National Transportation Safety Board

Office of Railroad, Pipeline and Hazardous Materials

Washington, DC 20594

DCA24FM013

HAZARDOUS MATERIALS

Specialist's Factual Report

September 10, 2025

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B. INCIDENT

Location: San Diego, CA
Date: December 25 and 28, 2023
Vehicle: M/V Genius Star XI – Class NK; IMO/9622710.

C. HAZARDOUS MATERIALS GROUP

Group Chair	Rachael Gunaratnam NTSB Washington, D.C.
Group Member	Kurt Stewart Pipeline and Hazardous Materials Safety Administration Oklahoma City, OK

D. SYNOPSIS

On December 25, 2023, a fire occurred on the tween deck of cargo Hold 1 of the M/V Genius Star XI (Genius Star XI), a 410-foot cargo vessel. On December 28, 2023, a second fire occurred on the tween deck of cargo Hold 2. The cargo vessel was destined for San Diego, California but due to the fires, was rerouted to Dutch Harbor, Alaska. After the vessel was deemed safe, it resumed its journey and docked in San Diego, California on February 23, 2024. The vessel was transporting shipments labeled s UN 3536, Lithium Batteries Installed in Cargo Transport Unit *lithium ion batteries or lithium metal batteries*. None of the 19 crew members were injured.

E. DETAILS OF THE INVESTIGATION

The Hazardous Materials Factual Report describes the shipment of the battery energy storage systems (BESS) aboard the Genius Star XI vessel. The report also documents the damages to the BESS and discusses the regulatory framework within International and U.S. transportation regulations.

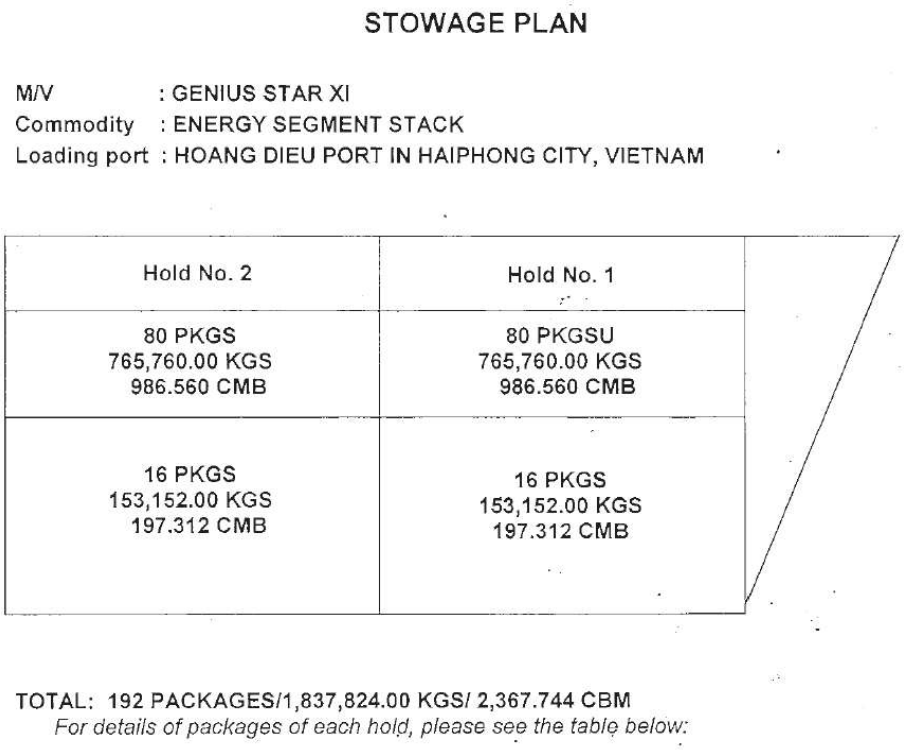
1.0 Hazardous Materials Shipment and Shipper

A total of 192 battery energy storage systems (BESS) were aboard the Genius Star XI, labeled as UN 3536, "Lithium Batteries installed in cargo transport unit *lithium-ion batteries or lithium metal batteries*" (See Table 1). As described on the stowage plan, a total of 160 BESS were arranged in eight rows of ten bays in Hold No. 1 and Hold

No. 2 on the tween deck of the vessel.[1] A cargo hatch covered the tween deck while in transportation. Another 32 BESS were arranged below the deck in a two by eight rectangular arrangement in the lower two holds (See Figures 1 and 2). A total of 41 BESS had shifted and broken free from its lashing on the tween deck; there was no evidence that the BESS in the lower holds were damaged. The BESS were lashed individually to the decks as seen in Figure 3:

Table 1: Hazardous Materials commodity and shipper for Genius XI Star

Hazardous Materials	Quantity and Weight	Shipper
UN 3536 PSN: Lithium Batteries installed in cargo transport unit *lithium ion batteries or lithium metal batteries* Class 9	192 Packages 1,837.824 Mass (KG) Gross/Net	MainFreight Vietnam Company Limited[2]



STOWAGE PLAN

M/V : GENIUS STAR XI
Commodity : ENERGY SEGMENT STACK
Loading port : HOANG DIEU PORT IN HAIPHONG CITY, VIETNAM

Hold No. 2	Hold No. 1
80 PKGS 765,760.00 KGS 986.560 CMB	80 PKGSU 765,760.00 KGS 986.560 CMB
16 PKGS 153,152.00 KGS 197.312 CMB	16 PKGS 153,152.00 KGS 197.312 CMB

TOTAL: 192 PACKAGES/1,837,824.00 KGS/ 2,367.744 CBM
For details of packages of each hold, please see the table below:

Figure 1: Stowage Plan of the 192 BESS aboard Genius Star XI

[1]See Attachment 1: Genius Star XI Stowage Plan and Cargo Manifest and Attachment 2: Genius Star XI Dangerous Goods Declaration and Manifest. All attachments are available on the NTSB investigation docket DCA24FM013.
[2] MainFreight Vietnam Co., Ltd, is a global logistics and forwarding company that offers logistics services that include international air and sea freight.

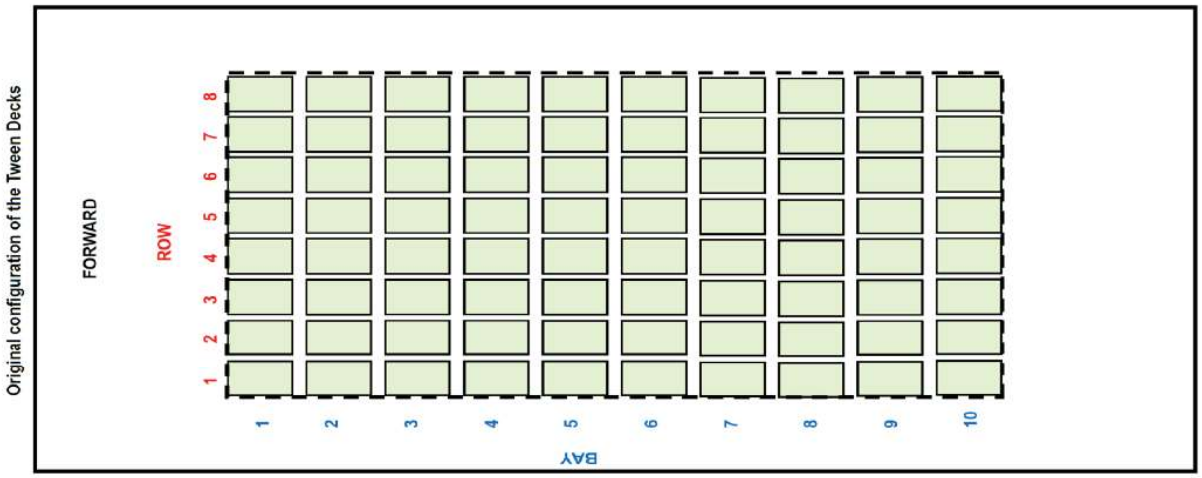


Figure 2: Original configuration of 80 BESS on the tween deck of Hold 1 (Image courtesy of Energy Security Agency)

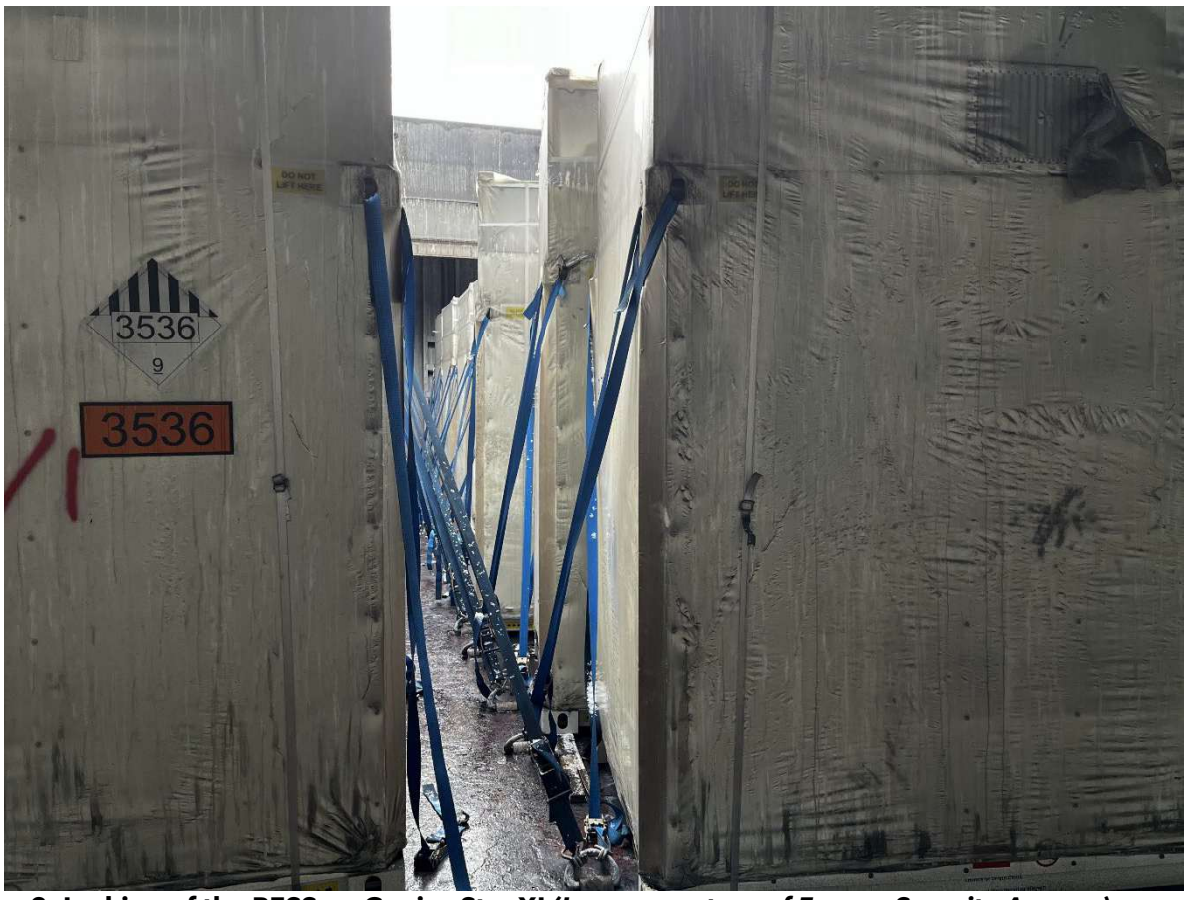


Figure 3: Lashing of the BESS on Genius Star XI *(Image courtesy of Energy Security Agency)*

1.1 Battery Energy Storage System Manufacturer

1.1.1 Powin LLC

Powin LLC (Powin) is a U.S. based company that designs and manufactures battery energy storage systems. The company started in 2010 and is headquartered in Oregon.[3]

Powin's BESS was manufactured and assembled in different countries, with the final assembly being completed in Vietnam. The components of the BESS include 28 battery packs that consist of lithium ion battery cell modules that are assembled into a single cabinet. The BESS specifications are described in section 3.2.

2.0 Hazardous Materials Description

2.1 Hazards

A typical lithium-ion cell is constructed with a cathode (multi-metal oxide) and anode (a porous carbon/graphite), which are contacted by an organic electrolyte containing lithium salts. The primary risk with a lithium-ion battery is thermal runaway when the battery is damaged and short circuits. During a thermal runaway event, the lithium-ion cell undergoes uncontrollable, self-heating that can result in high temperatures of over 500˚ F, leading to fire and explosions, as well as a release of toxic gases.[4]

Damages that lead to thermal runaway includes: [5]

- mechanical abuse when dropped, crushed or penetrated;
- thermal abuse when a battery is exposed to external heat sources;
- electrical abuse when the battery is overcharged, rapidly charged or discharged;
- and environmental impacts when weather conditions such as seismic activity, extreme heat and floods, as well as other conditions such as rodent damage that harm the battery.

The Safety Data Sheet (SDS) produced by the BESS cell manufacturer states: [6]

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[3] See Powin website, https://powin.com/.
[4] "What Is Thermal Runaway?", UL Research Institutes. https://ul.org/research/electrochemical-safety/getting-started-electrochemical-safety/what-thermal-runaway#:~:text=Thermal%20runaway%20is%20one%20of,Fire.
[5] "Battery Energy Storage Hazards and Failure Modes", National Fire Protection Association, December 3, 2021. https://www.nfpa.org/news-blogs-and-articles/blogs/2021/12/03/battery-energy-storage-hazards-and-failure-modes.
[6] Attachment 3: Powin Battery Safety Data Sheet

Special hazards arising from the substance or mixture:
When exposed to a fire environment, the battery may burst and release dangerous decomposition products, Lithium-ion batteries contain a flammable electrolyte that, when subjected to high temperatures (>150°C), damaged or abused (such as mechanical damage or electrical overcharging), may emit, ignite and spark; may burn rapidly with a flame burning effect; may ignite other nearby batteries.

The SDS also noted that the suitable extinguishing media for a fire is carbon dioxide, dry powder, wet sand, and large amount of water for cooling. It also recommends that for any fire, responders should "wear self-contained breathing apparatus, MSHA/NIOSH (approved or equivalent) and full protective gear."

2.2 Battery Energy Storage Systems

Power system operators (e.g. power plants) and utility companies use various strategies to manage their system to ensure there is a consistent generation of power for a stable energy grid. Battery energy storage systems are used by industry to store energy for later use to provide that stability. A BESS charges from the grid or power plant and then discharges energy at a later time to provide electricity or other grid services when needed. [7] A BESS can be constructed from different battery chemistries. Lithium-ion batteries are the primary type of BESS in the existing market.[8]

2.2.1 Powin Centipede Stack800

The Powin BESS model transported on the Genius Star XI was the Centipede Stack800. Each BESS cabinet consisted of 840 cells that were assembled into 84 modules and then arranged into 28 packs. These were then installed in a two-sided cabinet. All 192 cabinets were manufactured in 2023. See Figure 4 for an overview.[9]

[7] "Grid-Scale Battery Storage: Frequently Asked Questions" National Renewable Energy Laboratory (September 2019).
[8] Gehandler, J., Ellis, J., Karlsson, A., Quant, M, *Marine Transportation of Energy Storage Systems (ESS): Hazard Assessment & Regulatory Analysis*. NFPA Research Foundation (November 2023).
[9] See Attachment 4: Powin Battery Emergency Response Information



Figure 4: Components of the Centipede Stack800 *(Image courtesy of Powin)*

2.2.1.1 Battery Cells

The individual cell is a two-terminal prismatic AESC, 3.275 volts(V) (DC), 976 watt-hour (Wh), lithium ion battery.[10] The cell consisted of a lithium iron phosphate cathode, graphite anode, and lithium hexafluorophosphate electrolyte, with a polypropylene separator.[11] The cells were manufactured by Envision Dynamics Tech in Ordos City, China. The incident cells left the facility in Ordos City by truck in 40-foot containers with several shipments going to different locations. Some shipments were loaded on vessels from China destined for factories in New Taipei City (Formosa Electronic Industries, Inc.) and Taoyuan City, Taiwan to be assembled into modules. Another shipment from Ordos City went directly by truck to a factory in Huizhou, China (Huizhou Desay Battery Co., Ltd.), where the cells were also assembled into modules.[12]

2.2.2 Battery Module and Pack

After the modules were assembled, they were transported by truck, and then loaded onto a vessel in a 20-foot container to Vietnam, where the modules were installed in cabinets. The modules consisted of ten prismatic cells that is connected in series with laser-welded busbars made of T2 tool steel (See Figure 5).[13] Each module weighed 68.5 kg (~151 lbs.) and was rated 32 V(DC), 9760 Wh, 305 ampere-hours (Ah).[14] Three modules are then assembled into a battery pack, consisting of 30 cells in total, which are then placed on a shelf. The shelf with the battery pack weighed over 400 pounds.

[10] AESC is a manufacturer of batteries for electric vehicles and energy storage systems.
[11] See Attachment 3: Powin Battery Safety Data Sheet
[12] See Attachment 5: Powin Battery Segment Paths document
[13] T2 Tool Steel is an air-hardening medium allow tool steel.
[14] See Attachment 6: Powin Battery UN 38.3 Test Reports (Cell and Module)

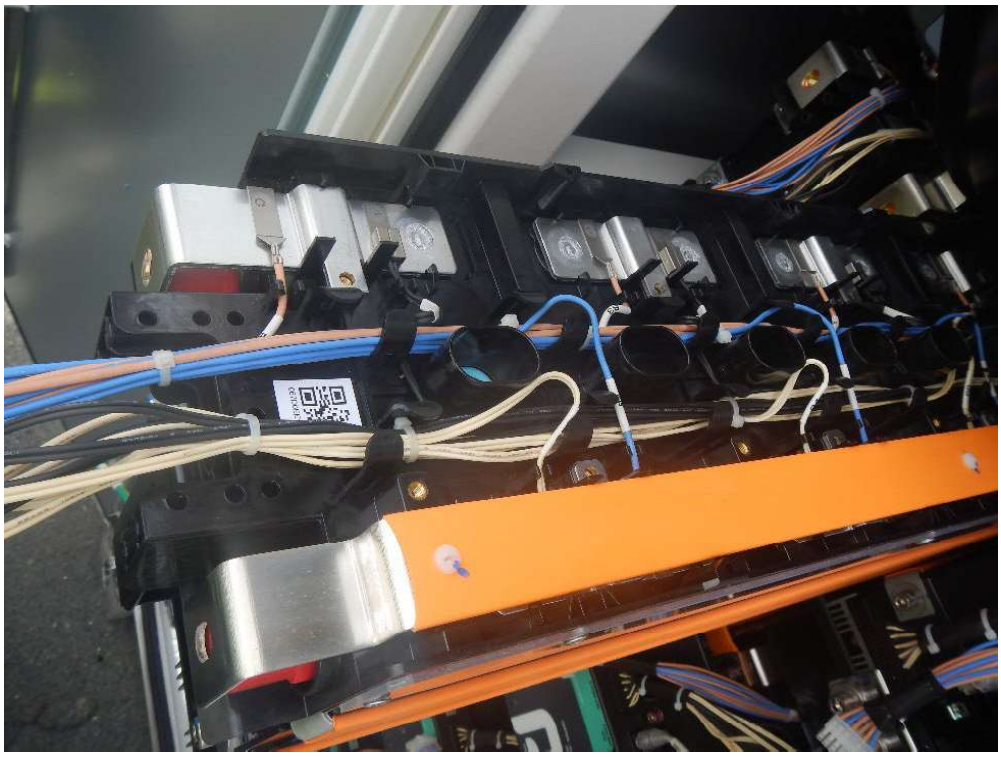


Figure 5: Single Module showing the laser welded busbars on top on February 25, 2024

2.2.3 Battery Cabinet

A total of 28 battery packs were arranged inside a two-sided cabinet (84 modules, 840 cells), referred to as a battery stack (See Figure 6). The dimensions (W/D/H) of the cabinet were approximately 1572 mm x 2433 mm x 3431 mm. Each side of the cabinet had 14 battery packs (42 modules, 420 cells). Each pack is arranged onto shelf with the dimensions(W/D/H) of 585 mm x 832 mm x 72.5 mm.[15] The entire cabinet with the modules weighed approximately 9,572 Kilograms (21,202 lbs.) and was rated with a nominal voltage of 1,344 V(DC), 800kWh (See Figure 7). Attached to the top of the cabinet, referred to as the "top hat," was an air conditioning unit, which is described further in section 4.3.3.

[15] See Attachment 7: Powin Battery Cabinet Structure Diagram.



Figure 6: One side of a Powin Stack800 cabinet showing 14 battery packs on February 25, 2024.



Figure 7: Data Label for Cabinet D

Powin submitted factory acceptance reports from their Vietnamese production facility that indicated that all 192 cabinets underwent a water tightness test, dielectric withstand voltage test, and grounding test (See Figure 8).[16]



Figure 8: Empty Powin Stack800 cabinet without the battery packs installed at the Vietnam production facility during factory testing. *(Image courtesy of Powin)*

3.0 Post-Incident Battery Examination

Dutch Harbor, Alaska

After the December fires occurred, the Genius Start XI was re-routed to anchor near Dutch Harbor, Alaska port. The ship was kept 2-miles from shore to stabilize the ship and minimize any risk of a re-flash of the fire. Once docked, the vessel operator, Wisdom Marine International, Inc., hired an emergency response contractor, T&T Salvage, and sub-contractor, Energy Security Agency (ESA), who were on-scene

[16] See Attachment 8: Powin Battery Cabinet Factory Acceptance Test Report Example. A dielectric withstand voltage test verifies that electrical insulation can withstand a specific voltage without equipment breaking down. A grounding test measures the resistance of the grounding system to ensure proper grounding to prevent electrical hazards.

starting January 27, 2024.[17] ESA performed a damage assessment, removed damaged cells and prepared them for disposal.[18] The vessel crew re-secured the batteries to the deck to continue its journey to San Diego, California.

ESA documented the initial position of the cabinets before conducting the damage assessment and found cabinets that had broken loose from its lashing in both Hold 1 and 2. Those cabinets were found in bays closest "amidship", i.e. center of the ship. Figures 9 and 10 show where the cabinets were positioned post-incident, after the vessel docked in Dutch Harbor. The grid patterns in red identifies cabinets that were physically damaged or had thermal abuse. The teal lines refer to the row numbers.



Figure 9: Photo of shifted cabinets in Hold 1 ***(Image courtesy of Energy Security Agency)***

[17] The vessel was owned by GS Navigation S.A. and operated by Wisdom Marine International Inc. a Taiwan based shipowner and operator. T&T Salvage is an U.S. company that provides marine salvage, emergency response and wreck removal services. ESA is also a U.S. company that provides support services for emergency response and industrial safety, with specific expertise in lithium battery safety. NTSB was not present during ESA's damage assessment in Dutch Harbor due to the potential exposure of electrical hazards.

[18] See Attachment 9: Genius Star XI ESA-Result Summary Report – 04FEB24

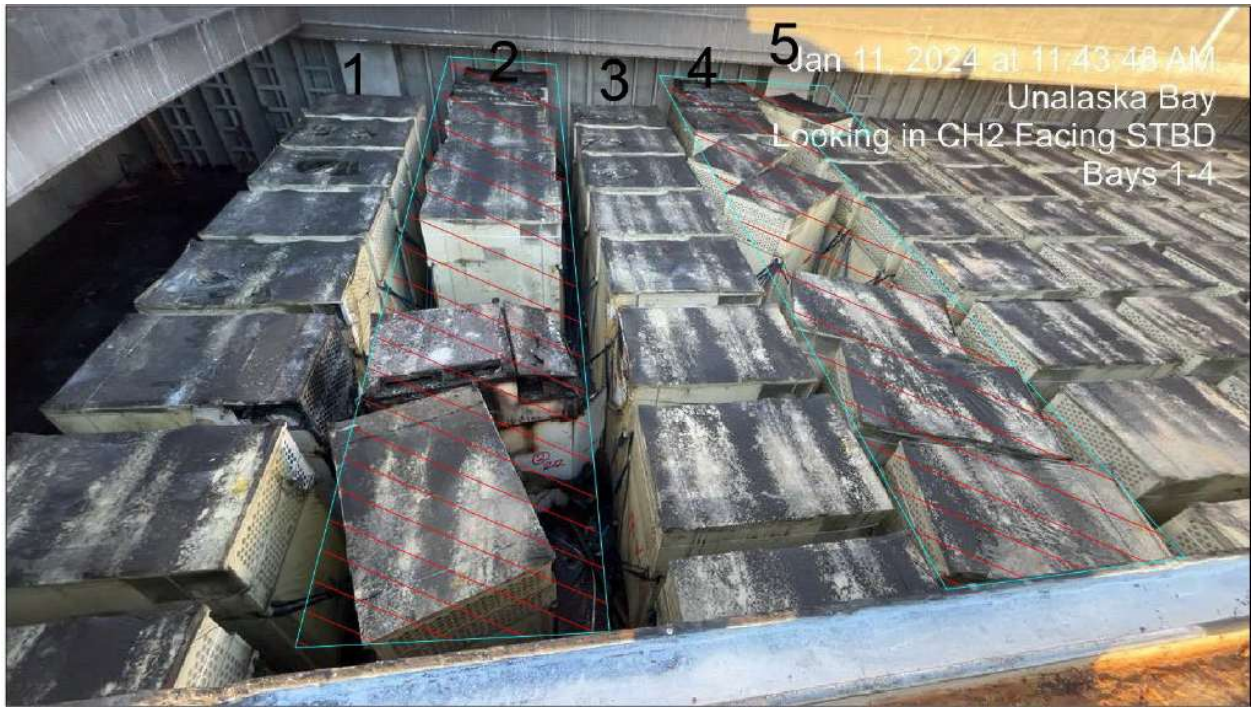
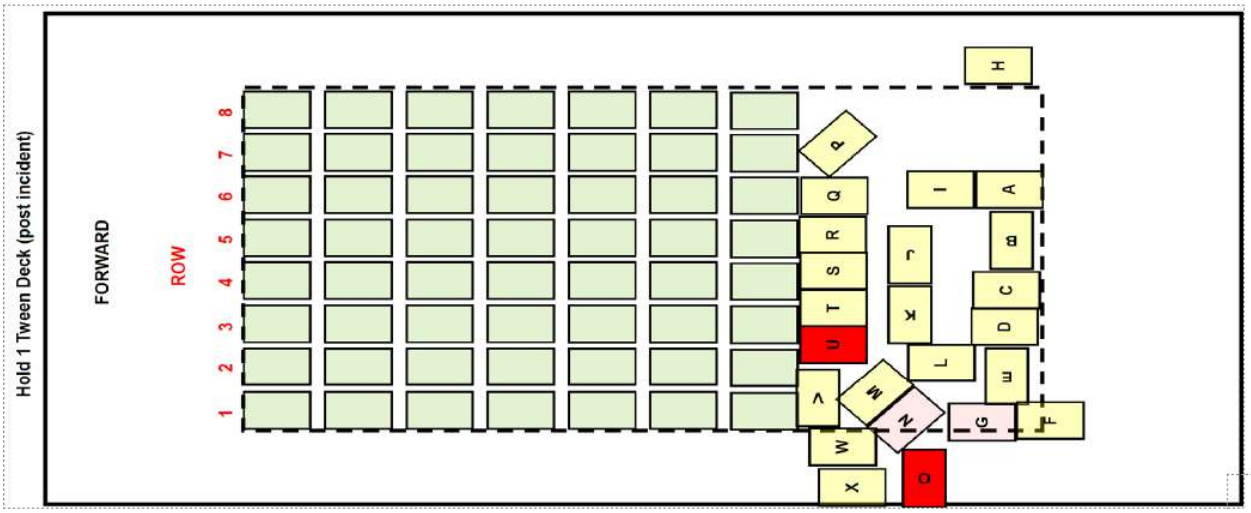


Figure 10: Photo of shifted cabinets in Hold 2 ***(Image courtesy of Energy Security Agency)***

ESA mapped the movement of the battery cabinets and identified those that went into thermal runaway (red), had severe thermal abuse (pink), or were displaced and shifted and found to have physical damage (yellow) (See Figure 11). The cabinets labeled green had not broken free from its lashing and had no thermal abuse or physical damage. The company examined all the cabinets labeled red, pink, yellow, and then green rows adjacent to yellow or red labeled cabinets.



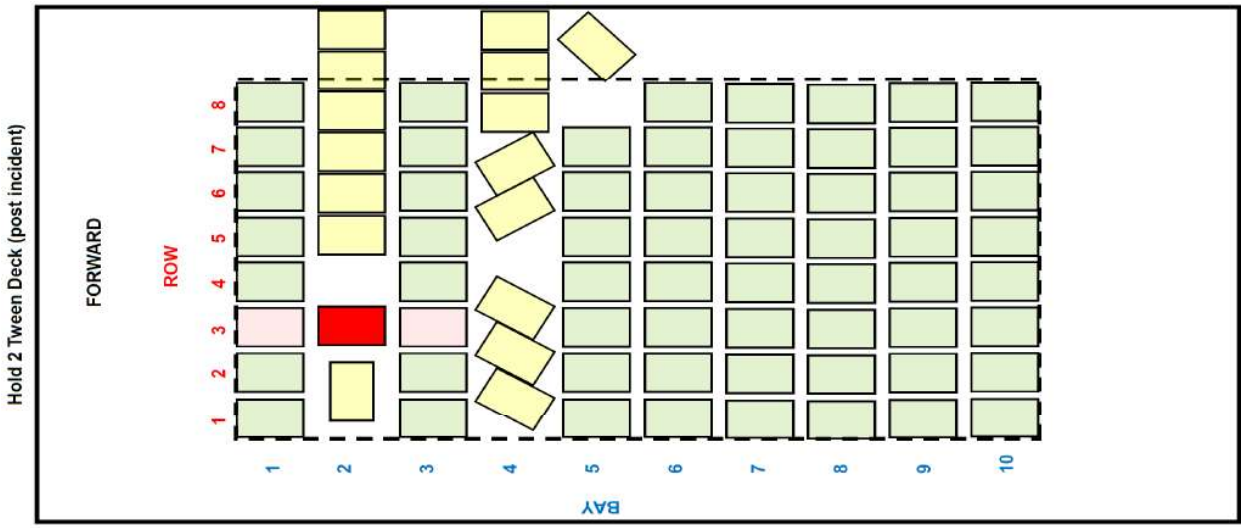


Figure 11: Mapped positions of the shifted modules aboard the Genius Star XI on tween decks for Holds 1 and 2 *(Image courtesy of Energy Security Agency)*

ESA performed a visual inspection on the BESS units, looking for signs of off-gassing, a thermal event, electrolyte sprayed, displaced cables, shelf displacement or movement, battery movement or tension on any vertical bus bar, and coolant leaking from the air conditioning system. The company measured the voltage to identify if the modules were balanced at 98 volts, which is the nominal voltage. If determined there was a potential risk of an electrical hazard through a loss of voltage reading or loosened/collapsed shelves, the busbars from the modules were removed.[19] The next step was to dismantle the severely burned modules, which were shipped as damaged, defective and recalled (DDR) batteries. Thermal imaging and gas monitors were continuously monitored by the response team. No incident occurred during the hazard evaluation of the batteries in Dutch Harbor.

The sub-contractor's damage assessment concluded:

- A total of 41 BESS shifted; 24 from Hold 1 and 17 from Hold 2
- Rigging and lashing mechanism had failed in both Hold 1 and 2
  - Bays 8 through 10 in Hold 1
  - Bays 2 and 4 in Hold 2
- A total of 3 BESS that broke loose from its rigging and lashing and were observed to have a thermal event that destroyed the entire BESS; two from Hold 1 and one from Hold 2.
- Approximately 8.3 BESS from Hold 1 and 2 were dismantled and the modules were packed into drums. ESA classified these repackaged

[19] A busbar serves as an electrical connection to conduct and distribute electrical power within a battery system. Removing the busbar will reduce the risk of an electrical hazard by preventing any transfer of electricity and isolating the electrical potential.

batteries as UN 3480 Lithium-Ion Batteries, “Damaged, Defective, or Recalled” (DDR).

- For the BESS that were most severely affected, the following damages were observed:
    - Burn patterns within the cabinet, indicating electrical arcing
    - Severe thermal damage inside and outside the cabinet
    - Shelves collapsed, causing modules to detach and impact the interior of the cabinet
    - Voltage loss
    - Electrolyte leakage
    - Smoke and soot found inside and outside cabin
    - Charred battery modules (See Figure 12)



Figure 12: A-side(L) and B-side(R) of battery unit Bay 2/Row 2 that went into thermal runaway and caught fire, found in situ on January 11, 2024 *(Image courtesy of Energy Security Agency*)

ESA later reported to the NTSB when they evaluated for structural integrity to determine whether some of the cabinets were capable of further transport movement without dismantling and removing the battery modules. They would evaluate whether the front shelf retainer clips were intact and not compromised and apply manual pressure to identify if they would further shift or move. If a shelf was completely displaced or “sagging,” or if the shelf was not fully seated and could be easily moved, then the modules were removed. ESA did not remove modules if the shelf position

were intact and in the proper position. They did however notice that many of the shelves had shifted, revealing gaps between the original seated position of the shelf mount and shelf bolt, but if the modules were not easily manipulated, they would keep them in the cabinet to continue in transport.[20]

San Diego, California

After the Coast Guard deemed the vessel safe to continue to its final destination, the vessel docked at San Diego on February 24, 2024. NTSB investigators examined 16 battery cabinets that were offloaded from the Genius Star XI. A group examination with the Coast Guard, Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF), Pipeline Hazardous Materials Safety Administration (PHMSA), and ESA took place at the Port of San Diego Port to evaluate the incident cabinets. A summary of that examination is described in Table 2.

Table 2: NTSB Damage Characterization of the cabinets

Serial No.	Cabinet Identifier	Damage observations
Hold 1		
Serial No. was not legible due to thermal damage.	O	Prior removal of batteries from entire cabinet; doors removed. Inside of cabinet is completely charred and covered in soot. Shelves rails bent downard. Scorch marks with indents observed inside the cabinet frame, indicating high temperature exposure from electrical arcing (See Figure 13).
Serial No. was not legible due to thermal damage.	U	Prior removal of batteries from entire cabinet; doors removed. Inside of cabinet is completely charred and covered in soot and some rust. Shelf rail bent downward. Scorch marks with indents observed inside the cabinet frame, and holes on shelf rails, indicating high temperature exposure from electrical arcing
3G1101023100009404	N	Prior removal of battery packs from the B-side; doors intact and has dents on the exterior. Dent and hole found in the interior of the door. Soot observed near the

[20]See Attachment 16: Powin Battery ESA Email to the NTSB September 3, 2025

		top hat of the air conditioning unit and charring on one of the inside walls B-side, with some rust on the inside door; metal deformation of the shelf rail bent downward; rails showed holes, metal was scorched, indicating high temperature exposure from electrical arcing.
3G1101023000024004	G	Prior removal of batteries from entire cabinet; doors intact; minor soot and charring of interior walls on one side of the cabinet; metal deformation of the shelf rail bent downward. Charring and soot on outer side of the cabinet. Dents on the outside of the cabinet.
3G1101023080039604	M	Prior removal of batteries from entire cabinet; dents on exterior of the cabinet. Metal deformation of the shelf brackets bent downward on both sides of the cabinet (See Figures 14a and 14b); Thermal damage observed only on A-side: soot and dent observed inside the cabinet door, soot on the upper brackets of the A-side. Hole observed on the middle shelf rail on the A-side, metal scorched. Evidence of high temperature exposure from electrical arcing.
3G1101023080023704	D	Battery packs in the cabinet; busbars removed. No thermal damage. Metal deformation of the shelf bracket bent downward. Module voltage noted measurement of 98 volts.
3G1101023080036504	E	Prior removal of batteries from entire cabinet; shelves still in place. No soot observed inside the cabinet. Physical abuse on the outside of the B-side and A-side doors. Inside B-side cabinet door has dents and scorch marks; Evidence of high temperature exposure from electrical arcing.

Hold 2		
3G1101023100043204	Bay 1/Row 3	Battery packs in the cabinet; busbars removed. Heavy thermal damage on outside the cabinet. Dents inside B-side door, note made about this door "bulging". Shelves were intact and did not move. Module voltage noted measurement of 98 volts. Cabinet did not break from its lashing.
Serial No. was not legible due to thermal damage.	Bay 2/Row 1	Battery packs in the cabinet; busbars removed. Soot observed on the outside of the cabinet on the top hat/air conditioning unit on the B-side with metal deformation on shelf rail bent downward; no thermal damage on the A-side.
Serial No. was not legible due to thermal damage.	Bay 2/ Row 2 (found in Row 3)	Prior removal of batteries from entire cabinet; thermal damage observed; shelves displaced and bent downward; soot found on the outside top hat on A-side.
3G1101023080007304	Bay 2/Row 4 (found in Row 6)	Battery packs in the cabinet; busbars and BMS panel removed. Heavy structural damage. Shifted shelves and bent downward on A-side on top left side. Sooting observed only on the outside of the cabinet. (See Figure 16)
3G1101023080015804	Bay 2/Row 7	Battery packs in the cabinet; busbars removed. Physical abuse observed on the outside of the cabinet on A-side. Module voltage noted measurement of 98 volts. Shelf shifted and bent downward.
3G1101023100049204	Bay 2/Row 8	Battery packs in the cabinet; busbars removed. No thermal damage inside. Shelves shifted on the A-side-bolt off the bolt seat in several places.
3G1101023100002404	Bay 3/Row 3	Battery packs in the cabinet; soot observed on the outside of the cabinet on the top hat on the B-side. No soot transfer to the A-side. Cabinet did not break from its lashing.

3G1101023100045204	Bay 4/Row 1	Battery packs in the cabinet; busbars removed. Cabinet shelfs shifted.
3G110102310007604	Bay 7/Row 6	Battery packs in the cabinet. Metal deformation of shelf rail bent downward. Gap between bolt and bolt seat in several places (See Figure 15). Cabinet did not break from its lashing.



Figure 13: Metal scorching in BESS unit "O" on February 25, 2024

(a)  (b) 

Figure 14: (a) Shelf rail bent downward inside cabinet "M", B-side (b) Dents on the exterior of cabinet “M” on February 25, 2024



Figure 15: Gap observed between bolt and bolt seat and shelf rail bent downward inside BESS unit Bay7/Row 6, on February 25, 2024



Figure 16: Collapsed modules in BESS unit Bay 2 Row 4 (found in Row 6) with busbars and BMS panel removed on February 25, 2024

4.0 Domestic and International Shipping Regulations

4.1 International Maritime Regulations

Mandatory provisions governing the international transport of dangerous goods by sea are found in the International Maritime Dangerous Goods (IMDG) Code of the International Maritime Organization.[21] The 2022 edition of the IMDG was required at the time of the incident and includes requirements for individual dangerous goods for their safe transport and requires that member state of the *International Convention for the Safety of Life at Sea, 1974* (SOLAS) comply with the IMDG for international shipments.[22] The United States is a member state.

The requirements for a UN 3536, *Lithium batteries Installed in cargo transport unit lithium ion batteries or lithium metal batteries*, are listed under Chapter 3.2 of the International Maritime Dangerous Goods regulations (IMDG) as described in Table 2:

Table 2: IMDG Provisions for UN 3536

Column 1	**UN No.**	3536
Column 2	**Proper Shipping name (PSN)**	Lithium Batteries Installed in Cargo Transport Unit, lithium ion batteries or lithium metal batteries
Column 3	**Class or Division**	9
Column 4	**Subsidiary Hazard**	-
Column 5	**Packing Group**	-
Column 6	**Special Provisions**	389
Column 7a	**Limited quantities**	0
Column 7b	**Excepted quantities**	E0 (No excepted quantities)
Column 8	**Packing Instructions**	-
Column 9	**Special packing provisions**	-
Column 10	**IBC packing provisions**	-
Column 11	**IBC Special provisions**	-
Column 12	**Reserved**	-
Column 13	**Tank and bulk container instructions**	-
Column 14	**Tank special provisions**	-
Column 15	**EmS**	F-A and S-I
Column 16a	**Stowage and Handling**	Category A
Column 16b	**Segregation**	-

[21] IMO is a specialized agency of the United Nations responsible for regulating maritime transport.
[22] *IMDG Code – 2022 Edition: International Maritime Dangerous Goods Code*, incorporating amendment 41-22, International Maritime Organization. https://doi.org/10.62454/KN200E.

Column 17	**Properties and Observation**	Cargo transport unit containing lithium metal or lithium ion batteries which is designed to serve as mobile power supply unit
Column 18	**UN No.**	3536

4.2 Column (1) UN Number (2) Proper Shipping Name and Column (3) Class or Division

The IMDG Section 2.0.0 requires the shipper/consignor or the appropriate competent authority to classify their dangerous goods and assign the appropriate UN number and shipping name. The proper shipping name listed in the IMDG for a UN 3536 battery was "Lithium Batteries installed in cargo transport unit *lithium-ion batteries or lithium metal batteries*" and is a class 9 substance. [23]

The IMO Dangerous Goods Manifest for the Genius Star XI shipment listed the 192 BESS as UN 3536 and listed the shipping name as "High-Power Lithium Ion Battery."[24]

The IMO Dangerous Goods Declaration is a document that is required to demonstrate that the shipper certified that the shipment was described, classified, packaged, marked and labelled/placarded and in proper condition for transport in accordance with both international and U.S. domestic government regulations. The declaration document that accompanied the Genius Star XI listed the battery shipment as "Lithium-ion battery (including lithium-ion polymer batteries)," UN 3536, Class 9.

4.3 Column (6) Special Provision

A UN 3536 must comply with Special Provision 389 (SP 389), which is summarized below:

- Section 2.9.4 of the IMDG for lithium cells and batteries, must:
  - Meet the requirements of the *Manual Tests and Criteria*, part III, subsection 38.3 and makes the test summary available for batteries manufactured after June 30, 2003, excluding button cells installed in equipment.
  - Incorporate a safety venting device to prevent a violent rupture under normal transport conditions.

[23] Class 9 is defined under the IMDG as substances and articles which, during transport, present a danger not covered by the eight other classes of dangerous goods.
[24] See Attachment 2: Genius Star XI Dangerous Goods Declaration and Manifest

    - Equipped with a means of preventing external short circuits.
    - If cells are connected in parallel, must be equipped with an effective means to prevent dangerous reverse current flow (e.g. diodes, fuses, etc.).
    - Manufactured under a quality management program.
- The batteries are to be securely attached to the interior structure of the cargo transport unit (e.g. by means of placement in racks, cabinets, etc.) to prevent short circuits, accidental operation, and significant movement relative to the cargo transport unit under the shocks, loadings and vibrations normally incident to transport.
- Dangerous goods necessary for safe and proper operation of the cargo transport unit (e.g. fire-extinguishing systems and air-conditioning systems) shall be properly secured to or installed in the cargo transport unit.
- Other dangerous goods not necessary for the safe and proper operation of the cargo transport unit are not to be transported within the cargo transport unit.

4.3.1 Testing

Before being offered for transport, lithium ion cells and batteries must be of a type proven to meet the requirements of the UN *Manual of Tests and Criteria*, Part III, sub-section 38.3 (7th revision). The tests and their procedures for lithium cells and batteries include Tests T.1 through T.8, includes an altitude simulation, thermal test, vibration, shock, external short circuit, impact/crush, overcharge, and forced discharge.[25]

The required tests vary slightly depending on whether it is a cell, component cell, or assembled battery, or non-rechargeable/rechargeable. If a lithium cell or battery fail to meet the test requirements, UN 38.8 specifies that "steps shall be taken to correct the deficiency or deficiencies that caused the failure before such cell or battery type is retested." Powin provided the UN 38.3 testing documentation from the both the cell, module and battery pack manufacturer in China and the module manufacturer in Taiwan. The documentation indicated the cell and individual modules passed their applicable tests.

Powin also reported they performed an end-of-line (EOL) battery test before the batteries were shipped to the U.S. This is a series of tests performed on a battery pack to confirm it meets performance standards. The test involved a 50kW charge and discharge for 100% strings. Cells connected in series experience the full string

[25] See PHMSA, *Lithium Battery Test Summaries (TS)* (accessed April 2, 2025: https://www.phmsa.dot.gov/training/hazmat/new-un-requirement-test-summaries).

current. Every cell is charged and discharged after the modules are integrated into the cabinet but before it is shipped.

4.3.2 State of Charge

The state-of-charge (SOC) is the amount of usable energy remaining in a battery and is expressed as a percentage. When shipping by cargo aircraft, international regulations require that lithium ion batteries may only be transported at an SOC not exceeding 30 percent of their rated design capacity, unless there is an exemption approved by a competent authority. [26] Lithium ion batteries transported at a reduced SOC pose a lower fire risk, should a cell go into a thermal runaway during transport. The IMDG regulations do not require a maximum limit SOC for lithium ion batteries when shipped by vessel.

Powin did not provide the SOC of the BESS when requested by the NTSB. ESA did measure the cell voltage on-scene of several BESS and found that it fell under the nominal voltage of 3.275V, indicating the SOC was below 50% (See Figure 17).

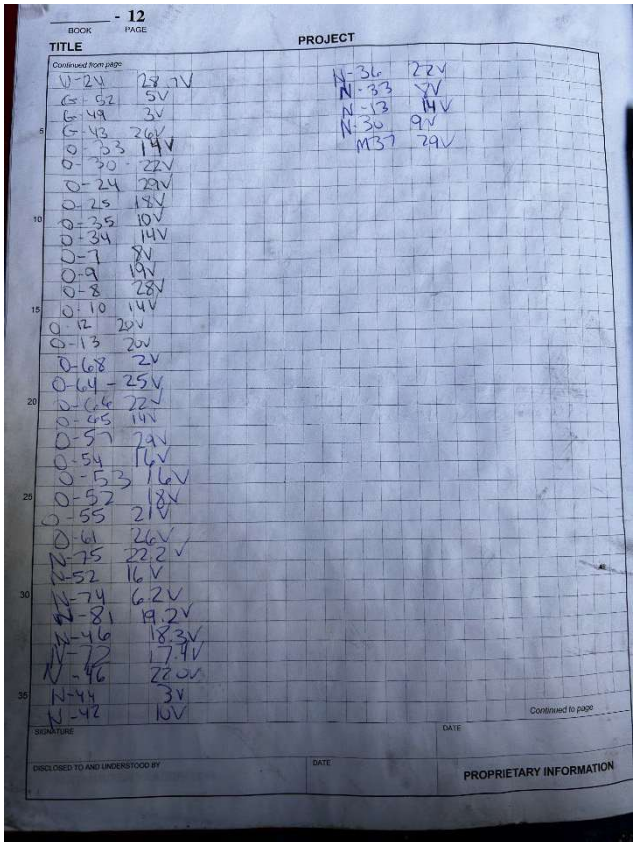


Figure 17: ESA voltage measurements recorded in Dutch Harbor, AK *(Image courtesy of Energy Security Agency*)

[26] This requirement went into effect in 2016 by the International Civil Aviation Organization (ICAO).

4.3.3 Safety Design

As specified SP 389 Dangerous Goods List, lithium battery cells and batteries offered for international transportation are required to have a safety venting device or be designed to preclude a violent rupture under conditions normally incident to transportation and be equipped with a means to preventing external short circuits, as well as dangerous reverse current flow if a battery contains cells, or a series of cells that are connected in parallel.

The battery cells within Powin's BESS did have a venting feature, as seen in Figure 5. The cells were connected in series and each side of the cabinet is in 420-cell series circuit, as seen in Figure 18. However, in transportation, this circuit is broken into smaller circuits of 150, 150, 120-cell series, which reduces the point-to-point voltage potential. [27] String controllers connect the cell strings and have fuses inside.

[27] The BESS features a manual service disconnect (MSD), which is used for maintenance purposes, that physically disconnects the entire 420-cell circuit into smaller circuits of 150, 150, 120. Powin reported that the MSDs are removed while in transportation, leaving series circuit broken into the smaller circuits, reducing the point-to point voltage potential to less than approximately 500 V(DC). See Attachment 10: Powin ATF NTSB USCG Questions.

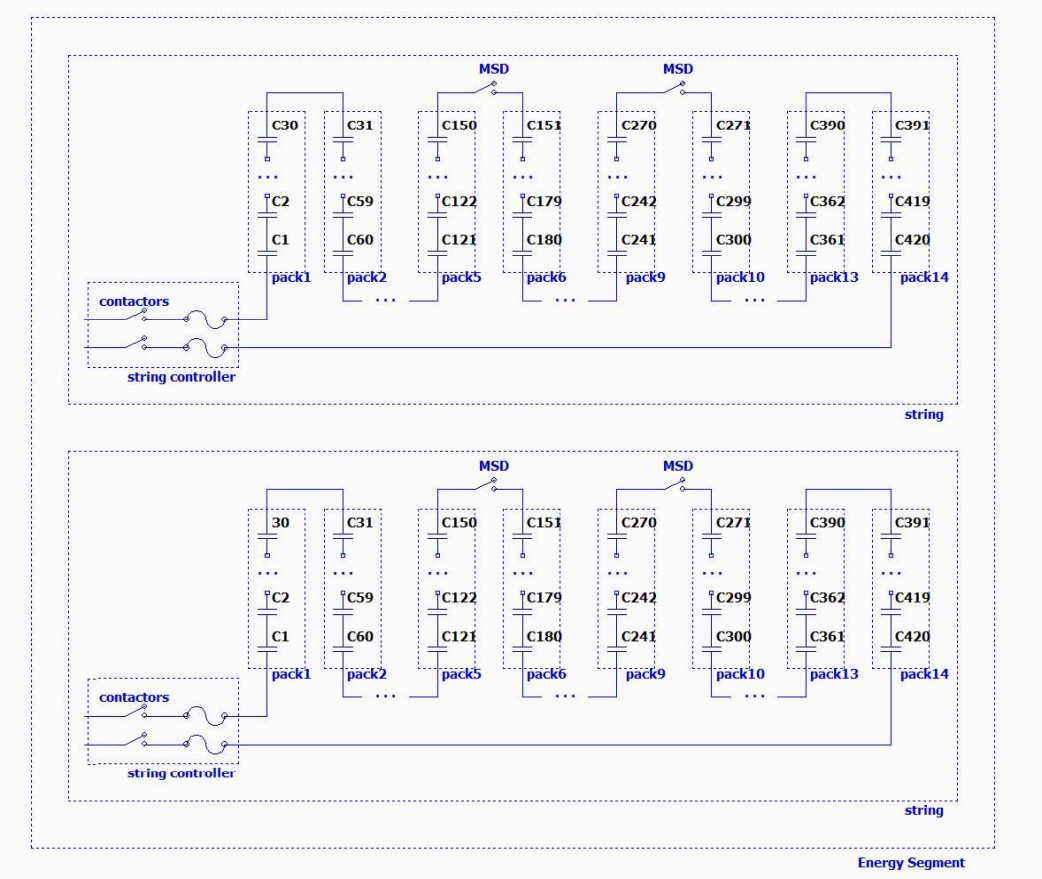


Figure 18: Schematic of one side of the BESS showing string controllers and disconnected series *(Image courtesy of Powin)*

However, majority of the safety features only apply while the BESS is in normal operation. Located underneath Powin's module was an aluminum heat sink that was electrically isolated by a polycarbonate sheet. The heat sink drew heat away through air from an air-conditioned unit attached to the top of the cabinet. This unit was charged with a proprietary coolant. The heat is then routed from the cell while the unit is in operation.

The BESS was also outfitted with a battery management system (BMS), which monitors the temperature and voltage of the individual modules and is connected to the AC unit.[28] Neither the air-conditioned unit nor the BMS was operational during transportation.

[28] According to Powin, battery health data such as temperature readings were being recorded while in transportation and later evaluated when the shipment was offloaded.

4.3.4 Placarding

Under Special Provision 389, UN 3536 batteries are not subject to the marking or labeling requirements. They are required to display the UN number for packaged dangerous goods in excess of 4000 kg and placarded on two opposing sides (as stated in IMDG section 5.3.2.1.1.2). The BESS were placarded on both sides of the cabinet with "UN 3536," as seen in Figure 19.



Figure 19: Powin cabinet from Genius Star XI shipment with UN 3536 placard being offloaded the Genius Star XI in San Diego, CA in February 2024 (Image *courtesy of Gallagher Marine Systems*)

4.4 Column (5) Packing Group and Column (8) Packing Instruction

A packing group is a classification according to the degree of danger presented by a dangerous good. Different classes of dangerous goods are assigned to Packing Groups I through III, which may refer to a Packing Instruction in Column (8) of the Dangerous Goods List.

No packing group or packing instruction is listed under the IMDG for UN 3536 shipments, even though the IMO Dangerous Goods Manifest and Declaration documents for the Genius Star XI listed the BESS shipment as a Packing Group II.[29]

4.4.1 Cargo Transport Unit

The IMDG does not specify what type of container the shipper must use for the dangerous goods but does specify performance criteria for containers, as well as how to appropriately pack the shipment. A cargo transport unit (CTU) is a type of container that is defined under the IMDG, which includes a "multimodal freight container".

When using a cargo transport unit, IMDG section 7.3 states, "Unless otherwise specified, the applicable provision of the *International Convention for Safe Containers, 1972 (CSC) Convention*, as amended, shall be followed for the use of any cargo transport unit which meets the definition of a "container" within the terms of that Convention." The CSC 1972 sets procedures for shipping containers used in international transport that must be "safety-approved" by the government, or an organization that is authorized by the government where the container was manufactured. The approval process includes specific structural safety requirements, test loads and loading forces that a container must meet.

However, for shipments of UN 3536 lithium batteries, the IMDG does not require that a UN 3536 lithium battery follow the referenced freight container standards within the code, though the shipping name includes "cargo transport unit."

For securement, the general provisions of the IMDG, Volume 1, Part 1, Chapter VII, Regulation 5 states that CTUs "shall be loaded, stowed and secured throughout the voyage in accordance with the Cargo Securing Manual approved by the Administration. The Cargo Securing Manual shall be drawn up to a standard at least equivalent to the guidelines developed by the Organization." The Cargo Securing Manual for the Genius Star was developed by Nippon Kaiji Kyokai, also known as ClassNK.[30]

4.5 Column (15) EmS Emergency Response

In response to the fire incidents, the crew on the Genius Star XI took several actions to control the fire. When the fire occurred in cargo hold 1 on December 25, the crew first closed the vents, and the master ordered the discharge of the vessel's fixed CO2 extinguishment system. Following the discharge of the CO2, cargo hold 1 remained secured and the vessel proceeded to the nearest port, Dutch Harbor, AK, for

[29] The IMDG defined a packing group II as "substances presenting medium danger."
[30] ClassNK is a ship classification society that is recognized by national authorities to assess and classify vessels for their suitability to carry specific types of hazardous cargo.

assistance. On December 28, as the vessel proceeded to Dutch Harbor, a second fire was discovered in cargo hold 2. The crew utilized fire hoses to externally cool the cargo hold, spraying sea water on the hatch cover to prevent the fire from expanding into the rest of the vessel.

Under the IMDG Section 3.2 Dangerous Goods List, UN 3536 shipments must follow schedules S-I, Spillage Schedule for Flammable Solids, and F-A, the General Fire Schedule, which are shown in the below images from the *Emergency Response Procedures for Ships Carrying Dangerous Goods* (EmS Guide).

For S-I, this schedule addresses what actions to take when responding to a spill on or below deck (See Figure 20):

S–I

FLAMMABLE SOLIDS (REPACKING POSSIBLE)

General comments		Wear suitable protective clothing and self-contained breathing apparatus. Avoid all sources of ignition (e.g. naked lights, unprotected light bulbs, electric handtools, friction). Wear non-sparking footwear. Stop leak if practicable.
Spillage on deck	Packages (small spillage)	Collect spillage and repack if practicable. Otherwise, wash overboard with copious quantities of water. Keep clear of effluent.
	Cargo transport units (large spillage)	
Spillage under deck	Packages (small spillage)	Collect spillage and repack if practicable.
	Cargo transport units (large spillage)	
Special cases: None.		

Figure 20: Spillage Schedule for Flammable Solids in IMDG

For F-A, this schedule addresses a cargo fire on or below deck, as well as for cargo exposed to fire (See Figure 21):

FIRE SCHEDULE Alfa

F–A

GENERAL FIRE SCHEDULE

General comments		In a fire, exposed cargoes may explode or their containment may rupture. Fight fire from a protected position from as far away as possible.
Cargo on fire on deck	Packages	Create water spray from as many hoses as possible.
	Cargo transport units	
Cargo on fire under deck		Stop ventilation and close hatches. Use cargo space fixed fire-extinguishing system. If this is not available, create water spray using copious quantities of water.
Cargo exposed to fire		If practicable, remove or jettison packages which are likely to be involved in fire. Otherwise, keep cool using water.
Special cases: UN 1381, UN 2447		After extinguishing the fire, treat immediately as for spillage (see relevant EmS SPILLAGE SCHEDULE).

Figure 21: EmS Schedule in IMDG

4.6 Column (16a) Stowage and Handling

Under the IMDG Section 3.2 Dangerous Goods List, this column indicates where the cargo can be placed on the ship. For Class 9 substances, Category A was listed, which indicates that cargo can be placed on or below deck for "cargo or passenger ships carrying a number of passengers limited to not more than 25 or to 1 passenger per 3 m of overall length, whichever is the greater number; or other passenger ships in which the limited number of passengers transported is exceeded." The 192 BESS were stowed on the tween decks, and the lower cargo holds.

A revision was approved for the IMDG 2024 edition which changed UN 3536 stowage to Category D, which went into effect on January 1, 2025, prohibiting storage of these batteries below deck. Vessels should now place these batteries on deck only "for cargo or passenger ships carrying a number of passengers limited to not more than 25 or to 1 passenger per 3 m of overall length, whichever is the greater number" and prohibited on "other passenger ships in which the limited number of passengers transported is exceeded."

4.7 U.S. Pre-transport requirements

The U.S. Department of Transportation authorizes shipments of dangerous goods to follow international standards instead of the DOT's Hazardous Materials

Transportation Regulations (HMR) under 49 CFR 171, Subpart C, with certain conditions and limitations.[31]

When importing into the United States, a shipper must have:

- Written shipper certification that the hazardous material being offered in transportation is properly classified, packaged, marked and labeled and in proper condition for transportation according to both international and national government regulations. (49 CFR § 172.204).
- Shipping paper information and packaging markings must be in English.
- Each person who provides for transportation or receives for transportation must retain a copy of the shipper paper or an electronic image that is accessible through its principles place of business (49 CFR § 172.201(e)).
- Emergency Response information in accordance with Part 172, subpart G
- Security requirements in accordance with Part 172, subpart I
- Incident reporting requirements in accordance with 49 CFR § 171.15 and 171.16.
- Registration requirements for persons who offer or transport hazardous materials, in accordance with subpart G of part 107.

For this incident, shipper certification, shipping papers, packaging markings and registration were required. The shipment of UN 3536 lithium batteries on the Genius Star XI was accompanied with shipper certification and a manifest. The cabinets were also marked with their UN number. Powin, however, is not a registered hazmat shipper under PHMSA because it did not meet the size requirement for the shipment under 49 CFR Part 107 Subpart G.[32]

5.0 Federal Guidance and Inspection

5.1 Pipeline Hazardous Materials Safety Administration (PHMSA)

PHMSA enforces the shipment of hazardous materials and the manufacture, fabrication, marking, maintenance, reconditioning, repair, or testing of multi-modal containers that are represented, marked, certified, or sold for use in the transportation of hazardous materials in the United States.

[31] Canadian shipments are excepted and must following 49 CFR 171.12.
[32] 49 CFR 107.601(a)(4) requires registration of a person who offers or transports hazardous materials a shipment of a quantity of hazardous materials in bulk packaging having a capacity equal to or greater than 13.24 cubic meters (468 cubic feet) for solids. The UN 3536 lithium battery on the Genius Star XI was approximately 450 cubic feet.

Before the shipment of the Geniux Star XI took place, Powin requested from PHMSA on November 30, 2022, a letter of interpretation requesting an assessment of their shipment of the BESS, the Stack750 Centipede Energy Segment, which was identical in design to the Stack800 model except for the power density of the cells. Powin asked PHMSA whether "a Stack 750…secured to a CTU meets the requirement of UN3536, and to synchronize those results across the UN, IMO and other association international bodies." The letter explained that the BESS includes a "fully integrated DC block, independent sensors (gas & temperature) and a fire suppression system…the internal batteries are secured via racks and are cooled by an air conditioning system."[33]

Included in the letter were recommended methods for securing their cabinet on a tractor trailer for highway transport, as well as by rail or vessel. Figure 22 shows the image Powin used for packaging shipments by vessel, which was not used aboard the Genius Star XI.



Figure 22: Image from Powin's November 2022 letter to PHMSA illustrating the recommended packaging for a BESS when shipped by vessel.

PHMSA responded to Powin's request on January 9, 2023, stating:

> "Based on the information and illustrations provided, it is the opinion of this Office that the Stack750 Centipede Energy Segment secured to a flat-rack, roll-on / roll-off, truck-trailer, or as bulk-freight is appropriately described and classed, as 'UN3536, Lithium batteries installed in cargo transport unit *lithium ion batteries or lithium metal batteries*,9' and meets the transportation requirements of special provision 389 assigned to the HM [hazardous materials] description."

[33] See Attachment 11: PHMSA Letter of Interpretation No. 22-0131, January 9, 2023

At the request of NTSB and the Coast Guard, the PHMSA Western Regional Hazardous Materials Office reviewed photos provided by the Coast Guard and contacted Powin regarding their shipment. The PHMSA office also reviewed the agency's January 2023 letter of interpretation to Powin and noted that the different model of BESS, the Stack750, did not limit the use of the letter just because the incident model was a Stack800, as long as Powin had followed SP 389 and performed the required UN 38.8 tests. PHMSA asserted that Powin reported the shipment was in compliance with both SP389 and UN38.3 for the shipment on the Genius Star XI. The agency did not evaluate further whether the shipment was in compliance with SP 389 or any other requirements under the IMDG.

On September 11, 2024, NTSB investigators requested from PHMSA a letter of interpretation of SP 389, which is also referenced under 49 CFR 172.102, which is nearly identical to the SP 389 in the IMDG.[34] The NTSB requested clarification on the following issues:

1) Is there performance packaging or specifications for a CTU/freight container for a UN 3536 lithium battery that is shipped by vessel or highway? If yes, what is the standard?
2) Clarification on whether a cabinet that housed lithium ion batteries is considered a cargo transport unit. If the cabinet itself is a CTU, what performance criteria must be met before the cabinet is transported by vessel or highway? (The NTSB used an image of Powin's BESS as an example of this cabinet, see Figure 23.)

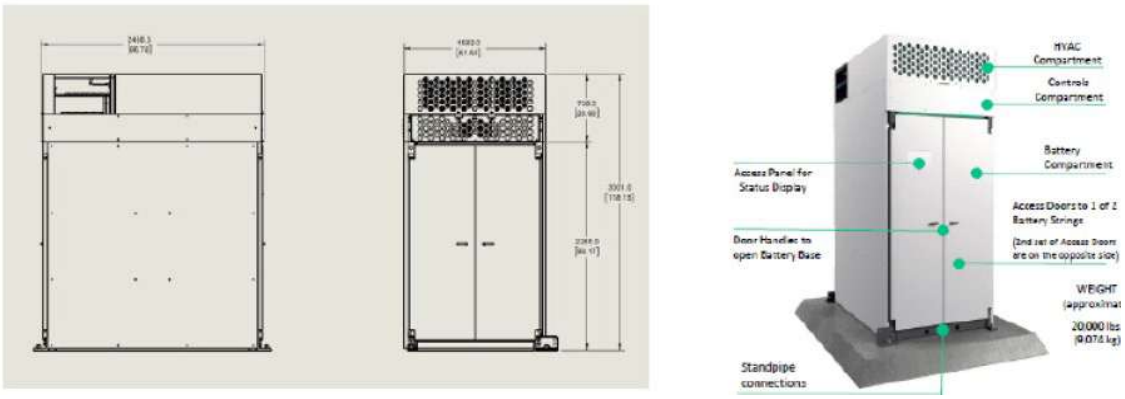


Figure 23: Exemplar BESS illustrated in the NTSB September 11, 2024, letter to PHMSA

3) When shipping a hazardous materials package by sea, the vessel may encounter a high sea state with significant speed winds and wave heights. Is

[34] See Attachment 12: PHMSA- NTSB Request for Letter of Interpretation (September 11, 2024)

a high sea state, such as gale force conditions, considered normal conditions of transportation by vessel?

4) A cargo transport unit equipped with an air conditioning system that was not energized during shipment, does that imply that the air conditioning system was not "necessary for the safe and proper operation" of the cargo transport unit?

PHMSA responded on March 26, 2025, stating that the battery cabinet illustrated in NTSB's letter is "a freight container that meets the definition of a CTU as defined in the HMR. See 49 CFR 49 CFR §176.2" The agency referred to the regulatory definition of a freight container and SP 389 as the performance criteria:

> A freight container is 'a reusable container having a volume of 64 cubic feet or more, designed and constructed to permit being lifted with its contents intact and intended primarily for containment of packages (in unit form) during transportation.' 49 CFR §171.8. Additional performance criteria, as provided in SP 389 and assigned to the UN 3536 entry to the Hazardous Materials Table, states that 'the batteries must be securely attached to the interior structure of the cargo transport unit (e.g., by means of placement in racks, cabinets, etc.) in such a manner as to prevent short circuits, accidental operation and significant movement relative to the cargo transport unit under the shocks, loadings, and vibrations normally incident to transport.' 49 CFR 172.102(c)(1)(389).

PHMSA's letter also addressed the air conditioning system for a BESS, which if not operational during transportation, would not determine whether it should be shipped within the CTU. If the air conditioning system was "only used for purposes other than the safe and proper operation of the CTU," then the system should not be transported within the CTU.

The agency also clarified that a "high sea state" refers to "rough and potentially dangerous ocean conditions with large waves, typically caused by strong winds or storms. While it is not unreasonable for a vessel to expect to encounter such rough seas during an ocean crossing, depending on the severity of the storm, such conditions may be considered abnormal."[35]

PHMSA Lithium Battery Guide

PHMSA developed a compliance resource to assist shippers to safely package lithium cells and batteries for transport by all modes of transportation, titled, "Lithium Battery Guide for Shippers." The guide is intended to provide the latest information on the

[35] See Attachment 13: PHMSA Response Letter to the NTSB, Reference No. 24-0082 (March 26, 2025).

existing requirements under the Hazardous Materials Regulations (HMR; 49 CFR Parts 171-180) and has undergone several revisions. [36]

At the time of the Genius Star incident, the Guide revised in September 2021 illustrated a packaging and hazard communication diagram for UN 3536, Lithium batteries installed in cargo transport unit *lithium ion batteries or lithium metal batteries*, depicting an intermodal shipping container as the packaging for this battery (See Figure 24):[37]



Figure 24: Diagram for UN 3536 from PHMSA's Lithium battery 2021 Guide

The latest edition of the Guide was revised in October 2024, which updated the diagram to illustrate a different packaging diagram (See Figure 25). [38]Neither the 2021 or 2024 guidance addressed performance criteria for a package, such as a CTU, to safely transport a UN 3536 lithium battery.

[36] HM-215O, Hazardous Materials: Harmonization with International Standards, 85 Fed. Reg. 27810 (May 11, 2020)
[37] See Attachment 14: PHMSA *Lithium Battery Guide for Shippers (2021)*
[38] See Attachment 15: PHMSA *Lithium Battery Guide for Shippers (2024)*

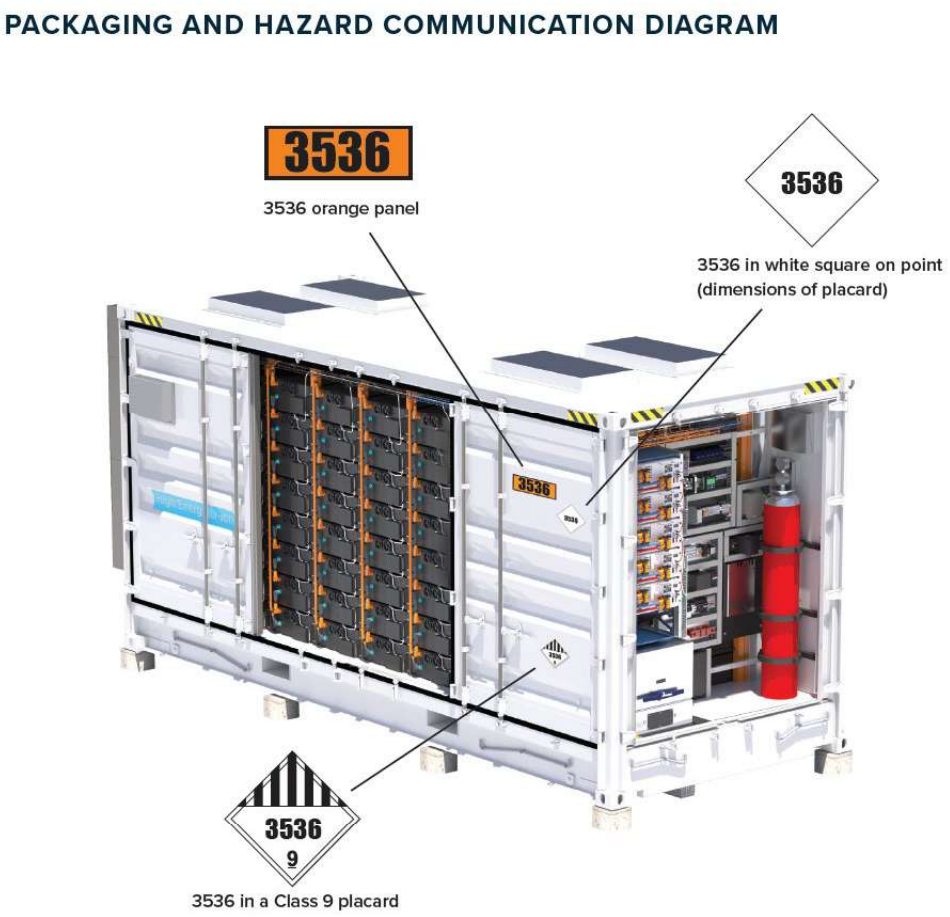


Figure 25: UN 3536 Diagram from PHMSA's Lithium battery 2024 Guide

6.0 Applicable codes and standards

According to the Stack800 specification sheet, Powin used the following industry standards to design and certify its battery. None of these standards provide guidance for safe transportation of a BESS:

- UL 9540A Test Method: This standard provides a test method for evaluating thermal runaway fire propagation in Battery Energy Storage Systems. The test method addresses key issues such as BESS installation and ventilation installation, the effectiveness of fire protection, fire service strategy and tactics.
- *ANSI/CAN/UL 1973 Standard for Safety for Batteries for Use in Stationary and Motive Auxiliary Power Applications*: This standard evaluates the battery systems' ability to safely withstand simulated abuse conditions, based upon the manufacturer's specified charge and discharge parameters. This standard is to certify the stationary batteries meet certain safety requirements while in operation in order to prevent potential fire and explosion hazards. The standard calls for

electrical, mechanical and environmental tests to be performed on the battery system, as well tests on the cell and module. The mechanical tests, however, are not intended to simulate transportation conditions to ensure safe shipment.

- *UL 1642, Standard for Safety Lithium Batteries*: This standard covers certification and testing of single cell, or two or more cells connected in series, parallel, or both, of a battery containing metallic lithium, or lithium alloy, or lithium ion. Electrical, mechanical, environmental and fire exposure tests are described within the standard.
- *NFPA 69 Standard on Explosion Prevention Systems*: This standard applies to design, installation, operation, maintenance and testing of explosion prevention systems.
- *NFPA 855, Standard for the Installation of Stationary Energy Storage Systems*: This standard applies to the design, construction, installation, commissioning and operation, maintenance and decommissioning of stationary energy storage systems including mobile and portable ESS installed in a stationary situation and the storage of lithium metal or lithium-ion batteries. Annex B of the standard notes that the hazards of an energy storage system, which vary by technology, include fire and explosion hazards, chemical hazards, electrical hazards, stranded or stored energy hazards and physical hazards.
- *IEC 62619*: This standard addresses safety requirement for secondary (rechargeable) lithium cells and batteries for use in industrial application for their safe operation.
- *IEC 61000-6-2*: This standard addresses electromagnetic compatibility for electrical and electronic equipment intended for use in industrial locations.
- *IEC 62477*: This standard applies to power electronic converter systems (PECS), any specified accessories, and their components for electronic power conversion and electronic power switching.

7.0 Previous Incidents

Powin has not previously reported any BESS incidents in transportation.

F. LIST OF ATTACHMENTS

Attachment 1: Genius Star XI Stowage Plan and Cargo Manifest
Attachment 2: Genius Star XI Genius Dangerous Goods Declaration and Manifest
Attachment 3: Powin Battery Safety Data Sheet
Attachment 4: Powin Battery Emergency Response Information
Attachment 5: Powin Battery Segment Paths
Attachment 6: Powin Battery UN 38.3 Test Reports (Cell and Module)
Attachment 7: Powin Battery Cabinet Structure Diagram
Attachment 8: Powin Battery Cabinet Factory Acceptance Test Report Example
Attachment 9: Genius Star XI ESA-Result Summary Report – 04FEB24
Attachment 10: Powin ATF NTSB USCG Questions
Attachment 11:PHMSA Letter of Interpretation No. 22-0131, January 9, 2023
Attachment 12: PHMSA/NTSB Request for Letter of Interpretation, September 11,2024
Attachment 13: PHMSA Response Letter to the NTSB, Reference No. 24-0082 (March 26, 2025)
Attachment 14: PHMSA Lithium Battery Guide for Shippers (2021)
Attachment 15: PHMSA Lithium Battery Guide for Shippers (2024)
Attachment 16: Powin Battery ESA Email to the NTSB September 3, 2025

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