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Chapter 6.1 Battery Safety

This could be you . . .

A sealed metal box containing a lead acid battery exploded and fatally injured a technician. Sparks from open electrical contacts in the box ignited the hydrogen released by charging and discharging the battery.

A battery pack with four D cell lithium batteries accidentally shorted on a metal work table and the battery exploded. A nearby technician fell from a chair but escaped serious injury.

A worker was checking out an auto-starter motor by placing the terminals across a lead acid battery. The motor was suspended over a battery. The motor ignited the venting hydrogen and blew the lid off the battery. The worker escaped serious injury from flying debris and battery electrolyte.

6.1.1 Applicability of this chapter

6.1.1.1 You are required to follow this chapter if you:

- a. Purchase, store, test, handle, maintain, or use batteries.
- b. Purchase, design, develop, build, handle, or test devices or systems that use batteries.
- c. Approve the activities in subparagraphs a or b above as an employee of or support contractor to the Safety and Mission Assurance Directorate (mail code NA), the Energy Systems Division (mail code EP), or the Facilities Management and Operations Division (mail code JM).

6.1.2 Scope of this chapter

6.1.2.1 This chapter defines the specific provisions required for handling batteries to be used for common battery, facility, and ground test for spaceflight operations as follows:

- a. **Common battery operations**, with the exception of disposal, are excluded from this chapter. These applications include batteries used in calculators, watches, cell phones, pagers, car batteries, etc. A list of these exemptions is contained in paragraph 6.1.4 of this chapter.
- b. **Facility operations** include a wide range of ground support operations that may or may not support space operations. Examples of such are ground test of non-flight batteries, new battery designs including research and development battery projects, maintenance facility batteries, battery back-up power systems, batteries for vehicles, etc.
- c. **Ground testing for spaceflight batteries** includes testing of prototype, flight, and flight type batteries to be used on ISS, or any NASA-related spacecraft application.

NOTE: The hazards associated with facility and spaceflight operations are unique to each other and require a different approval process. The extent of the hazard controls and verification

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required depends on the battery chemistry, capacity, complexity, charging profile, and application. A battery is defined as two or more cells connected in a series or parallel configuration.

6.1.3 Battery application

6.1.3.1 Certain battery chemistries are toxic and potentially lethal in certain environments. For instance, some batteries that are safe for facility operations may not be safe inside a crewed vehicle. It is important to understand the battery's application and seek advice from the appropriate experts. The activities listed in paragraph 6.1.1 require coordination and approval from one of the following sections depending on the application:

- a. **Facility Operations.** The Safety and Mission Assurance Directorate (NA) and the Utilities Branch of the Facilities Management and Operations Division (JM5). For battery facility operations, paragraph 6.1.4 lists the exceptions to the approval requirements.
- b. **For Ground Test for Spaceflight Operations.** The Safety and Mission Assurance Directorate (NA) and the Energy Systems Division (EP). For spaceflight battery uses, reference JSC 20793, "Crewed Space Vehicle Battery Safety Requirements."

6.1.4 Exemptions from approval requirements

6.1.4.1 There are currently no exemptions from the approval process for batteries used for facility or spaceflight operations. Refer to paragraph 6.1.2 for the definition of facility and ground test for spaceflight operations. The following batteries in the following applications do not require the approvals listed in paragraph 6.1.3 above if used for non- spaceflight applications. These exemptions apply only if you use the batteries or devices as the manufacturer intended with no modifications:

- a. In general, the battery uses an electrochemical couple (chemistry) that is well known, well understood, and nontoxic, and that has a long application history. Also, the battery is used in a device that:
 - (1) Is a commonly used commercial design and available commercially.
 - (2) Usually includes a user's manual that describes the use or maintenance of the battery
 - (3) Uses a battery with well-known hazards that are controlled with the battery's or device's design
- b. Lead-acid, nickel-cadmium (Ni-Cd), or nickel-iron secondary batteries to start or power:
 - (1) Vehicles such as cars, trucks, buses, mobile cranes, mobile manlifts, electric drive wheelchairs, earth-moving equipment, forklifts, and other materials-handling equipment
 - (2) Standard boats and aircraft
 - (3) Facility emergency lighting systems, emergency communications systems, or other commercially available emergency power systems
- c. Alkaline-manganese; lead-acid; lead-acid batteries with immobilized electrolyte(gel-type); leclanché cells; lithium-ion and lithium-ion polymer secondary batteries; lithium primary coin or button cells of 300 milliamperes or less; mercuric oxide-zinc; Ni-Cd; nickel-metal hydride; silver-zinc button cells; silver-zinc primary; and silver-zinc secondary batteries with no

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modifications may be used in the following commercial off-the-shelf (COTS) equipment for personal use and non-flight applications according to manufacturer's instructions:

- (1) Calculators, personal digital assistants, laptop computers, and small computer uninterruptible power supplies
- (2) Watches and clocks
- (3) Radios, walkie-talkies, and cellular telephones
- (4) Flashlights and lanterns
- (5) Cameras and flashes
- (6) Portable sound and video recorders and players, including battery-operated microphones, television sets, and compact disc players
- (7) Hearing aids
- (8) Radiation detectors (Radiacs)
- (9) Metal detectors
- (10) Test equipment such as multimeters, ohm-meters, or pyrometers
- (11) State-of-the-art medical equipment in wide use in hospitals and clinics

If a battery use is not listed above but meets the criteria in subparagraph 6.1.4.1.a of this chapter, contact the Safety and Mission Assurance Directorate (NA) and the Utilities Branch of the Facilities Management and Operations Division (JM5). You may request a deviation from this chapter.

6.1.5 Battery hazards

6.1.5.1 A Material Safety Data Sheet (MSDS)/ Safety Data Sheet (SDS) shall always be available for anyone using a nonexempt battery, regardless of the application (see paragraph 6.1.4 for a list of exceptions). Always refer to the MSDS/SDS to learn about specific hazards for the planned application. The Energy Systems Test Area (ESTA) covers planned abusive testing under its General Operating Procedure Manual (GOPM), EP-WI-004. General battery hazards may be any of the following:

- a. **Crushing Forces.** Certain batteries may require a lifting plan due to their mass to avoid crushing forces due to drop, which can then lead to other hazards. Chapter 8.5, "Lifting Operations and Equipment Safety," provides the details.
- b. **Electrical Potential.** All batteries possess the potential for electrical shock if mishandled or abused. Depending on the battery and chemistry, this can range from minor personal discomfort to a lethal shock.
- c. **Electrolyte Leakage.** A battery can leak electrolyte from a number of conditions such as charging or discharging incorrectly, dropping, penetration, short circuit, vacuum, etc.
 - (1) If electrolyte gets on your skin or clothing, flush the affected area with large amounts of water and get medical attention immediately. Do not put any neutralizing solution on your skin.

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(2) If electrolyte gets in your eyes, flush thoroughly and continuously with only water for a minimum of 15 minutes while rolling your eyes and lifting your eyelids. Do not put any neutralizing solution in the eyes. Get medical attention immediately; you may need help effectively flushing your eyes.

- d. **Environmental Pollution.** All batteries contain materials that are considered to be an environmental pollutant if venting or leakage occurs. Planned venting and release of polluting compounds shall be inside a controlled environment designed to handle such an event. Proper disposal of all batteries is required (see paragraph 6.1.12).
- e. **Fire:** Many batteries contain flammable electrolyte. Planned fires shall be inside a controlled environment designed to handle such an event. Completely prevent unintentional abuse of a battery, mechanically or electrically. An abuse chamber is recommended for all planned off-nominal abuse or safety tests.
- f. **High Sound Levels.** High sound levels include noise from the battery bursting or venting. Planned venting shall be inside a controlled environment designed to handle such an event. High sound levels can also be encountered in the vibration test area.
- g. **Oxygen-deficient Atmosphere.** This is typically not a hazard since the toxic atmosphere will come into effect before asphyxiation occurs. However, inadvertent or excessive release of inert gases used during battery testing may cause an oxygen-deficient atmosphere and should be examined on a case-by-case basis.
- h. **Shrapnel or Blast Wave Over-Pressurization.** High-temperature venting, rupture, or explosion may occur when a battery gets too hot from external heat sources or heat generated by the battery itself (runaway reaction). Planned venting or bursting shall be inside a controlled environment designed to handle such an event. Observe the following precautions:
 - (1) Hydrogen or mixtures of hydrogen and oxygen generated during open circuit storage, discharging, over-discharging, charging, and overcharging can be explosive.
 - (2) Brazing or soldering operations may be necessary for attaching pressure fitting and sealing vent on the battery for pressure testing. Test articles need to be prepared properly; that is, fully discharged, vented with a separate hole and have liquid electrolyte removed before attaching the pressure fitting.
- i. **Temperature.** During abusive conditions such as overcharge or over-discharge, battery case temperature may exceed the upper touch temperature limits of 45 °C (113°F). Planned abusive testing shall be done in the appropriate thermal chamber and the temperature verified before handling.
- j. **Toxic Atmosphere.** Batteries contain materials that may be considered toxic. This can be in the form of a liquid or a gas. In addition, batteries contain strong corrosives, either acid or alkali depending on battery chemistry. Planned abuse or safety tests should include purging of the test chamber after testing, with an inert gas, for a minimum of 4 hours. For batteries that have a highly toxic electrolyte (tox 4), a minimum of 8 hours of purging is recommended. Verify the absence of toxic gases by gas analysis before the chambers are opened to remove the test articles.

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NOTE: Toxicity categorization is based on the toxicity of the electrolyte and the clean up capability for a specified habitable volume. For batteries this categorization can range from a 4 to 0, with the exception of 3, which is for chronic health hazards due to damage of internal organs. See reference document JSC 25159, "Toxicological Hazard Assessments on Batteries used in Space Shuttle Missions".

6.1.6 General battery precautions

6.1.6.1 You shall follow these precautions in both facility and ground testing of spaceflight battery operations:

- a. Have all nonexempt batteries or related assembly and test procedures approved by Energy Systems Division personnel before performing any work. Assembly procedures shall include, where appropriate, mandatory inspection points and step-by-step assembly instructions or drawings.
- b. Keep metallic objects, which could cause short circuits or arcing, away from battery terminals.
- c. While storing or operating batteries, store or operate such that accidental shorting cannot occur. Use a nonconductive rack or a rack with a nonconductive coating, or use the original manufacturer's storage container or individually wrapped in plastic bags.
- d. Don't wear rings, metal watchbands, chains, or other jewelry while handling or working with batteries. If you can't remove your ring, cover it with insulation, tape, or a glove.
- e. Erect barriers or shields to protect nearby personnel from exploding or rupturing batteries in battery charging areas.
- f. Provide adequate ventilation systems.
- g. Never attempt to charge a non-rechargeable (primary) battery.
- h. Never charge or discharge batteries by any device or method other than that supplied by the equipment manufacturer. If a commercial battery test stand is to be used, a Test Readiness Review (TRR) shall approve the test before operations can proceed.
- i. Consider all leakage from batteries as toxic and corrosive. Take precautions to avoid touching, ingesting, or inhaling battery electrolyte liquid or gases.
- j. Never store batteries or battery electrolyte with food or drink items.
- k. Construction or Test Operations: Provide facilities for quick drenching or flushing within 25 feet of battery handling areas.
- l. Verify that the eyewash station is operational before starting battery work by flow testing a plumbed-in unit or visually inspecting a self-contained unit. Have an approved safety maintenance process for eyewash and safety shower upkeep that meets the requirements in Chapter 10.1, subparagraph. 10.1.3.1.e of this Handbook.
- m. All aqueous battery systems shall be vented (not gas tight).
- n. Use spot welding, not soldering, to attach leads directly to a cell. Soldering generates excessive heat and can lead to the cell venting. Never do any hot work unless you are

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qualified and understand the hazards of hot work on cells and batteries. (Hot work permit needed; see chapter 5.8, "Hazardous Operations, safety practices and certification," of this Handbook.)

- o. If a battery vents or catches on fire, take precautions to avoid inhalation of the fumes. In the event of an unplanned fire, call x33333.
- p. Provide equipment and supplies for emergency flushing and neutralizing spilled electrolyte in areas where electrolyte is used outside of the battery or the possibility exists for venting or leaking, such as in a test area. Wastes or wastewaters generated during flushing or neutralizing spilled electrolyte may not be discharged to the storm sewer, ground, or ditch unless they are generated during emergency response. Before discharging wastes or wastewaters to the sanitary or process sewer, you shall get approval from the Environmental Office. In general, call uncontrolled spills or releases of electrolyte into the Emergency Operations Center, x33333, and unplanned spills or releases into Facility Work Control, x32038. Always reference the MSDS/SDS for neutralizing agents, but in general use:
 - (1) Sodium carbonate or sodium bicarbonate (baking soda) for spills involving an acid electrolyte
 - (2) Citric acid for spills involving an alkali (base) electrolyte

Note: This subparagraph applies to unplanned releases and does not apply to routine discharges to the sanitary sewer that have been approved by the Environmental Office via JF1109, "Sanitary Sewer Discharge Approval Request."
- q. Review the MSDS/SDS for each battery and battery chemistry and have this MSDS/SDS locally available for operators of the battery.
- r. The ESTA routinely handles abusive tests on batteries, such as the ones listed below. Unless planning an abusive test with a TRR, take the following precautions:
 - (1) Never attempt to charge primary (non-rechargeable) batteries. They could vent toxic materials or explode.
 - (2) Do not allow short-circuiting or high-current discharging of batteries.
 - (3) Never allow overheating or exposing batteries to temperatures higher or lower than the manufacturer's recommendations.
 - (4) Do not allow over-discharging a battery. This includes discharging at high currents or below the manufacturer's recommended voltage cutoff.
 - (5) Do not allow opening, crushing, puncturing, or otherwise mutilating a battery.

6.1.7 Facility operation requirements

6.1.7.1 You shall follow these precautions:

- a. Provide emergency eyewashes and showers for quick drenching or flushing in accessible locations within 25 feet of the following activities:
 - (1) Doing maintenance work on or with electrolyte- or corrosive-based batteries (examples:

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removing battery cap to fill or refill or adding electrolyte or water)

- (2) Moving or handling batteries where they could be dropped
- b. Maintain batteries only in designated battery maintenance areas.
- c. Follow these requirements when lifting or moving batteries:
 - (1) See Chapter 8.5, "Lifting Operations and Equipment Safety," of this Handbook.
 - (2) Use a conveyor, an overhead hoist, or other material-handling equipment to handle heavy batteries, such as those used in forklifts, etc.
 - (3) Use a suitable spreader when lifting batteries with an overhead lifting device. This prevents the lifting cables or chains from squeezing and possibly cracking the battery case.
 - (4) Protect battery terminals and exposed conductive surfaces with nonconductive materials when using cables or chains for lifting.
 - (5) Use proper terminal straps to lift a battery, unless the battery case has lifting pad eyes or similar attachment points.
- d. Ground all switch, control, light, and indicator cases as described in NPA 70, "National Electric Code," Article 250, "Grounding and Bonding."
- e. If possible, route alternating and direct current circuits separately.
- f. Provide fire protection in charging areas.

6.1.8 Facility operation requirements for lead-acid batteries

6.1.8.1 You shall observe the following precautions to protect yourself from the following hazards:

- a. General lead-acid battery precautions:
 - (1) Wear a face shield and goggles when handling or servicing a battery.
 - (2) Locate servicing and charging installations in areas designated for that purpose.
 - (3) Guard charging equipment for industrial trucks to prevent damage by the trucks.
 - (4) Use replacement batteries of the same amp-hour or higher rating for industrial trucks as the original batteries.
 - (5) Position industrial trucks or vehicles properly and apply the brakes before changing or charging the batteries in place.
- b. Protection from explosion and fire hazards:
 - (1) Provide appropriate ventilation to prevent an explosive hydrogen-air mixture from accumulating.
 - (2) Never smoke where batteries are being charged, serviced, or worked on; in battery rooms; and near battery cabinets. Post NO SMOKING signs.
 - (3) Prevent open flames, sparks, or electrical arcs in battery storage and servicing areas.

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- (4) Provide fire protection in battery rooms and charging areas.
- (5) Open battery compartments or covers when charging batteries to aid ventilation and heat dissipation, if applicable.
- (6) Don't do any work involving heat sources or arcing on batteries until venting all of the hydrogen or oxygen gases by purging with an inert gas or positively ventilating all spaces that could trap explosive gas mixtures. Use a combustible gas meter to confirm ventilation is complete.

c. Protection from chemical hazards:

- (1) Wear a face shield or goggles, protective aprons, gloves, and boots while mixing electrolyte, activating dry charge batteries, or doing any work that could result in an electrolyte spill.
- (2) Coat charging benches or tables with a nonconductive material that can withstand an electrolyte spill.
- (3) Provide enough ventilation to prevent acid fumes from entering areas where alkaline batteries are serviced or used.
- (4) Service alkaline-electrolyte batteries in an area isolated from lead-acid batteries.
- (5) Label acid and alkaline electrolyte battery servicing equipment carefully and keep each kind of equipment separate.
- (6) Don't use acid electrolyte equipment with alkaline batteries or alkaline equipment with acid batteries; otherwise, you may generate large amounts of hydrogen and create an explosive mixture.
- (7) Keep vent caps in place and make sure the vent caps work to avoid electrolyte spray when charging batteries. If the vents are clogged, the battery case may rupture from internal overpressure causing electrolyte to spray over a large area.
- (8) Pour acid into water when mixing electrolyte. Note: Never pour water into an acid. The intense heat of the solution can cause violent boiling on the surface of the acid and can splatter onto your skin, eyes or clothing.

6.1.9 Facility operation requirements for Aqueous Electrolyte Batteries (NiCd, NiMH, NiH₂, alkaline, silver zinc)

6.1.9.1 The aqueous electrolyte batteries such as Nickel Cadmium (NiCd), Nickel metal hydride (NiMH) and alkaline are commonly used in portable equipment and the nickel chemistries are also used widely in power tools. Silver zinc and NiH₂ batteries are not commonly used in portable equipment but used in multiple flight hardware that will be tested on ground before flight. When using or handling aqueous electrolyte batteries, you shall follow the precautions listed below:

- a. Wear safety goggles, protective gloves, and a protective apron to work with aqueous electrolyte batteries or caustic electrolyte. Potassium hydroxide is a caustic electrolyte that can cause severe burns. Make portable battery containers for vented cells as follows:

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- (1) Keep the free volume in the battery container to an absolute minimum. The free volume is the space in which hazardous gases may accumulate. There is no restriction on volume filled with other materials.
 - (2) Coat the battery terminals, interconnects, and wiring with a suitable alkali-resistant potting material. Coat all current-carrying battery components, if possible.
 - (3) Make sure the potting material doesn't seal vented cells.
 - (4) Provide an easily removable cover for the battery container.
 - (5) Consider using a splash-proof pressure vent to relieve pressure in the container.
 - (6) Make sure that all individual cells are vented.
 - (7) Don't seal vented cells in a container that will trap gases.
- b. To control explosion and fire hazards:
- (1) Charge in a well-ventilated area under the manufacturer's recommendations with the battery box cover removed.
 - (2) An approved test program that has undergone a TRR may deviate from the manufacturer's charging recommendations.
 - (3) Make sure the individual cells are able to dissipate heat to prevent overheating during charge. For each sealed battery, select cells that are matched for charge voltage capacity and charge retention.
- c. To address chemical hazards, use absorbent wicking materials to control electrolyte leakage within the battery box or case.

6.1.10 Requirements for safely using and handling lithium primary (non-rechargeable) batteries

6.1.10.1 Lithium primary batteries are of two types- those with an organic electrolyte and those with an inorganic electrolyte. In the latter case, the electrolyte is also the cathode and is commonly referred to as the catholyte. You shall take the following precautions:

- a. Be aware of the hazards of handling lithium primary batteries:
 - (1) Lithium primary batteries with the inorganic electrolyte are typically highly toxic (tox 4) and can be lethal if the gases are inhaled (TLV: 5ppm). Lithium primary batteries with the inorganic electrolyte are also explosive in nature and have a TNT equivalency (For example a pound of lithium primary batteries with the inorganic electrolyte has a TNT equivalency of a pound of TNT).
 - (2) The lithium primary batteries with the organic electrolyte are typically corrosive (tox 2). Some lithium primary batteries with the organic electrolyte also exhibit explosive behavior in an unbalanced overdischarge into reversal condition which can also occur if the batteries experience external shorts.
 - (3) Under abusive conditions, lithium primary batteries can vent, explode, and burn, releasing highly toxic and corrosive materials. For more information on the toxic and explosive behavior of these batteries, reference ESTA-OP-0-49, "Lithium Battery

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Handler Certification,” and JSC 20793, “Crewed Space Vehicle Battery Safety Requirements.”

- (4) Some of the toxic, flammable, or corrosive ingredients that can be released from lithium primary batteries with organic or inorganic electrolytes are carbon disulfide, carbon monoxide, hydrobromic acid, hydrochloric acid, hydrocyanic acid, hydrogen, methane, methyl cyanide, sulfur dioxide, thionyl chloride. Caution should be exercised to avoid inhalation of tox 4 electrolyte vapors and gases.
- b. Keep lithium primary batteries safe at all times. Never put them on conductive surfaces, on metal shelves, in desks, in electronics assembly areas, in receiving inspection areas, in machine shops, etc.
- c. Assemble, process, and handle lithium cells and battery packs with caution:
 - (1) Protect batteries under assembly from shorting against foreign objects by storing them in plastic bags or in the original carton.
 - (2) Use spot welding, not soldering, to attach leads directly to a cell.
 - (3) Return lithium batteries to a controlled storage area in plastic or the original containers when the assembly or fabrication process is interrupted or stopped for any reason other than normal shift changes.
- d. Store lithium primary batteries at room temperature or lower in a dedicated, dry, well-ventilated location indoors in the appropriate storage bags. Batteries that will not be flown within 6 months of procurement should be stored in a refrigerator or freezer in appropriate storage bags to reduce capacity loss due to uncontrolled environments.
- e. JSC personnel operating and handling lithium primary batteries shall be certified using ESTA-OP-0-49, “Lithium Battery Handler Certification,” or equivalent process approved by the Propulsion and Power Division.
- f. Facilities for lithium battery operations and handling shall meet the requirements of Chapter 6.1, and undergo readiness review per Chapters 6.9 and 10.3.

6.1.11 Requirements for safely using and handling lithium-ion (secondary/rechargeable) batteries

6.1.11.1 Lithium-ion batteries are commonly used in portable equipment, experiments as well as main power for several spaceflight vehicles. They come in a variety of shapes and sizes and are manufactured in commercial as well as custom-designed configurations. The lithium-ion cells have a liquid organic electrolyte and can be obtained in cylindrical or prismatic metal cans or in a pouch format made of plasticized aluminum. Some of the low capacity lithium-ion cells used for memory back-up, timer type applications can be obtained in the coin cell or pouch formats. You shall take the following precautions:

- a. Be aware of the hazards of handling lithium-ion batteries:
 - (1) The organic electrolyte in lithium-ion cells are typically of Tox-2 nature and are corrosive.
 - (2) Under abusive conditions, lithium-ion secondary batteries can vent, burn, and go into

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thermal runaway. For more information on the behavior of these batteries, reference JSC 20793, "Crewed Space Vehicle Battery Safety Requirements."

- (3) Most safety issues with lithium-ion batteries stem from the fact that the electrolyte is flammable and the battery chemistry has a very high energy density.
- b. Keep lithium-ion batteries safe at all times. Never put them on conductive surfaces or on metal shelves.
 - c. Assemble, process, and handle lithium-ion cells and battery packs with caution to prevent inadvertent shorting. Shorting can cause a cell's internal protective devices to activate in those designs that are fitted with the protective devices.
 - d. Protect batteries under assembly from shorting against foreign objects by storing them in plastic bags or in the original carton.
 - e. Use spot welding, not soldering, to attach leads directly to a cell.
 - f. Return lithium-ion batteries to a controlled storage area in plastic bags or in the original containers when the assembly or fabrication process is interrupted or stopped for any reason other than normal shift changes.
 - g. Store lithium-ion cells and batteries at room temperature or lower in a dedicated, dry, well-ventilated location, indoors.
 - h. JSC personnel operating and handling lithium primary batteries shall be certified by the Propulsion and Power Division using ESTA-OP-0-49, "Lithium Battery Handler Certification," or equivalent process approved by the Propulsion and Power Division.
 - i. Facilities for lithium battery operations and handling shall meet the requirements of Chapter 6.1, and undergo readiness review per Chapters 6.9 and 10.3.

6.1.12 What to do if a primary lithium battery emergency occurs

6.1.12.1 If a primary lithium battery emergency occurs, take the following actions as appropriate for the emergency:

- a. If the primary lithium battery has toxic or corrosive electrolyte, or you have observed leaking, venting, or increasing battery temperature:
 - (1) Clear the area of personnel and have qualified and properly equipped personnel remove the batteries to a safe area.
 - (2) If possible, disconnect the batteries electrically from associated equipment after they have stabilized.
 - (3) Dispose of them using instructions in paragraph 6.1.14 below.
- b. If the primary lithium battery has toxic electrolyte or potentially lethal electrolyte and a rupture occurs, evacuate the area and notify the fire department by calling JSC's emergency number, x33333 . Response personnel shall use air breathing equipment, such as acid or base gas cartridge respirators, plus rubber gloves and a chemical apron.
- c. If a small fire occurs:

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- (1) Use a graphite powder or a Lith-X (Class D) extinguisher to extinguish burning lithium.
- (2) Don't use water, sand, carbon tetrachloride, carbon dioxide, or soda acid extinguishers in lithium metal battery fires.

6.1.13 What to do if a secondary lithium-ion battery emergency occurs

6.1.13.1 If the lithium-ion battery under test or assembly is observed to leak, vent, or display increasing battery temperature:

- a. Clear the area of all personnel who are not qualified and properly equipped. Properly qualified and equipped personnel should remove the batteries to a safe area.
- b. If possible, disconnect the batteries electrically from associated equipment after they have stabilized.
- c. Dispose of them using instructions in section 6.1.14 below.
- d. If the lithium-ion battery has vented or caught on fire, evacuate the area and notify the fire department by calling your emergency number (x33333). Response personnel must use air breathing equipment—such as acid gas respirators, rubber gloves, and chemical apron.
- e. If a small fire occurs, use copious amounts of water to put out the fire. An ABC fire extinguisher can be used to put out a lithium-ion fire.
- f. Use these extinguishers only on nearby materials to prevent the fire from spreading.

6.1.14 Disposing of batteries

6.1.14.1 Dispose of discrepant or depleted cells as quickly as possible. The method of disposal depends on the chemistry of the battery as follows:

- a. In small quantities, you may dispose of alkaline batteries in site trash or garbage disposals. You shall dispose of large quantities of leaked or vented batteries through the Environmental Services Office (JE) support contractor using a JSC Form 1161. You can contact the facilities work control center at x32038.
- b. You shall dispose of all other battery chemistries through the Environmental Office (JE) support contractor using a JSC Form 1161. You can contact the facilities Work Control Center at x32038.

Note: Refer to JPR 8550.1, "JSC Environmental Compliance Procedural Requirements," Chapter 3, for complete information on proper disposition of batteries.

- c. If disposing of large quantities of batteries, contact the Environmental Office (JE) support contractor in advance to plan for the proper accumulation, packaging, funding, and disposal to prevent a delay. You can contact the facilities Work Control Center at x32038.

Note: This does not apply to routine generation of large quantities of batteries from test activities where a JSC Form 1104, "Waste Notification," has been submitted.

- d. Before contacting the Environmental Office (JE) support contractor (facilities Work Control Center at x32038), perform the following actions:
 - (1) Tape each battery with fiberglass or Kapton tape across the positive terminal to prevent

Verify correct version before use at

<http://server-mpo.arc.nasa.gov/Services/CDMSDocs/Centers/JSC/Home.tml>.

JSC Form JF2420B (MS Word.....)

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inadvertent shorting. Place batteries dispositioned as “scrap” in an individual Ziplock plastic bag or a plastic container for each battery.

- (2) Separate the different chemistry batteries into different storage containers. For example, do not mix nickel metal hydrides with lithium ion batteries.

6.1.15 Reference documents

- a. EP-WI-004, “Energy Systems Test Branch’s General Operating Procedure Manual (GOPM)”
- b. ESTA-OP-0-49, “Lithium Battery Handler Certification”
- c. JPR 1700.1, Chapter 5.8, “Hazardous Operations: Safe Practices And Certifications”
- d. JPR 1700.1, Chapter 8.5, “Lifting Operations And Equipment Safety”
- e. JPR 8550.1, “JSC Environmental Compliance Procedural Requirements”
- f. JSC 25159, “Toxicological Hazard Assessments on Batteries used in Space Shuttle Missions”
- g. JSC 20793, “Crewed Space Vehicle Battery Safety Requirements”
- h. NASA Reference Publication 1099, “Lithium/Sulfur Cell and Battery Safety”
- i. NFPA 70, “National Electrical Code,” Article 250, “Methods of Grounding Conductor Connection to Electrodes”
- j. MSDS/SDS for the battery chemistry of the planned application