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DOD Contractor's Safety Manual For Ammunition and Explosives

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UNDER SECRETARY OF DEFENSE
FOR ACQUISITION, TECHNOLOGY, AND LOGISTICS

C6.4. STATIC ELECTRICITY AND GROUNDING

C6.4.1. Static Electricity. Two unlike materials (at least one of which is non-conductive) produce static electricity due to contact and separation. Contact creates a redistribution of charge across the area of contact and establishes an attractive force. Separation of the materials overcomes these attractive forces and sets up an electrostatic field between the two surfaces. If no conducting path is available to allow the charges to equalize on the surfaces, the voltage difference between the surfaces can easily reach several thousand volts as they separate.

C6.4.2. Static Electricity Hazards. The potential hazard of static electricity arises when an accumulated electrical charge subsequently discharges as a spark in the presence of hazardous atmospheres, flammable vapors, dusts, exposed sensitive explosives, or EEDs. ESD does not present a substantial hazard during the handling of most bulk explosive substances if the explosives are in approved containers. It also does not present a hazard near explosives totally contained and unexposed within loaded articles. It is not possible to prevent the generation of static electricity entirely. Elimination of potential ESD hazards requires proper grounding to dissipate static charges before they accumulate to dangerous levels. The NFPA, UL, and the U.S. Department of Commerce publish detailed discussions of the hazards of static electricity and ways of reducing it. Where electrostatic discharge (spark) may be hazardous, NFPA Standard No. 77 (Reference (u)) shall apply, except as otherwise specified.

C6.4.3. Static Ground System. A basic static ground system consists of one or more electrodes in contact with the earth and a conductor (i.e., metal wire) bonded to the electrode and routed throughout the protected facility. The static ground system may use building structural steel (unless structural steel is used as a lightning protection system down conductor), metallic water pipes, ground cones, buried copper plates, and rods driven into the earth as electrodes. The ground system shall not use gas, steam, or air lines, dry pipe sprinkler systems, or air terminals and down conductors of lightning protection systems as earth electrodes. A static ground system provides a conductive path to earth from conductive floors, conductive work surfaces, and AE equipment. A static ground system also allows any generated static charges to dissipate.

C6.4.4. Testing Equipment Grounds. Trained personnel shall test ground systems after installation, after repairs, and at locally determined intervals and shall keep all records. Remove all exposed explosives or exposed hazardous materials from the room or area before testing. The resistance of the electrode to earth shall not exceed 25 ohms. The electrical resistance from any point on the conductor to the electrode shall not exceed 1 ohm. The ground system design shall provide for interconnecting all ground electrodes of structures equipped with a lightning protection system. (See Reference (t), Annex E for further guidance.)

C6.4.5. Grounding of Equipment. Large ungrounded objects can accumulate and store electrostatic charges that can discharge in the form of a spark when approaching other conductive objects. Therefore, contractors shall perform a static electricity hazards evaluation of facilities housing AE operations to identify any objects (e.g., building structural steel, permanently installed equipment), including personnel, and any materials that could insulate and interfere with proper bonding and grounding. Unless the static electricity hazards evaluation indicates ESD is not a potential ignition source, contractor maintenance personnel shall bond all AE equipment (e.g., mixers, grinding mills, screening and sifting devices, assembly and disassembly machines, conveyors, elevators, steel work tables, presses, and hoppers) to the ground system. The resistance of the AE equipment to the grounding system shall not exceed 1 ohm. Trained personnel shall test this resistance initially at installation and at least annually thereafter, and shall keep all records. Exclude the resistance of conductive belting when testing for resistance of belt-driven machinery to the ground system. Bonding straps shall bridge contact points where oil, paint, or rust could disrupt electrical continuity. Permanent equipment in contact with conductive floors or tabletops does not meet the bonding requirement to the ground system. Maintain compatibility of metallic bonding and grounding cables, straps, or clamps with the explosives involved in the process.

C6.4.6. Conductive Belts. Use conductive belting wherever ESD is an ignition hazard. The resistance of conductive conveyor belts shall not exceed 1,000,000 ohms as measured between two electrodes placed on the belt and as measured between an electrode placed on the conductive conveyor belt and an electrode attached to the ground system. Do not use static combs to drain off static charges generated from belts or pulleys used in hazardous locations.

C6.4.7. Conductive Floors, Tabletops, and Footwear. Contractors shall use conductive tabletops, floors, and shoes for grounding personnel at operations involving exposed explosives with electrostatic sensitivity of 0.1 J or less, e.g., primer, initiator, detonator, igniter, tracer, and incendiary mixtures. Bonding wires or straps shall connect the tabletops and floors to the static ground system. Materials sensitive to initiation by ESD sparks include: lead styphnate, lead azide, mercury fulminate, tetrazene, diazodinitrophenol, potassium chlorate-lead styphanate mixtures, some igniter compositions, grade B magnesium powder, and exposed layers of black powder dust. Air and dust mixtures of ammonium picrate, tetryl, tetrytol, and solid propellants are also sensitive to initiation by ESD. Testing indicates mixtures of air with vapors from many flammable liquids (e.g., ethyl ether, ethyl alcohol, ethyl acetate, acetone, and gasoline) may ignite by ESD from the human body. Therefore, contractors shall equip areas where personnel might contact these kinds of explosives and flammable liquids with conductive floors and tabletops, except when hazard analysis indicates adequate housekeeping, dust collection, ventilation, or solvent recovery methods eliminate the ignition hazard. (Refer to Reference (u) for additional information concerning ESD test data; ESD ignition sensitivity may vary depending on variations within the process.)

C6.4.7.1. Alternate Operational Use. Unless hazard analyses indicate otherwise, conductive tabletops, floors, and shoes shall also protect operations involving:

C6.4.7.1.1. Unpackaged detonators and primers and EEDs.

C6.4.7.1.2. Electrically initiated items, such as rockets, with exposed circuits.

C6.4.7.1.3. Hazardous materials capable of initiation by ESD from the human body.

C6.4.7.2. Conducive Mats or Runners. When a hazard remains localized, the contractor may use conductive mats or runners instead of conductive floors throughout an entire building or room. These mats and runners shall meet all the specifications and test requirements that apply to conductive floors. When justified by hazard analysis, contractors may use conductive wrist straps in place of conductive floors and shoes for grounding personnel at small scale and isolated operations. When using wrist straps, operators shall test wrist straps before each use (whenever removed and re-worn) and record test results. The resistance of the wrist strap while the operator is wearing the strap shall fall within a range of 250,000ohms (minimum) and 1,200,000 ohms (maximum) when measured from opposite hand to ground. Use test equipment capable of testing 1,200,000 ohms + 10 percent. (Operators with dry skin may use special contact creams to decrease the resistance to the required value.)

C6.4.7.3. Conductive Floor and Tabletop Specifications. Conductive floors and tabletops made of or covered with non-sparking materials such as lead, conductive rubber, or conductive compositions shall meet these requirements:

C6.4.7.3.1. Provide a continuous electrical path to the static ground system and the electrical resistance shall not exceed the limits specified in subparagraph C6.4.7.5.1.

C6.4.7.3.2. Provide a reasonably smooth surface that is free from cracks.

C6.4.7.3.3. Maintain compatibility of conductive floor and tabletop materials with the energetic materials present.

C6.4.7.4. Conductive Footwear. Operators shall wear conductive shoes in areas requiring conductive mats, floors, or runners. Personnel visiting such areas shall wear conductive shoes, ankle straps, or similar devices, one on each leg. Prominent markings should identify conductive shoes to help supervisors ensure personnel compliance. Personnel required to work on electrical equipment in areas where conductive floors are installed shall not wear conductive shoes and shall not begin work until operators remove all AE sensitive to ESD.

C6.4.7.5. Testing Conductive Footwear, Floors, and Tabletops

C6.4.7.5.1. Test Criteria. The maximum resistance of a body, plus the resistance of the conductive shoes, plus the resistance of the floor to the ground system shall not exceed 1,000,000 ohms total. That is, if 500,000 ohms is the maximum resistance allowed from the floor to the ground system, then 500,000 ohms is the maximum combined resistance allowed for the person's body plus the resistance of the conductive shoes. The contractor can set the maximum resistance limits for the floor to the ground system and for the combined resistance of a person's body plus the shoes, as long as the total resistance does not exceed 1,000,000 ohms.

C6.4.7.5.2. Minimum Resistance. To protect against electrocution, the minimum resistance of the floor to the ground system and the minimum resistance of the tabletop to the ground system shall exceed 40,000 ohms in areas with 110 volts service and 75,000 ohms in areas with 220 volts service. A ground fault interrupt circuit also meets this requirement.

C6.4.7.5.3. Tabletop Test Criteria. The maximum resistance of conductive tabletops to the ground system shall not exceed 1,000,000 ohms.

C6.4.7.5.4. Conductive Footwear Test Criteria. All personnel shall test conductive footwear daily before use to ensure that the combined resistance of the person's body and the conductive shoes do not exceed the limit specified in subparagraph C6.4.7.5.1. Supervisors shall keep documentation of all test results, including calibration of test equipment. The test voltage of the shoe tester shall not exceed 500 volts. The short circuit current across the shoe tester electrodes (plates) should be limited between 0.5 ma and 2.0 ma. The design of the test instrument shall include built-in safeguards to prevent the test subject from experiencing electric shock. Personnel shall not test shoes in rooms or areas with exposed explosives or flammable gas mixtures. Personnel shall not wear

static generating stockings such as silk, wool, and synthetics; and shall not use foot powders, which have a drying action that can increase resistance. Dirt and grit increase resistance of conductive shoes. Personnel should avoid wearing conductive shoes outdoors and shall keep shoes clean.
C6.4.7.5.5. Test Procedure. Trained personnel shall test conductive floors and tabletops upon installation and at least annually thereafter using test equipment specifically designed for this purpose and shall keep records of all test results for at least 5 years. Testing shall proceed only when the room or area is free from exposed explosives and flammable gas mixtures. The test procedure shall measure the resistance of the floor between an electrode attached to the ground system and an electrode placed at any point on the floor or tabletop and also as measured between two electrodes placed 3 ft [1 m] apart at any points on the floor or tabletop. Make both electrode-to-electrode and electrode-to-ground system measurements at five or more locations in each room, with at least two of the test locations in heavily trafficked areas. If the resistance measurement changes appreciably with time, record the resistance at the 5-second interval. To prevent biased measurements, locate the electrodes for both the electrode-to-electrode and electrode-to-ground measurements a minimum of 3 ft [1 m] away from an earth ground or other grounded items such as a door frame, ordnance handling equipment, or any grounded item resting on a conductive floor. Only trained personnel shall operate and maintain test instruments. NOTE: The size of the floor or tabletop may make it impractical to conduct five surface resistance (electrode-to-electrode) or resistance-to-ground measurements and still remain 3 ft [1 m] away from all grounded items. In such cases, take enough measurements to ensure adequate testing of all parts of the conductive surface and document the justification for a reduced number of electrode-to-electrode or electrode-to-ground measurements in the grounding system test plan.
C6.4.8. Handling Low-Energy Initiators. Low-energy initiators are those that initiate when subjected to 0.1 joule of energy or less. The history of accidents involving low-energy initiators and their sensitivity to ESD requires supplemental safety precautions when handling these devices. When manufacturing, processing, using, or testing low-energy initiators, controls implemented are:
C6.4.8.1. Workstations shall have conductive floors or mats and conductive tabletops, unless the initiators are in their original packaging or are part of a finished metallic end item that provides complete protection from electromagnetic or electrostatic energy.
C6.4.8.2. Operators shall wear both conductive shoes and a conductive wrist strap bonded to the ground system. Operators shall test conductive shoes per subparagraph C6.4.7.5.1. and wrist straps per subparagraph C6.4.7.2. Special contact creams may be used to decrease the resistance to the required value.
C6.4.8.3. Operators shall wear non-static generating clothing.
C6.4.8.4. All metal parts of equipment shall be electrically bonded together and grounded.
C6.4.8.5. Glass, acrylic, or polycarbonate materials required for transparent shielding shall be periodically coated with an anti-static material to prevent buildup of static electricity.
C6.4.8.6. When procedures establish a humidity range for operations, the relative humidity and temperature in the work area shall be checked before starting operations and throughout the workday. (See section C6.6. for more information.)
C6.4.8.7. Metal surfaces subjected to rubbing or friction shall not be painted. If a lubricant is necessary, it shall not raise the metal's surface resistance above 25 ohms.
C6.4.8.8. Work shall not be conducted in the vicinity of actual or potential electromagnetic or electrostatic fields. Sources of static electricity and electromagnetic energy include radio transmission, electrical storms, transformer stations, high voltage transmission lines, improperly grounded electric circuitry, rotating equipment, belts, etc. Adequate lightning protection, grounding, and adequate resistances for fixed sources of energy shall be established for locations with low-energy initiator operations. These locations shall be shielded to afford protection against local mobile radio transmission.
C6.4.8.9. Locate electrical equipment out of the range of an operator working with a low-energy initiator. When using soldering irons, recommend obtaining commercially available irons made of anti-static plastic housings that are grounded and equipped with devices capable of limiting short-circuit current below initiating thresholds.
C6.4.8.10. When not part of an end item or end item subassembly, transport initiators only when packed according to the latest DOT requirements or equivalent packaging that protects against initiation by ESD.

C6.4.8.11. Periodically measure any potential static charges at workstations to ensure controls are working. Refer to Reference (u) for additional information.