved by the NSAA. Such systems shall be capable of being easily returned to an unarmed condition under the conditions of deployment.

6.8. Inclusion of Safety Features for Multiple Stage Rocket Motors. For munitions with multiple stage rocket motors, those elements of the IS that are used beyond the first stage shall include at least two safety features. The control and operation of these safety features shall be functionally isolated from other processes in the munition system, except those processes associated with arming of previous stage rocket motors. Each safety feature shall prevent unintentional arming of the IS. At least two of the safety features shall be independent and designed to minimize the potential for common cause failure. Operation of at least one of the independent safety features shall depend on the sensing of an environment after first motion in the launch cycle or on sensing a post-launch environment. At least one of the independent safety features shall prevent arming after launch or deployment until a specified or equivalent delay has been achieved.

6.9. Safety System Failure Rate.

6.9.1. Ignition Safety (IS) System Failure Rate. The safety failure rate of the IS shall be established by performing a safety analysis (see 6.2) and shall be verified to the extent practicable by test and analysis. Determination of the safety system failure rate shall include all logistical and tactical phases for the munition and weapon system from manufacture to intentional initiation of the launch sequence. As a minimum requirement, the ignition safety system failure rate shall not exceed one failure in one million for inadvertent functioning of the rocket motor. For munitions with multiple stage rocket motors, that portion of the IS that is used beyond the first stage shall have an estimated safety system failure rate that does not exceed one failure in one million to preclude arming of the IS prior to initiation of the launch sequence of the first stage.

6.9.2. ISD Safety Failure Rate. As a minimum requirement, the estimated ISD safety failure rate shall not exceed one failure in ten thousand for inadvertent arming. The safety failure rate of the ISD shall be established by performing a safety analysis (see 6.2) and shall be verified to the extent practicable by test and analysis. Determination of the ISD safety failure rate shall include all logistical and tactical phases for the munition and weapon system from manufacture to intentional initiation of the launch sequence. Additionally, in cases where acceptable environments are available to implement additional safety feature(s) the ISD failure rate shall not exceed one failure in one million for inadvertent firing.

6.10. Test Procedures. The assessment of the safety and suitability for service of the ISD shall be conducted in accordance with the applicable tests in STANAG 4157 using test procedures described in AOP-20 or national test procedures as approved by NSAA.

6.11. The design of the ignition system shall ensure that the incidence of Unexploded Ordnance (UXO) is at a level acceptable to the User and the NSAA.

6.12. Explosive Ordnance Disposal. The IS and ISD shall incorporate Explosive Ordnance Disposal (EOD) features to ensure that, in the event of accidents, extreme situations, or dud ordnance, EOD personnel can either return the munition to a safe-to-handle condition or, where necessary, implement field expedient disposal. Where practical, the IS and ISD shall also incorporate features that permit determination of the armed or unarmed state of the IS or ISD by EOD personnel in the event of a misfire, hung store, etc.

6.12.1. EOD Reviewing Authority. All new or altered designs, or new applications of existing designs shall be presented by the sponsor to the appropriate national EOD research, development, test and evaluation authority for technical advice and assistance in determining viable design approaches or trade-offs for EOD.

6.13. Unarmed Condition Assurance. The IS and/or ISD design shall incorporate one or more of the following:

a. A feature that prevents assembly of the IS in the armed condition;

b. A feature that prevents assembly of the ISD in the armed condition;

c. A feature that provides a positive means of determining that the ISD is not armed during and after its assembly and during installation into the munition; and

d. A feature that prevents installation of an armed, assembled ISD into a munition.

6.13.1. Arming and Reset During Manufacturing. If arming and reset of the assembled ISD in tests is a normal procedure in manufacturing, inspection, or at any time prior to its installation into a munition, subparagraph 6.13.b is not sufficient and either subparagraph 6.13.c or 6.13.d shall also be met.

6.13.2. Arming and Reset During Test. If arming and reset of the IS is a normal test procedure at any time during its life cycle, subparagraph 6.13.a is not sufficient and the Ignition System shall provide a positive means to determine whether the system is armed or unarmed whether or not a munition is present.

6.13.3. Visual Indication. If visual indication of the unarmed or armed condition is employed in the ISD, visible indicators shall be designed to provide a positive, unambiguous indication of condition. Indicator failure shall not result in a false non-armed indication. If color-coding is used to represent condition, the colors and coding shall be as follows:

a. Unarmed Condition. Fluorescent green background with the letter S or word SAFE superimposed thereon in white. Colors shall be non-specular.

b. Armed Condition. Fluorescent red or fluorescent orange background with the letter A or the word ARMED superimposed thereon in black. Colors shall be non-specular.

6.14. Electrical Firing Energy Dissipation. Ignition Systems and Ignition Safety Devices accumulating and/or storing functioning energy (e.g., using firing capacitors) shall dissipate the firing energy whenever the arming signal or energy is removed, within 30 minutes or within a time compatible with the operating requirements for the Ignition System. The dissipation means shall be designed to prevent single point and common cause failures.

6.15. Inadvertent Ground Impact Hazard for Tube Lunched Munitions. For tube launched munitions, in the event of inadvertent ground impact after launch and prior to ignition of the flight motor, the IS shall prohibit functioning of the IS/ISD for the flight motor.

6.16. Design for Quality Control, Inspection and Maintenance.

a. The IS and ISD shall be designed and documented to facilitate application of effective quality control and inspection procedures. Design characteristics critical to safety shall be identified to assure that the designed safety is maintained.

b. The design of the IS and ISD shall facilitate the use of inspection and test equipment for monitoring all characteristics which assure the safety and intended functioning of the IS at all appropriate stages. The IS and ISD designs should facilitate the use of automatic inspection equipment.

c. Embedded computing systems and their associated software shall be designed and documented for ease of future maintenance.

6.17. Design Approval. At the start of development of a rocket motor, the sponsor shall obtain approval from the NSAA for the proposed IS design concept, addressing all applicable STANAG requirements. New designs, modifications to approved designs which affect safety, and new applications of previously approved designs shall be presented with supporting evidence to the NSAA for safety evaluation and certification of compliance.

6.18. Pyrotechnic Trains and Firing Energy Paths.

6.18.1. Pyrotechnic or explosive sensitivity (transfer charge and igniter pyrotechnics).

a. Only those pyrotechnic and explosive materials qualified in accordance with STANAG 4170 which are approved by the NSAA for in-line use are allowed in a position leading to the ignition of a rocket or missile motor without interruption. Chemical compatibility shall be demonstrated in accordance with STANAG 4147; in particular, energetic component design shall be free from the risk of formation of unduly sensitive or dangerous compounds. Specific pass/fail criteria for the qualification of materials used in either interrupted or non-interrupted ignition trains shall be approved by the NSAA.

b. The pyrotechnic and explosive material used in ISD's shall not be altered by any means (precipitation, recrystalization, grinding, density changes, addition of materials, etc.) likely to increase its sensitivity beyond that at which the material was qualified and at which it is customarily used, unless it is requalified.

6.18.2. Pyrotechnic Train Interruption. When the pyrotechnic train contains material(s) other than those qualified for in-line use, at least one interrupter (shutter, slider, rotor, for example) shall separate these materials from the balance of the pyrotechnic train. The interrupter(s) shall prevent propagation to materials on the other side of the interrupter until it is removed during ISD arming as a consequence of an intentional initiation of the launch sequence. The safety features shall not be enabled prior to intentional initiation of the launch sequence.

6.18.2.1. Pyrotechnic Train Interrupter Methods of Restraint. The interrupter(s) shall comply with one of the following methods of restraint; a. is the preferred method and is considered safer than b.

a. The interrupter(s) shall be directly locked mechanically in the unarmed position by at least one safety feature. However, when possible, two independent safety features shall be employed using available independent environments and/or signals. The interrupter shall automatically return to an unarmed position upon removal of the arming energy.

b. The interrupter(s) shall be directly and redundantly restrained mechanically in the non-armed position by at least one safety feature. The safety feature shall be overcome by the arming energy and shall automatically return the interrupter to a non-armed position upon removal of the arming energy.

6.18.2.2. Interrupter Position.

a. Designs are acceptable where the sensitive pyrotechnic element is positioned such that omission of the interrupter will prohibit pyrotechnic train transfer.

b. Designs where the sensitive pyrotechnic element is positioned such that safety is dependent upon the presence of an interrupter, the design shall include positive means to prevent the ISD from being assembled without the properly positioned interrupter.

6.18.2.3. Interruption Effectiveness. The effectiveness of the interruption prior to initiation of the arming sequence shall be determined by test and analysis. The results shall be presented and justified to the appropriate NSAA.6.18.3. Non-interrupted Pyrotechnic Train Control. When the pyrotechnic train contains only those materials qualified for in-line use, no pyrotechnic train interruption is required. In this case, one of the following methods of energy control is required:

6.18.3.1. Firing Energy Path Interruption for Out-of-line Energy Conversion Devices. Firing energy path interruption is required for an ignition system using a out-of-line energy conversion devices, (i.e., a laser diode activated by less than 500 volts), with associated transmission hardware and an approved non-interrupted pyrotechnic. At least one firing energy path interrupter (i.e., shutter, slider, rotor, etc.) shall separate the out-of-line energy conversion device from the approved non-interrupted pyrotechnic; interruption of the low voltage alone is not an acceptable design. The interrupter(s) shall prevent propagation to materials on the other side of the interrupter until it is removed during ISD arming as a consequence of an intentional initiation of the launch sequence. The safety features shall not be enabled prior to intentional initiation of the launch sequence. The method of restraint of the interrupter shall meet the requirements of 6.18.2.1. The interrupter effectiveness shall meet the requirements of 6.18.2.3.

6.18.3.1.1. Firing Energy Path Interrupter Position. The interrupter(s) shall comply with one of the following methods of restraint; a. is the preferred method and is considered safer than b.

a. Designs are acceptable where the out-of-line energy conversion device is positioned such that omission of the interrupter will prohibit initiation of the pyrotechnic train.

b. Designs where the out-of-line energy conversion device is positioned such that safety is dependent upon the presence of an interrupter, the design shall include positive means to prevent the ISD from being assembled without the properly positioned interrupter.

6.18.3.2. Arming Energy Accumulation Control with In-line Initiators . Firing energy path interruption is not required if initiators meeting the requirements of paragraph 6.18.4.1 are used. However, Arming energy shall be controlled to preclude unintentional arming and firing. The following shall apply to the ISD design:

a. At least two safety features shall enable at least three energy breaks;

b. At least one energy break shall function in a dynamic mode;

c. At least one energy break shall function in the static mode;

d. Independent control of energy breaks shall be implemented to the maximum extent possible; a minimum of two separate logic devices or circuits shall be used to validate the arming events and control the energy breaks;

e. The signals enabling the safety features shall be chosen to be sufficiently unique and robust; and

f. Removal of the arming signal or energy shall return the ISD to the unarmed state.

6.18.4. Initiator Electrical Requirements.

6.18.4.1. In-Line Initiator. The initiator for an electrically initiated non-interrupted ISD shall:

a. Be characterised in accordance with STANAG 4560.

b. Not be capable of being initiated when exposed to the greater of:

   1) Commonly available electrical potentials;

   2) Any electrical potential that may be present in the IS prior to an irreversible commit to launch; and

3) The maximum allowable electrical sensitivity inputs as defined in paragraph 6.18.4.3

Note: Deflagration of the initiator is acceptable if initiator detonation is required to propagate to the pyrotechnic train and it does not otherwise adversely affect the safety of the system in the end use configuration. Damage to or destruction of the initiator is acceptable if it does not otherwise adversely affect the safety of the system. The test procedures and acceptance criteria which demonstrate compliance with this requirement shall be approved by the NSAA.

c. Not be capable of being initiated by any electrical potential as defined in paragraph 6.18.4.3.b when applied to any accessible part of the ISD after installation into the munition or any munition subsystem.

6.18.4.2. Interrupted Firing energy path or Pyrotechnic Train. Unless otherwise specified, the initiator for an electrically initiated interrupted firing energy path or pyrotechnic train ISD shall be characterized in accordance with STANAG 4560. [In addition the initiator shall have a no fire threshold of at least 1 amp 1 watt for 5 minutes as determined by the No Fire Threshold Power/Current Test in STANAG 4560]. For initiators where the above requirements are not considered appropriate, approval for the qualification test and acceptance criteria shall be obtained from the NSAA.

6.18.4.3. Maximum Allowable Electrical Sensitivity Requirement. For initiators to be used in electrically initiated non-interrupted ISD, an allowable electrical sensitivity test program for qualification of the initiator shall be established and approved by the National Safety Approving Authority. The test shall include, as a minimum:

a. Electrical potentials up to 500 volts at various frequencies, waveforms as defined in STANAG 4560; and

b. Electrical potentials that may be present in the ignition system, whether resulting from normal functioning or failures.

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 above requirements. When voltages greater than 500 volts are present in the munition, evidence shall be presented to the NSAA that demonstrates the ISD and the in-line initiator are insensitive to voltages up to and including the highest voltage present in the munition, excluding the firing voltage.

6.19. Connectors in the IS. The electrical connectors used in the ignition system shall be designed so that it is impossible to connect them in such a way that can compromise the safety of the IS.

IMPLEMENTATION OF THE AGREEMENT

7. This STANAG is implemented when a nation has issued instructions that all future non-nuclear rockets and guided missiles entering service shall be designed in accordance with this agreement.

NATIONAL SAFETY APPROVING AUTHORITIES

AUTORITES NATIONALES COMPETENTES EN MATIERE DE SECURITE

CAN
National Defence Headquarters
101 Colonel By Drive
OTTAWA K1A0K2

DEN Army Material Command,
Arsenalvej 55
DK-9800 HJORRING
Denmark

Navy Material Command,
Holmen
DK-1433 COPENHAGEN
Denmark

Air Material Command,
Postboks 130
DK-3500 VAERLOSE
Denmark

DEU Bundesamt für Wehrtechnik und Beschaffung
K 1.3
Postfach 7360
D- 56057 KOBLENZ

FRA Pyrotechnic Safety Authority
Inspecteur de l’armement pour les poudres et explosifs
Cellule Sécurité des munitions (INSP/IPE/SM)
8 Boulevard Victor
00303 ARMEES

Technical Authority
Laboratoire de Recherches Ballistiques et Aerodynamiques
Forêt de Vernon
BP 914
27207 VERNON

GBR Defence Equipment and Support (DES)
Defence Ordnance Safety Group (DOSG)
Weapon Systems Division (WS)
Ash 2c
MOD Abbey Wood #3218
BRISTOL BS34 8JH

ITA Ministero della Difesa
Direzione Generale Armamenti Terrestri
Via Marsala n. 104
00185 ROMA

Marina Militaire (Navy)
Mariperman
Viale San Bartolomeo nr.396
19138 LA SPEZIA

NLD Royal Naval Material Command (DMkM)
Frederik Kazerne
PO Box 20702
2500 ES Den Haag

Royal Army Material Command (DMkL)
Ammunition Division
Frederik Kazerne
PO Box 90822
2509 LV Den Haag

Royal Air Force Material Command (DMkLU)
Brinkhorsthof
PO Box 20703
2500 ES Den Haag

NOR Norwegian Army Material Command
Weapon and Ammunition Branch/ROMAN 6.2
OSLO Mil/Loren
0018 OSLO 1

USA Army

Chairman
Ignition System Safety Review Board
ATTN: AMSAM-SF-M
Redstone Arsenal, AL 35898

Navy and Marine Corps

Chairman
Weapon System Explosives Safety Review Board
Naval Ordnance Safety & Security Activity
23 Strauss Ave., Building D-323
Indian Head, MD 20640-5070

Air Force

USAF
Nonnuclear Munitions Safety Board
Attn: AAC/SES
1001 North 2nd Street, Suite 366
Eglin Air Force Base
FL 32542-6838

EXAMPLE ARCHITECTURES FOR IGNITION SYSTEMS (IS) AND IGNITION SYSTEM DEVICES (ISD)

B.1. IGNITION SYSTEM

The architecture shown in Figure 1 is for illustrative purposes, displaying all the basic components and their possible locations in an ignition system, paragraph 6.6, and is not intended to demonstrate an actual implementation.

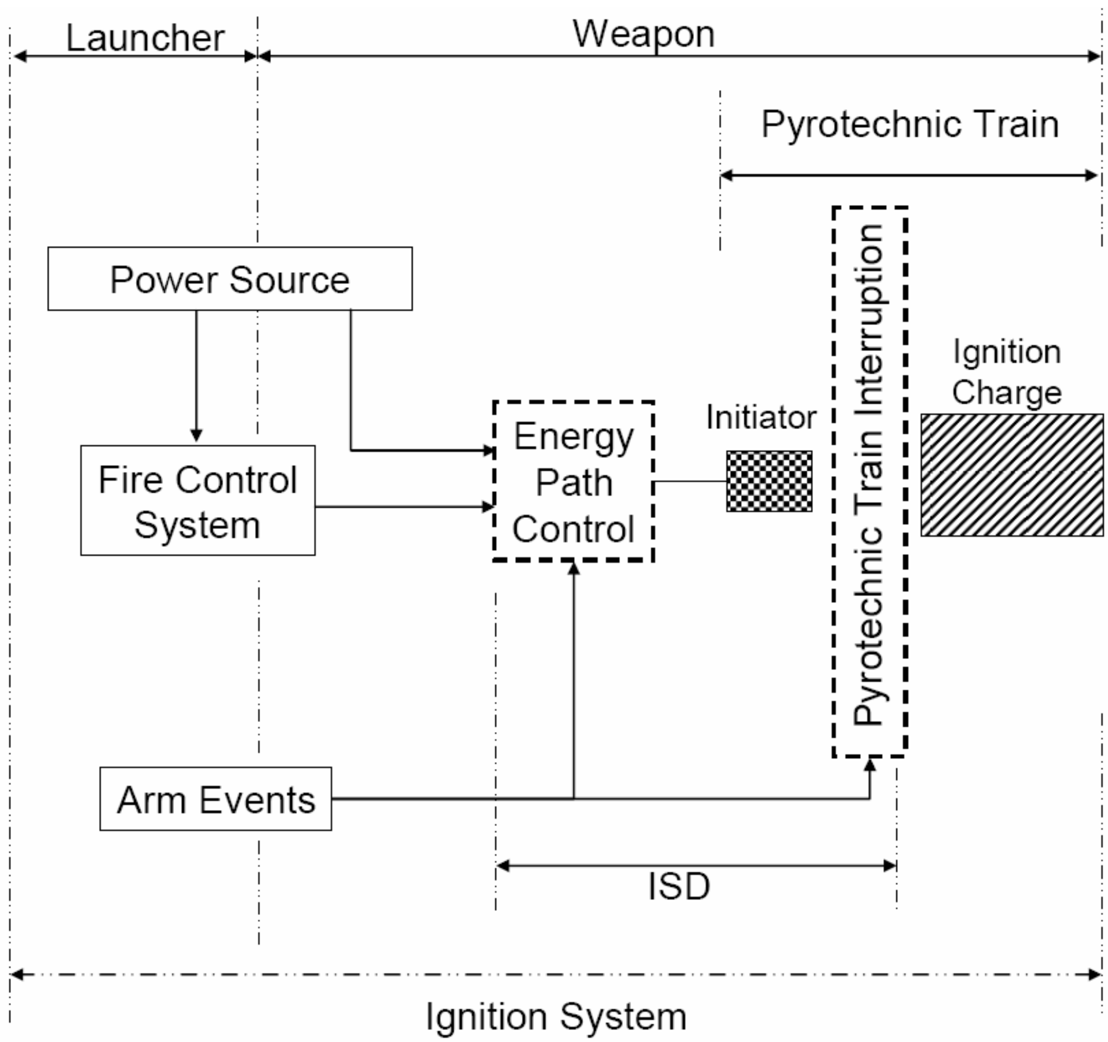

FIGURE 1: Illustrative Architecture of IS

B.2. PYROTECHNIC TRAINS AND ENERGY PATHS (Paragraph 6.18)

B.2.1. PYROTECHNIC TRAIN INTERRUPTION.

Examples of pyrotechnic train interruption, paragraph 6.18.2, are illustrated in Figures 2 through 5.

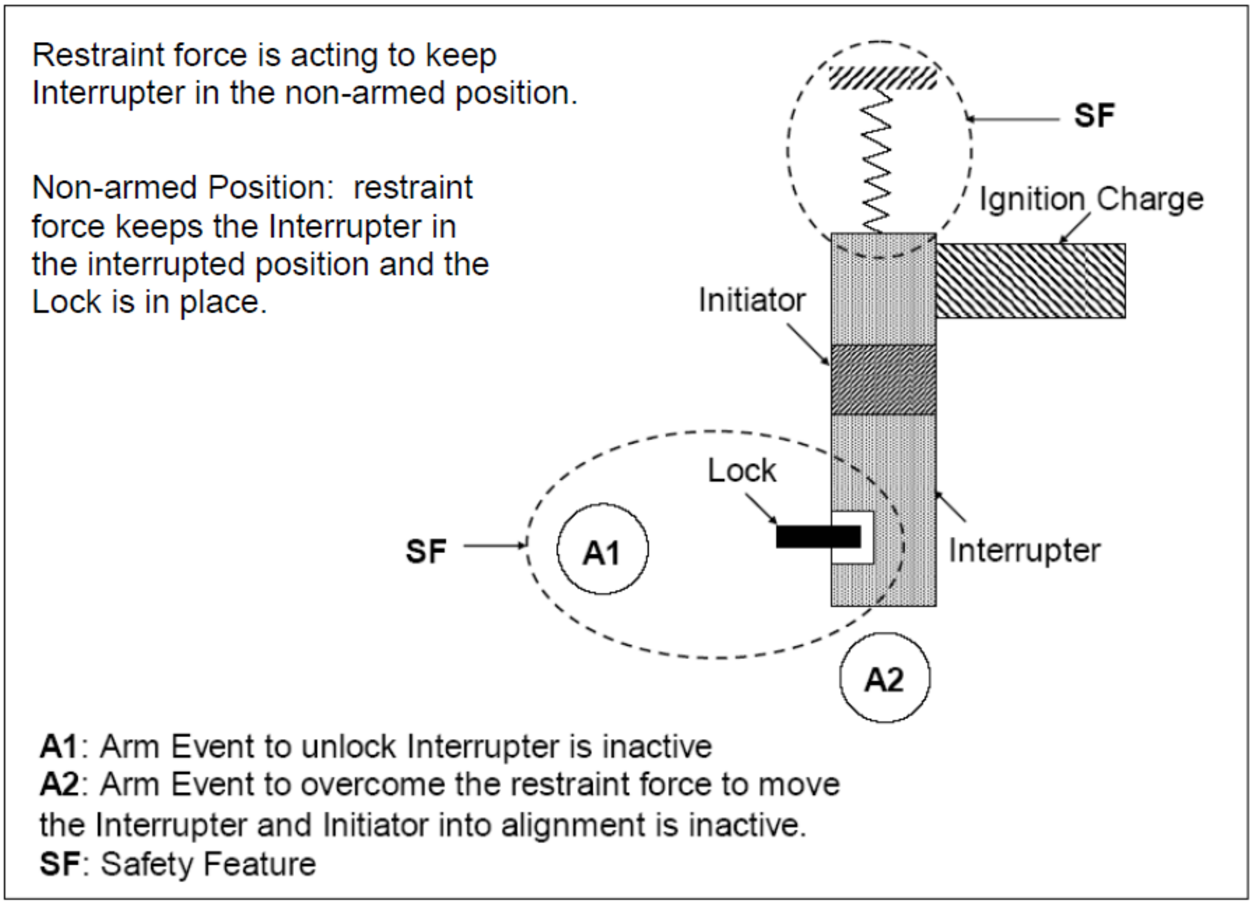

FIGURE 2: Pyrotechnic Train Interrupter Method of Restraint, paragraph 6.18.2.1.a., Non-armed Position Example

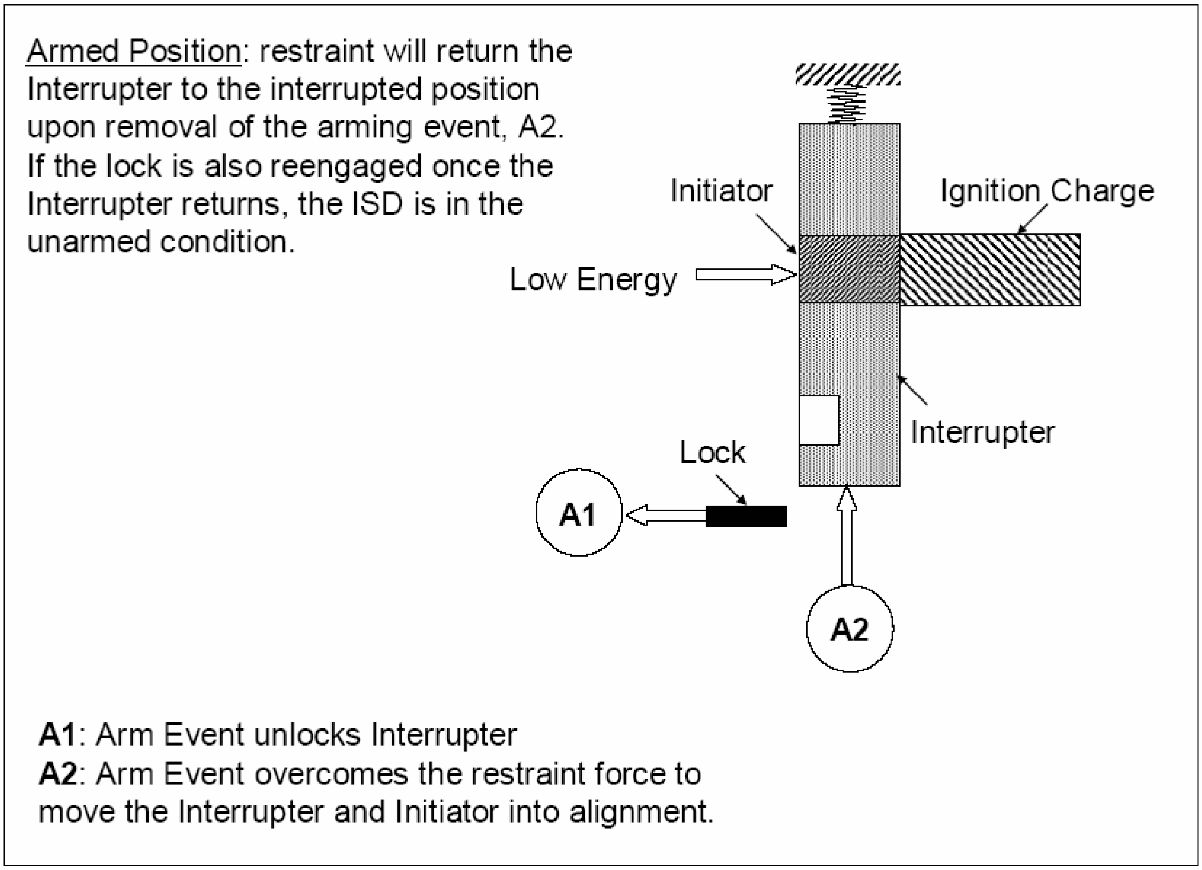

FIGURE 3: Pyrotechnic Train Interrupter Method of Restraint, paragraph 6.18.2.1.a., Armed Position Example

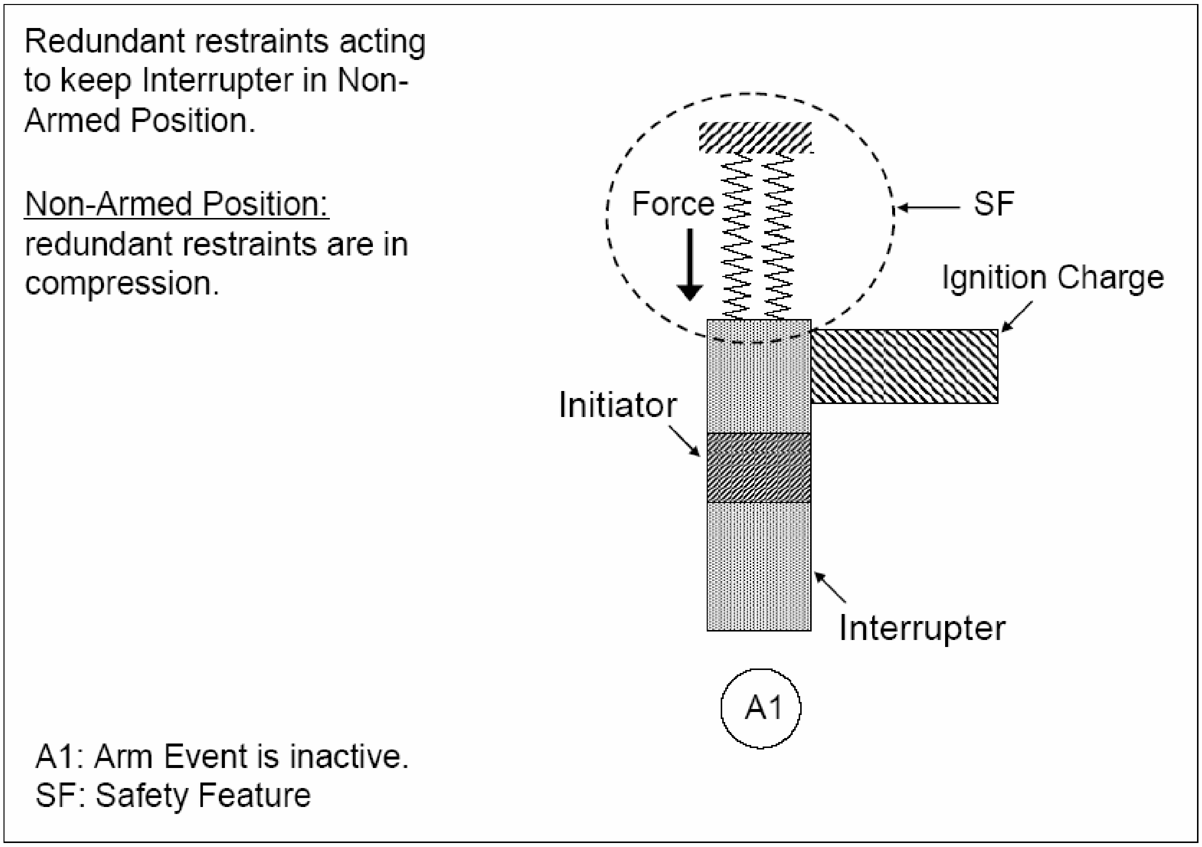

FIGURE 4: Method of Restraint, paragraph 6.18.2.1.b., Non-Armed Position Example

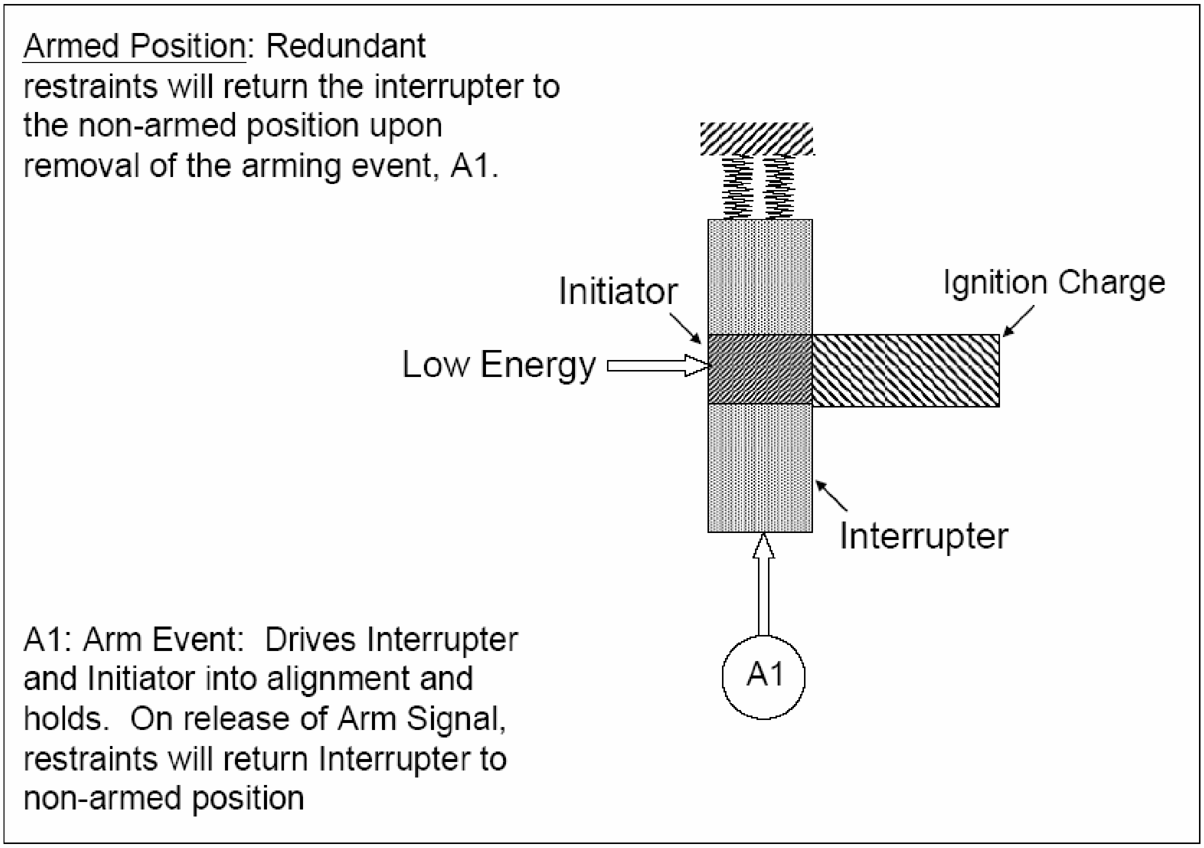

FIGURE 5: Method of Restraint, paragraph 6.18.2.1.b., Armed Position Example

B.2.2 FIRING ENERGY PATH INTERRUPTION FOR OUT-OF-LINE ENERGY CONVERSION DEVICES

Figures 6 through 9 illustrate examples of methods of a firing energy path interruption for out-of-line energy conversion devices, paragraph 6.18.3.1.

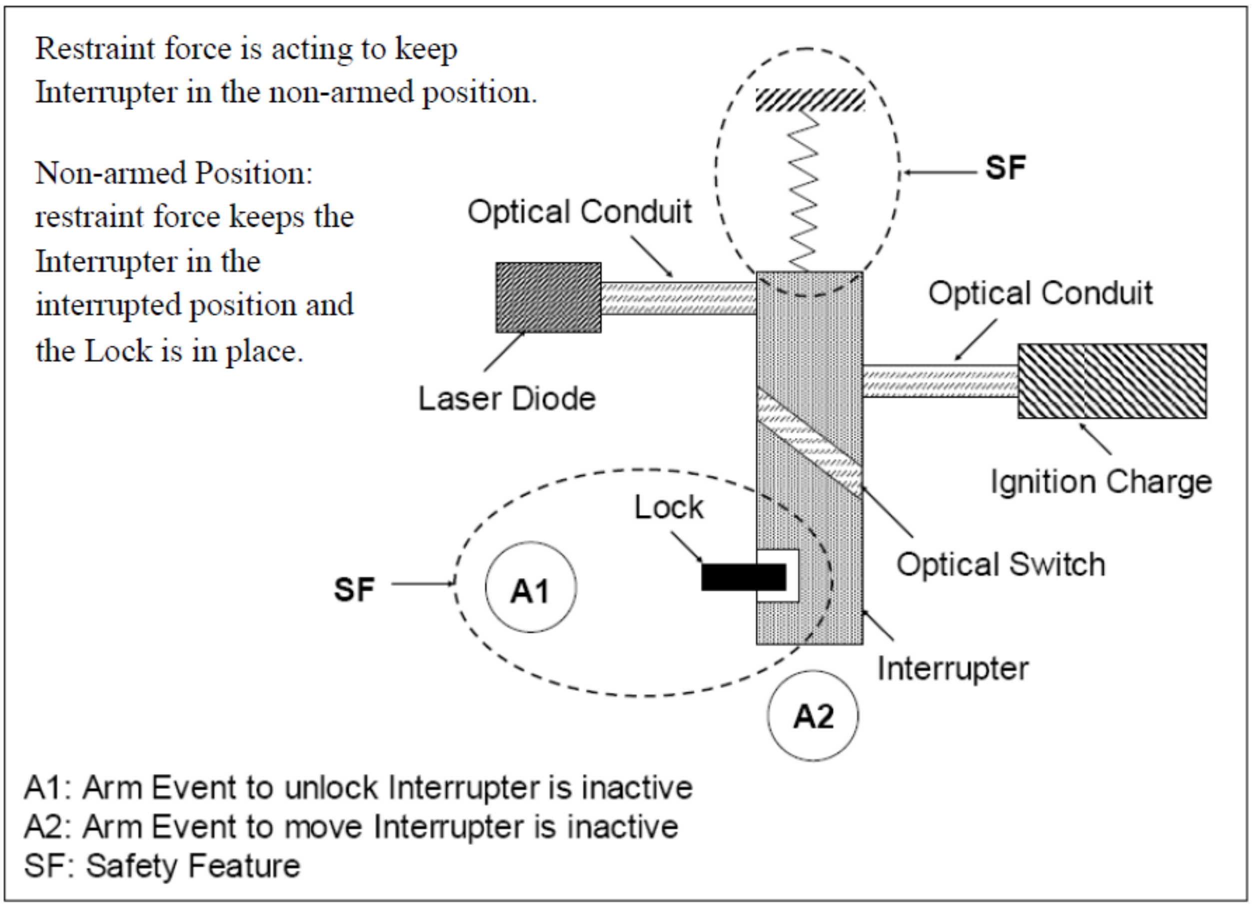

FIGURE 6: Firing Energy Path Interruption Method of Restraint, paragraph 6.18.3.1.a., Non-armed Position Example

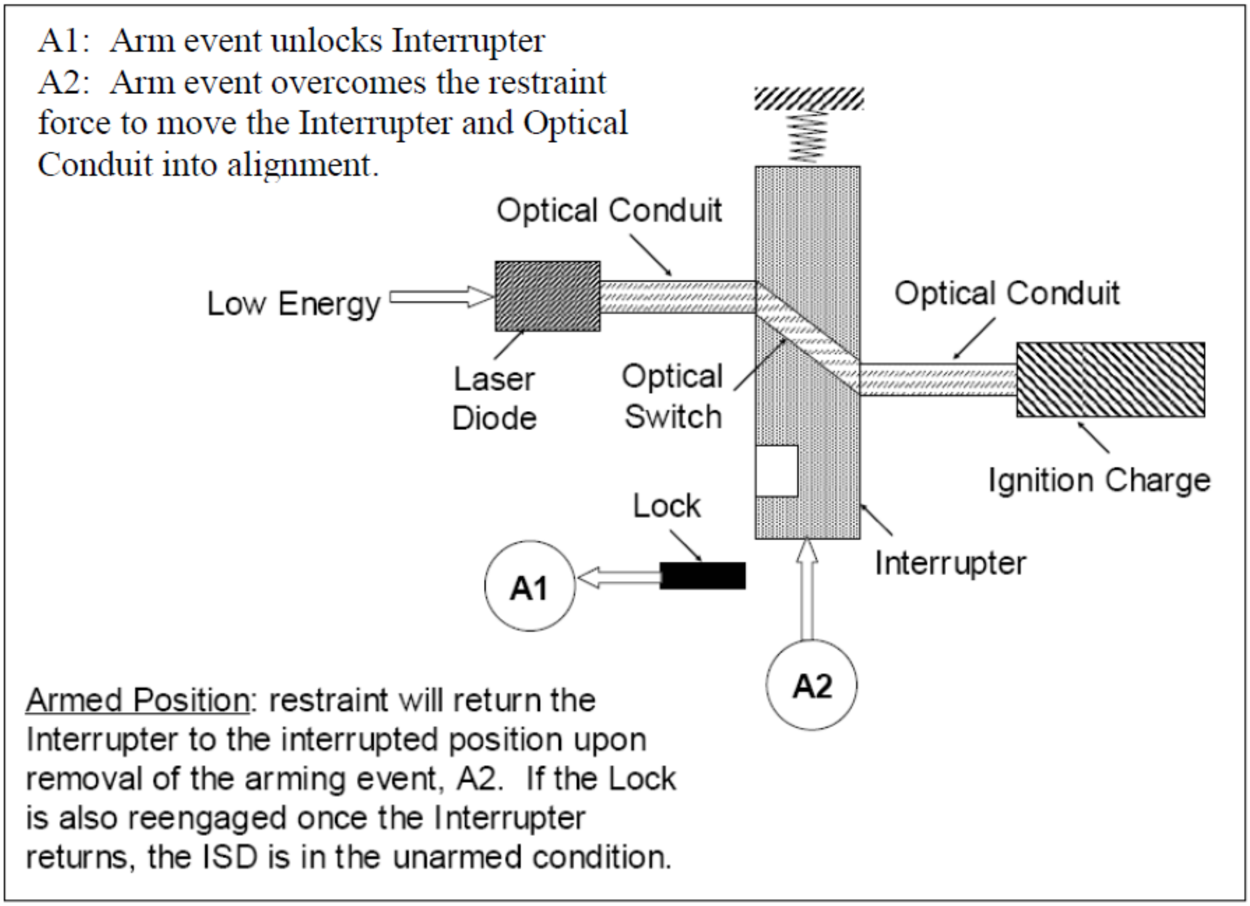

FIGURE 7: Firing Energy Path Interruption Method of Restraint, paragraph 6.18.3.1.a., Armed Position Example

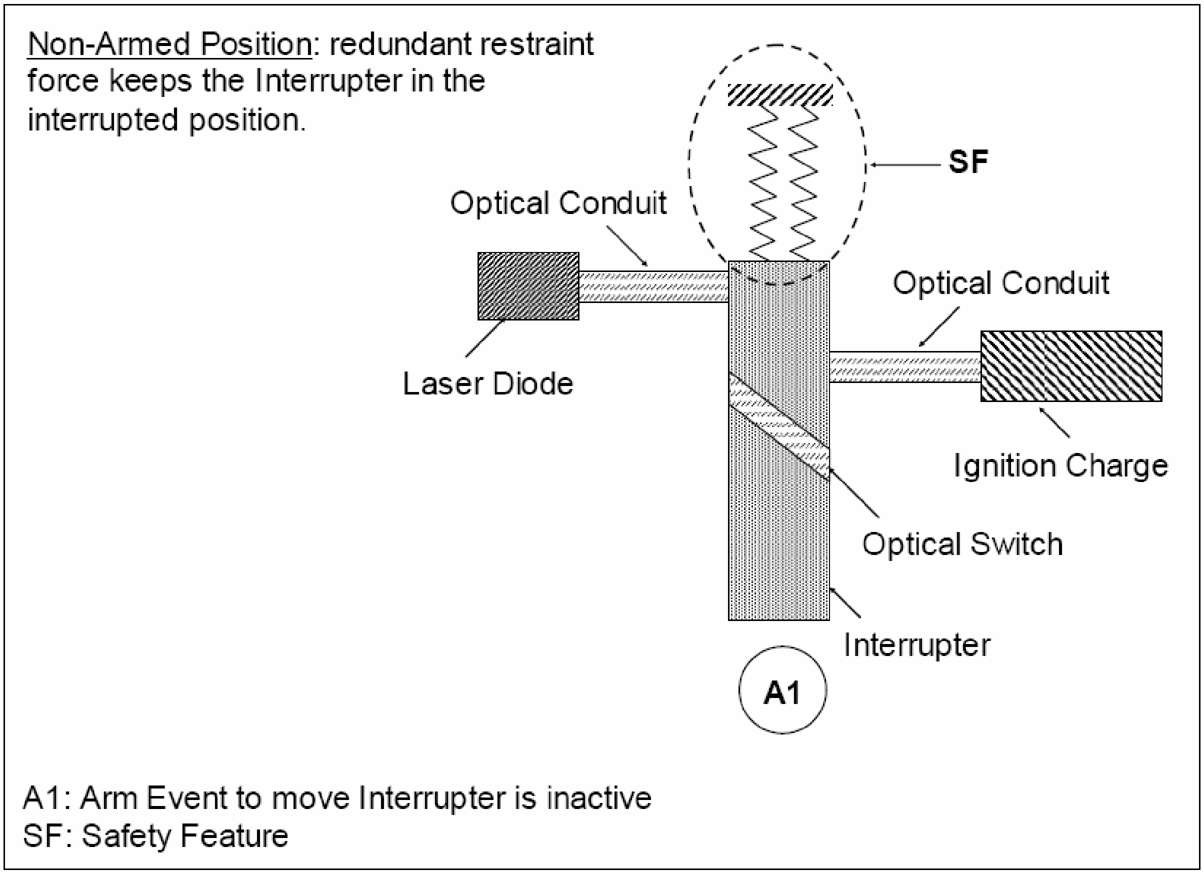

FIGURE 8: Firing Energy Path Interruption Method of Restraint, paragraph 6.18.3.1.b., Non-armed Position Example

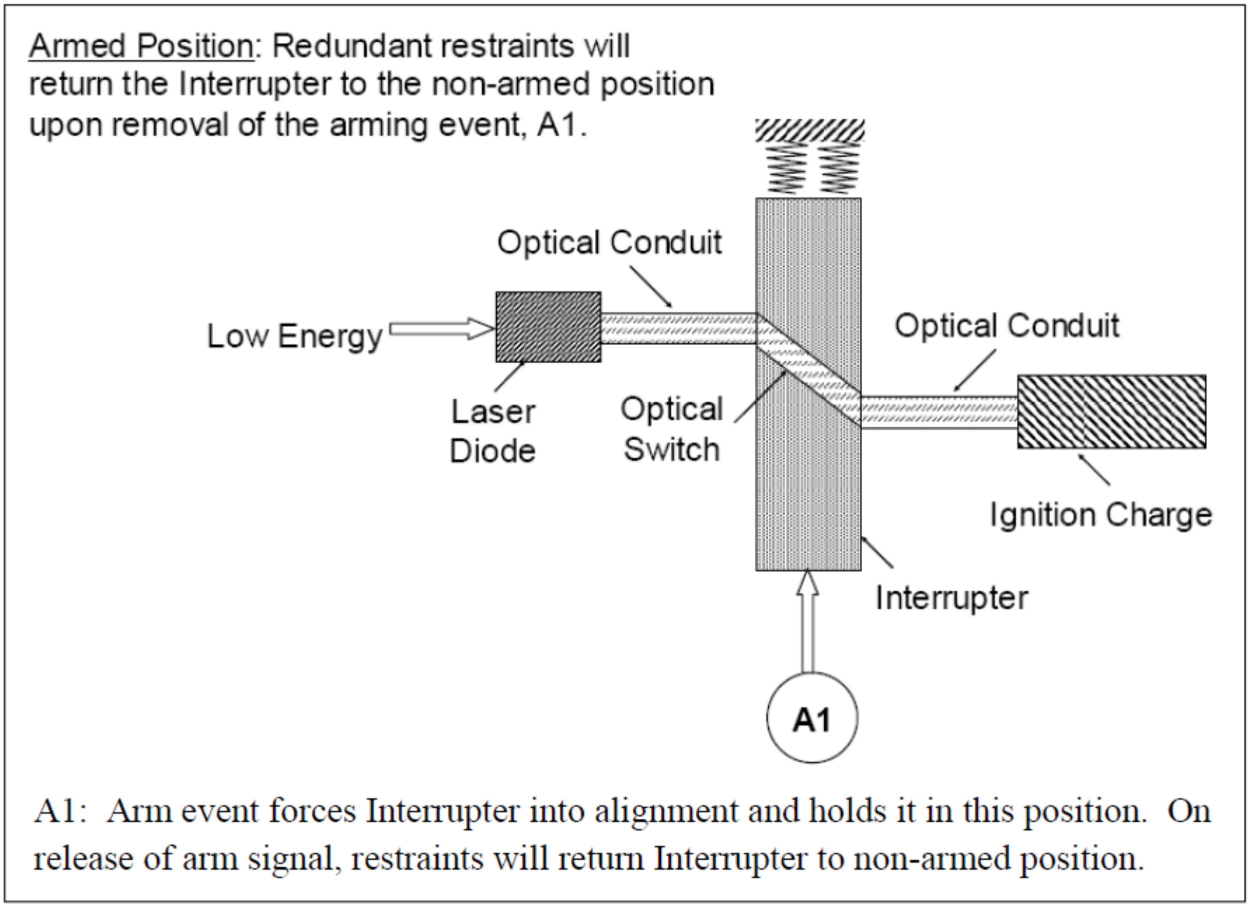

FIGURE 9: Firing Energy Path Interruption Method of Restraint, paragraph 6.18.3.1.b., Armed Position Example

B.2.3 ARMING ENERGY ACCUMULATION CONTROL FOR IN-LINE INITIATORS

Figures 10 and 11 are examples of arming energy accumulation control, paragraph 6.18.3.2, with in-line intiators.

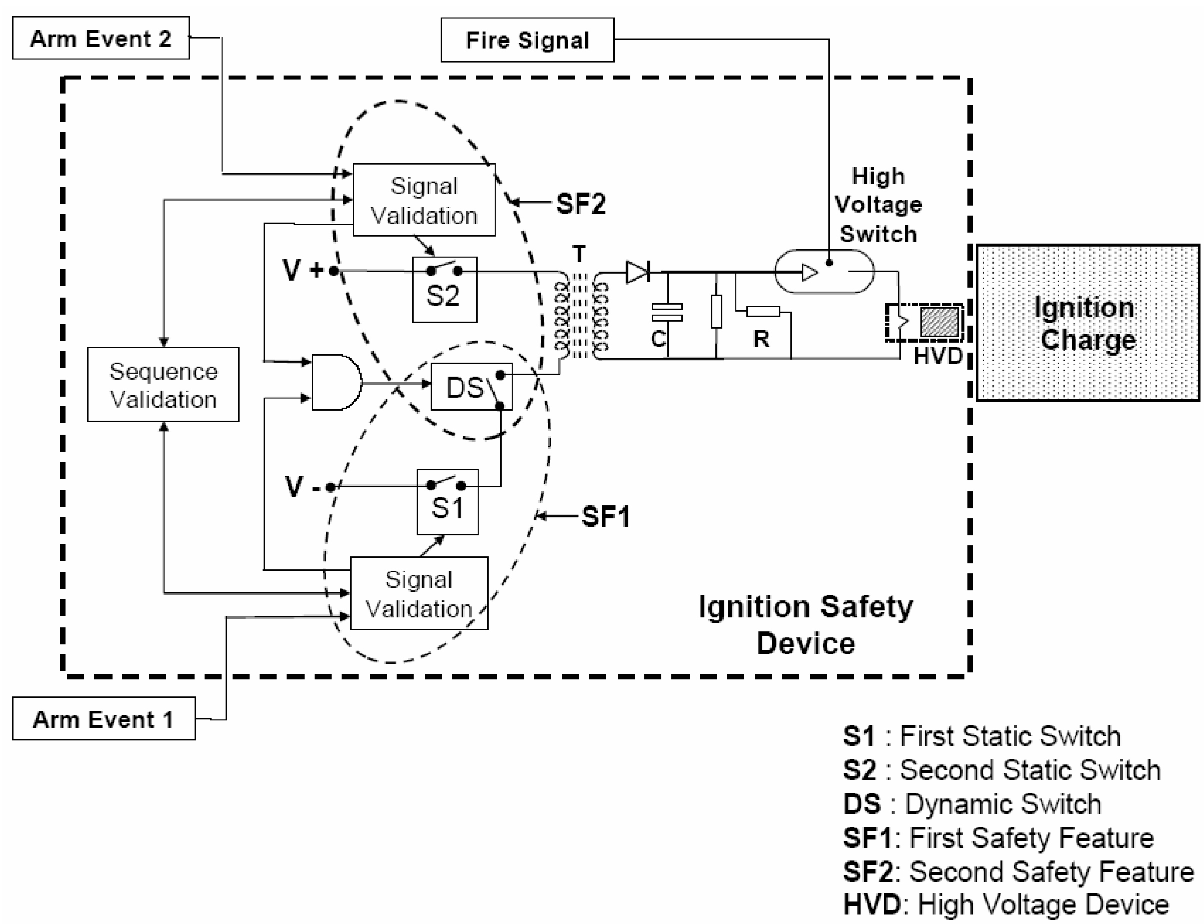

FIGURE 10: Arming Energy Accumulation Control with In-Line Initiators, paragraph 6.18.3.2., Example 1.

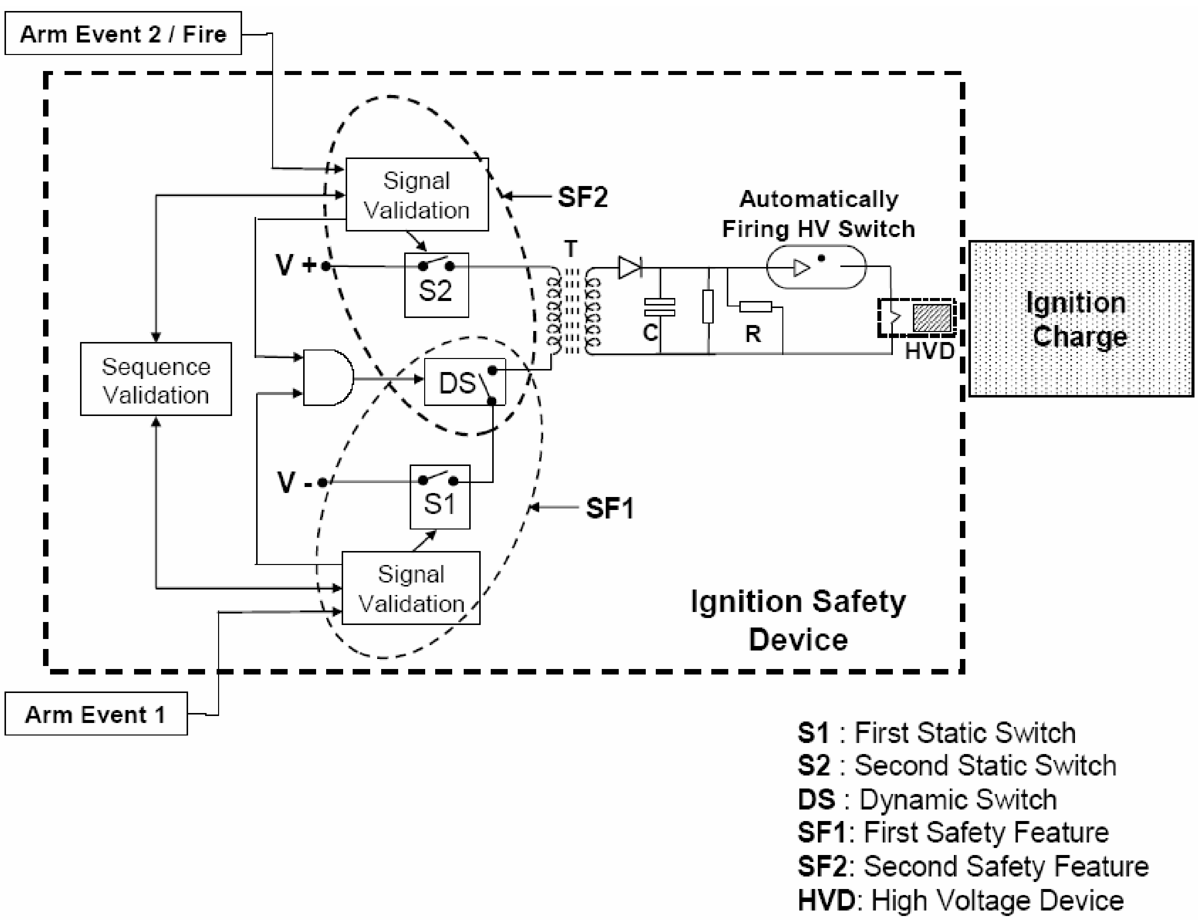

FIGURE 11: Arming Energy Accumulation Control with In-Line Initiators, paragraph 6.18.3.2., Example 2.