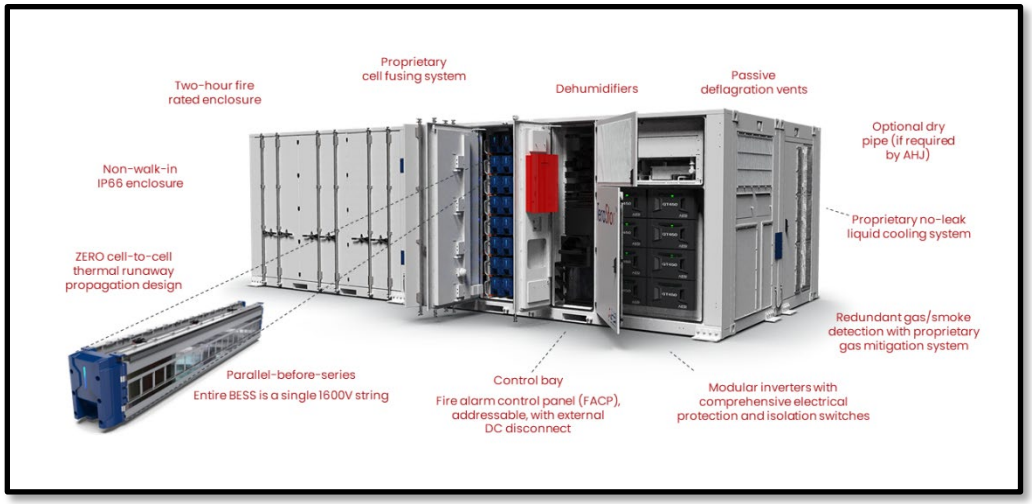
# TeraStor™

## Engineered for Safety

TeraStor is the brainchild of a team of battery energy storage solution (BESS) experts with 400+ cumulative years of experience designing, manufacturing, deploying and maintaining grid-scale BESS. The same team was responsible for the world's first system-level safety approval, awarded by TÜV Rhineland, back in 2013. The current TeraStor design is a game-changer; the result of extensive R&D combined with the team's hands-on experience with hundreds of projects worldwide (1.5+ GWh).

It was designed with maximum safety at the core of every architectural decision, ensuring safety throughout the entire lifetime comprising transit, installation, commissioning, operation, maintenance and decommissioning.



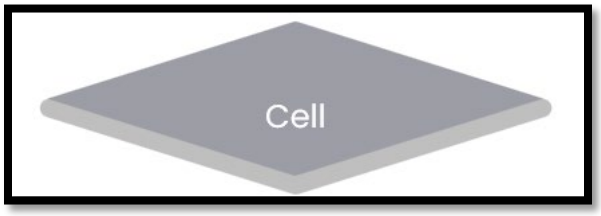
# Safety at every level

American Energy Storage Innovations' (AESI) comprehensive design and testing approach to safety encompasses every level of TeraStor. Vertical integration across design, manufacturing and testing ensures that the safety features of the supercell battery module, inverter, thermal management and overall system-level components are designed to work together, seamlessly, as one. All elements are thoroughly tested and certified—both separately and as a whole (see list pp. 6-7).

## Cell-level safety

**Cell quality assurance:** we prioritize cell quality by exclusively sourcing top-tier battery cells from esteemed brands with exceptional ratings and warranties. Every cell in the system is compliant with UL 9540A, UN 38.3, UL 1973, UL 1642 and IEC 62619.

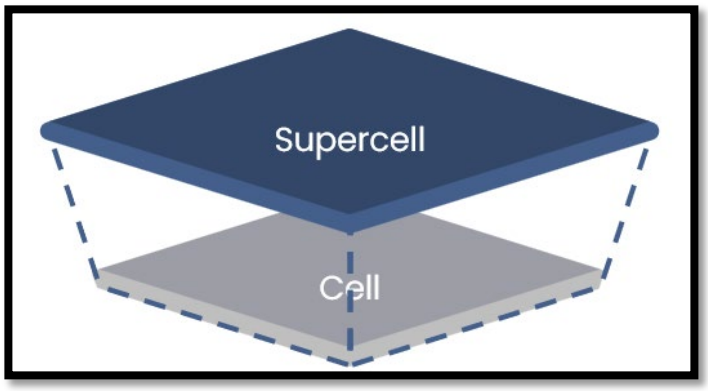
Further, our commitment to safety extends to rigorous in-house testing protocols, meticulously verifying quality and performance to ensure only the highest-caliber cells make their way into TeraStor.




## Supercell module-level safety

**Cell-to-cell isolation:** in our relentless pursuit of ultimate safety, we started our design with the recognition that random single-cell failures, though exceptionally rare, can happen due to cell manufacturing issues (a recent American Clean Power publication on lithium-ion cells indicates the single-cell failure rate is better than 1 in 40,000,000). Because of this, AESI leadership made a ZERO propagation mandate for the design. Our focus on ultimate safety, then, led the team to invent mechanisms to effectively sequester any thermal runaway incident to just that one anomalous cell. The supercell modules in the TeraStor are compliant with UL 9540A, UL 1973, IEC 62619 and UN 38.3.

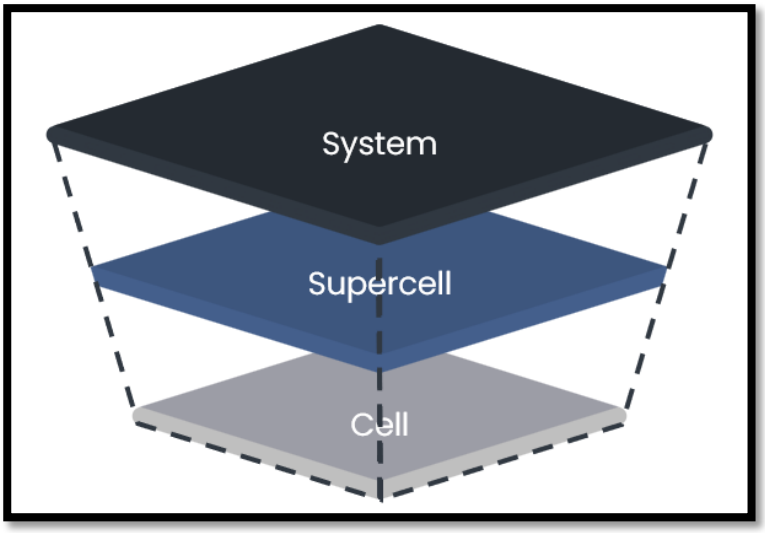
To achieve this, TeraStor incorporates multiple fire-resilient interstitial materials that create a robust isolation barrier between each and every cell. This seclusion strategy extends both side-to-side and top-to-bottom, safeguarding neighboring cells all around against cell-to-cell propagation of thermal runaway.



While other BESS suppliers opt for containment strategies at the module or unit level, employing a "burn in place" strategy, the architecture of the TeraStor unit takes a more proactive approach. Our design doesn't merely contain issues; it intercepts and mitigates them at the source, ensuring a heightened level of safety compliance for TeraStor.

## System-level safety

TeraStor adheres to stringent safety standards, ensuring compliance with industry-recognized certifications such as UL 9540/9540A, IEEE 1547, UL 1741 SA/SB and NFPA 855. This comprehensive safety approach seamlessly integrates with downstream protection measures. The system employs modular inverters equipped with comprehensive electrical protection and isolation switches, further enhancing safety and reliability. These measures collectively safeguard the TeraStor system, ensuring its compatibility with various grid requirements and minimizing potential hazards.




Select safety features include:

- Functional safety certified BMS (IEC 61508, SIL 2)
- ZERO cell-to-cell thermal propagation mandate
- Sequenced high voltage fusing system
- Ground fault protection system
- System condition annunciator for first responders
- Passive deflagration venting
- Redundant smoke/gas detection with proprietary gas mitigation system
- Fire alarm control panel (FACP), addressable, with external DC disconnect
- Non-walk-in, two-hour fire-rated enclosure
- IP66-rated battery enclosure
- Proprietary no-leak liquid cooling system
- Modular inverters with comprehensive electrical protection & isolation switches

**Battery Management System (BMS):** The fifth generation BMS (controls hardware and software) includes fully redundant voltage/temperature monitoring of all components. Compliant with UL 1973 and IEC 62619, the BMS provides functional safety certified to IEC 61508 Safety Integrity Level 2 (SIL 2).

The system employs multiple redundant fault detection monitors for voltage and temperature and includes integrated cell fusing. Should any cell in the system show anomalous activity, the system is designed to detect, alert and react to the issue before it progresses. With all issues already confined to their cell-level source, this ensures that any single-cell anomalous thermal runaway would self-extinguish in less than one hour.

**Thermal management:** liquid-cooled cold plates are an integral part of the physical structure. These cold plates beneath each supercell module effectively maintain safe operating temperatures to a narrow range of only two degrees ΔT across the entire system, and fully segregate each module from layers of cells above and below. Because the connections are permanent, the proprietary liquid cooling system ensures no leakage of glycol from the system at any time, even though we use food-grade material for extra peace of mind.

**Factory controlled assembly:** TeraStor's factory-controlled assembly and testing process removes the risk of human error in installation on-site and ensures the highest safety standards.

**Enclosure:** TeraStor's rugged enclosure safeguards against a range of threats. Internally, the always-on redundant smoke/gas detection and proprietary gas mitigation system works together to ensure immediate response. Should the system detect a single cell in runaway, the vented gas from that cell would be immediately addressed and rendered non-hazardous.

The IP66-rated battery enclosure also ensures complete protection against external threats such as dust and water ingress, preventing electrical failures and corrosion. The two-hour fire-resistance rated enclosure will contain issues and prevent them from spreading to the surrounding area. Additionally, the enclosure maintains a controlled humidity level, protecting the internal components from moisture damage and corrosion that could impair safety and performance. The enclosure is designed to survive or, if needed, to fail safely under extreme environmental conditions such as earthquake, hurricane or flood. Because the TeraStor enclosure is divided into four quarter-blocks, each its own fire-rated section, any single-cell event would always be limited to only that quarter block which also limits impact to overall system should any block contain a cell that needs replacement. The enclosure is NFPA 70/70E, UN 38.3, IEC 62040-1 compliant and is tested to, and meets, 9540/9540A criteria.

# System certifications and compliance

TeraStor is designed to be compliant with the following regulatory standards and requirements.

**Safety**

| | |
|---|---|
| UL 9540 | Safety for Energy Storage Systems and Equipment |
| UL 9540A | Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems |
| UL 1973 | Batteries for Use in Light Electric Rail Applications and Stationery |
| Low Voltage Directive (LVD) | Directive 2014/35/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits (recast). Text with EEA relevance. |
| IEC 62933-5-2 | Electrical Energy Storage (EES) Systems - Part 5-2: Safety Requirements For grid-integrated EES systems - Electrochemical-based systems |
| IEC 62619 | Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries |
| IEC 60529 | Degrees of Protection Provided by Enclosures.<br>Battery enclosure IP rating: IP66 |
| UL 50E<br>CSA C22.2 No.94.2:20 | Enclosures for Electrical Equipment, Environmental Considerations Complies with:<br>• Outdoor corrosion protection 600-hour salt spray test<br>• Outdoor corrosion protection 1200-hour moist carbon dioxide sulphur dioxide air test<br>• Additional corrosion protection for type 3x 3rx 3sx 4x and 6p 200-hour salt spray test |
| UL/IEC 60730-1 | Functional Safety of electronic controls |
| CE/UKCA | Declaration of Conformity |
| NFPA 70; CSA C22.1 | National Electric Code (NEC); Canadian Electrical Code |
| NFPA 70E | Standard for Electrical Safety in the Workplace |
| ANSI/IEEE C-2 | National Electrical Safety Code (NESC) |
| NFPA 13 | Standard for the Installation of Sprinkler Systems |
| NFPA 69 | Standard on Explosion Prevention Systems |
| NFPA 72 | National Fire Alarm and Signaling Code |
| NFPA 855 | Standard for the Installation of Stationary Energy Storage Systems |
| NFPA 1 | Fire Code |
| IFC | International Fire code |

**Grid Interconnect**

| | |
|---|---|
| UL 1741 (SB) 3rd Edition | Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources |
| IEEE 1547-2018 | IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces |
| IEEE 1547.1 | IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces |
| G99 | Requirements for the connection of generation equipment in parallel with public distribution networks on or after 17 May 2019 |

**Seismic & Transportation**

| | |
|---|---|
| IEEE693-2018 | Seismic Design of Substations |
| UN 38.3 | United Nations Recommendations on the Transport of Dangerous Goods Manual of Test and Criteria |

**EMC Electromagnetic**

| | |
|---|---|
| CE/UKCA | Declaration of Conformity |
| FCC CFR 47 Subpart C §15.247 ANSI C63.10 2020 (Test Procedures) | Short Range Devices (radio) |
| EN 300 328 v.2.2.2 conducted radio tests. EN 301 489-1 Immunity requirements EN 301 489-17 Immunity requirements | Wideband radio devices. Harmonized Standard for access to radio spectrum. |
| EU Electromagnetic Compatibility (EMC) Directive | Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to electromagnetic compatibility (recast). Text with EEA relevance. |
| EN/IEC 61000-6-2 | Electromagnetic compatibility (EMC)<br>Part 6-2: Generic Immunity standard for industrial environments |
| EN/IEC 61000-6-4 | Electromagnetic compatibility (EMC)<br>Part 6-4: Generic Emission standard for industrial environments |
| EN/IEC 55011 | Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement. |
| IEC 61000-6-7 | Electromagnetic Compatibility (EMC) - Part 6-7: Generic Standards - Immunity Requirements For Equipment Intended To Perform Functions In A Safety-Related System (Functional Safety) In Industrial Locations. |

**Materials Compliance**

| | |
|---|---|
| EU Battery Regulation (Planned when infrastructure is available) | Regulation (EU) 2023/1542 of the European Parliament and of the Council of 12 July 2023 concerning batteries and waste batteries, amending Directive 2008/98/EC and Regulation (EU) 2019/1020 and repealing Directive 2006/66/EC (Text with EEA relevance) – [Regulation (EU) 2023/1542 of the European Parliament and of the Council of 12 July 2023 concerning batteries and waste batteries, amending Directive 2008/98/EC and Regulation (EU) 2019/1020 and repealing Directive 2006/66/EC (Text with EEA relevance)]. |
| EU Battery Directive and Amendments | Directive 2006/66/EC of the European Parliament and of the Council of 6 September 2006 on batteries and accumulators and waste batteries and accumulators and repealing Directive 91/157/EE |
| Restriction of Hazardous Substances (RoHS) | 2011/65/EU Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS).<br>Note: Including amendments. |
| REACH | Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) |
| CA Prop 65 | Proposition 65 Safe Drinking Water and Toxic Enforcement Act of 1986 |
| EPA TSCA | The Toxic Substances Control Act (TSCA) |
| Section 1502 of the Dodd Frank Act (planned) | Conflict Minerals |
| China RoHS | Management Methods for the Restriction of the Use of Hazardous Substances in Electrical and Electronic Products Order No. 32 (China RoHS II) |