(d) The design of an ordnance interrupter must provide for the ordnance interrupter to function without degradation in performance after being subjected to any inadvertent transportation, handling, or installation environment that could go undetected.

(e) The design of an ordnance interrupter that uses ordnance rotor leads must provide for the device to not initiate and be safe to handle after being subjected to the worst-case drop and resulting impact that it could experience during storage, transportation, and installation.

(f) The design of an ordnance interrupter must provide for the ordnance interrupter to withstand, without degradation, repetitive functioning for five times the expected number of arming cycles required for acceptance testing, pre-flight checkout, and flight operations, including an allowance for re-tests due to potential schedule delays.

(g) An ordnance interrupter must not fragment during ordnance initiation.

(h) While in the safe position, an ordnance interrupter must be protected from conditions that could degrade its performance or cause inadvertent initiation during transportation, storage, installation, preflight testing, and potential preflight failure conditions. Safing of an ordnance interrupter must be in accordance with the following:

(1) While in the safe position, an ordnance interrupter shall prevent the functioning of an ordnance train with a reliability of 0.999 at a 95% confidence level.

(2) When locked in the safe position, an ordnance interrupter must prevent initiation of an ordnance train and the ordnance interrupter's performance must not degrade when locked in the safe position and subjected to a continuous operational arming voltage.

(3) The design of an ordnance interrupter must provide for the ordnance interrupter to be manually and remotely safed from any rotor or barrier position and must provide for a manual and remote status indication of when the ordnance interrupter is in the safe position.

(4) An ordnance interrupter must include a safing interlock that prevents moving from the safe position to the arm position while an operational arming current is being applied. The design of a safing interlock must provide for the interlock to be positively locked into place and must provide for a means of verifying proper function of the interlock. The design of a safing interlock and any related operation procedure must eliminate the possibility of inadvertent disconnection of the interlock.

(i) Arming of an ordnance interrupter must be in accordance with the following:

(1) An ordnance interrupter is armed when all ordnance interfaces, such as a donor explosive transfer system, rotor charge, and acceptor explosive transfer system are aligned with one another to propagate the explosive charge.

(2) An ordnance interrupter must provide a local and remote status indication of when the ordnance interrupter is in the arm position.

(3) The design of an ordnance interrupter must provide for the ordnance interrupter to be remotely armed.

D417.27 Ordnance Initiators

(a) The requirements of this section apply to low voltage electro-explosive devices and high voltage exploding bridgewire ordnance initiators.

(b) An ordnance initiator must have a specified all-fire energy level. When the all-fire energy level is applied, the ordnance initiator must initiate with a reliability of no less than 0.999 at a 95 percent confidence level.

(c) An ordnance initiator must have a specified no-fire energy level. When exposed to continuous application of the no-fire energy level, the ordnance must not initiate with a reliability of no less than 0.999 at a 95 percent confidence level. An ordnance initiator's reliability to initiate must not degrade when subjected to continuous application of the no-fire energy level.

(d) The lowest temperature at which an ordnance initiator would experience autoignition, sublimation, or melting or in any other way experience degradation in performance must be no less than 30 °C higher than the highest temperature that could be experienced during handling, testing, storage, transportation, installation, or flight.

(e) An ordnance initiator must be capable of withstanding, without firing or degradation in performance, the maximum expected electrostatic discharge that it could experience from personnel or conductive surfaces. An ordnance initiator must be capable of withstanding workmanship discharges of no less than a 25-kV, 500-pF pin-to-pin discharge through a 5-kΩ resistor and a 25-kV, 500-pF pin-to-case discharge with no resistor.

(f) An ordnance initiator must not initiate or degrade in performance when exposed to stray electrical energy that is at a 20dB margin greater than the greatest stray electrical energy that the ordnance initiator could experience during handling, test, storage, transportation, installation, or flight. When determining the 20dB margin, a launch operator shall account for all potential sources of stray electrical energy including leakage current from other electronic components and radio frequency induced electrical energy. Note: The intent of this requirement is generally met through the use of ordnance initiators that are capable of withstanding no less than one amp and one watt for five minutes without initiating or degrading in performance.

(g) The design of an ordnance initiator must provide for the device to function without degradation in performance after being exposed to any inadvertent transportation, handling, or installation environment that could go undetected.

(h) The design of an ordnance initiator must provide for the device to not initiate and be safe to handle after being subjected to the worst-case drop and resulting impact that the device could experience during storage, transportation, or installation.

(i) An ordnance initiator must be hermetically sealed to the equivalent of 5×10^{-6} scc/sec of helium.

(j) The insulation resistance between mutually insulated points must ensure that an ordnance initiator's performance will not degrade at the maximum applied voltage during testing and flight. The insulation material must not deteriorate, whether due to workmanship, heat, dirt, oxidation, or other causes. An ordnance initiator must be capable of withstanding a workmanship voltage of no less than 500 volts.

D417.29 Exploding Bridgewire

(a) An exploding bridgewire must satisfy the ordnance initiator requirements contained in D417.27 of this appendix and the requirements of this section.

(b) An exploding bridgewire's electrical circuitry, such as connectors, pins, wiring and header assembly, must transmit an all-fire pulse at a level 50% greater than the lowest exploding bridgewire firing unit's operational firing voltage. This includes allowances for effects such as corona and arcing of a flight configured exploding bridgewire exposed to altitude, thermal vacuum, salt-fog, and humidity environments.

(c) An exploding bridgewire must not fragment during ordnance initiation.

(d) The design of all exploding bridgewire connector pins must provide for the pins to withstand the largest axial tension and compression loads that could be induced during connector mating.

D417.31 Percussion Actuated Device

(a) A percussion actuated device's lanyard pull system must include protective covers to prevent inadvertent pulling of the lanyard.

(b) A percussion actuated device must not fragment upon initiation.

(c) A percussion actuated device must have a specified guaranteed no-fire pull force of no less than twice the largest inadvertent pull force that the device could experience during installation, preflight checkout, or flight.

(d) The reliability of a percussion actuated device to not initiate when exposed to its maximum no-fire pull force and then released must be no less than 0.999 at a 95% confidence level.

(e) A percussion actuated device must have a primer all-fire energy level, including spring constant and pull distance that ensures initiation with a reliability of 0.999 at a 95% confidence level. The design of a percussion actuated device must ensure that the all-fire energy level reliability does not degrade when subjected to preflight and flight environments.

(f) A percussion actuated device must deliver an operational impact force to the primer of no less than twice the all-fire energy level.

(g) A percussion actuated device's primer must initiate and not degrade in performance when subjected to two times the operational impact energy or four times the all-fire impact energy level.

(h) A percussion actuated device's reliability must not degrade when subjected to a no-fire pull force and then released.

(i) The lowest temperature at which a percussion actuated device would experience autoignition, sublimation, or melting or in any other way experience degradation in performance must be no less than 30 °C higher than the highest temperature that could be experienced during handling, testing, storage, transportation, installation, or flight.

(j) The design of a percussion actuated device must provide for the device to function without degradation in performance after being exposed to any inadvertent transportation, handling, or installation environment that could go undetected.

(k) A percussion actuated device's ordnance must be hermetically sealed to the equivalent of 5×10^{-6} scc/sec of helium.

(l) The design of a percussion actuated device must provide for the device's structural and firing components to withstand 500 percent of the largest pull or jerk force that it could experience during breakup of the launch vehicle.

(m) The design of a percussion actuated device must provide for the device to not initiate and be safe to handle after being subjected to the worst-case drop and resulting impact that it could experience during storage, transportation, and installation.

(n) A percussion actuated device must include a safing interlock that prevents the percussion actuated device assembly from pulling more than 50% of the guaranteed no-fire pull distance. The design of the safing interlock must provide for the interlock to be positively locked into place and must provide for a means of verifying proper function of the interlock. The design of the safing interlock must eliminate the possibility of inadvertent disconnection or removal of the interlock should a pre-load condition exist on the lanyard. The safing interlock must prevent initiation of the percussion actuated device when subjected to the greatest possible inadvertent pull force that could be experienced during preflight processing.

D417.33 Explosive Transfer System

(a) Ordnance used in an explosive transfer system must utilize secondary explosives except under the provisions of D417.1(a).

(b) The design of all explosive transfer system donor, acceptor, and transition elements must provide for transfer of the explosive charge with a reliability of 0.999 at a 95% confidence level.

(c) An explosive transfer system must function with the smallest bend radius that it would subjected to when implemented in its flight configuration. The reliability of an explosive transfer system must not degrade when subjected to preflight and flight environments with this smallest bend radius.

(d) All explosive transfer connectors must include a positive locking capability and provide for verification of proper connection through visual inspection.

(e) Each explosive transfer system component must not degrade in performance when subjected to the largest pull force that could be experienced during storage, handling, transportation, installation, or flight.

(f) The design of an explosive transfer system must provide for the system to function without degradation in performance after being exposed to any inadvertent transportation, handling, or installation environment that could go undetected.

(g) The design of an explosive transfer system must provide for the system to not initiate and be safe to handle after being subjected to the worst-case drop and resulting impact that it could experience during storage, transportation, and installation.

D417.35 Destruct Charge

(a) A destruct charge must utilize secondary explosives except under the provisions of D417.1(a).

(b) When initiated, a destruct charge acceptor, where applicable, or main charge must ensure the transfer of the explosive charge with a reliability of 0.999 at a 95% confidence level.

(c) Initiation of a destruct charge must result in a flight termination system action in accordance with the flight termination system functional requirements in § 417.303 of this part.

(d) The design of a destruct charge must provide for the charge to sever or penetrate 150% of the thickness of the material that must be severed or penetrated in order for the destruct charge to accomplish its intended flight termination function. A destruct charge, when initiated to terminate the flight of a launch vehicle, must not detonate any launch vehicle or payload propellant.

(e) All destruct charge fittings must withstand 200% of the installation, qualification, and breakup loads without degradation.

(f) The design of a destruct charge must provide for the charge to function without degradation in performance after being exposed to any inadvertent transportation, handling, or installation environment that could go undetected.

(g) The design of a destruct charge must provide for the charge to not initiate and be safe to handle after being subjected to the worst-case drop and resulting impact that it could experience during storage, transportation, or installation.

D417.37 Vibration and Shock Isolators

(a) The design of a vibration or shock isolator must provide for the isolator to have repeatable natural frequency and resonant amplification parameters when subjected to flight environments. The design must account for all effects that could cause variations in repeatability, including acceleration preloads, temperature, component mass, and vibration level variations.

(b) The design of a vibration or shock isolator must provide for the isolator to withstand the qualification test and breakup loads without degradation in performance.

(c) All components mounted on a vibration or shock isolator must withstand the environments introduced by isolator amplification. In addition, all component interface hardware, such as connectors, cables, and grounding straps, must withstand any added deflection introduced by an isolator.

D417.39 Miscellaneous Components

The design of any flight termination system component not specifically identified in this appendix must provide for the component to accomplish its intended function when subjected to non-operating and operating environments that are determined in accordance with D417.3 of this appendix. The design of a miscellaneous component must provide for the component to be tested in accordance with appendix E of this part. The FAA may identify additional requirements for new or unique components in coordination between the launch operator and the FAA through the licensing process.

Appendix E to Part 417—Flight Termination System Component Testing and Analysis

E417.1 General

(a) This appendix contains requirements for qualification, acceptance, and age surveillance testing of flight termination system components. A launch operator shall employ on its launch vehicle only those flight termination system components that satisfy the requirements of this appendix. A launch operator's test program must satisfy § 417.315 and the specific test requirements of this appendix as they apply to the launch operator's flight termination system.

(b) A launch operator shall demonstrate, by test or analysis, that each flight termination system component withstands the environments identified in the applicable test matrices provided in this appendix without degradation in performance.

(c) Compliance with this appendix shall be documented at the time of license application in accordance with § 415.129 of this chapter and for each launch in accordance with § 417.315.

(d) This appendix contains test requirements that are common to all flight termination system components and requirements that apply to specific components. A launch operator shall meet the test requirements that apply to each component unless the launch operator demonstrates, clearly and convincingly through the licensing process, that an alternative provides an equivalent level of safety. The FAA may identify additional test requirements, not contained in this appendix, through the licensing process for new technology or any unique application of existing technology. A launch operator's flight termination system testing for a launch shall accord with the testing compliance matrix approved by the FAA during the licensing process in accordance with § 415.129 of this chapter.

(e) A component sample whose test data reflects that it is out-of-family when compared to other samples of the component shall be considered a test failure even if the component satisfies other test criteria. An unexpected change in the performance of a component sample occurring from the start to the end of testing shall be considered a test failure. For such failures, a launch operator shall perform a failure analysis to determine the root cause of the failure and ensure that there are no generic design, workmanship, or process problems with other flight components of similar configuration.

(f) A component sample that exhibits any sign that a part is stressed beyond its design limit, such as a cracked circuit board, bent clamps, worn part, or loose connector or screw, shall be considered a test failure even if the component passes the final functional test.

(g) If a test discrepancy occurs, the test shall be interrupted, and the discrepancy verified. If the discrepancy is regarded as a failure of the test item, a failure analysis shall be performed and documented along with all corrective actions. The failure analysis shall identify the cause of the failure, the mechanism of the failure, and isolation of the failure to the smallest replaceable item(s).

(h) A launch operator shall apply test tolerances to the nominal test values specified in this appendix and in accordance with the following:

(1) Measurements taken during functional tests must have tolerances that provide the accuracy needed to detect out-of-family and out-of-specification anomalies.

(2) The required qualification design margins for flight termination system components include allowances for test fixture tolerances. These tolerances are identified in this appendix where applicable for each component. Where there are differences between the test tolerances specified in this appendix and the actual test tolerance values, the test levels shall be adjusted accordingly to maintain the required design margin.

(i) All qualification testing shall be performed with the component in its flight configuration, and with flight hardware such as flight connectors, cables, cable clamping scheme, attaching hardware such as vibration and shock isolators, brackets and bolts in flight configuration. Cables and explosive transfer systems shall be secured in the flight configuration at the first tie-down point.

(j) A launch operator shall ensure that flight hardware being acceptance tested is not subjected to forces or environments that are not tested during qualification testing. When special test fixtures are used, such as, to test multiple components during acceptance testing, a launch operator shall ensure that each component is subjected to the required environmental test levels. A test fixture shall be certified for use by measuring and verifying the environmental input at each component position on the fixture.

(k) Components that fail to meet their performance specifications during testing may be reworked and repaired. For any repair requiring disassembly of the component or soldering operations, full acceptance testing shall be performed again. The number of acceptance tests performed on a component must not exceed the duration used during qualification testing. A component that fails to pass any acceptance test shall not be used for flight.

E417.3 Component Test Matrices

(a) *General.* The test matrices provided in E417.17 through E417.39 identify test requirements for specific flight termination system components. Each component must withstand the required test environment without degradation in performance. A launch operator shall apply one of the following to each test requirement identified in the test matrices:

(1) Perform the required test identified in the test matrix and as described in the paragraph referenced by the test matrix.

(2) Demonstrate the test environment is not applicable to the launch operator's flight termination system component.

(3) Perform an analysis that clearly and convincingly demonstrates that the component is unaffected by the subject test.

(4) Perform an analysis that clearly and convincingly demonstrates that another test or combination of tests performed on the component imparts equal or greater stress on the component than the test in question. For any qualification test, a launch operator may implement qualification by similarity to tests performed on identical or similar hardware in accordance with E417.323.

(b) *Test plans, procedures, and reports.* A launch operator shall develop written test procedures and reports in accordance with §§ 415.129 of this chapter and 417.315. Any analysis performed in lieu of testing shall be documented in the test reports.

(c) *Testing sequence.* The testing sequence must detect any component anomaly incurred during testing. Testing shall be performed in the order specified in the test matrices contained in this appendix.

(d) *Quantity of sample components tested.* The number of sample components to be tested that is indicated in each test matrix applies to a new component design. A launch operator may test fewer than the required number of sample components if the launch operator demonstrates, clearly and convincingly through the licensing process, that the component has experienced comparable environmental tests or the component is similar to a design that has experienced comparable environmental tests. A component used for comparison must have been subjected to all required environmental tests to develop cumulative effects.

(e) *Performance verification tests.* Performance verification tests shall be performed to validate that a component satisfies its performance specifications and functions without degradation in performance. Performance verification tests shall be performed before and after a component is exposed to a test environment and must include status-of-health tests where measurements of performance parameters are used to identify potential component performance degradation. Status-of-health performance indicators need not be linked to a component's performance specifications. Where applicable, all performance verification tests of a component shall be performed at the low, nominal, and high operating voltages that will be experienced during preflight and flight operations.

(f) *Abbreviated performance verification tests.* Abbreviated performance verification tests shall be performed to validate a sampling of critical component performance parameters while a component is being subjected to the test environment. These tests shall ensure that all minimum functions critical to flight termination system performance are exercised along with status-of-health indications to identify potential component degradation. Where applicable, the abbreviated performance verification tests of a component shall be performed at the component's nominal operating voltage.

(g) *Status-of-health tests.* Components and subsystems shall be subjected to status-of-health tests to verify that all critical parameters are within their performance specification. A critical parameter is one that acts as an indicator of an internal anomaly that may not be detectable by means of functional performance tests. A launch operator shall identify all critical parameters for each component, which must include the critical parameters identified in this appendix for specific components. Status-of-health test data shall be recorded and used for comparison to determine performance degradation after environmental test exposure.

E417.5 Component Examination

(a) *General.* Each component shall be examined to identify manufacturing defects that may not be detectable during performance testing. The presence of a defect constitutes a failure. The examinations applicable to each component are identified in the test matrices provided in this appendix. The examinations shall be performed in accordance with the requirements of this section.

(b) *Visual.* Visual examination shall be performed to ensure that good workmanship was employed during manufacture of a component and that the component is free of obvious physical defects. Visual examination may include the use of optical magnification, mirrors, or specific lighting, such as ultra violet illumination.

(c) *Dimension.* The physical dimension of a component shall be checked to ensure that it is within the component's dimensional design limits.

(d) *Weight.* A component shall be weighed to verify that its weight is within its performance specification.

(e) *Identification.* Component identification tags shall be checked to ensure that they contain information that allows for configuration control and tracing of each component.

(f) *X-ray and N-ray examination.* For a component that is required to undergo X-ray or N-ray examination in accordance with the test matrixes in this appendix, the quality and resolution of the film must allow detailed inspection of the internal parts of the component and determination of potentially anomalous conditions. Multiple photographs shall be taken from different angles to allow complete coverage of the required areas. A certified technician shall perform evaluation of X-ray and N-ray photographs. Technician certification and training must satisfy § 417.105 and be documented in accordance with § 415.113.

(g) *Disassembly.* A component shall be inspected for excessive wear and damage after exposure to qualification test environments. The level of inspection may vary depending on the type of component and in accordance with following:

(1) A component that can be disassembled shall be completely taken apart to the point at which all internal parts can be inspected.

(2) All internal components and subassemblies, such as circuit board traces, internal connectors, welds, screws, clamps, electronic piece parts, battery cell plates and separators and mechanical subassemblies shall be examined using an applicable inspection method, such as, magnifying lens or radiographic techniques.

(3) For a component that cannot be disassembled, such as an antenna, potted

unit, or welded structure, the FAA shall identify special inspection requirements in coordination with the launch operator through the licensing process in accordance with § 415.11 of this chapter to ensure that there are no internal defects. Special inspection requirements may include depotting units, cutting components into cross-sections, or radiographic inspection.

(h) *Leakage.* A component that is required to undergo leak tests according to the test matrixes in this appendix shall be subjected to leak checks to ensure that the component's seal is within its design limit before and after being subjected to the test environment. A leak test must have the accuracy and resolution to verify the component's leak rate is no greater than its design limit in accordance with the following:

(1) An electronic component shall be tested to verify a leak rate of no greater than the equivalent of 10^{-4} standard cubic centimeters/second (scc/sec) of helium. Leak testing is not required for unsealed components that have successfully completed salt-fog, humidity, and fine sand qualification testing.

(2) An ordnance component shall be tested to verify a leak rate of no greater than the equivalent of 10^{-6} scc/sec of helium.

E417.7 Qualification Testing and Analysis

(a) A launch operator shall ensure that the design of each flight termination system component provides for the component to function according to its performance specifications when subjected to normal flight environments and environments that would result in breakup of the launch vehicle. A launch operator shall demonstrate, by analysis or test, that a component will satisfy all its performance specifications when subjected to test conditions at the design environmental levels required by D417.3 of appendix D of this part and in accordance with the qualification non-operating and operating environmental test requirements of this appendix.

(b) Prior to being subjected to qualification test environments, a component shall be subjected to environmental acceptance test conditions without physical damage or degradation in performance. Acceptance test requirements are provided in E417.11 and the acceptance test matrices of this appendix.

(c) Each component must be tested in its flight configuration, with all flight hardware such as connectors, cables, and any cable clamps, and with all attachment hardware, such as dynamic isolators, brackets and bolts, as part of that flight configuration. When using any test fixture, such as that used to test multiple component samples, any effects that the fixture has on the testing shall be determined and the test levels that each component sample receives shall be verified.

(d) A component design shall undergo qualification testing again if there is a change in the design of the component or in the environmental levels to which it will be exposed. A component must be re-qualified if the manufacturer's location, parts, materials, or processes have changed since the previous qualification. A change in the name of the manufacturer as a result of a sale does not require re-qualification if the personnel, factory location or the parts, material and processes remain unchanged since the last component qualification. The extent of re-qualification testing must be the same as the initial qualification unless the launch operator demonstrates, clearly and convincingly through the licensing process, that other testing achieves an equivalent level of safety.

(e) A component sample that has been subjected to qualification testing shall not be used for flight.

(f) Contingent upon approval by the FAA, the testing involved in qualifying a component's design may be reduced through qualification by similarity to tests performed on identical or similar hardware. A component ''A'' will be considered as a candidate for qualification based on similarity to component ''B'' that has already been qualified for use, under the following conditions:

(1) ''B'' shall have been qualified through testing, not by similarity.

(2) The environments encountered by ''B'' during its qualification or flight history must have been equal to or more severe than the qualification environments required for ''A.''

(3) ''A'' must be a minor variation of ''B.'' A launch operator shall describe the design differences in terms of weight, mechanical configuration, thermal effects, dynamic response, changes in piece part quality level, addition or subtraction of piece parts, including moving parts, ceramic or glass parts, crystals, magnetic devices, and power conversion or distribution equipment.

(4) ''A'' and ''B'' must perform the same functions, with ''A'' having equivalent or better capability with variations only in terms of performance such as accuracy, sensitivity, formatting, and input/output characteristics.

(5) ''A'' and ''B'' must be produced by the same manufacturer in the same location using identical tools and manufacturing processes.

(6) The time elapsed since last production of ''A'' and ''B'' must be no greater than three years.

(g) For any flight termination system component to be used for more than one flight, the component qualification tests must demonstrate that the component functions without degradation in performance when subjected to the qualification test environmental levels plus the total number of exposures to the maximum predicted environment levels for each of the flights to be flown. For each such component, a launch operator shall implement a component reuse qualification, refurbishment, and acceptance plan approved by the FAA through the licensing process.

E417.9 Qualification Non-Operating Environments

(a) *General.* A launch operator shall ensure that a flight termination system component functions according to its performance specifications when subjected to non-operating environments that the component will experience before flight. A launch operator shall demonstrate, by analysis or testing of test samples of a component, that the component will satisfy all of its performance specifications when subjected to test conditions that emulate each maximum predicted non-operating environment that the component would experience during storage, transportation, or installation and any other non-operating environment. Each test must emulate the actual configuration that the component will be in when exposed to the non-operating environment.

(b) *Storage temperature.* A component shall be tested to demonstrate its ability to satisfy its performance specifications when subjected to the maximum predicted high and low temperatures, thermal cycles, and thermal dwell times (time spent at the high and low temperatures) that the component would experience under storage conditions in accordance with the following:

(1) Thermal testing shall be performed at temperatures from 10 °C lower to 10 °C higher than the maximum predicted storage thermal range. The thermal rate of change from one thermal extreme to the other used during testing shall be no less than the maximum predicted thermal rate of change.

(2) All thermal dwell times used for qualification testing must be three times the maximum predicted storage environment. The number of thermal cycles used for qualification testing must be three times the maximum predicted storage environment.

(3) An analysis may be performed in lieu of storage temperature testing if the operating thermal cycle test is shown to be a more severe test. This may be accomplished by performing thermal fatigue equivalence calculations that demonstrate that the large change in temperature for a few thermal cycles experienced during flight is a more severe environment than the relatively small change in temperature for many thermal cycles that would be experienced during storage.

(c) *High temperature storage of ordnance.* For tests being performed to extend the service life of an ordnance component production lot, sample components from the production lot shall be tested to demonstrate that the performance of each component does not degrade after being subjected to +71 °C and 40 to 60 percent relative humidity for no less than 30 days.

(d) *Transportation shock test.* A component shall be tested to demonstrate that it satisfies its performance specifications after being subjected to the maximum predicted transportation induced shock levels that the component would experience in its transported configuration. Analysis may be performed in lieu of transportation shock testing if the operating environment shock testing is shown to be a more severe test.

(e) *Bench handling shock.* A component shall be tested to demonstrate that it satisfies its performance specifications after being subjected to maximum predicted bench handling induced shock levels. Component testing shall include drop testing from the maximum predicted handling height onto a representative surface in any orientation that could occur during servicing.

(f) *Transportation vibration.* A component shall be tested to demonstrate that it meets all performance specifications after being subjected to maximum predicted transportation induced vibration levels when in its transportation configuration.

(1) The transportation vibration tests shall include a three axis component test at the following levels for 60 minutes per axis:

(i) 0.01500 g^2/Hz at 10 Hz to 40 Hz.

(ii) 0.01500 g^2/Hz at 40 Hz to 0.00015 g^2/Hz at 500 Hz

(2) If the component is resonant below 10 Hz, the test vibration curve shall be extended to the lowest resonant frequency.

(3) Analysis may be performed in lieu of transportation vibration testing if the operating vibration test is shown to be a more severe test. This may be accomplished by performing vibration fatigue equivalence calculations that demonstrate that the high vibration levels with short duration experienced during flight is a more severe environment than the relatively low-vibration levels with long duration that would be experienced during transportation.

(g) *Fungus resistance.* A component shall be tested to demonstrate that it satisfies its performance specifications after being subjected to a fungal growth environment. Analysis may be performed in lieu of testing if it is shown that all unsealed and exposed surfaces do not contain fungus nutrient materials.

(h) *Salt fog.* A component that will be exposed to salt fog conditions while in service shall be tested to demonstrate that it satisfies its performance specifications after being subjected to the effects of a moist, salt-laden atmosphere. All externally exposed surfaces shall be tested to demonstrate the ability to withstand a salt-fog environment. Also, each internal part of a component shall be tested to demonstrate its ability to withstand a salt-fog environment unless the part is sealed and acceptance testing is performed on 100 percent of the part samples to verify that the seal works before the part sample is installed in a component.

(i) *Fine sand.* A component shall be tested to demonstrate that it satisfies its performance specifications after being subjected to the effects of dust or fine sand particles that may penetrate into cracks, crevices, bearings and joints. All externally exposed surfaces shall be tested to demonstrate the ability to withstand a fine sand environment. Also, each internal part of a component shall be tested to demonstrate its ability to withstand a fine sand environment unless the part is sealed and acceptance testing is performed on 100 percent of the part samples to verify that the seal works before the part sample is installed in a component.

(j) *Tensile load.* A component shall be tested to demonstrate its ability to withstand handling tensile and compression loads during transportation and installation without damage or degradation in performance. Qualification test loads shall be at twice the expected level or the following criteria, whichever is greater:

(1) For an explosive transfer system and associated fittings, a pull test shall be performed at no less than 100 lbs.

(2) For a destruct charge and associated fittings, a pull test shall be performed at no less than 50 lbs.

(3) Flight radio frequency connectors shall be pull tested at one-half the design specification.

(4) Electro explosive devices wires shall be pull tested to 18 pounds

(5) Exploding bridgewire devices electrical pins shall be tested to demonstrate the ability to withstand an 18-pound force in axial and compression modes.

(k) *Handling drop of ordnance.* An ordnance component shall be tested to demonstrate that its performance does not degrade after being subjected to the maximum predicted drop and resulting impact that could go undetected during storage, transportation, or installation or a six-foot drop onto a representative surface in any orientation that could occur during storage, transportation, or installation; whichever drop and resulting impact is more severe.

(l) *Abnormal drop of ordnance.* An ordnance component shall be tested to demonstrate that it does not initiate and is safe to handle, although it need not function, after being subjected to the maximum predicted drop that it could experience during storage, transportation, or installation, regardless of whether or not the drop could go undetected, or the applicable drop defined below onto a representative surface in any orientation that could occur during storage, transportation, or installation; whichever drop is more severe:

(1) For a safe and arm device with internal ordnance, the test must use a minimum drop height of 20 feet.

(2) For ordnance that is not internal to a safe and arm device, the test must use a minimum drop height of 40 feet.

E417.11 Qualification Operating Environments

(a) *General.* A launch operator shall ensure that a flight termination system component functions according to its performance specification when subjected to operating environments that the component will experience during acceptance testing, launch countdown, and flight. A launch operator shall demonstrate, by analysis or testing of test samples of a component in accordance with this section, that the component will meet all of its performance specifications during and after exposure to physical environments that flight components will experience during acceptance testing and during launch countdown and flight. For ordnance components, the testing requirements of this section apply to qualification, age surveillance and lot acceptance testing.

(b) *Qualification sinusoidal vibration.* Each component, whether hard-mounted or isolator mounted, and any isolator, grounding strap, bracket, explosive transfer system, and flight cable to the first tie-down that interface with the component, shall be tested to demonstrate their ability to satisfy their performance specifications when subjected to qualification sinusoidal vibration environments that are more severe than the workmanship and maximum predicted flight sinusoidal vibration environments satisfy the following:

(1) The qualification sinusoidal vibration test level shall be 6dB greater than the maximum predicted environment.

(2) Test duration for each of three axes must be no less than three times the maximum predicted duration. The sinusoidal sweep rate used for the test must be no less than three times the maximum predicted sweep rate on each of three axes.

(3) The test tolerance used shall be ±10%.

(4) The sinusoidal frequency range shall be the maximum predicted environment frequency range, plus and minus 50%.

(5) Analysis may be performed in lieu of testing if a launch operator demonstrates that the qualification operating random vibration testing, performed in accordance with paragraph (c) of this section, envelops the qualification test sinusoidal vibration levels. For this analysis, the peak random vibration levels, as a function of time, must envelop the sinusoidal qualification test levels and duration.

(6) All performance and status-of-health parameters shall be continuously monitored and recorded during testing with a resolution of no less than one millisecond.

(c) *Qualification random vibration.* Each component, whether hard-mounted or isolator mounted and any isolator, grounding strap, bracket, explosive transfer system, and flight cable to the first tie-down that interface with the component shall be tested to demonstrate their ability to satisfy their performance specifications when subjected to qualification random vibration environments that are more severe than the workmanship and maximum predicted flight random vibration environments. The qualification random vibration environments and testing must satisfy the following:

(1) For each component required by this appendix to undergo 100% acceptance testing, the qualification random vibration testing must maintain no less than a 3dB margin between the minimum qualification test level and the maximum acceptance test level from 20 Hz to 2000 Hz. For the random vibration tests required by this appendix to have a test tolerance of ±1.5dB, the qualification test random vibration level must be the acceptance test level plus 6 dB.

(2) For each component that is required by this appendix to be lot acceptance tested or that is not individually acceptance tested, such as ordnance and any silver-zinc battery, the qualification random vibration testing must maintain no less than a 4.5dB margin between the minimum qualification test level and the greater of the maximum predicted environment or the minimum workmanship test level from 20 Hz to 2000 Hz. Minimum workmanship levels are provided in table E417.11–1. For the random vibration tests required by this appendix to have a test tolerance of ±1.5dB, the qualification random vibration test level must be the greater of the maximum predicted environment or the minimum workmanship test level, plus 6 dB.

(3) For a component using vibration isolators, the component and isolators shall be tested as one unit to the qualification levels required by paragraphs (c)(1) and (c)(2) of this section. In addition, the component, without isolators, shall be tested to the minimum workmanship levels of table E417.11–1.

(4) The test duration, in each of three mutually perpendicular axes, must last three times as long as the acceptance test duration or minimum workmanship qualification duration of 180 seconds, whichever is greater.

(5) Qualification tests and acceptance tests shall be performed using identical test configuration and methods.

(6) Performance verification tests shall be performed while the component is subjected to the qualification random vibration environment. Where the duration of the qualification random vibration environment is such that there is insufficient time to complete the testing of all functions and modes while the component is subjected to the full qualification random vibration level, extended testing at the acceptance random vibration level shall be conducted as necessary to complete functional testing.

(7) All performance and status-of-health parameters shall be continuously monitored and recorded during testing with a resolution of no less than one millisecond. This testing shall be performed at nominal operating voltage, where applicable.

(8) Random vibration testing may be used in lieu of testing for other dynamic qualification test environments, such as acceleration, acoustic and sinusoidal vibration if the launch operator demonstrates that the required forces, displacements, and test duration imparted on a component during random vibration testing are equal to or more severe than the other qualification test environment.

TABLE E417.11–1.—MINIMUM WORKMANSHIP POWER SPECTRAL DENSITY FOR QUALIFICATION RANDOM VIBRATION TESTING

Frequency range (Hz)	Minimum power spectral density
20	0.021 g^2/Hz.
20–150	3 dB/octave slope.
150–600	0.16 g^2/Hz.
600–2000	−6 dB/octave slope.
2000	0.014 g^2/Hz.
Overall G_{rms} = 12.2	

(d) *Qualification acoustic.* Each component, whether hard-mounted or isolator mounted, and any isolator, grounding strap, bracket, explosive transfer system, and flight cable to the first tie-down, that interface with the component shall be tested to demonstrate their ability to satisfy their performance specifications when subjected to qualification acoustic environments that are more severe than the workmanship and maximum predicted flight acoustic environments. The qualification acoustic environments and testing shall satisfy the following:

(1) For each component required by this appendix to undergo 100% acoustic acceptance testing, the qualification acoustic vibration testing must maintain a positive margin between the minimum qualification test level and the maximum acceptance test level from 20 Hz to 2000 Hz. For the random acoustic vibration tests required by this appendix to have a tolerance of ±3 dB, the qualification test level must be the acceptance test level plus 6 dB.

(2) For each component that is not required by this appendix to be individually acoustic acceptance tested, such as ordnance and any silver-zinc battery, the qualification acoustic vibration testing must maintain no less than a 3 dB margin between the minimum qualification test level and the greater of the maximum predicted environment or the minimum workmanship test level of 144 dBA from 20 Hz to 2000 Hz. For the acoustic vibration tests required by this appendix to have a tolerance of ±3.0 dB, the test level must be the greater of the maximum predicted environment or the minimum workmanship test level, plus 6 dB.

(3) For a component using one or more vibration isolators, the component and isolators shall be tested as one unit to the qualification levels required by paragraphs (d)(1) and (d)(2) of this section. In addition, the component, without isolators, shall be tested to no less than the minimum workmanship level of 144 dBA.

(4) All performance and status-of-health parameters shall be continuously monitored and recorded during testing with a resolution of no less than one millisecond.

(5) Analysis may be performed in lieu of testing if a launch operator demonstrates that the qualification operating random vibration testing performed in accordance with paragraph (c) of this section envelops the qualification acoustic environments. For this analysis, the peak random vibration levels, as a function of time, must envelop the qualification acoustic levels and duration.

(e) *Qualification shock.* Each component, whether hard mounted or isolator mounted, and any isolator, grounding strap, bracket, explosive transfer system, and flight cable to the first tie-down that interface with the component, shall be tested to demonstrate their ability to satisfy their performance specifications when subjected to qualification shock environments that are more severe than the maximum predicted flight shock environments. The qualification shock environments and testing must satisfy the following:

(1) Qualification shock testing must maintain no less than a 3.0 dB margin between the minimum qualification test shock level and the greater of the maximum predicted environment or the minimum workmanship test levels from 100 Hz to 10000 Hz. The minimum workmanship shock levels as a function of frequency are provided in table E417.11–2. For a shock test required by this appendix to have a -3 dB lower tolerance, the qualification test level shall be the greater of the maximum predicted environment or the minimum workmanship test level, plus 6 dB.

(2) The applied shock transient must provide a simultaneous application of all frequencies. It must not provide a serial application of the frequencies.

(3) A component shall be subjected to three shocks in each direction along each of the three orthogonal axes.

(4) The shock duration must simulate the maximum predicted event.

(5) A component's critical performance parameters shall be continuously monitored for discontinuities or inadvertent output while the component is subjected to the shock environment. Any discontinuity or inadvertent output constitutes a test failure.

(6) All performance and status-of-health parameters shall be continuously monitored and recorded during testing with a resolution of no less than one millisecond.

TABLE E417.11–2.—MINIMUM WORKMANSHIP QUALIFICATION SHOCK LEVEL

Frequency range (Hz)	Minimum acceleration spectral density
100	100 G.
2000	1300 G.
10000	1300 G.
Q=10	

(f) *Qualification acceleration.* Each component, whether hard-mounted or isolator mounted, and any isolator, grounding strap, bracket, explosive transfer system, and flight cable to the first tie-down that interface with the component, shall be tested to demonstrate their ability to satisfy their performance specification when subjected to qualification acceleration environments that are more severe than the flight acceleration environments. The qualification acceleration environments and testing must satisfy the following:

(1) The acceleration test level must be no less than two times the maximum predicted environment.

(2) The duration of the acceleration must last three times the duration of the maximum predicted environment in each direction for each of the three orthogonal axes.

(3) If the test tolerance used is more than ±10%, an appropriate factor must be added to the qualification acceleration test level to maintain the margin between the maximum predicted environment and the qualification level required by paragraph (f)(1) of this section.

(4) Analysis may be performed in lieu of testing if a launch operator demonstrates that the qualification operating random vibration testing performed in accordance with paragraph (c) of this section envelops the qualification acceleration environments. For this analysis, the peak random vibration levels, as a function of time, must envelop the qualification acceleration levels and duration.

(5) All performance and status-of-health parameters must be continuously monitored and recorded during testing with a resolution of no less than one millisecond.

(g) *Qualification humidity.* A component shall be tested to demonstrate that it satisfies its performance specifications when subjected to the maximum expected relative humidity environment that could occur during storage and transportation and when installed. The qualification humidity environments and testing must satisfy the following:

(1) Humidity testing must include at least four thermal cycles while being exposed to a 100% relative humidity environment.

(2) Electrical performance tests shall be conducted at the cold, ambient, and hot temperatures during the first, middle and last thermal dwell cycles.

(3) All performance and status-of-health parameters shall be continuously monitored and recorded during testing with a resolution that detects component performance degradation for all cycles and thermal transitions.

(h) *Qualification thermal cycle.* A component shall be tested to demonstrate that it satisfies its performance specifications when subjected to workmanship, preflight, and flight thermal environments. Each component must meet its performance specifications when subjected to qualification thermal cycle environments in accordance with the following:

(1) *Electronic components.* The following qualification thermal cycle test requirements apply to all command receiver decoders and any other electronic component that contains piece-part circuitry, such as microcircuits, transistors, diodes and relays.

(i) The qualification thermal cycle must range from the acceptance test high temperature plus 10°C to the acceptance test low temperature minus 10°C.

(ii) The component must be subjected to no fewer than 24 thermal cycles. For each cycle, the dwell times at the high and low temperatures must be long enough for the component to achieve internal thermal equilibrium and must be no less than one hour. During each dwell time at the high and low temperatures, the component shall be turned off until the temperature stabilizes and then turned on.

(iii) The thermal rate of change between the low and high temperatures shall be an average rate of 1 °C per minute or the maximum predicted rate, whichever is greater.

(iv) Performance verification tests shall be conducted at the component's low and high operating voltage when the component is at the high, ambient, and low temperatures during the first, middle and last thermal dwell cycles.

(v) Critical performance and status-of-health parameters shall be continuously monitored and recorded with a resolution that detects component performance degradation. These tests shall be performed at the nominal operating voltage for all cycles and thermal transitions.

(2) *Passive components.* A passive component is any component that does not contain active electronic piece parts. Passive components include, but need not be limited to, radio frequency antennas; rechargeable batteries, such as nickel cadmium batteries; couplers; and cables. Qualification thermal cycle tests for passive components must satisfy the following:

(i) The qualification thermal cycle must range from the acceptance test high temperature plus 10°C to the acceptance test low temperature minus 10°C.

(ii) The component must be subjected to no fewer than 24 thermal cycles. For each cycle, the dwell times at the high and low temperatures must be long enough for the component to achieve internal thermal equilibrium and must last no less than one hour.

(iii) The thermal rate of change between the low and high temperatures shall be an average rate of 1°C per minute or the maximum predicted rate, whichever is greater.

(iv) Performance verification tests shall be conducted when the component is at the high, ambient, and low temperatures during the first, middle, and last thermal cycles.

(v) Critical performance and status-of-health parameters shall be continuously monitored and recorded with a resolution that detects component performance degradation. These tests shall be performed for all cycles and thermal transitions.

(3) *Silver zinc batteries.* Qualification thermal cycle tests for a flight termination system silver-zinc battery shall satisfy the following:

(i) The qualification thermal cycle must range from the maximum predicted high temperature plus 10°C to the maximum predicted low temperature minus 5.5°C.

(ii) The battery must be subjected to no fewer than eight thermal cycles. For each cycle, the dwell times at the high and low temperatures must be long enough for the battery to achieve internal thermal equilibrium and must be no less than one hour.

(iii) The thermal rate of change between the low and high temperatures must be an average rate of 1 °C per minute or the maximum predicted rate, whichever is greater.

(iv) Performance verification tests shall be conducted when the battery is at the high, ambient, and low temperature during the first, middle, and last thermal cycle.

(v) Critical performance and status-of-health parameters shall be continuously monitored and recorded for all thermal cycles and transitions with a resolution that detects component performance degradation.

(4) *Electro-mechanical safe and arm devices with internal explosives:*

(i) The qualification thermal cycle must range from the acceptance test high temperature plus 10°C to the acceptance test low temperature minus 10°C.

(ii) The component shall be subjected to no fewer than 24 thermal cycles. For each cycle, the dwell times at the high and low temperatures must be long enough for the component to achieve internal thermal equilibrium and must last no less than one hour.

(iii) The thermal rate of change between the low and high temperatures must be an average rate of 1°C per minute or the maximum predicted rate, whichever is greater.

(iv) Performance verification tests shall be performed when the component is at the high, ambient, and low temperatures during the first, middle, and last thermal cycles.

(v) All performance and status-of-health parameters shall be continuously monitored and recorded at all temperature cycles and transitions using a resolution that detects component performance degradation.

(5) *Ordnance components.* Qualification thermal cycle tests for ordnance components must satisfy the following:

(i) The qualification thermal cycle must range from the maximum predicted high temperature plus 10°C, or 71°C, whichever is higher, to the predicted low temperature minus 10°C, or −54°C, whichever is lower.

(ii) The ordnance component must be subjected to no fewer than eight thermal cycles. For an ordnance component that is used inside a safe and arm device, the ordnance component must be subjected to 24 thermal cycles. For each cycle, the dwell times at the high and low temperatures must be long enough for the component to achieve internal thermal equilibrium and must last no less than two hours.

(iii) The thermal rate of change between the low and high temperatures must be an average rate of 3°C per minute or the maximum predicted rate whichever is greater.

(i) *Qualification thermal vacuum.* A component shall be tested to demonstrate that it satisfies its performance specifications, including structural integrity, when it is subjected to a combination of altitude and thermal environments in accordance with the following:

(1) The qualification thermal vacuum temperatures must be at the acceptance test high temperature plus 10°C and the acceptance test low temperature minus 10°C.

(2) The pressure gradient must be the maximum predicted rate of altitude change that will be experienced during flight. The final vacuum dwell time must be long enough for the component to achieve pressure equilibrium.

(3) The number of thermal cycles must be three times the maximum predicted thermal cycles. These thermal cycles shall be performed during the final vacuum dwell time.

(4) Performance verification tests shall be performed using the component's low and high operating voltage and when the component is at the high, ambient, and low temperatures during the first, middle and last thermal cycles.

(5) Critical performance and status-of-health parameters shall be continuously monitored and recorded during chamber pressure reduction and the final vacuum dwell time, using a resolution that detects component performance degradation. This test must be performed at the high operating voltage for all cycles and thermal transitions.

(6) Analysis may be performed in lieu of testing in accordance with the following:

(i) For a low voltage component, less than 50 volts, analysis may be performed in lieu of testing if the analysis demonstrates that the component is not susceptible to corona, arcing, or structural failure.

(ii) For a high voltage component, greater than 50 volts, thermal vacuum testing shall be performed unless the component is environmentally sealed and analysis demonstrates that any low voltage externally exposed part is not susceptible to corona, arcing, or structural failure. A component with any high voltage externally exposed part shall be subjected to thermal vacuum testing.

(j) *Electromagnetic interference and electromagnetic compatibility.* A component shall be tested to demonstrate that it does not degrade in performance when subjected to radiated or conducted emissions from all flight vehicle systems and external ground transmitter sources. In addition, a component shall not radiate or conduct electromagnetic interference that would degrade the performance of any other flight termination system component.

(k) *Explosive atmosphere.* A launch operator shall demonstrate, through testing or analysis, that a component operates in an explosive atmosphere without creating an explosion.

E417.13 Acceptance Testing

(a) *General.* Each flight termination system component that is to be flown on a launch vehicle must undergo acceptance tests in accordance with this section. Each component shall be tested to detect any material and workmanship defects and to demonstrate its ability to satisfy its performance specifications when exposed to each maximum predicted environment that the component will be exposed to during flight. A component that fails to pass any acceptance test shall not be used for flight.

(1) Each acceptance test must be conducted at all maximum predicted environments determined in accordance with § 417.307. Each component must withstand the environmental acceptance test conditions without physical damage or violating its performance specifications.

(2) Each acceptance test must be performed on all flight termination system component samples that are intended for flight use except for single-use components such as ordnance and batteries, which shall be subjected to production lot sample acceptance tests. The specific tests to be performed and the number of single-use components to be tested shall be in accordance with the acceptance test and lot sample acceptance test matrices provided in this appendix unless the launch operator clearly and convincingly demonstrates that a proposed alternative provides an equivalent level of safety.

(3) Reuse acceptance tests shall be performed on any previously flown and recovered flight termination system component to demonstrate that the component still functions without degradation in performance when subjected to all maximum predicted environments if the component is to be reused. A reused component shall be subjected to the same tests performed for initial acceptance testing unless the launch operator demonstrates, clearly and convincingly, that a proposed alternative provides an equivalent level of safety. For each such component, a launch operator shall implement a component reuse qualification, refurbishment, and acceptance plan approved by the FAA through the licensing process. Performance parameter measurements taken during reuse acceptance tests shall be compared to previous acceptance test measurements to ensure there are no data trends that indicate degradation in performance.

(b) *Acceptance random vibration.* A component shall be tested to demonstrate that it satisfies performance specifications when exposed to workmanship or maximum predicted random vibration levels in accordance with the following:

(1) Random vibration testing shall be performed at the greater of the maximum predicted random vibration level or the minimum workmanship acceptance test level provided in table E417.13–1, from 20 Hz to 2000 Hz in all three axes.

(2) The component shall be subjected to the acceptance random vibration environment for a duration that is the greater of three times the maximum predicted duration or a minimum workmanship screening level of 60 seconds, per axis.

(3) Acceptance tests and qualification tests shall be performed using identical test configurations and methods.

(4) Performance verification tests shall be performed while the component is subjected to the acceptance random vibration environment. Where the duration of the acceptance random vibration environment is such that there is insufficient time to complete testing of all functions and modes while the component is subjected to the full acceptance random vibration level, extended testing at a random vibration level 6 dB lower shall be conducted as necessary to complete the functional testing.

(5) Each acceptance test tolerance must be consistent with the tolerances established for qualification operating environmental test tolerances established in accordance with E417.11.

(6) Performance and status-of-health parameters shall be continuously monitored with a resolution of no less than one millisecond. These tests shall be performed at nominal operating voltage, where applicable.

TABLE E417.13–1.—MINIMUM WORKMANSHIP POWER SPECTRAL DENSITY FOR ACCEPTANCE RANDOM VIBRATION

Frequency range	Minimum power spectral density
20	0.0053 g^2/Hz.
20–150	3 dB/Octave Slope.
150–600	0.04 g^2Hz.
600–2000	−6 dB/Octave Slope.
2000	0.0036 g^2/Hz.
Overall G_{rms}=6.1	

(c) *Acceptance acoustic.* A component shall be tested to demonstrate that it satisfies its performance specifications when exposed to workmanship or maximum predicted acoustic vibration levels in accordance with the following:

(1) An acceptance acoustic vibration level must be no less than the maximum predicted acoustic level from 20 Hz to 2000 Hz.

(2) The acceptance acoustic duration must be the greater of the maximum predicted acoustic duration or 60 seconds, per axis, in three mutually perpendicular axes.

(3) Performance verification tests shall be performed while the component is subjected to the acceptance acoustic environment. Where the duration of the acceptance acoustic environment is such that there is insufficient time to complete the testing of all functions and modes while the component is subjected to the full acceptance test level, extended testing at a level 6 dB lower shall be conducted as necessary to complete the functional testing.

(4) Analysis may be performed in lieu of testing if the launch operator demonstrates that the operating random vibration level envelops the acceptance acoustic levels and duration.

(5) Each acceptance test tolerance must be consistent with the qualification operating environmental test tolerances established in accordance with E417.11.

(6) All performance and status-of-health parameters shall be continuously monitored with a resolution of no less than one millisecond. This testing shall be performed at nominal operating voltage, where applicable.

(d) *Acceptance thermal cycle.* A component shall be tested to demonstrate that it meets performance specifications when exposed to workmanship or maximum predicted thermal levels in accordance with the following:

(1) *Electronic components.* Each acceptance thermal cycle test for an electronic component must satisfy the following:

(i) The acceptance thermal cycle test temperatures must range from the maximum predicted environment high temperature or a 61°C-workmanship screening level, whichever is higher, to the predicted low temperature or a −24°C-workmanship screening level, whichever is lower.

(ii) The component shall be subjected to no fewer than 18 thermal cycles. For each cycle, the dwell times at the high and low temperatures shall be long enough for the component to achieve internal thermal equilibrium and must be no less than one hour. During each dwell time at the high and low temperatures, the component shall be turned off until the temperature stabilizes and then turned on.

(iii) The thermal rate of change between the low and high temperatures must be an average rate of 1°C per minute or the maximum predicted rate, whichever is greater.

(iv) Performance verification tests, including functional tests, shall be performed while at the component's low and high operating voltage and while the component is at the high, ambient, and low temperatures during the first, middle, and last thermal cycles.

(v) Critical performance and status-of-health parameters shall be continuously monitored and recorded with a resolution that detects component performance degradation. This test shall be performed at the nominal operating voltage for all cycles and thermal transitions.

(2) *Passive components.* A passive component is any component that does not contain active electronic piece parts. Passive components include, but need not be limited to, radio frequency antennas; couplers; rechargeable batteries, such as nickel cadmium batteries; and cables. Acceptance thermal cycle tests for passive components must satisfy the following:

(i) Unless otherwise noted, the acceptance thermal cycle test temperatures must range from the maximum predicted environment high temperature or a 61°C-workmanship screening temperature, whichever is higher, to the predicted low temperature or a −24°C-workmanship screening temperature, whichever is lower.

(ii) The component must be subjected to no fewer than eight thermal cycles. The dwell times at the high and low temperatures must be long enough for the component to achieve internal thermal equilibrium and must be no less than one hour.

(iii) The thermal rate of change between the low and high temperatures must be an average rate of at least 1°C per minute or the maximum predicted rate, whichever is greater.

(iv) Performance verification tests, including functional tests, shall be performed while the component is at the high, ambient, and low temperatures during the first, middle, and last thermal cycles.

(v) Critical performance and status-of-health parameters shall be continuously monitored and recorded during all thermal cycles and transitions with a resolution that detects any component performance degradation.

(3) *Electro-mechanical safe and arm devices with internal explosives.* Each acceptance thermal cycle test for electro-mechanical safe and arm devices with internal explosives must satisfy the following:

(i) The acceptance thermal cycle temperatures must range from the maximum predicted environment high temperature or the minimum workmanship screening temperature of 61°C, whichever is higher, to the predicted low temperature or the minimum workmanship screening temperature of −24°C, whichever is lower.

(ii) The component must be subjected to no fewer than eight thermal cycles. For each cycle, the dwell times at the high and low temperatures must be long enough for the component to achieve internal thermal equilibrium and must be no less than one hour.

(iii) The thermal rate of change between low and high temperatures must be an average rate of 1°C per minute or the maximum predicted rate, whichever is greater.

(iv) Performance verification tests, including functional tests of critical electrical parameters, shall be performed while the component is at the high, ambient, and low temperatures during the first, middle, and last thermal cycles.

(v) Critical performance and status-of-health parameters shall be continuously monitored and recorded during all thermal cycles and transitions with a resolution that detects component performance degradation.

(e) *Acceptance thermal vacuum.* A component shall be tested to demonstrate that it meets performance specifications when exposed to workmanship or maximum predicted thermal and altitude environments in accordance with the following:

(1) The acceptance thermal vacuum temperatures must range from the maximum predicted environment high temperature or the workmanship screening high temperature of 61°C, whichever is higher, to the predicted low temperature or the workmanship screening low temperature of −24°C, whichever is lower.

(2) The pressure gradient must be the maximum predicted rate of altitude change that will be experienced during flight. The pressure gradient must allow for no less than ten minutes for reduction of chamber pressure at the pressure zone from ambient to 20 Pascal. The final vacuum dwell time must be long enough for the component to achieve pressure equilibrium and must be no less than the maximum predicted dwell time or 12 hours, whichever is greater.

(3) An acceptance thermal cycle test shall be performed during the final vacuum dwell time. The number of thermal cycles must be the maximum predicted number of cycles.

(4) Performance verification tests, including functional tests, shall be performed during the final vacuum dwell time at the component's low and high operating voltage and while the component is at the high, ambient, and low temperatures during the first, middle, and last thermal cycles.

(5) Critical performance and status-of-health parameters shall be continuously monitored during chamber pressure reduction and during the final vacuum dwell time using the component's high operating voltage and a resolution that detects component performance degradation.

(6) Analysis may be performed in lieu of testing in accordance with the following:

(i) For a low voltage component, a component that operates at less than 50 volts, analysis may be performed in lieu of testing if the analysis demonstrates that the component is not susceptible to corona, arcing, or structural failure.

(ii) For a high voltage component, a component that operates at 50 volts or more, thermal vacuum testing shall be performed unless the component is hermetically sealed or pressurized and the analysis demonstrates that any low voltage externally exposed part is not susceptible to corona, arcing, or structural failure. A component with any high voltage externally exposed part shall be subjected to acceptance thermal vacuum testing.

(f) *Tensile loads.* A component shall be tested to demonstrate its ability to withstand handling tensile loads during transportation and installation without damage or degradation of performance. An acceptance tensile load test shall be conducted at twice the maximum predicted pull-force that could occur during normal or improper handling.

E417.15 Age Surveillance Testing

(a) *General.* A launch operator shall perform age surveillance testing in accordance with this section and the test matrices provided in this appendix to verify or extend the storage, operating, or service life of a component established in accordance with § 417.305(h). For a single use component, such as ordnance, the component's initial service life shall be established by the lot acceptance testing required by this appendix for the specific component.

(b) *Ordnance age surveillance tests.* A launch operator shall ensure that each ordnance component, any component that contains ordnance or is used to directly initiate ordnance, functions within its performance specification throughout its specified service life. Service life starts upon completion of the initial production lot sample acceptance tests and includes both storage and time after installation until completion of flight. Age surveillance tests shall be performed to extend an ordnance component's service life in accordance with the following:

(1) The number of ordnance components to be tested, the specific tests to be performed for age surveillance tests, and the number of years that the service life may be extended shall be in accordance with the ordnance lot acceptance and age surveillance test matrices provided in this appendix.

(2) All samples used for ordnance age surveillance testing must be from the same lot and must consist of identical parts and materials and be manufactured through identical processes. These samples must be stored with the ordnance components to be used for flight or in an environment that duplicates flight ordnance component's storage conditions.

(c) *Battery storage surveillance tests.* A launch operator shall ensure that each battery functions within its performance specification throughout its specified service life. Service life starts upon completion of the initial production acceptance tests and includes both storage and time after installation until completion of flight. Battery storage life may be extended with testing specified in the matrices provided in this appendix.

(d) *Electronic component age surveillance tests.* A launch operator shall ensure that each electronic component functions within its performance specifications throughout its specified service life. Service life starts upon completion of the initial production acceptance tests and includes both storage and operating life, which begins upon installation on a launch vehicle. An electronic component whose storage, operating life, or service life has been exceeded shall not be used for flight, unless the launch operator identifies proposed age surveillance testing and demonstrates, clearly and convincingly through the licensing process, that the proposed testing provides an equivalent level of safety.

E417.17 Radio Frequency Receiving System

(a) *General.* A radio frequency receiving system includes each flight termination system antenna and radio frequency coupler and any radio frequency cable or other passive device used to connect a flight termination system antenna to a command receiver. A radio frequency receiving system shall be tested to demonstrate that it delivers command control system radio frequency energy to each flight termination system receiver when subjected to non-operating and operating environments and performance degradation sources such as command control system transmitter variations, non-nominal launch vehicle flight conditions, and flight termination system performance variations. This testing shall be accomplished in accordance with the acceptance and qualification test matrices and the accompanying requirements of this section.

TABLE E417.17–1

Radio frequency receiving system acceptance tests	Reference E417.13	Quantity (in percent)		
		Cable	Coupler	Antenna
Component Examination	E417.5	....	....	....
Visual Inspection	E417.5(b)	100	100	100
Dimension	E417.5(c)	100	100	100
Identification	E417.5(e)	100	100	100
Performance Verification [1]	E417.3(e)	....	....	....
Status-of-Health	E417.17(b)	....	....	100
Link Performance	E417.17(c)	100	100	....
Isolation	E417.17(d)	....	100	....
Abbreviated Antenna Pattern [2]	E417.17(g)	....	....	100
Abbreviated Performance Verification	E417.3(f)			
Abbreviated Status of Health [2]	E417.17(e)	100	100	100
Operating Environment Tests	E417.13	....	....	....
Thermal Cycling	E417.13(d)	100	100	100
Acoustic	E417.13(c)	....	100	100
Random Vibration	E417.13(b)	....	100	100
Tensile Load	E417.13(f)	100	....	....

[1] This test shall be performed prior to the first and after the last operating environment test.
[2] These tests shall be performed prior to and after each operating environment test.

TABLE E417.17–2

Radio frequency receiving system qualification tests	Reference E417.7	Quantity [6]		
		Cable X=3	Coupler X=3	Antenna X=3
Acceptance Tests [1]	Table E417.17–1	X	X	X
Antenna Patterns [2]	E417.17(f)	X	X	X
Abbreviated Antenna Pattern	E417.17(g)	....	....	X
Performance Verification [3]	E417.3(e)			
Status-of-Health	E417.17(b)	....	....	X
Link Performance	E417.17(c)	X	X	....
Isolation	E417.17(d)	....	X	....
Non-Operating Environment Tests	E417.9	....	....	....
Storage Temperature	E417.9(b)	X	X	X
Transportation Shock	E417.9(d)	X	X	X
Bench Handling Shock	E417.9(e)	X	X	X
Transportation Vibration	E417.9(f)	X	X	X
Fungus Resistance	E417.9(g)	1	1	1
Salt Fog	E417.9(h)	1	1	1
Fine Sand	E417.9(i)	1	1	1
Abbreviated Performance Verification [4]	E417.3(f)	....	....	....
Abbreviated Status-of-Health	E417.17(e)	X	X	X
Operating Environment Tests [5]	E417.11			
Thermal Cycling	E417.11(h)	X	X	X
Humidity	E417.11(g)	X	X	X
Acceleration	E417.11(f)	X	X	X
Shock	E417.11(e)	X	X	X
Sinusoidal Vibration	E417.11(b)	X	X	X
Acoustic	E417.11(d)	X	X	X
Random Vibration	E417.11(c)	X	X	X
Tensile Load	E417.9(j)	X	....	....
Abbreviated Antenna Pattern	E417.17(g)	....	....	X
Disassembly	E417.5(g)	....	X	X

[1] Each sample component to undergo qualification testing must first successfully complete all applicable acceptance tests.
[2] This test is performed of the radio frequency receiving system including the antenna, radio frequency cables, and radio frequency coupler.
[3] These tests shall be performed before the first and after the last non-operating environment test and before the first and after the last operating environment test.
[4] These tests shall be performed during the operating environment tests.
[5] For these tests, flight radio frequency cables shall be attached to each component in the flight configuration.
[6] The same three sample components shall be subjected to each test designated with an X. For tests designated with a quantity of less than three, each sample component tested shall be selected from the original three sample components.

(b) *Status-of-health.* Radio frequency components and subsystems shall be subjected to status-of-health tests performed in accordance with E417.3(g). Status-of-health tests of radio frequency components and subsystems shall include antenna voltage standing wave ratio testing that measures the assigned operating frequency at the high and low frequencies of the operating bandwidth.

(c) *Link performance.* All radio frequency components and subsystems shall be tested to demonstrate that they function within their design specification when subjected to performance degradation caused by ground transmitter variations and non-nominal vehicle flight. Link performance tests must satisfy the following:

(1) Testing shall be performed to demonstrate the ability of the radio frequency receiving system to provide command signals to each command destruct receiver at an electromagnetic field intensity of 12 dB above the level required for reliable receiver operation over 95% of the antenna radiation sphere surrounding the launch vehicle.

(2) Radio frequency coupler insertion loss and voltage standing wave ratio shall be measured at the assigned operating frequency and at the high and low frequencies of the operating bandwidth.

(3) Cable insertion loss shall be measured at the assigned operating frequency and at the high and low frequencies of the operating bandwidth.

(d) *Isolation.* Tests shall be performed to demonstrate that couplers isolate redundant antennas and receiver decoders from one another such that an open or short-circuit in one string of the redundant system, antenna or receiver decoder, will not prevent functioning of the other side of the redundant system. The tests must demonstrate that the isolation is in accordance with the isolation design specification and that it is in-family.

(e) *Abbreviated status-of-health.* While a component is under environmental stress conditions, testing shall be performed to verify the voltage standing wave ratio and any other critical performance parameter that acts as an indicator of an internal anomaly. Critical performance parameters shall be continuously monitored during environmental testing to detect variations in amplitude with a 0.1-millisecond accuracy. Any unexplained variations shall be considered a test failure.

(f) *Antenna patterns.* Testing shall be performed as part of qualification testing to demonstrate that the radiation gain pattern of the entire radio frequency receiving system, including the antenna, radio frequency cables, and radio frequency coupler will meet the system's performance specifications during vehicle flight in accordance with the following:

(1) Testing shall be performed to demonstrate a link margin of no less than 12 dB over 95 percent of the antenna radiation sphere surrounding the launch vehicle.

(2) Testing shall emulate flight conditions, including ground transmitter polarization.

(3) Radiation pattern testing shall be performed on a simulated flight vehicle utilizing a flight configured radio frequency command destruct system. The increments used to determine an antenna pattern must be sufficient to identify any deep pattern null and to verify that the required 12dB link margin is maintained throughout flight. The increments used for antenna pattern determination shall be no less than two degrees.

(4) Antenna patterns determined as a result of testing shall be recorded in a data format that is compatible with the format needed to perform the flight safety system radio frequency link analysis required in § 417.329(h).

(g) *Abbreviated antenna pattern.* Abbreviated antenna pattern testing shall be performed on just the antenna as part of qualification and acceptance testing using a standard ground plane test fixture. This testing shall be performed before and after exposure to qualification and acceptance test environments to determine any pattern changes that may occur due to damage resulting from exposure to the test environments. Gain measurements shall be taken and shall include, but need not be limited to, radiation pattern measurements in the 0° and 90° plane vectors along with a conical cut at 80°. The test configuration need not generate antenna pattern data that is representative of the actual system-level patterns.

E417.19 Command Receiver Decoder

(a) *General.* A command receiver decoder shall be tested to demonstrate that it functions according to its performance specification when subjected to non-operating and operating environments and command control system transmitter variations. This testing shall be accomplished in accordance with the acceptance and qualification test matrices and accompanying requirements of this section. A command receiver decoder must undergo all tests identified by each matrix in this section and in the manner identified.

TABLE E417.19–1

Command receiver decoder acceptance tests	Reference E417.13	Quantity (percent)
Component Examination	E417.5	
Visual Inspection	E417.5(b)	100
Dimension	E417.5(c)	100
Identification	E417.5(e)	100
Performance Verification [1]	E417.3(e)	
Status-of-health	E417.19(b)	100
Functional Performance	E417.19(c)	100
Radio Frequency Processing	E417.19(e)	100
Decoder Logic	E417.19(f)	100
Abbreviated Performance Verification	E417.3(f)	
Input Current Monitor [2]	E417.19(g)	100
Output Functions [2]	E417.19(h)	100
Radio Frequency Level Monitor [2]	E417.19(i)	100
Thermal Performance Testing [3]	E417.19(j)	100
Operating Environment Tests	E417.13	
Thermal Cycling	E417.13(d)	100
Thermal Vacuum	E417.13(e)	100
Acoustic	E417.13(c)	100
Random Vibration	E417.13(b)	100
Leakage	E417.5(h)	100

[1] These tests shall be performed prior to the first and after the last operating environment test.
[2] These tests shall be performed during vibration and acoustic operating environment test.
[3] These tests shall be performed during operating thermal cycle and thermal vacuum testing.

TABLE E417.19–2

Command receiver decoder qualification tests	Reference E417.7	Quantity [5] X=3
Acceptance Tests [1]	Table E417.19–1	X

TABLE E417.19–2—Continued

Command receiver decoder qualification tests	Reference E417.7	Quantity [5] X=3
Performance Verification [2]	E417.3(e)	
Status-of-health	E417.19(b)	X
Functional Performance	E417.19(c)	X
Radio Frequency Processing	E417.19(e)	X
Decoder Logic	E417.19(f)	X
Non-Operating Environment Tests	E417.9	
Storage Temperature	E417.9(b)	X
Transportation Shock	E417.9(d)	X
Bench Handling Shock	E417.9(e)	X
Transportation Vibration	E417.9(f)	X
Fungus Resistance	E417.9(g)	1
Salt Fog	E417.9(h)	1
Fine Sand	E417.9(i)	1
Abbreviated Performance Verification	E417.3(f)	
Input Current Monitor [3]	E417.19(g)	X
Output Functions [3]	E417.19(h)	X
Radio Frequency Level Monitor [3]	E417.19(i)	X
Thermal Performance Testing [4]	E417.19(j)	X
Operating Environment Tests	E417.11	
Thermal Cycling	E417.11(h)	X
Humidity	E417.11(g)	X
Thermal Vacuum	E417.11(i)	X
Acceleration	E417.11(f)	X
Shock	E417.11(e)	X
Sinusoidal Vibration	E417.11(b)	X
Acoustic	E417.11(d)	X
Random Vibration	E417.11(c)	X
Electromagnetic Interference and Compatibility	E417.11(j)	2
Explosive Atmosphere	E417.11(k)	1
Leakage	E417.5(h)	X
Circuit Protection Test	E417.19(d)	X
Disassembly	E417.5(g)	X

[1] Each sample component to undergo qualification testing must first successfully complete all applicable acceptance tests.
[2] These tests shall be performed before the first and after the last non-operating environment test and before the first and after the last operating environment test.
[3] These tests shall be performed during shock and vibration testing.
[4] These tests shall be performed during operating thermal cycle and thermal vacuum testing.
[5] The same three sample components shall be subjected to each test designated with an X. For tests designated with a quantity of less than three, each sample component tested shall be selected from the original three sample components.

(b) *Status of health.* A command receiver decoder shall be subjected to status-of-health tests performed in accordance with E417.3(g). These tests must include measurements of pin-to-pin resistances, pin-to-case resistances and input current.

(c) *Functional performance.* Functional performance tests shall be conducted to demonstrate compliance with the electronic components general design and performance requirements provided in appendix D, D417.13 applicable to a command receiver decoder in accordance with the following:

(1) Functional testing must demonstrate that a command receiver decoder's response time, from receipt of destruct sequence to initiation of destruct output, is in accordance with its performance specification.

(2) Functional testing must demonstrate a command receiver decoder's ability to output arm and destruct commands that deliver the specified power to each specified load at the specified minimum, maximum, and transient input power voltages in accordance with the command receiver decoder's performance specification.

(3) Testing must demonstrate that the maximum leakage current through the command destruct output port is at a level that can not degrade performance of down-string ordnance initiation systems or result in an unsafe condition.

(d) *Circuit protection.* The following tests shall be conducted to demonstrate that a receiver decoder's circuit protection provides for the component to satisfy its performance specifications when subjected to improper launch processing, abnormal flight conditions, and any non-flight termination system vehicle component failure:

(1) Testing must demonstrate that any circuit protection allows a command receiver decoder to function without violating performance specifications when subjected to the maximum input voltage of the open circuit voltage of the command receiver decoder's power source and when subjected to the minimum input voltage of the loaded voltage of the power source.

(2) Testing must demonstrate that, in the event of an input power dropout, any control or switching circuit that contributes to the reliable operation of a command receiver decoder, including solid-state power transfer switches, does not change state for at least 50 milliseconds.

(3) Testing must demonstrate that any watchdog circuit functions according to its design specification.

(4) Testing must demonstrate that a command receiver decoder's performance does not degrade when any of its monitoring circuits or non-destruct output ports are subjected to a short circuit or the highest positive or negative voltage capable of being supplied by the monitor batteries or other power supplies.

(5) Testing must demonstrate that a command receiver decoder functions without violating performance specifications when subjected to a reverse polarity voltage that could occur during launch processing.

(e) *Radio frequency processing.* A command receiver decoder shall be tested to demonstrate that its radio frequency processing satisfies its performance specifications in a flight configured radio frequency environment, where the environment includes locally induced radio frequency noise sources and the maximum predicted noise-floor, ground transmitter performance variations, and abnormal launch vehicle flight. Tests shall be conducted to demonstrate compliance with the design requirements contained in appendix D, D417.15(c) in accordance with the following:

(1) Testing must demonstrate that a command receiver decoder satisfies all its performance specifications at twice the

minimum and maximum tolerances associated with the command control system transmitting equipment frequency modulation variations. This test shall be performed using the minimum and maximum number of tones that could be simultaneously transmitted including any pilot tone or check channel.

(2) Testing must demonstrate that a command receiver decoder satisfies all its performance specifications at twice the worst-case command control system transmitter radio frequency shift, Doppler shifts of the carrier center frequency, and shifts in flight hardware center frequency during flight. This test must be performed at the command receiver's sensitivity guaranteed by its performance specifications.

(3) Testing must demonstrate that a command receiver decoder satisfies all its performance specifications when exposed to the maximum radio frequency energy that the command control system transmitter is capable of imposing plus a 3 dB margin without change or degradation in performance after such exposure.

(4) Testing must demonstrate that the command receiver cannot be captured by another transmitter. Testing must show that the application of any unmodulated radio frequency at a power level of up to 80% of the command control system transmitter's modulated carrier signal does not capture the receiver or interfere with a signal from the command control system.

(5) Testing must demonstrate that a command receiver decoder's radio frequency input power will be monitored accurately during flight. Testing must show that the output signal strength monitor is directly related and proportional to the radio frequency input signal.

(6) Testing must demonstrate that a command receiver decoder does not produce an inadvertent output when subjected to a radio frequency input short-circuit, open-circuit, or changes in input voltage standing wave ratio.

(7) Testing must demonstrate that the command receiver guaranteed input sensitivity is no less than 6dB higher than the maximum predicted noise-floor.

(f) *Decoder logic.* A command receiver decoder shall be tested to demonstrate its ability to reliably decode an uplink command when subjected to operating conditions that can occur during abnormal vehicle flight and ground system performance variations. Tests shall be conducted to demonstrate compliance with the design and performance requirements contained in appendix D, D417.15(d) in accordance with the following:

(1) Testing must demonstrate that a command receiver decoder reliably processes a commanded signal at twice the minimum and maximum tolerances associated with the command control system transmitting equipment. At a minimum, tone balance, tone frequency, audio tone distortion, FM deviation per tone, and command transmitter variations in command logic sequence timing shall be tested.

(2) Testing must demonstrate that the bandwidth of a command receiver decoder's tone filter provides for accurate recognition of the command signal tones. The testing must demonstrate that the receiver decoder distinguishes between tones that are capable of inhibiting a command output or inadvertently issuing an output.

(3) Testing must demonstrate that a command receiver decoder requires two commanded steps to issue a destruct command. Testing must show that the receiver processes an arm command as a prerequisite for the destruct command. Testing must demonstrate that a command receiver is capable of simultaneously outputting arm, destruct, and check channel signals.

(4) Testing must demonstrate the decoding and output of a tone, such as a pilot tone or check tone, is representative of link and command closure. The presence or absence of the tone signal must have no effect on a command receiver decoder's command processing and output capability.

(g) *Input current monitor.* Testing shall be performed to obtain an indication of status-of-health of the unit under test during environmental stress conditions. Variations in input current are indicators of internal component damage. The command receiver decoder power input current shall be continuously monitored to detect variations in amplitude. There must be no fluctuations in nominal current draw when the command receiver decoder is in the steady state.

(h) *Output functions.* Testing shall be performed to verify critical performance parameters during environmental stress conditions. Arm and destruct commands shall be sent at the guaranteed radio frequency input power level. All command outputs shall be continuously monitored to detect variations in amplitude.

(i) *Radio frequency monitor.* The radio frequency level monitor, also known as radio frequency signal strength, signal strength telemetry output, or automatic gain control shall be continuously monitored. Any unexpected fluctuations or drop out would constitute a test failure. The radio frequency level monitor shall be used as a status-of-health indication to determine the receiver's radio frequency processing functionality. The radio frequency level used for this testing shall be at the manufacturer's guaranteed radio frequency level.

(j) *Thermal performance testing.* A command receiver decoder shall be tested to demonstrate that it satisfies its performance specifications when subjected to operating and workmanship thermal environments. The following tests shall be performed using the receiver decoder's low and high operating voltage while the receiver decoder is at the high and low temperatures during the first, middle, and last thermal cycles. The following tests shall also be performed during thermal vacuum testing using the receiver decoder's low and high operating voltage while the receiver decoder is at the high and low temperatures for all thermal cycles.

(1) Arm and destruct commands shall be sent, with a pilot tone, at the lowest radio frequency input power level required for reliable receiver decoder operation according to its performance specifications. All command outputs shall be continuously monitored. Any variations in amplitude that violate the performance specifications and any inadvertent output constitute a test failure.

(2) The command receiver decoder's power input current shall be continuously monitored to detect variations in amplitude. There must be no fluctuations in nominal current draw when the command receiver decoder is in the steady state.

(3) The radio frequency level monitor shall be continuously monitored in accordance with paragraph (i) of this section.

(4) Testing shall be performed at a radio frequency bandwidth greater than twice the total combined maximum tolerances of all applicable radio frequency performance factors. The performance factors include frequency modulation deviation of multiple tones, command control transmitter inaccuracies within its performance specifications, and variations in flight hardware performance during thermal and dynamic environments.

(5) Arm and destruct commands with a pilot tone shall be tested at the threshold sensitivity at the maximum and minimum tone modulation and center frequency.

E417.21 Batteries

(a) *General.* A battery used as part of a flight termination system shall be tested to demonstrate that it functions according to its performance specification when subjected to non-operating and operating environments. This testing shall be accomplished in accordance with the acceptance, qualification, and age surveillance test matrices and accompanying requirements of this section. The requirements in this section apply to silver zinc and nickel cadmium batteries. A launch operator shall clearly and convincingly demonstrate equivalent test requirements for any other type of battery through the licensing process.

TABLE E417.21–1

Manually activated silver zinc battery acceptance tests [1]	Reference E417.13(a)	Quantity (percent)
Component Examination	E417.5	
Visual Inspection	E417.5(b)	100
Dimensions	E417.5(c)	100
Identification	E417.5(e)	100

TABLE E417.21–1—Continued

Manually activated silver zinc battery acceptance tests[1]	Reference E417.13(a)	Quantity (percent)
Battery Mounting and Case Integrity[2]	E417.21(w)	100
Safety Tests	E417.21(c)	100
Electrolyte	E417.21(d)	100
Performance Verification	E417.3(e)	
Status-of-health	E417.21(e)	100
Monitoring Capability	E417.21(h)	100
Heater Circuit Verification	E417.21(f)	100
Activation	E417.21(g)	100
Status-of-health	E417.21(e)	100
Electrical Performance	E417.21(i)	100
Cell Acceptance Verification	E417.21(j)	1 cell per flight battery

[1] These battery acceptance tests shall be performed at the launch site just prior to installation.
[2] This test applies to battery cases that contain welds.

TABLE E417.21–2

Manually activated silver zinc battery qualification tests	Reference E417.7	Quantity[4]	
		Batteries X=3	Cells X=12
Component Examination	E417.5		
Visual Inspection	E417.5(b)	X	X
Dimensions	E417.5(c)	X	X
Identification	E417.5(e)	X	X
Battery mounting and Case Integrity[1]	E417.21(x)	X	....
Safety Tests	E417.21(c)	X	X
Electrolyte	E417.21(d)	X	X
Performance Verification	E417.3(e)		
Status-of-health	E417.21(e)	X	X
Monitoring Capability	E417.21(h)	X	X
Heater Circuit Verification	E417.21(f)	X	....
Non-Operating Environment Tests	E417.9		
Storage Temperature	E417.9(b)	X	X
Transportation Shock	E417.9(d)	X	X
Bench Handling Shock	E417.9(e)	X	X
Transportation Vibration	E417.9(f)	X	X
Fungus Resistance	E417.9(g)	X	....
Salt Fog	E417.9(h)	X	....
Fine Sand	E417.9(i)	X	....
Performance Verification	E417.3(e)		
Status-of-health	E417.21(e)	X	X
Monitoring Capability	E417.21(h)	X	X
Heater Circuit Verification	E417.21(f)	X	....
Activation	E417.21(g)	X	X
Status-of-health	E417.21(e)	X	X
Electrical Performance[2]	E417.21(i)	X	X
Operating Environment Tests	E417.11		
Activated Stand Time	E417.21(m)	X	X
Overcharge	E417.21(n)	X	....
Humidity[2]	E417.11(g)	X	....
Acoustic[3]	E417.11(d)	X	X
Shock[3]	E417.11(e)	X	X
Acceleration[3]	E417.11(f)	X	X
Sinusoidal Vibration[3]	E417.11(b)	X	X
Random Vibration[3]	E417.11(c)	X	X
Thermal Cycle[2]	E417.21(k)	X	X
Electromagnetic Interference and Compatibility	E417.11(j)	1	....
Explosive Atmosphere	E417.11(k)	1	....
Performance Verification	E417.3(e)		
Status-of-health	E417.21(e)	X	X
Monitoring Capability	E417.21(h)	X	X
Heater Circuit Verification	E417.21(f)	X	....
Discharge and Pulse Capacity	E417.21(o)	X	X
Leakage	E417.21(l)	X	X
Disassembly	E417.21(w)	X	X

[1] This test applies to battery cases that utilize welds.
[2] Electrical performance tests, E417.21(i), shall be performed under ambient conditions before the first operating environment test and while the batterey is subjected to each operating environment test.

[3] The battery shall be continuously monitored to verify that the required voltage regulation is maintained while supplying the required operating steady-state current. Monitoring for these tests shall be performed at a 0.1 ms resolution with no dropouts.
[4] The same three sample batteries and 12 sample cells shall be subjected to each test designated with an X. For tests designated with a quantity of less than three, the batteries tested shall be selected from the original batteries.

TABLE E417.21–3

Silver zinc battery storage life extension tests	Reference E417.15	Quantity X=2 cells per year [2]
Component Examination	E417.5	
Visual Inspection	E417.5(b)	X
Dimensions	E417.5(c)	X
Identification	E417.5(e)	X
Safety Tests	E417.21(c)	X
Electrolyte	E417.21(d)	X
Performance Verification	E417.3(e)	
Status-of-Health	E417.21(e)	X
Activation	E417.21(g)	X
Status-of-Health	E417.21(e)	X
Electrical Performance [1]	E417.21(i)	X
Operating Environment Tests	E417.11	
Activated Stand Time	E417.21(m)	X
Thermal Cycling [1]	E417.21(k)	X
Discharge Design Capacity	E417.21(o)	X
Leakage	E417.21(l)	X
Disassembly	E417.21(w)	X

[1] Electrical performance tests, § E417.21(i), shall be performed under ambient conditions before the first operating environment test and while the battery is subjected to each operating environment test.
[2] Two silver zinc cells from the production lot used for qualification testing shall be tested each year of the manufacturer's specified storage life to determine that they still satisfy their performance specifications.

TABLE E417.21–4

Nickel cadmium cell lot acceptance and qualification tests [1]	Reference	Quantity
Cell Screening: [2]		
Cell Inspection and Preparation	E417.21(q)	100%
Cell Conditioning and Characterization Tests	E417.21(s)	100%
Status-of-health	E417.21(b)	
Charge Retention	E417.21(b)(1)	100%
0 °C capacity and overcharge determination	E417.21(b)(2)	100%
Cell Qualification Tests: [3]		X=70 [5]
Thermal Cycling	E417.21(u)	X
X-ray Inspection [4]	E417.5(f)	5
Vent Pressure	E417.21(c)(2)	5
Cycle Life Testing	E417.21(y)	30
Charge Retention	E417.21(b)(1)	X
Calendar Life Testing	E417.21(t)	5 cells per year of storage

[1] All nickel cadmium cells used in a qualification or flight battery must be from a production lot that has successfully passed the lot acceptance and qualification tests required by this test matrix. These tests shall be performed to ensure the cells are consistent and will provide the required performance and to detect any manufacturer variation introduced into the lot of cells since the original database was formed. All the results of the tests executed on multiple lots shall be entered into an engineering database to establish "family characteristics" that meet the performance requirements. These tests shall be performed for each cell production lot. Cells used in these cell qualification tests shall not be used in the construction of qualification or flight batteries.
[2] Any cell that fails to meet a screening test shall be rejected and not used. This rejection does not invalidate the lot.
[3] The failure of any cell to pass a cell qualification test will invalidate the lot.
[4] X-ray inspection is only required for cells with multiple internal tabs. X-ray shall demonstrate tab integrity at 0° and 90°.
[5] The same 70 cells from the same production lot as the flight cells shall be subjected to each cell qualification test designated with an X. For tests designated with a quantity of less than 70, the cells shall be selected from the original 70 sample cells.

TABLE E417.21–5

Nickel cadmium battery acceptance tests	Reference E417.13(a)	Quantity
Cell Lot Acceptance and Qualification Tests [1]	Table E417.21–4	100% of Cells
Component Examination(Complete Battery)	E417.5	
Inspection	E417.5(b)	100%
Weight	E417.5(d)	100%
Dimensions	E417.5(c)	100%
Identification	E417.5(e)	100%
Safety Tests	E417.21(c)	
Safety Devices Repeatable Function	E417.21(c)(1)	100%

TABLE E417.21–5—Continued

Nickel cadmium battery acceptance tests	Reference E417.13(a)	Quantity
Safety Devices One Time Operation	E417.21(c)(2)	Lot Sample
Proof Pressure Leak Test	E417.21(c)(3)	100%
Monitoring Capability	E417.21(h)	100%
Heater Circuit Verification	E417.21(f)	100%
Discharge and pulse capacity	E417.21(o)	100%
Operating Environment Tests	E417.11	
Thermal Cycling	E417.21(u)	100%
Random Vibration	E417.13(b)	100%
Status-of-health	E417.21(b)	
Charge Retention	E417.21(b)(1)	100%
Discharge and Pulse Design Capacity	E417.21(o)	100%
Leakage (2)	E417.5(h)	100%
Status-of-health	E417.21(b)	
Charge Retention	E417.21(b)(1)	100%
Component Examination Inspection	E417.5(b)	100%
Post acceptance discharge and storage	E417.21(v)	100%

[1] All cells used in a qualification or flight battery must be from a production lot that has successfully passed the lot acceptance and qualification tests required Table E417.21–4.
[2] This test is required only for batteries that are sealed.

TABLE E417.21–6

Nickel cadmium battery qualification tests	Reference E417.7	Quantity X = 3 Batteries
Acceptance Tests [1]	Table E417.21–5	X
Non-Operating Environment Tests	E417.9	
Storage Temperature	E417.9(b)	X
Transportation Shock	E417.9(d)	X
Bench Shock	E417.9(e)	X
Transportation Vibration	E417.9(f)	X
Fungus Resistance	E417.9(g)	X
Salt Fog	E417.9(h)	X
Discharge and Pulse Capacity	E417.21(o)	X
Status-of-health	E417.21(b)	
Charge Retention	E417.21(b)(1)	X
Operating Environment Tests	E417.11	
Sinusoidal Vibration [2]	E417.11(b)	X
Acoustic [2]	E417.11(d)	X
Shock [2]	E417.11(e)	X
Acceleration [2]	E417.11(f)	X
Humidity [3]	E417.11(g)	X
Thermal Cycling	E417.21(k)	X
Random Vibration [2]	E417.11(c)	X
Proof Pressure Leak Test	E417.21(c)(3)	X
Electromagnetic Interference and Compatibility	E417.11(j)	1
Status-of-health	E417.21(b)	
Charge Retention	E417.21(b)(1)	X
Operating Charge Retention	E417.21(p)	X
Cycle Life	E417.21(y)	X
Leakage [4]	E417.21(l)	X
Disassembly	E417.21(w)	X
X-ray Inspection [5]	E417.5(f)	5 cells
Explosive Atmosphere	E417.11(k)	1

[1] A qualification battery shall first be subjected to acceptance testing except for any acceptance testing that is destructive, such as testing of burst disks.
[2] The battery shall be continuously monitored to verify that the required voltage regulation is maintained while supplying the required operating steady-state current. Monitoring for these tests shall be performed at a 0.1-millsecond resolution with no dropouts.
[3] A charge retention test shall be performed throughout this test in accordance with E417.21(p). The results of this test shall be compared with previous data to ensure that humidity environments do not degrade battery capacity.
[4] This test is only required for sealed batteries.
[5] X-ray inspection is only required for cells with multiple internal tabs. X-ray shall demonstrate tab integrity at 0° and 90°.

(b) *Nickel cadmium battery and cell status of health.* A flight termination system battery or cell shall be subjected to status-of-health tests performed in accordance with § E417.3(g), as required by the test matrices in this section and the following:

(1) *Charge retention.* The launch operator shall perform testing to determine the capability of a battery or cell to consistently retain its charge and provide the required capacity margin from the final charge used for the end-to-end destruct test to the end of flight safety responsibility. A 72-hour storage test of the battery or cell at room temperature

shall be performed in accordance with the following to acquire a data point for comparison to be used as a status of health indication of the battery or cell:

(i) The battery or cell shall be charged in accordance with paragraph (r) of this section and stored at room temperature for 72 hours.

(ii) Each cell performance must be greater than 90% of the 0.90-volt capacity determined in accordance with paragraph (s)(2) of this section.

(iii) Battery performance must be in accordance with the cell capacity determined in accordance with paragraph (s)(2) of this section multiplied times the number of cells in the battery.

(iv) Status of health data for each battery and cell tested shall be maintained to establish family performance data. Any cell or battery whose performance is out-of-family shall not be used for flight.

(2) *0°C capacity and overcharge determination.* Testing shall be performed in accordance with the following to ensure cell case pressure integrity, validate cell chemistry status-of-health at a high charge efficiency temperature, and allow cell matching for capacity:

(i) A capacity discharge test in accordance with paragraph (r) of this section shall be performed on each cell at 0°C ±2°C.

(ii) Repeat charge and discharge cycles until the capacities for two cycles agree to 1% for the cell. Cells shall be inspected for cracks.

(iii) The end of charge shall be less than 1.55 volts at 0°C ±2°C to prevent an explosive hazard due to H_2 generation.

(c) *Safety tests.* Each battery and cell shall be tested to ensure it will not create a loss of structural integrity or create a hazardous condition when subjected to normal and abnormal operating conditions in accordance with the following:

(1) All safety devices that function repeatedly without degradation, such as vent valves, shall be tested to demonstrate that they meet the manufacturer's design specification.

(2) Safety devices that do not function repeatedly without degradation, such as burst discs, shall be lot acceptance tested using a 10% lot sample but not less than five samples to demonstrate compliance with the manufacturer's design specification. Vents must open within ±10% of the design specification average vent pressure with a maximum vent pressure no higher than 350 pounds per square inch. All five cells must pass or the lot shall be rejected.

(3) The battery case shall be leak tested at 1.5 times the greatest operating differential pressure that could occur during qualification, preflight and flight conditions.

(d) *Electrolyte.* Each lot of electrolyte used for battery activation shall be tested to ensure compliance with the manufacturer's specification.

(e) *Silver zinc battery status-of-health.* A flight termination system battery shall be subjected to status-of-health tests performed in accordance with E417.3(g). These tests shall be performed as required by the test matrices and must include the following:

(1) *Pre-activation.* Insulation resistance shall be measured between mutually insulated pin-to-pin and pin-to-case points using a minimum 500-volt workmanship voltage. Continuity resistance shall be measured between mutually insulated pin-to-pin and pin-to-case points. The insulation resistance and continuity resistance measurements must be in accordance with the manufacturer's design specifications.

(2) *Post activation.* Leakage current shall be measured from each pin to case to verify no current leakage paths exist as a result of electrolyte leakage. This measurement must have a resolution that detects any leakage current of 0.1 milliamps or greater.

(f) *Heater circuit verification.* All heater and control circuitry shall be tested to verify that it performs in accordance with the manufacturer's design specification.

(g) *Activation.* A battery shall be activated following an activation procedure that includes the manufacturer's activation steps. The identical battery activation procedure shall be used for qualification, storage extension life, and acceptance testing.

(h) *Monitoring capability.* The ability to monitor voltage, current, or temperature shall be tested to ensure any and all monitoring devices perform in accordance with their performance specifications.

(i) *Electrical performance.* Electrical performance tests shall be performed before during and after a battery or cell is subjected to operating environments to ensure the battery will function within its performance specification during flight. Electrical performance parameters critical to battery or cell operation shall be monitored while performing the following to verify a battery or cell is performing according to the manufacturer's design specifications and within-family:

(1) A no-load voltage test of the battery or cell shall be performed as identified by the matrices in this section with the activated battery. For a silver-zinc battery or cell, this test shall be performed after the battery is activated and after the manufacturer's specified soak period. This test must demonstrate that voltage measurements are in accordance with the manufacturer's design specification.

(2) A load profile test of each battery or cell shall be performed. The test must consist of, without interruption, a steady-state load test at the flight power current level for one minute.

(3) An acceptance test pulse load test shall be performed at the operating arm and destruct pulse current level at twice the pulse duration or a minimum workmanship screening level of 100 milliseconds.

(4) A qualification test pulse load test must be performed at the operating arm and destruct pulse current level at twice the pulse duration or a minimum workmanship screening level of 200 milliseconds.

(5) The battery or cell must supply the required current while maintaining the required voltage regulation in accordance with the manufacturer's design specification.

Monitoring during the current pulse test must have a resolution of 0.1 milliseconds.

(j) *Cell acceptance verification.* All cell acceptance tests shall be performed on one non-flight battery cell that is from the same production lot as the flight battery, with the same lot date code as the cells in the flight battery. This cell must be attached to the battery from the time of the manufacturer's acceptance test and subjected to the same non-operating environments as the battery. The following tests shall be performed on this cell immediately before activation of the battery to verify that the flight battery cells were manufactured the same as the qualification battery cells and that no degradation in performance has occurred:

(1) The test cell shall be discharged at a moderate rate, in accordance with the manufacturer's design specification, and two load profile tests shall be performed as described in paragraph (i)(2) of this section, until the minimum design specification voltage is achieved. The resultant cell amp-hour capacity must demonstrate that the minimum capacity specification is achieved.

(2) For a rechargeable battery, the cell shall be tested in the same manner as required by paragraph (j)(1) of this section but repeated for the number of charge and discharge cycles used during qualification testing. The testing must demonstrate that the cell capacity and electrical characteristics are in accordance with the manufacturer's design specification for each charge and discharge cycle.

(k) *Qualification thermal cycle.* Qualification thermal cycle testing shall be performed to ensure that preflight environments, acceptance testing environments, and flight environments do not adversely affect battery performance. A battery shall be tested in accordance with E417.11(h) of this appendix and in accordance with the following:

(1) *Silver zinc batteries.* A silver zinc battery shall be tested in accordance with § E417.11(h)(3) and the following:

(i) Electrical performance tests shall be conducted in accordance with paragraph (i) of this section, during the first, fourth, fifth, and eighth thermal cycles.

(ii) A silver zinc battery shall be continuously monitored during testing to verify that the required open circuit voltage is maintained for all thermal cycle dwells and thermal transitions.

(2) *Nickel cadmium batteries.* A nickel cadmium battery shall be tested in accordance with E417.11(h)(2) and the following:

(i) The battery must be charged in accordance with paragraph (r) of this section. A battery must not be recharged at anytime during thermal cycle testing.

(ii) Each electrical performance test shall be conducted in accordance with paragraph (i) of this section, during the first, middle and last thermal cycles at ambient, hot and cold qualification temperatures.

(iii) The battery shall be continuously monitored to verify that the required open circuit voltage is maintained throughout testing. This test must be performed at all thermal cycle dwells and thermal transitions.

(iv) The qualification high temperature shall be a minimum workmanship level of 40°C or the maximum predicted environment high temperature plus 10°C, whichever is higher. The qualification low temperature shall be a minimum workmanship level of −20°C or the predicted environment low temperature minus 10°C, whichever is lower.

(v) The battery's remaining capacity shall be determined at the end of thermal cycle testing to demonstrate that temperature does not adversely affect capacity and that the battery capacity will support an in-flight battery capacity margin of no less than 50 percent. Capacity and performance determination shall be demonstrated by performing a discharge and pulse test in accordance with paragraph (o) of this section. The self-discharge stand-time used for this test shall be the time that the battery must support launch processing, including any launch delays.

(l) *Leakage.* A battery's cells shall be tested to verify their seal integrity when in the battery configuration and individually as required by the test matrices of this section and in accordance with the following:

(1) Fully charged cells shall be exposed to a vacuum of less than 10^{-2} torr and then charged at a C/20 rate for 20 hours.

(2) The cells shall be individually weighed and tested with a chemical indicator to identify any cells that may have leaked. A weight loss greater than three-sigma from the average weight loss constitutes a test failure. Any cell that fails this first test shall be cleaned and discharged in accordance with paragraph (r) of this section. The cell shall then be recharged in accordance with paragraph (r) and re-tested using a chemical indicator. If the chemical indicator shows a leak after the second test, the cell shall not be used for flight.

(3) The temperature of the cells shall be controlled to prevent cell damage and must not exceed the maximum predicted thermal environment.

(m) *Activated stand time.* A silver zinc battery or cell shall be tested to demonstrate that it satisfies its performance specifications after being activated and subjected to an environment that simulates preflight battery conditioning environments, including the launch vehicle installation environment. The time period that the activated battery is subjected to the preflight environments is its activated stand time. Open-circuit voltage testing shall be performed at the beginning and end of the activated stand time to determine the health of the battery or cell. A load test shall be performed at the end of the activated stand time to verify whether the battery or cell is in a peroxide or monoxide chemical state in accordance with its performance specifications prior to proceeding with operating environmental tests.

(n) *Overcharge.* A battery or cell shall be tested to demonstrate that it is capable of being overcharged without degrading performance beyond its performance specifications. An overcharge shall be applied to the battery or cell using a nominal-charging rate up to the manufacture's specified overcharge limit.

(o) *Discharge and pulse capacity.* A battery or cell shall be tested to ensure that it satisfies all electrical performance specifications at the end of its specification capacity limit in accordance with the following:

(1) *Silver zinc batteries and cells.* A silver zinc battery or cell shall be tested to ensure it meets its electrical performance specification at its capacity limit. The capacity consumed in all previous tests must be calculated and used as input for the following tests:

(i) A battery shall be discharged at flight loads until the capacity has reached the manufacturer's specified capacity value. The total amount of capacity consumed during the discharge test and qualification discharge shall be calculated and verified that it meets the minimum performance specification. A high current pulse of 150% of the expected current pulse shall then be applied to the flight loads. The pulse duration for this test shall be twice the expected operating flight pulse time or a minimum workmanship level of 100 milliseconds whichever is greater.

(ii) The minimum voltage shall be no less than the flight termination system component acceptance test voltage or the manufacturer's specified voltage value, whichever is greater. The total amount of capacity consumed during the discharge test shall be calculated and verified that it meets the minimum performance specification.

(iii) The battery or cell shall then be completely discharged in accordance with paragraph (r) of this section to determine the remaining capacity as a status-of-health indicator.

(2) *Nickel cadmium batteries and cells.* A nickel cadmium battery or cell shall be subjected to the following:

(i) The battery or cell shall be fully charged in accordance with paragraph (r) of this section.

(ii) The battery or cell shall then be discharged at flight loads. When the battery or cell is discharged to 150% of its rated amp/hour capacity, a high current pulse of 150% of the expected operating current pulse shall be applied to the flight loads. The high current pulse shall be applied to the flight loads again when the battery or cell reaches 75% of its rated capacity, and again when the battery or cell reaches the end of its capacity. The duration of the high current pulse shall be twice the expected operating flight pulse time or a minimum workmanship level of 100 milliseconds for acceptance testing and 200 milliseconds for qualification testing, whichever is greater.

(iii) The minimum voltage shall be no less than the flight termination system component acceptance test voltage or the manufacturer's specified value, whichever is greater. The total amount of capacity consumed during the discharge test shall be calculated and verified to meet the minimum design specification.

(iv) The battery cell shall then be completely discharged in accordance with paragraph (r) of this section to determine the remaining capacity as a status-of-health indicator.

(p) *Operating charge retention testing.* A battery shall be tested to ensure that it maintains the required energy margin when subjected to the operating stand time between the final charge used for the end-to-end test prior to flight and the no longer endanger time determined in accordance with § 417.221(c). The operating stand time must include any launch processing and launch delay contingencies. Testing shall be performed in accordance with the following:

(i) The battery shall be charged in accordance with paragraph (r) of this section and allowed to stand in an open-circuit configuration.

(ii) After the operating stand time has elapsed, the battery shall be discharged in accordance with paragraph (r) of this section and the capacity loss shall be calculated. This capacity lost due to discharge in an open-circuit configuration shall be accounted for in the battery analysis performed in accordance with § 417.329(k) to demonstrate the required battery capacity margin.

(q) *Nickel cadmium cell inspection and preparation.* Each nickel cadmium cell shall be inspected to ensure it is free of manufacturing defects. The launch operator shall ensure inspection and preparation are in accordance with the following:

(1) The manufacturer's lot-code shall be recorded and the cell shall be verified to be clean with no cracks or leaks.

(2) Each cell shall be completely discharged at a rate that will not result in damage to the cell.

(3) The integrity of each tab to cell weld will be established by a pull test to ensure sufficient strength to meet its performance specification.

(4) Weight measurements shall be taken to support leak testing for subsequent tests. Each cell must be weighed to ±0.001 grams.

(r) *Nickel cadmium cell and battery capacity charge and discharge.* A nickel cadmium cell or battery shall be charged and discharged at a rate that prevents damage and provides for the cell or battery's electrical characteristics to remain consistent. Unless otherwise specified, the charge and discharge rates used for testing shall be identical to that used for operating flight battery conditioning. The following cell charge and discharge requirements shall be applied to a battery by multiplying the required voltages by the number of cells in the battery:

(1) Each cell shall be discharged to 0.9 volt, then discharged at a slower rate to 0.10 volt and finally completely discharged. The discharge rate between 0.9 volt and 0.1 volt shall not exceed C/10.

(2) The rate of discharge shall allow a sufficient resolution to determine out-of-family data.

(3) Each cell shall be charged at no greater than the C/10 rate to 160% of rated capacity.

(s) *Nickel cadmium cell conditioning and characterization tests.* Each cell or battery shall be subjected to the following characterization and conditioning tests to ensure proper electrical performance:

(1) *Initial charging and cycling.* Each cell shall be initially conditioned to ensure repeatable electrical performance throughout its service life. A launch operator shall perform the following:

(i) Prior to any testing, each nickel cadmium cell shall be aged for no less than 11 months after the manufacturer's lot date code to ensure consistent electrical performance of the cell for its entire service life.

(ii) The first charge shall be performed at no greater than a C/20-rate to initialize the chemistry within the cell. Batteries stored for over one month after the first charge must be recharged at the same rate.

(2) *Formation of plates and determination of cell capacities.* Testing shall be performed to stabilize the cell chemistry and determine cell capacity. Discharge tests shall be performed in accordance with paragraph (r) of this section at room temperature and repeated until the capacities for two cycles agree to within 1%.

(3) *Cell impedance pulse voltage determination.* Each electrical performance test shall be performed for each cell to acquire data for cell matching. Each cell shall be charged in accordance with paragraph (r) of this section and cold soaked to the lowest predicted temperature environment. The cell shall then be subjected electrical tests in accordance with paragraph (i) of this section. Repeat this procedure three times to establish adequate data for cell matching.

(t) *Calendar life testing.* Testing shall be performed to validate that any cell aging effects will not adversely affect flight battery performance. Each year, five cells for the same lot as the flight batteries that have been stored with flight batteries shall be tested in accordance with the following:

(1) Five cells shall undergo testing in accordance with paragraphs (s)(1), (s)(2), (b)(1) and (b)(2) of this section.

(2) Cycle life testing shall be performed in accordance with paragraph (y) of this section.

(3) A final leak test shall be performed in accordance with paragraph (l) of this section.

(u) *Nickel cadmium acceptance thermal cycle test.* Acceptance thermal cycle testing shall be performed to ensure proper workmanship and to validate that flight environments do not adversely affect battery or cell performance. Testing shall be performed in accordance with E417.13(d)(2) and in accordance with the following:

(1) The battery or cell must be charged in accordance with paragraph (r) of this section.

(2) Electrical performance tests shall be conducted in accordance with paragraph (i) of this section during the first and last hot, ambient, and cold maximum predicted thermal environments.

(3) The thermal cycle acceptance high temperature must be a 30 °C minimum workmanship screening level or the maximum predicted environment high temperature, whichever is higher. The acceptance low temperature must be −10 °C workmanship screening temperature or the predicted environment low temperature, whichever is lower.

(4) Critical parameters shall be monitored during thermal extremes on all cycles and during thermal transition. The battery or cell shall be continuously monitored to verify that the required open circuit voltage is maintained throughout testing.

(5) The remaining capacity must be determined at the end of thermal cycle testing to demonstrate that temperature will not adversely affect open circuit discharge and capacity of the battery or cell. Capacity and performance shall be determined by performing a discharge and pulse test in accordance with paragraph (o) of this section. The total capacity consumed due to open circuit discharge shall be used as a status-of-health indicator of the cell or battery.

(v) *Post acceptance discharge and storage.* A battery shall be stored and transported in a configuration that prevents electrical performance damage and allows accurate representation of calendar life cell samples. The battery shall be discharged and stored in accordance with the following:

(1) The battery shall be discharged in accordance with paragraph (r) of this section.

(2) The battery shall be discharged to prevent cell reversal to a maximum of 0.05 volts per cell.

(3) After the discharge, the battery shall be stored in an open circuit configuration consistent with the calendar life test samples described in paragraph (t) of this section.

(w) *Battery and cell disassembly.* A battery and all cells within the battery shall be inspected for excessive wear and damage after exposure to qualification test environments. Battery and cell inspection must be performed in accordance with E417.5(g) and the following:

(1) The inspection shall include full battery inspection and verification that there was no movement of any component within the battery.

(2) The integrity of cell and wiring interconnects must be verified through inspection.

(3) The integrity of potting and shimming materials must be verified through inspection.

(4) Cells shall be removed and inspected for physical damage.

(5) Cells shall be individually tested with a chemical indicator to identify any cells that may have leaked. Any cell that shows signs of chemical leakage will be considered a test failure.

(6) One cell from each corner and the middle of the battery shall be removed and subjected to destructive physical analysis to validate plate tab to cell terminal, and plate and separator integrity.

(x) *Battery mounting and case integrity.* Battery cases and mounting hardware shall be tested to demonstrate the capability to withstand normal and abnormal flight environments. Inspection or test criteria shall be implemented to ensure welds are free of workmanship defects. Welds must be inspected by X-ray in accordance with E417.5(f).

(y) *Battery cycle life testing.* For a rechargeable battery, such as a nickel cadmium battery, testing shall be performed to validate that there is adequate margin between the number of operating charge and discharge cycles and the design limit of all the cells and battery. Tests shall be performed to demonstrate at least five times the number of cycles expected of a flight battery throughout its life, including acceptance testing, preflight checkout phases, and flight in accordance with the following criteria:

(1) The battery must be charged and discharged in accordance with paragraph (r) of this section for at least five times the number of cycles expected of the flight battery throughout its life.

(2) Discharge and pulse capacity testing in accordance with paragraph (o) of this section shall be performed on the first 10 charge and discharge cycles, every fifth cycle thereafter, and the last five cycles.

(3) If any cell fails to meet the discharge and pulse capacity testing required by paragraph (o) of this section the lot shall be rejected.

E417.23 Miscellaneous Components

Any flight termination system component not specifically identified in this appendix shall be tested to demonstrate that it accomplishes its intended function after being subjected to the non-operating, operating, and workmanship screening environments in accordance with the test matrices of this section. The FAA will identify and impose any test requirements necessary for safety for new or unique components through the licensing process and in accordance with § 415.11 of this chapter.

TABLE E417.23–1

Miscellaneous component acceptance tests	Reference E417.13(a)	Quantity (percent)
Component Examination	E417.5	
Visual Inspection	E417.5(b)	100
Dimension	E417.5(c)	100
Identification	E417.5(e)	100
Performance Verification [1]	E417.3(e)	100
Abbreviated Performance Verification[2]	E417.3(f)	100
Operating Environment Tests	E417.13	
Thermal Cycling	E417.13(d)	100
Thermal Vacuum	E417.13(e)	100
Acoustic	E417.13(c)	100
Random Vibration	E417.13(b)	100

TABLE E417.23–1—Continued

Miscellaneous component acceptance tests	Reference E417.13(a)	Quantity (percent)
Leakage	E417.5(h)	100

[1] These tests shall be performed before the first and after the last operating environment test.
[2] This test shall be performed during each operating environment test.

TABLE E417.23–2

Miscellaneous component qualification tests	Reference E417.11	Quantity [4] X=3
Acceptance Tests [1]	Table E417.23–1	X
Performance Verification[2]	E417.3(e)	X
Non-Operating Environment Tests	E417.9	
Storage Temperature	E417.9(b)	X
Transportation Shock	E417.9(d)	X
Bench Handling Shock	E417.9(e)	X
Transportation Vibration	E417.9(f)	X
Fungus Resistance	E417.9(g)	1
Salt Fog	E417.9(h)	1
Fine Sand	E417.9(i)	1
Abbreviated Performance Verification [3]	E417.3(f)	X
Operating Environment Tests	E417.11	
Thermal Cycling	E417.11(h)	X
Humidity	E417.11(g)	X
Thermal Vacuum	E417.11(i)	X
Acceleration	E417.11(f)	X
Shock	E417.11(e)	X
Sinusoidal Vibration	E417.11(b)	X
Acoustic	E417.11(d)	X
Random Vibration	E417.11(c)	X
Electromagnetic Interference and Compatibility	E417.11(j)	1
Explosive Atmosphere	E417.11(k)	1
Leakage	E417.5(h)	X
Disassembly	E417.5(g)	X

[1] Each sample component to undergo qualification testing must first successfully complete all applicable acceptance tests.
[2] These tests shall be performed before the first and after the last non-operating environment test and before the first and after the last operating environment test.
[3] These tests shall be performed during each operating environment test.
[4] The same three sample components shall be subjected to each test designated with an X. For each test designated with a quantity of less than three, each component tested shall be selected from the original three sample components.

E417.25 Safe and Arm Devices and Electro Explosive Devices

(a) *General.* A safe and arm device that is part of a flight termination system and any accompanying electro explosive device shall be tested to demonstrate that it satisfies its performance specifications when subjected to non-operating and operating environments. This testing shall be accomplished in accordance with the acceptance, qualification, and age surveillance test matrices and accompanying requirements of this section.

TABLE E417.25–1

Safe and arm device acceptance tests	Reference E417.13(a)	Quantity (percent)
Component Examination	E417.5	
Visual Inspection	E417.5(b)	100
Dimension	E417.5(c)	100
Identification	E417.5(e)	100
Performance Verification[1]	E417.3(e)	
Status-of-Health	E417.25(b)	100
Safety Tests	E417.25(e)	
Manual Safing	E417.25(e)(4)	100
Safing Interlock test	E417.25(e)(5)	100
Abbreviated Performance Verification[2]	E417.3(f)	
Dynamic Performance	E417.25(g)	100
Thermal Performance	E417.25(f)	100
Operating Environment Tests	E417.13	
Thermal Cycling	E417.13(d)	100
Random Vibration	E417.13(b)	100
X-ray	E417.5(f)	100
Leakage	E417.5(h)	100

[1] These tests shall be performed before the first and after the last operating environment test.

[2] These tests shall be performed during each operating environment test.

TABLE E417.25–2

Safe and arm device qualification tests	Reference E417.7	Quantity		
		X=1 [4]	X=6 [5]	X=2 [6]
Barrier Alignment	E417.25(o)			
Acceptance Tests[1]	Table E417.25–1	X	X	
Safety Tests	E417.25(e)			
Extended Stall	E417.25(e)(3)	X		
Abnormal Drop	E417.9(1)	X		
Containment	E417.25(e)(1)	....	....	X
Barrier Functionality	E417.25(e)(2)	....	....	X
Safing Verification	E417.25(e)(6)	....	X	
Non-Operating Environment Tests	E417.9			
Storage Temperature	E417.9(b)	....	X	
Transportation Shock	E417.9(d)	....	X	
Bench Handling shock	E417.9(e)	....	X	
Transportation Vibration	E417.9(f)	....	X	
Fungus Resistance	E417.9(g)	....	1	
Salt Fog	E417.9(h)	....	1	
Fine Sand	E417.9(i)	....	1	
Handling Drop	E417.9(k)	....	X	
Performance Verification[2]	E417.3(e)			
Status-of-Health	E417.25(b)	....	X	
Abbreviated Performance Verification[3]	E417.3(f)			
Dynamic Performance	E417.25(g)	....	X	
Thermal Performance	E417.25(f)	....	X	
Operating Environment Tests	E417.11			
Thermal Cycling	E417.11(h)	....	X	
Humidity	E417.11(g)	....	X	
Acceleration	E417.11(f)	....	X	
Shock	E417.11(e)	....	X	
Sinusoidal Vibration	E417.11(b)	....	X	
Acoustic	E417.11(d)	....	X	
Random Vibration	E417.11(c)	....	X	
Explosive Atmosphere	E417.11(k)	....	X	
Safe and Arm Transition	E417.25(c)	....	X	
Stall	E417.25(d)	....	X	
X-ray	E417.5(f)	....	X	
Leakage	E417.5(h)	....	X	
Disassembly	E417.5(g)	....	2	
Firing Test at Operating Current	E417.25(j)			
High Temperature	E417.25(j)(6)	....	2	
Low Temperature	E417.25(j)(7)	....	2	

[1] The sample safe and arm devices designated in the test matrix that are to undergo qualification testing must first successfully complete all applicable acceptance tests.

[2] Performance verification tests shall be performed before the first and after the last operating environment test.

[3] These tests shall be performed during each operating environment test.

[4] One safe and arm device shall be subjected to the extended stall and abnormal drop tests designated with an X.

[5] The same six sample safe and arm devices shall be subjected to each test designated with an X. For tests designated with a quantity of less than six, each safe and arm device tested shall be selected from the original six sample components.

[6] Two safe and arm devices shall be subjected to the containment and barrier functionality tests designated with an X. These tests are not required to be performed on flight safe and arm devices. The test samples must duplicate all dimensions of a flight safe and arm device, including gaps between explosive components, free-volume, and diaphragm thickness. The test samples must also have the explosive transfer assemblies installed.

TABLE E417.25–3

Electro-explosive device lot acceptance tests	Reference	Quantity
Component Examination	E417.5	
Visual Inspection	E417.5(b)	100
Dimension	E417.5(c)	100
Leakage	E417.5(h)	100
X-ray and N-ray	E417.5(f)	100
Performance Verification	E417.3(e)	
Static Discharge	E417.25(i)	100
Status-of-Health	E417.25(h)	100
Non-Operating Environment Tests and Operating Environment Tests	E417.9, E417.11	
Thermal Cycling [1]	E417.11(h)	Lot Sample [3]
High Temperature Storage [2]	E417.9(c)	Lot Sample
Shock [1]	E417.11(e)	Lot Sample

TABLE E417.25–3—Continued

Electro-explosive device lot acceptance tests	Reference	Quantity
Random Vibration [1]	E417.11(c)	Lot Sample
No Fire Verification	E417.25(p)	Lot Sample
Performance Verification	E417.3(e)	
Status-of-Health	E417.25(h)	Lot Sample
Component Examination	E415.5	
Visual Inspection	E417.5(b)	Lot Sample
Leakage	E417.5(h)	Lot Sample
X-ray and N-ray	E417.5(f)	Lot Sample
Firing Tests	E417.25(j)	
Ambient Temperature	E417.25(j)	
All-Fire Current	E417.25(j)(1)	1⁄6 Lot Sample
Operating Current	E417.25(j)(2)	1⁄6 Lot Sample
High Temperature	E417.25(j)(6)	
All-Fire Current	E417.25(j)(1)	1⁄6 Lot Sample
Operating Current	E417.25(j)(2)	1⁄6 Lot Sample
Low Temperature	E417.25(j)(7)	
All-Fire Current	E417.25(j)(1)	1⁄6 Lot Sample
Operating Current	E417.25(j)(2)	1⁄6 Lot Sample

[1] These environmental tests shall be performed at the qualification test levels.
[2] The high temperature storage test is optional. If performed, the lot will have an initial service life of three years. If not performed, the lot will have an initial service life of one year.
[3] The lot sample must be 10 percent of the production lot but not less than 30 electro explosive devices.

TABLE E417.25–4

Electro explosive device qualification tests [1]	Reference E417.7	Quantity [5] X=				
		5	SS [6]	SS [7]	SS [8]	105
Component Examination	E417.5					
Visual Inspection	E417.5(b)	X	X	X	X	X
Dimension	E417.5(c)	X	X	X	X	X
Leakage	E417.5(h)	X	X	X	X	X
X-ray and N-ray	E417.5(f)	X	X	X	X	X
Performance Verification	E417.3(e)					
Static Discharge	E417.25(i)	X	X	X	X	X
Status-of-Health	E417.25(h)	X	X	X	X	X
Component Examination	E417.5	X	X	X	X	X
Visual Inspection	E417.5(b)	X	X	X	X	X
Dimension	E417.5(c)	X	X	X	X	X
Leakage	E417.5(h)	X	X	X	X	X
X-ray and N-ray	E417.5(f)	X	X	X	X	X
Radio Frequency Impedance	E417.25(k)		10			
Radio Frequency Sensitivity	E417.25(l)		X			
No-Fire Level	E417.25(m)			X		
All-Fire Level	E417.25(n)				X	
Non-Operating Environment Tests and Operating Environment Tests:.	E417.9, E417.11					
Thermal Cycling [2]	E417.11(h)					X
High Temperature Storage [3]	E417.9(c)					30
Shock [2]	E417.11(e)					X
Random Vibration [2]	E417.11(c)					X
No-Fire Verification	E417.25(p)					30
Tensile Load [4]	E417.9(j)					30
Performance Verification	417.3(e)					
Static Discharge	E417.25(i)	X				X
Status-of-Health	E417.25(h)	X				X
Component Examination	E415.5					
Visual Inspection	E417.5(b)	X				X
Leakage	E417.5(h)	X				X
X-ray and N-ray	E417.5(f)	X				X
Firing Tests	E417.25(j)					
Ambient Temperature	E417.25(j)					
All-Fire Current	E417.25(j)(1)					15
Operating Current	E417.25(j)(2)					15
22 Amps Current	E417.25(j)					5
High Temperature	E417.25(j)(6)					
All-Fire Current	E417.25(j)(1)					15
Operating Current	E417.25(j)(2)					15
22 Amps Current	E417.25(j)					5
Low Temperature	E417.25(j)(7)					
All-Fire Current	E417.25(j)(1)					15

TABLE E417.25–4—Continued

Electro explosive device qualification tests [1]	Reference E417.7	Quantity [5] X=				
		5	SS [6]	SS [7]	SS [8]	105
Operating Current	E417.25(j)(2)					15
22 Amps Current	E417.25(j)					5

[1] All sample electro explosive devices used in qualification testing must be from a production lot that has passed the lot acceptance tests required by Table E417.25–3.
[2] These environmental tests shall be performed at the qualification environmental test levels.
[3] This test is optional. If performed, the lot will have an initial service life of three years. If not performed, the lot will have an initial service life of one year.
[4] This test is not required if other tests verify that each electro explosive device is not damaged during installation.
[5] For each column, the quantity required at the top of the column shall be from the same production lot and shall be subjected to each test designated with an X. For a test designated with a lessor quantity, each sample tested shall be selected from the original quantity of samples for that column.
[6] The statistical sample (SS) quantity needed to perform a statistical firing series to determine the radio frequency sensitivity of the electro explosive device shall be subjected to each test designated with an X. The quantity must be greater than the 10 samples needed for the radio frequency impedance tests.
[7] The statistical sample (SS) quantity needed to perform a statistical firing series to determine the electro explosive device's no-fire energy level shall be subjected to each test designated with an X.
[8] The statistical sample (SS) quantity needed to perform a statistical firing series to determine the electro explosive device's all-fire energy level shall be subjected to each test designated with an X.

TABLE E417.25–5

Electro explosive device age surveillance tests	Reference E417.15	Quantity [2]	
		1 Year [3] X=5	3 Years [4] X=10
Component Examination	E417.5		
Visual Inspection	E417.5(b)	X	X
Dimension	E417.5(c)	X	X
Leakage	E417.5(h)	X	X
X-ray and N-ray	E417.5(f)	X	X
Performance Verification	E417.3(e)		
Static Discharge	E417.25(i)	X	X
Status-of-Health	E417.25(h)	X	X
Non-Operating Environment Tests and Operating Environment Tests [1]	E417.9, E417.11		
Thermal Cycling	E417.11(h)	X	X
High Temperature Storage	E417.9(c)	X	X
Shock	E417.11(e)	X	X
Random Vibration	E417.11(c)	X	X
Performance Verification	E417.3(e)		
Status-of-Health	E417.25(h)	X	X
Component Examination	E417.5		
Visual Inspection	E417.5(b)	X	X
Leakage	E417.5(h)	X	X
X-Ray and N-ray	E417.5(f)	X	X
Firing Tests	E417.25(j)		
All-Fire Current	E417.25(j)(1)		
Ambient Temperature	E417.25(j)(1)	1	3
High Temperature	E417.25(j)(6)	2	3
Low Temperature	E417.25(j)(7)	2	4

[1] All environmental tests shall be performed at the qualification test levels.
[2] For each column, the quantity of sample electro explosive devices required at the top of the column shall be from the same production lot and shall be subjected to each test designated with an X. For a test designated with a lessor quantity, each electro explosive device shall be selected from the original samples for that column.
[3] Five electro explosive devices from the same lot shall be tested to extend the service life of the remaining electro explosive devices from the same lot for one year.
[4] Ten electro explosive devices from the same lot shall be tested to extend the service life of the remaining electro explosive devices from the same lot for three years.

TABLE E417.25–6

Safe and arm rotor lead and booster charge lot acceptance tests	Reference E417.13(a)	Quantity
Component Examination	E417.5	
Visual Inspection	E417.5(b)	100%
Dimension	E417.5(c)	100%
Leakage	E417.5(h)	100%
X-ray and N-ray	E417.5(f)	100%
Non-Operating Environment Tests and Operating Environment Tests	E417.9, E417.11	
Thermal Cycling [1]	E417.11(h)	Lot Sample [3]

TABLE E417.25–6—Continued

Safe and arm rotor lead and booster charge lot acceptance tests	Reference E417.13(a)	Quantity
High Temperature Storage [2]	E417.9(c)	Lot Sample
Component Examination	E417.5	
Leakage	E417.5(h)	Lot Sample
X-Ray and N-ray	E417.5(f)	Lot Sample
Firing Tests	E417.25(j)	
High Temperature	E417.25(j)(6)	½ Lot Sample
Low Temperature	E417.25(j)(7)	½ Lot Sample

[1] These environmental tests shall be performed at the qualification test levels.
[2] The high temperature storage test is optional. If performed, the lot will have an initial service life of five years. If not performed, the lot will have an initial service life of one year.
[3] The lot sample size must be 10 percent of the lot, but not less than 10 units.

TABLE E417.25–75

Safe and arm rotor lead and booster charge qualification tests	Reference E417.17	Quantity [3] X=21
Component Examination	E417.5	
Visual Inspection	E417.5(b)	X
Dimension	E417.5(c)	X
Leakage	E417.5(h)	X
X-ray and N-ray	E417.5(f)	X
Non-Operating Environment Tests and Operating Environment Tests	E417.9, E417.11	
Thermal Cycling [1]	E417.11(h)	X
High Temperature Storage [2]	E417.9(c)	10
Shock [1]	E417.11(e)	X
Random Vibration [1]	E417.11(c)	X
Component Examination	E417.5	
X-Ray and N-ray	E417.5(f)	X
Leakage	E417.5(h)	X
Firing Tests	E417.25(j)	
Ambient Temperature	E417.25(j)	7
High Temperature	E417.25(j)(6)	7
Low Temperature	417.25(j)(7)	7

[1] These environmental tests shall be performed at the qualification test levels.
[2] The high temperature storage test is optional. If performed, the lot will have an initial service life of five years. If not performed, the lot will have an initial service life of one year.
[3] The same 21 sample components, from the same production lot, shall be subjected to each test designated with an X. For tests designated with a quantity of less than 21, each component tested shall be selected from the original 21 sample components.

TABLE E417.25–8

Safe and arm rotor lead and booster charge age surveillance tests	Reference E417.15	Quantity [2]	
		1 Year([3]) X=5	5 Years [4] X=10
Component Examination	E417.5		
Visual Inspection	E417.5(b)	X	X
Dimension	E417.5(c)	X	X
Leak	E417.5(h)	X	X
X-ray and N-ray	E417.5(f)	X	X
Non-Operating Environment Tests and Operating Environment Tests	E417.9, E417.11		
Thermal Cycling [1]	E417.11(h)	X	X
High Temperature Storage	E417.9(c)	....	X
Component Examination	E417.5		
Leakage	E417.5(h)	X	X
X-Ray and N-ray	E417.5(f)	X	X
Firing Tests	E417.25(j)		
High Temperature	E417.25(j)(6)	2	5
Low Temperature	417.25(j)(7)	3	5

[1] These environmental tests shall be performed at the qualification test levels.
[2] For each column, the quantity of sample components required at the top of the column shall be from the same production lot and shall be subjected to each test designated with a X. For a test designated with a lessor quantity, each component tested shall be selected from the original samples for that column.
[3] The test lot sample quantity shall be equal to five for tests to extend the service life of components remaining from the same lot for one year.
[4] The test lot sample quantity shall be equal to 10 for tests to extend the service life of components remaining from the same lot for five years.

(b) *Safe and arm device status-of-health.* A safe and arm device shall be subjected to status-of-health tests performed in accordance with E417.3(g). These tests must include measurements of insulation resistance from pin-to-pin and pin-to-case, safe and arm transition time, and bridgewire resistance consistency through multiple transition cycles.

(c) *Safe and arm transition.* A safe and arm shall be tested to demonstrate that the safe and arm transition, such as rotational or sliding operation, functions according to its performance specifications. At a minimum, the following performance parameters shall be validated:

(1) Testing must verify that the safe and arm monitors accurately determine safe and arm transition and whether the safe and arm device is in the proper configuration.

(2) Transition testing must verify that a safe and arm device is not susceptible to inadvertent initiation or degradation in performance of the electro-explosive device during preflight processing.

(3) Transition testing must demonstrate the ability of a safe and arm device to withstand five times the maximum predicted number of arming cycles without degradation in performance.

(d) *Stall.* A safe and arm device shall be tested to demonstrate that its performance is not degraded after being locked in its safe position and subjected to an operating arming voltage for the maximum predicted time that could occur inadvertently during launch processing or for five minutes, whichever time is greater.

(e) *Safety tests.* The following tests shall be performed to demonstrate that a safe and arm device can be handled and implemented safely:

(1) *Containment.* A safe and arm device shall be tested to demonstrate that it will not fragment when any internal electro explosive device or rotor charge is initiated.

(2) *Barrier functionality.* Testing shall be performed to demonstrate that, when in its safe position, if a safe and arm device's internal electro explosive devices is initiated, the ordnance output will not propagate to an explosive transfer system that is configured for flight. Test firings shall be performed at high and low temperature extremes in accordance with the following:

(i) High temperature firings shall be initiated at the high temperature design specification or a 71°C workmanship screening level, whichever is higher.

(ii) Low temperature firings shall be initiated at the low temperature design specification or a −54°C workmanship screening level, whichever is lower.

(3) *Extended stall.* A safe and arm device shall be tested to verify that it does not inadvertently initiate when locked in its safe position and subjected to a continuous operating arming voltage for the maximum predicted time that could occur accidentally during launch processing or one hour, whichever is greater.

(4) *Manual safing.* A safe and arm device shall be tested to demonstrate that it can be manually safed in accordance with its performance specifications.

(5) *Safing interlock.* A safe and arm device shall be tested to demonstrate that its safing interlock prevents arming when operational arming current is applied in accordance with its performance specifications.

(6) *Safing verification.* A safe and arm device shall be tested to demonstrate that, while in the safe position, any internal electro explosive device will not initiate if the safe and arm device input circuit is accidentally subjected to a firing voltage, such as a command receiver or inadvertent separation destruct system output.

(f) *Safe and arm thermal performance.* Testing shall be performed which demonstrates that the safe and arm device satisfies its performance specifications when subjected to operating and workmanship thermal environments. Tests performed while the safe and arm device is subjected to the design thermal environments must include the following:

(1) A safe and arm device shall be placed in its arm position and the bridgewire continuity shall be continuously monitored to detect any variations in amplitude.

(2) The bridgewire resistance shall be measured for the first and last thermal cycle at the high and low temperature dwells. The bridgewire resistance must be within its design specification.

(3) A safe and arm device shall be cycled through five arm and safe cycles and the bridgewire continuity shall be measured during each cycle for consistency. The cycle time shall also be measured during this test to verify that it is within its design specification.

(g) *Safe and arm dynamic performance.* Testing shall be performed which demonstrates that the safe and arm device satisfies its performance specifications when subjected to dynamic environments, such as vibration and shock, and is in accordance with its design specification. Tests performed while the safe and arm device is subjected to each design dynamic environment must include the following:

(1) A safe and arm device shall be placed in the arm position and bridgewire continuity shall be continuously monitored to detect any variations in amplitude with an accuracy of 1⁄10 millisecond.

(2) A safe and arm device's monitor circuits shall be continuously monitored to detect any variations in amplitude with an accuracy of one millisecond.

(3) A safe and arm device shall be monitored to verify that it remains in the locked-armed position throughout dynamic environment testing.

(h) *Electro explosive device status-of-health.* An electro explosive device shall be subjected to status-of-health tests performed in accordance with E417.3(g). These tests shall include tests of insulation resistance and bridgewire continuity.

(i) *Static discharge.* An electro explosive device shall be tested to verify that it can withstand an electrostatic discharge that it could experience from personnel or conductive surfaces without firing or degradation in performance. This test must include subjecting the electro explosive device to a 25k-volt, 500-picofarad pin-to-pin discharge through a 5k-ohm resistor and a 25k-volt, 500-picofarad pin-to-case discharge with no resistor or to the maximum predicted electrostatic discharge, whichever is greater.

(j) *Firing tests.* Test firings shall be performed on safe and arm device, electro-explosive device, rotor lead, and booster charge samples to establish that the initiation and transfer of ordnance charges meets performance requirements. The number of samples to be fired and the test conditions, including firing current and temperature, must be in accordance with the test matrices in this section and the following:

(1) The safe and arm device and electro-explosive device all-fire current test firings required by the test matrices shall be performed using the manufacturer's specified all-fire current value.

(2) The safe and arm device and electro-explosive device operating current test firings required by the test matrices shall be performed using the launch vehicle operating value if known at the time of testing. If the operating current is unknown, testing shall be performed using at least 200% of the all-fire current value.

(3) All safe and arm device and electro-explosive device test firings shall be performed using a current source that duplicates the operating output waveform and impedance.

(4) A rotor lead or booster charge shall be tested to demonstrate that it will be initiated by a flight configured energy source and to demonstrate that its output energy transfer meets its design specification.

(5) Each test shall include measurements, such as swell cap or dent block measurements, to verify that the ordnance output is within its performance specification.

(6) The high temperature test firings required by the test matrices must be initiated while the sample it subjected to the design specification high temperature level or at a +71 °C workmanship screening level, whichever is higher.

(7) The low temperature test firings required by the test matrices shall be initiated while the sample is subjected to the design specification low temperature level or at a minus 54 °C workmanship screening level, whichever is lower.

(8) For a safe and arm device that has more than one internal electro explosive device, each firing test of the safe and arm device must demonstrate that the initiation of one internal electro explosive device does not affect the performance of any other internal electro explosive device.

(k) *Radio frequency impedance.* Tests shall be performed during qualification testing to determine the radio frequency impedance of an electro explosive device. This impedance value is used to perform the flight termination system radio frequency susceptibility analysis.

(l) *Radio frequency sensitivity.* A statistical firing series shall be performed during qualification testing to determine the radio frequency no-fire energy level of the electro explosive device. The demonstrated radio frequency no-fire energy level must not exceed the level used in the flight termination system design and analysis.

(m) *Electro explosive device no-fire energy level verification.* A statistical firing series shall be performed during qualification testing to determine the highest electrical energy level at which an electro explosive device will not fire with a reliability of 0.999 at a 95% confidence level when subjected to a continuous current pulse. The demonstrated no-fire energy level must not be less than the no-fire energy level used in the flight termination system design and analysis.

(n) *Electro explosive device all-fire energy level verification.* A statistical firing series shall be performed during qualification testing to determine the lowest electrical energy level at which the electro explosive device will fire with a reliability of 0.999 at a 95% confidence level when subjected to a current pulse that simulates the launch vehicle flight termination system firing characteristics. The demonstrated all-fire energy level must not be greater than the all-fire energy level use in the flight termination system design and analysis.

(o) *Barrier alignment.* A safe and arm device shall be subjected to a statistical test firing series to verify the safe to arm and arm to safe transition motion that provides ordnance initiation with a reliability of 0.999 at a 95% confidence level and the transition motion that provides no ordnance initiation with a reliability of 0.999 at a 95% confidence level. These test firings may be performed in a reusable safe and arm subassembly that simulates the flight configuration.

(p) *No-fire verification.* Testing shall be performed to demonstrate that a flight configured electro explosive device within an armed safe and arm device will not inadvertently initiate and that its performance will not be degraded when exposed to the maximum predicted circuit leakage. The time used for this test must reflect the actual worst-case exposure that could occur in an operating condition. The minimum level used for this test must be 1 amp/1 watt for five minutes.

E417.27 Exploding Bridgewire Firing Units and Exploding Bridgewires

(a) *General.* All exploding bridgewire firing units and all exploding bridgewires shall be tested to demonstrate that they satisfy their performance specifications when subjected to non-operating and operating environments. This testing shall be conducted in accordance with the acceptance, qualification, and age surveillance test matrices and accompanying requirements of this section.

TABLE E417.27–1

Exploding bridgewire firing unit acceptance tests	Reference E417.13	Quantity (percent)
Component Examination	E417.5	
Visual Inspection	E417.5(b)	100
Dimension	E417.5(c)	100
Identification	E417.5(e)	100
Performance Verification [1]	E417.3(e)	100
Status-of-Health	E417.27(b)	100
Input Command Processing	E417.27(c)	100
High Voltage Output	E417.27(d)	100
Output Monitors	E417.27(e)(2)	100
Abbreviated Performance Verification [2]	E417.3(f)	
Abbreviated Status-of-Health	E417.27(f)	100
Abbreviated Command Processing	E417.27(g)	100
Output Monitors	E417.27(h)	100
Operating Environment Tests	E417.13	
Thermal Cycling [3]	E417.13(d)	100
Thermal Vacuum [3]	E417.13(e)	100
Acoustic	E417.13(c)	100
Random Vibration	E417.13(b)	100
Leakage	E417.5(h)	100

[1] These tests shall be performed prior to the first and after the last operating environment test.
[2] Abbreviated performance verification tests shall be performed during the operating environment tests.
[3] The abbreviated status-of-health parameters and output monitors shall be continuously monitored during all thermal cycles and transitions.

TABLE E417.27–2

Exploding bridgewire firing unit qualification tests	Reference E417.7	Quantity		
		X=1	X=1	X=1
Acceptance Tests [1]	Table E417.27–1	X	X	X
Performance Verification [2]	E417.3(e)	X	X	X
Status-of-Health	E417.27(b)	X	X	X
Input Command Processing	E417.27(c)	X	X	X
High Voltage Output	E417.27(d)	X	X	X
Abbreviated Performance Verification [3]	E417.3(f)			
Abbreviated Status-of-Health	E417.27(f)	X	X	X
Abbreviated Command Processing	E417.27(g)	X	X	X
Abbreviated Output Monitoring	E417.27(h)	X	X	X
Non-Operating Environment Tests	E417.9	X	X	X
Storage Temperature	E417.9(b)	X	X	X
Transportation Shock	E417.9(d)	X	X	X
Bench Handling Shock	E417.9(e)	X	X	X
Transportation Vibration	E417.9(f)	X	X	X
Fungus Resistance	E417.9(g)	X		
Salt Fog	E417.9(h)	X		
Fine Sand	E417.9(I)	X		
Operating Environment Tests	E417.11			
Thermal Cycling [4]	E417.11(h)	X	X	X
Humidity	E417.11(g)	X	X	X
Thermal Vacuum [4]	E417.11(I)	X	X	X

TABLE E417.27–2—Continued

Exploding bridgewire firing unit qualification tests	Reference E417.7	Quantity		
		X=1	X=1	X=1
Acceleration	E417.11(f)	X	X	X
Shock	E417.11(e)	X	X	X
Sinusoidal Vibration	E417.11(b)	X	X	X
Acoustic	E417.11(d)	X	X	X
Random Vibration	E417.11(c)	X	X	X
Electromagnetic Interference and Compatibility	E417.11(j)	X	X	....
Explosive Atmosphere	E417.11(k)	....	X	....
Repetitive functioning	E417.27(i)	X	X	X
Output Monitoring	E417.27(e)	X	....	....
Leakage	E417.5(h)	X	X	X
Disassembly	E417.5(g)	X	X	X

[1] Each qualification test component must successfully complete all acceptance tests before undergoing qualification testing.
[2] These tests shall be performed prior to the first and after the last environmental test.
[3] Abbreviated performance tests shall be performed during each operating environment test.
[4] Abbreviated status-of-health and output monitor testing shall be performed during all thermal cycles and transitions.

TABLE E417.27–3

Exploding bridgewire lot acceptance tests	Reference	Quantity
Component Examination and	E417.5	
Performance Verification	E417.3(e)	
Visual Inspection	E417.5(b)	100%
Dimension	E417.5(c)	100%
Static Discharge	E417.27(j)	100%
Status-of-Health	E417.27(k)	100%
Safety Devices [1]	E417.27(l)	100%
Leakage	E417.5(h)	100%
X-ray and N-ray	E417.5(f)	100%
Non Operating Environment Tests and	E417.9	
Operating Environment Tests [2]	E417.11	
Thermal Cycling [2]	E417.11(h)	Lot Sample [4]
High Temperature Storage [3]	E417.9(c)	Lot Sample
Shock [2]	E417.11(e)	Lot Sample
Random Vibration [2]	E417.11(c)	Lot Sample
Component Examination and	E417.5	
Performance Verification	E417.3(e)	
Status of Health	E417.27(k)	Lot Sample
Safety Devices [2]	E417.27(l)	Lot Sample
Leakage	E417.5(h)	Lot Sample
X-ray and N-ray	E417.5(f)	Lot Sample
Firing Tests	E417.27(m)	
Ambient Temperature	E417.27(m)	
All-Fire Voltage	E417.27(m)(1)	1/6 Lot Sample
Operating Voltage	E417.27(m)(2)	1/6 Lot Sample
High Temperature	E417.27(m)(4)	
All-Fire Voltage	E417.27(m)(1)	1/6 Lot Sample
Operating Voltage	E417.27(m)(2)	1/6 Lot Sample
Low Temperature	E417.27(m)(5)	
All-Fire Voltage	E417.27(m)(1)	1/6 Lot Sample
Operating Voltage	E417.27(m)(2)	1/6 Lot Sample

[1] The safety device tests shall be performed only if the exploding bridgewire contains internal protection circuitry such as a spark gap.
[2] These environmental tests shall be performed at the qualification test levels.
[3] The high temperature storage test is optional. If performed, the lot will have an initial service life of three years. If not performed, the lot will have an initial service life of one year.
[4] The lot sample must be 10 percent of the production lot but not less than 30 exploding bridgewires.

TABLE E417.27–4

Exploding bridgewire qualification tests	Reference	Quantity [4] X=				105
		5	SS [5]	SS [6]	SS [7]	
Lot Acceptance Tests [1]	Table E417.27–3					
Component Examination and Performance Verification.	E417.5, E417.3(e)					
Visual Inspection	E417.5(b)	X	X	X	X	X
Dimension	E417.5(c)	X	X	X	X	X

TABLE E417.27–4—Continued

Exploding bridgewire qualification tests	Reference	Quantity [4] X=				105
		5	SS [5]	SS [6]	SS [7]	
Static Discharge	E417.27(j)	X	X	X	X	X
Status-of-Health	E417.27(k)	X	X	X	X	X
Safety Devices [2]	E417.27(l)	X	X	X	X	X
Leakage	E417.5(h)	X	X	X	X	X
X-ray and N-ray	E417.5(f)	X	X	X	X	X
Radio Frequency Impedance	E417.27(n)		10			
Radio Frequency Sensitivity	E417.27(o)		X			
No-Fire Level	E417.27(p)					
All-Fire Level	E417.27(q)			X	X	
Non-Operating Environment Tests and Operating Environment Tests.	E417.9, E417.11					
Storage Temperature	E417.9(b)					X
Transportation Shock	E417.9(d)					X
Bench Handling Shock	E417.9(e)					X
Transportation Vibration	E417.9(f)					X
Fungus Resistance	E417.9(g)					5
Salt Fog	E417.9(h)					5
Fine Sand	E417.9(i)					5
Thermal Cycling	E417.11(h)					X
High Temperature Storage [3]	E417.9(c)					30
Shock	E417.11(e)					X
Random Vibration	E417.11(c)					X
Handling Drop	E417.9(k)					X
Tensile Load	E417.9(j)	X				
Abnormal Drop	E417.9(l)	X				
Component Examination and Performance Verification.	E417.5, E417.3(e)					
Status of Health	E417.27(k)					X
Safety Devices [2]	E417.27(l)					X
Leakage	E417.5(h)					X
X-ray and N-ray	E417.5(f)					X
Firing Tests	E417.27(m)					
Ambient Temperature	E417.27(m)					
All-Fire Voltage	E417.27(m)(1)					15
Operating Voltage	E417.27(m)(2)					15
Twice the Operating Voltage	E417.27(m)					5
High Temperature	E417.27(m)(4)					
All-Fire Voltage	E417.27(m)(1)					15
Operating Voltage	E417.27(m)(2)					15
Twice the Operating Voltage	E417.27(m)					5
Low Temperature	E417.27(m)(5)					
All-Fire Voltage	E417.27(m)(1)					15
Operating Voltage	E417.27(m)(2)					15
Twice the Operating Voltage	E417.27(m)					5

[1] All sample-exploding bridgewires used in qualification testing must be from a production lot that has passed the lot acceptance tests required by table E417.27–3.

[2] The safety device tests shall be performed only if the exploding bridgewire contains internal protection circuitry such as a spark gap.

[3] The high temperature storage test is optional. If performed, the lot will have an initial service life of three years. If not performed, the lot will have an initial service life of one year.

[4] For each column, the quantity required at the top of the column shall be selected from the same production lot and shall be subjected to each test designated with an X. For a test designated with a lessor quantity, each sample exploding bridgewire tested shall be selected from the original samples for column.

[5] The statistical sample (SS) quantity needed to perform a statistical firing series to determine the radio frequency sensitivity of the exploding bridgewire shall be subjected to each test designated with an X. The quantity must be greater than the 10 samples needed for the radio frequency impedance tests.

[6] The statistical sample (SS) quantity needed to perform a statistical firing series to determine the electro exploding bridgewire's no-fire energy shall be subjected to each test designated with an X.

[7] The statistical sample (SS) quantity needed to perform a statistical firing series to determine the exploding bridgewire's all-fire energy level shall be subjected to each test designated with an X.

TABLE E417.27–5

Explosive bridgewire (EBW) aging surveillance tests	Reference E417.15	Quantity [3]	
		1 year [4] X=5	3 years [5] X=10
Component examination and Performance Verification	E417.5, E417.3(e)		
Visual Inspection	E417.5(b)	X	X
Dimension	E417.5(c)	X	X

TABLE E417.27–5—Continued

Explosive bridgewire (EBW) aging surveillance tests	Reference E417.15	Quantity [3]	
		1 year [4] X=5	3 years [5] X=10
Static Discharge	E417.27(j)	X	X
Status-of-Health	E417.27(k)	X	X
Safety Devices [1]	E417.27(l)	X	X
Leakage	E417.5(h)	X	X
X-ray and N-ray	E417.5(f)	X	X
Non-Operating Environment Tests and Operating Environment Tests [1]	E417.9, E417.11	....	....
Thermal Cycling	E417.11(h)	X	X
High Temperature Storage	E417.9(c)	X	X
Shock	E417.11(e)	X	X
Random Vibration	E417.11(c)	X	X
Component examination and Performance Verification	E417.5, E417.3(e)	....	....
X-ray and N-ray	E417.5(f)	X	X
Status-of-Health	E417.27(k)	X	X
Safety Devices [2]	E417.27(l)	X	X
Leakage	E417.5(h)	X	X
Firing Tests	E417.27(m)		
All Fire Voltage	E417.27(m)(1)		
Ambient Temperature	E417.27(m)(1)	1	3
High Temperature	E417.27(m)(4)	2	3
Low Temperature	E417.27(m)(5)	2	4

[1] All environmental tests shall be performed at qualification levels.
[2] Safety device tests shall be performed only if the exploding bridgewire contains internal protection circuitry such as a spark gap.
[3] For each column, the quantity required at the top of the column shall be selected from the same production lot and shall be subjected to each test designated with an X. For a test designated with a lessor quantity, each sample exploding bridgewire tested shall be selected from the original samples for column.
[4] Five exploding bridgewires from the same lot shall be tested to extend the service life of the remaining exploding bridgewires from the same lot for one year.
[5] Ten exploding bridgewires from the same lot shall be tested to extend the service life of the remaining exploding bridgewires from the same lot for three years.

(b) *Exploding bridgewire firing unit status-of-health.* An exploding bridgewire firing unit shall be subjected to status-of-health tests performed in accordance with E417.3(g) to verify that each critical parameter is within its performance specification. These tests shall include measurements of input current, pin-to-pin and pin-to-case resistances, trigger circuit threshold, capacitor charge time and arming time to verify that they are within their performance specification.

(c) *Exploding bridgewire firing unit input command processing.* An exploding bridgewire firing unit shall be tested to demonstrate that the input trigger circuit will function within performance specifications when exposed to maximum predicted normal and abnormal flight environments in accordance with the following:

(1) An exploding bridgewire firing unit must be tested to demonstrate sufficient margin over the worst-case trigger signal that could be delivered on the launch vehicle. The trigger circuitry must meet the following minimum criteria:

(i) The amplitude sensitivity of the firing unit trigger circuit shall be tested to demonstrate that it satisfies its performance specifications when subjected to a worst-case low input signal. Component testing must demonstrate that the firing unit triggers at 50% of the amplitude and 50% of the pulse duration of the lowest trigger signal that could be delivered during flight.

(ii) The amplitude sensitivity of the firing unit trigger circuit shall be tested to demonstrate that it satisfies its performance specifications when subjected to worst-case high input signal. Component testing must demonstrate that the firing unit triggers at 120% amplitude and the pulse duration of the worst-case trigger signal that could be delivered during flight.

(2) An exploding bridgewire firing unit shall be tested to demonstrate that it does not degrade in performance when subjected to the maximum input voltage of the open circuit voltage of the power source, ground or airborne, and the minimum input voltage of the loaded voltage of the power source.

(3) Control or switching circuits critical to the reliable operation of an exploding bridgewire firing unit shall be tested to demonstrate that they do not change state when subjected to a minimum input power drop-out for a period of 50 milliseconds.

(4) An exploding bridgewire firing unit shall be tested to demonstrate that its response time is in accordance with its performance specification with input at the specified minimum and maximum vehicle supplied trigger signal.

(5) An exploding bridgewire firing unit with differential input shall be tested to demonstrate that it operates according to its performance specification with all input combinations at the specified trigger amplitude input signals.

(d) *Exploding bridgewire firing unit high voltage circuitry.* An exploding bridgewire firing unit shall be tested to demonstrate that its high voltage circuitry will function according to its performance specifications to initiate the exploding bridgewire when subjected to the maximum predicted normal and abnormal flight conditions in accordance with the following:

(1) An exploding bridgewire firing unit shall meet performance specifications when tested at worst-case high and low arm voltages that could be delivered during flight.

(2) Exploding bridgewire firing unit charging and output circuitry shall be tested to ensure the output wave form, rise-time and amplitude delivers no less than a 50% voltage margin to the exploding bridgewire using the identical test parameters, such as capacitor values and circuit and load impedance, as those used for the exploding bridgewire all-fire value.

(3) An exploding bridgewire firing unit shall be monitored to ensure there is no arcing or corona during high voltage discharge.

(4) High energy trigger circuits used to initiate an exploding bridgewire firing unit's main firing capacitor must be tested to ensure the output signal delivers no less than a 50% voltage margin at the nominal threshold level.

(e) *Exploding bridgewire firing unit output monitoring.* An exploding bridgewire firing unit shall be tested to verify that the failure of any non-flight termination system vehicle system equipment or ground support equipment will not degrade the performance or reliability of the firing unit. Flight termination system circuitry that interfaces with non-flight termination system vehicle systems and ground support equipment shall be tested to ensure failure modes will not degrade flight termination system performance. In addition, all monitor circuits shall be tested to ensure their functionality during preflight checkout and flight environments. At a minimum, the following tests shall be performed:

(1) An exploding bridgewire firing unit shall be tested to verify that its performance is not degraded when its monitor circuits and output ports are subjected to a short circuit with the worst-case positive and negative voltage capable of being supplied by the monitor batteries or ground power supplies.

(2) An exploding bridgewire firing unit's monitor circuits shall be tested to verify that all the required monitor signals are within their performance specifications. These monitor signals shall include the voltage of all high voltage capacitors and arm power to the firing unit.

(f) *Exploding bridgewire firing unit abbreviated status-of-health.* Abbreviated status-of-health tests represent a limited sampling of critical parameters, and are performed during dynamic tests to identify potential component degradation. These tests shall include measurements of the exploding bridgewire firing unit's input, which shall be continuously monitored to detect variations in amplitude with an accuracy of one millisecond.

(g) *Exploding bridgewire firing unit abbreviated command processing.* All flight critical functions of an exploding bridgewire firing unit shall be tested to demonstrate that the component meets its performance specifications when subjected to dynamic environments. An exploding bridgewire firing unit shall be commanded to fire throughout each environment while function time and the high voltage output waveform is monitored to verify that they each satisfy their performance specifications.

(h) *Exploding bridgewire firing unit environmental output monitoring.* An exploding bridgewire firing unit's output monitors shall be continuously monitored to detect variations in amplitude with an accuracy of 1 millisecond or any condition that may indicate degradation in performance.

(i) *Exploding bridgewire firing unit repetitive function.* An exploding bridgewire firing unit shall meet its performance specifications when subjected to worst-case repetitive functioning during acceptance, launch site processing, testing and flight. An exploding bridgewire firing unit output circuit shall be tested to demonstrate that it withstands, without degradation in performance, repetitive functioning for five times the worst-case number of cycles required for acceptance, checkout and operations, including retests due to schedule delays.

(j) *Static Discharge.* An exploding bridgewire shall be tested to verify that it can withstand, without firing or degradation in performance, an electrostatic discharge that it could experience from personnel or conductive surfaces. This test must include subjecting an exploding bridgewire to a 25k-volt, 500-picofarad pin-to-pin discharge through a 5k-ohm resistor and a 25k-volt, 500-picofarad pin-to-case discharge with no resistor or to the maximum predicted electrostatic discharge, whichever is greater.

(k) *Exploding bridgewire status-of-health.* An exploding bridgewire shall be subjected to status-of-health tests performed in accordance with E417.3(g) to verify that each critical parameter is within its performance specification. These tests shall include measurements of bridgewire insulation resistance at operating voltage.

(l) *Exploding bridgewire safety devices.* An exploding bridgewire that incorporates any safety device shall be tested to ensure that the safety device functions within its performance specifications and will not degrade the exploding bridgewire's performance or reliability after exposure to environmental qualification testing. The tests shall include static gap breakdown, dynamic gap breakdown, and specification hold-off voltage under sustained exposure.

(m) *Firing tests.* An exploding bridgewire shall be tested to ensure that it satisfies its performance specifications when subjected to qualification stress conditions. An exploding bridgewire shall be test fired utilizing a high voltage initiation source that duplicates the exploding bridgewire firing unit output waveform and impedance, including high voltage cabling. Each test shall include measurements, such as swell cap or dent block measurements, to verify that the ordnance output is within its performance specifications. The number of samples to be fired and the test conditions, including firing current and temperature, must be in accordance with the test matrices in this section and the following:

(1) The all-fire test firings required in the test matrices shall be performed using the manufacturer's specified all-fire energy level. The all-fire energy level must be specified in terms of voltage, current and pulse duration.

(2) The operating test firings required in the test matrices shall be performed using the firing unit's operating specification. If the operating energy is unknown, testing shall be performed using at least 200% of the all-fire current value.

(3) All test firings shall be performed using a firing source that duplicates the operational output waveform and impedance.

(4) All high temperature test firings required by the test matrices must be initiated while the sample it subjected to the design specification high temperature level or at a +71 °C workmanship screening level, whichever is higher.

(5) The low temperature test firings required in the test matrices shall be initiated at the design specification low temperature level or at a −54 °C workmanship screening level, whichever is lower.

(n) *Radio frequency impedance.* The radio frequency impedance of an exploding bridgewire shall be determined during qualification testing. This impedance shall be used to ensure that the system radio frequency susceptibility analysis utilizes a worst-case parameter, such as DC resistance.

(o) *Radio frequency sensitivity.* A statistical firing series shall be performed during qualification testing to determine the radio frequency sensitivity of the exploding bridgewire. The demonstrated radio frequency no-fire energy level must not exceed the level used in the flight termination system design and analysis.

(p) *No-fire level.* A statistical firing series shall be performed during qualification testing to determine the highest electrical energy level at which the exploding bridgewire will not fire with a reliability of 0.999 with a 95% confidence level when subjected to a continuous current pulse. The demonstrated no-fire energy level must not be less than the no-fire energy level used in the flight termination system design and analysis.

(q) *All-fire level.* A statistical firing series shall be performed during qualification testing to determine the lowest electrical energy level at which the exploding bridgewire will fire with a reliability of 0.999 with a 95% confidence level when subjected to a current pulse simulating the firing unit output waveform and impedance characteristics. All firings shall utilize a flight configured exploding bridgewire, with any internal safety devices such as a spark gap. The demonstrated all-fire energy level must not exceed the all-fire energy level used in the flight termination system design and analysis.

E417.29 Ordnance interrupter.

(a) *General.* An ordnance interrupter that is part of a flight termination system shall be tested to demonstrate that it functions within its performance specifications when subjected to non-operating and operating environments. This testing shall be accomplished in accordance with the acceptance, qualification, and age surveillance test matrices and accompanying requirements of this section.

TABLE E417.29–1

Ordnance interrupter acceptance tests	Reference	Quantity (percent)
Component Examination	E417.5	
Visual Inspection	E417.5(b)	100
Dimension	E417.5(c)	100
Identification	E417.5(e)	100
Performance Verification [1]	E417.3(e)	
Status-of-Health	E417.29(b)	100
Safe and arm position monitor	E417.29(c)	100

TABLE E417.29–1—Continued

Ordnance interrupter acceptance tests	Reference	Quantity (percent)
Safety Tests	E417.29(e)	
Manual Safing	E417.29(e)(4)	100
Safing Interlock	E417.29(e)(5)	100
Abbreviated Performance Verification	E417.3(f)	
Interrupter Abbreviated Performance	E417.29(f)	100
Operating Environment Tests	E417.13	
Thermal Cycling	E417.13(d)	100
Random Vibration	E417.13(b)	100
X-ray	E417.5(f)	100
Leakage	E417.5(h)	100

[1] These tests shall be performed prior to the first and after the last environmental tests.

TABLE E417.29–2

Ordnance interrupter qualification tests	Reference	Quantity X=		
		1	6	2
Barrier Alignment	E417.29(h)			
Acceptance Tests	Table E417.29–1	X	X	
Safety Tests	E417.29(e)			
Extended Stall [1]	E417.29(e)(3)	X		
Abnormal Drop [1]	E417.9(1)	X		
Containment	E417.29(e)(1)			X
Barrier Functionality	E417.29(e)(2)			X
Non-Operating Environment Tests	E417.9			
Storage Temperature	E417.9(b)		X	
Transportation Shock	E417.9(d)		X	
Bench Handling	E417.9(e)		X	
Transportation Vibration	E417.9 (f)		X	
Fungus Resistance	E417.9(g)		1	
Salt Fog	E417.9(h)		1	
Fine Sand	E417.9(i)		1	
Handling Drop	E417.9(k)		X	
Performance Verification [2]	E417.3(e)			
Status-of-Health	E417.29(b)		X	
Abbreviated Performance Verification [3]	E417.3(f)			
Interrupter Abbreviated Performance	E417.29(f)		X	
Operating Environment Tests [4]	E417.11			
Thermal Cycling	E417.11(h)		X	
Humidity	E417.11(g)		X	
Acceleration	E417.11(f)		X	
Shock	E417.11(e)		X	
Sinusoidal Vibration	E417.11(b)		X	
Acoustic	E417.11(d)		X	
Random Vibration	E417.11(c)		X	
Explosive Atmosphere	E417.11(k)		X	
Stall	E417.29(j)		X	
X-ray	E417.5(f)		X	
Leakage	E417.5(h)		X	
Disassembly	E417.(g)		2	
Firing Test	E417.(g)			
At High Temperature	E417.29(g)(4)		2	
At Low Temperature	E417.29(g)(5)		2	
Repetitive Function	E417.29(i)		X	

[1] This test is only required for ordnance interrupters containing rotor or booster charges.
[2] These tests shall be performed before the first and after the last operating environment test.
[3] These tests shall be performed during the operating environment tests.
[4] Environmental tests shall be performed at qualification levels.

TABLE E417.29–3

Ordnance interrupter rotor lead and booster charge acceptance tests [1]	Reference	Quantity
Non-Destructive Component Examination	E417.5	
Visual Inspection	E417.5(b)	100%
Dimension	E417.5(c)	100%
Leakage	E417.5(h)	100%
X-ray and N-ray	E417.5(f)	100%

TABLE E417.29–3—Continued

Ordnance interrupter rotor lead and booster charge acceptance tests [1]	Reference	Quantity
Non-Operating Environment Tests and	E417.9	
Operating Environment Tests [2]	E417.11	
Thermal Cycling	E417.11(h)	Lot Sample [4]
High Temperature Storage [3]	E417.9(c)	Lot Sample
Component Examination	E417.5	
Leakage	E417.5(h)	Lot Sample
X-ray and N-ray	E417.5(f)	Lot Sample
Firing Tests	E417.29(g)	
High Temperature	E417.29(g)(4)	1/2 Lot Sample
Low Temperature	E417.29(g)(5)	1/2 Lot Sample

[1] This matrix is only applicable to ordnance interrupters that use rotor lead charges.
[2] Environmental tests shall be performed at qualification levels.
[3] The high temperature storage test is optional. If performed, the lot will have an initial service life of five years. If not performed, the lot will have an initial service life of one year.
[4] The lot sample size must be at least 10 percent of the lot, but not less than 10 units.

TABLE E417.29–4

Ordnance interrupter rotor lead and booster charge qualification tests [1]	Reference E417.7	Quantity [4] X=21
Component Examination	E417.5	....
Visual Inspection	E417.5(b)	X
Dimension	E417.5(c)	X
Leakage	E417.5(h)	X
X-ray and N-ray	E417.5(f)	X
Non-Operating and Operating Environment Tests [2]	E417.9, E417.11	....
Thermal Cycling	E417.11(h)	X
High Temperature Storage [3]	E417.9(c)	10
Shock	E417.11(e)	X
Random Vibration	E417.11(c)	X
Component Examination	E417.5	
X-ray and N-ray	E417.5(f)	X
Leakage	E417.5(h)	X
Firing Tests	E417.29(g)	
Ambient Temperature	E417.29(g)	7
High Temperature	E417.29(g)(4)	7
Low Temperature	E417.29(g)(5)	7

[1] This matrix is only applicable to ordnance interrupters that use rotor lead charges.
[2] These environmental tests shall be performed at qualification test levels.
[3] The high temperature storage test is optional. If performed, the lot will have an initial service life of five years. If not performed, the lot will have an initial service life of one year.
[4] The same 21 sample components, from the same lot, shall be subjected to each test designated with an X. For tests designated with a quantity of less than 21, each component tested shall be selected from the original 21 sample components.

TABLE E417.29–5

Ordnance interrupter rotor lead and booster charge age surveillance tests [1]	Reference E417.15	Quantity [3] 1 Year [4] X=5	5 Years [5] X=10
Component Examination	E417.5	....	....
Visual Inspection	E417.5(b)	X	X
Dimension	E417.5(c)	X	X
Leak	E417.5(h)	X	X
X-ray and N-ray	E417.5(f)	X	X
Non-Operating Environment Tests and Operating Environment Tests [2]	E417.9, E417.11	....	....
Thermal Cycling	E417.11(h)	X	X
High Temperature Storage	E417.9(c)	....	X
Component Examination	E417.5	....	....
Leakage	E417.5(h)	X	X
X-ray and N-ray	E417.5(f)	X	X
Firing Tests	E417.29(g)	....	....
High Temperature	E417.29(g)(4)	2	5
Low Temperature	E417.29(g)(5)	3	5

[1] This matrix is only applicable to ordnance interrupters that use rotor lead charges.
[2] These environmental tests shall be performed at the qualification test levels.
[3] For each column, the required quantity of sample components from the same lot shall be subjected to each test designated with an X. For a test designated with a lessor quantity, each component shall be selected from the original samples for that column.
[4] The test lot sample quantity shall be equal to five for tests to extend the service life of components remaining from the same lot for one year.
[5] The test lot sample quantity shall be equal to 10 for tests to extend the service life of components remaining from the same lot for five years.

(b) *Status-of-health.* An ordnance interrupter shall be subjected to status-of-health tests performed in accordance with E417.3(g) to verify that each critical parameter is within its performance specification. These tests shall include measurements of safe and arm transition time.

(c) *Safe and arm position monitor.* An ordnance interrupter shall be tested to demonstrate that its transition operation, such as rotational or sliding, functions in accordance with its design specification when subjected to flight environments. In addition, the testing must demonstrate that any ordnance interrupter monitoring devices can determine, prior to flight, if the ordnance interrupter is in the proper flight configuration.

(1) The arm indication shall be verified to be present when the ordnance interrupter is armed.

(2) The safe indication shall be verified to be present when the ordnance interrupter is safed.

(d) *Ordnance initiation.* The ordnance initiation train shall be tested to ensure that it functions in accordance with the required performance specifications during normal and abnormal flight conditions. Testing shall demonstrate the capability of the ordnance systems to perform to the following requirements:

(1) Two interrupters shall be functioned during the hot and cold firing tests at the 0.999 at 95% confidence transition motion.

(2) One interrupter shall be tested to show that the performance of the ordnance train components will not be degraded when the interrupter is locked in the safe position and subjected to a continuous operating arming voltage.

(3) When dual firing paths are used within a single interrupter, all firing tests shall demonstrate that one firing path does not affect the performance of the other path.

(e) *Safety tests.* The following tests shall be performed to demonstrate that an ordnance interrupter can be handled and implemented safely:

(1) *Containment.* If an ordnance interrupter has an internal rotor charge the interrupter shall be tested to demonstrate that it will not fragment when the internal rotor charge is initiated.

(2) *Barrier functionality.* Testing shall be performed to demonstrate that, when the ordnance interrupter is in the safe position, neither the donor transfer line nor the internal rotor charge will initiate the explosive transfer system. Test firings shall be performed at high and low temperature extremes in accordance with the following:

(i) High temperature firings shall be initiated at the high temperature design specification or a 71 °C workmanship screening level, whichever is higher.

(ii) Low temperature firings shall be initiated at the low temperature design specification or a −54 °C workmanship screening level, whichever is lower.

(3) *Extended stall.* An ordnance interrupter with internal rotor or booster charges shall be tested to verify that it does not inadvertently initiate when locked in its safe position and subjected to a continuous operating arming voltage for the maximum predicted time that could occur accidentally during launch processing or one hour, whichever is greater. The ordnance interrupter need not function after being subjected to this test.

(4) *Manual safing.* An ordnance interrupter shall be tested to demonstrate that it can be manually safed in accordance with its performance specifications.

(5) *Safing interlock.* An ordnance interrupter shall be tested to demonstrate that its safing interlock prevents arming when operating arming current is applied in accordance with its performance specifications.

(f) *Interrupter abbreviated performance verification.* Abbreviated performance verification tests represent a limited sampling of critical parameters, and must be performed during dynamic tests. These tests shall ensure that all functions critical to flight termination system operation are exercised in conjunction with verification of sufficient status-of-health indications to identify potential component degradation. The ordnance interrupter must be armed for this test and the arm monitoring circuit shall be continuously monitored.

(g) *Firing tests.* Test firings shall be performed on interrupter, rotor lead, and booster charge samples to establish that the initiation and transfer of ordnance charges meets performance requirements. The number of samples to be fired and the test conditions, including firing current and temperature, must be in accordance with the test matrices in this section and the following:

(1) An interrupter shall be tested in a flight configuration using flight configured explosive transfer system lines on the input and output.

(2) A rotor lead or booster charge shall be tested to demonstrate that it will be initiated by a flight configured energy source and to demonstrate that its output energy transfer meets its design specification.

(3) A measurement technique, such as a swell cap or dent block, shall be used to verify that the explosive transfer system output satisfies its performance specifications.

(4) High temperature firings shall be initiated at the qualification high temperature or a +71 °C workmanship level, whichever is higher.

(5) Low temperature firings shall be initiated at the qualification low temperature or a minus 54 °C workmanship level, whichever is lower.

(h) *Barrier alignment.* The interrupter configuration shall be tested to determine the 0.999 at 95% confidence transition motions where reliable initiation and no initiation of the ordnance train components occurs. These firings may be performed in a reusable interrupter subassembly that reflects the flight configuration.

(i) *Repetitive Function.* Testing shall show the ability of the interrupter to withstand five times the worst-case arming cycles without degradation in performance.

(j) *Stall.* An ordnance interrupter shall be tested to demonstrate that its performance is not degraded after being locked in its safe position and subjected to an operating arming voltage for the maximum predicted time that could occur inadvertently during launch processing or for five minutes, whichever time is greater.

E417.31 Percussion Activated Device (PAD)

(a) *General.* A percussion activated device that is part of a flight termination system shall be tested to demonstrate that it functions within its performance specifications when subjected to non-operating and operating environments. This testing shall be accomplished in accordance with the acceptance, qualification, and age surveillance test matrices and accompanying requirements of this section.

TABLE E417.31–1

Percussion activated device lot acceptance tests[1]	Reference	Quantity
Component Examination	E417.5	
Visual Inspection	E417.5(b)	100%
Dimension	E417.5(c)	100%
Identification	E417.5(e)	100%
Status of Health	E417.5(c)	100%
Leakage	E417.5(h)	100%
X-ray and N-ray	E417.5(f)	100%
Non-Operating Environment Tests and Operating Environment Tests[2]	E417.9, E417.11	
Thermal Cycling	E417.11(h)	Lot Sample[4]
High Temperature Storage[3]	E417.9(c)	Lot Sample
Shock	E417.11(e)	Lot Sample
Random Vibration	E417.11(c)	Lot Sample
Component Examination	E417.5	
Leakage	E417.5(h)	Lot Sample
Safety Tests	E417.31(b)	Lot Sample

TABLE E417.31–1—Continued

Percussion activated device lot acceptance tests[1]	Reference	Quantity
X-ray and N-ray	E417.(f)	Lot Sample
Firing Test at Specification Pull Force	E417.31(d)	
At Ambient Temperature	E417.31(d)	⅓ of Lot Sample
At High Temperature	E417.31(d)(3)	⅓ of Lot Sample
At Low Temperature	E417.31(d)(4)	⅓ of Lot Sample

[1] These tests shall be performed at the percussion activated device final assembly level.
[2] The environmental tests shall be performed at qualification test levels.
[3] The high temperature storage test is optional. If performed, the lot shall have an initial service life of three years. If the high temperature storage test is not performed, the service life shall be one year.
[4] A lot sample shall consist of 10% of the lot or nine units, whichever is greater.

TABLE E417.31–2

Percussion activated device qualification tests	Reference	Quantity[3]	
		X=1	X=21
Component Examination Tests	Table E417.31–1	X	X
Safety Tests	E417.31(b)	....	X
Non-Operating Environment Tests and Operating Environment Tests[1]	E417.9, E417.11	X	
Storage Temperature	E417.9(b)	....	X
Transportation Shock	E417.9(d)	....	X
Bench Handling	E417.9(e)	....	X
Transportation Vibration	E417.9(f)	....	X
Fungus Resistance	E417.9(g)	....	4
Salt Fog	E417.9(h)	....	4
Fine Sand	E417.9(i)	....	4
Handling Drop	E417.9(k)	....	X
Thermal Cycling	E417.11(h)	....	X
High Temperature Storage[2]	E417.9(c)	....	X
Humidity	E417.11(g)	....	4
Acceleration	E417.11(f)	....	X
Shock	E417.11(e)	....	X
Sinusoidal Vibration	E417.11(b)	....	X
Random Vibration	E417.11(c)	....	X
Component Examination	E417.5	....	....
Leakage	E417.5(h)	....	X
X-ray and N-ray	E417.5(f)	....	X
Disassembly	E417.5(g)	....	3[4]
Firing Test at Specification Pull Force	E417.31(d)	....	....
At Ambient Temperature	E417.31(d)	....	6
At High Temperature	E417.31(d)(3)	....	6
At Low Temperature	E417.31(d)(4)	....	6
Abnormal Drop	E417.9(1)	X	....

[1] Environmental tests shall be performed at qualification test levels.
[2] The high temperature storage test is optional. If performed, the lot shall have an initial service life of three years. If not performed, the lot shall have an initial service life of one year.
[3] For each column, the required quantity of sample components from the same lot shall be subjected to each test designated with an X. For a test designated with a lessor quantity, each component tested shall be selected from the original samples for that column.
[4] One of the three disassembled sample components shall be a sample that was subjected to all non-operating environment tests required by this test matrix except for the abnormal drop test.

TABLE E417.31–3

Percussion activated device primer charge lot acceptance tests[1]	Reference	Quantity
Component Examination[2]	E417.5	
Visual Inspection	E417.5(b)	[1] 100%
Dimension	E417.5(c)	[1] 100%
Leakage	E417.5(h)	[1] 100%
X-ray and N-ray	E417.5(f)	[1] 100%
Operating Environment Test	E417.11	
Thermal Cycle	E417.11(h)	Lot Sample[5]
Firing Tests	E417.31(f)	
All-Fire Impact[3]	E417.31(f)	
High Temperature	E417.31(f)(4)	½ Lot Sample
Low Temperature	E417.31(f)(5)	½ Lot Sample

TABLE E417.31–3—Continued

Percussion activated device primer charge lot acceptance tests [1]	Reference	Quantity
All-Fire [4]	E417.31(e)	Statistical Sample.

[1] These tests shall be performed at the component level on the percussion primer prior to installation.
[2] These tests shall be performed before and after the operating environment test.
[3] The all-fire impact is the specification value determined by the statistical all-fire impact series performed during qualification testing.
[4] Results from the lot acceptance all-fire test must demonstrate that the production lot is a representative sample of the all-fire baseline established during qualification testing performed in accordance with table E417.31–4.
[5] The lot sample shall consist of 10% of the lot or 30 units whichever is greater.

TABLE E417.31–4

Percussion activated device primer charge qualification tests	References	Quantity X=	
		Statistical Sample	105
Component Examination	Table E417.31–3	X	X
All-Fire	E417.31(e)	X	
Operating Environmental Test [1]	E417.11		
Thermal Cycling	E417.11(h)		X
Component Examination	E417.5		
Leakage	E417.5(h)		X
X-ray and N-ray	E417.5(f)		X
Firing Tests	E417.31(f)		
Ambient Temperature	E417.31(f)		
All-Fire Impact [2]	E417.31(f)		15
Operational Impact [3]	E417.31(f)		15
200% Operational Impact	E417.31(f)		5
High Temperature	E417.31(f)(4)		
All-Fire Impact [2]	E417.31(f)		15
Operational Impact [3]	E417.31(f)		15
200% Operational Impact	E417.31(f)		5
Low Temperature	E417.31(f)(5)		5
All-Fire Impact [2]	E417.31(f)		15
Operational Impact [3]	E417.31(f)		15
200% Operational Impact	E417.31(f)		5

[1] Environmental tests shall be performed at qualification test levels.
[2] All-fire is determined by the statistical all-fire impact series.
[3] Operational impact represents the impacted required by the performance specifications that will be delivered by the percussion activated device assembly. The operational impact is at least twice as great as the all-fire impact.

TABLE E417.31–5

Percussion activated device aging surveillance tests [1]	Reference	Quantity [3]	
		1 Year [4] X=5	3 Year [5] X=10
Component Examination:	E417.5		
Visual Inspection	E417.5(b)	X	X
Dimension	E417.5(c)	X	X
Leakage	E417.5(f)	X	X
X-ray and N-ray	E417.5(f)	X	X
Non-Operating Environmental Tests and	E417.9		
Operating Environmental Tests [2]	E417.11		
Thermal Cycling	E417.11(h)	X	X
High Temperature Storage	E417.9(c)		X
Shock	E417.11(e)	X	X
Random Vibration	E417.11(c)	X	X
Component Examination	E417.5		
Leakage	E417.5(h)	X	X
X-ray and N-ray	E417.5(f)	X	X
Firing Test	E417.31(d)		
High Temperature	E417.31(d)(3)	2	5
Low Temperature	E417.31(d)(4)	3	5

[1] These tests shall be performed at the percussion activated device assembly level.
[2] Environmental tests shall be performed at qualification levels.
[3] For each column, the quantity of sample components required at the top of the column shall be taken from the same production lot and shall be subjected to each test designated with an X. For a test designated with a lessor quantity, each component subjected to the test shall be selected from the original samples for that column.

[4] X shall be equal to five for tests to extend the service life of remaining percussion activated devices from the same lot for one year.
[5] X shall be equal to 10 for tests to extend the service life of remaining percussion activated devices from the same lot for three years.

(b) *Safety tests.* A percussion activated device shall be tested to ensure that it can be handled and operationally implemented safely. The following safety tests must be performed:

(1) *No-fire impact test.* Testing shall be performed to demonstrate that a percussion activated device will not fire when pulled with the guaranteed no-fire force. In addition, testing shall performed by pulling the maximum guaranteed no-fire pull force and then releasing the mechanism; the percussion activated device shall not fire and its performance must not be degraded. The percussion activated device primer initiation assembly shall not disengage inadvertently when pulled with the guaranteed no-fire force.

(2) *Pin locking test.* A percussion-activated device shall be tested to demonstrate the capability of the safing pin to withstand twice the worst-case pull force that can be experienced after installation on the vehicle. The percussion activated device shall be pulled at the all-fire pull-force with the safing pin installed. The percussion activated device firing assembly shall not move more than half the no-fire pull distance nor experience any mechanical anomalies. At a minimum, this test shall be performed using a 200-pound pull test.

(3) *Pin retention test.* A percussion-activated device shall be tested to demonstrate that its safing pin is not removable when a no-fire pull or greater force is applied to the percussion activated device lanyard. Testing must verify that the safing pin resists removal such that the no-fire pull pre-load can be detected when attempting to remove the pin with the pre-load applied. The force needed to remove the safing pin with the lanyard in an unloaded condition shall be quantified and verified as within its performance specification.

(c) *Status-of-health.* A percussion activated device shall be subjected to status-of-health tests performed in accordance with E417.3(g) to verify that each critical parameter is within its performance specification. These tests shall include validation of spring constant and firing pull distance at the subassembly level.

(d) *Percussion activated device firing tests.* A percussion activated device shall be tested at the specification pull-force to ensure it meets its performance specifications after being subjected to qualification stress conditions in accordance with the following:

(1) A percussion activated device shall be tested in a flight configuration using flight configured explosive transfer system lines on the output.

(2) A measurement technique, such as swell cap or dent block, shall be used to verify that the explosive transfer system output initiates according to its performance specification.

(3) High temperature firings shall be initiated at the qualification high temperature or a +71 °C workmanship level, whichever is higher.

(4) Low temperature firings shall be initiated at the qualification low temperature or a −54 °C workmanship level, whichever is lower.

(e) *All-fire energy level.* A statistical firing series shall be performed to determine that the primer will fire with a 0.999 at 95% confidence when subjected to an all-fire energy impact utilizing a flight configured firing pin.

(f) *Primer charge firing tests.* The primer charge shall be tested to ensure that it functions reliably after being subjected to operational firing conditions plus margin.

(1) The primer charge shall be tested in a flight configuration using a flight configured firing pin.

(2) Measurements shall be taken to verify that the output initiates within its performance specifications.

(3) A percussion activated device that incorporates booster charges or ordnance delays as an integral unit shall be tested to ensure that the performance is within its performance specification.

(4) High temperature firings shall be initiated at the qualification high temperature or a +71 °C workmanship level, whichever is higher.

(5) Low temperature firings shall be initiated at the qualification low temperature or a −54 °C workmanship level, whichever is lower.

E417.33 Explosive transfer system, ordnance manifold, and destruct charge.

(a) *General.* An explosive transfer system, ordnance manifold, or destruct charge that is part of a flight termination system shall be tested to demonstrate that it functions within its performance specifications when subjected to non-operating and operating environments. This testing shall be accomplished in accordance with the acceptance, qualification, and age surveillance test matrices and accompanying requirements of this section.

TABLE E417.33–1

Explosive transfer system, ordnance manifold and destruct charge acceptance tests	References	Quantity		
		Ordnance manifolds [3] [4]	Explosive transfer system [5]	Destruct charges
Component Examination	E417.5			
Visual Inspection	E417.5(b)	100%	100%	100%
Dimension	E417.5(c)	100%	100%	100%
Leakage	E417.5(h)	100%	100%	100%
X-ray and N-ray	E417.5(f)	100%	100%	100%
Non-operating and Operating Environments [1]	E417.9, E417.11			
Thermal Cycling	E417.11(h)	Lot Sample [6]	Lot Sample [6]	Lot Sample [6]
High Temperature Storage [2]	Lot Sample	Lot Sample	Lot Sample	
Shock	E417.11(e)	Lot Sample	Lot Sample	Lot Sample
Random Vibration	E417.11(c)	Lot Sample	Lot Sample	Lot Sample
Tensile Load	E417.9(j)		Lot Sample	Lot Sample
Component Examination	E417.5			
X-ray and N-ray	E417.5(f)	Lot Sample	Lot Sample	Lot Sample
Leakage	E417.5(h)	Lot Sample	Lot Sample	Lot Sample
Firing Test	E417.33(b)			
Ambient Temperature	E417.33(b)	⅓ Lot Sample	⅓ Lot Sample	⅓ Lot Sample
High Temperature	E417.33(b)(4)	⅓ Lot Sample	⅓ Lot Sample	⅓ Lot Sample
Low Temperature	E417.33(b)(5)	⅓ Lot Sample	⅓ Lot Sample	⅓ Lot Sample

[1] Tests shall be performed at qualification levels.
[2] This test is optional. If performed, the lot shall have an initial service life of five years. If not performed, the lot service life shall be one year.
[3] For inert manifolds, only visual inspection and dimension measurements are required.
[4] This column applies to manifolds that contain booster charges. All tests must be performed at the manifold level.
[5] The quantity specified is required for each configuration of explosive transfer line end-tip.
[6] The lot sample size shall be 10 percent of the lot, but not less than nine units from the lot.

TABLE E417.33–2

Destruct charge qualification tests	References	Quantity			
		X=5	X=2	X=1	X=21
Component Examination	E417.5				
Visual Inspection	E417.5(b)			X	X
Dimension	E417.5(c)			X	X
Leakage	E417.5(h)			X	X
X-ray and N-ray	E417.5(f)			X	X
Non-Operating Environment Tests and Operating Environment Tests [1].	E417.9, E417.11				
Storage Temperature	E417.9(b)				4
Transportation Shock	E417.9(d)				4
Bench Handling	E417.9(e)				4
Transportation Vibration	E417.9(f)				4
Fungus Resistance	E417.9(g)				4
Salt Fog	E417.9(h)				4
Fine Sand	E417.9(i)				4
Thermal Cycling	E417.11(h)				X
High Temperature Storage [2]	E417.9(c)				10
Humidity	E417.11(g)				4
Acceleration	E417.11(f)				X
Shock	E417.11(e)				X
Sinusoidal Vibration	E417.11(b)				X
Random Vibration	E417.11(c)				X
Handling Drop	E417.9(k)				X
Abnormal Drop	E417.9(l)			X	
Tensile Load	E417.9(j)				X
Component Examination	E417.5				
Leakage	E417.5(h)				X
X-ray and N-ray	E417.5(f)				X
Penetration Margin Test	E417.33(c)	X			
Propellant Detonation	E417.33(d)		X		
Firing Tests	E417.33(b)				
Ambient Temperature	E417.33(b)				7
High Temperature	E417.33(b)(4)				7
Low Temperature	E417.33(b)(5)				7

[1] If an explosive transfer system manifold is used, it shall be tested with its explosive transfer system assembly attached during all operating environment tests.

[2] This test is optional. If performed, the lot shall have an initial service life of five years. If not performed, the lot shall have an initial service life of one year.

TABLE E417.33–3

Explosive transfer system and ordnance manifolds qualification tests	References	Quantity [3] [4]	
		X=1	X=21
Component Examination	E417.5	X	X
Visual Inspection	E417.5(b)	X	X
Dimension	E417.5(c)	X	X
Leakage	E417.5(h)	X	X
X-ray and N-ray	E417.5(f)	X	X
Non-Operating Environment Test and Operating Environment Tests	E417.9, E417.11		
Storage Temperature	E417.9(b)		4
Transportation Shock	E417.9(d)		4
Bench Handling	E417.9(e)		4
Transportation Vibration	E417.9(f)		4
Fungus Resistance	E417.9(g)		4
Salt Fog	E417.9(h)		4
Fine Sand	E417.9(i)		4
Thermal Cycling	E417.11(h)		X
High Temperature Storage [1]	E417.9(c)		10
Humidity	E417.11(g)		4
Acceleration	E417.11(f)		X
Shock [2]	E417.11(e)		X
Sinusoidal Vibration [2]	E417.11(b)		X
Random Vibration [2]	E417.11(c)		X
Handling Drop	E417.9(k)		X
Abnormal Drop	E417.9(l)	X	
Tensile Load	E417.9(j)		X
Component Examination	E417.5		
Leakage	E417.5(h)		X
X-ray and N-ray	E417.5(f)		X

TABLE E417.33–3—Continued

Explosive transfer system and ordnance manifolds qualification tests	References	Quantity [3] [4]	
		X=1	X=21
Firing Test	E417.33(b)	....	....
Ambient Temperature	E417.33(b)	....	7
High Temperature	E417.33(b)(4)	....	7
Low Temperature	E417.33(b)(5)	....	7

[1] This test is optional. If performed, the lot shall have an initial service life of five years. If not performed, the lot shall have an initial service life of one year.
[2] A dynamically equivalent test fixture that simulates each flight configured interface shall be tested with the explosive transfer system assembly attached during all operating environment tests.
[3] The number of test samples indicated applies to explosive transfer lines and explosive manifolds with internal ordnance.
[4] The quantity specified is required for each configuration of explosive transfer line end-tip.

TABLE E417.33–4

Explosive transfer system, explosive manifolds and destruct charge age surveillance tests [1]	References	Quantity [3]	
		1 year [4] X=5	5 years [5] X=10
Component Examination	E417.5		
Visual Inspection	E417.5(b)	X	X
Dimension	E417.5(c)	X	X
Leakage	E417.5(h)	X	X
X-ray and N-ray	E417.5(f)	X	X
Non-Operating Environment Test and Operating Environment Tests [2]	E417.9, E417.11	....	....
Thermal Cycling	E417.11(h)	X	X
High Temperature Storage	E417.9(c)	....	X
Shock	E417.11(e)	X	X
Random Vibration	E417.11(c)	X	X
Tensile load	E417.9(j)	X	X
Component Examination	E417.5	....	....
Leakage	E417.5(h)	X	X
X-ray and N-ray	E417.5(f)	X	X
Firing Tests	E417.33(b)	....	....
High Temperature	E417.33(b)(4)	2	5
Low Temperature	E417.33(b)(5)	3	5

[1] Explosive manifolds with internal ordnance are also required to meet this requirement. Internal ordnance used in these manifolds may be tested at the manifold assembly level or externally at the ordnance level.
[2] These tests shall be performed at the qualification level.
[3] The quantity specified is required for each configuration of explosive transfer line end-tip.
[4] X shall be equal to five for tests to extend the service life of remaining components from the same lot for one year
[5] X shall be equal to 10 for tests to extend the service life of remaining components from the same lot for five years.

(b) *Firing tests.* Each ordnance initiation and transfer component shall be tested to demonstrate that it satisfies its performance specifications after being subjected to all qualification stress conditions.

(1) The destruct charge shall be initiated against a witness plate to validate that the ordnance output is within its performance specifications. The performance specification value shall be consistent with the in-family ordnance output determined during qualification testing.

(2) A measurement technique, such as swell cap or dent block, shall be used to verify that the explosive transfer system output is within its performance specifications.

(3) Each explosive manifold containing ordnance must be initiated in a flight configuration with an explosive transfer system.

(4) High temperature firings shall be performed at the qualification high temperature or a +71 °C workmanship temperature, whichever is higher.

(5) Low temperature firings shall be performed at the qualification low temperature or a −54 °C workmanship temperature, whichever is lower.

(c) *Penetration margin.* Testing must demonstrate the capability of the destruct charge to meet the requirements of § 417.303(b), (d), and (e) with margin. Five destruct charges shall be tested to ensure they penetrate 150% of the target thickness. These tests shall also correlate equivalent penetration depth into a witness plate. This witness plate penetration depth will be used to develop a specification used for future tests as a status-of-health indication to determine out-of-family ordnance.

(d) *Propellant detonation.* Each destruct charge shall be tested to demonstrate that it will not detonate the propellant of its intended target.

E417.35 Shock and vibration isolator.

(a) *General.* A shock and vibration isolator that is part of a flight termination system shall be tested to demonstrate that it functions within its performance specifications when subjected to non-operating and operating environments. The results of the testing in this section shall be used to determine the component qualification and acceptance test levels for any component using isolators. This testing shall be accomplished in accordance with the acceptance and qualification test matrices and accompanying requirements of this section.

(1) *Component qualification and lot acceptance testing on isolators.* Each component mounted on one or more isolators must withstand all qualification environments introduced by isolator amplification and variability due to operating environments. Each of the following required tests may be performed separately or in combination with other tests:

(i) Component qualification testing must be performed using isolators that have undergone the testing of this section. The isolator screening test does not need to reflect a flight configuration but must demonstrate repeatable performance and workmanship.

(ii) Flight termination system components mounted on isolators must be subjected to qualification test environments that reflects the required predicted environments plus the required margins. This qualification test may be performed with the component on its isolators or hard-mounted.

(iii) Flight termination system components shall be subjected to a qualification workmanship screening random vibration test in accordance with E417.11(c)(3) and Table E417.11–1. This qualification test may be performed with the component on its isolators or hard-mounted.

(iv) Each flight termination system component and all component interface hardware such as connectors, cables, and grounding straps must demonstrate survivability in a flight-configured test using isolators. This test must use a flight configured isolator set-up subjected to the qualification operating environment.

(v) All qualification testing must account for variations in isolator performance due to operating environments. At a minimum, thermal effects and acceleration pre-load performance variability must be tested as part of the qualification test.

(2) *Component acceptance testing on isolators.* Any flight termination system component mounted on one ore more isolators must be subjected to acceptance test environments. Component acceptance testing must use the same configuration that was used during qualification testing whether on isolators or hard-mounted.

TABLE E417.35–1

Shock and vibration isolator acceptance test requirements	Reference	Quantity (percent)
Component Examination	E417.5	
Visual Inspection	E417.5(b)	100
Dimension	E417.5(c)	100
Performance Verification Tests	E417.3	
Load Deflection	E417.35(b)	100
Status-of-Health	E417.35(c)	100

(b) *Load deflection.* Testing shall be performed to determine the ability of the vibration isolator to withstand full-scale deflection expected in flight while maintaining its performance specifications and to provide status-of-health. Each isolator shall be subjected to varying increments from the null position to the full-scale flight deflection. Spring constant shall be measured at each increment and verified to be within its performance specification. Each isolator used for qualification testing shall be first tested in accordance with this paragraph; the values of the initial testing will be used for generating a specification value for future flight units.

(c) *Status-of-health.* A shock and vibration isolator shall be subjected to status-of-health tests performed in accordance with E417.3(g). Each isolator shall be subjected to a random vibration or sinusoidal sweep vibration input which generates amplitudes representative of the flight environment. This test must include the following:

(1) The natural frequency for each isolator shall be determined by subjecting the isolator to vibration at the flight environment amplitude and measuring the isolator's natural frequency. The natural frequency measured must be within the isolator's performance specification. All tolerances used in the performance specification shall be added to the qualification margins to ensure that the specification criteria are sufficiently bounded to maintain the required qualification test margins.

(2) The dynamic amplification value shall be determined for each isolator by subjecting the isolator to vibration at the flight environment amplitude and measuring the isolator's dynamic amplification. The dynamic amplification measured must be within the isolator's performance specification. All tolerances used in the performance specification shall be added to qualification margins to ensure that the specification criteria are sufficiently bounded to maintain the required qualification test margins.

E417.37 Electrical Connectors and Harnesses

(a) *General.* Each electrical connector or harness that is part of a flight termination system shall be tested to demonstrate that it functions in accordance with its performance specification when subjected to non-operating and operating environments. This matrix applies to cables and connectors that are part of a flight termination system but are not part of a flight termination system component. This testing shall be accomplished in accordance with the test matrices and accompanying requirements of this section.

(1) Cable and connector qualification testing shall be performed as part of the component-level qualification testing. Component qualification testing shall be conducted using a flight configured connector and harness connected to the worst-case flight tie-down point.

(2) Acceptance testing must be performed to ensure that each connector to be used for flight meets its performance specification and is free of workmanship defects.

TABLE E417–37–1

In-line and staging and component connectors	Reference	Quantity X=2
Non Operating Environments:	E417.9	
Salt Fog [1]	E417.9(h)	X
Status of Health	E417.37(b)	X
Operating Environments	E417.11	
Humidity [1]	E417.11(g)	X
Shock [2]	E417.11(e)	
Sinusoidal Vibration [2]	E417.11(b)	X
Random Vibration [2]	E417.11(c)	X
Status of Health	E417.37(b)	X

[1] Connector and cable pin to pin, and pin to case resistance shall be tested immediately after this testing is completed.
[2] Connector and cable continuity or component functioning shall be continuously monitored for dropouts at a resolution of one millisecond.

(b) *Harness status-of-heath.* Each harness shall be electrically tested utilizing all critical indicators necessary to ensure flight integrity.

(1) The dielectric withstanding voltage between mutually insulated portions of a component part shall be measured to demonstrate that the connector operates without degradation in performance at its rated voltage and withstands momentary over-potentials due to switching, surge, or any other similar phenomena.

(2) The isolation resistance between mutually insulated points shall be sufficient for ensuring the connector operates without degradation at its rated voltage. Insulation resistance shall be used as status-of-health indication to ensure that insulation material has not been damaged. Minimum workmanship level testing shall be performed to ensure that potentially damaged flight harnesses or wires, which could fail during nominal and abnormal flight conditions, are identified before launch.

(3) Insulation resistance between wire shields and conductors and connector pin to pin shall be tested to demonstrate the insulation's ability to withstand a minimum workmanship voltage of 500 VDC or 150% of the rated output voltage, whichever is greater. Wire and harness insulation resistance values shall be measured to demonstrate the connector meets its performance specification.

E417.39 Ordnance Interfaces and Manifold Qualification

(a) *General.* Each ordnance interface or manifold that is part of a flight termination system shall be tested to demonstrate that it satisfies a reliability of 0.999 at a 95% confidence level. The following apply to all interface testing:

(1) All tests shall utilize simulated flight configured interfaces. These tests shall be performed using test hardware that duplicates the geometry and volume of any closed firing systems.

(2) Testing must account for performance variability due to manufacturing and workmanship tolerances such as minimum gap, maximum gap, and axial and angular offset.

(b) *Detonation flier plate ordnance transfer systems.* A detonation flier plate ordnance transfer system is composed of components such as, electro-explosive devices, exploding bridgewires, ordnance delays, explosive transfer systems, destruct charges, and percussion activated devices. Such a system shall be tested to demonstrate its reliability using one of the following:

(1) Perform a statistical firing series that varies critical performance parameters, including gap and axial and angular alignment, to ensure that ordnance initiation occurs across each flight configured interface with a reliability of 0.999 at a 95% confidence level.

(2) Test 2994 flight units in a flight configuration to demonstrate that ordnance initiation occurs across each flight configured interface with a reliability of 0.999 at a 95% confidence level.

(3) Demonstrate a significant gap margin by performing the following:

(i) Test five units at four times the combined system gap.

(ii) Test five units at four times the combined system axial misalignment.

(iii) Test five units at four times the combined system angular misalignment.

(iv) Test five units at half the combined system gap.

(c) *Deflagration and pressure sensitive ordnance transfer systems.* A deflagration or pressure sensitive ordnance transfer system is composed of devices such as ordnance delays, electro explosive system low energy end-tips, and percussion activated device primers. Such a system shall be tested to demonstrate its reliability using one of the following:

(1) Perform a statistical firing series that varies critical performance parameters, including gap interface, to ensure that ordnance initiation occurs across each flight configured interface with a reliability of 0.999 at a 95% confidence level.

(2) Test 2994 flight units in a flight configuration to demonstrate that ordnance initiation occurs across each flight configured interface with a reliability of 0.999 at a 95% confidence level.

(3) Demonstrate a significant gap margin by performing the following:

(i) Test five units using a 75% downloaded donor charge across the maximum gap.

(ii) Test five units using a 120% overloaded donor charge across the minimum gap.

Appendix F to Part 417—Flight Termination System Electronic Piece Parts

F417.1 General

This appendix contains requirements that apply to electronic piece parts used in a flight termination system. A launch operator shall ensure the high reliability of all electronic piece parts used in the production of all flight termination system components by employing U.S. military-quality piece parts in accordance with F417.5 of this appendix or custom or non-military piece parts in accordance with F417.7 of this appendix.

F417.3 Piece Parts Program Plan

A launch operator shall describe its compliance with the requirements of this appendix in its flight termination system piece parts program plan prepared during the licensing process in accordance with § 415.119(o) of this chapter and updated for each launch in accordance with part 417. All electronic piece parts used in a flight termination system must successfully undergo derating, qualification, screening, lot acceptance testing, and lot destructive physical analysis in accordance with the launch operator's piece parts program plan and the requirements of this appendix. Any failure or out of family test results and a description of any corrective actions shall be submitted to the FAA for review and approval before the part, including any part from the same production lot, is installed in a flight termination system component. A launch operator's piece parts program must include a monthly review of information disseminated by the Government Industry Data Exchange Program (GIDEP) and must account for any GIDEP alerts related to the quality and reliability of piece parts used in a flight termination system component. GIDEP alert information is available at the GIDEP Internet Web page (www.gidep.corona.navy.mil).

F417.5 U.S. Military-Quality Piece Parts

(a) U.S. military-quality piece parts used in a flight termination system must meet the performance, quality, and reliability levels required by the Department of Defense product qualification program as they apply to the following parts and classifications:

(1) JANTX, JANTXV, or JANS classes for diodes and transistors.

(2) Class B or Class S for microcircuits.

(3) Class H or Class K for hybrids.

(4) Established reliability level R or S level for passive parts.

(5) Established reliability level R for relays.

(6) Class B for crystal oscillators or filters

(b) All internal cavity piece parts must undergo particle impact noise detection (PIND) testing in accordance with F417.7(b) of this appendix.

(c) The Defense Supply Center, Columbus (DSCC) Sourcing and Qualification Unit (DSCC–VQ) maintains lists of suppliers of U.S. military-quality parts with the classifications required by paragraph (a) of this section. When using U.S. military-quality parts, a launch operator shall select parts from a Qualified Manufacturers List (QML) or Qualified Product List (QPL), which are available at the DSCC–VQ Web page (www.dscc.dla.mil/offices/sourcing__and__qualifications).

F417.7 Custom or Non-Military Piece Parts

(a) All custom or non-military parts used in a flight termination system shall be subjected to screening tests, lot acceptance testing, qualification testing, and destructive physical analysis to demonstrate equivalence to the military-quality parts in F417.5 of this appendix. Each piece part must successfully undergo testing in accordance with the following:

(1) 100% of all parts shall be subjected to screening tests to detect any electrical or mechanical workmanship defects and infant mortality failure modes.

(2) Each part's mechanical and electrical design shall be qualified through sample qualification testing to confirm the ability of the part to operate without mechanical or electrical degradation. The quality of the manufacturing processes for each part shall be demonstrated through lot acceptance testing of production lot samples to confirm that the manufacturing process produces parts consistent with the part's qualified design. For qualification and lot acceptance testing, each sample piece part shall be subjected to mechanical, electrical, and environmental stress tests that demonstrate the part meets its performance specifications. Where applicable, a 1000-hour life test meets these requirements.

(3) As part of the lot acceptance testing, lot samples of each piece part must undergo a destructive physical analysis after those samples have been subjected to the environmental stress tests. The destructive physical analysis shall demonstrate that the part's design, materials, and processes are consistent with its specification and must detect any internal anomalies and defects that may occur during environmental testing that cannot be detected by other tests. The number of samples from each piece part production subjected to destructive physical analysis is dependent on the type of component and may vary from two to five samples. A description of any anomaly or defect and any corrective actions shall be

submitted to the FAA for review and approval of the test and before any part from the same production lot is installed in a flight termination system.

(b) All internal cavity piece parts must undergo particle impact noise detection (PIND) testing, unless they have external and internal pressure contacts (die to electrical contacts), optical coupled isolators, and double plug diodes. PIND testing must insure that applicable electronic parts are free of workmanship induced internal debris that could degrade the part's performance. If a production lot experiences a failure rate greater than one percent during PIND testing, additional PIND test runs shall be performed or the entire lot shall be rejected and not used in any flight termination system. If subsequent PIND test runs are made, the failure rates for each subsequent run must not increase from any previous run or the entire production lot shall be rejected. If the one-percent failure criterion is not met within five PIND test runs, the entire production lot shall be rejected. Any device from a production lot that failed PIND testing is not acceptable for use in a flight termination system and shall be marked accordingly.

(c) Each part shall be derated according to the launch operator's piece part program plan approved during the licensing process in accordance with § 415.119(o) of this chapter. A launch operator's derating criteria must ensure that the variability in electronic parts within a part production lot and the relationship between that variability and the variability of other parts used in the same flight termination system component will not result in a degradation of functional performance of the flight termination system. The stresses applied to a piece part during operation in its component circuit must be below the manufacturer's specified ratings for that piece part. The specifications that must be derated for each piece part include, but need not be limited to voltage, current, power, operating temperature range, and voltage or current over temperature.

(d) All piece parts shall be separately packaged and identified, including identification of the testing to which they have been subjected. Piece parts to be used for flight shall be subjected to life testing only. Piece parts that have been subjected to destructive testing shall not be used for flight.

Appendix G to Part 417—Natural and Triggered Lighting Flight Commit Criteria

G417.1 General

This appendix provides flight commit criteria to protect against natural lightning and lightning triggered by the flight of a launch vehicle. A launch operator shall implement these criteria in accordance with § 417.113(b) for any launch vehicle that utilizes a flight safety system. The launch operator shall employ any weather monitoring and measuring equipment and procedures needed to implement these flight commit criteria. These criteria cover a broad range of conditions, which apply to most launches at most launch sites; however there may be exceptions. A launch operator shall demonstrate to the FAA whether any of these criteria do not apply to a planned launch during the licensing process according to § 415.115(e) of this chapter.

G417.3 Definitions

For the purpose of this appendix:

Anvil means a stratiform or fibrous cloud produced by the upper level outflow or blow-off from thunderstorms or convective clouds.

Associated means that two or more clouds are causally related to the same weather disturbance or are physically connected. *Associated* is not synonymous with occurring at the same time. An example of clouds that are not associated is air mass clouds formed by surface heating in the absence of organized lifting. Also, a cumulus cloud formed locally and a physically separated cirrus layer generated by a distant source are not associated, even if they occur over or near the launch point at the same time.

Bright band means an enhancement of radar reflectivity caused by frozen hydrometeors falling through the 0 degree C level and beginning to melt.

Cloud edge means the location of the edge of a cloud determined visually where possible or by a 10–dBZ radar reflectivity measurement.

Cloud layer means a vertically continuous array of clouds, not necessarily of the same type (*e.g.* cumulus, anvil, debris, etc.), whose bases are approximately at the same level.

Cloud top means the altitude of the top of a cloud determined visually where possible or by a 10–dBZ radar reflectivity measurement.

Cumulonimbus cloud means any convective cloud with any part higher than any altitude where the temperature is −20 degrees Celsius.

Debris cloud means any cloud, except an anvil cloud, that has become detached from a parent cumulonimbus cloud or thunderstorm, or that results from the decay of a parent cumulonimbus cloud or thunderstorm.

Electric field measurement aloft means the magnitude of the instantaneous, vector, electric field (E) at a known position in the atmosphere, as measured by a suitably instrumented, calibrated, and located airborne-field-mill aircraft.

Electric field measurement at the surface of the Earth means the one-minute arithmetic average of the vertical electric field (Ez) at the ground measured by a ground based field mill. The polarity of the electric field is the same as that of the potential gradient; that is, the polarity of the field at the ground is the same as the dominant charge overhead. Electric field contours are used for the electric field measurement at the surface.

Field mill means a device used to measure the intensity of electric fields.

Flight path means the planned normal trajectory.

Moderate precipitation means a precipitation rate of 0.1 inches/hr or a radar reflectivity factor of 30 dBZ.

Nontransparent means sky cover through which forms are blurred, indistinct, or obscured, sky cover through which forms are seen distinctly only through breaks in the cloud cover, or clouds with a radar reflectivity of 10 dBZ or greater.

Optically thin means having a vertical optical thickness of unity or less at visible wavelengths.

Precipitation means detectable rain, snow, sleet, etc. at the ground, or virga, or a radar reflectivity greater than 18 dBZ at altitude.

Thunderstorm means any convective cloud that produces lightning.

Transparent means optically thin. Sky cover is transparent if other objects in the sky such as higher clouds, blue sky, stars, and the disk of the sun, can be distinctly seen from below, if the sun casts distinct shadows of objects on the ground, or if objects on the ground such as terrain, buildings, and lights can be distinctly seen from above.

Weather disturbance means a weather system where dynamical processes destabilize the air on a scale larger than the individual clouds or cells. Examples of disturbances are fronts, troughs and squall lines.

Within means a function word that specifies a margin in all directions (horizontal, vertical, and slant separation) between the cloud edge or top and the flight path. For example, ''*within* 10 nautical miles of a thunderstorm cloud'' means that there must be a 10 nautical mile margin between the closest part, whether cloud edge or cloud top, of a thunderstorm cloud and the flight path.

G417.5 Lightning

(a) A launch operator shall not initiate flight for 30 minutes after any type of lightning occurs in a thunderstorm if the flight path will carry the launch vehicle within 10 nautical miles of that thunderstorm.

(b) A launch operator shall not initiate flight for 30 minutes after any type of lightning occurs within 10 nautical miles of the flight path unless:

(1) The cloud that produced the lightning moves beyond 10 nautical miles of the flight path;

(2) There is at least one working field mill within five nautical miles of each such lightning flash; and (3) The absolute values of all electric field measurements at the Earth's surface within five nautical miles of the flight path and measurements made by each field mill employed according to paragraph (b)(2) of this section are less than 1000 Volts/meter for 15 minutes.

G417.7 Cumulus Clouds

(a) The criteria in this section apply to cumulus clouds. This section does not apply to altocumulus, cirrocumulus, or stratocumulus clouds.

(b) A launch operator shall not initiate flight if the flight path will carry the vehicle within 10 nautical miles of any cumulus cloud with a cloud top higher than any altitude where the temperature is (20 degrees Celsius.

(c) A launch operator shall not initiate flight if the flight path will carry the vehicle within five nautical miles of any cumulus cloud with a cloud top higher than any altitude where the temperature is (10 degrees Celsius.

(d) A launch operator shall not initiate flight if the flight path will carry the launch vehicle through any cumulus cloud with a cloud top higher than any altitude where the temperature is (5 degrees Celsius.

(e) A launch operator shall not initiate flight if the flight path will carry the launch vehicle through any cumulus cloud with a cloud top at an altitude that is between any altitude where the temperature is +5 degrees Celsius and any altitude where the temperature is (5 degrees Celsius unless:

(1) The cloud is not producing precipitation;

(2) The horizontal distance from the center of the cloud top to at least one working field mill is less than two nautical miles; and (3) All electric field measurements at the Earth's surface within 5 nautical miles of the flight path and the measurements made at each field mill employed according to paragraph (d)(2) of this section have been between minus 100 Volts/meter and plus 500 Volts/meter for 15 minutes.

G417.9 Attached Anvil Clouds

(a) A launch operator shall not initiate flight if the flight path will carry the vehicle through nontransparent parts of any attached anvil cloud.

(b) A launch operator shall not launch if the flight path will carry the vehicle within five nautical miles of a nontransparent part of any attached anvil cloud for the first three hours after the last lightning discharge from the parent cloud or anvil cloud.

(c) A launch operator shall not launch if the flight path will carry the launch vehicle within 10 nautical miles of a nontransparent part of any attached anvil cloud for the first 30 minutes after the last lightning discharge from the parent cloud or anvil cloud.

G417.11 Detached Anvil Clouds

(a) A launch operator shall not initiate flight if the flight path will carry the launch vehicle through a nontransparent part of any detached anvil cloud for the first three hours after the anvil cloud is observed to be detached from the parent cloud.

(b) A launch operator shall not initiate flight if the flight path will carry the launch vehicle through a nontransparent part of a detached anvil cloud for the first four hours after the last lightning discharge from the detached anvil cloud.

(c) A launch operator shall not initiate flight if the flight path will carry the vehicle within five nautical miles of a nontransparent part of a detached anvil cloud for the first three hours after the last lightning discharge from the parent cloud or anvil cloud before detachment or after any lighting discharge from the detached anvil cloud unless:

(1) There is at least one working field mill within five nautical miles of the detached anvil cloud;

(2) The absolute values of all electric field measurements at Earth's surface within five nautical miles of the flight path and measurements made at each mill employed according to paragraph (c)(1) of this section have been less than 1000 Volts/meter for 15 minutes; and

(3) The maximum radar return from any part of the detached anvil cloud within five nautical miles of the flight path has measured less than 10 dBZ for 15 minutes.

(d) A launch operator shall not initiate flight if the flight path will carry the vehicle within 10 nautical miles of a nontransparent part of a detached anvil cloud for the first 30 minutes after the last lightning discharge from the parent cloud or anvil cloud before detachment or after any lighting discharge from the detached anvil cloud.

G417.13 Debris Clouds

(a) A launch operator shall not initiate flight if the flight path will carry the launch vehicle through any nontransparent part of a debris cloud during the three-hour period that begins at the time when the debris cloud is observed to be detached from the parent cloud or when the debris cloud is observed to have formed from the decay of the parent cloud top below any altitude where the temperature is −10 degrees Celsius. The three-hour period must begin anew at the time of any lightning discharge from the debris cloud.

(b) A launch operator shall not initiate flight if the flight path will carry the launch vehicle within five nautical miles of any nontransparent part of a debris cloud during the three-hour period defined by paragraph (a) of this section, unless:

(1) There is at least one working field mill within five nautical miles of the debris cloud;

(2) The absolute values of all electric field measurements at the Earth's surface within five nautical miles of the flight path and measurements at each field mill employed according to paragraph (b)(1) of this section have been less than 1000 Volts/meter for 15 minutes; and

(3) The maximum radar return from any part of the debris cloud within five nautical miles of the flight path has measured less than 10 dBZ for 15 minutes.

(c) A launch operator shall not consider a detached anvil cloud to be a debris cloud. The criteria in this section do not apply to detached anvil clouds. Criteria applicable to detached anvil clouds are provided in G417.11 of this appendix.

G417.15 Disturbed Weather

A launch operator shall not initiate flight if the flight path will carry the launch vehicle through any nontransparent cloud associated with a weather disturbance having clouds with cloud tops at or higher than any altitude where the temperature is 0 degrees Celsius and where the clouds contain moderate or greater precipitation or where there is evidence of melting precipitation in the clouds (such as, a radar bright band) within 5 nautical miles of the flight path.

G417.17 Thick Cloud Layers

(a) Except as noted in paragraph (b) of this section, a launch operator shall not initiate flight if the flight path will carry the vehicle through any nontransparent part of a cloud layer that is:

(1) Greater than 4,500 ft thick and any part of the cloud layer along the flight path is located between any altitude where the temperature is 0 degrees Celsius and any altitude where the temperature is −20 degrees Celsius; or

(2) Connected to a cloud layer that, within five nautical miles of the flight path, is greater than 4,500 ft thick and has any part located between any altitude where the temperature is 0 degrees Celsius and any altitude where the temperature is −20 degrees Celsius.

(b) A launch operator shall apply the flight commit criteria in paragraph (a) of this section to flying through a cloud layer unless the cloud layer is a cirriform cloud that has never been associated with convective clouds, is located entirely at altitudes where the temperatures are −15 degree Celsius or colder, and the cloud layer shows no evidence of containing liquid water.

G417.19 Smoke Plumes

A launch operator shall not initiate flight if the flight path will carry the launch vehicle through any cumulus cloud that has developed from a smoke plume from a fire while the cloud is attached to the smoke plume, or for the first 60 minutes after the cumulus cloud is observed to have detached from the smoke plume. Cumulus clouds that have formed above a fire but have been detached from the smoke plume for more than 60 minutes come under the requirements for cumulus clouds of G417.7 of this appendix.

G417.21 Surface Electric Fields

(a) A launch operator shall not initiate flight for 15 minutes after the absolute value of any electric field measurement at the Earth's surface within five nautical miles of the flight path has been greater than 1500 Volts/meter.

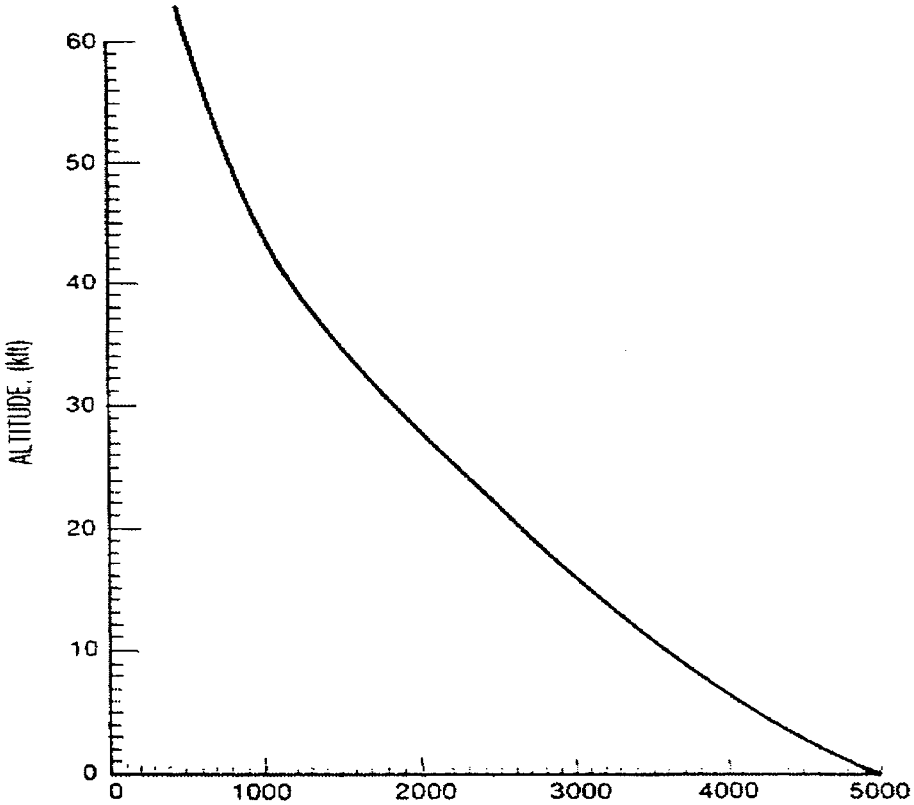
(b) A launch operator shall not initiate flight for 15 minutes after the absolute value of any electric field measurement at the Earth's surface within five nautical miles of the flight path has been greater than 1000 Volts/meter unless:

(1) All clouds within 10 nautical miles of the flight path are transparent; or

(2) All nontransparent clouds within 10 nautical miles of the flight path have cloud tops below any altitude where the temperature is +5 degrees Celsius and have not been part of convective clouds that have cloud tops higher than any altitude where the temperature is −10 degrees Celsius within the last three hours.

G417.23 Electric Fields Aloft

A launch operator need not apply the flight commit criteria in G417.9, G417.11, G417.13, G417.15, G417.17, G417.19, and G417.21(b) of this appendix if, during the 15 minutes prior to flight, the instantaneous electric field aloft, throughout the volume of air expected to be along the flight path, does not exceed the electric field values shown as a function of altitude in figure G417–1.



Volts/meter

Figure G417-1, Instantaneous Critical Electric Field, Volts/meter vs. Altitude.

G417.25 Triboelectrification

(a) A launch operator shall not initiate flight if a launch vehicle has not been treated for surface electrification and the flight path will go through any clouds above any altitude where the temperature is −10 degree Celsius up to the altitude at which the vehicle's velocity exceeds 3000 feet/second.

(b) A launch vehicle is ''treated'' for surface electrification if:

(1) All surfaces of the vehicle susceptible to precipitation particle impact are such that:

(i) The surface resistivity is less than 10^9 ohms/square; and

(ii) All conductors on surfaces (including dielectric surfaces that have been treated with conductive coatings) are bonded to the vehicle by a resistance that is less than 10^5 ohms; or

(2) A launch operator demonstrates by test or analysis that electrostatic discharges (ESD) on the surface of the vehicle caused by triboelectrification by precipitation particle impact will not be hazardous to the launch vehicle or the mission.

Appendix H to Part 417—Safety Critical Computing Systems and Software

H417.1 General

This appendix provides safety requirements for all flight and ground systems where computing systems perform or potentially perform any software safety critical function as defined in H417.3 of this appendix. A launch operator shall ensure that any computing system that has a software safety critical function is in accordance with this appendix.

H417.3 Software Safety Critical Functions

(a) A launch operator shall identify all software safety critical functions associated with its computing systems and software. This includes any function that, if not performed, if performed out of sequence, or if performed incorrectly, may directly or indirectly cause a public safety hazard. For each software safety critical function, a launch operator shall define the boundaries of the associated system or software.

(b) Software safety critical functions must include, but need not be limited to the following:

(1) Software used to control or monitor the functioning of safety critical hardware.

(2) Software used to or having the capability to monitor or control hazardous systems.

(3) Software associated with fault detection of safety critical hardware or software. A software fault is defined as the manifestation of an error in software. The term fault detection includes software associated with fault signal transmission.

(4) Software that responds to the detection of a safety critical fault.

(5) Any software that is part of a launch operator's flight safety system.

(6) Processor-interrupt software associated with any other software that has a software safety critical function.

(7) Any software used to compute real-time safety critical data used in any other software that has a software safety critical function.

H417.5 Central Processing Units and Firmware

(a) A launch operator shall ensure that a central processing unit's functionality is validated for its intended use and environment. Such validation must include testing under intended operational conditions and environments. This testing may be conducted incrementally such that each environmental factor is accounted for individually.

(b) A central processing unit's throughput must not exceed 80 percent of its total capacity.

(c) A central processing unit must have separate instruction and data memories and busses or separate program memory and data memory through memory protection hardware, segment protection, or page protection.

(d) Software safety critical function flight architecture must protect against a central processing unit single event upset at altitudes of 30,000 feet and above. The system must accomplish this through redundancy, error correcting memory, or voting between parallel central processing units.

(e) Firmware design and installation procedures must account for expected handling, electrostatic discharge, and storage environments to prevent firmware damage. A launch operator shall ensure the expected environments are not exceeded.

H417.7 Computing System Power

(a) A computing system must power up in a safe state.

(b) A computing system must not enter an unsafe or hazardous state after an intermittent power transient or fluctuation.

(c) In the event of a total power loss, a computing system must degrade in a controlled manner to a secondary mode of operations or shutdown without creating any potentially unsafe state.

H417.9 Failure Detection

(a) A computing system with a software safety critical function must incorporate an initialization test that verifies the following:

(1) The system is in a safe state and functioning properly prior to initiation of hazardous activities.

(2) Continuity and proper functioning of software safety critical function circuits, components, inhibits, interlocks, exception limits, and safing logic are tested to ensure safety operation.

(3) Memory integrity.

(4) Program loads.

(b) A computing system with a software safety critical function must periodically verify the following:

(1) Safety critical hardware and software safety critical functions, including any safety data transmission are operating correctly.

(2) Any safety data transmission has not been corrupted.

(3) The validity of real-time software safety critical function data.

(c) Any software must be capable of detecting the following input or output errors:

(1) Improper entries.

(2) Improper sequences of entries.

(3) Improper sequences of operations.

(4) Invalid output.

(5) Timing.

H417.11 Failure Response

(a) If a failure or error is detected within any system with a software safety critical function the system must:

(1) Revert to a safe state.

(2) Provide provisions for safing hardware subsystems under the control of software.

(3) Reject erroneous input.

(4) Ensure the logging of all detected software safety critical function related system errors.

(5) Notify the operator if any ARM and SAFE logic error pattern, other than the ARM and SAFE codes, is present.

(6) Initiate an anomaly alert:

(i) Anomalies must be prioritized; for example, warning/caution/advisory.

(ii) Anomalies of the same priority must be grouped together; for example, all warnings displayed first, cautions next, and advisories last.

(iii) The most recent anomaly must be displayed at the top of the priority subgroup.

(iv) The display must support reporting multiple anomalies. Details of each anomaly may be accessed with a single action; in other words, expand each anomaly summary into a write-up that delineates actions automatically taken and recommended actions for the operator to take.

(v) The display must differentiate between read and unread anomaly alerts.

(vi) All anomaly alerts must be cleared after predefined operator input. Such inputs must provide feedback of the corrective actions taken and confirm corrective action states.

(b) If a failure or error is detected within a flight safety system software safety critical function or associated safety critical hardware, the system must:

(1) Maintain the flight safety system in an ARMED state throughout the flight even if errors are detected.

(2) Reject erroneous input.

(3) Ensure all detected software safety critical function flight safety system related errors are transmitted via telemetry to the range.

(4) Notify the operator if any ARM or SAFE logic pattern other than the ARM or SAFE code is present.

H417.13 Testing and Maintenance

(a) If any non-operational hardware, such as test sets and simulators, or software is required for testing or maintenance of a system, the design of the system must ensure that identification of such equipment is fail-safe.

(b) The system identification must prevent operational hardware or software from being inadvertently identified as non-operational.

(c) A system with a software safety critical function must include one or more interlocks as needed to mitigate all hazards when performing maintenance or testing of the system.

(1) The system must prevent any interlock from being inadvertently overridden.

(2) When an interlock is overridden, disabled, removed, or bypassed to perform tests, the following apply:

(i) The interlock must not be left in an overridden state once the system is restored to operational use.

(ii) The interlock must not be autonomously controlled by a computing system.

(iii) The system must display the status of all interlocks on the operator console.

(iv) The system must verify the restoration of all interlocks prior to resuming any operation where the interlocks are needed to mitigate a hazard.

H417.15 Electromagnetic Interference and Electrostatic Discharge

Any computer system with a software safety critical function must provide protection against the harmful effects from electromagnetic radiation, or electrostatic discharge for the sensitive components of the computer system.

H417.17 Operator Console

(a) The design of an operator console must provide for the operator to cancel current processing with a single action and have the system revert to a known safe state. This action may consist of pressing two keys at the same time. For a flight safety system the in-flight safe state may be in a SAFE or ARMED mode.

(b) The design of an operator console must provide for the operator to exit potentially unsafe states to a known safe state with a single action. This action may consist of pressing two keys at the same time.

(c) Two or more unique operator actions must be required to initiate any potentially hazardous function or sequence of functions.

(d) The design of operator actions at an operator console must minimize the potential for inadvertent actuation.

(e) Operator displays, legends, and other interactions must be clear, concise, and unambiguous.

(f) Any operator console software must provide positive confirmation of valid data entry or actions taken; for example, the system must provide visual and/or aural feedback to the operator so the operator knows that the system has accepted the action and is processing it.

(g) An operator console must provide feedback for any software safety critical function actions not executed.

(h) An operator console must provide a real-time indication that it is functioning.

(i) For real-time processing functions requiring several seconds or longer, the system must provide a status indicator to the operator during processing. The indication must confirm that the commanded action has occurred and not just that the command was sent thus providing the operator with a closed-loop indication. This indication process must not interfere with the immediate performance of any other functions.

(j) The system must incorporate multiple devices and logical paths as needed to ensure that a single failure or error cannot prevent the operator from taking safing actions.

(k) The system must provide error messages that distinguish safety critical states or errors from non-safety critical states or errors.

H417.19 Software Development Process

(a) A launch operator shall ensure that desk audits, independent peer reviews, static analysis, and dynamic analysis tools and techniques are used to verify implementation of software safety critical function design requirements in any source code or system.

(b) A launch operator shall ensure that reviews of software source code are conducted to ensure that the code and comment lines within the code agree.

(c) Safety critical software function software must not incorporate any object code patches.

H417.21 Timers

(a) A system with a software safety critical function must incorporate watchdog timers or similar devices to ensure that the microprocessor or computer is operating properly.

(b) The design of a watchdog timer or similar device must prohibit software from entering an inner loop and resetting the timer or similar device as part of that loop sequence.

(c) The computer must control all software safety critical function timing functions.

(d) Software safety critical function timing values must not be modifiable by the operator from an operator console.

(e) Software safety critical function timer values and their applicability for their intended function shall be verified.

H417.23 Modular Code

(a) Software safety critical function software design and code must be modular.

(b) A launch operator shall ensure that the number of software safety critical function program modules is minimized within the constraints of operational effectiveness, computer resources, and good software design practices.

(c) Software safety critical function program modules must have no greater than one entry and one exit point.

H417.25 Loops

(a) A software safety critical function program loop must not exceed a predefined constant maximum execution time.

(b) The design of a feedback loop must ensure that the software cannot cause a runaway condition due to the failure of a feedback sensor.

(c) Branching into a software safety critical function program loop shall be prohibited.

(d) A branch out of a software safety critical function program loop must lead to a single exit point placed after the loop within the same module.

H417.27 Object Code

(a) Operational software safety critical function object code must not incorporate any STOP instruction.

(b) Non-executive operational software safety critical function object code must not incorporate a HALT instruction.

(c) After a task has been HALTED, the executive must restart central processing unit task processing no later than the start of the next computing frame.

(d) WAIT instructions may be used where necessary to synchronize input/output where appropriate handshake signals are not available.

(e) The design of a system must prevent unauthorized or inadvertent access to or modification of software safety critical function source code or assembly software or object code.

(f) The design of a system must prevent self-modification of the software safety critical function object code.

(g) Software safety critical function operational program loads must not contain unused executable codes.

(h) A software safety critical function operational program load must not contain any unreferenced variables.

H417.29 Data

(a) Each variable used in software safety critical function program code must be explicitly defined.

(b) A software safety critical function must not employ a logic ''1'' and ''0'' to denote any potentially hazardous state including any SAFE and ARM.

(c) Any ARM and SAFE states must be represented by at least a unique 4-bit pattern.

(d) A SAFE-state must be a pattern that cannot represent the ARM-state pattern as a result of a 1 or 2-bit error.

H417.31 Interfaces

(a) A launch operator shall ensure that the requirements in this section are applied to any software safety critical function interface between central processing units and any hardware input and output devices.

(b) A launch operator shall ensure that parity checks, checksums, cycle redundancy checks, or other data verification techniques are used to verify correct data transfer.

(c) Data transfer messages must be of a predetermined format and content.

(d) Limit and reasonableness checks must be performed on all software safety critical function inputs and outputs.

(e) Functions requiring two or more software safety critical function signals, such as ARM and FIRE, must not receive all of the necessary signals from a single register or input/output port.

(f) A function requiring two or more software safety critical function signals, such as ARM and FIRE, must not be generated by a single software module.

H417.33 Logic

(a) Software safety critical function conditional statements must have all required conditions satisfied; there must not be a potential for invalidated data input to the conditional statement.

(b) Decision statements in software safety critical function must not rely on inputs of all 1s or 0s, particularly when this information is obtained from external sensors.

(c) Flags and variable names must be unique and have a single purpose.

(d) Files must be unique and have a single purpose.

(e) Scratch files must not be used for storing or transferring software safety critical function information, data, or control functions between processes.

(f) Software must contain only those features and capabilities required by the system. Software safety critical function programs must not contain undocumented or unnecessary features.

(g) Indirect addressing methods must not be used unless the address is verified as being within acceptable limits prior to execution of software safety critical function operations. The compiled code must check the address boundary of any data written to arrays in software safety critical function operations.

(h) The accuracy of results of a software safety critical function program must not be dependent on the time taken to execute the program or time at which execution is initiated.

(i) The design of software safety critical function software must ensure that the full scale and zero representations of the software are fully compatible with the scales of any digital-to-analog, analog-to-digital, digital-to-synchro, or synchro-to-digital converters used in the system.

(j) Software safety critical function code must not incorporate one-to-one assignment statements.

H417.35 Memory

(a) All ground or preflight process static memory not used for or by the operational program must be initiated to a pattern that causes the system to revert to a safe state if executed.

(b) All flight processor static memory not used for or by the operational program must be initiated to a pattern that will cause the system to revert to a predefined state if executed. This predefined state must not stop a central processing unit from operating. For a flight safety system, reverting to a predefined state must not change the operating mode; for example, ARMED must not be SAFED.

(c) Dynamic memory usage must not exceed 85 percent. This assumes average memory usage; however, a launch operator shall verify memory usage by testing against the projected worst case to ensure protection from memory saturation as a result of memory leakage.

(d) Random numbers, HALT, STOP, WAIT, or NO-OPERATION instructions must not fill processing memory.

(e) Data or code from previous overlays or loads must not be allowed to remain.

(f) An overlay of software safety critical function software must occupy the same amount of memory.

(g) Safety kernels must be resident in nonvolatile read only memory or in protected memory that cannot be overridden by the computing system.

H417.37 Configuration Control

(a) A launch operator shall ensure that configuration control is established as soon as a software baseline is established.

(b) A launch operator shall establish a software configuration control board to approve changes to configuration controlled software prior to their implementation.

(c) A member from the system safety engineering team shall be a member of the software configuration control board and tasked with the evaluation of all software changes for their potential safety impact.

(d) A member of the hardware configuration control board shall be a member of the software configuration control board and vice versa to keep members apprised of hardware/software changes and to ensure that hardware/ software changes do not conflict with or introduce potential safety hazards due to hardware/software incompatibilities.

(e) A launch operator shall ensure that all software changes are coded into the source code, compiled, and tested prior to being introduced into operational equipment.

(f) A launch operator shall ensure that all firmware changes are issued as a fully functional and tested circuit card.

(g) A launch operator shall ensure the following requirements are applied to electrically erasable programmable read only memory:

(1) Electrically erasable programmable read only memory changes must pass hardware/software functionality testing on like hardware prior to installation onto the system.

(2) Electrically erasable programmable read only memory changes must contain an embedded version identification number and be validated via checksum.

(h) A launch operator shall ensure that all software safety critical function software and associated interfaces are under configuration control.

H417.39 Software Analyses

(a) A launch operator shall ensure that internal independent validation and verification or a similar formal process is used to ensure safety design requirements have been correctly and completely implemented for software safety critical function code.

(b) A launch operator shall ensure that any conditional statements are analyzed to ensure that the conditions are correct for the task and that all potential conditions are satisfied and not left to a default condition.

(c) Comment statements must describe the functionality of the code.

(d) A launch operator shall ensure that all test results are analyzed to identify potential safety anomalies that may occur. A launch operator shall ensure that all hazards are investigated from a system level with hardware and software components.

H417.41 Software Testing

(a) A launch operator shall ensure that software safety critical function software testing includes the following:

(1) GO/NO–GO path testing (functioning properly/not functioning properly).

(2) Reaction of software to system (hardware, software, or combination of hardware and software) errors or failures.

(3) Boundary conditions (in, out, crossing).

(4) Input values of zero, zero crossing, and approaching zero from either direction.

(5) Minimum and maximum input data rates in worst case configurations.

(6) Regression testing for changes to software safety critical function software code.

(7) Operator interface/human errors during software safety critical function operations.

(8) Error handling.

(9) Any special features such as a kernel upon which the protection of software safety critical function features is based.

(10) Formal Test coverage for software testing to include analysis and documentation.

(b) A launch operator shall document and maintain test results in test reports.

H417.43 Software Reuse

(a) A launch operator shall ensure that any reused baseline software is evaluated to determine if it supports a software safety critical function in accordance with H417.3 of appendix H.

(b) A launch operator shall ensure that any software safety critical function reused baseline software is analyzed for the following:

(1) Correctness of new or existing system design assumptions and requirements.

(2) Replaced or new hardware that the software runs on or interfaces with.

(3) Changes in environmental or operational assumptions.

(4) Impact to existing hazards.

(5) Introduction of new hazards.

(6) Correctness of interfaces between system hardware, other software and the operator.

(c) A launch operator shall ensure that any unused or unneeded functionality in software safety critical function reuse baseline software is eliminated.

(d) A launch operator shall ensure that any software safety critical function reused baseline software changes in system design, environment, or operation assumptions are requalified or revalidated.

(e) A launch operator shall ensure that any software safety critical function reuse baseline software compiled with a different compiler is analyzed and tested.

H417.45 Commercial Off-the-Shelf Software

(a) When employing commercial-off-the shelf software, a launch operator shall ensure that every software safety critical function that the software supports is identified and satisfies the requirements of this appendix.

(b) A launch operator shall ensure that software safety hazard analyses is performed on all software safety critical commercial-off-the-shelf software to verify such software satisfies the requirements of this appendix.

H417.47 Language Compilers

(a) A launch operator shall ensure that only production qualified higher order language compilers are used for software safety critical function code.

(b) A launch operator shall ensure that no beta test versions of higher order language compilers are used for software safety critical function code.

(c) A launch operator shall ensure that the heritage of each language and compiler used for software safety critical function code is clearly identified for each portion of the system design.

(d) A launch operator shall ensure that translation routines and hardware between languages used in software safety critical functions are analyzed and tested.

(e) A launch operator shall ensure that any non-standard languages, those languages without production qualified compilers, used in software safety critical functions are analyzed and tested.

(f) A launch operator shall ensure that any programs or routines, compiled from different compiler versions, supporting software safety critical functions are analyzed and tested.

(g) A launch operator shall not use a programmable logic controller in a software safety critical function system unless its use is specifically approved by the FAA as part of the licensing process and the following is documented in the software development plan:

(1) The process to preclude hazardous or erroneous logic development.

(2) The process to preclude erroneous logic entry into the programmable logic controller.

(3) The validation process to ensure proper program operation to be accomplished with the system in a non-hazardous state.

Appendix I to Part 417—Methodologies for Toxic Release Hazard Analysis

I417.1 General

This appendix provides methodologies for performing toxic release hazard analysis for the flight of a launch vehicle as required by § 417.229 and for launch processing at a launch site in the United States as required by § 417.407(f).

I417.3 Identification of Non-Toxic and Toxic Propellants

(a) *General.* A launch operator's toxic release hazard analysis for launch vehicle flight (I417.5) and for launch processing (I417.7) must identify all propellants used for each launch and identify whether each propellant is toxic or non-toxic in accordance with the requirements of this section.

(b) *Non-toxic exclusion.* A launch operator need not conduct a toxic release hazard analysis in accordance with the requirements of this appendix for flight or launch processing if its launch vehicle, including all launch vehicle components and payloads, uses only those propellants listed in Table I417–1.

TABLE I1417–1.—COMMONLY USED NON-TOXIC PROPELLANTS

Item	Chemical name	Formula
1	Liquid Hydrogen	H_2
2	Liquid Oxygen	O_2
3	Kerosene (RP–1)	$CH_{1.96}$

(c) *Identification of toxic propellants.* A launch operator's toxic release hazard analysis for flight and for launch processing must identify all toxic propellants used for each launch, including all toxic propellants on all launch vehicle components and payloads. Table I417–2 lists commonly used toxic propellants and the associated toxic concentration thresholds used by the federal launch ranges for controlling potential public exposure. The toxic concentration thresholds contained in Table I417–2 are peak exposure concentrations in parts per million (ppm). A launch operator shall perform a toxic release hazard analysis to ensure that the public is not exposed to concentrations above the toxic concentration thresholds for each toxicant involved in a launch. A launch operator shall use the toxic concentration thresholds contained in table I417–2 for those propellants unless the launch operator demonstrates, clearly and convincingly through the licensing process, that another concentration is applicable to the launch and public exposure to the proposed concentration will not produce a casualty. Any propellant not identified in table I417–1 or table I417–2 falls into the category of unique or uncommon propellants, such as those identified in table I417–3, which are toxic or produce toxic combustion by-products. Table I417.3 is not an exhaustive list of possible toxic propellants and combustion by-products. For a launch that uses any propellant listed in table I417–3 or any other unique propellant not listed, a launch operator shall identify the chemical composition of the propellant and all combustion by-products and the release scenarios. A launch operator shall determine the toxic concentration threshold in ppm for any uncommon toxic propellant or combustion by-product in accordance with the following:

(1) For a toxicant that has a Level of Concern (LOC) established by the U.S. Environmental Protection Agency (EPA), Federal Emergency Management Agency (FEMA), or Department of Transportation (DOT), a launch operator shall use the LOC as the toxic concentration threshold for the toxic release hazard analysis except as required by paragraph (c)(2) of this section.

(2) If an EPA Acute Emergency Guidance Level (AEGL) exists for a toxicant and is more conservative than the LOC (that is, lower after reduction for duration of exposure), a launch operator shall use the AEGL in place of the LOC as the toxic concentration threshold.

(3) A launch operator shall use the EPA's Hazard Quotient/Hazard Index (HQ/HI) formulation to determine the toxic concentration threshold for mixtures of two or more toxicants.

(4) If a launch operator must determine a toxic concentration threshold for a toxicant for which an LOC has not been established, the launch operator shall clearly and convincingly demonstrate through the licensing process that public exposure at the proposed toxic concentration threshold will not cause a casualty.

TABLE I417–2.—COMMONLY USED TOXIC PROPELLANTS

Chemical name	Formula	Toxic concentration threshold (ppm)
Nitrogen Tetroxide	N_2O_4	4
Mixed Oxides of Nitrogen (MON)	NO, NO_2, N_2O_4	4
Nitric Acid	HNO_3	4
Hydrazine	N_2H_4	8
Monomethylhydrazine (MMH)	CH_3NHNH_2	5
Unsymmetrical Dimethylhydrazine (UDMH)	$(CH_3)_2NNH_2$	5
Ammonium Perchlorate/Aluminum	NH_3ClO_4/Al	10

TABLE I417–3.—UNCOMMON TOXIC PROPELLANTS AND COMBUSTION BY-PRODUCTS

Item	Chemical name	Formula	Toxic concentration threshold (ppm)
1	Fluorine	F_2	
2	Hydrogen Fluoride	HF	Determined according to § I417.3(c)
3	Potassium Perchlorate	$KClO_4$	
4	Lithium Perchlorate	$LiClO_4$	
5	Chlorine Oxides	Cl_2O, ClO_2, CL_2O_6, Cl_2O_7	
6	Chlorine Trifluoride	ClF_3	
7	Beryllium	Be	
8	Beryllium Borohydride	$Be(BH_4)_2$	
9	Boron	B	
10	Boron Trifluoride	BF_3	
11	Diborane	B_2H_6	
12	Pentaborane	B_5H_9	
13	Hexaborane	B_6H_{10}	
14	Aluminum Borohydride	$Al(BH_4)_3$	
15	Lithium Borohydride	$Li(BH_4)_2$	
16	Ammonia	NH_3	
17	Ammonium Nitrate	NH_4NO_3	
18	Ozone	O_3	
19	Methylamine	CH_3NH_2	
20	Ethylamine	$CH_3CH_2NHH_2$	
21	Triethylamine	$(C_2H_5)_3N$	
22	Ethylenediamine	$NH_2CH_2CH_2NH_2$	
23	Diethylenetriamine	$NH_2C_2H_4NHC_2H_4NH_2$	
24	Aniline	$C_6H_5NH_2$	
25	Monoethylaniline	$C_6H_5NHC_2H_5$	
26	Xylidine	$(CH_3)_2C_6H_3NH_3$	
27	Trimethylaluminum	$Al(CH_3)_3$	
28	Dimethylberyllium	$Be(CH_3)_2$	
29	Nitromethane	CH_3NO_2	
30	Tetranitromethane	$C(NO_2)_4$	
31	Nitroglycerine	$C_3H_5(ONO_2)_3$	
32	Butyl Mercaptan	$CH_3(CH_2)_2CH_2SH$	
33	Dimethyl Sulfide	$(CH_3)_2S$	
34	Tetraethyl Silicate	$(C_2H_5)_4SiO_4$	

I417.5 Toxic Release Hazard Analysis for Launch Vehicle Flight

(a) *General.* For each launch, a launch operator's toxic release hazard analysis must determine all hazards to the public from any toxic release that will occur during the proposed flight of a launch vehicle or that would occur in the event of a flight mishap. A launch operator shall use the results of the toxic release hazard analysis to establish for each launch, in accordance with § 417.113(b), flight commit criteria that protect the public from a casualty arising out of any potential toxic release. A launch operator's toxic release hazard analysis must determine if toxic release can occur based on an evaluation of the propellants, launch vehicle materials, and estimated combustion products. This evaluation must account for both normal combustion products and the chemical composition of any unreacted propellants.

(b) *Evaluating toxic hazards for launch vehicle flight.* Each launch must satisfy either the exclusion requirements of I417.3(b), the containment requirements of paragraph (c) of this section, or the statistical risk management requirements of paragraph (d) of this section, to prevent any casualty that could arise out of exposure to any toxic release.

(c) *Toxic containment for launch vehicle flight.* For a launch that uses any toxic propellant, a launch operator's toxic release hazard analysis must determine a hazard distance for each toxicant and a toxic hazard area for the launch. A hazard distance for a toxicant is the furthest distance from the launch point where toxic concentrations may be greater than the toxicant's toxic concentration threshold in the event of a release during flight. A launch operator shall determine the toxic hazard distance for each toxicant in accordance with paragraphs (c)(1) and (c)(2) of this section. A toxic hazard area defines the region on the Earth's surface that may be exposed to toxic concentrations greater than any toxic concentration threshold for any toxicant involved in a launch in the event of a release during flight. A launch operator shall determine a toxic hazard area in accordance with paragraph (c)(3) of this section. In order to achieve containment, a launch operator shall evacuate the public from a toxic hazard area in accordance with the requirements of paragraph (c)(4) of this section or employ meteorological constraints in accordance with the requirements of paragraph (c)(5) of this section. A launch operator shall determine the hazard distance for a quantity of toxic propellant and determine and implement a toxic hazard area for a launch in accordance with the following:

(1) *Hazard distances for common propellants.* Table I417–4 lists toxic hazard distances as a function of propellant quantity and toxic concentration threshold for commonly used propellants released from a catastrophic launch vehicle failure. Tables I417–10 and I417–11 list the hazard distance as a function of solid propellant mass for HC1 emissions during a launch vehicle failure and during normal flight for ammonium perchlorate based solid propellants. A launch operator shall use the hazard distances corresponding to the toxic concentration thresholds established for a launch to determine the toxic hazard area for the launch in accordance with paragraph (c)(3) of this section.

(2) *Hazard distances for uncommon or unique propellants.* For a launch that involves any uncommon or unique propellant, a launch operator shall determine the toxic hazard distance for each such propellant using an analysis methodology that accounts for the following worst case conditions:

(i) Surface wind speed of 2.9 knots with a wind speed increase of 1.0 knot per 1000 feet of altitude.

(ii) Surface temperature of 32 degrees Fahrenheit with a dry bulb temperature lapse rate of 13.7 degrees Fahrenheit per 1000 feet over the first 500 feet of altitude and a lapse rate of 3.0 degrees F per 1000 feet above 500 feet.

(iii) Directional wind shear of 2 degrees per 1000 feet of altitude.

(iv) Relative humidity of 50 percent.

(v) Capping temperature inversion at the thermally stabilized exhaust cloud center of mass altitude.

(vi) Worst case initial source term assuming instantaneous release of fully loaded propellant storage tanks or pressurized motor segments.

(vii) Worst case combustion or mixing ratios such that production of toxic chemical species is maximized within the bounds of reasonable uncertainties.

(viii) Evaluation of toxic hazards for both normal launch and vehicle abort failure modes.

TABLE I417–4.—HAZARD DISTANCES FROM THE LAUNCH POINT

Quantity [pounds]	Concentrations [ppm] and Hazard Distances [km]						
	NO_2 4 ppm [1] [km]	UDMH 5 ppm [1] [km]	N_2H_4 8 ppm [1] [km]	MMH 5 ppm [1] [km]	NO 4 ppm [1] [km]	HNO_3 4 ppm [1] [km]	HCl [2] 10 ppm [1] [km]
100	8	4	3	5	9	8	0
300	14	8	7	9	17	15	0
500	18	10	8	12	20	19	0
1000	26	15	11	17	26	24	0
2000	36	19	13	21	33	31	0
3000	44	22	15	24	39	35	1
4000	47	24	16	27	42	39	2
5000	50	26	17	29	45	42	2
7500	58	30	20	35	52	48	2
10000	64	34	22	37	58	52	3
20000	78	42	27	47	71	66	4
30000	91	47	29	55	81	76	5
40000	99	52	31	59	88	81	5
50000	105	56	34	64	100	87	6
60000	111	59	35	67	104	92	7
70000	116	62	36	72	109	100	8
80000	123	64	37	74	114	104	9
90000	126	68	38	77	118	108	9
100000	130	69	39	79	122	111	10
125000	138	74	42	85	131	119	12
150000	145	78	44	95	138	125	13
175000	151	81	45	99	144	131	14
200000	160	88	47	103	156	136	16
250000	167	94	49	110	163	148	18
300000	175	99	50	117	171	155	21
350000	182	103	52	122	179	161	22
400000	189	107	53	128	186	167	25
450000	203	110	54	132	193	173	27
500000	207	114	57	136	196	178	28

TABLE I417–4.—HAZARD DISTANCES FROM THE LAUNCH POINT—Continued

Quantity [pounds]	Concentrations [ppm] and Hazard Distances [km]						
	NO_2 4 ppm [1] [km]	UDMH 5 ppm [1] [km]	N_2H_4 8 ppm [1] [km]	MMH 5 ppm [1] [km]	NO 4 ppm [1] [km]	HNO_3 4 ppm [1] [km]	HCl [2] 10 ppm [1] [km]
750000	230	127	61	157	206	184	37
1000000	247	140	64	170	220	195	43

[1] Indicates a toxic concentration threshold from Table I417–2.
[2] HCL emissions from catastrophic launch vehicle failure.

(3) *Toxic hazard area.* Having determined the toxic hazard distance for each toxicant, a launch operator shall determine the toxic hazard area for a launch as a circle centered at the launch point with a radius equal to the greatest toxic hazard distance determined in accordance with paragraphs (c)(1) and (c)(2) of this section, of all the toxicants involved in the launch. A launch is exempt from any further requirements in this section if:

(i) The launch operator demonstrates that there are no populated areas contained or partially contained within the toxic hazard area; and

(ii) The launch operator ensures that no member of the public is present within the toxic hazard area during preflight fueling, launch countdown, flight and immediate postflight operations at the launch site. To ensure the absence of the public, a launch operator shall develop flight commit criteria and related provisions for implementation as part of the launch operator's flight safety plan and security and hazard area surveillance plan developed according to § 415.115(d) and § 415.119(h) of the chapter, respectively.

(4) *Evacuation of populated areas within a toxic hazard area.* For a launch where there is a populated area that is contained or partially contained within a toxic hazard area, the launch is exempt from any further requirements in this section if the launch operator evacuates all people from all populated areas at risk and ensures that no member of the public is present within the toxic hazard area during preflight fueling and flight. A launch operator shall develop flight commit criteria and provisions for implementation of the evacuations as part of the launch operator's flight safety plan, security and hazard area surveillance plan, and local agreements and plans developed according to § 415.115(d), § 415.119(h) and § 415.119(j) of the chapter, respectively.

(5) *Flight meteorological constraints.* For a launch where there is a populated area that is contained or partially contained within a toxic hazard area and that will not be evacuated according to paragraph (c)(4) of this section, the launch is exempt from any further requirements of this section if the launch operator constrains the flight of a launch vehicle to favorable wind conditions or during times when atmospheric conditions result in reduced toxic hazard distances such that any potentially affected populated area is outside the toxic hazard area. A launch operator shall employ wind and other meteorological constraints in accordance with the following:

(i) When employing wind constraints, a launch operator shall re-define the toxic hazard area by reducing the circular toxic hazard area determined in accordance with paragraph (c)(3) of this section to one or more arc segments that do not contain any populated area. Each arc segment toxic hazard area must have the same radius as the circular toxic hazard area and must be defined by a range of downwind bearings.

(ii) The launch operator shall demonstrate that there are no populated areas within any arc segment toxic hazard area and that no member of the public is present within an arc segment toxic hazard area during preflight fueling, launch countdown, and immediate postflight operations at the launch site.

(iii) A launch operator shall establish wind constraints to ensure that any winds present at the time of flight will transport any toxicant into an arc segment toxic hazard area and away from any populated area. For each arc segment toxic hazard area, the wind constraints must consist of a range of downwind bearings that are within the arc segment toxic hazard area and that provide a safety buffer, in both the clockwise and counterclockwise directions, that accounts for any uncertainty in the spatial and temporal variations of the transport winds. When determining the wind uncertainty, a launch operator shall account for the variance of the mean wind directions derived from measurements of the winds through the first 6000 feet in altitude at the launch point. Each clockwise and counterclockwise safety buffer must be no less than 20 degrees of arc width within the arc segment toxic hazard area. A launch operator shall ensure that the wind conditions at the time of flight are in accordance with the wind constraints. To accomplish this, a launch operator shall monitor the launch site vertical profile of winds from the altitude of the launch point to no less than 6,000 feet above ground level. The launch operator shall proceed with a launch only if all wind vectors within this vertical range satisfy the wind constraints. A launch operator shall develop wind constraint flight commit criteria and implementation provisions as part of the launch operator's flight safety plan and its security and hazard area surveillance plan developed according to § 415.115(d) and § 415.119(h) of the chapter, respectively.

(iv) A launch operator may reduce the radius of the circular toxic hazard area determined in accordance with paragraph (c)(3) of this section by imposing operational meteorological restrictions on specific parameters that mitigate potential toxic downwind concentrations levels at any potentially affected populated area to levels below the toxic concentration threshold of each toxicant in question. The launch operator shall establish meteorological constraints to ensure that flight will be allowed to occur only if the specific meteorological conditions that would reduce the toxic hazard area exist and will continue to exist throughout the flight.

(d) *Statistical toxic risk management for flight.* If a launch that involves the use of a toxic propellant does not satisfy the containment requirements of paragraph (c) of this section, the launch operator shall use statistical toxic risk management to protect public safety. For each such case, a launch operator shall perform a toxic risk assessment and develop launch commit criteria that protect the public from unacceptable risk due to planned and potential toxic release. A launch operator shall ensure that the resultant toxic risk meets the collective and individual risk criteria requirements contained in § 417.107(b). A launch operator's toxic risk assessment must account for the following:

(1) All credible vehicle failure and non-failure modes, along with the consequent release and combustion of propellants and other vehicle combustible materials.

(2) All vehicle failure rates.

(3) The effect of positive or negative buoyancy on the rise or descent of each released toxicant.

(4) The influence of atmospheric physics on the transport and diffusion of each toxicant.

(5) Meteorological conditions at the time of launch.

(6) Population density, location, susceptibility (health categories) and sheltering for all populations within each potential toxic hazard area.

(7) Exposure duration and toxic propellant concentration or dosage that would result in casualty for all populations.

(e) *Flight toxic release hazard analysis products.* The products of a launch operator's toxic release hazard analysis for launch vehicle flight to be submitted in accordance with § 417.203(c) must include the following:

(1) For each launch, a listing of all propellants used on all launch vehicle components and any payloads.

(2) The chemical composition of each toxic propellant and all toxic combustion products.

(3) The quantities of each toxic propellant and all toxic combustion products involved in the launch.

(4) For each toxic propellant and combustion product, identification of the toxic concentration threshold used in the toxic risk analysis and a description of how

the toxic concentration threshold was determined if other than specified in table I417.2.

(5) When using the toxic containment approach of paragraph (c) of this section:

(i) The hazard distance for each toxic propellant and combustion product and a description of how it was determined.

(ii) A graphic depiction of the toxic hazard area or areas.

(iii) A listing of any wind or other constraints on flight, and any plans for evacuation.

(iv) A description of how the launch operator determines real-time wind direction in relation to the launch site and any populated area and any other meteorological condition in order to implement constraints on flight or to implement evacuation plans.

(6) When using the statistical toxic risk management approach of paragraph (d) of this section:

(i) A description of the launch operator's toxic risk management process including an explanation of how the launch operator ensures that any toxic risk from launch meets the toxic risk criteria of § 417.107(b).

(ii) A listing of all models used.

(iii) A listing of all launch commit criteria that protect the public from unacceptable risk due to planned and potential toxic release.

(iv) A description of how the launch operator measures and displays real-time meteorological conditions in order to determine whether conditions at the time of flight are within the envelope of those used by the launch operator for toxic risk assessment and to develop flight commit criteria, or for use in any real-time physics models used to ensure compliance with the toxic flight commit criteria.

I417.7 Toxic Release Hazard Analysis for Launch Processing

(a) *General.* A launch operator shall perform a toxic release hazard analysis to determine any potential public hazards from any toxic release that will occur during normal launch processing and that would occur in the event of a mishap during launch processing. The requirements of this section apply to launch processing at a launch site in the United States pursuant to the ground safety requirements of subpart E of part 417. A launch operator shall use the results of the toxic release hazard analysis to establish hazard controls for protecting the public. These results shall be included in the launch operator's ground safety plan according to § 415.117(b) of this chapter and § 417.403(c) of part 417 to be implemented in accordance with § 417.407. A launch operator's toxic release hazard analysis must determine if toxic release can occur based on an evaluation of the design and certification of propellant ground storage tanks, propellant transfer systems, launch vehicle tanks, and vehicle processing procedures that handle either liquid or solid propellants. This evaluation must account for potential release of unreacted toxic propellants and any combustion or other reaction products that may result from a release.

(b) *Process hazards analysis.* A launch operator shall perform a process hazards analysis on all processes to identify toxic hazards and determine the potential for release of a toxic propellant. A process hazards analysis must account for the complexity of the process and shall identify and evaluate the hazards and each hazard control involved in the process. A launch operator's process hazards analysis must be in accordance with the following:

(1) A launch operator shall identify and evaluate the hazards of a process involving a toxic propellant using an analysis method such as a failure mode and effects analysis or fault tree analysis.

(2) A process hazard analysis must account for:

(i) All toxic hazards associated with the process and the potential for release of any toxic propellant.

(ii) Any mishap or incident experienced which had a potential for catastrophic consequences.

(iii) Engineering and administrative controls applicable to the hazards and their interrelationships, such as application of detection methodologies to provide early warning of releases and evacuation of toxic hazard areas prior to conducting an operation that involves a toxicant.

(iv) Consequences of failure of engineering and administrative controls.

(v) Location of the source of the release.

(vi) Human factors.

(vii) Opportunities for equipment malfunctions or human errors that could cause an accidental release.

(viii) The safeguards used or needed to control the hazards or prevent equipment malfunctions or human error.

(ix) Any steps or procedures needed to detect or monitor releases.

(x) A qualitative evaluation of a range of the possible safety and health effects of failure of controls.

(3) A process hazards analysis completed to comply with 29 CFR 1910.119(e) satisfies the requirements of paragraphs (b)(1) and (b)(2) of this section.

(4) A launch operator shall ensure that a process hazards analysis is updated for each launch. For all launch processing, the launch operator shall conduct a review of the hazards associated with each process involving a toxic propellant. The review must include inspection of all equipment to determine whether the process is designed, fabricated, maintained, and operated according to the current process hazards analysis. A launch operator shall revise a process hazards analysis to reflect any changes in processes, types of toxic propellants stored or handled, or any other aspect of a source of a potential toxic release that could affect the results of overall toxic release hazard analysis.

(5) A launch operator shall ensure that the personnel who perform a process hazard analysis possess expertise in engineering and process operations, and at least one person has experience and knowledge specific to the process being evaluated. Also, at least one person must be knowledgeable in the specific process hazard analysis methodology being used.

(6) A launch operator shall ensure that any recommendations resulting from a process hazards analysis are resolved in a timely manner prior to launch processing and that the resolution is documented. The documentation must identify any corrective actions to be taken and include a written schedule of when such actions are to be completed.

(c) *Evaluating toxic hazards of launch processing.* For each potential toxic hazard involved in launch processing as identified by the process hazards analysis required by paragraph (b) of this section, a launch operator shall protect the public in accordance with either the exclusion requirements of I417.3(b) of this appendix, the containment requirements of paragraph (d) of this section, or the statistical risk management requirements of paragraph (l) of this section, to prevent any casualty that could arise out of exposure to any toxic release.

(d) *Toxic containment for launch processing.* A launch operator's toxic release hazard analysis for launch processing must determine a toxic hazard area surrounding the potential release site for each toxic propellant based on the amount and toxicity of the propellant and the meteorological conditions involved. A launch operator shall determine whether there are any populated areas located within a toxic hazard area in accordance with paragraph (h) of this section. In order to achieve containment, a launch operator shall evacuate the public in accordance with the requirements of paragraph (i) of this section or employ meteorological constraints in accordance with the requirements of paragraph (j) of this section. To determine a toxic hazard area, a launch operator shall first perform a worst-case release scenario analysis according to paragraph (e) of this section or a worst-case credible alternative release scenario analysis in accordance with paragraph (f) of this section for each process that involves a toxic propellant and then determine a toxic hazard distance for each process according to paragraph (g) of this section.

(e) *Worst-case release scenario analysis.* A launch operator's worst-case release scenario analysis must be in accordance with the following:

(1) *Determination of worst-case release quantity.* A launch operator's worst-case release quantity of a toxic propellant must be the greater of the following:

(i) For substances in a vessel, the greatest amount held in a single vessel, taking into account administrative controls that limit the maximum quantity; or

(ii) For toxic propellants in pipes, the greatest amount in a pipe, taking into account administrative controls that limit the maximum quantity.

(2) *Worst-case release scenario for toxic liquids.* A launch operator's worst-case release scenario for a toxic liquid propellant must be in accordance with the following:

(i) For toxic propellants that are normally liquids at ambient temperature, a launch operator shall assume that the quantity in the vessel or pipe, as determined in accordance with paragraph (e)(1) of this section, is spilled instantaneously to form a liquid pool.

(ii) The surface area of the pool shall be determined by assuming that the liquid spreads to one centimeter deep unless