LG Energy Solution
Energy Storage System (ESS) Product Safety Guide

Section 1: Hazard(s) Identification

Hazard Classification: Electrical, physical, chemical, environmental and fire risk

		
Electricity Hazard	Physical Hazard Chemical Hazard Environmental Hazard	Flammable Material Hazard

Caution:

This document includes descriptions of products that are dangerous if handled improperly. Property damage or injuries to people, including loss of life, are possible.

LG Energy Solution ESS products contain lithium-ion batteries and are sources of energy. Do not expose to temperatures and humidity levels above the specified operating ranges as specified below in Section 2c, immerse in liquid, puncture, crush, short circuit, incinerate, or force discharge. Internal or external short circuits can cause severe overheating and provide ignition sources that can result in fires of surrounding materials or materials within the cell or battery. The battery design is such that when the battery integrity is completely maintained, the electrode materials and electrolyte remain contained within the battery. Only cases of abuse (mechanical, thermal, and electrical) will result in risk of exposure.

This document provides safety guidelines that encompass both Grid ESS and Residential ESS. For content that does not cover both, we have specified which type of ESS it pertains to.

In this document, we refer to battery cells (or cells), battery packs (or packs), battery racks (or racks), and battery enclosures (or enclosures). An enclosure refers to the structure that houses the battery racks.

[Grid ESS]
Enclosures, typically used for grid purposes, are containers or buildings measuring 20 feet (approximately 6.1m) or 40 feet (approximately 12.2m). A battery pack consists of multiple series-parallel battery cells, which are electrically connected in series and housed within a battery rack.

[Residential ESS]
A battery pack consists of multiple series-parallel battery cells, which are electrically connected in parallel and housed within a battery rack or enclosure. However, some residential battery packs may not be installed in a rack or enclosure.

Battery cells refer to the basic electrochemical devices storing the energy. LG Energy Solution ESS products are typically restricted to battery packs or battery racks.

1A: High Voltage Hazards

During normal conditions, the LG Energy Solution ESS does not pose an electrical hazard. LG Energy Solution ESS products include designed safeguards to tolerate a number of expected abuse conditions. The battery cells are sealed within the battery pack. Connectors are touch-safe and the battery pack exterior is isolated from internal cell components. Battery packs are floating (i.e. positive or negative terminals are not grounded) with the battery pack housing and battery rack being grounded.

If the battery enclosure, battery rack, battery packs, and/or safety circuits have been compromised or have been significantly damaged, the ESS product poses significant risks of high voltage and electrocution. Regardless of the state of charge and even in a normally discharged condition, battery packs contain electrical energy and mishandling can cause injury or death. If there is visible damage to an LG Energy Solution ESS product, preventative measures should be taken until the danger is assessed and next steps identified.

WARNING: Due to the high voltage and the associated electrocution risks, NEVER DISASSEMBLE LG Energy Solution ESS products. Contact LG Energy Solution tor proper installation and removal instructions.

1B: Mechanical Damage Hazards

When not in use and prior to installation, battery packs should be stored in their original packaging for protection from mechanical damage.

Hazardous conditions can result from mechanical damage, including:

- Fire
- Electric shock
- Injuries due to sharp edges
- Electrolyte leakage
- Individual cells rapidly heating up, cell venting, thermal runaway, and propagation

If Battery Packs Are Dropped:

- Battery packs must be handled carefully and any exposure to shock or excessive mechanical load could cause significant damage. In the event of a pack being dropped during handling, storage, or installation, the following steps should be followed.

  Step 1: Perform visual inspection

  For a period of least twenty (20) minutes after the event, undertake a detailed physical inspection and note if there are unusual odors. Should there be abnormal conditions, please refer to:

  - Section 2D: Hazards Associated with Leaked Electrolyte
  - Section 2E: Hazards Associated with Vented Gases
  - Section 4: First Aid Measures
  - Section 5: Firefighting Measures

In the absence of abnormal conditions, proceed to Step 2 below.

Step 2: Perform voltage check
To confirm the electrical integrity of the battery pack, a voltage check should be performed. To avoid injury or electrical shock, personnel must not touch metal parts. When measuring the voltage, the installer should wear insulated gloves and avoid body contact with any metal parts. After the voltage check, repack the battery into its original packaging box.

[Voltage Verification for Grid ESS]
Measure the voltage between the negative terminal of the pack and the pack base plate to ensure the battery pack terminals are floating, and record the voltage value. Perform the same procedure for the positive terminal.

[Voltage Verification for Residential ESS]
Since the voltage measurement method varies by model, please contact your local LG Energy Solution service center and follow the LG Energy Solution guide for voltage measurement.

Step 3: Set aside the dropped battery pack
Regardless of whether the battery pack has visible damage, any pack that has been dropped should not be used. Batteries that have failed the voltage check should be repacked into its packaging box and have a "V" mark noted on the top of the packaging box.

Step 4: Store the pack
Keep the pack indoors and protect the pack from direct sunlight, rain, snow, and the elements. Lithium-ion cells or batteries, that have been damaged or identified by the manufacturer as being defective for safety reasons, that have the potential of producing a dangerous evolution of heat, fire, or short circuit (*e.g.,* those being returned to the manufacturer for safety reasons) may be transported by highway, rail or vessel only, and must be packaged and shipped according to the Code of Federal Regulations Title 49 → Subtitle B → Chapter I → Subchapter C → Part 173 → Subpart E → §173.185.

1C: High Temperature Exposure Hazards

The normal operating ranges for LG Energy Solution ESS products are temperatures of 0~40°C (32~104°F) with a non-condensing humidity value of less than 85%. The LG Energy Solution ambient temperature recommendation is 19~27°C (66.2~80.6°F) based on the battery enclosure inlet temperature.

Exposure to elevated temperatures can cause thermal runaway of battery cells, which can result in fires.

- Electrolyte leakage can occur if: Stored for more than 24 hours at temperatures above approximately 80°C (176°F). Please see Section 2D on electrolyte leak hazards.
- Cell thermal runaway can occur if: Stored for more than a few minutes at temperatures above approximately 150°C (302°F) or subjected to localized heat sources.

1D: Electrolyte Leak Hazards

Under normal conditions, the battery electrolyte is absorbed in the electrodes and the separator area within individual sealed cells. As a result, there should be no visible signs of and no contact with the electrolyte. Mechanical damage can cause a small quantity of electrolyte to leak out of a cell and in order for the electrolyte liquid to come into contact with an LG Energy Solution ESS user, mechanical damage would have to occur to the battery enclosure and/or the battery racks and/or the battery pack and/or the cell.

The electrolyte is generally composed of a volatile hydrocarbon-based liquid with a dissolved lithium salt, such as lithium hexofluorophosphate. If electrolyte liquid is released, it is likely to rapidly evaporate and leave a white residue (salt). The evaporated electrolyte is flammable and contains compounds of alkyl-carbonates. Some of the characteristics of leaked electrolyte include a colorless appearance and a sweet odor. Upon detecting an odor, evacuate the surrounding area and ventilate the area. WARNING: AVOID CONTACT WITH ELECTROLYTE.

Leaked electrolyte solution is an eye and skin irritant, as well as flammable and corrosive. If there is suspected liquid electrolyte leakage, ventilate the area and avoid contact with the liquid until the identity of the liquid is verified and proper personal protective equipment is available for protecting the eyes, skin, and respiration.

To aid in the identification of spilled liquid, chemical classifier strips can be used since the electrolyte contains organic solvents and fluoride compounds.

The following personal protective equipment is recommended: respirator with organic vapor/acid gas cartridges for air purification, full face respiration with face shield or chemical safety goggles, and safety gloves (butyl rubber or laminated film), and protective clothing. Spills can be cleaned up using a dry absorbent material, such as kitty litter, sand, or vermiculite.

1E: Vented Gas Hazards

Under normal operating conditions, venting should not occur since lithium-ion cells are sealed. If ESS products are subjected to abuse conditions or abnormal heating, venting can occur due to the vaporization of electrolyte and electrolyte decomposition products. In addition, if a hazardous and abnormal thermal runaway reaction occurs, it can often be detected by vented gases.

In the event of gas or smoke, evacuate the area and notify the local fire department and other first responders. Venting gases or smoke should be considered flammable and could unexpectedly ignite. Only trained first responders with appropriate personal protective equipment should approach a venting LG Energy Solution ESS product.

The vented gases from battery cells are dependent on cell composition, cell state of charge, and the cause of cell venting. The corresponding cell vent gases can include volatile organic compounds (VOCs), such as alkyl-carbonates, methane, ethylene, and ethane, as well as hydrogen gas, carbon dioxide, carbon monoxide, soot, and some particulates containing oxides of nickel, aluminum, lithium, copper, manganese and cobalt. There is also the possibility of the formation of phosphorus pentafluoride, POF_3 and HF vapors.

WARNING: AVOID ALL CONTACT WITH VENTED GASES AND TREAT VENTED GASES AS FLAMMABLE. Vent gas temperatures can exceed 600 ºC (1,110 ºF) and contact with hot gases can result in thermal burns. The eyes, skin, nose, and throat can be irritated by vented gas. Vented gas is flammable, and ignition sources should be mitigated.

Section 2: Composition/ Information on Ingredients

The table below for battery cells is being provided for general informational purposes.

The Occupational Safety and Health Administration (OSHA) Hazard Communication Standard, 29 CFR Subpart 1910.1200 does not apply to various subcategories including anything defined by OSHA as an "article". The LG Energy Solution ESS products are defined as "articles", and are exempted from the requirements for Safety Data Sheets.

Materials in Battery Cells			
Chemical Name	**Synonym**	**CAS#**	**Content (%)**
Aluminum	Aluminum Foil	7429-90-5	2-10
Metal Oxide (proprietary)			20-50
1,1-Difluoroethene homopolymer	Polyvinylidene Fluoride (PVDF)	24937-79-9	<5
Copper	Copper Foil	7440-50-8	5-20
Poly-olefin		9003-07-0	<1
Carbon (proprietary)		7440-44-0	10-20
Electrolyte (proprietary)			10-20
Aluminum, Copper plate and inert materials		Not applicable	Remainder

Section 3: First Aid Measures

Electric Shock / Electrocution: Seek medical assistance immediately.

Contact with Leaked Electrolyte: Flush with water immediately and wash the affected area with soap and water. Seek medical assistance if there is a chemical burn occurs or if irritation persists. Should eye contact occur, flush with significant amounts of water for 15 minutes. Do not rub the eyes. Seek medical attention.

Electrolyte Vapor or Vent Gas Inhalation: Move the person into fresh air. If there is difficult or painful breathing, seek medical attention immediately.

If electrolyte vapor (has an ester odor, which is typically a sweet or fruity odor) or vent gases are present, then there is a likelihood that the outer casing of the cell is damaged and exposure to the cell internal materials may occur. In such a case, get medical attention immediately. If possible, the following actions are recommended

- Do not handle until all safety precautions have been read and understood.
- Keep oneself away from heat/sparks/open flames/hot surfaces.
- Keep oneself away from clothing /combustible materials.
- Do not breathe dust/fume/gas/mist/vapors/spray.
- Do not get in eyes, on skin, or on clothing.
- Avoid public places and contact with others.

- Wear protective gloves/protective clothing/eye protection/face protection.
- Use personal protective equipment as required.

After skin contact:
- Wash with plenty of soap and water.
- Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower.
- Take off contaminated clothing and wash it before reuse.
- Get medical attention immediately.
- If skin irritation or rash occurs, Get medical advice/attention.
- Wear gloves when washing the patient, and please avoid contact with contaminated clothing.

After eye contact:
- Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do so. Continue rinsing.
- Get medical attention immediately.

After inhalation:
- Remove victim to fresh air and keep at rest in a position comfortable for breathing.

- Get immediate medical advice/attention.
- If breathing is stopped or irregular, give artificial respiration and supply oxygen.

After swallowing:
- Rinse mouth.
- Immediately call a poison center or doctor/physician.
- Get immediate medical advice/attention.
- Whether to induce vomiting: Consult with a doctor for advice.

Section 4: Firefighting Measures

[Response Measures During Smoke Generation Incidents]

Responding to a Battery Enclosure high temperature event: There can be cases where the battery enclosure which houses the battery racks experiences a rise in temperature. Note that this may not always be accompanied by externally visible venting of smoke or gases. However, internally inside the enclosure there could be venting. As a result, there is the possibility of pressure buildup inside the enclosure due to these combustible gases which can ignite and explode. Therefore, never open the enclosure door and maintain a minimum distance of 10 meters from the enclosure. Additionally, never cut off internal power to ensure the smooth operation of the Active Ventilation System (AVS) (unless the AVS power is supplied by a UPS). Immediately notify the LG Energy Solution representative and the nearest fire station upon the occurrence of a smoke generation incident.
In the event of fire department dispatch, whether to proceed with additional water application to the exterior of the enclosure must be executed in consultation with LG Energy Solution representatives.

Before Opening the Battery Enclosure Door: Response measures may vary depending on the smoke situation. Therefore, maintain continuous communication with the LG Energy Solution representative until they arrive on site to receive appropriate guidance for the specific smoke incident. Once AVS normal operation is confirmed, firefighters who have arrived on site should approach the enclosure, connect the fire nozzle to the FDC (Fire Department Connection), and decide whether to add more water based on the LG Energy Solution representative's guidance.

Opening of closed Battery Enclosure: After reconfirming normal AVS operation, if the LG Energy Solution representative or firefighters decide to have an enclosure door opened, the door opening operation should be performed remotely at a safe distance using non-conducting ropes, hooks, poles, or similar devices without anyone standing directly in front of the door. The main intent is to minimize personnel exposure in front of the open door or to avoid a life-threatening situation due to heated gas or a flying object by potential explosion.

[Notes]

Development of Fire: If a fire develops, the Incident Commander should determine whether an attempt will be made to suppress the fire (aggressive firefighting) or allow the battery to burn itself out, while protecting surrounding materials (defensive firefighting).

Virtually all fires involving lithium-ion batteries can be controlled with water. Based on currently available information, water has been found to be the most effective agent for controlling lithium-ion battery fires. Water can help suppress flames, cool cells and battery packs, and limit thermal runaway propagation. If water is used, there is a possibility that the electrolysis of water (which is the splitting of water into hydrogen and oxygen) can contribute to the flammable gas mixture formed by venting cells and the burning of plastic and other combustibles. Abundant and significant amounts of water should be used to fight a lithium-ion battery fire.

Gaseous agents (carbon dioxide (CO_2), Novec 1230, or FM-200) or dry chemical suppressants may temporarily suppress flaming of lithium-ion battery packs, but they will not provide sufficient cooling of lithium-ion batteries and will not suppress the propagation thermal runaway. Metal fire suppressants, such as copper powder or graphite powder are not appropriate agents for suppressing fires involving lithium-ion battery packs as they are unlikely to be effective.

A battery fire may continue for several hours and it may take 24 hours or longer for the battery pack to cool. A lithium-ion battery fire that has been extinguished can re-ignite due to the exothermic reaction of constituent materials from broken or damaged cells. To avoid this, remove sources of ignition and cool the burned mass by flooding with water.
In the event of fire department dispatch, whether to proceed with additional water application to the exterior of the enclosure must be executed in consultation with LG Energy Solution representatives.

Aggressive Firefighting: One possible approach for aggressive firefighting is to apply abundant amounts of water into the battery enclosure. Applying water into the battery enclosure may help provide cooling of the incident cell and could slow down the propagation. If a decision is made for trained first responders to apply water, it should be noted that plenty significant amount of water needs to be available and responders should maintain safe distances at all times.

Defensive Firefighting: One possible defensive reaction to a fire is to allow the fire to burn itself out (self-extinguish). Simultaneously, fire crews may spread water from a safe distance to reduce exposures to and diffusion of smoke. Please be aware that lithium-ion batteries can burn for several hours and there is the possibility of re-ignition events.

Firefighter Personal Protective Equipment: Firefighters should protect themselves at all times and wear turnout gear rated for fire protection, as well as a self-contained breathing apparatus (SCBA). There is a possibility that cells or packs could develop flames or leak potentially hazardous organic vapors if exposed to excessive heat, fire or overvoltage conditions. These vapors may include, but are not limited to carbon monoxide, hydrogen gas, carbon dioxide, volatile organic compounds (VOCs), soot, and particulates containing oxides of nickel, aluminum, lithium, copper, and cobalt. There is also the possibility that vapors of phosphorus pentafluoride, POF_3 and HF may form.

Fire Behavior Considerations: Some conditions and situations that can potentially occur during the course of the fire should be considered. This section examines these potential conditions, risks, and safety concerns. Lithium-ion battery fires can cause abnormalities such as Backdraft and Flashover.

Backdraft: A backdraft phenomenon occurs when a fire in an enclosed space depletes the oxygen, making the fire appear extinguished or smolder, and then it reignites explosively with the sudden introduction of a large amount of external oxygen. Many battery enclosures are isolated fire-resistant structures, so when a fire proceeds, the combustion process typically involves slow smoke generation while lacking a supply of oxygen. In the event that large amounts of air (oxygen) are supplied to hot flammable gas, an explosive ignition can occur momentarily, resulting in backdraft.

Flashover: Flashover is the transition phase in the development of a contained fire in which surfaces exposed to thermal radiation from gases in excess of 600°C (1112°F), reach ignition temperature more or less simultaneously and fire spreads rapidly through the space. This is the most dangerous stage of fire development.

The following should be considered in a lithium-ion battery fire.
1) Flashover appears more frequently than backdraft.
2) During Backdraft and Flashover, windows can be broken, thereby enabling smoke and flames to hit the openings as shock waves are generated. This can result in parts of the enclosure collapsing.
3) If the combined gas generated by the fire occupies about 25% of the total space, an explosion can occur. If high-temperature vented gases are concentrated in a corner of the enclosure, an explosion can occur when the enclosure door is opened for search operations or for any other reason.

4) Explosive pressure generated within a limited space is a fatal hazard. Pressure levels higher than ambient pressure can destroy windows, collapse partitions, and even collapse brick walls.

When heat is transferred directly to the lithium-ion battery, thermal runaway can occur, which can result in an explosion. Cooling the lithium-ion battery through copious amounts of water and venting of smoke and gas away from the battery enclosure is the recommended approach for handling lithium-ion battery fires.

Section 5: Leak Response Measures

A. Personal precautions, protective equipment and emergency procedures

- Protective equipment: Wear proper protective equipment

- Emergency procedures:
On Land: Place material into suitable containers and call local fire/police department.
In Water: If possible, remove from water and call local fire/police department.

- If required, notify relevant authorities according to all applicable regulations.

B. Environmental precautions

- Prevent runoff and contact with waterways, drains or sewers.
- Advise emergency services.

C. Methods and materials for containment and cleaning up

- Control personal contact by using protective equipment.
- Prevent, by any means available, contaminants from entering drains or waterways.
- Dispose of waste in accordance with local regulation.

Section 6: Handling and Storage

A. Precautions for safe handling
- No special protective clothing required for handling individual cells.
- Do not expose battery or cell to extreme temperatures or fire.
- Do not disassemble, crush or puncture battery.
- Do not overcharge or over discharge the battery.
- Do not connect (short circuit) positive and negative terminals.
- Do not place the batteries on conductive metal.
- Charging without approval from LG Energy Solution is prohibited. Only charging and discharging through compatible inverters are allowed.
- Even if forced charging is necessary, it is prohibited for anyone other than LG Energy Solution / ASC personnel to perform forced charging.

B. Conditions for safe storage, including any incompatibilities
- Store in a cool, dry place.

Section 7: Exposure Controls/Personal Protection

A. Exposure limits
○ ACGIH TLV
- Not available
○ OSHA PEL
- Not available

B. Engineering controls
- Keep away from heat and open flame.
- Store in cool and dry place.

C. Personal protective equipment
○ Respiratory protection
- Not required during normal operations.
- SCBA required in the event of fire.
○ Eye protection
- Not required beyond safety practices of employer.
○ Hand protection
- Required to use insulation gloves.
○ Skin protection
- Steel toed shoes recommended for large container handling.

Section 8: Stability and Reactivity

A. Chemical Stability
- Stable during normal operating conditions.

B. Possibility of hazardous reactions
- None during normal operating conditions.

C. Conditions to avoid
- Avoid exposure to heat, high moisture, foreign particles, open flame, corrosives, etc.
- Do not puncture, crush or incinerate.

D. Incompatible materials
- None during normal operating conditions.

E. Hazardous decomposition products
- None during normal operating conditions.
- If cells are damaged, hydrogen fluoride, hydrogen gas, hydro carbons and carbon monoxide may be released.

Section 9: Toxicological Information

A. Information on the likely routes of exposure

○ (Respiratory tracts)

- None during normal operating conditions.

○ (Oral)

- None during normal operating conditions.

○ (Eye, Skin)

- None during normal operating conditions.

B. Delayed and immediate effects and also chronic effects from short and long term exposure

○ Acute toxicity

* Oral

- This product does not elicit toxicological properties during routine handling and use.

* Dermal

- This product does not elicit toxicological properties during routine handling and use.

* Inhalation

- This product does not elicit toxicological properties during routine handling and use.

○ Skin corrosion/irritation

- No irritation.

- If the cells are opened through misuse or damage, discard immediately. Internal components of cell are irritants and sensitizers.

○ Skin sensitization

- No sensitization.

- If the cells are opened through misuse or damage, discard immediately. Internal components of cell are irritants and sensitizers.

○ Reproductive toxicity

- This product does not elicit toxicological properties during routine handling and use.

Section 10: Transport Information (non-mandatory)

A. UN No.
- 3480 / 3481

B. Proper shipping name
- Lithium Ion Batteries / Lithium Ion Batteries contained in equipment

C. Hazard Class
- Class 9
- Hazard label: Miscellaneous

D. Packing group
- II

E. Special precautions for user related to transport or transportation measures

○ ICAO/IATA
- Packing Instruction: 965, 967
- Maximum Gross Weight per Package on Passenger and Cargo Aircraft: 5 kg
- Maximum Gross Weight per Package on Cargo Only Aircraft: 35 kg
- Special Provision: A45, A88, A99

○ IMO
-Packing Instruction: P903
- Special Provision: 188, 230, 310, 957
- EmS: F-A, S-I

○ US DOT
- This product is not subject to any other requirements of dangerous goods under 49 CFR 173.185 (Lithium Batteries and Cells).
- The shipping of hazardous materials should be performed according to the Code of Federal Regulations.

Section 11: Regulatory Information (non-mandatory)

○ Information of EU Classification
- Information according to Regulation (EC) No 1272/2008 [CLP]

- Information according to Directive 67/548/EEC

○ U.S. Federal regulations
- Information according to ISHA
- Information according to TCCA and other chemical management regulations
- Dangerous Substances Safety Management Act
- Regulation of Disposal

- OSHA hazard communication standard (29 CFR 1910.1200)

Section 12: Other Information

Safety Guide date of preparation/update: December 09, 2025

○ Notice: The information and recommendations set forth are made in good faith and believed to be accurate as of the date of preparation. LG Energy Solution, Ltd. and its subsidiaries and affiliates make no warranty, expressed or implied, with respect to this information.

○ U.S.A
- The Occupational Safety and Health Administration (OSHA) Hazard Communication Standard, 29 CFR Subpart 1910.1200 does not apply to various subcategories including anything defined by OSHA as an "article". The LG Energy Solution ESS products are defined as "articles", and are exempted from the requirements for Safety Data Sheets.

○ EU
- The products are no “substances” or “mixtures” according to Regulation (EC) No 1907/2006 EC. Instead they have to be regarded as “articles”, no substances are intended to be released during handling. Therefore there is no obligation to supply a Safety Data Sheet according to Regulation (EC) 1907/2006, Article 31.

○ General remarks
- This Safety Guide is provided as a service to our customers. This information is based on our current knowledge and is intended to describe the product for the purposes of health, safety and environmental requirements only. Therefore, it should not be construed as guaranteeing any specific property of the product or the results of any specific actions.

The content of this safety guide may be periodically updated or revised as the scope of product environmental regulations expands.