



**GODDARD TECHNICAL
STANDARD**

GSFC-STD-8715.1A

**Goddard Space Flight Center
Greenbelt, MD 20771**

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Goddard Space Flight Center (GSFC) Explosive Safety Program

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Goddard Space Flight Center (GSFC) Explosive Safety Program

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FOREWORD

This standard is published by the Goddard Space Flight Center (GSFC) to provide uniform engineering and technical requirements for processes, procedures, practices, and methods that have been endorsed as standard for NASA programs and projects, including requirements for selection, application, and design criteria of an item.

This standard establishes the requirements for implementing the Explosive Safety Program for GSFC including the component facilities which comply with 29 CFR 1910.109, *Occupational Safety and Health Standards for Explosives and Blasting Agents* as supplemented by NASA-STD-8719.12, *Safety Standards for Explosives, Propellants, and Pyrotechnics*. It defines the Explosive Safety Program process for applicable work performed at GSFC and other sites designated for GSFC approved programs and projects.

Requests for information, corrections, or additions to this standard should be submitted via “Contact Us” on the GSFC Technical Standards website at <http://standards.gsfc.nasa.gov>.

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GSFC Explosive Safety Program

1. SCOPE**1.1. Purpose**

The purpose of this standard is to define procedures required for the Goddard Space Flight Center (GSFC) Explosive Safety Program in accordance with 29 CFR 1910.109, *Occupational Safety and Health Standards for Explosives and Blasting Agents*, as supplemented by NASA-STD-8719.12, *Safety Standard for Explosives, Propellants, and Pyrotechnics*, specifically applied to locations under the influence of GSFC.

1.2. Applicability

This standard is applicable to all GSFC facilities, including Wallops Flight Facility (WFF), Independent Verification and Validation Facility (IV&V), Goddard Institute for Space Studies (GISS), Columbia Scientific Balloon Facility (CSBF), Poker Flat Research Range (PFRR), and other sites designated for GSFC approved programs and projects.

This standard may be cited in contract, program, and other Agency documents as a technical requirement. Mandatory requirements are indicated by the word “shall.” Tailoring of this standard for application to a specific program or project shall be approved by the Technical Authority for that program or project.

2. APPLICABLE DOCUMENTS**2.1. General**

The documents listed in this section contain provisions that constitute requirements of this standard as cited in the text of section 4. These documents are in addition to those already identified in NASA-STD-8719.12. The latest issuances of cited documents shall be used unless otherwise approved by the assigned Technical Authority. The applicable documents are accessible via the NASA Technical Standards System at <http://standards.nasa.gov>, directly from the Standards Developing Organizations, or from other document distributors.

2.2. Government Documents

| | |
|----------------------|---|
| 29 CFR 1910.157 | OSHA Standards for Portable Fire Extinguishers |
| 40 CFR 265.382 | EPA Open Burning; Waste Explosives |
| 40 CFR 266.202 | EPA Definition of Solid Waste |
| 47 CFR Part 15 | Radio Frequency Devices |
| 47 CFR 15.231 | Periodic operation in the band 40.66-40.70 MHz and above 70 MHz |
| 49 CFR 172 Subpart F | DoT Placarding Requirements |

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| 49 CFR 173.56 | DoT New Explosives - Definition and Procedures for Classification and Approval |
| 800-WI-8715.2.1 | Wallops Flight Facility Severe Weather Notification |
| AFI 91-208 | USAF Hazards of Electromagnetic Radiation to Ordnance Certification and Management |
| DEF 149-30-01 | U.S. Army Corps of Engineers Definitive Drawings for Barricades |
| DESR 6055.09 | Defense Explosives Safety Regulation |
| GPR 8500.3 | Waste Management |
| GPR 8715.5 | Fire Protection at GSFC |
| MIL-C-43122 | Military Specification for Cloth, Sateen, Cotton, Flame Retardant Treated |
| MIL-HDBK-240 | Hazards of Electromagnetic Radiation to Ordnance Test Guide |
| MIL-STD-464 | Electromagnetic Environmental Effects Requirements for Systems |
| NASA-STD-8719.11 | NASA Safety Standard for Fire Protection |
| NPR 1600.1 | NASA Security Program Procedural Requirements |
| NPR 1620.3 | Physical Security Requirements for NASA Facilities and Property |
| NPR 1800.1 | NASA Occupational Health Program Procedure |
| NPR 8621.1 | NASA Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping |
| NPR 8715.3 | NASA General Safety Program Requirements |
| TB 700-2 | Joint Tech Bulletin Ammunition and Explosives Hazard Classification Procedures |
| Technical Paper 16 | Department of Defense (DoD) Explosives Safety Board (DDESB) |
| Technical Paper 17 | Methodologies for Calculating Primary Fragment Characteristics DDESB Blast Effects Computer User's Manual and Documentation |
| UFC 3-340-02 | DoD Unified Facilities Criteria for Structures to Resist the Effects of Accidental Explosions |
| WFF-UXO-02/09/2018 | UXO/MEC Response Plan |

2.3. Non-Government Documents

| | |
|----------------|--|
| ETUG-GS01-15 | Explosive Testing Users Group Standard for In-Process Hazard Classification of Explosives |
| NFPA 1 | Fire Code |
| NFPA 495 | Explosive Materials Code |
| NFPA 704 | Standard System for the Identification of the Hazards of Materials for Emergency Response |
| NFPA 780 | Standard for the Installation of Lightning Protection Systems |
| NFPA 1122 | Code for Model Rocketry |
| NFPA 1125 | Code for the Manufacture of Model Rocket and High-Power Rocket Motors |
| NFPA 1127 | Code for High Power Rocketry |
| ST/SG/AC.10/11 | United Nations Recommendations on the Transport of Dangerous Goods, Manual of Tests and Criteria |

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2.4. Order of Precedence

When this standard is applied as a requirement or imposed by contract on a program or project, the technical requirements of this standard take precedence, in the case of conflict, over the technical requirements cited in applicable documents or referenced guidance documents.

3. ACRONYMS AND DEFINITIONS

Acronyms will only be listed in this section if defined in this standard. The acronyms used in this standard are intended to be common industry terms and recognizable by users. In some cases, GSFC specific acronyms are used to identify Center unique hardware, software, and/or support systems. Definitions that are defined in referenced documents are not repeated in this standard unless a GSFC specific application is highlighted. GSFC specific definitions may also be listed to elaborate on Center unique concepts, organizations, individuals, and/or systems.

3.1. Acronyms and Abbreviations

| | |
|----------------|--|
| CBE | Certification-by-Equivalency |
| CERT | Certified |
| CNG | Compressed Natural Gas |
| CONUS | Continental United States |
| CSBF | Columbia Scientific Balloon Facility |
| DDESB | Department of Defense Explosives Safety Board |
| DoD | Department of Defense |
| DoT | United States Department of Transportation |
| E | Electric Field Strength |
| E _f | Expected Fatalities |
| E3 | Electromagnetic Environmental Effects |
| EELP | Explosives, Energetic Liquids, and Pyrotechnics |
| E _f | Expected Fatalities |
| EID | Electrically Initiated Device |
| EIRP | Effective Isotropic Radiated Power |
| EME | Electromagnetic Environment |
| EOD | Explosive Ordnance Disposal |
| EPA | Environmental Protection Agency |
| ES | Exposed Site |
| ESO | Explosive Safety Officer |
| ETUG | Explosives Testing Users Group |
| f | Frequency |
| FCC | Federal Communications Commission |
| FOM | Facility Operations Manager |
| GHS | Globally Harmonized System of Classification and Labeling of Chemicals |
| GISS | Goddard Institute for Space Studies |
| GSFC | Goddard Space Flight Center |
| HD | Hazard Division |
| HERO | Hazards of Electromagnetic Radiation to Ordnance |

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| HMR | Hazardous Materials Regulations |
| IBD | Inhabited Building Distance |
| IDS | Intrusion Detection System |
| IGUS | International Group of Experts on the Explosion Risks of Unstable Substances |
| ILD | Intraline Distance |
| IMD | Intermagazine Distance |
| IMESAFR | Institute of Makers of Explosives Safety Analysis for Risk |
| IT | In-Training |
| IV&V | Independent Verification and Validation Facility |
| JHCS | Joint Hazard Classification System |
| JOCG | Joint Ordnance Commands Group |
| LP | Liquid Propane |
| MAE | Maximum Allowable Environment |
| ME | Mobile Emitter |
| MEC | Munitions and Explosives of Concern |
| MME | Modern Mobile Emitter |
| NEW | Net Explosive Weight |
| NEWQD | Net Explosive Weight for Quantity-Distance |
| NHR | No HERO Requirement |
| OBOD | Open Burn/Open Detonation |
| OJT | On-the-Job Training |
| OSHA | Occupational Safety and Health Administration |
| Pd | Power Density |
| PES | Potential Explosion Site |
| P _f | Probability of Fatality |
| PHA | Process Hazard Analysis |
| PHMSA | Pipeline of Hazardous Material Safety Administration |
| PFRR | Poker Flat Research Range |
| PSM | Process Safety Management |
| PTRD | Public Traffic Route Distance |
| QD | Quantity-Distance |
| QRA | Quantitative Risk Assessment |
| R&D | Research and Development |
| RORO | Roll-on/roll-off |
| S4 | Stockpile-to-Safe Separation Sequence |
| SATERN | System for Administration, Training, and Educational Resources for NASA |
| SHE | Safety, Health & Environment |
| SHetrak | Safety, Health, and Environmental-Finding Tracking System |
| SSD | Safe Separation Distance |
| SG | Subgroup |
| TFE | Traditional Fixed Emitter |
| UN | United Nations |
| UXO | Unexploded Ordnance |
| WFF | Wallops Flight Facility |

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3.2. Definitions

After-flame time: Time during which the material continues to flame after the ignition source has been removed or extinguished.

Antenna: That part of the receiving or emitting system designated to radiate or receive electromagnetic energy.

Antenna Gain: Performance figure combining the antenna's directivity and electrical efficiency. In an antenna, antenna gain describes how well the antenna converts input power into electromagnetic fields headed in a specific direction. In a receiving antenna, antenna gain describes how well the antenna converts electromagnetic fields arriving from a specific direction into electrical power. For the purposes of this document, antenna gain is expressed in dBi, unless otherwise noted.

Approved: Complying with the provision(s) of this document and with instructions and details issued by the GSFC Explosive Safety Officer (ESO).

Authorized User: All personnel that handle explosive material(s) are certified to the task assigned and competent for safe execution of the program, project, or mission regardless of onsite, offsite, host, or tenant activity.

Bridgewire: A metal wire heated by the passage of electrical current, which initiates the deflagration or detonation charge surrounding the wire.

Competent Authority Approval: An approval letter by the competent authority (national agency that is responsible, under its national law, for the control or regulation of some aspect of hazardous materials transportation) that is required under international standard, to authorize offering in commerce hazardous material. For example, United States Department of Transportation (DOT), Pipeline of Hazardous Material Safety Administration (PHMSA) is one of the national agencies for the United States.

Continuous Signal: An emitter producing uninterrupted electromagnetic energy. Amplitude modulation, frequency modulation, and phase modulation are considered continuous because the electromagnetic energy is continuously present. The power may vary with time due to modulation, but electromagnetic energy is always present.

Custodian: An individual (designated by a Program Office, Branch, and/or Project Manager) responsible for the accountability of all explosive materials, receiving, storing, issuing, transfers, and disposition.

Dudding: The inability of the EIDs to function as intended because the physical/electrical properties have been altered due to the application or repeated application of energy below that required to initiate the device.

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Effective Isotropic Radiated Power (EIRP): Amount of power in watts a theoretical isotropic antenna would emit to produce a peak power density observed in the direction of maximum antenna gain.

Electric Field Strength (E): Magnitude of the electric field vector with units of volts (V) per meter (V/m).

Electromagnetic Environment (EME): Resulting product of the power and time distribution, in various frequency ranges, of the radiated or conducted electromagnetic emission levels that may be encountered by a military force, system, or platform when performing its assigned mission in its intended operational environment (in the case of ordnance, during its S4). It is dynamically comprised of electromagnetic energy from a multitude of natural sources, such as lightning, precipitation static (p-static), electrostatic discharge, galactic and stellar noise, and so forth, and man-made sources, such as electrical and electronic systems, RF systems, electromagnetic devices, ultra-wideband systems, high-power microwaves systems, and so forth. When defined, the EME will be for a particular time and place. Specific equipment characteristics, such as operating frequencies and EMR emitter power levels, operational factors, such as distance between items and force structure and frequency coordination, all contribute to the EME.

Electromagnetic Environmental Effects (E3): Impact of the EME upon the operational capability of military forces, equipment, systems, and platform/systems. It encompasses all electromagnetic disciplines, including electromagnetic compatibility; electromagnetic interference; electromagnetic vulnerability; electromagnetic pulse; electronic protection; electrostatic discharge; and hazards of electromagnetic radiation to personnel, ordnance, and volatile materials such as fuel; and includes the electromagnetic effects generated by all EME contributors including RF systems; ultra-wideband devices; high-powered microwaves systems; p-static; and so forth.

Electrically Initiated Device (EID): Single unit, device, or subassembly that uses electrical energy to produce an explosive, pyrotechnic, thermal, or mechanical output (e.g., electro explosive devices (such as hot bridge wire, semiconductor bridge, carbon bridge, and conductive composition), exploding foil initiators, laser initiators, burn wires, and fusible links).

Escort: The management of a visitor's movements and/or accesses implemented through the constant presence and monitoring of the visitor by appropriately designated and properly trained U.S. Government or approved contractor personnel.

Explosives, Energetic Liquids, and Pyrotechnics (EELP): Applicable to energetic liquids used for propulsion or operation of missiles, rockets, and other related devices.

Explosives Facility License: Formal documented permission from the GSFC Explosives Safety Officer to operate a Licensed Explosive Location.

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Explosive Safety Officer (ESO): A trained and experienced person is designated as the ESO at each NASA Center to manage the Installation Explosives, Propellants, and Pyrotechnic Safety Program.

Facility: Buildings, structures, and other real property improvements including utilities and collateral equipment.

Facility Operations Manager (FOM): Individual having responsibility for conducting operations at a NASA facility. Monitoring matters that affect safety utilization and general livability of their assigned buildings and facilities including adjacent grounds, sidewalks, and parking lots. Central point of contact for coordination of building maintenance, repair, rehabilitation, and modifications.

Frequency (f): For a period function, frequency (f) is the number of cycles or events per unit time measured in hertz (Hz) or cycles per second.

Hazards of Electromagnetic Radiation to Ordnance (HERO): The situation in which exposure to external EME results in specified safety or reliability margins of EIDs or electrically powered ordnance firing circuits to be exceeded, or EIDs to be inadvertently actuated.

HERO Margin: Difference between the maximum no-fire stimulus and the permissible EID response level. For EIDs used in conventional ordnance, the margin is defined in MIL-STD-464, *Electromagnetic Environmental Effects Requirements for Systems*, as 16.5 dB for EIDs having a safety consequence and 6 dB for EIDs having a reliability consequence.

HERO Safe: Any ordnance item that is sufficiently shielded or otherwise so protected that all EIDs contained by the item are immune to adverse effects (safety and reliability) when the item is employed in the RF environment delineated in MIL-STD-464. The general HERO requirements defined in the hazards from EMR manuals must still be observed.

HERO Susceptible: Any ordnance item containing EIDs proven by test or analysis to be adversely affected by EMR to the point that the safety and/or reliability of the system is in jeopardy when the system is employed in the EME delineated in MIL-STD-464.

HERO Unsafe: Any ordnance item containing EIDs not certified as HERO SAFE or HERO SUSCEPTIBLE as a result of a HERO analysis or test. Additionally, any ordnance item containing EIDs (including those previously certified as HERO SAFE or HERO SUSCEPTIBLE) that has its internal wiring exposed; when tests are being conducted on that item resulting in additional electrical connections to the item; when EIDs having exposed wire leads are present and handled or loaded in any but the tested condition; when the item is being assembled or disassembled; or when such ordnance items are damaged causing exposure of internal wiring or components or destroying engineered HERO protective devices.

Incompatible Material(s): Materials that, when in contact with each other and outside of the condition of intended use, have the potential to react in a manner that generates heat, fumes, gases, or by-products that are hazardous to life and property.

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LITE Box: An approved container of EELP that has been opened and items removed or a container, certified by documentation or Performance Oriented Packaging (POP), with less than the approved amount of EELP within. This container should be properly marked and labeled as “LITE BOX”.

Maximum Allowable Environment (MAE): Highest radiated electric field strength levels to which ordnance can be exposed to without exceeding EID HERO margins.

Mobile Emitter (MEs): Similar to Traditional Fixed Emitters (TFE) except they can move, e.g., mobile ATC system, AN/TPS-75 radar system, etc.

Mode Stirring and Reverberation: RF techniques whose goals are to describe an enclosed space stochastically in terms of the distribution of the electric fields due to energy that may be within the space, either through internal EMR emitters or leakage into the space from external sources. They are particularly useful for describing the frequency response of aircraft weapon compartments which are often very complex structures. The tests are performed such that the boundary conditions of the compartment are maintained constant while the frequency of the RF radiation is allowed to vary over a narrow interval about some center frequency. The contributions of each reverberant mode to a given spatial point in the compartment, known as eigen-modes, are averaged over each narrow frequency band tested resulting in an approximation of the field homogeneity within the compartment. The results allow an evaluation of the likelihood of fields at, above, or below certain levels.

Modern Mobile Emitter (MMEs): Have the capability of moving with respect to the location of the EIDs, as well as any other low power EMR emitters, part of modern communication and data systems, e.g., cellular telephones, barcode readers, wireless laptops, tablets, network access points, and any other EMR emitter potentially brought close to EIDs.

No HERO Requirement (NHR): Category of ordnance that do not contain EIDs. The ordnance may be totally inert or it may contain explosive material that cannot be initiated by RF energy. These items are not subject to HERO testing/analysis or the HERO requirements of Services’ publications. These items may be included in the ordnance databases as NHR ordnance.

Power density (Pd): Power flow per unit area with units of W/m² or mW/cm². Average power density is the quantity related to the heating properties of EMR and, hence, to personnel and other hazards, while peak power density becomes important in the study of the effects to electromagnetic fields on EIDs and on fuel hazards.

Pulse-Modulated Signal: Electromagnetic energy transmitted by pulse-modulated radars consists of a series of equally spaced pulses separated by very short but relatively long periods during which no electromagnetic energy is transmitted. The pulse width (pw) is the duration of the radar pulse. The pulse repetition frequency (prf) is the number of pulses per second. Peak power of the system is the power of the transmitter contained in the radiated pulses. Because the radar is resting for a time that is long with respect to the operating time, the average power

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delivered during one cycle of operating is relatively low compared with the peak power available during the pulse time. The operating cycle of the radar can be described in terms of the fraction of the total time electromagnetic energy is radiated. This time relationship is the DC.

Reliability Consequence: The inadvertent actuation of an EID that does not result in a safety consequence, but degrades system performance; i.e., renders the ordnance item either ineffective or unable to function as intended. In addition, the definition has been expanded to include dudding where the system would no longer be reliable.

Safe Separation Distance (SSD): For HERO, the calculated distance, in feet or meters, from an EMR emitter beyond which the radiated power density from the EMR emitter has decreased to a level too low to couple enough energy into the EIDs to initiate detonation. Measurements of the SSD may take into account both the horizontal and vertical difference in length and height between the EMR emitter and the EIDs.

Safety Consequence: The inadvertent actuation of an EID that creates an immediate catastrophic event with the potential to either destroy equipment or injure personnel, such as the firing of an inline rocket motor igniter by EMR energy; or the inadvertent actuation of an EID that increases the probability of a future catastrophic event by removing or otherwise disabling a safety feature or the ordnance item. This, e.g., might be caused by the EMR initiation of a piston actuator that removes a lock of the safety-and-arming rotor of an artillery fuze, thus allowing a sensitive detonator to rotate-in-line with the explosive train.

Stockpile-to-Safe Separation Sequence (S4): Consists of six phases as defined in MIL-HDBK-240, *Hazards of Electromagnetic Radiation to Ordnance Test Guide*, are as follows:

- **Transportation/Storage:** The phase in which the ordnance is packaged, containerized, or otherwise prepared for shipping or stored in an authorized storage facility. This includes transporting of the ordnance.
- **Assembly/Disassembly:** The phase involving all operations required for ordnance build-up or breakdown and typically involves personnel.
- **Staged:** The phase where the ordnance has been prepared for loading and is pre-positioned in a designated staging area.
- **Handling/Loading:** The phase where physical contact is made between the ordnance item and personnel, metal objects, or structures during the process of preparing, checking out, performing built-in test, programming/reprogramming, installing, or attaching the ordnance item to its end-use platform/system; e.g., aircraft, launcher, launch vehicle, or personnel. These procedures may involve making or breaking electrical connections, opening and closing access panels, and removing/installing safety pins, shorting plugs, clips, and dust covers. This configuration also includes all operations required for unloading; i.e., removing, disengaging, or repackaging the ordnance item.

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- **Platform-Loaded:** The phase where the ordnance item has been installed on or attached to the host platform/system (e.g., aircraft, ground vehicle, and personnel and so forth) and all loading procedures have been completed.
- **Immediate Post-Launch:** The phase where the ordnance item has been launched from its platform/system, but up to its SSD with regards to the actuation of its explosives, pyrotechnics, or propellants.

Surveillance Program: A surveillance program involves monitoring potentially damaging changes to explosives caused by aging or environmental factors. A surveillance program includes routine inventory reporting, internal inspections, and may involve stability testing.

Traditional Fixed-Location Emitter (TFEs): All EMR emitters are in a fixed location, usually mounted on a tower, mast, or rooftop.

4. REQUIREMENTS

This section of the GSFC standard has been organized to resemble NASA-STD-8719.12 by using the same section headings and arranging the headings in a similar order. The intention is to facilitate easier cross referencing between the Agency-level and Center-level documentation. The requirements defined in the Agency-level and other applicable documents are only referenced for traceability, but are not repeated verbatim in this standard. This standard focuses on implementation strategies of higher level requirements.

4.1. Equivalency

NASA-STD-8719.12 allows for the determination of equivalency on a case-by-case basis based on a hazard analysis of the proposed siting so long as there is no increase in acceptable risk. This section provides the basis for quantifying the risks from a Potential Explosion Site (PES) to personnel at each Exposed Site (ES) (individual risk (probability of fatality (P_f))) and at all exposed ESs (group risk (expected fatalities (E_f))) by performing a quantitative risk assessment when the Quantity-Distance (QD) criteria cannot be met.

P_f is a function of the probability of an explosives event, the probability of fatality given an event and exposure, and the exposure of one person. E_f is a function of the probability of an explosives event, the probability of fatality given an event and exposure, and the exposure of all persons within the risk-based evaluation distance. The acceptable level of risk identified for explosive related operations has been identified in the table below:

| Risk to: | Criteria: |
|--|----------------------------------|
| Any one related individual - Related P_f | $\leq 1 \times 10^{-4}$ per year |
| All related individuals - Related E_f | $\leq 1 \times 10^{-3}$ per year |
| Any one unrelated individual - Unrelated P_f | $\leq 1 \times 10^{-6}$ per year |
| All unrelated individuals - Unrelated E_f | $\leq 1 \times 10^{-5}$ per year |
| (Reference DESR 6055.09 Table V6.E5.T1) | |

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If a quantitative risk assessment is to be performed, then the GSFC Explosive Safety Officer (ESO) shall approve the assumptions used, the assessment method, and the associated software tools used to perform the assessment.

4.2. Process Safety Management

29 CFR 1910.109 requires a Process Safety Management (PSM) program when explosive chemical compounds, mixtures, or devices are manufactured. In a 1998 letter, the Occupational Safety and Health Administration (OSHA) clarified the requirement for a PSM program to not include activities conducted in a separate, non-production research or test area or facility; and do not have the potential to cause or contribute to a release or interfere with mitigating the consequences of a catastrophic release from the explosive manufacturing process include:

- product testing and analysis which is not part of any in-production sampling and testing of the explosive manufacturing process;
- chemical and physical property analysis of explosives and propellants and pyrotechnics formulations;
- scale-up research chemical formulations to develop production quantity formulations;
- analysis of age tests conducted on finished products;
- failure analysis tests conducted on pre-manufactured or finished products;
- x-raying;
- quality assurance testing (not including the extraction of samples from an active explosive manufacturing [production] process);
- evaluating environmental effects, such as hot, cold, jolt, jumble, drop, vibration, high altitude, salt, and fog; and
- assembly of engineering research and development models.

Programs conducting operations involving explosives at GSFC and its component facilities shall coordinate with the GSFC ESO to determine if the PSM requirement is applicable. If it is determined to be applicable, then the GSFC ESO will work cooperatively with the Program to develop a tailored implementation strategy to meet the OSHA requirement.

4.3. Audits

The GSFC ESO will conduct routine facility inspections and program audits per established mechanisms to meet or exceed the requirement for biennial audits defined in NASA-STD-8719.12. Facility inspections and program audits include, but are not limited to, the following:

- safety spot inspections with findings tracked in Safety, Health, and Environmental-Finding Tracking System (SHEtrak)
- annual safety inspections with findings tracked in SHEtrak
- annual Internal Audit Program (IAP) Review, tracked Wallops Safety Office
- routine explosive inventory audits, tracked by GSFC ESO
- explosives facility license inspections, tracked by GSFC ESO

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These facility inspections and program audits may be performed by the GSFC ESO or designee authorized by the GSFC ESO. Programs conducting operations involving explosives at GSFC and its component facilities are required to participate in these facility inspections and program audits as deemed necessary by the GSFC ESO.

4.4. Minimum Use of Explosives

It is the cardinal principle of the GSFC explosive safety program to minimize exposures consistent with safe and efficient operations (i.e. expose the minimum number of people for the minimum time to the minimum amount of explosives). One key aspect of achieving this goal is to avoid the accumulation of excess and unneeded Explosives, Energetic Liquids, and Pyrotechnics (EELP). EELP shall be deemed in excess and/or unneeded unless the following criteria are met:

- there is a clearly identifiable owner of the EELP
- there is a funded (in place or anticipated from an identified source) requirement for the EELP within the next five years
- there is a funded and active surveillance program for the EELP
- the storage and/or handling of the EELP has been authorized by the GSFC ESO
- the EELP is identified as serviceable for its intended use

If the above criteria are not met, then the EELP is in violation of the minimum quantity rule and represents an unnecessary hazard to personnel and property. If another offsite user cannot be found, the Environmental Office should be contacted in preparation for proper disposal.

4.5. Personnel Limits

4.5.1. Establishing Personnel Limits - Explosive Site Plan

The GSFC ESO will work with the facility users to establish personnel limits based on a Process Hazard Analysis (PHA) of activities envisioned for the facility when use of energetic materials are authorized via an approved site plan.

4.5.2. Establishing Personnel Limits - Explosives Facility License

The GSFC ESO will work with the manager of the activity involving energetic materials to establish personnel limits based on a PHA of activities to be executed at the location authorized via an approved explosive license.

4.6. Explosive Area Placarding

Personnel limits shall be prominently posted in explosive areas, included in explosives operating procedures, and briefed in pre-operational briefings. Personnel limits will distinguish between supervisors, workers, and casuals.

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Casuals are defined as persons not normally part of an explosives operation but have duties that require their presence, such as quality assurance, safety or inspection personnel. Casuals are different from non-essential visitors who should have limited access. Hazardous operations are to be stopped when non-essential visitors are present.

Do not post personnel limits at aircraft parking locations, even if used for uploading or downloading explosives. Also, do not post personnel limits at licensed explosive locations. Inclusion of personnel limits in written explosives operating procedures and pre-operational briefings will suffice for personnel limit posting at licensed explosive locations.

4.7. Item Labeling

4.7.1. Declaring Used, Expended, or Fired Articles as Inert

Programs conducting operations involving EELP at GSFC and its component facilities that result in used, expended, or fired articles shall develop a visual inspection procedure for ensuring that the EELP is consumed and the remaining vessel no longer represents an explosive hazard. The procedure shall be reviewed and approved by the GSFC ESO.

The purpose of the visual inspection is not to declare the vessel as non-hazardous. The used, expended, or fired vessel may still represent a hazard (e.g., chemical, heavy metal, etc.), but not specifically an explosive hazard. Where an explosive hazard is defined as a condition where danger exists because explosives are present that may react leading to a detonation or deflagration in a mishap with potential unacceptable effects (e.g., death, injury, damage) to people, property, operational capability, or the environment.

4.7.2. Labeling of Used, Expended, or Fired Articles as Inert

Used, Expended, or Fired Article that have passed a visual inspection per approved procedure shall be labeled as inert per local policies and procedures.

4.8. ESO Responsibility

The GSFC ESO shall serve as the Chairperson of the GSFC Explosive Safety Advisory Committee with responsibility for the technical direction of the committee. The GSFC ESO may appoint an Administrator for the Explosive Safety Advisory Committee who is responsible for capturing meeting minutes and assisting with generating committee presentations and reports.

NASA-STD-8719.12 authorizes the GSFC ESO to revoke an individual's explosive handler certification. The justification for revoking an individual's explosive handler certification would be a lapse in qualifying requirements, an inability to demonstrate job proficiency, or sufficient violation of safe practices.

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Any violations of safe practices involving explosives shall be reported to the GSFC ESO and addressed immediately with a corrective action issued by the GSFC ESO in collaboration with the GSFC Explosive Safety Advisory Committee. The corrective action will be commensurate with the severity of the violation.

4.9. ESO and Explosives Handlers Training and Qualifications

GSFC's organizational complexity justifies a multi-faceted explosive handler training and qualification program tailored to the particular needs of the larger divisions, branches, program offices, and equivalent groups. The request for tailoring should be balanced against limitations in resources and in turn necessitates a standard of commonality across the different training and qualification programs.

The following outlines the NASA-STD-8719.12 guidelines for explosive handler training and qualification programs with tailoring within as defined in this standard:

- a. The organization-specific explosive handler training and qualification programs shall be approved by the GSFC ESO before implementation. The approvals are captured in memorandums signed by the GSFC ESO in which the organization specific explosive handler training and qualification programs is described.
- b. The organization-specific explosive handler training and qualification programs must contain provisions for course(s) (online, instructor led, etc.) specific to the types of explosives handled by those qualified. The course(s) shall be completed within a three-year recurring time period.
- c. The organization specific explosive handler training and qualification programs shall contain provisions for on-the-job training (OJT) specific to the types of explosives handled by those qualified. The OJT shall be documented and associated paperwork submitted on a three-year recurring time period.
- d. The organization explosive handler training and qualification program shall comply with the explosive handler certification classifications and organizational limitations as identified in this standard.
- e. The explosive handlers within the organization-specific explosive handler training and qualification programs shall comply with the general qualification requirements identified in this standard.

4.9.1. Explosive Handler Certification Classifications

Explosive handler certifications consist of the following classifications:

- a. In-Training (IT) - Personnel that have completed the minimum requirements defined in the general and organization-specific explosive handler training and qualification programs. The IT classification applies to personnel that have little to no explosive

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handling experience concerning explosive operations and/or newly qualified personnel who require supervision during activities involving explosives.

IT personnel shall be directly supervised in the performance of functions for which he/she is being certified by an individual who holds a certified status on the particular articles and/or systems of interest. IT classified personnel typically retain an IT classification for a set period determined by their organization's specific explosive handler training and qualification programs prior to applying for a qualification upgrade to the CERT level where they can operate unsupervised.

- b. Certified (CERT) – Personnel shall have knowledge of the basic explosive safety precautions pertaining to tasks associated explosive devices. The CERT classification applies to personnel that have an appropriate level of explosive handling experience as defined by the organization's specific explosive handler training and qualification programs. CERT personnel are authorized to conduct operations involving explosives without direct supervision. CERT personnel can also supervise an individual who is categorized as IT. CERT personnel typically retain this certification for no more than three years before re-certification is required.
- c. Certification-by-Equivalency (CBE) – Personnel have provided adequate information in order to receive explosive handler certification similar to their current certification outside of GSFC. Adequate information includes:
 - (1) Description of relevant training with dates (classroom and/or OJT)
 - (2) Description of relevant operational experience with dates
 - (3) A completed physician examination form (contact GSFC ESO), when applicable

Any restrictions implemented by the external certifying organization will also be applicable at GSFC.

4.9.2. Explosive Handler Certification Limitations

Organizational specific explosive handler training and qualification programs shall be assigned with accompanying limitations to avoid explosive handlers performing tasks for which they have not been qualified. These limitations shall be identified in the organizations explosive handler training and qualification programs and approved by the GSFC ESO. These limitations typically fall into the following categories:

- a. Expiration Date – Date on which an individual's certification expires. An individual's certification expires at midnight on the date identified. An individual's certification shall expire and require renewal after (at most) three years.
- b. ACTIVE / INACTIVE – Status given to granted certifications by CERTRAK. ACTIVE certifications denote all requirements are being met. INACTIVE certifications denote

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one or more requirements are not being met. An individual with an INACTIVE certification is not authorized to perform explosive handling operations. An INACTIVE certification will automatically return to ACTIVE status once all requirements are met without re-certification.

- c. Qualifying Organization/Program – Organization and/or program sponsoring an individual's certification. An organization and/or program can only assign an IT and/or CERT status specific to its training and qualification program. Organizations and/or programs are not allowed to assign an IT and/or CERT status outside of its training and qualification program. Individuals with an IT and/or CERT status are only authorized to conduct activities within that specific organization and/or program.
- d. Organization/Program Specific Assignment Code(s) – Organizations and/or programs may subdivide its IT and/or CERT status assignments. Individuals with an IT and/or CERT status are only authorized to conduct activities within that specific subdivision as defined in that organization's specific program.

These limitations will be associated with an individual's explosive handler certification allowing spot checks by the responsible onsite safety representative(s) to ensure that individual is operating within the bounds of their specific qualifications.

An individual's explosive handler certification is limited to sites and facilities where the GSFC ESO holds sole safety oversight authority for the explosive safety program. If a site/facility is under the oversight of a different safety organization, then an individual shall also be certified to conduct activities involving explosives per that safety organization's qualification program or have that safety organization accept their GSFC certification(s).

4.9.3. General Explosive Handler Certification Requirements

The below general certification requirements have been approved by the GSFC ESO for all organization specific explosive handler training and qualification programs in compliance with NASA-STD-8719.12 and in recognition of best practices at other NASA Centers.

To obtain explosive handler certification, applicants, or the applicants' organization(s) shall:

- a. Submit a request for explosive handler training and/or qualification via the CERTRAK system for adjudication by their management and the GSFC ESO. Requests are submitted by the immediate supervisor, or a designated training coordinator, for the individual seeking training and/or qualification.
- b. Have their organizational Approving Official validate the need to handle explosives in the execution of work duties or responsibilities. This validation is facilitated via the CERTRAK system as part of the standard approval process.
- c. Successfully complete the approved organization's specific explosive safety training course(s), the Basic Explosive Safety Training, the Explosive Safety Management

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Course, and review NPR 8621.1, *Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping*. Organizational specific explosive safety training courses shall be included in the organizations specific explosive handler training and qualification program approved by the GSFC ESO.

All explosive safety training courses shall include a written/oral exam covering the course items. Eighty percent (80%) correct is the minimum passing score. Test scores are to be reported directly by the course instructor to the CERTRAK Administrator.

- d. Demonstrate a proficiency in explosive handling techniques through on-the-job training, direct experience, or by “classroom demonstration” for assignment of CERT status. For personnel requesting recertification, they need to demonstrate adequate explosive handling experience per the organization’s specific explosive handler training and qualification program.

Demonstration of proficiency is validated by the immediate supervisor and facilitated via the CERTRAK system as part of the standard approval process.

- e. Demonstrate through a certification provided by a licensed medical provider that the applicant possesses no disqualifying health problems by undergoing routine physical exams. All explosive handlers shall obtain physical exams in accordance with the requirements of NPR 1800.1, *NASA Occupational Health Program Procedures*.

NOTE: Do not provide any specific medical documentation or information to the GSFC ESO or CERTRAK Administrator. Any medical information inadvertently provided will be transmitted to the appropriate GSFC Health Unit.

NOTE: At any time that an approved explosive handler experiences or is diagnosed with a medical condition that would be disqualifying, the individual will so notify their supervisor and their certification be placed on INACTIVE status.

Demonstration of medical clearance shall be captured on the appropriate medical surveillance clearance form and submitted via the CERTRAK system as part of the standard approval process.

- f. Submit any other relevant artifacts defined in CERTRAK attesting that the applicant has met the minimum requirements for assignment of IT status or all the certification requirements for assignment of CERT status. Applicable artifacts shall be submitted via the CERTRAK system as part of the standard approval process.

4.9.4. Explosive Handler Certification Approval Process

The following steps outline the training request and qualification approval process:

- a. An immediate supervisor, or designated training coordinator, will initiate a training and/or qualification request via CERTRAK. The person initiating the request is

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responsible for inputting the necessary information for a new request or validating existing information for re-certifications. This information is specified in this standard and the organization's approved explosive handler training and qualification program.

The immediate supervisor, or designated training coordinator, is responsible for confirming the applicant's completion of required OJT.

- b. Information related to required online and/or instructor led courses administered via the System for Administration, Training, and Educational Resources for NASA (SATERN) will automatically populate. All SATERN courses related to general prerequisites, program specific prerequisites, and recurring educational requirements shall be met before a request will be adjudicated.
- c. The CERTRAK Administrator will verify that the required physical examination has been completed through collaboration with the appropriate governmental health unit and/or medical organization.

The organizational approving official shall validate the applicant's need for training and/or certification and accuracy of the applicant's submitted information within the request package. This advances the request package to the next level of approvals.

- d. CERTRAK will automatically query the GSFC ESO seeking approval of the submitted request package as the Certifying Official.
- e. Upon the GSFC ESO's approval, an explosive handler certification is assigned in CERTRAK specific to the terms of the original request.

If an individual disagrees with the GSFC ESO's decision related to their certification in any way, then they can appeal to the GSFC Explosive Safety Advisory Committee for reconsideration. If the committee arrives at a different assessment than the GSFC ESO, then the Wallops Safety Office Chief is empowered to levy the final determination based on counsel from the committee members and the GSFC ESO.

Personnel desiring to modify their certification may do so at any time during their certification period by completing and submitting a training and/or certification request via CERTRAK with appropriate justification. Certification modifications can include advancing from IT status to CERT status under one training/qualification program or gaining certification status under multiple programs.

4.9.5. In-Training Status

Each organization's approved explosive handler training and qualification program shall include criteria for individuals meeting a minimum set of general and program specific prerequisites but lacking sufficient hands-on experience. Individuals meeting these requirements can request training under an IT Status. Individuals conducting activities during this IT period must be under the direct supervision of an explosive handler certified on the specific explosive being handled.

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The explosive being handled shall be within the individual's IT authorization and the certified explosive handler's certification.

Certified explosive handlers are prohibited from supervising IT individuals on activities involving explosives for which the certified explosive handlers are not certified.

The IT period on all organizational explosive handler training and qualification programs shall be no less than six months in duration before an individual can request to be certified under that program. Organizations may set an IT period for any length of time beyond six months commensurate to their OJT requirements.

4.9.6. Certification Extensions

The GSFC ESO has the authority to extend an explosive handler's certification up to three months for those who have not had any recent refresher training. The GSFC ESO cannot extend a certification beyond an expiration date linked to the medical clearance requirement.

4.9.7. Exemption from Training and Qualification Requirements

The following personnel are exempt from parts or all of the explosive handler training and qualification requirements defined within this standard:

- a. Federal and State Explosive Ordnance Disposal (EOD) personnel, GSFC Protective Service Division Special Agents/Contractor Security Police Officers, and other law enforcement personnel handling explosives when certified by formal training or qualifications programs acceptable to the GSFC ESO.
- b. NASA personnel and contractors supporting educational outreach programs involving the handling and launch of model rockets with class A to E motors. This exemption does not apply to the use of model rocket motors in conjunction with other explosives.
- c. NASA Aircraft Office personnel handling articles related to safety equipment (i.e. firing mechanisms for engine fire suppression systems and flight crew rescue equipment).
- d. Any personnel operating vehicles or performing non-maintenance operations involving vehicles where small explosive devices are intrinsic to the functioning of the vehicle's safety systems (i.e. gas generators for automotive airbags, firing mechanisms for pilot ejector seats, etc.).

4.9.8. Training Activities Involving Explosives

The following are minimum requirements for training activities involving EELP:

- a. A risk assessment of EELP operations for the training activity.

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- b. A list of all explosives to be used in the training activity, to include explosive identifiers/nomenclature, Hazard Division (HD), and explosives weights.
- c. A detailed list of locations where explosives will be deployed for the training activity.
- d. A procedure for accountability and reconciliation of all items used in the training.
- e. Required separation distances based on explosive weights or maximum credible event.
- f. Required Personal Protective Equipment.
- g. The GSFC ESO shall approve the training plan verifying reasonable controls are in place to mitigate explosives hazards to non-essential personnel and proper notifications to emergency response and security personnel are included.

4.9.9. Explosive Detection Dog Training

EELP (including HD 1.1) used in association with training of explosive detection dogs may be transported and handled by qualified personnel in areas that provide realistic and effective training. Exposure of non-essential personnel to the training is to be precluded through prudent scheduling and selection of training sites.

Provide non-essential personnel safe separation distance equivalent to Inhabited Building Distance (IBD) from the training site if more than 15 lbs. TNT equivalent weight is being used for the exercise and at least 100 feet separation distance from the training site if less than or equal to 15 lbs. TNT equivalent weight is being used.

Post proper fire symbols and explosives operation signs at training sites. Train using locally written instructions. These instructions shall include a documented post-training inventory of explosives samples ensuring no explosives are inadvertently left at the training site or discarded.

Inform the GSFC ESO, local emergency response, and nearby building occupants (if applicable) before conducting operations.

4.10. Preparing and Controlling Procedures for Explosives Operations

As part of the explosive licensing or siting processes for storage and/or handling of EELP, a PHA shall be coordinated with the GSFC ESO. The PHA includes a review of operating procedures to be conducted as part of the associated authorization. The explosive license or site plan, the PHA, and thereby the operating procedures are reviewed on a set schedule.

The GSFC ESO shall define guidelines with the custodians of authorized EELP on handling changes to existing operating procedures, introducing new operating procedures, and distribution of operating procedures when granting authorization for storage/handling of EELP. The guidelines should be tailored to the organization receiving the EELP authorization.

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4.11. Facility Construction

4.11.1. Additional Technical References and Analysis Tools

In addition to the technical references identified in NASA-STD-8719.12, the references identified below provide additional information for the design and construction of explosive related facilities:

- DEF 149-30-01 U.S. Army Corps of Engineers Definitive Drawings for Barricades
- UFC 3-340-02 DoD Unified Facilities Criteria for Structures to Resist the Effects of Accidental Explosions

The DDESB has also authorized the use of additional analysis tools for fragmentation and blast effects. See below:

- Technical Paper 16 Methodologies for Calculating Primary Fragment Characteristics
- Technical Paper 17 Blast Effects Computer User's Manual and Documentation

The above references and analysis tools should be used for the design and construction of explosive related facilities or facilities impacted by explosive activities at GSFC and its component locations.

4.11.2. Facility Design and Modification Review

GSFC Facilities Management Division, Code 220, shall coordinate with the GSFC ESO in advance of all construction and modification projects within facilities used for EELP storage and/or handling at GSFC and its component facilities in compliance with NASA-STD-8719.12.

The GSFC ESO shall review and approve all construction and modification designs for facilities being used for EELP storage and/or handling at GSFC and its component facilities.

The GSFC ESO shall review and provide comments on all construction and modification designs for facilities within 120% of the IBD of a facility being used for EELP storage and/or handling at GSFC and its component facilities.

The GSFC ESO shall review and provide comments on all construction and modification designs for transportation routes within 120% of the Public Traffic Route Distance (PTRD) of a facility being used for EELP storage and/or handling at GSFC and its component facilities.

4.12. Explosives Site Plans and Explosives Facility Licenses

In accordance with NASA-STD-8719.12, the GSFC ESO shall review and approve all EELP storage and/or handling on GSFC and its component facilities. There are two mechanisms by which authorization for the storage and handling of EELP is granted and documented at GSFC and its component facilities: Site Plans or Facility Licenses. Both of these mechanisms involve the conduct and documentation of a comprehensive assessment of PESs and effected ESs. The

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main different between the two mechanisms is the time domain of the associated project requiring the EELP authorization.

- a. Explosive Site Plans are part of a larger facility planning process when the scale of the project allows for the construction of specialized facilities and/or the establishment of engineering controls to be used over many years.
- b. Explosives Facility Licenses are intended to provide short term storage or operational capabilities for relatively small quantities of EELP which are normally outside of GSFC and its component facilities' traditional explosives storage and handling area(s).

The time scale associated with a license is typically less than a year although a license can be renewed annually.

The GSFC ESO holds the final decision authority on whether a site plan or facility license will be used based on project specific circumstances. Typically, a purpose-built facility used for a long-term project or a series of similar projects will likely be granted EELP authorization under a site plan. In contrast, a facility that was not purpose-built or involves a short-term project will likely result in EELP authorization being granted under a facility license.

There are cases where a facility license may be chosen over a site plan regardless of the project involved. As examples, the involved organization has relatively high employee turnover or the project is located in an area with a relatively high pace of nearby construction.

4.12.1. Explosive Site Plans

Per the NASA-STD-8719.12, the site planning process includes evaluations of blast, fragment, thermal flux, and glass breakage hazards; protective construction; grounding, bonding, and lightning protection systems; electrical installations; natural or man-made terrain features; or other operations or local requirements. These evaluations should be completed as early as possible in the facility design review process.

The explosive site planning process shall be engaged under the following circumstances:

- a. New construction of PESs
- b. New construction of ESs within the QD arcs of a PES
- c. Facility modifications, change of mission, or change of operations that increase explosive hazard (e.g., personnel exposures, Net Explosive Weight (NEW), change in HD, nature of operation)
- d. Change of use of ESs that require application of more stringent explosives safety criteria

The explosive site planning process does not need to be engaged under these circumstances:

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- a. Facility modifications, mission changes, or changes in operations, NEW increases, or HD additions that do not: increase explosives safety or personnel risks; identify requirements for additional or increased explosives or hazard controls; or increase any QD arcs
- b. Storage and associated handling of solely HD 1.4S
- c. Interchange yards when used exclusively: for the interchange of vehicles containing EELP between the common carrier and NASA; to conduct external inspection of the vehicle containing EELP or to conduct visual inspection of the external condition of the cargo in vehicles (e.g., trucks or trailers) that passed the external inspection
- d. Inspection stations when used exclusively for: external visual inspection of the motor vehicles; visual inspection of the external condition of the cargo packaging in vehicles that have passed the aforementioned external visual inspection; or interchange of vehicles between the common carrier and NASA
- e. Parking of aircraft loaded with HD 1.2.2 gun ammunition, 30 mm or less; HD 1.3 captive missiles, aircraft defensive flares, or chaff; or HD 1.4 ammunition while in designated aircraft parking areas that meet airfield criteria (when evaluated as a PES), and the associated handling of these munitions, provided the quantity of munitions involved in the operation is limited to a single aircraft load
- f. Storage of, and operations involving, limited quantities of HD 1.2.2, HD 1.3 (such as document destroyers, signaling devices, riot control munitions, and the like) or HD 1.4 (such as small arms AE and riot control munitions), for reasons of operational necessity, in facilities such as hangars, arms rooms, and manufacturing or operating buildings. Storage of limited quantities of those HD 1.4 munitions may also be in small magazines next to those facilities
- g. Inert storage accessed by personnel related to the explosives mission
- h. Roll-on/roll-off (RORO) operations where: a sited location is not available; the RORO location is as remote as practicable from populated areas to minimize exposure of unrelated personnel; the total Net Explosive Weight for Quantity-Distance (NEWQD) present does not exceed 30,000 lbs.; the only EELP present (e.g., trailers, trucks, barges) is associated with the RORO operation being conducted; and the EELP is located on-site for the minimum time necessary, but not longer than 24 hours

4.12.2. Explosives Facility Licenses

When the storage and handling of EELP is required at locations not covered by an explosive site plan, an explosives facility license can be issued for the short-term use of EELP. An explosives facility license is not meant to be used for convenience or as a way of avoiding requirements for specialized construction, establishment of engineering controls, or when QD separation requirements cannot be met. To compensate for the lack of specialized construction and associated engineering controls, there is a heavy reliance on the following provisions:

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- a. Strict limitations on quantities of EELP to only that necessary to support specific, mission essential, and explosives operations or missions.
- b. Strict limitations on location occupancy to only that necessary to support specific, mission essential, and explosives operations or missions. These restrictions should include clearly defined procedures for handling dubbed, suspect, unserviceable, waste, and unused EELP throughout the life cycle of the project, operation, or mission.
- c. Thorough PHA taking into consideration factors of explosives initiation sensitivity, quantity of materials, heat output, rate of burn, potential ignition and initiation sources, protection capabilities of shields, various types of clothing, fire protection systems and personnel exposure.
- d. Clearly defined practical engineering and administrative controls for safely conducting activities involved in each covered process authorized under the facility license.

4.12.3. Process Hazard Analysis

The organization requesting authorization to store and/or handle EELP on GSFC and its component facilities shall coordinate with the GSFC ESO on the conduct of a PHA. The PHA shall be appropriate to the complexity of the process and shall identify, evaluate, and control the hazards involved in the process.

The PHA should use one or more of the following methodologies that are appropriate to determine and evaluate the hazards of the process being analyzed:

- | | |
|---------------------------------|---------------------------------------|
| a. What-If | e. Failure Mode and Effects Analysis |
| b. Checklist | f. Fault Tree Analysis |
| c. What-If/Checklist | g. Appropriate equivalent methodology |
| d. Hazard and Operability Study | |

The PHA should address:

- a. The hazards of the process
- b. The identification of any previous incident that had a likely potential for catastrophic consequences.
- c. Engineering and administrative controls applicable to the hazards and their interrelationships such as appropriate application of detection methodologies to provide early warning of releases. (Acceptable detection methods might include process

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monitoring and control instrumentation with alarms, and detection hardware such as hydrocarbon sensors.)

- d. Consequences of failure of engineering and administrative controls
- e. Stationary source siting
- f. Human factors
- g. A qualitative evaluation of a range of the possible safety and health effects in the event of a failure of established engineering and administrative controls.

The PHA relating to explosives and pyrotechnics may include such topics as: inherent chemical and physical properties of specific explosives and/or explosive compounds, QD requirements, building design, human factors, and prior incident reports.

The PHA should be performed by a team with expertise in engineering, process operations, and human factors. The PHA team shall include at least one employee who has experience and knowledge specific to the process being evaluated. Also, one member of the team shall be knowledgeable in the specific process hazard analysis methodology being used.

The requesting organization should establish a system to promptly address the team's findings and recommendations; assure that the recommendations are resolved in a timely manner and that the resolution is documented; document what actions are to be taken; complete actions as soon as possible; develop a written schedule of when these actions are to be completed; communicate the actions to operating, maintenance and other employees whose work assignments are in the process and who may be affected by the recommendations or actions.

4.12.4. Risk-Based Explosive Siting

Risk-based explosive siting addresses PESs and ESs that do not meet the deterministic QD criteria as referenced in NASA-STD-8719.12, but meet risk-based siting acceptance criteria as defined by Section 4.1 Equivalency of this document. Risk-based explosive siting is determined using a quantitative risk assessment (QRA) tool such as the Institute of Makers of Explosives Safety Analysis for Risk (IMESA FR), or other equivalent risk assessment tool.

The GSFC ESO holds the final decision authority on whether to use of risk-based explosive siting as part of the PHA in determining approval of a site plan or facility license. Risk-based explosive siting should only be considered as a viable option when QD criteria cannot be achieved within reasonable project or mission constraints.

If a risk-based equivalency for explosive siting cannot be demonstrated using a QRA, then a variance to the QD criteria shall be approved by the Center Director, or their assigned designee, in accordance with NASA-STD-8719.12, before the GSFC ESO can approve a site plan or facility license.

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4.12.5. Sites Exclusively Storing Small Arms Ammunition

Armories and weapons issue points used exclusively for the storage and/or distribution of small arms ammunition are exempted from the GSFC Explosive Safety Program. The control, issuance, storage, and accountability of the small arms ammunition at locations shall be the responsibility of the GSFC Protective Services Division per NPR 1600.1, *NASA Security Program Procedural Requirements*.

4.12.6. Sites Exclusively Storing Model Rocket Motors

Locations used exclusively for the storage and/or handling of model rocket motors are exempted from the GSFC Explosive Safety Program. Model rocket motors are defined by NPR 8715.3, *NASA General Safety Program Requirements*, in Section 3.7.3 as those articles with North American (NA) numbers NA0276 and NA0323.

These articles are the sole responsibility of the GSFC Fire Protection Program.

4.12.7. Host Coordination

Pursuant to NPR 8715.3 Section 3.11.4, the GSFC ESO shall review agreements where NASA is the tenant organization and there is the stated potential for storage and/or handling of EELP within the agreement. The GSFC ESO is responsible for assuring EELP related compliance with the host requirements through formal negotiations and documentation with the end goal of maximizing the health and safety of GSFC employees while conducting EELP related operations at the host location.

4.12.8. Tenant Coordination

Pursuant to NPR 8715.3 Section 3.11.4, the GSFC ESO shall review agreements where NASA is the host organization and there is the stated potential for storage and/or handling of EELP within the agreement. The GSFC ESO is responsible for assuring EELP related compliance with NASA requirements while conducting EELP related operations at GSFC and its component facilities.

Tenants should coordinate all construction and modification designs for PESs and/or ESs at GSFC and its component facilities with the GSFC ESO. Once this coordination is completed, the GSFC ESO will adjudicate the request for authorization of storage and handling of EELP. This may result in the issuance of an explosive site plan or facility license.

Tenants should provide the GSFC ESO with written acknowledgment of exposures and the associated risk from the GSFC or component facilities' EELP activities, and documentation indicating their acceptance of the potential risk. The GSFC ESO should include this documentation with the GSFC or component facilities' site plan or facility license. Prior to providing approval, the GSFC ESO should coordinate the GSFC or component facilities' site plan or facility license with the tenant's Safety, Health & Environment Manager or equivalent.

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4.12.9. Minimum Review and Renewal Periods

The following are the minimum review and renewal periods for site plans and facility licenses:

- a. Facility licenses shall be reviewed and renewed at most annually in compliance with NASA-STD-8719.12.
- b. Site Plans shall be reviewed and renewed at most every five years in recognition of OSHA's requirement to review the underlying PHA on that same interval.

4.13. Explosives Waste Requirements

4.13.1. General Guidance

Waste management of explosives at GSFC and its component facilities is addressed in GPR 8500.3, *Waste Management*. This document covers Unexploded Ordnance (UXO), Munitions and Explosives of Concern (MEC), and unneeded explosive materials designated as hazardous waste.

4.13.2. Unexploded Ordnance Guidance at Wallops Flight Facility

Additional guidance for WFF is provided in the Protective Services Division's local work instruction, WFF-UXO-02/09/2018, *UXO/MEC Response Plan*. This work instruction details the process of coordination of Emergency Response, Safety, and Environmental assets, isolation of the suspected article, evacuation of any hazarded personnel, and search/clearance protocols of UXO/MEC at WFF.

4.13.3. Used or Fired Military Munitions

Per 40 CFR 266.202, *Definition of Solid Waste*, used or fired military munitions (current or re-purposed for scientific purposes) are considered solid waste:

- a. When transported off GSFC property or from the site of use, where the site of use is not on GSFC property, for the purposes of storage, reclamation, treatment, disposal, or treatment prior to disposal.
- b. If recovered, collected, and then disposed of by burial, or landfilling either on or off GSFC property.

Used or fired explosive articles shall be treated as solid waste for the purposes of disposal. The organization responsible for generating the solid waste should coordinate disposal with the GSFC Information and Logistics Management Division or local equivalent.

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4.14. Fire Protection Criteria

4.14.1. Fire Protection Requirements

Guidance for fire protection is outlined at the Agency-level in NASA-STD-8719.11, *NASA Safety Standard for Fire Protection*, and implemented at GSFC and its component facilities in GPR 8715.5, *Fire Protection at GSFC*. Additionally, NPR 8715.3 specifies compliance with Federal, State, and local regulations and national consensus standards.

In addition to the above identified NASA fire protection regulatory documents, these are the applicable fire protection consensus standards by which GSFC and its component facilities may be audited against during safety inspections:

- NFPA 495 Explosive Materials Code
- NFPA 1122 Code for Model Rocketry
- NFPA 1125 Code for the Manufacture of Model Rocket and High-Power Rocket Motors
- NFPA 1127 Code for High Power Rocketry

4.14.2. Fire Extinguishers in Explosive Areas

For GSFC and its component facilities, portable fire extinguishers with UL rating 6A:80B:C shall be distributed for use by employees so that the travel distance from any location where explosives are being stored and/or handled to any extinguisher is 30 feet or less. Depending on the PES, this requirement may be met with a single portable fire extinguisher.

For PESs involved in the storage and/or handling of solely HD 1.4, portable fire extinguisher requirements as defined by 29 CFR 1910.157, *OSHA Standards for Portable Fire Extinguishers*, have been reviewed, deemed sufficient, and shall be the only applicable requirements for these locations with regard to portable fire extinguishers.

4.15. Display of Fire, Chemical and/or Apply No Water Symbols

4.15.1. Type of Firefighting Symbols by GSFC Location

In accordance with NASA-STD-8719.12, GSFC and its component facilities have the flexibility to select the applicable fire and chemical hazard symbols for display at PESs. The available options for signage are identified in the following technical references:

- DESR 6055.09 Defense Explosives Safety Regulation
- 49 CFR Part 172 Subpart F – DoT Placarding Requirements
- NFPA 704 Standard System for the Identification of the Hazards of Materials for Emergency Response

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GSFC and its component facilities shall use NFPA signage on PESs associated with the storage and/or handling of energetic liquids.

NOTE: For energetic liquids, the DoD and DoT signage does not provide sufficient specificity to the type of hazards associated with the materials involved.

GSFC and its component facilities shall use either DoD or DoT signage on PESs associated solely the storage and/or handling of energetic solids. For energetic solids, NFPA signage does not provide sufficient specificity to the type of hazards associated with the materials involved.

The determination of the type of signage to be used at a GSFC location should be coordinated through the GSFC ESO, the local Safety, Health & Environment (SHE) Manager or equivalent, and the local emergency responders.

4.15.2. Posting Requirements for Firefighting Symbols

Programs conducting operations involving EELP at GSFC and its component facilities shall coordinate with the GSFC ESO on posting firefighting symbols at PES(s). The programs shall post firefighting symbols compliant with these requirements:

- a. Post the fire symbol and chemical symbol that applies to the most hazardous material present at the PES.
- b. Post firefighting symbols when EELP is located at a PES, and remove the symbols when the EELP is removed. When the EELP is removed, an "EMPTY" sign should be posted. The person in charge of the operation is responsible for posting or changing the symbols.
- c. Notify the appropriate local emergency management authorities each time firefighting symbols are changed. Local emergency management should be able to relay this information to emergency responders in the event of an incident.
- d. Post symbols on building's exterior and interior entrances to room within the building used for storage and/or handling of EELP. Half-sized symbols may be used on doors or lockers inside buildings.
- e. Post symbols on lockers or containers used for storing EELP.
- f. For multi-bay facilities, post full size symbols for the highest hazard and applicable sets to be visible from all approach roads. Half-size symbols may be used for individual bays denoting the individual hazard within each bay.
- g. For the WFF Airfield, post symbols at each aircraft loaded with weapons. One fire symbol may be posted at the entry point (point of entry for fire-fighting personnel) to an aircraft area for multiple aircraft. Notify the WFF Fire Department when each armed aircraft arrives and departs giving the aircraft parking location and type of explosives

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involved. During mass fueling operations of three or more armed aircraft, a fire truck should be present until fueling is complete.

4.16. Vegetation Control

The primary purpose of vegetation control is to limit the probability of combustible vegetation catching fire and to slow the spread of vegetation fires. In addition to the general provisions outlined in NASA-STD-8719.12, programs conducting operations involving EELP at GSFC and its component facilities should implement the following vegetation control practices:

- a. Use varieties of vegetation that are resistant to burning where feasible.
- b. Do not allow dead or cut vegetation to accumulate.
- c. When animals are used for vegetation control on barricade surfaces and igloo earth cover, avoid overgrazing to prevent erosion.
- d. Do not conduct controlled burning within 200 feet of any explosives location.
- e. Close windows, doors and ventilators of facilities containing explosives within 600 feet of burning operations.
- f. Firefighting personnel and equipment should be present during all burning operations.

NOTE: Pursuant to 29 CFR 1910.109, the land surrounding magazines (both above ground and earth-covered) shall be kept clear of brush, dried grass, leaves, and all combustibles for a distance of at least 25 feet. NASA adds more conservatism by requiring a 50 foot firebreak around above ground magazines thereby exceeding the OSHA requirement.

NOTE: Pursuant to NFPA 495, *Explosive Materials Code*, the land within 10 feet of any fence or gate surrounding a facility where explosives are mixed, blended, extruded, assembled, disassembled, and other functions involved in making a product or device that is intended to explode (i.e. detonate or deflagrate) shall be maintained for a clear field of view.

At GSFC and its component facilities, a firebreak of 50 feet shall be maintained around above ground magazines pursuant to the NASA requirement.

At GSFC and its component facilities, a firebreak of 25 feet shall be maintained around earth-covered magazines pursuant to the OSHA requirement.

At GSFC and its component facilities, a firebreak of 10 feet shall be maintained on either side of fencing surrounding facilities used for the handling of explosives material and/or device pursuant to the NFPA requirement.

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4.17. Motor Vehicle Safety Requirements

These requirements for parking near PESs at GSFC and its component facilities augment those identified in NASA-STD-8719.12.

4.17.1. Applicability

These requirements apply to locations where the use of EELP has been authorized by the GSFC ESO via an approved explosive site plan or facility license. Parking requirements near PESs at locations where the use of EELP are authorized by means other than the expressed approval of the GSFC ESO in the form of a published site plan or issued facility license may differ.

It is program management's responsibility to be aware of any site-specific requirements when conducting operations at locations other than GSFC and its component facilities.

These requirements are not applicable at PESs when EELP is not present as denoted by "EMPTY" signage in place of fire, chemical, and/or other warning symbols.

4.17.2. Exceptions

- a. This rule does not apply to PESs solely authorized storage and related operations involving NEW of less than 1,000 lbs. of explosives classified as HD 1.4.
- b. There are no separation limitations for GHE involved in loading and unloading operations at a PES during the actual loading/unloading operation.
- c. Temporary parking is allowed within 25 feet of any PES for the performance of work related duties with temporary being defined as the length of time for which the presence of the vehicle is essential to complete of a single task (e.g., a single work order number).

4.17.3. Equivalency

The minimum distance of 100 feet may be reduced to 50 feet if these criteria are met and attested to by the local Fire Protection Authority Having Jurisdiction:

- a. The PES is of non-combustible construction.
- b. There is a barrier sufficient to prevent the vehicle from rolling within 50 feet of the PES located between the parking spaces and the PES.
- c. There are sufficient administrative controls in place to prevent vehicles being parked within 50 feet that could project debris directly towards and impact the PES.

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4.17.4. Program Responsibilities

Determining emergency withdrawal distance requirements for essential personnel is solely the responsibility of the program who has been authorized to use explosives by the GSFC ESO in the form of a published site plan or issued facility license:

- a. There are no defined requirements in the regulations referenced in this document related the emergency withdrawal distances for essential personnel involved in explosive activities. The referenced regulations provide guidelines based on the withdrawal distances for non-essential personnel.
- b. If a program establishes emergency withdrawal distances for essential personnel and associated rally points, then this information should be included in pre-activity briefings and emergency response rehearsals.
- c. There are no defined requirements in the regulations referenced in this document related the directionality of parked vehicles near PESs or the location of keys in parked vehicles.
- d. If a program determines that vehicles are to be used as a means of egress from areas near PESs, then personnel should be trained on any policies concerning the directionality of parked vehicles near PESs and the location of keys in those parked vehicles. These policies should also be included in pre-activity briefings and emergency response rehearsals.

4.18. Grounding and Bonding

PESs at GSFC and its component facilities shall be equipped with an ordnance grounding system per the specifications defined in NASA-STD-8719.12.

Test reports from the visual inspections performed every six-months and the annual electrical continuity tests shall be provided to the GSFC ESO for archiving in accordance with NASA-STD-8719.12.

4.19. Lightning Protection

In accordance with NASA-STD-8719.12, PESs at GSFC and its component facilities shall be equipped with Lightning Protection Systems that comply with NPFA 780, *Standard for the Installation of Lightning Protection Systems*, unless exempted by the GSFC ESO.

Test reports from the visual inspections performed every six-months and the annual electrical continuity tests shall be provided to the GSFC ESO for archiving in accordance with NASA-STD-8719.12.

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4.20. Explosives in Process during Electrical Storms

In accordance with NASA-STD-8719.12, programs at GSFC and its component facilities shall implement protocols for the suspension of activities involving the handling of EELP during electrical storms.

4.20.1. Locations under WFF Safety Office Oversight

For WFF and other locations under WFF Safety Office oversight, these protocols have been outlined in 800-WI-8715.2.1, *Severe Weather Notification*, and RSM2002, *Range Safety Manual for GSFC WFF*.

4.20.2. Locations not under WFF Safety Office Oversight

For locations not under WFF Safety Office oversight, these general protocols shall apply:

- a. A Lightning Watch will go into effect 30 minutes prior to when any thunderstorm is predicted to develop or move within a ten-mile radius of the PES(s). Initiate controlled termination procedures for all explosives operations at outdoor locations equipped with a lightning protection system, at locations (outdoor and indoor) not equipped with a lightning protection system, and facilities containing exposed explosives, explosive dust, or explosive vapor.
- b. A Lightning Warning will be in effect whenever any lightning is occurring within a ten-mile radius of the PES(s) and the following actions will be taken.
 - (1) Immediately provide personnel protection equivalent to PTRD from PES(s) containing exposed explosives, explosive dust, or explosive vapor, regardless of whether the facility is equipped with a lightning protection system; this includes providing protection equivalent to PTRD for all locations within the PTRD arc. PTRD will be based on airblast overpressure only (minimum fragment distances do not apply).
 - (2) Explosives operations in facilities equipped with a lightning protection system may continue (except where noted in the circumstance note above.); however, assess the need and urgency for doing so. Cease operations involving Electrically Initiated Devices (EID) that are uncapped, unplugged, or susceptible to electrostatic discharge and vacate the immediate area where these operations are located. Evacuation of the surrounding areas is not required.
 - (3) Immediately provide personnel protection equivalent to PTRD from explosives locations (indoor and outdoor, to include parked explosives-laden conveyances and flightline PES locations) not having a lightning protection system; this includes providing protection equivalent to PTRD for all locations within the PTRD arc of a facility having a lightning protection system. PTRD will be based on airblast overpressure only (minimum fragment distances do not apply).

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- (4) Cease all explosives operations at outdoor locations equipped with a lightning protection system and not specifically mentioned in the paragraphs above.

For programs operating at host locations under another organization's safety oversight, it is the program's responsibility to coordinate with the cognizant safety authority and understand the local safety protocols to be implemented in the event of an electrical storm during activities involving EELP while at the host location.

4.21. Static Electricity and Control of ESD

In addition to the technical references identified in NASA-STD-8719.12, the references identified below provide additional information for the design and installation of systems for the control of static electricity:

- AFI 32-1065 U.S. Air Force Grounding Systems
- NFPA 77 Recommended Practice on Static Electricity

Technical information from the above references is applicable for implementation at GSFC and its component facilities.

4.22. Laboratory Testing of Explosives

NASA-STD-8719.12 defines the general safety requirements for laboratory testing of explosives. GSFC and its component facilities are engaged in Research and Development (R&D) efforts involving the manufacture and/or test of EELP at the Greenbelt Campus, WFF, and multiple off-site mission locations.

4.22.1. R&D Manufactured Items

Any programs involved in the production of potentially explosive samples, substances, sub-assemblies, and/or articles to be stored and/or handled at GSFC or at its component facilities shall coordinate with the GSFC ESO on development of related safety protocols. These safety protocols should address the storage, handling, and transport of these items on Center or development location before hazard classification is determined.

It is the originating program's responsibility to ensure these items are not offered for transportation off Center or development location until the necessary hazard classification is assigned. Traversing a public roadway between gates or sites on the same installation is considered on Center transportation provided the transportation is in a government owned or contractor owned vehicle.

4.22.2. Hazard Classification Testing for a Competent Authority

In accordance with NASA-STD-8719.12, new explosives material or explosives device shall obtain a hazard classification per 49 CFR 173.56, *New Explosives - Definition and Procedures*

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for Classification and Approval. Within these Federal Regulations, the DoT directs users to ST/SG/AC.10/11, *United Nations (UN) Recommendations on Transport of Dangerous Goods, Manual of Tests and Criteria*. UN Manual of Tests and Criteria provides a standardized test series relating to the hazard classification of explosives.

Any testing of explosives material or explosives device for the purpose of potential hazard classification by a Federal Competent Authority at GSFC and its component facilities shall be performed per the UN Manual of Tests and Criteria.

The International Group of Experts on the Explosion Risks of Unstable Substances (IGUS) maintains a website available to the public on the explosives related UN test series. The IGUS website can be found here: <https://www.etusersgroup.org/un-manual-classification-system/>

The IGUS website provides the following for each test in the explosives related UN test series:

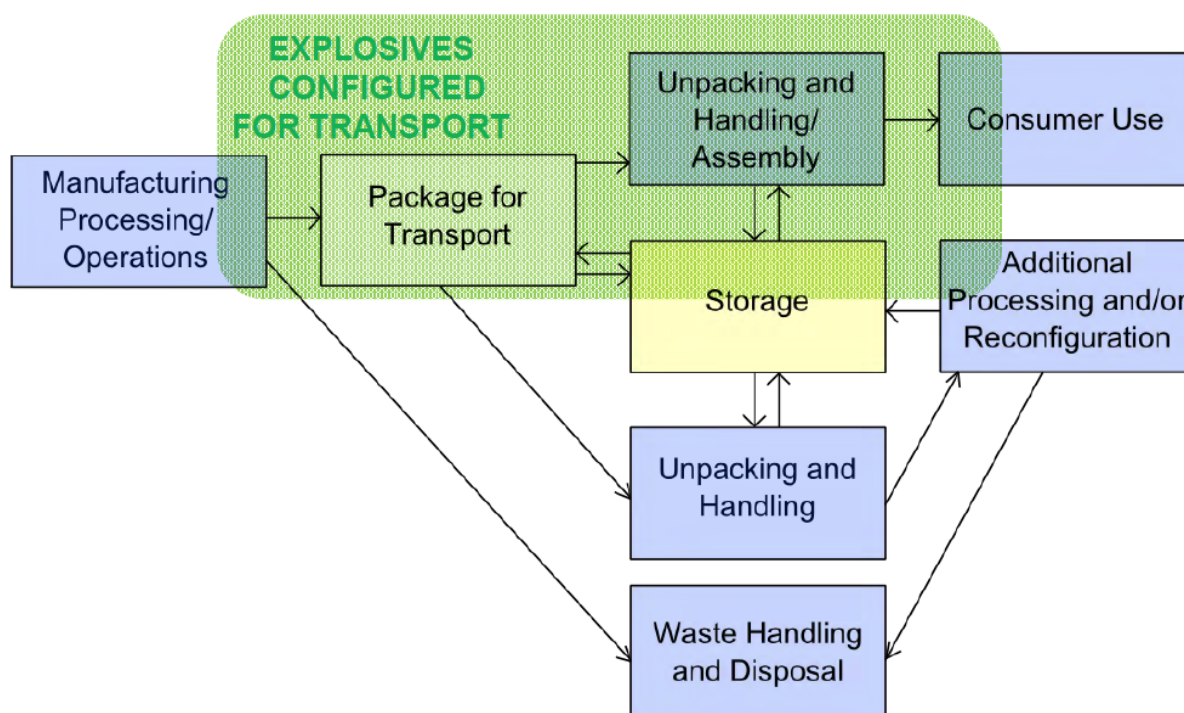
- specific test details, test purpose, test variations, and key test parameters
- an example test procedure, test hazards analysis, photos of test setup, and videos of test outcomes

The results of the UN test series can be presented to the DoT for potential hazard classification allowing shipment of the new explosives material or explosives device via commercial transport to locations off Center or development location.

4.22.3. In-Process Hazard Classification of Explosives

Explosives testing as defined by the UN Manual of Tests and Criteria Part I focuses on a standardized series of tests typically leading to a shipping authorization for packaged materials or articles. Within the life-cycle of an explosive operation, there are numerous phases where the explosives material and/or article are not in the tested packaged configuration (refer below):

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**Explosives Life-Cycle Stages**

Unless defined in the manufacturer's specifications, the hazard classification of explosives material and/or articles in its unpackaged configuration may not be known. If the explosives material and/or articles are being combined with other explosives, then the overall hazard classification may not be known.

In-process hazard classification is used as a mechanism to address this knowledge gap. This type of hazard classification can be achieved by analogy when possible, through analysis when practical, or by testing when fidelity is required. The GSFC ESO who holds the final decision authority on the method of in-process hazard classification determination.

The Explosives Testing Users Group (ETUG) maintains a website available to the public on the explosives related in-process hazard classification testing. The ETUG website can be found here: <https://www.etusersgroup.org/in-process-classification/>

The ETUG website provides the following for each in-process hazard classification test:

- specific test details, test purpose, test variations, and key test parameters
- provides an example test procedure, test hazards analysis, photos of test setup, and videos of test outcomes

In-process hazard classification testing is similar to the UN series testing, but allows for customization specific to the operating environments to which the explosives material and/or articles will be exposed.

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Any testing of explosives material or explosives device to determine an in-process hazard classification for handling at GSFC and its component facilities shall be performed per the ETUG-GS01-15, *ETUG Standard for In-Process Hazard Classification of Explosives*.

4.23. Concurrent Explosives Operations

In accordance with NASA-STD-8719.12, concurrent explosives operations are discouraged but allowable when operationally necessary under these conditions:

- PHA shall be performed
- identified engineering and administrative controls implemented
- operational procedures shall be approved by the GSFC ESO

As general guidelines, concurrent explosives operations should be governed by these criteria:

- a. Authorization granted via explosive facility license instead of explosive site plan.
- b. Concurrent explosives operations separated by a minimum of Intraline Distance (ILD)
- c. Non-concurrent explosives operations may be performed on the same pad, site, or facility provided the EELP of the first party is removed prior to the second party beginning EELP operations.
- d. Provide ILD level of protection to EELP operations from EELP storage sites.
- e. Provide Intermagazine Distance (IMD) level of protection to EELP storage sites from EELP operations.

If the above general guidelines cannot be met, then risk-based explosive siting may be considered as an alternative method. Under risk-based explosive siting, concurrent operations sponsored by the same parent organization (e.g. NASA, DoD, etc.) can be treated as related operations. Concurrent operations sponsored by different parent organizations (e.g. one by DoD and one by commercial customer) are treated as unrelated operations.

If a risk-based equivalency for explosive siting cannot be demonstrated using a QRA, then a variance to the QD criteria shall be approved by the Center Director, or their assigned designee, in accordance with NASA-STD-8719.12, before the GSFC ESO can approve a facility license for the concurrent operations.

4.24. Housekeeping

The primary goal of housekeeping is to reduce the potential ignition sources of a workspace fire and the accompanying fuel load used as a conveyance to carry the fire throughout the facility.

Incompatible materials that are in storage and storage of materials that are incompatible with materials in use shall be separated by one of the following methods:

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- a. Segregating incompatible materials in storage from those materials in use by a distance of not less than 20 feet.
- b. Isolating incompatible materials in storage by a noncombustible partition extending not less than 18 inches above and to the sides of the stored material.
- c. Storing liquid and solid materials in hazardous materials storage cabinets that comply with NFPA 1, *Fire Code*.

Tools and equipment shall be kept in designated areas when not in use.

4.25. RF Transmissions

4.25.1. Overview

GSFC works closely with the DoD on numerous projects involving the storage and/or handling or EELP: GSFC sub-orbital projects are executed at DoD test ranges, GSFC serves as host to multiple DoD customers, GSFC spacecraft are launched from DoD controlled ranges, and GSFC uses de-militarized DoD rocket motors as part of numerous projects. For Hazards of Electromagnetic Radiation to Ordnance (HERO), the DoD relies on the Joint Ordnance Commanders Group (JOCG) Electromagnetic Environmental Effects (E3) Ordnance Safety Subgroup (JOCG E3 Ordnance Safety SG).

The JOCG E3 Ordnance Safety SG is responsible for the development and maintenance of technical safety information, tools, data sharing, and standardized test methodologies for the development, testing, and acquisition and deployment of ordnance. Additionally, it will influence harmonization and standardization as it relates to the dissemination of safety information and additional guidance across the DoD.

It is paramount that GSFC, its component facilities, and GSFC projects communicate in a common language as the DoD as established by the JOCG and flowed down to the individual armed services via their explosives standards. AFMAN 91-201, *Air Force Explosives Safety Standards*, serves as an applicable reference to NASA-STD-8719.12. The Air Force standard points to AFI 91-208, *Air Force Hazards of Electromagnetic Radiation to Ordnance Certification and Management*, for addressing HERO concerns and identifying mitigation strategies.

Common terms, analysis methods, and hazard mitigation strategies identified in the Air Force Instruction have been adapted for application at GSFC and its component facilities. It is the responsibility of GSFC, its component facilities, programs, and tenants to coordinate with the GSFC ESO to ensure HERO related analysis is performed for any EELP being stored and/or handled and to implement any identified HERO related mitigation strategies.

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4.25.2. HERO Susceptibility

MIL-STD-464, *Electromagnetic Environmental Effects Requirements for Systems*, sets general requirements that each system (i.e., aircraft, ground vehicles, ordnance containing Electrically Initiated Devices (EIDs), etc.) will be electromagnetically compatible among all subsystems and equipment within the system and with environments generated by Electromagnetic Radiation (EMR) emitters and other electromagnetic sources external to the system to ensure safe and proper operation and performance. Design techniques used to protect ordnance against EMR effects should be verifiable, maintainable, and effective over the rated lifecycle of the system. Verification addresses all lifecycle aspects of the system, including (as applicable) normal in-service operations, checkout, maintenance, storage, transportation, handling, packaging, loading, unloading, launch, and normal operating procedures associated with each aspect.

MIL-STD-464 requirement of intra-system electromagnetic compatibility indicates the system will be electromagnetically compatible with itself such that system operational performance requirements are met. Compliance should be verified by system-level test, analysis, or combination thereof in accordance with guidance provided by MIL-HDBK-240, *Hazards of Electromagnetic Radiation to Ordnance Test Guide*. Integration of individual components shown to be HERO SAFE does not imply the resulting system is a HERO SAFE system.

MIL-HDBK-240 defines HERO as the situation in which exposure to external Electromagnetic Environments (EMEs) results in specified safety or reliability margins of EIDs or electrically powered ordnance firing circuits to be exceeded, or EIDs to be inadvertently actuated. External EMEs may originate from intentional transmitting sources (e.g., radios, radars, electronic countermeasures equipment) or unintentional sources (e.g., arcing, high current switching transients). Consequences include both safety (premature firing) and reliability (EID dudding or altered functional characteristics) effects.

MIL-STD-464 and MIL-HDBK-240 define HERO SAFE, HERO SUSCEPTIBLE, and HERO UNSAFE as follows:

- a. **HERO SAFE:** Any ordnance item that is sufficiently shielded or otherwise so protected that all EIDs contained by the item are immune to adverse effects (safety and reliability) when the item is employed in the radio frequency (RF) environment delineated in MIL-STD-464. The general HERO requirements defined in the hazards from EMR manuals shall still be observed.
- b. **HERO SUSCEPTIBLE:** Any ordnance item containing EIDs proven by test or analysis to be adversely affected by EMR to the point that the safety and/or reliability of the system is in jeopardy when the system is employed in the EME delineated in MIL-STD-464.
- c. **HERO UNSAFE:** Any ordnance item containing EIDs not certified as HERO SAFE or HERO SUSCEPTIBLE as a result of a HERO analysis or test. Additionally, any ordnance item containing EIDs (including those previously certified as HERO SAFE or HERO SUSCEPTIBLE) that has its internal wiring exposed; when tests are being

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conducted on that item resulting in additional electrical connections to the item; when EIDs having exposed wire leads are present and handled or loaded in any but the tested condition; when the item is being assembled or disassembled; or when such ordnance items are damaged causing exposure of internal wiring or components or destroying engineered HERO protective devices.

- d. Percussion-initiated ordnance have no HERO requirements and shall be notated as no HERO requirement (NHR).

The ultimate objective of the HERO program is to have all GSFC ordnance certified as HERO SAFE. The programs, projects, and missions executed at GSFC and its component facilities often must rely on de-militarized munitions from the DoD or commercial vendors. In the former, the articles default to HERO UNSAFE once removed from the DoD's inventory. In the latter, commercial vendors typically do not perform HERO related testing thereby causing the articles to also default to HERO UNSAFE. Mitigation strategies should be identified and implemented to protect the EIDs assuming worse case without HERO testing data.

4.25.3. General HERO Requirements

The primary method to protect ordnance from EMR hazards is to ensure the ordnance is never located where EMR electric field/power density is sufficiently high to couple enough electrical energy into the device to initiate the device or degrade performance. In addition, shielding, filtering, bonding, grounding, or a combination may be used if an approved analysis and/or test supports protection against Electromagnetic Environment.

The following shall be implemented when conducting operations with any ordnance, regardless of HERO certification. Personnel handling ordnance shall:

- a. Plan ordnance operations so that the ordnance has a minimal exposure to EME. Use the Radiation Hazard (RADHAZ) survey information for guidance when available.
- b. Not alter ordnance, associated umbilical cables, and/or connectors unless authorized or approved by procedure, supervisor, or safety authority.
- c. Not expose internal wiring and firing circuits by assembling or disassembling the ordnance, unless authorized by procedure, supervisor, or safety authority.
- d. Transport all HERO UNSAFE and HERO SUSCEPTIBLE ordnance in sealed, all-metal containers, which is considered a HERO SAFE configuration. When transporting ordnance in a vehicle, the minimum Safe Separation Distance (SSD) requirements are applicable.
- e. Treat ordnance containing disassembled EIDs or when exposed EIDs, firing circuits, or wiring are present as HERO UNSAFE.

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- f. Maintain a **minimum SSD of 10 feet** for HERO SAFE ordnance unless the EMR emitter Effective Isotropic Radiated Power (EIRP) and frequency meet the criteria of Table A-5, then the minimum SSD listed applies. For Modern Mobile Emitter (MME) SSD, refer to requirements in section 4.25.5 of this document. For ordnance on a flight vehicle, where a minimum of 10 feet may not be possible, coordinate with the GSFC ESO to conduct an analysis and/or test proving the Maximum Allowable Environment (MAE) of the ordnance is not exceeded.
- g. Maintain the appropriate SSD for HERO UNSAFE or HERO SUSCEPTIBLE ordnance. If relying on a RADHAZ survey, ensure the EME does not exceed Table A-1 levels for HERO UNSAFE ordnance and, when no measured data are available, Table A-2 levels for HERO SUSCEPTIBLE ordnance. If a RADHAZ survey is not available or does not take into account all EMR emitters present, determine the appropriate SSD using requirements in Appendix A.
- h. HERO SAFE ordnance is considered unserviceable after exposure to EME above those defined in MIL-STD-464 due to the potential for both direct EMR induced actuation of the EIDs and inadvertent activation of an electrically powered firing circuit. Report the unserviceable condition through appropriate safety channels.
- i. HERO SUSCEPTIBLE ordnance may not necessarily be susceptible to the levels in Table A-2. The susceptibility may be a level between Table A-2 levels and MIL-STD-464 levels. HERO SUSCEPTIBLE ordnance is considered unserviceable after exposure to EME above those determined by analysis or testing resulting in a HERO SUSCEPTIBLE certification, due to the potential for both direct EMR induced actuation of the EIDs and inadvertent activation of an electrically powered firing circuit. Report the unserviceable condition through appropriate safety channels.
- j. HERO UNSAFE ordnance is considered unserviceable after exposure to EME above those defined in Table A-1 due to the potential for both direct EMR induced actuation of the EIDs and inadvertent activation of an electrically powered firing circuit. Report the unserviceable condition through appropriate safety channels.

4.25.4. Traditional Fixed-Location and Mobile Emitters Requirements

Traditional Fixed-Location Emitters (TFEs) are in a fixed location, usually mounted on a tower, mast, or rooftop. Mobile Emitters (MEs) are similar to TFEs except they can be moved to different locations. The following are the general HERO requirements for these emitters:

- a. Determine the EME utilizing the RADHAZ survey or determine the SSD using guidance provided in Appendix A. If the minimum distance (SSD) is maintained between the ordnance and the TFE/ME, the EMR electric field/power density at the location of the ordnance, even under optimal transmission and coupling conditions, is too low to provide sufficient energy to initiate or degrade the EIDs within the ordnance.

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- b. GSFC ESO shall evaluate the potential for HERO, i.e., HERO certification, SSD, RADHAZ survey results, etc., for all explosive locations with ordnance.

4.25.5. Modern Mobile Emitters Requirements

Modern Mobile Emitter (MMEs) may emit lower power levels than conventional EMR emitters (TFEs/MEs), but may also be brought much closer to ordnance even into the near-field of their antenna. MMEs, such as cellular telephones, active pagers, tablets, and some walkie-talkies automatically emit EMR without operator action. The following are the general HERO requirements for these emitters:

- a. Use of a MME less than a SSD of 10 feet requires approval from GSFC ESO, which determine SSDs using Table A-5.
 - (1) The organization (NASA, tenant, or customer) needing to use the MME shall request approval for use from GSFC ESO and provide the average output power, antenna gain, and frequency(ies), actual EMR test data, and/or Federal Communications Commission (FCC) identification.
 - (2) GSFC ESO should respond with an approval memorandum documenting the appropriate SSDs thirty days after receiving the request.
 - (3) Organizations employing these devices should address other hazards and security concerns with the appropriate security office. Final authority for use resides with the GSFC ESO.
- b. MMEs authorized for use in storage, build-up, and assembly areas where EELP are present, shall not be connected to power via power cords. Batteries shall not be charged in the magazines, in storage, build-up, or assembly areas when EELP are present due to the possibility of the batteries exploding.
- c. Multiple MMEs (two or more) shall not be used in enclosed, reflective spaces such as magazines or facilities where ordnance is stored or built-up, unless authorized by the GSFC ESO.

NOTE: Aggregated effects on the ambient or volumetric electromagnetic field in those spaces may increase as a results of complex cavity effects.

- (1) If the RADHAZ survey included the use of two or more approved MMEs while maintaining EME levels that did not exceed HERO EME levels for ordnance (HERO SUSCEPTIBLE or HERO UNSAFE), multiple MMEs are permissible.
- (2) Use of multiple MMEs inside enclosed spaces is not a concern around HERO SAFE ordnance because the electromagnetic energy produced by the MMEs is unable to exceed MIL-STD-464C levels. Multiple MMEs shall maintain an SSD of 10 feet from ordnance even if one or more meet the criteria of Table A-5.

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- d. All remote entry devices including car entry keys in compliance with 47 CFR 15.231, *Periodic operation in the band 40.66-40.70 MHz and above 70 MHz*, are only restricted from coming into physical contact with ordnance, regardless of certification. Remote entry devices not in compliance with regulations or not properly labeled shall maintain a SSD of 10 feet. If a planned operation occurs outside the United States where FCC regulations are not applicable, request assistance from GSFC ESO.

4.25.6. Other Electromagnetic Radiation Emitter Requirements

Items, such as desktop computers, laptops, tablets, associated hardware (such as printer, mice, etc.), etc., not configured with radiating wireless capability, e.g., cellular, Wi-Fi, Bluetooth, etc., are authorized for use in storage, build-up, and assembly areas where ordnance are present with the following restrictions:

- a. Items shall be certified to meet 47 CFR Part 15, *Radio Frequency Devices*, Class A or B limits and labeled accordingly. They require no SSD and can be used in close proximity but cannot come in direct contact with ordnance regardless of certification. If the item is not properly labeled or cannot be determined to meet the appropriate regulation, a SSD of 10 feet applies. If a planned operation occurs outside the United States where FCC regulations are not applicable, request assistance from GSFC ESO.
 - (1) Example of acceptable FCC Statement: *“This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules.”*
 - (2) Example of unacceptable FCC Statement: *“This device complies with Part 15 of the FCC Rules.”*
- b. Items with RF wireless capabilities are considered MMEs and this requirement applies.

Damage to EELP, resulting from exposure to X-ray radiation, is related to total dose, exposure time (dose rate in some instances), and the physical properties of the material. With the addition of a safety margin, the X-ray rate dose will not exceed 1,400 rads/minute, and/or the total dosage will not exceed 100,000 rads. Under these conditions, no HERO problems are expected and explosives should remain safe and reliable. Total doses exceeding 100,000 rads will likely change decomposition rates and increase the time to explosion.

4.25.7. Flight Vehicle On-board Emitters

Flight vehicles include aircraft, sounding rockets, scientific balloons, spacecraft, etc. On-board emitters have a variety of uses including, but not limited to, downlinking information to ground stations, environmental sensors for data collection, and in-flight communications.

The characterization process for the flight vehicle’s EME is a key step in system integration process and supports compliance to the HERO certification requirements. Regardless of

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ordnance HERO certification, ordnance should be integrated onto the flight vehicle so as not to exceed the safe exposure levels of EME dictated by the ordnance certification. This integration process is an assessment looking at the balance of locating the ordnance at a sufficient distance apart from on-board emitters in order to adhere to the SSD criteria of the given ordnance. To properly manage that balance, knowledge is required of the ordnance capability to withstand EME (i.e., HERO certification) and the flight vehicle emitters' capability to produce EME.

The following steps outline the flight vehicle's EME characterization process. The data can be acquired by accessing existing historical data, component/system testing, analysis, or a combination thereof:

- a. **Ordnance Locations:** A full list of ordnance locations on the flight vehicle need to be known and cataloged prior to performing this analysis.
- b. **Platform Emitter Data:** Obtain the following data for each emitter on the flight vehicle to support EME characterization:
 - (1) Emitter antenna location(s) on the flight vehicle.
 - (2) Emitter antenna transmit patterns, including side lobes and gain.
 - (3) Emitter transmitter power characteristics, i.e., peak power, average power, and duty cycle.
 - (4) Frequency(ies) of operation of emitters and associated bandwidths.
- c. **SSD Determination:** From the data acquired above, determine the EME/SSD at each ordnance location as it related to each of the three HERO ordnance certifications.
 - (1) For HERO SAFE ordnance, EME levels shall be less than MIL-STD-464 levels.
 - (2) For HERO SUSCEPTIBLE and HERO UNSAFE ordnance, calculate SSDs in accordance with Appendix A requirements.
 - (3) In cases where the EME/SSD is not met, a corrective action to remedy the conflict shall be accomplished or limitations shall be placed on the host platform to reduce or eliminate risk.

If a correction action cannot be accomplished and the situation impacts airworthiness, ordnance reliability, or ordnance premature firing, the limitation placed upon the host platform or the ordnance to reduce or eliminate risk shall be coordinated and accepted by the appropriate risk acceptance authority.
- d. **Documentation:** Each characterization package shall be submitted to the appropriate RF Spectrum Manager. The package should include a cumulative HERO summation for the flight vehicle based on test or engineering analysis. This summation is the most

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restrictive HERO certification of all involved ordnance. A risk acceptance package is required for each ordnance location not meeting MIL-STD-464 EME levels for HERO SAFE ordnance. Also, document if the flight vehicle cannot accommodate HERO SUCEPTIBLE or HERO UNSAFE ordnance or what mitigation steps to be taken to reduce the EME to accommodate such ordnance.

Characterization of the EME may require using computer-based calculations/equations because of the complexities of a typical flight vehicle geometry. The EME and resulting SSDs have very strong dependency upon the geometry of the flight vehicle, the complexity of the emitter radiation patterns and side lobes, reflections, multiple antenna locations and cavities/enclosed flight vehicle bays. Also, variables such as transmitter DCs, modulations, power settings, and equipment with classified performance parameters add to the overall complexity of the analysis. In some cases, it is prudent and sufficient to make simplifying assumptions to keep calculations in a first order line of sight SSD calculation. When these simplifications yield noncompliant EME, SSDs, or overly severe limitations, a more detailed analysis or in some cases testing will be required.

4.26. Clothing

NASA-STD-8719.12 requires explosive handlers' clothing be compliance with MIL-C-43122, *Military Specification for Cloth, Sateen, Cotton, Flame Retardant Treated* or untreated cotton. The key provisions of this military specification for explosive handlers' clothing is as follows:

- be made of natural fabrics
- have an after-flame time of no more than two (2) seconds
- not be more than 40 percent consumed after two (2) seconds
- after-flame time and consumption rates are good for fifteen (15) launderings

GSFC and its component facilities shall coordinate with the GSFC ESO if deviations from the Agency clothing requirements are project or mission necessary. A deviation from the Agency clothing requirements shall not be made for the sake of convenience.

4.27. Heat Conditioning of Explosives Equipment

All ovens, conditioning chambers, dry houses, and other devices and facilities that are capable, in ordinary service, of heating EELP to temperatures in excess of 90 °F are heat-conditioning devices for the purposes of the application within the GSFC Explosive Safety Program.

Incompatible materials shall not be heated simultaneously in the same heat-conditioning device. Oxidizers shall not be heated in a heat-conditioning device previously used for processing flammable or other incompatible materials until after cleaning and inspection shows it is free of any residual contamination.

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4.28. Classification System

NASA-STD-8719.12 mandates the use of the UN Globally Harmonized System of Classification and Labeling of Chemicals (GHS) as adopted by the DoT. It is essential that explosive handlers understand that under the GHS, EELP will have two hazard classifications: packaged and unpackaged. These two hazard classifications do not have to match and can vary drastically. An explosive material can even ship as a non-explosive material. It is the responsibility of explosive handlers and their supervisors to understand the difference in the packaged and unpacked hazard classifications of the explosives material and device being used.

4.28.1. Hazard Classification – Packaged

A packaged hazard classification can be issued by a recognized Competent Authority (e.g. DoD and DoT) based on the recommendation of a certified testing facility after the EELP has completed a series of tests as defined in the UN Manual of Tests and Criteria. The DoT mandated tests for packaged hazard classification are as follows:

- Drop Weight Impact Sensitivity Test (UN Test Method 3(a)(i))
- Friction Sensitivity Test (UN Test Method 3(b)(iii))
- Thermal Stability Test (UN Test Method 3(c)) at 167 °F)
- Small-Scale Burning Test (UN Test Method 3(d)(i))

The manufacturer of the EELP has a vested interest in packaging the explosives material or device in such a way to ensure successful completion of these tests. There is also an incentive to package the EELP in such a way to minimize its reaction during testing. This makes it safer and thereby cheaper to ship. A HD 1.4 material or device is cheaper to transport as compared to a HD 1.1 material or device.

The packaged hazard classification can be found on the ‘Classification of Explosives’ memorandum issued by the DoT along with the packaging requirements associated with hazard classification. Note that the packaged hazard classification is only valid while packaged according to the defined on the DoT’s memorandum.

The packaged hazard classification can also be found on commercial materials’ Safety Data Sheet in “Section 14 Transport Information”.

At GSFC and its component facilities, the packaged hazard classification shall be recognized for the purpose of a storage hazard classification so long as the EELP is in its tested and verifiable packaged configuration.

4.28.2. Hazard Classification – Unpackaged

The manufacturers of the EELP are not required to perform unpacked hazard classification testing and have little incentive to do so. When manufacturers do not perform this testing, it becomes the end user’s responsibility to determine the unpackaged hazard classification. This

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can be done through a conservative blanket hazard classification of HD 1.1, through issuance of an interim hazard classification, or by in-process hazard classification testing.

- a. If the manufacturer provides an unpacked hazard classification, then one place it can be found for a commercial product's Safety Data Sheet in "Section 2 Hazard Identification". For larger articles like rocket motors, contact the GSFC ESO who can help coordinate with the appropriate safety representative and with the specific manufacturer.
- b. An interim hazard classification should be assigned to explosives under development, test articles, components, and commercial products not having an unpacked hazard classification if they are handled at GSFC and its components. The GSFC ESO will acknowledge the interim hazard classification in a memorandum, safety plan, safety data package, procedure, or other signed document. This interim hazard classification is only valid at GSFC at its component facilities. The interim hazard classification can be made by analogy through review of test and/or performance data of similar EELP. The use of interim hazard classifications is meant to be temporary until a final hazard classification can be made through testing. Interim hazard classifications are not meant to be used for the sake of convenience or as a way of avoiding in-process hazard classification testing.
- c. A final unpacked hazard classification is required for EELP whose use has become or will become routine. The final unpacked hazard classification should be made based on test data provided via UN Series testing or in-process hazard classification testing. GSFC accepts the final unpacked hazard classifications issued by other governmental agencies, such as the DoD. The DoD's tracks the issuance of hazard classifications via the Joint Hazard Classification System (JHCS).

4.28.3. Explosives that Do Not Ship as Explosives

Within the GHS and DoT regulations, there are provisions for transporting explosives without classifying the materials or articles as explosives. Examples of this are as follows:

- a. **DoT Special Permits:** A Special Permit or Approval is a document which authorizes a person to perform a function that is not currently authorized under the authority of the Hazardous Materials Regulations (HMR). Organizations can negotiate with the DoT for special shipping allocations of hazardous materials under certain circumstances.
- b. **Flammable Solid, Division 4.1:** Flammable solids are any materials in the solid phase of matter that can readily undergo combustion in the presence of a source of ignition under standard circumstances, without artificially changing variables such as pressure or density or adding accelerants. Examples:
 - Black Powder for Small Arms, Class 4.1, Identification Number NA0027, is handled as Black Powder, HD 1.1D when out of its shipping configuration
 - Smokeless Powder for Small Arms, Class 4.1, Identification Number NA3178, is handled as Powder, Smokeless, HD 1.3C when out of its shipping configuration

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- c. **Not Regulated as Hazard Class 1:** Small amount of material or articles containing limited amounts of pyrotechnic composition that are packaged in such a way that only a "normal" fire results if a shipping carton containing it.

Categories of EELP that are classified as non-explosive can be stored per their packaged hazard classification at GSFC and its component facilities. These items shall be kept in their packaged configuration at all times while in storage. It is the user's responsibility to perform the quarterly inspections and annual inventories as required by NPR 8715.3. These inspections will ensure the condition of the packaging has not changed thereby invalidating the Class 4.1 designation.

4.29. Quantity of Explosives and Distances

NASA-STD-8719.12 provides general requirements for determining the maximum credible event for a given quantity of explosives of a specific HD. The following are additional requirements for implementation at GSFC and its component facilities:

4.29.1. Equivalent Weight Requirements for Propellants

Given the large quantity of solid-fueled rocket motors used at WFF, additional guidance has been adopted for the determination of NEWQD for those explosive articles. TB 700-2, *Joint Tech Bulletin Ammunition and Explosives Hazard Classification Procedures*, defines a requirement to use specific test data, when available, to determine maximum propellant contribution to an explosive device's NEWQD.

When no test data is available for NEWQD determination, the following propellant contributions shall be used if the propellant formulation and explosive device's configuration are analogous:

- 0% for single and double base gun propellants (5-inch diameter or less)
- 50% for composite rocket propellants
- 100% for gun propellants (greater than 5-inch diameter)
- 100% for double base rocket propellants
- 100% composite / double base rocket propellants
- 125% for high energy propellants

For the purpose of categorization, composite rocket propellants consist of a powdered oxidizer and powdered metal fuel intimately mixed and immobilized with a rubbery binder. Composite propellants are often either ammonium nitrate-based or ammonium perchlorate-based. Double-base propellants are composed of two monopropellant fuel components where one typically acts as a high-energy (yet unstable) monopropellant and the other acts as a lower-energy stabilizing (and gelling) monopropellant. In typical circumstances, nitroglycerin is dissolved in a nitrocellulose gel and solidified with additives. Composite double-base propellants start with a nitrocellulose/nitroglycerin double base propellant as a binder and add solids (typically ammonium perchlorate and powdered aluminum) normally used in composite propellants.

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4.29.2. Personnel Safe Separation Distances

A safe separation distance is the minimum distance required between a given quantity of explosive material and personnel in order to provide a defined level of protection from explosive hazards. These distances do not provide total containment of the primary explosive effects given an intentional or inadvertent initiation, but are rather based on an acceptable level of risk to personnel for their stipulated exposure (essential vs. non-essential).

Personnel are deemed non-essential when they are not essential to, or involved with, the immediate operation presenting the energetic materials hazard. There are two exceptions to the non-essential personnel designation:

- a. When employing the buddy system, the second person can be deemed essential even though only one person may be required to perform the work.
- b. Some observers can also be deemed essential even though they may not normally be part of an explosives operation, but have duties that require their presence, such as quality assurance, safety or inspection personnel.

A safe separation distance acts as the radius of a circular perimeter centered on the potential explosion site where operations involving explosives are being conducted. The delineation between essential and non-essential personnel is key when performing risk-based explosive siting. Calculating an equivalent level of risk as compared to the QD approach of siting is predicated on the distinction between the two types of personnel.

4.30. Hazard Divisions and QD Tables

NASA-STD-8719.12 provides general requirements for determining the QD associated with a given quantity of explosives of specific HD. The following are additional guidelines for implementation at GSFC and its component facilities:

4.30.1. Center Boundary Encroachment

If a proposed PES would create an IBD arc extending beyond GSFC property boundary, the hazard becomes a legal issue. An IBD arc may fall outside of the property boundary, without causing an exception to QD requirements, provided one of the following methods of protecting the public and public property is complied with:

- a. Off-Center land owned by a Federal, State, or Municipal agency in the Continental United States (CONUS) or its possessions or territories.
 - (1) An existing restrictive easement agreement encompasses the off-Center land encumbered by the IBD arc of the PES.

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- (2) A new restrictive easement or agreement is obtained from the land owner for the off-Center land encumbered by the IBD arc prior to establishing or constructing the PES.
 - (3) Off-Center land owned by another NASA organization. In cases where a GSFC PES generates an explosives IBD clear zone encroaching onto property owned by another NASA Center, the local NASA ESO responsible for the encroached upon property will need to provide written acknowledgement and acceptance for the exposure to the GSFC ESO.
 - (4) Off-Center land owned by other Federal Agencies. In cases where a GSFC PES generates an explosives IBD clear zone encroaching onto property owned by another federal agency, the GSFC ESO shall coordinate with his/her appropriate counterpart in the other agency to obtain written acknowledgement and acceptance for the exposure prior to establishing or constructing the PES.
- b. Off-Center land owned by a private land owner requires a restrictive easement prior to establishing or constructing the PES.
 - c. Off-Center land encumbered by the explosives clear zone is open and manifestly unsuitable for habitation or public gatherings, is government land that is not open to the public, or access is restricted and controlled by other means. Only appropriate local government agencies for public safety, environment and health can declare land outside the Center boundary unsuitable for habitation or public gatherings.
 - d. Establishing a clear zone beyond the property boundary that does not involve a private land owner and where no new construction is involved. If the IBD clear zone extends past the property boundary, an exception shall accompany the QD safety submission unless the following compensatory measures can be accomplished:
 - (1) A signed agreement between GSFC and airport manager stating that non-related personnel and activities are not exposed when the mission generating the clear zone is implemented. The agreements are not intended to insinuate the land owner accepts the risk, but rather to confirm exposures are eliminated when mission accomplishment dictates need.
 - (2) The agreements should address termination terms of the agreement in writing with the appropriate parties.

4.30.2. QD Table for Open Burning of Explosives

Reference 40 CFR 265.382, EPA Requirements for Open Burning; Waste Explosives, for specific QD requirements for Open Burn/Open Detonation (OBOD) activities.

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4.31. Refueling Procedures

The following are the minimum requirements for conducting battery charging operations in a facility authorized for the storage and/or handling of EELP:

- a. Only trained and qualified personnel shall be permitted to change, maintain or charge batteries.
- b. Battery charging operations shall be conducted in adequately ventilated areas designated for that purpose.
- c. Tools and other metallic objects shall be kept away from the top of uncovered batteries.
- d. When charging batteries, the vent caps shall be kept in place to avoid electrolyte spray.
- e. The battery compartment or covers shall be open to dissipate heat.

If services other than removal and replacement of batteries are performed, operators shall wear appropriate protective equipment, i.e., rubber apron, face shield and gloves. Additionally, when working with corrosives, an emergency shower or eyewash unit shall be provided for emergency use. Rings, watches and similar jewelry shall not be worn.

4.32. Storage of Powered Equipment

Battery, gasoline, Liquid Propane (LP), Compressed Natural Gas (CNG), or diesel-powered equipment shall be stored in a magazine, storehouse, or other suitable location that contains only non-explosives materials. Equipment shall be kept at least 10 feet from combustible material. Aisles shall be kept clear at all times and space to minimize spread of fire from one unit to another. Equipment essential for daily operations may be parked in fire-resistive buildings containing explosives. The following minimum requirements shall be met:

- a. Use properly rated fire walls and closed doors to completely separate equipment from bays, rooms or cubicles containing explosives.
- b. Ensure designed fire-resistant ratings for the enclosures containing explosives are not degraded.
- c. GSFC ESO and local Fire Protection personnel shall review the local situation for any additional measures necessary to enhance safety.

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5. GUIDANCE

5.1. Reference Documents

N/A

5.2. Key Word Listing

N/A

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Appendix A: Calculating HERO Safe Separation Distances

A.1. Maximum Allowable Environment

For ordnance certified as HERO UNSAFE, the A.1. Maximum Allowable Environment (MAE) electric field strength (E_{MAE}) is defined in Table A-1 and illustrated in Figure A-1.

| Frequency Ranges (MHz) | EMAE (V/M-rms) |
|----------------------------|----------------|
| $0.01 \leq f < 2.0$ | $\frac{1}{f}$ |
| $2.0 \leq f < 80.0$ | 0.5 |
| $80.0 \leq f \leq 100,000$ | $0.00625f$ |

Table A-1: E_{MAE} for HERO UNSAFE Ordnance

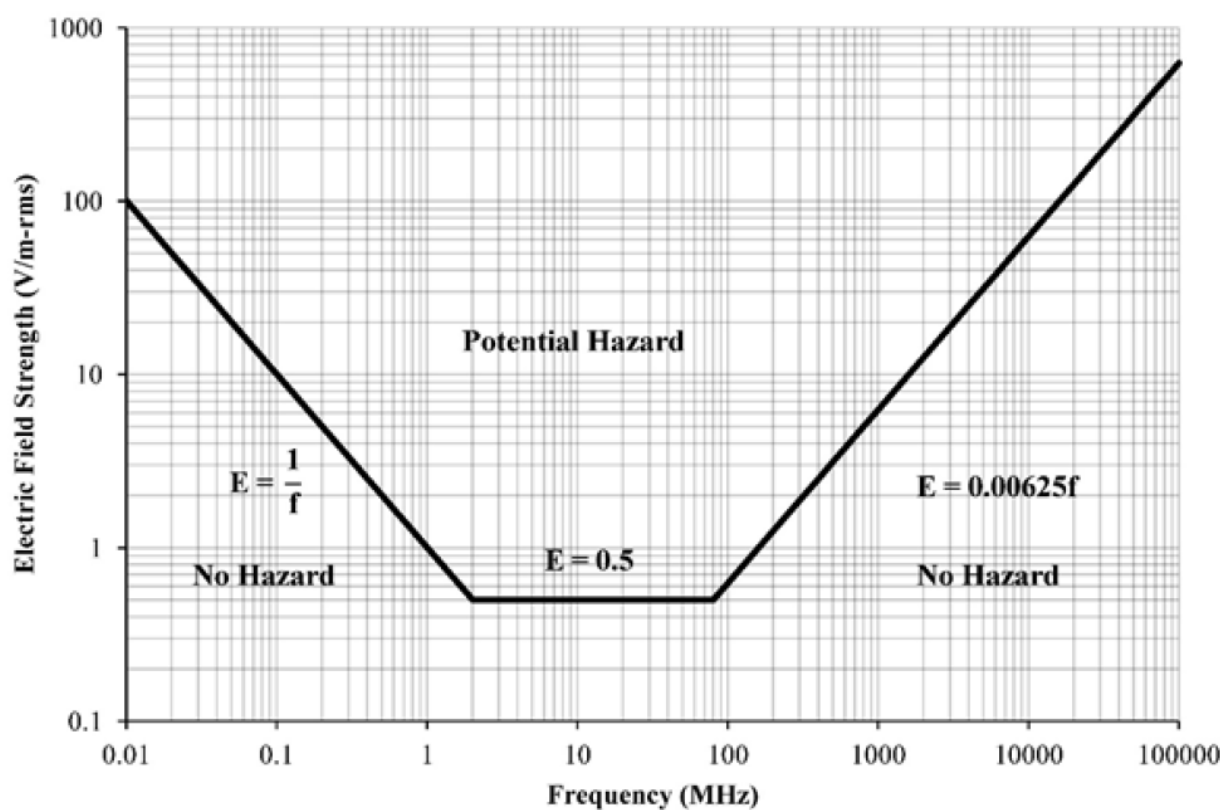
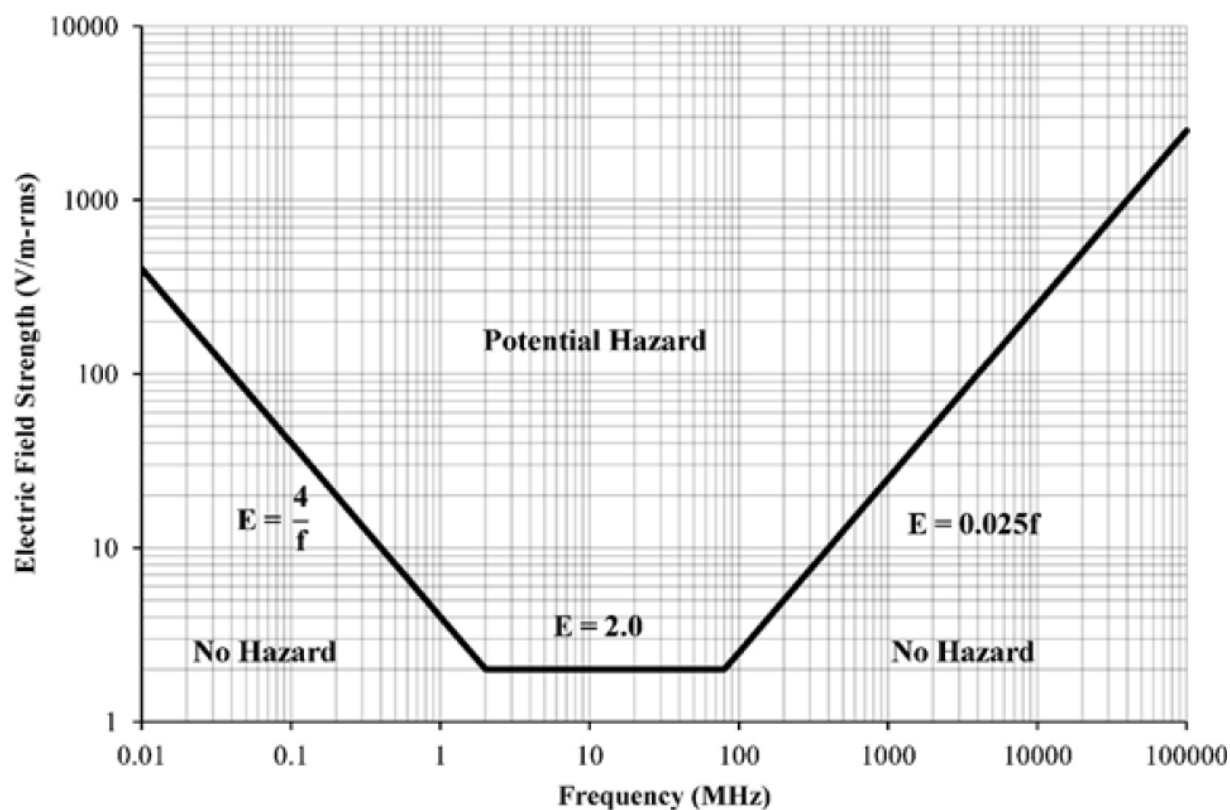


Figure A-1: HERO UNSAFE E_{MAE} Curve

For ordnance certified as HERO SUSCEPTIBLE, the minimum EMAE is defined in Table A-2 and illustrated in Figure A-2.

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| Frequency Ranges (MHz) | EMAE (V/M-rms) |
|----------------------------|----------------|
| $0.01 \leq f < 2.0$ | $\frac{4}{f}$ |
| $2.0 \leq f < 80.0$ | 2.0 |
| $80.0 \leq f \leq 100,000$ | $0.025f$ |

Table A-2: EMAE for HERO SUSCEPTIBLE Ordnance**Figure A-2: HERO SUSCEPTIBLE EMAE Curve**

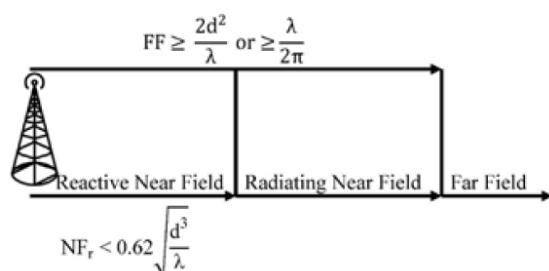
Ordnance certified as HERO SUSCEPTIBLE may have a MAE that is less restrictive than the MAE presented in the general HERO curve given in Table A-2 and illustrated in Figure A-2. Equations given in Table A-4 allow for a calculated SSD for HERO SUSCEPTIBLE when no measured data are available.

A.2. Near- and Far-Field Regions

The electromagnetic fields around an antenna are divided into three regions: the reactive near-field, radiating near-field (Fresnel Region), and the far-field (Fraunhofer Region) which are illustrated in Figure A-3.

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**Figure A-3: Antenna Field Regions**

The reactive near-field always exists around a radiating antenna. But if the antenna is small compared to the wavelength ($\lambda > 10d$), the radiating near-field (Fresnel Region) will not exist. λ is the wavelength and d is the largest linear dimension of the antenna. If an antenna is not radiating, no fields exist.

The reactive near-field is closest to the source (i.e., EMR emitters). In this region, the electromagnetic energy does not behave like EMR because it does not radiate away from the source. The changing electrical potential in the antenna separates the moving charges thereby producing an electric dipole field (i.e., electric charge of equal magnitude but opposite signs, positive versus negative) and magnetic dipole field (i.e., a closed circulation of electric current) where the electromagnetic energy oscillates back and forth so that any energy not received by a receiver is returned to the source instead of radiating away from it. The reactive near-field is capable of only affecting receivers close by (e.g., feedback within the source, magnetic induction inside a nearby electrical transformer, increased load in the source, etc.).

The reactive near-field extends from the antenna a distance of:

$$0.62 \sqrt{\frac{d^3}{\lambda}} \leq NF_{\text{rad}} \leq \frac{2d^2}{\lambda}$$

Equation A-1: Radiating Near-field Regions

where

NF_{rad} = radiating near-field region (meters)

λ = wavelength (meters)

d = maximum linear dimension of an antenna (meters)

For the reactive near-field region, the equation is valid for all types of antennas. This guidance assumes that most radar antennas behave as aperture type antennas and most communication antennas behave as wire antennas.

In the radiated near-field, the EMR travels away from the source in a straight beam about the size of the aperture's projected area with the power level remaining fairly constant with distance. In this region the source's terminal voltage, impedance, and driver current affect the electric and magnetic fields comprising the EMR causing them to vary at different rates where one field becomes dominant. This means that these field do not exhibit a constant ratio of $120\pi \Omega$,

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approximately 377Ω , the intrinsic impedance of free space. However, as the EMR approaches the far-field, the ratio of the two fields begins approximating 377Ω , the variation between them lessens, and they settle into phase.

The vast majority of radar antennas can be treated as aperture antennas while the vast majority of communication antennas can be treated as wire antennas.

For most radar antennas (apertures antennas), the near-field (radiating near-field if it exists, otherwise the reactive near-field) extends from the antenna a distance of:

$$0.62 \sqrt{\frac{d^3}{\lambda}} \leq \text{NF}_{\text{rad}} \leq \frac{2d^2}{\lambda}$$

Equation A-2: Radiating Near-field Regions for Radars

where

NF_{rad} = radiating near-field region (meters)

λ = wavelength (meters)

d = maximum linear dimension of an antenna (meters)

For communication antennas (wire antennas) the near-field extends to one wavelength (λ) from the antenna:

$$0.62 \sqrt{\frac{d^3}{\lambda}} \leq \text{NF}_{\text{rad}} \leq \frac{\lambda}{2\pi}$$

Equation A-3: Radiating Near-field Regions for Communications Antennas

where

NF_{rad} = radiating near-field region (meters)

λ = wavelength (meters)

d = maximum linear dimension of an antenna (meters)

The far-field is the region in which the antenna is focused. At the leading edge of the far-field the radiated beam from the source starts to spread out. This means that the power density along the beam axis decreases with distance until the antenna becomes a point source and the power density obeys the inverse square law.

The boundary between the near-field and the far-field for apertures antennas is:

$$\text{FF} \geq \frac{2d^2}{\lambda}$$

Equation A-4: Radiating Far-field Region

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where

FF = far-field region (meters)

λ = wavelength (meters)

d = maximum linear dimension of an antenna (meters)

The boundary between the near-field and the far-field for wire antennas is:

$$FF \geq \frac{\lambda}{2\pi}$$

Equation A-5: Radiating Far-field Region for Wire Antennas

where

FF = far-field region (meters)

λ = wavelength (meters)

d = maximum linear dimension of an antenna (meters)

The antenna maximum linear dimension is the length of the longest dimension of the antenna itself. For example, a parabolic dish, the dimension is the diameter of the dish. For any other shape, use the longest single dimension, which could be diagonal across a rectangular element such as a grid sectional parabolic antenna.

In the far-field region of an antenna, the power density and electric field are related to each other by the intrinsic impedance of free space:

$$E = \sqrt{P_d Z_0}$$

Equation A-6: Electric Field Strength

where

E = electric field strength (V/m)

P_d = power density (W/m²)

Z_0 = intrinsic impedance of free space, approximately $120\pi \Omega$ or 377Ω

In the far-field, assuming a lossless system, the power density of a directional antenna is:

$$P_d = \frac{P_t G_t}{4\pi r^2} = \frac{\text{EIRP}}{4\pi r^2}$$

Equation A-7: Power Density

where

P_d = power density (W/m²)

P_t = EMR emitter power (W)

G_t = numerical (far-field) antenna gain ratio (unitless)

r = distance or range from an antenna (meters)

EIRP = effective isotropic radiated power (W)

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This equation is generally accurate in the far-field of an antenna but will over-predict power density when close to the antenna, or in the near-field, making worst case or conservative prediction.

Most EMR emitters either produce continuous or pulse-modulated signals. A continuous EMR emitter produces uninterrupted RF such as from an oscillator. Amplitude modulation, frequency modulation, and phase modulation are considered continuous because the RF is continuously present. The power may vary with time due to modulation, but RF is always present. For pulse-modulated signals, typically radars, have differences between peak and average rms power.

Determine the average power by using the ratio of time-on and time-off over an interval. The time-on/off is the DC:

$$DC = \frac{pw}{pri} \quad \text{or} \quad DC = pw * prf$$

Equation A-8: Duty Cycle

where

DC = duty cycle (unitless)
 pw = pulse width (seconds)
 pri = pulse repetition interval (seconds)
 prf = pulse repetition frequency (Hz)

The product of the peak power and DC is the average power:

$$P_a = P_p DC$$

Equation A-9: Average Power

where

P_p = peak power (W)
 DC = duty cycle (unitless)

EMR emitter power is equal to peak power for pulse-modulated systems with pw one millisecond or greater or average power for pw less than one millisecond.

The numerical (far-field) antenna gain ratio, not the dBi value, of an antenna can be determined from the antenna gain expressed in dBi:

$$G_t = \log^{-1} \left(\frac{G_{dBi}}{10} \right) = 10^{\left(\frac{G_{dBi}}{10} \right)}$$

Equation A-10: Antenna Gain Ratio

where

G_t = numerical (far-field) antenna gain ratio (unitless)
 G_{dBi} = antenna gain (dBi)

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Decibel isotropic is the measurement of antenna gain in a directional antenna compared with a theoretical isotropic antenna radiating the exact same energy in all directions. Gain may also be expressed relative to a dipole antenna with units of dBd. Convert from dBd to dBi:

$$G_{\text{dBi}} = G_{\text{dBd}} + 2.15$$

Equation A-11: Antenna Gain Conversion

where

G_{dBi} = antenna gain (dBi)

G_{dBd} = antenna gain (dBd)

Assuming a lossless system, EIRP is the product of EMR emitter power and numerical (far-field) antenna gain ratio:

$$\text{EIRP} = P_t G_t$$

Equation A-12: Effective Isotropic Radiated Power

where

EIRP = effective isotropic radiated power (W)

P_t = EMR emitter power (W)

G_t = numerical (far-field) antenna gain ratio (unitless)

For EIRP in terms of power ratio, EMR emitter power to a milliwatt, with a unit of decibel milliwatt (dBm), or EMR emitter power to one watt, with a unit of decibel watt (dBW), use the following equations to convert from dBm or dBW to watts:

$$\text{EIRP}_W = \log^{-1} \left(\frac{\text{EIRP}_{\text{dBm}}}{10} \right) = 10^{\left(\frac{\text{EIRP}_{\text{dBm}}}{10} \right)}$$

Equation A-13: EIRP Conversion for dBm

$$\text{EIRP}_W = \log^{-1} \left(\frac{\text{EIRP}_{\text{dBW}}}{10} \right) = 10^{\left(\frac{\text{EIRP}_{\text{dBW}}}{10} \right)}$$

Equation A-14: EIRP Conversion for dBW

In some cases, the EMR emitter power may be expressed in terms of effective radiated power (ERP) instead of EIRP. ERP is referenced to a half-wave dipole radiator instead of an isotropic radiator. To convert ERP to EIRP, multiply ERP by a factor of 1.64, the antenna gain of a half-wave dipole antenna relative to an isotropic radiator:

$$\text{EIRP} = 1.64 \text{ERP}$$

Equation A-15: Emitter Power Conversion

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where

EIRP = effective isotropic radiated power (W)

ERP = effective radiated power (W)

In the near-field region of an antenna, determination of electromagnetic field characteristics is more complicated. The electric and magnetic fields are generally dependent on the source of the radiation and can vary with both angular position and distance around an antenna. Furthermore, the wave impedance of the radiation is no longer a constant value, as it was in the far-field region. Determine the electric field/power density at the near-field using guidance provided in Technical Order 31Z-10-4, *Joint Services Command, Control, Communication, and Computer Systems Electromagnetic Radiation Hazards*, or MIL-HDBK-235-1, *Military Operational Electromagnetic Environment Profiles, Part 1C, General Guidance*.

A prediction for electric field/power density in the far-field of the antenna can be made by using equations A-6 and A-7. These equations are generally accurate in the far-field of an antenna but will over-predict electric field/power density when close to the antenna, or in the near-field. In this case they are used for making a worst case or conservative prediction. Therefore, equations in Table A-3 take this assumption into consideration and the resulting SSD equations are considered conservative predictions.

A.3. Traditional Fixed-Location and Mobile Emitters

The following SSD determinations apply to situation involving TFEs/MEs and HERO certified ordnance. A RADHAZ survey provides actual measured data and can be used if the EME exceeds the required levels. Otherwise use the following to determine the SSD in situation involving TFEs/MEs and HERO certified ordnance.

A.3.1. HERO SAFE Ordnance

Maintain a minimum SSD of 10 feet. If the EMR emitter EIRP and frequency(ies) meet the criteria of Table A-5, the minimum SSD listed applies; otherwise the minimum SSD is 10 feet.

A.3.2. HERO UNSAFE Ordnance

If the EMR emitter EIRP and frequency(ies) meets the criteria of Table A-5, the minimum SSD listed applies. Otherwise calculate the SSD using equations in Table A-3. If the calculated SSD is less than 10 feet, then the resulting SSD is 10 feet.

A.3.3. HERO SUSCEPTIBLE Ordnance

If the EMR emitter EIRP and frequency(ies) meets the criteria of Table A-5, when no measured data are available, the minimum SSD listed applies. Otherwise calculate the SSD using equations in Table A-4, when no measured data are available. If the calculated SSD is less than 10 feet, then the resulting SSD is 10 feet.

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A.3.4. Considerations for Multi-Band Emitters

For TFEs/MEs that operate over a frequency band and maintain similar power and antenna gain over the frequency band, apply the following guidance:

- If the EMR emitter's frequency band has a start or lower frequency greater than 80 MHz, use the lowest frequency to determine the SSD for the frequency band.
- If the EMR emitter's frequency band has an end or upper frequency less than 2 MHz, use the highest frequency to determine the SSD for the frequency band.
- If the EMR emitter's frequency band has a start or lower frequency greater than or equal to 2 MHz and an end or upper frequency less than 80 MHz, calculate the SSD using the formula for the frequency range of $2.0 \text{ MHz} \leq f < 80 \text{ MHz}$ because this is the worst case SSD for the frequency band.

A.3.5. Application of Average vs. Peak Emitter Power

For continuous systems and pulse-modulated systems, with pw less than one millisecond, the EMR emitter power is average power and for pulse-modulated systems with pw one millisecond or greater the EMR emitter power is peak power.

| Frequency Ranges (MHz) | SSD Equations |
|----------------------------|---------------------------------------|
| $0.01 \leq f < 2.0$ | $18f\sqrt{P_t G_t}$ feet |
| $2.0 \leq f < 80.0$ | $36\sqrt{P_t G_t}$ feet |
| $80.0 \leq f \leq 100,000$ | $\frac{2,873 \sqrt{P_t G_t}}{f}$ feet |

Table A-3: Equations for Computing SSDs for HERO UNSAFE Ordnance

where

f = frequency (MHz)

P_t = EMR emitter power (W)

$P_t = P_a$ = average power (W) for TFE/ME continuous systems and TFE/ME pulse-modulated systems with pulse width < 1 millisecond

$P_t = P_p$ = peak power (W) for TFE/ME continuous systems and TFE/ME pulse-modulated systems with pulse width ≥ 1 millisecond

G_t = numerical (far-field) antenna gain ratio (not the dBi value)

$$G_t = \log^{-1} \left(\frac{G_{\text{dBi}}}{10} \right) = 10^{\left(\frac{G_{\text{dBi}}}{10} \right)}$$

G_{dBi} = antenna gain (dBi)

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| Frequency Ranges (MHz) | SSD Equations |
|----------------------------|-------------------------------------|
| $0.01 \leq f < 2.0$ | $4.5f\sqrt{P_t G_t}$ feet |
| $2.0 \leq f < 80.0$ | $9\sqrt{P_t G_t}$ feet |
| $80.0 \leq f \leq 100,000$ | $\frac{718 \sqrt{P_t G_t}}{f}$ feet |

Table A-4: Equations for Computing SSDs for HERO SUSCEPTIBLE Ordnance

where

f = frequency (MHz)

P_t = EMR emitter power (W)

$P_t = P_a$ = average power (W) for TFE/ME continuous systems and TFE/ME pulse-modulated systems with pulse width < 1 millisecond

$P_t = P_p$ = peak power (W) for TFE/ME continuous systems and TFE/ME pulse-modulated systems with pulse width ≥ 1 millisecond

G_t = numerical (far-field) antenna gain ratio (not the dBi value)

$G_t = \log^{-1} \left(\frac{G_{\text{dBi}}}{10} \right) = 10^{\left(\frac{G_{\text{dBi}}}{10} \right)}$

G_{dBi} = antenna gain (dBi)

A.4. Multiple Traditional Fixed-Location and Mobile Emitters

For multiple TFEs/MEs that are collocated and operating in phase, the SSD is determined as:

$$SSD_M = \sqrt{\sum_{i=1}^n SSD_i^2}$$

Equation A-16: Summation of SSDs

where

Σ = summation operator

$i = 1, 2, \dots, n$, number of TFEs/MEs

SSD_m = SSD for multiple TFEs/MEs

SSD_i = SSD for each TFE/ME (feet)

For multiple TFEs/MEs operating at different frequency/bands, the largest individual SSD applies.

A.5. Minimum Safe Separation Distance Exceptions

There are exceptions whereby EMR emitters are expected to be, or are required to be, closer than 10 feet to HERO certified ordnance. Their proximity to HERO certified ordnance and low-power EMR emitters require different techniques for mitigating HERO.

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Table A-5 is used for TFEs/MEs if the EIRP and frequency(ies) requirements are met. The GSFC ESO also uses Table A-5 when determining the appropriate SSD for MMEs. Multiple MMEs (two or more) are not authorized in enclosed spaces such as magazines or facilities where ordnance is stored or built-up; the aggregated effects on the ambient or volumetric electromagnetic field in those spaces may increase as a results of complex cavity effects, unless authorized by GSFC ESO.

- a. If the RADHAZ survey included the use of two or more approved MMEs while maintaining EME levels that did not exceed HERO EME levels for ordnance (HERO SUSCEPTIBLE or HERO UNSAFE), multiple MMEs are permissible.
- b. Use of multiple MMEs in enclosed areas is not a concern around HERO SAFE ordnance because the electromagnetic energy produced by the MMEs is unable to exceed MIL-STD-464C levels. Multiple MMEs shall maintain an SSD of 10 feet from ordnance even if one or more meet the criteria of Table A-5.

| Minimum SSD (feet) | HERO Certification | | |
|--------------------------|--|---|--|
| | SAFE | SUSCEPTIBLE | UNSAFE |
| ≥ 10 | General HERO requirements per section 4.25.3 | Use either calculated SSD per Table A-4 or 10 feet, whichever is greater. | Use either calculated SSD per Table A-3 or 10 feet, whichever is greater |
| 5 | $0.5 < \text{EIRP} \leq 5$ All f | $\text{EIRP} \leq 0.5$ $f \geq 100 \text{ MHz}$ | $0.025 < \text{EIRP} \leq 0.1$ $200 \text{ MHz} \leq f < 1 \text{ GHz}$ |
| 1 | $0.1 < \text{EIRP} \leq 0.5$ All f | $0.025 < \text{EIRP} \leq 0.1$ $f \geq 200 \text{ MHz}$ | $0.025 < \text{EIRP} \leq 0.1$ $f \geq 1 \text{ GHz}$ |
| 0* | $\text{EIRP} \leq 0.1$ All f | $\text{EIRP} \leq 0.025$ All f | $\text{EIRP} \leq 0.025$ $f \geq 100 \text{ MHz}$ |

Table A-5: Minimum SSD Exceptions for HERO Certified Ordnance

*** WARNING: Do not touch antennas to ordnance. ***

where

f = frequency (MHz)

EIRP = $P_t G_t$, effective isotropic radiated power (w)

P_t = EMR emitter power (W)

$P_t = P_a$ = average power (W) for TFE/ME continuous systems and TFE/ME pulse-modulated systems with pulse width < 1 millisecond

$P_t = P_p$ = peak power (W) for TFE/ME continuous systems and TFE/ME pulse-modulated systems with pulse width ≥ 1 millisecond

G_t = numerical (far-field) antenna gain ratio (not the dBi value)

$$G_t = \log^{-1} \left(\frac{G_{\text{dBi}}}{10} \right) = 10^{\left(\frac{G_{\text{dBi}}}{10} \right)}$$

G_{dBi} = antenna gain (dBi)

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