

Prüfbericht-Nr.: <i>Test report no.:</i>	CN26SVV2 001	Auftrags-Nr.: <i>Order no.:</i>	326178369	Seite 1 von 75 Page 1 of 75
Kunden-Referenz-Nr.: <i>Client reference no.:</i>	2487803	Auftragsdatum: <i>Order date:</i>	2026-03-24	
Auftraggeber: <i>Client:</i>	NINGBO DEYE ESS TECHNOLOGY CO., LTD No.568, South Rixian Road, Binhai Economic Development Zone, Cixi, Ningbo, Zhejiang, P.R. China			
Prüfgegenstand: <i>Test item:</i>	Rechargeable Li-ion Battery System			
Bezeichnung / Typ-Nr.: <i>Identification / Type no.:</i>	SE-FX Max-6 (X=16, 32, 48, 64, 80, 96, 112, 128, 144, 160, 176, 192, 208, 224, 240, 256, 272, 288, 304, 320, 336, 352, 368, 384, 400, 416, 432, 448, 464, 480, 496, 512, which represents the total energy (kWh) of the parallel battery module)			
Auftrags-Inhalt: <i>Order content:</i>	TÜV Rheinland cTÜVus Mark Certificate			
Prüfgrundlage: <i>Test specification:</i>	ANSI/CAN/UL 9540:2025			
Wareneingangsdatum: <i>Date of sample receipt:</i>	2026-05-18			
Prüfmuster-Nr.: <i>Test sample no.:</i>	3300N000E3270001- 3300N000E3270005			
Prüfzeitraum: <i>Testing period:</i>	2026-06-01 - 2026-06-18			
Ort der Prüfung: <i>Place of testing:</i>	See page 4 for details			
Prüflaboratorium: <i>Testing laboratory:</i>	TÜV Rheinland (Shanghai) Co., Ltd.			
Prüfergebnis*: <i>Test result*:</i>	Pass			
geprüft von: created by: Feiyu Chen		genehmigt von: authorized by: Anhui Wu		
Datum: Date: 2026-08-25		Ausstellungsdatum: Issue date: 2026-08-25		
Stellung / Position:	Sachverständige(r)/Expert	Stellung / Position:	Sachverständige(r)/Expert	
Sonstiges / <i>Other:</i>	See the following pages for General product information and comment.			
Zustand des Prüfgegenstandes bei Anlieferung: <i>Condition of the test item at delivery:</i>	Prüfmuster vollständig und unbeschädigt <i>Test item complete and undamaged</i>			
* Legende:	P(ass) = entspricht o.g. Prüfgrundlage(n)	F(ail) = entspricht nicht o.g. Prüfgrundlage(n)	N/A = nicht anwendbar	N/T = nicht getestet
* Legend:	P(ass) = passed a.m. test specification(s)	F(ail) = failed a.m. test specification(s)	N/A = not applicable	N/T = not tested
Dieser Prüfbericht bezieht sich nur auf das o.g. Prüfmuster und darf ohne Genehmigung der Prüfstelle nicht auszugsweise vervielfältigt werden. Dieser Bericht berechtigt nicht zur Verwendung eines Prüfzeichens. <i>This test report only relates to the above mentioned test sample. Without permission of the test center this test report is not permitted to be duplicated in extracts. This test report does not entitle to carry any test mark.</i>				

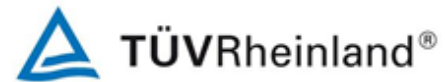
Prüfbericht-Nr.: CN26SVV2 001

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Test report no.:

Anmerkungen
Remarks

1	Alle eingesetzten Prüfmittel waren zum angegebenen Prüfzeitraum gemäß eines festgelegten Kalibrierungsprogramms unseres Prüfhauses kalibriert. Sie entsprechen den in den Prüfprogrammen hinterlegten Anforderungen. Die Rückverfolgbarkeit der eingesetzten Prüfmittel ist durch die Einhaltung der Regelungen unseres Managementsystems gegeben. Detaillierte Informationen bezüglich Prüfkonditionen, Prüfequipment und Messunsicherheiten sind im Prüflabor vorhanden und können auf Wunsch bereitgestellt werden. <i>The equipment used during the specified testing period was calibrated according to our test laboratory calibration program. The equipment fulfils the requirements included in the relevant standards. The traceability of the test equipment used is ensured by compliance with the regulations of our management system. Detailed information regarding test conditions, equipment and measurement uncertainty is available in the test laboratory and could be provided on request.</i>
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3	Prüfklausel mit der Note * wurden an qualifizierte Unterauftragnehmer vergeben und sind unter der jeweiligen Prüfklausel des Berichts beschrieben. Abweichungen von Prüfspezifikation(en) oder Kundenanforderungen sind in der jeweiligen Prüfklausel im Bericht aufgeführt. <i>Test clauses with remark of * are subcontracted to qualified subcontractors and described under the respective test clause in the report.</i> <i>Deviations of testing specification(s) or customer requirements are listed in specific test clause in the report.</i>
4	Die Entscheidungsregel für Konformitätserklärungen basierend auf numerischen Messergebnissen in diesem Prüfbericht basiert auf der "Null-Grenzwert-Regel" und der "Einfachen Akzeptanz" gemäß ILAC G8:2019 und IEC Guide 115:2023, es sei denn, in der auf Seite 1 dieses Berichts genannten angewandten Norm ist etwas anderes festgelegt oder vom Kunden gewünscht. Dies bedeutet, dass die Messunsicherheit nicht berücksichtigt wird und daher auch nicht im Prüfbericht angegeben wird. Zu weiteren Informationen bezüglich des Risikos durch diese Entscheidungsregel siehe ILAC G8:2019. <i>The decision rule for statements of conformity, based on numerical measurement results, in this test report is based on the "Zero Guard Band Rule" and "Simple Acceptance" in accordance with ILAC G8:2019 and IEC Guide 115:2023, unless otherwise specified in the applied standard mentioned on Page 1 of this report or requested by the customer. This means that measurement uncertainty is not taken in account and hence also not declared in the test report. For additional information to the resulting risk based of this decision rule please refer to ILAC G8:2019.</i>



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TEST REPORT
ANSI/CAN/UL 9540:2025
STANDARD FOR SAFETY
Energy Storage Systems and Equipment

Report Number..... : CN26SVV2 001

Date of issue : see cover page

Total number of pages : see cover page

Testing Laboratory : TÜV Rheinland (Shanghai) Co., Ltd.

Address : No. 177, Lane 777, West Guangzhong Road, Jing'an District, Shanghai 200072, P. R. China

Applicant's name : NINGBO DEYE ESS TECHNOLOGY CO., LTD

Address : No.568, South Rixian Road, Binhai Economic Development Zone, Cixi, Ningbo, Zhejiang, P.R. China

Test specification:

Standard : ANSI/CAN/UL 9540:2025

Test procedure : cTÜVus mark approval

Non-standard test method..... : N/A

Test Report Form No. : UL 9540_2025C

Test Report Form(s) Originator.... : TÜV Rheinland (Shanghai) Co., Ltd.

Master TRF : Dated 2025-03

General disclaimer:

The test results presented in this report relate only to the object tested.
 This report shall not be reproduced, except in full, without the written approval of the Issuing Testing Laboratory. The authenticity of this Test Report and its contents can be verified by contacting the Laboratory responsible for this Test Report.

Test item description Trademark(s) Manufacturer Model/Type reference Ratings	Rechargeable Li-ion Battery System  Same as applicant See cover page See copy of marking label and model list																				
List of Attachments (including a total number of pages in each attachment): - Attachment 1: Photo documentation. (7 pages)																					
Summary of testing:																					
Tests performed (name of test and test clause): Following tests performed during evaluation: <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr style="background-color: #d3d3d3;"> <th style="text-align: left;">Clause(s)</th> <th style="text-align: left;">Test(s)</th> </tr> </thead> <tbody> <tr><td>☒ cl. 30</td><td>Normal Operations Test</td></tr> <tr><td>☒ cl. 32</td><td>Dielectric Voltage Withstand Test</td></tr> <tr><td>☒ cl. 33</td><td>Impulse Test</td></tr> <tr><td>☒ cl. 34</td><td>Equipment Grounding and Bonding Test</td></tr> <tr><td>☒ cl. 35</td><td>Insulation Resistance Test</td></tr> <tr><td>☒ cl. 36</td><td>Electromagnetic Immunity Tests</td></tr> <tr><td>☒ cl. 40</td><td>Enclosure and Mounting Tests</td></tr> <tr><td>☒ cl. 41.2</td><td>Outdoors installations subject to moisture exposure</td></tr> <tr><td>☒ cl. 41.3</td><td>Outdoor installation in marine environments</td></tr> </tbody> </table> The DUT was complied with the requirements of ANSI/CAN/UL 9540:2025.	Clause(s)	Test(s)	☒ cl. 30	Normal Operations Test	☒ cl. 32	Dielectric Voltage Withstand Test	☒ cl. 33	Impulse Test	☒ cl. 34	Equipment Grounding and Bonding Test	☒ cl. 35	Insulation Resistance Test	☒ cl. 36	Electromagnetic Immunity Tests	☒ cl. 40	Enclosure and Mounting Tests	☒ cl. 41.2	Outdoors installations subject to moisture exposure	☒ cl. 41.3	Outdoor installation in marine environments	Test Location: TMP NINGBO DEYE ESS TECHNOLOGY CO., LTD No.568, South Rixian Road, Binhai Economic Development Zone, Cixi, Ningbo, Zhejiang, P.R. China
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Test item particulars	
Energy Storage System Technologies	☒ Electrochemical ESS ☐ Chemical ESS ☐ Mechanical ESS ☐ Thermal ESS
Output field wiring terminals	☐ AC ESS ☒ DC ESS
Interaction	☐ Standalone mode ☐ Utility grid interaction ☐ Standalone and multi-mode
Installation of ESS	☒ Stationary ☐ Mobile ☐ For building-in ☐ Fixed
Environmental category	☒ Indoor ☐ Outdoor (Moisture exposure) ☒ Outdoor (Marine environments) ☐ In seismic environments
Access location	☒ Instructed person accessible ☐ Walk-in Unit ☐ Restricted access location
Considered current rating of protective device as part of the building installation (A)	N/A
Overvoltage Category	OVC II
Pollution degree	PD 3 (PD 2 inside)
Protection class of enclosure	NEMA type 3R
Chemical technology of Battery system	Rechargeable Lithium-ion (LFP)
Heating / Cooling systems	N/A
Maximum energy capacity of individual electrochemical ESS (kWh)	See model list
Mass of equipment (kg)	See model list
Possible test case verdicts:	
- test case does not apply to the test object	N/A
- test object does meet the requirement	P(ass)
- test object does not meet the requirement	F(ail)
Testing	
Date of receipt of test item	See cover page
Date(s) of performance of tests	See cover page
General remarks:	
"(See attachment #)" refers to additional information appended to the report. "(See appended table)" refers to a table appended to the report. Throughout this report a ☐ comma / ☒ point is used as the decimal separator.	

Factory location:

NINGBO DEYE ESS TECHNOLOGY CO., LTD

No.568, South Rixian Road, Binhai Economic Development Zone, Cixi, Ningbo, Zhejiang, P.R. China

Purpose of This Report:

cTÜVus Mark approval

Report History:

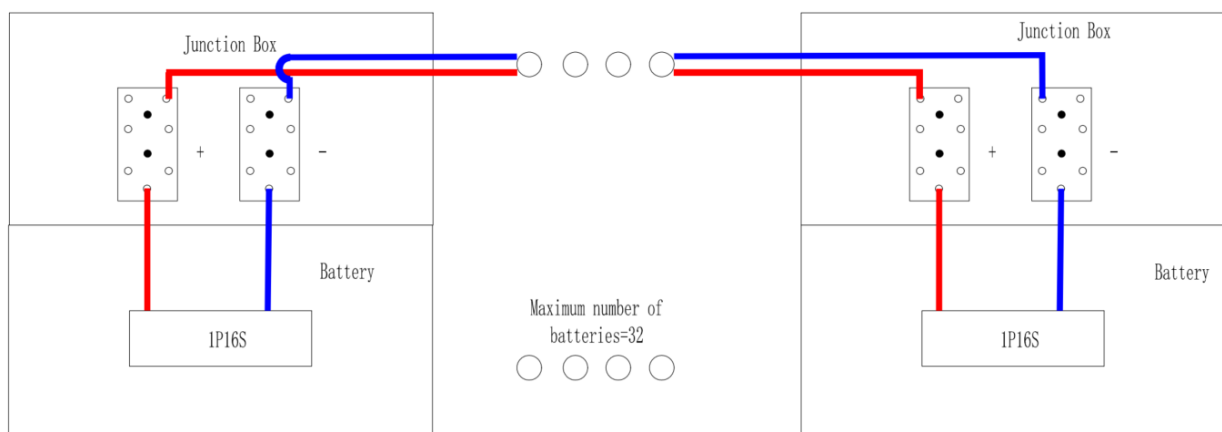
N/A

Description of the product:

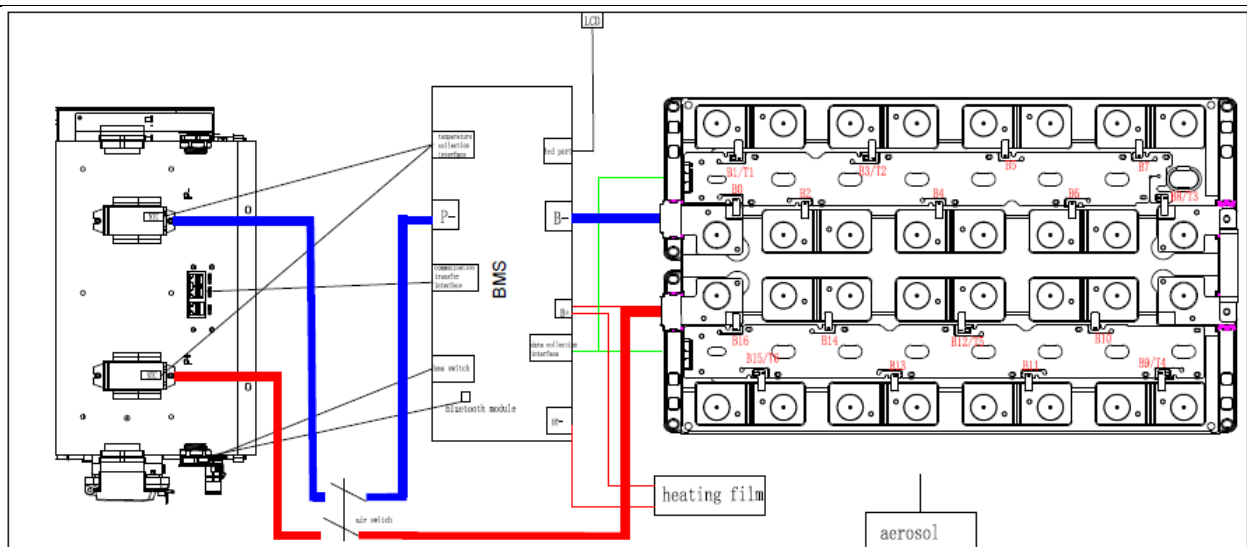
Product Description:

1. SE-FX Max-6 is a residential energy storage battery of DEYE's SE-F series, with a specification of 51.2V, 16kWh. It is specially designed for high-capacity applications and long-term outdoor reliability.
2. The model number(s): SE-FX Max-6 (X=16, 32, 48, 64, 80, 96, 112, 128, 144, 160, 176, 192, 208, 224, 240, 256, 272, 288, 304, 320, 336, 352, 368, 384, 400, 416, 432, 448, 464, 480, 496, 512, which represents the total energy (kWh) of the parallel battery module)
3. The SE-FX Max-6 is constructed with YPH3L7-314Ah battery cells in YP16S. (Y=1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32))
4. The battery system in a low voltage box has an over-charge, over-discharge, over-current, over-temperature, under-temperature, and short-circuit protection circuit.
5. The electronic circuits and software controls for the battery relied upon the protective functions of the battery management system which have been evaluated in accordance with UL 60730-1 Annex H.
6. Model SE-FX Max-6 has two variants: US version and AU version, supplied for different target markets. The only difference between them lies in the plugs for wiring ports, refer to the attached component list of this report. This difference has no impact on the tests.
7. An optional metal junction box is provided for parallel-connected modules where $X \geq 32$ (number of battery modules ≥ 2). See the block diagram below and attached photo documents.
8. SE-FX Max-6 shall be used within a system equipped with a manual disconnect device that can isolate both positive and negative poles simultaneously.
9. The EUT is indoor or outdoor type with NEMA type 3R, PD2 was evaluated for inside and PD3 for outside.

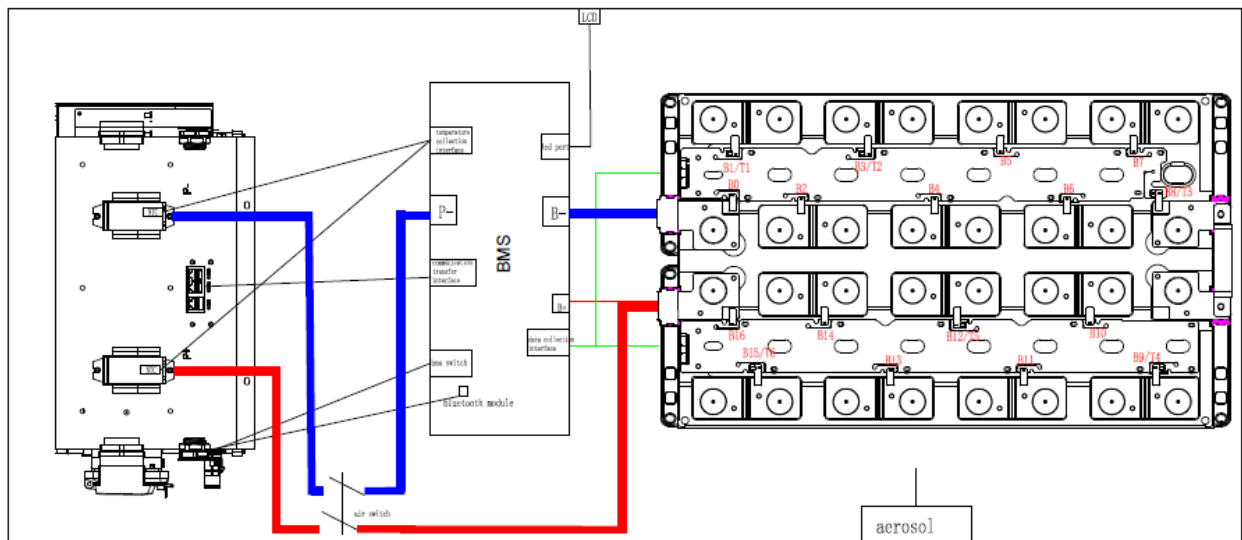
Block diagram as below:



Block diagram of the battery system



Block diagram of the module with heating film



Block diagram of the module without heating film

Model list:

Table1 Single Battery System Parameters:

	Battery Cell	Battery System
Product	Rechargeable Li-ion Cell	Rechargeable Li-ion Battery System
Type/model	YPH3L7-314Ah	SE-F16 Max-6
Rated capacity [Ah]	314	314
Cell quantity	1	16
Battery structure	--	1P16S
Nominal voltage [V]	3.2	51.2
Rated energy [kWh]	1.0048	16

Upper limit charging voltage [V]	3.83	57.6
Recommend charging current [A]	157	157
Maximum charging current [A]	314	160
Recommend discharging current [A]	157	157
Maximum discharging current [A]	314	200
Discharge cut-off voltage [V]	2.5 ($T \geq 0^{\circ}\text{C}$) 2.0 ($T < 0^{\circ}\text{C}$)	44.8
Temperature range for charging [$^{\circ}\text{C}$]	-4 to 65	0 to 55 (without heating film) -20 to 55 (with heating film)
Temperature range for discharging [$^{\circ}\text{C}$]	-30 to 65	-20 to 55
Temperature threshold for protection	--	60
Overcharge protected voltage supply by battery system	--	$\geq 3.65\text{V /Cell}$
Recommend charging method by manufacturer	Charge at constant current 157A until the voltage reaches 3.65V, then switch to constant voltage 3.65V till charge current drops to 15.7A	At constant current 160A until any cell voltage reaches 3.6V
Dimension [mm]	$(71.7 \pm 0.5) * (174.7 \pm 0.8) * (207.0 \pm 0.8)$ T*W*H(mm) without terminal	464mm(W)×914mm(H) ×244.5mm(D)
Weight [kg]	5.57 ± 0.15	118 ± 2
Enclosure ingress protection type	--	NEMA type 3R
Protective Class	--	I
Cooling type	--	Natural air cooling
Altitude	--	$\leq 3000\text{m}$

Table 2 Battery System Parallel Connection Parameter:

Product name	Rechargeable Li-ion Battery System
Type/model	SE-FX Max-6 (X=16, 32, 48, 64, 80, 96, 112, 128, 144, 160, 176, 192, 208, 224, 240, 256, 272, 288, 304, 320, 336, 352, 368, 384, 400, 416, 432, 448, 464, 480, 496, 512, which represents the total energy (kWh) of the parallel battery module)

DC ESS	Rated capacity [Ah]	314*Y (Y=1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32)
	Cell quantity	16*Y (Y=1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32)
	Rated energy [kWh]	16*Y (Y=1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32)
	Temperature range for charging [°C]	0 to 55 (without heating film) -20 to 55 (with heating film)
	Temperature range for discharging [°C]	-20 to 55
	Altitude [m]	≤3000m
	Pollution degree	PD 3 (PD 2 inside)
	Protective Class	Class I
	Enclosure ingress protection type	NEMA type 3R
	Weight [kg]	(118±2)*Y (Y=1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32)

Nameplate, Warning, and Label, etc.:



Product Model: SE-FX Max-6
X=16,32,48,64,80,96,112,128,144,160,176,192,
208,224,240,256,272,288,304,320,336,352,368,
384,400,416,432,448,464,480,496,512

Ambient Operating Temperature -20~55℃

Protection Class Class I

Pollution Degree II

Battery Model: SE-F16 Max-6

Battery Module Data

Battery Type	Li-Ion
Nominal Battery Voltage	51.2Vd.c.
Max.Charging Current	160Ad.c.
Max.Discharging Current	200Ad.c.
Fuse Max. Current	600Ad.c.
Rated Energy	16kWh
Dimensions (W x H x D)	464x894x244.5mm
Weight	120kg
Ingress Protection	NEMA Type 3R
Short Current/Time	1kA/1ms



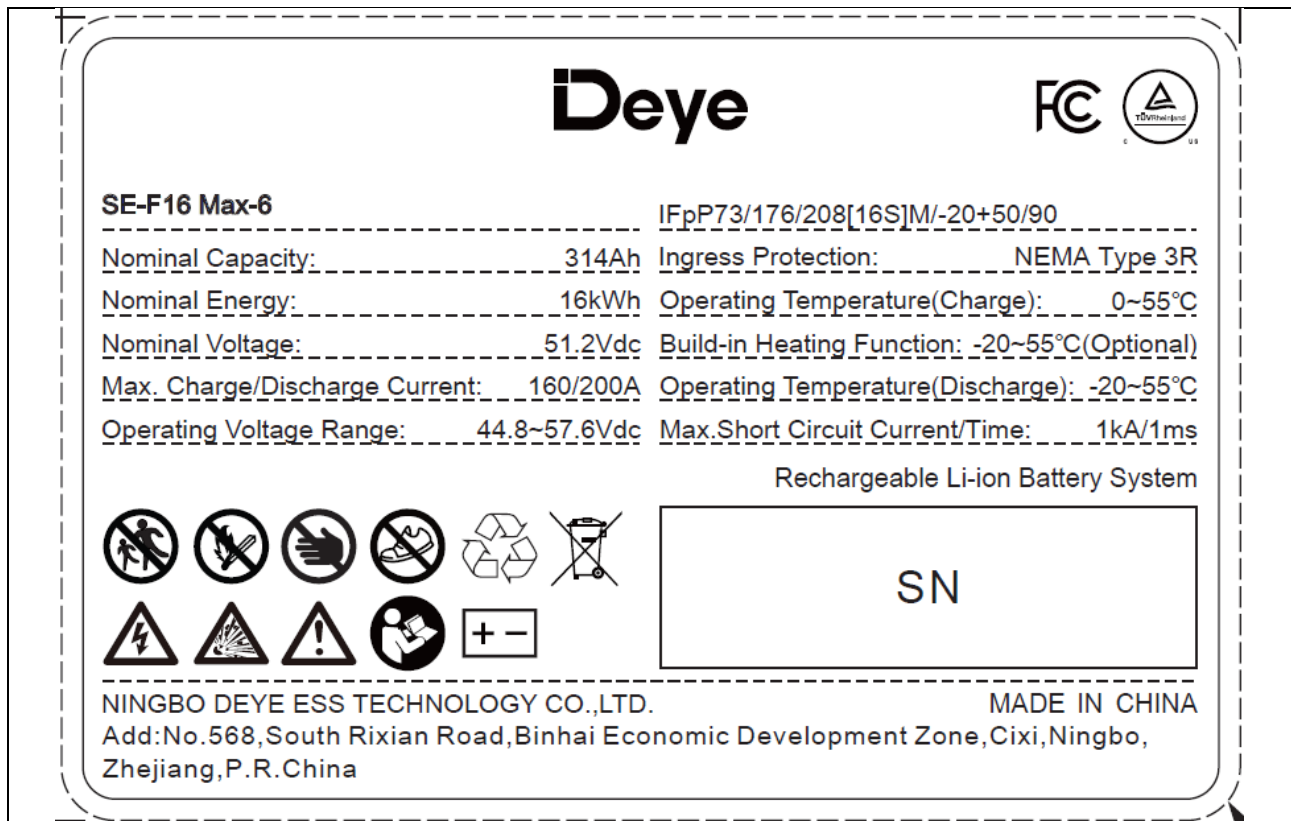
Safety Warning

- The AC and DC circuits must be disconnected and the maintenance personnel must wait for 5 minutes before they are completely powered off before they can start working.
- It is strictly forbidden for users to open the casing. Professional maintenance is required for internal maintenance of the inverter.
- Surface high temperature, please do not touch the inverter case.
- The DC input terminals of the inverter must not be grounded.
- Please read the instructions carefully before use.
- Do not put it in the waste bin! Recycle it by licensed professional!
- Hazardous voltage circuits.
- To reduce the risk of injury, read all instructions.
- For use only in remote outdoor locations as permitted in applicable installation codes and standards.
- Suitable for use in residential non-habitable spaces.

- Les circuits AC et DC doivent être débranchés et le personnel de maintenance doit attendre 5 minutes avant qu'ils ne soient complètement débranchés avant de pouvoir commencer à fonctionner.
- Il est strictement interdit aux utilisateurs d'ouvrir le boîtier. Un entretien professionnel est nécessaire pour l'entretien interne de l'onduleur.
- Surface à haute température, veuillez ne pas toucher le boîtier de l'onduleur.
- Les bornes d'entrée CC de l'onduleur ne doivent pas être mises à la terre.
- Veuillez lire attentivement les instructions avant utilisation.
- Ne le mettez pas à la poubelle ! Recyclez-le par un professionnel agréé !
- Circuits de tension dangereux.
- Pour réduire le risque de blessure, lisez toutes les instructions.
- Pour être utilisé uniquement dans des endroits extérieurs isolés autorisés par les codes et normes d'installation applicables.
- Convient aux espaces résidentiels non habitables.

C/O NINGBO DEYE ESS TECHNOLOGY CO., LTD
 Add: No.590, South Rixin Road, Binhai Economic Development Zone, Cixi, Ningbo,
 Zhejiang, P.R.China
www.deyesolar.com

Label for Battery System



Label for Battery Module

Note:

1. The 1st to 3rd digits of the SN code are 3 arbitrary digits, each digit ranges from 0 to 9, representing the product model code.

The 4th to 5th digits of the SN code are 2 arbitrary digits, each digit ranges from 0 to 9, representing the production line code.

The 6th to 8th digits of the SN code "XXXXXXXXXXXXXXXX" identify the battery cells used internally in the product. The specific encoding rules are shown in the table below:

The 6th to 8th digits of the SN code	Corresponding cell model
A01	GSP71173204F
A02	YPH3L7-314Ah
A03	MB31
A04	7VH4L4-314Ah
A05	PF173-314Ah

The 9th digital to 12th digital of SN number "XXXXXXXXXXXXXXXX"represents for production date, where the 9th digital represents production year, the 10th digital represents production month, and 11th and 12th represents production day. Specific coding rules are as shown in the table below.

Year	A for year 2022, B for year 2023, C for year 2024,..... Z for year 2047
Month	1 for January, 2 for February, ... , A for October, B for November, C for December
Day	Exact day, 01 to 31

The 13th to 16th digits of the SN code are 4 arbitrary digits, each digit ranges from 0 to 9, representing the production running number.

2. The SE-FX Max-6 model evaluated in this report adopts YPH3L7-314AH battery cells.

Caution:

- Prohibition short circuit.
- Don't discard the battery in fire or heater.
- Don't reverse the positive and negative terminals.
- Don't pierce the battery with a nail or other sharp object.
- Disposal acc. to local regulations!
- In the event of an emergency or problems with the system, please call Deye Services at 0086-0574-6378 7513

Attention :

- Interdiction de provoquer un court-circuit.
- Ne jetez pas la batterie dans le feu ou près d'un chauffage.
- Ne pas inverser les bornes positive et négative.
- Ne percez pas la batterie avec un clou ou tout autre objet pointu.
- Élimination conforme aux réglementations locales !
- En cas d'urgence ou de problèmes avec le système, veuillez appeler Deye Services au 0086-0574-6378 7513


WARNING
ARC FLASH HAZARD

Nominal system voltage:	57.6V
Arc flash boundary:	45cm
Available incident energy:	0.00043cal/cm ²
Working distance:	450mm
Minimum arc rating of clothing:	PPE1


ATTENTION
RISQUE D'ÉCLAIR D'ARC

Tension nominale du système:	57.6V
Limite de l'éclair d'arc:	45cm
Énergie incidente disponible:	0.00043cal/cm ²
Distance de travail:	450mm
Tenue à l'arc minimale des vêtements:	PPE1

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict

INTRODUCTION			
1	Scope		P
1.1	The energy storage system is designed to receive and store energy, and consists of at least an energy storage function and energy storage protective function. The ESS can be an AC ESS or a DC ESS.	DC ESS	P
1.2	Standalone or utility interactive		P
1.3	Requirements for installation		P
1.4	Location of ESS (including indoor, outdoor, mobile ESS, residential and non-residential)	Indoor, outdoor and residential	P
1.5	Systems using lead acid or Ni-cad batteries that fall within the scope of UL 1778/CSA C22.2 No.107.3 and only serve an uninterruptible power system (UPS) application are outside the scope of this Standard.		N/A
1.6	Maximum Energy Capacities: a) Residential use electrochemical ESS shall not exceed 20 kWh (72 MJ), and may be greater if ESS meets the UL 9540A Unit Level test requirements; b) Non-residential use electrochemical ESS shall not exceed 50 kWh (180 MJ), and may be greater if ESS meets the UL 9540A Installation Level test requirements and is marked in accordance with 45.20; c) No maximum energy capacity limit for non-residential use electrochemical ESS tested in accordance with UL 9540A and meeting the performance criteria for cell level testing; d) Non-residential electrochemical ESS for use in remote outdoor locations has no maximum energy capacity limit, and shall be marked in accordance with 45.21.	Refer to the TUV test report of UL 9540A: CN26H50G 002	P
2	Components		P
2.1	A component or equipment of an energy storage system covered by this Standard shall comply with the safety requirements for that component or equipment.	See CDF for details	P
3	Units of Measurement		P
3.1	Values and their respective units of measurement that are stated without parentheses constitute the requirement of the standard.		P
4	Undated References		P
4.1	Undated references imply the latest edition of the standard.		P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
5	Normative References		P
5.1	Refer to Standard document for list of references.		P
6	Glossary		P
6.1-6.46	Refer to Standard for a list of definitions		P
CONSTRUCTION			
7	Non-Metallic Materials		P
7.1	a) The polymeric materials employed for enclosures shall comply with UL 746C, Path III of the Enclosure Requirements, or CSA C22.2 No. 0.17; and b) The enclosure shall be evaluated to meet the Unit Level performance criteria of UL 9540A.	Metal enclosure	N/A
	<i>Exception: Equipment of a multi-part ESS that complies with the enclosure requirements in the appropriate standard for that equipment is not required to comply if the equipment enclosure is determined suitable for the intended environmental conditions that the ESS will be exposed to.</i>		N/A
7.2	The following factors in (a) – (e) are taken into consideration about nonmetallic enclosure. a) Resistance to impact b) Crush resistance c) Abnormal operations d) Severe conditions; and e) Mold-Stress Relief Distortion		N/A
7.3	Additional properties about polymeric enclosures: a) Minimum 5VA flame rating b) Insulation material Property Considerations table UL 746C c) Strain-Relief Test after Mold Stress-Relief Distortion of UL 746C d) UV exposure test of UL 746C e) Water exposure and immersion test of UL 746C f) Conduit connections of UL 746C <i>Exception: 7.4</i>		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
7.4	The requirements in 7.3 do not apply to non-metallic parts forming part of the enclosure in any of the following conditions in accordance with UL 94 or CSA C22.2 No. 0.17: a) The part made of V-0, V-1, V-2, or HB-rated materials cover an opening no dimension greater than 25.4 mm (1 in.); b) The part made of V-0, V-1, V-2, or HB-rated materials cover an opening that do not give access to the user to hazardous live parts, when it is removed; c) The part made of V-0, V-1, V-2, or HB-rated materials cover an opening no dimension greater than 101.6 mm (4 in). There is no fire hazard closer than 101.6 mm (4 in) from the surface of the enclosure; or d) A barrier or device made of V-0 classed material between parts made of V-0, V-1, V-2, or HB rated material and the source of a fire risk.		N/A
	<i>Exception: A part of a component is not required to be Classed V-0, V-1, V-2, or HB when it complies with the flammability requirements applicable to the component.</i>		N/A
7.5	Materials employed as electrical insulation shall be resistant to deterioration that would result in an electrical shock, fire or other safety hazard. And shall comply with UL 746C. Insulated wiring is subjected to the requirements outlined in Section 11.		P
7.6	Gaskets and Seals relied upon for safety, shall be determined suitable for the environmental conditions and chemical substances they are anticipated to be exposed to in their end use.		N/A
7.7	Compliance with 7.6 for gaskets and seals relied upon to prevent ingress of moisture into the enclosure, can either comply with the Gaskets Tests Clause of UL 50E/CSA C22.2 No. 94.2 or comply with UL 157 or ASTM D412 for the anticipated exposures.		N/A
8	Metallic Enclosures and Parts Resistance to Corrosion		P
8.1	Metallic enclosure parts for BESS shall be of non-combustible materials; otherwise, it shall be evaluated to verify compliance with its performance criteria through UL 9540A Unit Level testing.		P
8.2	Metallic enclosures shall be corrosion resistant		P
8.3	Conductive parts with dissimilar metals in contact at terminals and connections shall not be subject to corrosion due to electrochemical action.		P

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Clause	Requirement + Test	Result - Remark	Verdict
9	Enclosures and Guarding of Hazardous Parts		P
9.1	The enclosure(s) shall have the strength and rigidity required to resist the possible physical during its intended use. The enclosure strength requirements outlined in UL 50, UL 1741, IEC 62477-1, UL 2755, ISO 1496-1 or equivalent standard shall be applied to demonstrate compliance.		P
	<i>Exception: For smaller systems that are less than or equal to 50 kWh, the enclosure strength may be evaluated to the enclosure requirements of this Standard and tested in accordance with the applicable tests of Section 40.</i>		N/A
9.2	UL 2416 compliant rack assemblies that serve as the internal support structure for the ESS are used within the rated load range		N/A
9.3	Openings in the enclosure shall be designed to prevent inadvertent access to hazardous parts. For a minimum IP rating of IP2X with consideration of the end use installation.		P
	<i>Exception: An Energy storage system intended for location in restricted access locations need not meet this accessibility criterion if provided with warning markings for service and other personnel having access to the system.</i>		N/A
9.4	In service access areas, bare parts of hazardous voltage circuits, shall be located or guarded so that accidental shorting is unlikely		P
9.5	Enclosures of systems located where they will be subject to exposure to water and other elements shall be rated for the level of intended exposure		P
10	General Electrical Safety of Systems and Additional Requirements for Walk-in Units	Not a walk-in System	N/A
10.1	Instructions include measures and procedures for worker safety per NFPA70E, CSA Z462 and section 2 of the C22.1		N/A
10.2	Walk in enclosures have suitable mechanical load ratings for equipment and persons inside		N/A
10.3	Shipping container type enclosures if modified comply with ASTM D3169		N/A
10.4	The enclosures for outdoor walk-in units exceeding 53x8.5x9.5ft shall be evaluated as an indoor environment		N/A
10.5	Explosion venting system of walk-in unit shall comply with the applicable requirements in 24.5		N/A
10.6	Procedures for safe entry and exit		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
10.7	Personnel doors of walk-in units shall be designed to prevent persons from becoming trapped within the unit and shall be able to be opened from the inside without use of a tool or key.		N/A
10.8	Work space dimensions and requirements shall be in accordance with NFPA 70, or CSA C22.1, or in accordance with IEEE C2 as applicable to where the system is installed. The space requirement shall also provide for appropriate arc flash safety under specified personal protective equipment (PPE).		N/A
10.9	Areas of access shall be designed to prevent tripping, slipping or falling when persons enter, exit. Surfaces and parts within a walk-in unit shall be designed to prevent inadvertent hazards to personnel within the enclosure through appropriate guarding, electrical and thermal insulation methods and cautionary warnings and signage in accordance with this Standard.		N/A
10.10	Protection against contact with hazardous voltage parts in the energy storage system shall be in accordance with 9.3 or through the use of guarding to prevent access with cautionary warnings and signage where only qualified personnel are allowed access.		N/A
10.11	Type of protection shall be determined by an arc flash risk assessment conducted according to NFPA 70E and CSA Z462. The arc flash assessment results shall be labeled on the ESS.		N/A
10.12	Unprotected arc flash boundary shall be considered one that has an arc rating above 5 J/cm ² (1.2 cal/cm ²) incident energy level		N/A
10.13	A fully walk in enclosure shall be designed to automatically provide mechanical ventilation using 100 % outdoor air.		N/A
10.14	Electrical circuits that are an integral part of the ESS including those that are part of a walk-in enclosure including lighting, controls, power, HVAC, emergency lighting, alarm circuits, and the like shall comply with the appropriate requirements for the type of equipment and the specific application within the ESS.		N/A
10.15	Electrical equipment subject to condensation shall be suitable for outdoor use or suitably protected against contact with water and protected against unsafe conduction of hazardous voltages to personnel via water as a conduction path.		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
10.16	Lighting shall be supplied in enclosed working spaces in accordance with Article 410 of the NFPA 70 or Section 30 of CSA C22.1		N/A
10.17	ESS of more than one supply source shall be provided with information and markings to indicate which disconnect device or devices are required to be operated to completely isolate the equipment.		N/A
10.18	Protection against lightning surges in accordance with NFPA 70, CSA C22.1 or IEEE C2 as applicable		N/A
11	Wiring and Electrical Supply Connections		P
11.1	Wiring shall be insulated and acceptable for the purpose		P
11.2	Wiring methods and electrical supply connections of energy storage systems shall be in accordance with NFPA 70 or CSA C22.1, or IEEE C2 as applicable to where the system is installed.		P
11.3	An ESS shall have provision for connection of the system to an external wiring system consisting of: a) Wiring terminals or wiring leads; b) A means for connection of cable or conduit in accordance with the codes in 11.2.		P
11.4	A wiring terminal or lead that is supplied as a component of the ESS shall be rated and sized for connection to a field wiring conductor having an ampacity of no less than 125% of the ac or dc current that the circuit carries during rated conditions and in accordance with the codes in 11.2.		P
11.5	A field-wiring lead shall not be more than two wire sizes smaller than the copper conductor to which it is to be connected, and shall not be smaller than 2.08 mm ² (14 AWG). A field-wiring lead shall not be less than 152.4-mm (6-in) long.		P
	<i>Exception No. 1: Communications cable may be less than 2.08 mm² (14 AWG).</i>		P
	<i>Exception No. 2: Field wiring harness accessories supplied by the manufacturer and evaluated for use with the system.</i>		P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
11.6	Field-wiring compartments, in which branch circuit connections are to be made, shall: a) Permit the connection of the supply wires after the ESS is installed; b) Permit the connection to be introduced and connected easily and safely; and c) Be located so that the connections can be readily inspected after the ESS is installed.		P
11.7	Internal wiring shall be routed, supported, clamped or secured in a manner that reduces the likelihood of excessive strain on wire and on terminal connections; loosening of terminal connections; and damage of conductor insulation.		P
11.8	A hole by which insulated wires pass through the system enclosure or elements providing separation within the enclosure shall be provided with a smoothly rounded bushing or shall have smooth surfaces, free of burrs, fins, sharp edges, and the like, to prevent abrasion of the insulation.		P
11.9	Where multiple conductors are installed in parallel, they shall be installed in groups consisting of not more than one conductor per phase, neutral or ground so that the current in each group sums to zero. Where conductors pass through a metal opening, all conductors in a group shall pass through the same opening.		N/A
12	General Electrical Equipment		P
12.1	Replaceable fuses marking with the fuse ratings & type shall be located adjacent to each fuse or fuse holder. Information on proper fuse shall also be included in the routine service manual instructions.		P
12.2	A hazardous voltage ESS shall have a manual disconnect to prevent inadvertent access to hazardous voltage parts during servicing. If not provided, the installation instructions shall indicate the type and ratings of the disconnect to be provided in the installation and how it is to be installed in accordance with NFPA 70E and CSA Z462.		P
12.3	Fuses, circuit breakers and disconnect devices shall be rated for the application.		P
12.4	Transformers installed as part of the ESS shall be of the dry type or type filled with a non- combustible dielectric medium. Such transformers shall be installed in accordance with the requirements of NFPA 70 or CSA C22.1, or in accordance with Section 15 of IEEE C2 as applicable to where the system is installed.		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
12.5	Oil filled transformers shall be permitted for use in outdoor locations in accordance with the applicable local codes or utility requirements.		N/A
12.6	Convenience receptacles provided for maintenance and servicing of the ESS shall be rated for outdoor use if the system is intended to be installed where the receptacle is exposed to the outdoor environment or outdoor environmental conditions.		N/A
12.7	The inverter and other equipment connected to the output terminals of the battery or other storage device of the ESS shall be able to safely withstand the potential short circuit current from the storage device. The rated input short circuit current of the inverter and other equipment shall be equal to or greater than the rated output short circuit current of the battery or other energy storage mechanism. Compliance can be determined through evaluation of the output short circuit ratings of the energy storage mechanism (e.g., for the battery) as determined by testing in UL 1973.		N/A
13	Electrical Spacings and Separation of Circuits	See appended table Cl.13	P
13.1	Electrical circuits within the ESS at opposite polarity shall be provided with reliable physical spacing to prevent inadvertent short circuits or potential for arc flash.		P
13.2	Electrical spacings in circuits shall have the following minimum over surface and through air spacings as outlined in Table 13.1 or as outlined in UL 62368-1/CSA C22.2 No. 62368-1, Clearances, Clause 5.4.2, and Creepage Distances, Clause 5.4.3.	Comply with UL 62368-1	P
	<i>Exception No. 1: The spacing requirements in UL 840, CSA C22.2 No. 62109-1, UL 62109-1, IEC 60664- 1, or CSA C22.2 No. 0.2, shall be acceptable alternatives. The anticipated pollution degree and overvoltage category is determined by the design and application of the ESS assembly or subassembly under evaluation.</i>		N/A
	<i>Exception No. 2: Electrical spacings within components and parts of an ESS previously determined to comply with an appropriate safety standard for the equipment need not be evaluated.</i>		P

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Clause	Requirement + Test	Result - Remark	Verdict
13.3	Under voltages above 60 volts DC or 30 volts AC, if the insulating compound is completely filled within the enclosure and the insulation layer is at least 0.4 millimeters thick, providing supplementary or reinforced insulation, and the components have passed the dielectric withstand test, then there are no minimum clearance requirements for these parts. For circuits at or below 60 volts DC, as well as for basic or functional insulation, there are no minimum insulation thickness requirements.		N/A
13.4	Conductors of circuits operating at different voltages shall be reliably separated from each other through the use of mechanical securements unless they are each provided with insulation acceptable for the highest voltage involved.		P
14	Insulation Levels and Protective Grounding		P
14.1	Hazardous voltage circuits shall be insulated from accessible conductive parts and SELV circuits as outlined in 14.2 through the following: a) Basic insulation and provided with a protective grounding system for protection in the event of a fault of the basic insulation that complies with 14.3; b) A system of double or reinforced insulation; or c) A combination of (a) and (b).		P
14.2	Safety extra low voltage (SELV) circuits, as defined in 6.40, that are insulated from accessible conductive parts through functional insulation only are considered accessible.		P
14.3	Accessible non-current carrying metal parts that could become live in the event of an insulation fault shall be bonded to the equipment ground terminal.		P
14.4	The methods of protective bonding and grounding of an ESS shall be in accordance with Article 250 of NFPA 70 or Section 9 of IEEE C2 as applicable to where the system is located. When sizing the protective bonding and grounding wire, the rating and fault current path of all sources of supply connected to the equipment or system shall be considered. If used, grounding (bonding) braids used in the ESS or from the ESS to the grounding electrode shall comply with UL 467/CSA C22.2 No. 41, and sized according to the Grounding – Size of Terminal or Bonding Conductor requirements of UL 508A or CSA C22.1. In Canada, the methods of bonding and grounding an ESS shall be in accordance with Section 10 and 36 of CSA C22.1.		P

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Clause	Requirement + Test	Result - Remark	Verdict
14.5	Parts of the protective grounding system shall be securely fastened and provided with metal-to-metal contact that will ensure the continuity of the grounding system.		P
14.6	With reference to 14.5, when connecting conductive parts to be bonded, paint or coatings in areas of contact shall be removed or paint piercing lock washers shall be used with securement bolts or screws to provide good metal to metal contact.		P
14.7	With reference to 14.5, methods of securement considered reliable and ensuring good metal-to-metal contact can consist of the following methods: a) Terminal blocks; b) Pressure connectors, grounding lugs and similar grounding and bonding equipment connectors; c) Fusion welding processes; d) Machine screw-type fasteners that engage not less than two threads or are secured with a nut; and e) Thread-forming machine screws that engage not less than two threads in the enclosure.		P
14.8	For ESS greater than 100 V between conductors or to ground, the battery circuits can be ungrounded if the system is provided with a ground fault detector and indicator to monitor ground faults.		N/A
15	Safety Analysis and Control Systems		P
15.1	ESS shall be provided with a safety analysis such as a failure modes and effects analysis (FMEA) that identifies critical safety components and circuits of the system. Guidance for analysis can be found in the following standards: a) IEC 60812 b) IEC 61025; and c) MIL-STD-882E.		P
15.2	When conducting this analysis, it is important that the interaction of the various parts of the ESS be evaluated as noted in 15.1 to determine that there are no hazards introduced in the system as a result of their interaction.		P
15.3	Mechanical, thermal and other hazards besides electrical to be considered.		P
15.4	Analysis of thermal ESS shall ensure that there is sufficient monitoring and control of pressure, thermal and fluid flow to ensure that the various parts of the system are maintained within their specifications for pressure temperature and fluid levels.		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
15.5	Electrical and electronic controls of the ESS that are determined to be critical for safety shall comply with an appropriate safety standard for the control and used within their ratings. Electronics and software controls determined to be critical for safety are to be tested to verify electromagnetic immunity in accordance with Section 36 if this testing is not part of the functional safety standard requirements, and shall be evaluated for functional safety to one of the following sets of standards and safety ratings as applicable to the system: a) UL 991 and UL 1998; b) CSA C22.2 No. 0.8 (Function Class B requirements); c) The Annex for Requirements for Electronic Controls, Annex H of UL 60730-1 or CSA E60730-1 (Function Class B requirements); d) IEC 61508 (all parts) (minimum of Safety Integrity Level (SIL) "2" requirements for active protective devices with software controls); e) ISO 13849-1 and ISO 13849-2 (minimum of Performance Level (PL) "c" requirements for active protective devices with software controls); or f) ISO 26262 (all parts) (minimum Automotive Safety Integrity Level (ASIL) "C" requirements for active protective devices with software controls).	Evaluated with UL 60730-1 Annex H	P
15.6	Required SIL, PL, or ASIL for a safety function shall be permitted to be reduced if the manufacturer provides additional safety analysis.		N/A
15.7	Considering interaction of the various parts of the system for their impact on each other. In particular, a number of disruptive interactions shall be considered in all cases.		P
15.8	Software that can be updated remotely to meet the requirements outlined in Section 16.		N/A
16	Remote Software Update Enabled ESS	No such function	N/A
16.1	Critical and/or critical supervisory software (UL 1998)		N/A
16.1.1	The requirements in 16.1.2 – 16.1.7 apply when the manufacturer declares the ESS has critical and supervisory and related critical supervisory sections of software per UL 1998, and has the functionality to remotely update this software.		N/A
16.1.2	The critical/supervisory sections of UL 1998 software, intended to be updated, shall comply with UL 1998.		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
16.1.3	User authorization is required prior to any remote update of critical/supervisory sections of UL 1998 software.		N/A
16.1.4	The remote update of software shall occur when the ESS is in a risk addressed state.		N/A
16.1.5	The remote software update shall comply with UL 5500		N/A
16.1.6	The correct operation of the ESS safety functions shall be maintained after the critical/supervisory sections of software in accordance with UL 1998 software is updated.		N/A
16.1.7	Functional test of a remote software update using the procedure outlined in Operational Verification of Remote Software Update Capability in 36.9 after implementing a remote software update.		N/A
16.2	Class B software (UL 60730-1 or CSA E60730-1)		N/A
16.2.1	The ESS has Class B software in accordance with UL 60730-1 or CSA E60730-1, and has the functionality to remotely update this software.		N/A
16.2.2	The requirements for Controls Using Software in UL 60730-1 or CSA E60730-1 are met.		N/A
16.2.3	The remotely actuated control function, including the software update function, shall comply with the requirements for Remotely Actuated Control Functions in UL 60730-1 or CSA E60730-1.		N/A
16.2.4	Remotely actuated control functions may be connected to separate, independent devices, which may themselves contain control functions or provide other information. Any data exchange between these devices shall not compromise the integrity of the Class B control function.		N/A
16.2.5	User authorization is required prior to any remote update of Class B software, UL 60730-1 or CSA E60730-1.		N/A
16.2.6	The remote update of software shall occur when the ESS is in a risk addressed state.		N/A
16.2.7	The correct operation of the ESS's safety functions shall be maintained after the Class B software is updated per UL 60730-1 or CSA E60730-1.		N/A
16.2.8	A functional test of a remote software update using the procedure outlined in Operational Verification of Remote Software Update Capability in 36.9 after implementing a remote software update.		N/A
17	Remote Controls	No such function	N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
17.1	Energy storage systems which have the ability to be controlled and operated remotely shall be provided with an accessible means to disconnect the system from the remote control for maintenance or other local servicing of the system.		N/A
17.2	Remote disconnect controls marking		N/A
18	Communication Systems		N/A
18.1	General		N/A
18.1.1	Communication protocols used by ESS for communication between its various parts and the grid shall be in accordance with those of the intended grid application.		N/A
18.2	External warning communication system (EWCS)		N/A
18.2.1	Electrochemical ESS using lithium-ion batteries have an energy capacity of 500 kWh or greater shall be provided with an external warning communication system	Less than 500kwh	N/A
18.2.2	The information inputs to the EWCS comes from the battery management systems (BMS) or the energy storage management system (ESMS)		N/A
18.2.3	The EWCS shall communicate with an operator station and be capable of sending information to an external operating station.		N/A
18.2.4	The EWCS and the sources providing information to the EWCS shall be evaluated as part of the safety analysis of the system		N/A
18.2.5	The EWCS can be supplied by the lithium batteries it is monitoring, and shall also have a dedicated backup power source independent of the batteries		N/A
18.2.6	Instructions of the EWCS including its back up power source shall be provided. If installed indoors, the instructions shall reference the Notification Appliances Chapter of NFPA 72. Visual alarms shall be in accordance with UL 1638, and audio alarms shall be in accordance with UL 464/ULC 525 with the maximum sound level not exceed 110 dBA at the minimum hearing distance. For outdoor installations, visible alarms installed on the ESS, shall be located no less than 203.2 cm (80 in) nor more than 243.8 cm (96 in) above the ground.		N/A
19	Heating and Cooling Systems		N/A
19.1	ESS that relies upon integral thermal management systems to prevent overheating or operation outside the specified safe operating range, shall be designed to safely shutdown upon failure of the thermal management system.		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
20	Piping Systems, Pressure Vessels, Fuel and Other Fluid Supply Connections and Controls		N/A
20.1	Piping systems, pressure vessels, fuel and other fluid supply connections and controls shall comply with 20.2 – 20.10.		N/A
	<i>Exception No. 1: Systems that are evaluated as part of a battery to UL 1973 need not comply with 20.2 – 20.10.</i>		N/A
	<i>Exception No. 2: Coolant systems can be evaluated to the performance requirements of the Specific Requirements for Liquid Cooled PDS clause in UL 61800-5-1 or CSA C22.2 No. 61800-5-1.</i>		N/A
20.2	Piping systems utilized to carry fluids in an ESS such as water, heated air, fuel gases, etc. shall comply with ASME B31 (all applicable parts), or CSA B51, or CSA B52, or CSA Z662, or CSA B149.1 as applicable.		N/A
20.3	Pressure vessels and related equipment including pressure relief devices that fall under the scope of ASME BPVC, or CSA B51, shall comply with the applicable requirements.		N/A
20.4	Flammable fuel supply connections on the ESS shall be suitable for the material contained and in accordance with the applicable part of ASME B31 based upon the fluid, temperatures and pressures they are subjected to.		N/A
20.5	A means shall be provided to prevent backflow of process gases, etc. into the fuel supply lines either as part of the ESS design or indicated in the installation instructions.		N/A
20.6	The ESS shall be designed so that process water used in the system shall be prevented from contaminating potable water sources in accordance with local regulations through the use of check valves or other means as part of the system design.		N/A
20.7	Piping, hose, and tubing containing fluids, shall be routed and secured to prevent leakage that could result in a fire, explosion or shock hazard (e.g. liquid leaking onto electrical circuits that can lead to short circuits). Pressure relief valves shall be located so that fluids are not directed toward live parts or safety critical circuits should they operate.		N/A
20.8	Coolant leaks shall be detected, and a warning signal shall be sent to the ESS monitoring and control system, as well as an alarm if provided.		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
20.9	Manual shut off valves shall be provided on or near the ESS. If not provided, installation instructions shall indicate type, ratings and location for installation of appropriate manual shut off valves.		N/A
20.10	Pressure regulators used on flammable or other hazardous gas lines shall comply with UL 252, CSA Z662, or CSA B149.1, as applicable.		N/A
21	Containment of Moving Parts in Mechanical ESS		N/A
21.1	Moving parts shall be provided with a means to contain the parts in the event they could become loosened during operating.		N/A
21.2	The alternator/generator elements associated with mechanical ESS shall comply with UL 1004-1 and other parts (UL 1004-2, UL 1004-3, UL 1004-5, UL 1004-6, UL 1004-7, UL 1007-8, UL 1004-9) as applicable or CSA 22.2 No. 100.		N/A
22	Noise Levels		P
22.1	The noise level shall be limited to an 8-hr time-weighted average of 85 dBA when tested in accordance with 29 CFR 1910.95 (C)(1)(2). Systems that have noise levels in excess of this limit shall be provided with warning labels and instructions.		P
23	Hazardous Fluid Control		N/A
23.1	Where the system contains fluid in excess of 208 L (55 gal) in a single vessel or an aggregate of more than 3785 L (1000 gal), secondary containment shall be provided. Methods utilized for spill control shall be sufficient to contain all of the fluid from the largest liquid vessel within the system and designed to prevent inadvertent filling with rain if located outdoors. Where flammable liquids are contained, any applicable fire detection and protection systems shall be specified or included as determined per Section 26. The spill control system shall accommodate additional water from any specified fire protection system for a period of 10 min. Automatic leak detection to annunciate the spillage of fluid shall be provided.		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
	<i>Exception: If containment is not provided as part of the product, then instructions regarding the need to provide containment, fire detection and protection systems and leak detection shall be included in the instruction manual. The instructions shall also specify the minimum volume of the containment and information about compatibility of the containment system with the fluid to be contained. See 46.12.</i>		N/A
23.2	Systems containing conductive fluids shall be designed in a manner to prevent the fluids from causing a short circuit in the event of a spill. If spill control is not provided, then the instruction manual shall provide directions on the spill control system design to prevent any short circuits from fluid spilled.		N/A
23.3	Neutralization of spills of any hazardous fluids shall be provided if necessary to insure compatibility with any materials the fluids may contact when in the spill control system.		N/A
	<i>Exception: If neutralization is not provided as part of the product, then instructions regarding the need to provide neutralization shall be included in the instruction manual. The instructions shall also specify the type and quantity of neutralizing material required to meet the requirements of 23.3. See 46.12.</i>		N/A
23.4	Energy storage systems that contain fluids shall be designed to prevent venting of toxic vapors in concentrations considered to be hazardous based on an evaluation conducted in accordance with Sections 38 and 39.		N/A
24	Combustible Vapor Concentrations		N/A
24.1	Enclosures or areas that contain flammable fluid systems or batteries that vent hydrogen to the atmosphere shall be ventilated to prevent hazardous concentrations of flammable materials.		N/A
	<i>Exception: Vented battery systems with aqueous electrolytes such as lead acid or nickel cadmium that are provided with ventilation openings in their enclosures in accordance with 24.3, need not comply.</i>		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
24.2	Electrochemical ESS which are not addressed in 24.1 and which are dependent on mechanical ventilation as a protection measure against emission of flammable gas that can occur during fault conditions to prevent hazardous gas concentrations within the system, shall be equipped with a fault detection system that activates the mechanical ventilation in a manner which prevents the LFL from exceeding 25% in any non-hazardous area/zone within the ESS.		N/A
24.3	For ESS that contain batteries or similar storage devices, openings to prevent hazardous concentrations of flammable gases within an enclosure can be used. Openings in the enclosure provided for ventilation shall be constructed to prevent accumulation of flammable gases that could lead to a hazardous condition from concentrations of hydrogen gas due to electrolysis of aqueous electrolytes for applicable battery technologies, such as vented or valve regulated lead acid and nickel batteries and applicable electrochemical capacitor technologies, greater than 25% of the LFL of hydrogen (equivalent to 1 % concentration in a volume of air).		N/A
24.4	As an alternative to 24.3, ventilation openings shall have a minimum opening area of: $A = 0.005NC_5 (cm^2)$ Where: A = Total cross sectional net free area of ventilation openings required (cm ²) N = Number of cells in battery C5 = Capacity of battery at the 5-h rate (Ah)		N/A
	<i>Exception: The area of ventilation openings can be reduced if it can be demonstrated that there is sufficient ventilation within the battery to prevent hydrogen accumulations above 25 % of the LFL of hydrogen.</i>		N/A
24.5	Electrochemical ESS with integral enclosures where there is the potential for a flammable gas concentration within the enclosure from an abnormal condition shall be provided with deflagration or explosion protection in accordance with NFPA 68 or NFPA 69.		N/A
	<i>Exception No. 1: The protection is not required if the testing in accordance with UL 9540A with a deflagration hazard analysis demonstrates that the concentration of flammable gas measured during testing remains under 25 % LFL within the room, building, ESS cabinet, or walk-in ESS and there is no potential for partial volume deflagration.</i>		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
	<i>Exception No. 2: For ESS cabinets/enclosures, protection other than as noted can be used if it has been determined that the ESS cabinet/enclosure has been designed to effectively protect against hazards due to combustible concentrations when the ESS has been tested in accordance with the Unit Level or Installation Level test of UL 9540A.</i>		N/A
24.6	Portions of ESS, in which flammable vapor concentrations above 25 % LFL may be present during normal operating conditions, shall be provided with construction suitable for the classification in accordance with NFPA 70, CSA C22.1, or IEEE C2 as applicable to the intended installation.		N/A
24.7	Electrical compartments adjacent to classified zones within the ESS enclosure shall be maintained at positive pressure in accordance with NFPA 497, UL 60079-2 or CSA C22.2 No. 60079-2.		N/A
25	Flammable Solids		N/A
25.1	ESS containing hazardous solids (i.e. pyrophoric or water reactive metals) shall be designed and installed in accordance with NFPA 484.		N/A
26	Fire Detection, Suppression and Propagation		P
26.1	General		P
26.1.1	Fire detection and fire suppression equipment provided as an integral part of an ESS shall comply with applicable product safety standards and shall be installed in accordance with the applicable safety product standards and the manufacturer's instructions.		P
26.1.2	Energy storage systems with integral fire detection or fire suppression systems shall be provided with instructions for installing, commissioning, maintaining and testing these systems in accordance with applicable installation codes and standards. NFPA 1 and ICC IFC provide information on applicable requirements and codes for fire suppression systems. See also Appendix A.		P
26.1.3	If an integral fire detection or fire suppression system optional the ESS meets applicable requirements with or without it.		P
26.2	Large Scale Fire Testing	Refer to the TUV test report of UL 9540A: CN26H50G 002	P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
26.2.1	Electrochemical type ESS, including but not limited to capacitor and battery ESS, shall be subjected to the large-scale fire testing in accordance with UL 9540A as follows in (a) – (d). a) Systems with increased energy capacities as required in codes and standards; b) Systems with decreased separation distances to adjacent ESS units, doors and windows, or exposures. See 46.2 and/or 46.4; c) Indoor systems; or d) Systems for installation in dwelling units (where permitted).		P
26.2.2	ESS for habitable or living space meet UL 9540A cell level test requirements		N/A
26.2.3	Electrochemical ESS intended for use in dwelling units where UL 9540A testing is indicated per the codes and standards, shall minimally meet the Unit Level Performance Criteria for residential installations identified in UL 9540A with a test that aligns with the manufacturer's installation instructions. These ESS shall be marked in accordance with 45.3(e)(3).		N/A
26.2.4	Electrochemical ESS intended for non-residential use shall be subjected to specific large scale fire testing in accordance with UL 9540A for installations described in the manufacturer's instructions.		P
27	Power Conversion Equipment		N/A
27.1	General		N/A
27.1.1	Inverters, chargers, and charging charge control equipment that are part of an energy storage system shall be designed and rated for use with the battery system employed in the energy storage system and evaluated to UL 1741, UL 62109-1 or CSA C22.2 No. 62109-1, UL 1012, UL 62368-1/CSA C22.2 No. 62368-1, or CSA C22.2 No. 107.1 as applicable to the power conversion equipment and its application in the system.		N/A
	<i>Exception: UL 1778/CSA C22.2 No. 107.3 may be used as an alternative to the power conversion and charger equipment standard references if applicable to the ESS application serving an uninterruptible power system (UPS).</i>		N/A
27.2	Utility Grid Interaction		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
27.2.1	Energy storage systems intended to export energy to the electric power systems (EPS)/electric utility shall be designated as utility-interactive, grid support utility-interactive, or special purpose utility interactive and shall utilize the appropriately evaluated power conditioning systems. See 6.41, 6.44, and 6.45.		N/A
27.2.2	The inverter shall be designed to properly interconnect with the particular energy storage technology it is connected to as determined by the system safety analysis.		N/A
27.2.3	Products that rely upon internal or external utility interconnection protection functions or devices shall be specifically identified for the particular product in the ESS instructions.		N/A
27.3	Utility grid interactive inverter		N/A
27.3.1	A utility-interactive inverter, grid support utility-interactive inverters, or subassembly of an ESS shall comply with UL 1741, UL 62109-1 or CSA C22.2 No. 62109-1, or CSA C22.2 No. 107.1.		N/A
27.3.2	Utility-interactive ESS inverters shall be evaluated for compliance with additional utility interactive document(s) and standard(s) if those specific documents or requirements are referenced in the product ratings or instructions.		N/A
27.4	Standalone and multi-mode power conditioning systems		N/A
27.4.1	Power conditioning systems for standalone and multi-mode applications shall comply with UL 1741, UL 62109-1 or CAN/CSA C22.2 No. 62109-1, or CSA C22.2 No. 107.1.		N/A
28	Energy Storage System Technologies		P
28.1	Electrochemical ESS		P
28.1.1	Batteries, electrochemical capacitors, hybrid battery-capacitor systems or flow batteries used in an electrochemical ESS shall comply with the requirements of UL 1973. Testing and evaluation of the battery system, which would include the battery and its battery management system is conducted as part of evaluation to UL 1973.	Refer to UL1973 test report no.: CN26W9UU 001&002	P
	<i>Exception: For valve regulated or vented lead acid or nickel cadmium battery systems, see Annex D for an alternative approach.</i>		N/A
28.2	Chemical ESS	Electrochemical ESS	N/A
28.2.1	Fuel cell systems that are part of a chemical ESS shall comply with CSA FC 1, Fuel Cell Power Systems.		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
28.2.2	Stationary engine generators that are part of a chemical ESS shall comply with UL 2200 or CSA C22.2 No. 100, and CSA C22.2 No. 286.		N/A
28.2.3	Water electrolysis type hydrogen generators used in an energy storage system to provide hydrogen for storage shall be evaluated and found to be in compliance to an appropriate safety standard for the equipment.		N/A
28.2.4	Hydrogen fuel containing parts of a chemical energy storage system shall be constructed of materials suitable for gaseous hydrogen service at the pressures and temperatures of use. Pressure vessels used for storage of gaseous hydrogen and piping employed as part of a chemical energy storage system shall comply with Section 20.		N/A
28.3	Mechanical ESS	Electrochemical ESS	N/A
28.3.1	Mechanical ESS such as, but not limited to, flywheel systems or compressed air energy storage (CAES) systems shall be evaluated to determine that hazards associated with moving parts with the capacity to store kinetic energy, and high pressure and high temperature fluids contained in the system are mitigated. Compliance is determined by evaluation to the requirements of this Standard.		N/A
28.3.2	Flywheel systems and other systems with moving parts with the capacity to store kinetic energy shall comply with the Containment of Moving Parts tests of Section 37 and the Strength Tests of Section 39. Parts containing hazardous fluids shall comply with the Leakage Tests of Section 38 and the Strength Tests of Section 39.		N/A
28.3.3	Flywheel energy storage devices with a maximum surface speed of 200 m/s or less fall within standard electric generator design practice and shall be evaluated in accordance with the Standard for Electric Generators, UL 1004-4 or the Standard for Motors and Generators, CSA 22.2, No. 100.		N/A
	<i>Exception: In some cases, flywheel energy storage systems with maximum surface speeds of 200 m/s or less may have features such as magnetic bearings that are not commonly found on ordinary electric machines as covered in UL 1004-4 or CSA 22.2, No. 100. The safety of these features shall be evaluated and tested to all applicable requirements in this Standard.</i>		N/A
28.4	Thermal ESS	Electrochemical ESS	N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
28.4.1	A thermal ESS consists of gases, fluids, and/or solids storing heat energy that can be turned into electrical energy when needed through the use of energy conversion equipment (e.g. engines, generators).		N/A
28.4.2	Thermal ESS shall be evaluated to determine hazards associated with containment of high temperature and high pressure and potentially hazardous fluids are mitigated. Compliance is determined by evaluation to the requirements of this Standard. Parts containing hazardous fluids and fluids at high temperatures and pressures shall comply with the Leakage Tests of Section 38 and the Strength Tests of Section 39.		N/A
28.4.3	Stationary engine generators that are part of a thermal ESS shall comply with UL 2200 or CSA C22.2 No. 100, and CSA C22.2 No. 286. Generators that are part of a thermal ESS shall comply with UL 1004-4 or CSA C22.2 No. 100.		N/A
28.4.4	Hazardous fluid containing parts of a thermal ESS shall be constructed of materials suitable for use with that fluid at the pressures and temperatures of use. Pressure vessels used for storage and piping employed as part of a thermal ESS shall comply with Section 20. Stresses on containment parts associated with swings of high and low temperature extremes shall be considered when evaluating the suitability.		N/A
28.4.5	Containment systems for combustible materials (solids or fluids) shall be designed to prevent the potential for explosion hazards as a result of contact with moisture, contaminants, etc.		N/A
28.4.6	A thermal ESS shall have sufficient pressure controls, fluid level controls and temperature controls to prevent the potential for a hazardous condition from occurring through an out of specification operation. Compliance is determined through the safety analysis of the system and the functional safety investigation of the controls per Section 15 and the abnormal operations tests for thermal ESS in accordance with Section 31.		N/A
PERFORMANCE			
29	General		P
29.1	To be tested and determined compliant to an applicable technology safety standard. Where no applicable safety standard exists, they are to be tested in accordance with this standard.		P
29.2	All tests, unless noted otherwise, are conducted in a room ambient $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$).		P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
29.3	Temperature shall be measured using thermocouples consisting of wires not larger than 0.21 mm ² (24 AWG) and not smaller than 0.05 mm ² (30 AWG). Measuring junction of the thermocouple held tightly against the component/location being measured.		P
29.4	The test area should be well ventilated and testers should observe safety regulations and not approach the DUT until the temperature of the test specimen has returned to ambient room temperature.		P
ELECTRICAL TESTS			
30	Normal Operations Test	See appended table Cl.30	P
30.1	A normal operations test can be waived for equipment of an ESS where a similar evaluation such as a temperature test has already been conducted under the specific technology standard.		P
30.2	An ESS is operated through a maximum of 2 cycles of charge and discharge of the system under maximum loading conditions.		P
	<i>Exception: Normal operations testing on a subassembly may be conducted instead of the complete ESS if through analysis it can be determined to be representative of the ESS.</i>		N/A
30.3	During the test, consideration shall be given to maximum and minimum room ambient conditions. During operation, temperatures on critical components that are temperature sensitive shall be monitored and operating parameters of components of the system monitored to determine that they are operating within their ratings. If the ESS is intended for mounting on a wall, it shall be mounted as intended in accordance with installation instructions on a flat wall in an alcove that is painted a dull black, and temperatures shall be monitored on the wall surfaces during the test.		P
30.4	During the normal operations test, the manufacturer's specified limits shall not be exceeded during the charging and discharging cycles. Temperatures measured on components shall not exceed their specifications in accordance with Table 30.1. Temperatures on accessible surfaces of the ESS shall not exceed the limits in accordance with Table 30.2.		P
31	Abnormal Operation Tests for Thermal Energy Storage Systems	Electrochemical ESS	N/A
31.1	General		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
31.1.1	Thermal ESS shall remain in a safe state should the thermal controls, fluid controls or pressure controls of the system fail.		N/A
31.2	Failure of thermal controls		N/A
31.2.1	The thermal ESS shall be operated during charging and discharging with a single fault within the thermal control system. The test shall be conducted at ambient conditions and the ESS shall be operated at maximum normal operating limits of the system. Temperatures on temperature sensitive components and accessible surfaces shall be measured during the test. Pressures shall also be monitored. The ESS shall be subjected to one charge and one discharge cycle.		N/A
31.2.2	The system shall be operated until the discharge or recharge is complete or until the controls shut the system down to prevent hazards. As a result of the test, there shall be no evidence of fire, explosion, rupture of parts containing hazardous fluids or leakage of hazardous fluids.		N/A
31.3	Exposure to out of specification thermal conditions		N/A
31.3.1	The thermal ESS shall be subjected to a temperature condition outside of the operating specifications of the system to determine if the controls will prevent an over temperature condition or other condition that could lead to a hazard. The ESS or a representative subassembly shall be subjected to an ambient of 70 °C (158 °F) or 20 °C (36 °F) above the maximum specified operating ambient, whichever is higher and then an ambient of -30 °C (-22 °F) or 20 °C (36 °F) below the lowest specified operating ambient, whichever is lower. The ESS shall be operated during this conditioning.		N/A
31.3.2	As a result of the tests, there shall be no evidence of fire, explosion, rupture of parts containing hazardous fluids or leakage of hazardous fluids. Thermal controls shall prevent the system from operating outside of safe limits.		N/A
31.4	Failure of pressure controls		N/A
31.4.1	The thermal ESS shall be operated during charging and discharging with a single fault within the pressure control system. The test shall be conducted at ambient conditions and the ESS shall be operated at maximum normal operating limits of the system. Temperatures on temperature sensitive components and accessible surfaces shall be measured during the test. Pressures shall also be monitored. The ESS shall be subjected to one charge and one discharge cycle.		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
31.4.2	The system shall be operated until the discharge or recharge is complete or until the controls shut the system down to prevent hazards. As a result of the tests, there shall be no evidence of fire, explosion, rupture of parts containing hazardous fluids or leakage of hazardous fluids.		N/A
31.5	Failure of fluid controls		N/A
31.5.1	The thermal ESS shall be operated during charging and discharging with a single fault within the various fluid level control systems relied upon for safety. Examples of these systems can include a gas system used to provide an inert atmosphere within containment chambers, a liquid leak control, etc. The test shall be repeated with the single fault in each separate fluid level control system. The test shall be conducted at ambient conditions and the ESS shall be operated at maximum normal operating limits of the system. Temperatures on temperature sensitive components and accessible surfaces shall be measured during the test. Pressures shall also be monitored. The ESS shall be subjected to one charge and one discharge cycle.		N/A
31.5.2	The system shall be operated until the discharge or recharge is complete or until the controls shut the system down to prevent hazards. As a result of the tests, there shall be no evidence of fire, explosion, rupture of parts containing hazardous fluids or leakage of hazardous fluids.		N/A
32	Dielectric Voltage Withstand Test		P
32.1	The dielectric voltage withstand test is an evaluation of the electrical spacings and insulation associated with the hazardous voltage circuits within the DUT.		P
32.2	Circuits at 42.4 Vpeak/ 30 Vrms or 60 Vdc or higher shall be subjected to a dielectric withstand voltage in accordance with the "Determining clearances using required withstand voltage" clause of UL 62368-1/CSA C22.2 No. 62368-1.	See appended table Cl.32&33 for details.	P
	<i>Exception No. 1: Semiconductors or similar electronic components liable to be damaged by application of the test voltage shall be bypassed or disconnected.</i>		P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
	<i>Exception No. 2: The dielectric voltage withstand test need not be conducted on integral ESS, fuel cells, and inverter systems, etc. that have already been evaluated in accordance with their individual standard requirements. Only those electrical parts external to the tested systems and their connections not previously evaluated need to be tested.</i>		P
32.3	The voltage applied during the dielectric voltage withstand test is to be applied between the hazardous voltage circuits of the DUT and accessible non-current carrying conductive parts.		P
32.4	The voltage applied during the dielectric voltage withstand test is also to be applied between the hazardous voltage charging circuit and the enclosure/accessible non-current carrying conductive parts of the DUT.		P
32.5	The voltages applied during the dielectric voltage withstand test shall be applied for a minimum of 1 min.		P
32.6	The test equipment shall consist of a 500 VA or larger capacity transformer, the output voltage, which is variable and which is essentially sinusoidal if using ac test method, a dc output if using a dc test method. There is no trip current setting for the test equipment since the test is checking for insulation breakdown, which results in a large increase of current. Setting a trip current may result in a false failure of this test, as it is not necessarily indicative of insulation breakdown.		P
	<i>Exception: A 500 VA or larger capacity transformer need not be used if the transformer is provided with a voltmeter that directly measures the applied output potential.</i>		P
32.7	There shall be no evidence of a dielectric breakdown as evidenced by an appropriate signal from the dielectric withstand test equipment as a result of the applied test voltage. Corona discharge or a single momentary discharge is not regarded as dielectric breakdown.		P
33	Impulse Test	See appended table Cl.32&33 for details.	P
33.1	The impulse voltage test is intended to evaluate the energy storage system's ability to withstand lightning or similar surges. Systems provided with protection that has already been evaluated for voltage surges (e.g. inverters meeting the Standard for Interconnecting Distributed Resources with Electric Power Systems, IEEE 1547 criteria) need not be tested.		P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
33.2	The impulse voltage test shall be performed with an impulse generator able to provide voltage having a 1.2/50 μ s waveform at voltages in accordance with Table 33.1, and is intended to simulate an overvoltage condition due to lightning or switching of equipment.		P
33.3	Pulses shall be applied at 1.2/50 μ s for each polarity in ≥ 1 s time intervals at the peak voltage for the rating of the circuit under test $\pm 5\%$ per Table 33.1. The test voltage is to be applied between the terminal/circuit under test and accessible parts. For circuits at 1000 V or less, three pulses at each polarity shall be applied. For circuits over 1000 V, 5 pulses at each polarity shall be applied.		P
	<i>Exception: Impulse test levels can be based on the transient voltage surge suppression device rating if provided.</i>		P
33.4	No insulation puncture, flashover, or spark-over		P
34	Equipment Grounding and Bonding Test	See appended table Cl.34	P
34.1	The impedance of the system grounding and bonding circuit shall be determined using one of the following methods: a) The circuit between the grounding terminal and the part to be grounded is measured using impedance measuring equipment; b) In accordance with the Continuity of the Equipment Grounding Circuit section, Section 18.2 of NFPA 79 (voltage drop measurement of the circuit using a 10 A low voltage supply source); or c) In accordance with test in the "Resistance of the Protective Bonding System" clause, Clause 5.6.6 of UL 62368-1/CSA C22.2 No. 62368-1 (measuring voltage drop in circuit using a low voltage supply source providing a current based upon circuit protection rating). d) The fault loop impedance measurement in accordance with IEC 60364-4-41.		P
34.2	The impedance for all grounding and bonding circuits tested shall not exceed 0.1 Ω , or if using the test method in 30.1(d), the compliance criteria shall be in accordance with IEC 60364-4-41.		P
35	Insulation Resistance Test	See appended table Cl.35	P
35.1	The resistance of insulation used on hazardous voltage circuits within an ESS shall be greater than or equal to 1 M Ω .		P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
35.2	The insulation resistance shall be measured using high impedance measuring equipment (e.g. mega ohmmeter) while applying a voltage of 500 Vdc between the live parts of the circuit under test and accessible conducting parts including the equipment grounding circuit, for 1 min.		P
	<i>Exception No. 1: Energy storage systems need not be tested if the insulation resistance has been previously evaluated as part of the particular technology safety standard.</i>		N/A
	<i>Exception No. 2: The insulation resistance test of IEC 60364-6 can be conducted instead.</i>		N/A
	<i>Exception No. 3: This test can be waived if the permanently connected wiring has: a) A cross-section of the protective earthing conductor of at least 10 mm² if copper, or 16 mm² if aluminum; or b) Provision of an additional terminal for a second protective earthing conductor of the same cross-sectional area as the original protective earthing conductor and installation instructions requiring a second protective earthing conductor to be installed.</i>		N/A
	<i>Exception No. 4: The touch current measurement test of IEC 62040-1 may be conducted instead.</i>		N/A
35.3	Resistor(s) and/or resistor networks may be removed when conducting the insulation resistance test.		P
36	Electromagnetic Immunity Tests	Refer to FCC test report no.: CN26MM9S 001	P
36.1	General		P
36.1.1	Electronics and software controls determined to be critical for safety shall demonstrate sufficient immunity to electromagnetic interference by complying with the tests specified in these sections.		P
	<i>Exception: This testing does not apply to controls within components of the ESS that have already been evaluated for EMI exposure in accordance to their applicable component standard such as UL 1741 for power conditioning systems.</i>		P
36.1.2	Each test begins with an operation unit		P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
36.1.3	The DUT shall be operated in mode(s) that include the safety function(s) being evaluated. If multiple modes are to be considered (example: equipment controlling the charging and discharging of the energy storage device), the DUT shall either be cycled through those modes during the tests, or the tests repeated in each mode. While cycling through modes, the DUT shall not exhibit any signs of loss of safety functions or risk of fire, electric shock, or personal injury.		P
36.1.4	After each test in this section, the DUT shall be inspected to verify that it is still operational. This may require Operational Verification (36.8) of the DUT if it is not possible to determine that it is fully operational by inspection. If the DUT is no longer operational, a failure analysis shall be conducted to determine the reason for the failure and to verify that the DUT has failed safely. A DUT that is no longer operational shall not be used on any remaining test.		P
36.1.5	All samples used comply with section 36.8 after the test.		P
36.2	Electrostatic Discharge		P
36.2.1	The DUT shall demonstrate immunity to electrostatic discharges in accordance with the test procedure specified in IEC 61000-4-2 and the modes of operation stated in 36.1.3.		P
36.2.2	The following test levels shall be used: a) ± 6 kV contact discharge; and b) ± 8 kV air discharge.		P
36.2.3	Complies with 36.1.4 after test		P
36.3	Radio-frequency electromagnetic field		P
36.3.1	The DUT shall demonstrate immunity to radio-frequency electromagnetic fields in accordance with the test procedure specified in IEC 61000-4-3 and the modes of operation stated in 36.1.3.		P
36.3.2	The following test levels shall be used: a) 10 V/m from 80 MHz to 1 GHz, 1 kHz (80% AM); and b) 3 V/m from 1.4 GHz to 6.0 GHz, 1 kHz (80% AM).		P
36.3.3	During the test complies with 36.1.3		P
36.3.4	After test complies with 36.1.4		P
36.4	Fast transient/burst Immunity		P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
36.4.1	The DUT shall demonstrate immunity to electrical fast transients/bursts in accordance with the test procedure specified in IEC 61000-4-4 and the modes of operation stated in 36.1.3.		P
36.4.2	The following test levels shall be used: a) On signal/control ports intended to be connected to cables longer than 3 m (118.1 in), ± 1 kV (5/50 ns, 5 kHz); capacitive clamp shall be used; b) On input and output DC ports, ± 1 kV (5/50 ns, 5 kHz); and c) On input and output AC ports, ± 2 kV (5/50 ns, 5 kHz).		P
36.4.3	With reference to 36.4.2, the test levels shall be applied to all external accessible ports of the equipment in an ESS. External accessible AC ports shall be conducted using the test level specified in 36.4.2(c). External accessible DC ports shall be conducted using the test level specified in 36.4.2(b).		P
36.4.4	After test complies with 36.1.4		P
36.5	Surge Immunity		P
36.5.1	The DUT shall demonstrate immunity to surges in accordance with the test procedure specified in IEC 61000-4-5 and the modes of operation stated in 36.1.3.		P
36.5.2	The following test levels shall be used: a) For I/O signal/control ports intended to be connected to long-distance cables longer than 30 m (1181.1 in), which leave the building, and/or are for outdoor use, ± 1 kV line-to-ground; b) For input and output DC ports, ± 0.5 kV line-to-line, and ± 1 kV line-to-ground; and c) For input and output AC ports, ± 1 kV line-to-line, and ± 2 kV line-to-ground.		P
36.5.3	With reference to 36.5.2, the test levels shall be applied to all external accessible ports of the equipment in an ESS. External accessible AC ports shall be conducted using the test level specified in 36.5.2(c). External accessible DC ports shall be conducted using the test level specified in 36.5.2(b).		P
36.5.4	After test complies with 36.1.4		P
36.6	Radio Frequency Common Mode		P
36.6.1	The DUT shall demonstrate immunity to radio-frequency conducted disturbances in accordance with the test procedure specified in IEC 61000-4-6 and the modes of operation stated in 36.1.3.		P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
36.6.2	The following test levels shall be used: a) For I/O signal/control ports intended to be connected to cables longer than 3 m (118.1 in), 10 V (150 kHz to 80 MHz, 1 kHz, 80% AM); b) For input and output DC ports, 10 V (150 kHz to 80 MHz, 1 kHz, 80% AM); and c) For input and output AC ports, 10 V (150 kHz to 80 MHz, 1 kHz, 80% AM).		P
36.6.3	With reference to 36.6.2, the test levels shall be applied to all external accessible ports of the equipment in an ESS. External accessible AC ports shall be conducted using the test level specified in 36.6.2(c). External accessible DC ports shall be conducted using the test level specified in 36.6.2(b).		P
36.6.4	During test complies with 36.1.3		P
36.6.5	After test complies with 36.1.4		P
36.7	Power Frequency Magnetic Field		P
36.7.1	The DUT shall demonstrate immunity to power-frequency magnetic fields in accordance with the test procedure specified in IEC 61000-4-8 and the modes of operation stated in 36.1.3.		P
36.7.2	Test level 10 A/m		P
36.7.3	During test complies with 36.1.3		P
36.7.4	After test complies with 36.1.4		P
36.8	Operational Verification		P
36.8.1	After the tests in 36.2 – 36.7 have been completed, all samples used during these tests shall comply with the following.		P
36.8.2	The manufacturer shall declare the anticipated performance of all safety functions performed by electronics and software controls.		P
36.8.3	The manufacturer shall provide test procedures to verify that each of the safety functions performed by electronics and software controls is working correctly. This may include, for example, verification of correct safety function performance by simulation.		P
36.8.4	During the test procedures specified in 36.8.3, each DUT shall exhibit one of the following behaviors: a) No loss of safety functions; or b) Transition to an appropriate state to ensure safe operation of the DUT.		P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
36.9	Operational verification of remote software update capability	No such function.	N/A
36.9.1	The test of 36.8 shall be conducted on safety controls intended for remote software updates in accordance with Section 16 to ensure that they are operational after the update. See 16.1.7 and 16.2.8.		N/A
MECHANICAL TESTS			
37	Containment of Moving Parts	No such part.	N/A
37.1	Control system fault overspeed test		N/A
37.1.1	An ESS with moving parts having the capacity to store kinetic energy that is capable of being subjected to overspeed conditions through a fault in the system controls shall be subjected to an overspeed test.		N/A
37.1.2	The system controls shall be subjected to single fault in the controls that would allow overspeed of the moving parts. The DUT shall be operated at overspeed conditions until a secondary protection control operates to stop operation of the DUT.		N/A
37.1.3	As a result of the overspeed condition, the moving part(s) shall not become loosened or disconnected in a manner that would result in a hazardous condition. If completely loosened or disconnected as a result of the overspeed conditions, the containment means shall safely contain the part(s) in accordance with the Faulted Securement Test in 37.2.		N/A
37.1.4	The system controls shall limit the overspeed to a level less than the speed defined in 37.4.		N/A
37.2	Faulted securement test		N/A
37.2.1	An ESS with moving parts with the capacity to store kinetic energy shall be subjected to the faulted securement test when a fault in primary securement means of the moving part has the potential to result in a hazard.		N/A
37.2.2	The moving parts of the system shall be subjected to a single fault of the primary means of securement while operated at the maximum speed anticipated during normal operation. The primary means of securement to be removed, such as a failed bearing, shaft, or other part of the securement of the moving part with respect to the stationary housing, shall be determined through a safety analysis that identifies failure of the selected means as representing the potential worst case condition. Refer to Section 15 for the safety analysis requirements.		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
37.2.3	This test is not required in cases where test or field data is available to support the safety analysis indicating that there is not a hazard associated with the loss of primary securement.		N/A
37.2.4	The system shall be operated until one of the following occurs: a) The part has operated for 30 min under the faulted condition; b) A protection control operates to stop operation of the DUT or hazardous moving part; or c) The part has loosened and is completely or partially disconnected from its securement means.		N/A
37.2.5	As a result of the operation with a faulted securement condition, the moving part(s) shall not become loosened or disconnected to result in a hazardous condition. If completely loosened or disconnected, the containment means for the part shall safely contained the part(s).		N/A
37.3	Blocked Shaft Test		N/A
37.3.1	An ESS with moving parts with the capacity to store kinetic energy shall be subjected to the blocked shaft test if blocking the shaft or moving parts has the potential to result in a hazard.		N/A
37.3.2	With the moving part blocked to prevent movement, the system shall be operated at the maximum ratings allowed for a zero speed condition.		N/A
37.3.3	The system shall be operated: a) With the part blocked for 30 min and then stopped; b) Until a protection control operates to stop operation of the DUT with the blocked part; or c) Until any moving parts break off or become completely or partially disconnected from its securement means.		N/A
	<i>Exception: Moving parts already evaluated for blocked shaft conditions as part of a component evaluation, need not be tested.</i>		N/A
37.3.4	As a result of operating the system with a blocked shaft/moving part condition, the part shall not become loosened or disconnected to result in a hazardous condition. If the part becomes completely loosened or disconnected, the containment means for the part shall safely contain the part(s). There shall be no overheating of parts that will result in a hazard such as fire or explosion.		N/A
37.4	Mechanical integrity Test		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
37.4.1	An ESS with any moving part having the capacity to store kinetic energy shall have the mechanical (i.e. rotating) energy storage elements designed to have a minimum margin factor of safety. The factor of safety requirements vary depending on the material of construction. The factor of safety based on material type shall be as follows: a) For assemblies composed of laminated composite materials, the minimum factor of safety shall be at least 2.0 between the maximum principal stress that exists at the point of highest stress in each layer of the mechanical energy storage element and the ultimate strength of that layer at that point. b) For assemblies composed of ductile metallic materials exhibiting a traditional nonlinear stress-strain curve, the minimum factor of safety shall be at least 1.3 between the maximum von Mises stress that exists anywhere in the mechanical energy storage element. c) For other material types and combinations of materials including metals and laminated composites, the minimum factor of safety shall be at least 2.0 between the maximum combined stress that exists anywhere in the mechanical energy storage element at maximum normal operating speed.		N/A
37.4.2	The mechanical energy storage element shall be subjected to an overspeed type test demonstrating the required factor of safety. The DUT shall be representative of the latest design revision and subjected to an overspeed and corresponding stress as follows in (a) or (b). For the purpose here, rotor working stress is presumed to scale exactly as the square of the rotation speed. a) Where the minimum required factor of safety is 2.0, the overspeed shall be at least 139 %. The DUT shall sustain the overspeed for a time period of 1 min without ruptures in of any part of the assembly. b) Where the minimum required factor of safety is 1.3, the overspeed shall be 120 % minimum. The DUT shall sustain the overspeed for a time period of 1 min.		N/A
37.4.3	With reference to 37.4.2, for a hollow cylindrical mechanical energy storage element, as an alternative to the dynamic test, a static test (e.g. hydrostatic or pneumatic strength test) may be performed whereby the DUT is subjected to an internal pressure that creates maximum stress in the DUT that is greater than 2x the maximum stress under normal operating conditions.		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
37.4.4	With reference to 37.4.2 and 37.4.3, the mechanical energy storage element DUT shall: a) Be a production mechanical energy storage element; b) Be according to the latest design revision; and c) Meet the manufacturer's quality assurance requirements for production units.		N/A
37.4.5	Alternative to 37.4.2		N/A
37.4.6	With reference to 37.4.1 – 37.4.5, the testing shall be repeated in the event of a deviation of any mechanical characteristic or material property that results in an increase of more than 10 % between calculated stress in production energy storage elements and demonstrated stress in the previously qualified mechanical energy storage element.		N/A
37.5	Bearing Failure Test		N/A
37.5.1	An ESS with moving parts with the capacity to store kinetic energy that relies upon a primary set of bearings in its moving mechanism, in any form, shall be subjected to a bearing failure test if failing the bearings has the potential to result in a hazard. Refer to Section 15 for the safety analysis requirements.		N/A
37.5.2	With the system operating at maximum operating conditions, a failure in the primary bearings shall be induced that results in the loss of the primary bearing function and forces the DUT to spin down on its backup bearing or other suitable support system.		N/A
37.5.3	The system shall be operated: a) Until the DUT's energy is dissipated and it has come to a stop; b) Until a protection control operates to stop operation of the DUT; or c) Until any moving parts break off or become completely or partially disconnected from its securement means.		N/A
37.5.4	This test is intended to verify that the backup bearing or support system for the energy storage element is effective. This test may also suffice as the faulted securement test described in 37.2 if the safety analysis indicates a bearing failure as the worst case condition.		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
37.5.5	As a result of operating the system with a failed bearing condition, the moving parts shall not become loosened or disconnected to result in a hazardous condition. If the part becomes completely loosed or disconnected, the containment means for the part shall safely contain the part(s). There shall be no overheating of parts that will result in a hazard such as fire or explosion.		N/A
38	Leakage Tests		N/A
38.1	Energy storage systems that utilize liquid coolant or contain hazardous fluids shall be subjected to the Leakage Test in accordance with 38.2 and 38.3.		N/A
	<i>Exception: Leakage testing need not be conducted if parts containing hazardous fluids and their connections have already been evaluated for external leakage as part of a component standard such as the appendix for Test Program for Flowing Electrolyte Batteries, Appendix C, of UL 1973 or CSA FC 1 for fuel cell systems.</i>		N/A
38.2	Leakage from ESS containing hazardous fluids shall not result in the risk of fire, electric shock, or injury to persons.		N/A
38.3	Compliance is determined by subjecting the fluid-containing parts and their connections to a fluid pressure of 1.5 times the maximum operating pressure (if testing with liquid) or 1.1 times the maximum operating pressure (if air pneumatic testing) of intended use during operation of the system. There shall be no leaks from fluid-containing parts or their connections as a result.		N/A
39	Strength Tests		N/A
39.1	General		N/A
39.1.1	Energy storage systems that contain hazardous fluids shall comply with the Strength Tests in accordance with 39.2 and 39.3.	39.3 Tested	N/A
39.2	Hydrostatic Strength Test		N/A
39.2.1	Parts of the ESS containing hazardous fluids (gases or liquids) shall be subjected to a hydrostatic strength test of 1.5 times the design pressure of the system for a period of 1 min after reaching the maximum pressure. The pressure shall be gradually increased until the maximum pressure is reached in approximately 1 min using either the liquid used in the system or water. Testing is done at room ambient temperature.		N/A
39.2.2	As a result of the hydrostatic strength test, there shall be no fracture, distortion, rupture or other damage to the fluid containing parts.		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
39.3	Pneumatic Strength Test		N/A
39.3.1	The pneumatic strength test is an alternative to the hydrostatic strength test of 39.2 and is conducted in accordance with 39.3.2.		N/A
39.3.2	Parts of the ESS containing hazardous fluids (gases or liquids) shall be subjected to a pneumatic strength test of 1.3 times the design pressure of the system for a period of 1 min after reaching the maximum pressure. The pressure shall be gradually increased until the maximum pressure is reached in approximately 1 min using either air or inert gas. Testing is conducted at room ambient temperature.		N/A
39.3.3	As a result of the pneumatic strength test, there shall be no fracture, distortion, rupture or other damage to the fluid containing parts.		N/A
40	Enclosure and Mounting Tests		P
40.1	Wall Mount Fixture/Test		P
40.1.1	A wall mounting apparatus of a wall mounted ESS shall have sufficient strength to support the system. Compliance is determined by the following test.		P
	<i>Exception: Individual components of an ESS that are provided with their own wall mount apparatus previously tested as part of their component evaluation, need not be tested.</i>		N/A
40.1.2	The wall mounting apparatus and ESS shall be installed in accordance with the manufacturer's specifications. A force equal to three times the weight of the ESS is additionally applied to the center of the mounting apparatus in a downward direction. The force shall be held for 1 min.		P
40.1.3	As a result of the applied force, there shall be no damage to the mounting apparatus and its securement means when testing the wall mounting fixture.		P
40.2	Enclosure impact		P
40.2.1	This test is to evaluate the mechanical integrity of the enclosure and its ability to provide mechanical protection to the ESS enclosure contents. This test is conducted on electrochemical ESS that are for residential applications or for non-residential applications that are less than or equal to 50 kWh.		P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
40.2.2	A fully charged DUT shall be subjected to a minimum of three impacts of 6.8 J (5 ft-lb) on any surface that can be exposed to a blow during intended use. The impact shall be produced by dropping a steel sphere, 50.8 (2 in) in diameter, and weighing 535 g (1.18 lb) from a height, H, of 1.29 m (50.8 in). For surfaces other than the top of an enclosure, the steel sphere shall be suspended by a cord and swung as a pendulum, dropping through the vertical height of 1.29 m (50.8 in), with the product being impacted placed against a restraining vertical wall. See Figure 40.1. A different sample may be used for each impact.		P
40.2.3	After the impacts, the DUT shall be subjected to a test in accordance with Section 32. The DUT shall be examined for signs of rupture or damage that could lead to a hazard.		P
40.2.4	As a result of the impact test, there shall be no damage to the enclosure that could result in a hazard such as exposure of hazardous parts or result in a dielectric breakdown.		P
40.3	Enclosure steady force		P
40.3.1	The purpose of this test is to determine if the enclosure has sufficient strength to safely withstand a static force that may be applied to it. This test is conducted on electrochemical ESS that are for residential applications or for non-residential applications that are less than or equal to 50 kWh.		P
40.3.2	The enclosure of a fully charged DUT shall withstand a steady force of 250 ± 10 N (56.2 lbf ± 2.25 lbf) for a period of 5 s, applied in turn to the top, bottom and sides of the enclosure fitted to the DUT, by means of a suitable test tool providing contact over a circular plane surface 30 mm (1.2 in) in diameter.		P
40.3.3	The DUT shall be subjected to a test between live parts and the enclosure in accordance with Section 32. The DUT shall be examined for signs of rupture or damage that could lead to a hazard.		P
40.3.4	As a result of the steady force test, there shall be no damage to the enclosure that could result in a hazard such as exposure of hazardous parts or result in a dielectric breakdown.		P
40.4	Mold stress	Metal enclosure	N/A
40.4.1	The purpose of this test is to determine if an enclosure made from molded polymeric material can withstand an accelerated aging test without compromising the safety of the enclosure.		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
40.4.2	One complete fully discharged sample shall be placed in a full-draft circulating-air oven maintained at a uniform temperature of at least 10°C (18°F) higher than the maximum temperature of the enclosure measured during the Normal Operations Test in Section 30, but not less than 70°C (158 °F). The sample shall remain in the oven for 7 h.		N/A
40.4.3	After removal from the oven the DUT shall be subjected to a test in accordance with Section 32. The DUT shall be examined for signs of rupture and damage.		N/A
40.4.4	As a result of the mold stress conditioning, the sample shall show no evidence of mechanical damage, such as cracking of the enclosure exposing hazardous parts or result in a dielectric breakdown.		N/A
ENVIRONMENTAL TESTS			
41	Special Environmental Installations		P
41.1	General		P
41.1.1	Energy storage systems intended for installation in special environments shall be evaluated for their ability to operate safely in those environments. These environmental conditions can include exposure to salt fog for marine environments, testing for seismic ratings, high altitudes, etc. The requirements of 41.2, 41.3 and 41.4 shall apply depending upon the particular exposure. The installation instructions and nameplate labels on the ESS shall identify the special environmental conditions in accordance with 45.3, 45.17, and Section 46.		P
	<i>Exception No. 1: Testing need not be conducted on systems or parts of the system if already covered as part of the specific technology safety standard.</i>		P
	<i>Exception No 2: Environmental testing on a subassembly may be conducted instead of the complete ESS if through analysis it can be determined to be representative of the ESS. The rationale used to determine the suitability of the subassembly to represent the complete ESS shall be documented.</i>		P
41.2	Outdoor Installations subject to moisture exposure		P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
41.2.1	Energy storage systems intended for installation outdoors where they will be subject to rated levels of moisture exposure shall be tested in accordance with their environmental ratings outlined in their nameplate labels and installation instructions of 45.17 and 46.13.		P
41.2.2	Based upon the ratings of the system, moisture resistance testing shall be done in accordance with either IEC 60529, UL 50E, or C22.2 No. 94.2.	Evaluation conducted to UL 50E confirms conformity to NEMA type 3R.	P
41.2.3	At the conclusion of the test, the sample is to be subjected to the electric insulation tests of Sections 32 and 35 and examined for signs of water in the system that could result in a hazardous condition.		P
41.2.4	As a result of the water exposure, there shall be no evidence of water on parts that could result in a hazard and no reduction of spacings or breakdown/deterioration in insulation levels.		P
41.3	Outdoor installation in marine environments		P
41.3.1	Energy storage systems intended for installation outdoors in marine environments in accordance with the installation instructions in 46.13 where they will be subject to salt fog exposure, shall be tested as outlined below.		P
41.3.2	The systems shall be tested in accordance with IEC 60068-2-52 for Severities 1 or 2.		P
41.3.3	At the conclusion of the testing, the systems shall be subjected to the electrical insulation tests of Sections 32 and 35 to determine that insulation has not been damaged in a manner that would result in an electric shock hazard.		P
41.3.4	The system shall be examined for signs of damage as a result of salt exposure that would indicate a potential for a safety hazard (e.g. corrosion of parts that could result in weakening of a securement or an enclosure, damage to insulation). If operational, the system is to be operated to determine that it can do so without hazard.		P
41.3.5	As a result of the test, the ESS shall not show evidence of damage from salt fog exposure that could result in a hazard such as electrical, shock, overheating or damage that could result in a physical hazard.		P
41.4	Installation in seismic environments	Not intended to be used in seismic environments	N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
41.4.1	Equipment of an ESS that contains the energy storage mechanism and is intended for installation where they will be subject to seismic activity shall be evaluated and if necessary tested in accordance with their seismic ratings and installations instructions per 45.3 and 46.13. The installation instructions shall indicate the limitations of the particular seismic rating of the equipment. Standards that provide guidance on seismic evaluation such as IEEE 693, IEC 60980, ICC IBC, the seismic testing in GR-63-CORE, or similar, shall be used for this evaluation. Compliance is determined through review of documentation of the seismic evaluation for the appropriate seismic level (i.e. level marked on the equipment) or through testing for the specific seismic level in accordance with a testing standard for this purpose.		N/A
	<i>Exception No. 1: There is equipment that cannot be practically evaluated by testing alone because of the size of the equipment. For those situations, it may be necessary to do a combination of analysis with testing of parts of the system. This approach is outlined in IEEE 344.</i>		N/A
	<i>Exception No. 2: Some standards allow for calculations and modelling as an approach for determining compliance for seismic ratings in lieu of testing.</i>		N/A
41.4.2	The ESS shall be examined for signs of explosion, fire, combustible concentrations (if applicable to technology), rupture of the enclosure, electrolyte leakage, electric shock and loss of protection controls that lead to any of the other non-compliant results in 41.4.3.		N/A
41.4.3	As a result of the test, any of the following results in (a) – (g) are considered a non-compliant result: a) Explosion; b) Fire; c) Combustible Concentrations (if applicable to technology); d) Rupture (enclosure); e) Electrolyte Leakage (external to enclosure); f) Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown); g) Loss of protection controls.		N/A
MANUFACTURING AND PRODUCTION TESTS			
42	Electrical Production Tests		P
42.1	Dielectric Voltage Withstand Test		P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
42.1.1	A dielectric withstand test as outlined in the Dielectric Voltage Withstand Test in Section 32 shall be conducted on 100 % production of ESS with working voltage exceeding 60 Vdc or 30 Vrms/42.4 Vpeak.		P
	<i>Exception No. 1: The time for the production Dielectric Withstand Test can be reduced to 1 s.</i>		P
	<i>Exception No. 2: Testing can be conducted on subassemblies of the system.</i>		P
	<i>Exception No. 3: Testing can be waived if conducted as part of the specific technology evaluation (i.e. tested per UL 1973, etc.).</i>		P
42.2	Grounding and Bonding system Check		P
42.2.1	The grounding and bonding system of an ESS shall be subjected to a check using an impedance measuring device. The measurements shall occur between any two locations of the grounding and bonding system.		P
42.2.2	No resistance measurements of the grounding and bonding system shall exceed 0.1 Ω or allowed limits per 34.2.		P
	<i>Exception: This testing can be waived if it is determined that the ESS construction and production methods to ensure good grounding and bonding of the system production can be determined through a review of production practices. However, if any point of the grounding system is maintained through a single fastener, a ground bond test shall be conducted.</i>		N/A
42.3	Check of Safety Controls		P
42.3.1	Energy storage systems shall be subjected to 100% production screening to determine that any active controls utilized for safety are functioning.		P
	<i>Exception: This check of the safety controls can be conducted on subassemblies or components of the system before final assembly.</i>		P
43	Mechanical Production Tests		N/A
43.1	Integrity at Maximum Abnormal Operating Speed	Electrochemical ESS.	N/A
43.1.1	Every production mechanical storage element shall be subjected to a maximum abnormal operating speed test. The test shall be performed at the maximum speed reached during the Overspeed Test of 37.1. The test shall be performed in an environment which will safely contain any mechanical failure of the mechanical storage element.		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
43.1.2	As an alternative to 43.1.1, the components of a mechanical energy storage element (e.g. forged disk) shall be processed consistently and tested to ensure that the materials used in its construction meet the minimum requirements assumed during the design and analysis of the element. The engineering development and production testing protocol for the components of the energy storage element shall demonstrate the level of uniformity of the material properties throughout critical sections of the component and that the material properties meet required minimum values consistently.		N/A
43.2	Production Screening of Rotors	Electrochemical ESS.	N/A
43.2.1	Rotor assemblies for mechanical ESS shall be subject to 100 % production screening through the use of non-destructive testing or other means to check for cracks and other flaws. Any cracks or flaws found shall be evaluated in accordance with manufacturer's specifications.		N/A
43.2.2	As an alternative to 43.2.1, additional in progress quality checks and testing can be incorporated into the manufacturing assembly process to limit the presence of cracks or flaws in finished product. Refer to 44.1.		N/A
43.3	Leak check of hazardous fluid systems	Electrochemical ESS.	N/A
43.3.1	ESS that contain hazardous fluids including ESS with liquid coolant systems shall be subjected to a leak check in accordance with Section 38 of the assembled fluid containment system.		N/A
44	Production Quality Control		P
44.1	Manufacturers of ESS shall have documented production process controls in place that continually monitor the following key elements of the manufacturing process that can affect safety, and shall include measured parametric limits enabling corrective/preventative action to address defects (out of limit parameters) found affecting these key elements: a) Supply chain control; and b) Assembly processes.		P
MARKINGS			
45	General		P
45.1	Markings shall be legible and permanent		P
45.2	Markings and signage shall be in lettering that is sized so that it is legible from the distance from which it must be read and shall have lettering in a color that contrasts with the background.		P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
45.3	An ESS shall be provided with a nameplate marking (main label) that includes parameters, product definitions, and manufacturer information, etc.		P
45.4	If the system is intended to be operated in a duty cycle, the intended duty cycle shall be included on the nameplate.		N/A
45.5	The suppression system to be installed, if applicable, shall be marked on the system.		N/A
45.6	The operating ambient conditions in °C or °F, the weight of the system in kilograms or pounds, and the overall dimensions of the system can either be marked on the system or provided in the installation instructions.		P
45.7	For multi-part ESS, a nameplate marking (main label) noted in 45.3 shall be provided on at least one of the parts and shall identify that the system has been evaluated as a multi-part ESS.		N/A
45.8	The items in 45.4 – 45.6 shall be included as applicable to the system. With reference to 45.7, each separate part of the multi-part ESS shall have a nameplate marking as required by the equipment safety standard to which it was evaluated.		P
45.9	Where not included in the end-product standard or label, the following information shall be included in the ESS installation instructions as applicable to the ESS: a) Single-line electrical diagram b) Input short circuit current rating (SCCR) in A/kA that each component can withstand from other parts of the ESS if the connection point is a power input or bi-direction power connection; and c) Available fault current (as defined in Article 100 of NFPA 70) and time duration that the ESS part can provide to other parts of the ESS if the connection point is a power output or bi-directional power connection.		P
45.10	Contact information for the system in the event of an emergency or problems with the system.		P
45.11	Energy storage systems shall also be marked with the date of manufacture, which is permitted to be in the form of a code that does not repeat within 20 years. All external terminals and connections shall be provided with identification.		P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
45.12	The point of connection to the charger earth grounding system shall be identified by the word "Ground" or the letters "G" or "GR" or the grounding symbol IEC 60417 Database, No. 5019 (upside down tree within a circle) or otherwise identified by a distinctive green color. Any other grounding terminals shall also be identified in a manner that is distinctive from the main earth ground terminal for the charger system.		P
45.13	The ESS that contains hazardous voltage circuits shall be marked "WARNING: Hazardous Voltage Circuits" or be marked with the electric shock hazard symbol ISO 3864 No. 5036 (lightning bolt within a triangle). Electrical equipment parts of the ESS such as control panels and the enclosures of disconnecting devices shall also be marked with arc flash markings according to NFPA 70E or CSA Z462 and arc flash personal protective equipment (PPE) requirements, to warn service personnel of potential for arc flash hazards, and necessary protection to be worn if applicable. See also 10.11 regarding arc flash label requirements for equipment.		P
45.14	ESS other than electrochemical ESS that contain hazardous materials such as flammable solids or fluids or toxic or other hazardous materials shall be marked in accordance with NFPA 704.		N/A
45.15	Energy storage systems shall be marked as follows: "WARNING: To Reduce the Risk of Injury, read all instructions" or marked with the symbols W001 (i.e. exclamation point in triangle) and M002 of ISO 7010.		P
45.16	Energy storage systems with walk-in enclosures shall be provided with necessary cautionary markings per 10.9 and 10.10, and shall be marked with the following or equivalent: "WARNING: Risk of Electric Shock or Other Serious Injury. Care shall be taken when entering enclosure – Authorized personnel only."		N/A
45.17	An ESS intended for installation where exposed to moisture shall be marked with the environmental rating of its enclosure (i.e. IPX2, Type 4X, etc.) suitable for that type of exposure. See 41.2.		P
45.18	The control devices and indicators required for operation or maintenance shall be marked with their function on or adjacent to the control. See also 10.7 and 45.19 regarding door signs.		P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
45.19	An egress door per 10.7 shall be marked with the word "Exit" and the line-of-sight to an exit sign shall not be interrupted. Any doorway or passage that might be mistaken for an exit shall be marked "Not an Exit" or with an indication of its actual use.		N/A
45.20	A non-residential use electrochemical ESS that complies with 1.6(b) shall be marked, "ESS with capacities exceeding 50 kWh shall include the additional fire suppression and/or fire protection identified in the installation instructions."		N/A
45.21	A non-residential use electrochemical ESS intended for use in remote outdoor locations per 1.6(d) shall be marked "For use only in remote outdoor locations as permitted in applicable installation codes and standards."		N/A
45.22	ESS disconnect controls, such as manual Emergency Power Off (EPO) disconnects, shall be marked to clearly indicate what system or part of the system they control. An EPO need not be provided with this marking if it disconnects and de-energizes the entire ESS.		P
INSTRUCTIONS			
46	General		P
46.1	The ESS shall be provided with complete instructions for installation, commissioning, operation and maintenance that includes the following information: a) Procedures for system commissioning and decommissioning; b) Complete installation instructions, including calibration, programming, control sequence descriptions for battery management and other monitoring systems; c) Initial acceptance testing procedures; d) Ongoing inspection and testing procedures; e) Instructions for retrofitting system components (non-residential use systems); f) Instruction for providing working clearances; and g) Where applicable, the completed Manufacturer's Installation Instructions Template for Residential ESS, Table H.1, in Annex H.		P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
46.2	The installation instructions shall identify the maximum rated energy capacity for the system and minimum separation distances from other ESS and from exposures (e. g. combustibles, structures) in accordance with the limitations to the system based on applicable codes or in accordance with the large scale fire testing of 26.2.		P
46.3	Installation instructions for exterior wall-mounted ESSs shall identify the minimum separation distances from other ESS or from openings (e.g. windows, doors, HVAC inlets or other operable openings) in accordance with the code limitations or in accordance with the large scale fire testing of 26.2. Outdoor rated ESS marked "Suitable for Use in Residential Non-Habitable Spaces" are suitable for installation on exterior walls of residential dwelling units as indicated in the manufacturer's instructions.		P
46.4	For systems that require the large scale fire testing of 26.2 in order to exceed code capacity limitations or reduce separation distances for their anticipated installation, the instructions shall identify the UL 9540A test report that was used to validate the anticipated installation including the testing organization, report designation, and date.		P
46.5	For ESS requiring large scale fire testing per 26.2, any additional fire suppression and/or fire protection and explosion protection identified in the UL 9540A test report shall be included in the installation instructions.		N/A
46.6	Unless further limited by manufacturer's installation instructions, instructions for electrochemical ESS for indoor residential use shall indicate that the units are only intended to be installed in attached or detached garages, sheds, enclosed utility closets, basements, storage or utility spaces within dwelling units and are not intended for installation in habitable spaces and living spaces in dwelling units.		N/A
46.7	Installation instructions for indoor electrochemical ESS marked "Suitable for Use in Residential Habitable Spaces" shall be permitted to indicate the units are suitable for use in residential dwelling units, including in the living or habitable spaces, provided that they meet the criteria as noted in 26.2.2.		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
46.8	The instructions shall be in accordance with the Technical Documentation section, Section 17 of NFPA 79, or CSA C22.2 No. 301, and in accordance with 46.2 – 46.10. For additional guidance see NEMA Z535.6. Instructions for installation, operation and maintenance of the ESS shall address electrical safety including arc flash in accordance with NFPA 70E or CSA Z462.		P
46.9	All cautionary markings and ratings provided on the system, as well as system specifications needed for installation and operation of the system, shall be included in the instructions. If provided with remote controls, the system installation, operation and maintenance instructions shall be provided with instructions regarding operation of the remote controls and disconnecting the remote control in accordance with 17.1.		P
46.10	The installation information shall include instructions for making all necessary connections for electrical, communications, piping for fuels and other fluids, etc. as well as connections to other equipment that are part of the system.		P
46.11	The installations instructions shall specify that the system be installed in accordance with local electrical, building, fire and other codes or utility requirements as applicable to the installation and equipment, by qualified service personnel in accordance with the installation instructions and appropriate practices.		P
46.12	With reference to 46.9, the installation instructions for ESS, such as flow batteries, lead acid batteries, etc., containing free electrolyte (greater than 208 L (55 gal) in a single vessel or an aggregate of 3785 L (1000 gal)) shall be provided with instructions for location of eye wash stations. In addition, if necessary in accordance with building codes, installation instructions shall provide information on spill control to be installed with the system per 23.1 and 23.3.		N/A
46.13	Energy storage systems intended for installation only in certain environments such as indoors only or where exposed to moisture, seismic activity or marine environments, or to be installed in restricted access locations, shall indicate this in the installation instructions. Systems intended for exposure to moisture, marine environments or seismic activity per installation instructions shall be evaluated per Section 41.	Units intended for installation in marine environments shall state this information in the installation instructions	P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
46.14	The installation instructions for a DC ESS shall include specifications for the equipment performing electric power conditioning or conversion function that is intended to be connected for supplying the DC ESS, including if it is part of the DC load that the DC ESS is supplying.		N/A
46.15	Indoor installation instructions for residential use ESS shall provide instructions on smoke alarms to be provided in the residence in accordance with building, fire and installation codes.		N/A
46.16	The installation instructions shall include any special handling and safeguard measures to be followed during installation and shall include details of support structures such as concrete pads, etc. required for installation at the site.		P
46.17	An ESS shall be provided with instructions for the proper operation of the system including charging and discharging for battery systems, and operation of system controls, including identification of the communication protocols used for the system per 18.1.1.		P
46.18	The ESS shall be provided with maintenance instructions for service personnel as well as a separate set of instructions for any basic maintenance procedures, including fuse replacement per 12.1, that would be handled by operators of the system.		P
46.19	The maintenance instructions shall be provided with information on field replacement of replaceable materials, components and parts for ongoing maintenance and repair of the system.		P
46.20	Mechanical ESS utilizing bearings for their moving parts, shall have a scheduled routine inspection and maintenance for bearings outlined in the manual.	Electrochemical ESS.	N/A
46.21	The installation instructions shall contain all ESS operation mode/settings, operation function/settings and protection/settings, which the inverters can provide.		N/A
ANNEX A (Normative)			P
A1	Standards for Components		P
A1.1	The CSA Group and UL standards listed below are used for evaluation of components and features of products covered by this Standard.		P
ANNEX B (Informative) – General Battery Safety Considerations			P
B1	General		P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
B1.1	The battery specific safety requirements for this Standard can be found in the Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications, UL 1973. See 28.1. The following includes some general safety recommendations for cells and batteries used in electrochemical type ESS.		P
B2	Design Recommendations		P
B2.1	Battery systems should have two-fault tolerance for all catastrophic failures including overcharge, overdischarge, short circuit and extreme temperatures.		P
B2.2	The chargers used for charging the energy storage battery systems should be designed for the chemistry of the battery to be charged. The charging algorithm should be verified to ensure that the charging procedure is suitable for the battery chemistry and battery design.		P
B2.3	Protection circuits should be verified by test in the relevant battery design configuration and worst case environments to confirm that they provide the required protective functions.		P
B2.4	Cell level protection should not be relied upon for battery pack protection unless it can be verified through analysis and testing of the battery that the cell protection provides sufficient protection at the battery pack level.		P
B2.5	For lithium ion batteries and any other chemistry as determined by the battery system safety analysis, voltage should be monitored for every series element, temperatures should be monitored throughout the battery pack, and battery level current monitoring should be carried out continuously with alarm and control circuits able to react. Thermal runaway protection should be provided. Such protection should be verified through testing that it provides sufficient protection of the battery pack. Any off-nominal values should be recorded by the battery management system (BMS).		P
B2.6	For aqueous battery chemistries such as lead acid or nickel cadmium, battery or module level voltage, temperature and current monitoring should be carried out continuously with alarm and control circuits able to react. If possible, any off-nominal values should be recorded by the control system.		N/A
B2.7	Consideration should be given for conducting high fidelity thermal analysis when developing battery designs to determine the appropriate locations of the thermal sensors used in the battery.		P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
B2.8	All temperature sensor readings should be continuously recorded and controls set in place to trigger a stoppage of charging or discharging of the battery when the temperature readings go above the manufacturer's rating of that particular cell or battery design.		P
B2.9	If the battery is used only periodically, the battery should be designed to prevent cells from going into an overdischarge mode due to the long term storage conditions.		P
B2.10	For lithium battery designs and other technologies as determined through safety analysis, cells should be spaced or insulated from other cells appropriately or through other mechanisms to prevent cell to cell thermal runaway propagation in the event that any one cell experiences a thermal runaway event.		P
B2.11	If temperature control is required for the battery system, the failure of the temperature controls, such as failure of heaters, cooling systems, or their controls, should not impose a safety hazard.		P
B2.12	For systems requiring heaters for operation, heater designs should not result in temperatures that exceed specified safe operating temperatures of the batteries.		N/A
B12.13	For systems requiring active cooling systems, a failure of the cooling system due to breach or breakage in the cooling lines should not result in a leakage that will cause short circuiting of the cells inside the battery pack leading to a hazardous condition. Coolant leakage lines should be routed or secured to mitigate the potential for leakage on live parts and if necessary fluid monitor and controls of the coolant system may need to be provided.		N/A
B12.14	For lithium batteries and other technologies as determined by the battery safety analysis, to prevent any unforeseen hazards due to a complex design and usage environment, the thermal runaway propagation test should be performed on a subset of the battery system design.		P
B12.15	All parameters such as cell voltages, battery voltage, battery current (sub-module currents, if applicable) and temperatures should be verified to be within the specification for the cells and battery system.		P
ANNEX C (Normative for Canada and Informative for the US) – Safety Marking Translations			P

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
	This Annex includes the markings required to be translated and suggested French translations. For Canada, this Annex is a normative (mandatory) part of this Standard. For the US, this Annex is an informative (non-mandatory) part of the Standard.		P
ANNEX D (Normative) – Approach For Evaluating Valve Regulated Of Vented Lead Acid Or Nickel Cadmium Battery Energy Storage Systems			N/A
D1	General		N/A
D1.1	Scope of appendix - vented lead acid and nickel cadmium battery energy storage systems	Rechargeable Li-ion Battery system	N/A
D1.2	Safety concerns of lead acid or nickel cadmium		N/A
D1.3	Address hydrogen venting in installation of lead acid or nickel cadmium		N/A
D2	Construction		N/A
D2.1	The batteries and components of the battery systems shall be installed in accordance with NFPA 70 or CSA C22.1.		N/A
D2.2	Valve regulated or vented lead acid or nickel cadmium cells and monobloc batteries shall comply with the requirements of the Annex for Alternative Approach for Evaluating Valve Regulated or Vented Lead Acid or Nickel Cadmium Batteries in UL 1973 for these types of batteries.		N/A
D2.3	Cells and monobloc batteries shall be installed in an ESS in accordance with the battery manufacturer's instructions for spacings between batteries and other required spacings, cell/battery installation orientation, wiring and connection requirements, environmental and other protections to be provided in the installation.		N/A
D2.4	Support structures for vented and valve regulated lead acid and nickel cadmium batteries shall be suitable for handling the maximum anticipated weight of the installed cells and batteries. The rack system shall comply with the criteria outlined in the Annex for Alternative Approach for Evaluating Valve Regulated or Vented Lead Acid or Nickel Cadmium Batteries of UL 1973.		N/A
D2.5	ESS employing lead acid or nickel cadmium batteries shall comply with the applicable criteria outlined in this Standard with regard to materials, enclosures, electrical safety, insulation levels and protective earthing, combustible concentrations, fire detection and suppression, and power conversion equipment as applicable to the ESS. Short circuit protection used in the system to protect the batteries and limit their short circuit current output shall be rated for dc applications.		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
D2.6	The charging system for these batteries shall prevent charging outside of the battery specifications through the use of current and temperature monitoring and control on the batteries. The system may also use voltage monitoring and controls to prevent out of condition specifications. Charging systems for these batteries shall comply with the requirements for power conversion equipment in Section 27 and shall also comply with the battery manufacturer's specifications for chargers.		N/A
D2.7	Ventilation provided for the ESS shall maintain hydrogen concentration within the ESS to less than 25 % LFL. If relying upon mechanical ventilation to maintain the safe concentrations within an ESS enclosure, it shall be monitored and alarmed at a constantly attended location, should the mechanical ventilation fail.		N/A
D2.8	The battery system exceeding 240 Vdc shall be provided with disconnects in accordance with Article 706 of NFPA 70 or Section 64 of CSA C22.1, for servicing of the battery system.		N/A
D2.9	Installation of ESS systems of lead acid or nickel cadmium batteries, shall be installed with ventilation in accordance to applicable fire and building code requirements and the battery manufacturer's installation instructions.		N/A
D2.10	ESS systems with vented lead acid or nickel cadmium batteries shall be provided with spill control in accordance with the building, fire and installation codes and manufacturer's instructions. See 23.1.		N/A
D2.11	ESS systems with lead acid or nickel cadmium cells or batteries shall be marked in accordance to Section 45 as applicable to the system.		N/A
D2.12	Installation instructions for an ESS with lead acid or nickel cadmium batteries shall provide sufficient details of installation including any separation distances, limits to the installations such as indoors only installation in accordance with Section 46.		N/A
D2.13	Maintenance and operating instructions for ESS employing lead acid or nickel cadmium cells and batteries.		N/A
D3	Performance		N/A
D3.1	General		N/A
D3.1.1	Table D3.1 shall be applied to an ESS system using lead acid or nickel cadmium batteries, which have been evaluated to the UL 1973.		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict

ANNEX E (Informative) – Guidance On Capacity And Separation Distance Limits For Electrochemical ESS			P
E1	General		P
E.1.1	Installation Codes control fire and other hazards in electrochemical ESS installations through the use of limitations on energy capacity and through separation distances between ESS and exposures (e.g. walls, openings, etc.). These limitations may be revised based upon large scale fire testing and authority having jurisdiction (AHJ) approval at the installation site. The information provided below in Table E1.1 and Table E1.2 is based upon the limitations for energy capacity and separation distances for electrochemical ESSs in accordance with the model fire and installations codes in the United States. Since the limitations in these codes are subject to revision and also because they are subject to local adaptation, this information should be used for guidance only.		P
ANNEX F (Normative) – Metal Compatibility Table			P
ANNEX G (Normative) – Cleanagent Direct Injection Battery Rack Coolant System Units			N/A
G1	General		N/A
G1.1	These requirements cover the construction and operation of halocarbon clean agent direct injection battery rack coolant system units intended to be installed, inspected, tested, and maintained in accordance with NFPA 2001, NFPA 855, and NRC NFC.		N/A
G1.2	These clean agent direct injection battery rack coolant system units are intended to distribute clean agent directly onto lithium ion or similar battery modules following detection by the system that the cells are overheating and/or venting. The design of the integral battery rack clean agent coolant system is dependent upon the battery module and rack assembly and is ultimately evaluated for effectiveness through large scale fire testing in accordance with UL 9540A.		N/A
G2	Glossary		N/A
G2.1-G2.6	Explanations of relevant terms		N/A
G3	Construction		N/A
G3.1	Piping		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
G3.1.1	Piping and tubing used in the system shall have a piping thickness in accordance with ASME B31.1. Piping, tubing, fittings, and the joints so formed shall comply with the Valve Leakage Test and Hydrostatic Pressure Test of UL/ULC 2166. The assembled piping system shall comply with the Leakage Tests of UL 9540.		N/A
G3.2	Pressure relief valves		N/A
G3.2.1	Pressure relief valves in the agent distribution network shall be subjected to the Start-To-Discharge Test of UL 1973 unless the pressure release valves comply with ASME BPVC. The relief valve shall not release to an area where the agent can result in a hazard.		N/A
G3.3	Pressure regulators		N/A
G3.3.1	Pressure regulators shall be evaluated in accordance with UL/ULC 2166, UL 252 or UL 144 for suitability.		N/A
G3.4	Solenoid valves		N/A
G3.4.1	Electrically operated valves shall comply with UL 864, ULC S527, UL 429 or CSA C22.2 No. 139 and be suitable for the conditions of service.		N/A
G3.5	Electrical controls		N/A
G3.5.1	An analysis of the direct injection battery rack coolant system unit control assembly consisting of the various input sensors, the fire alarm control panel and outgoing signals to the agent supply cylinder shall be analyzed to ensure that all components of the control system work in coordination as anticipated to react to a cell propagation event in the modules. Methods outlined in Section 15 of this Standard shall be utilized to perform this analysis.		N/A
G3.5.2	Fire Alarm Control Panels shall comply with UL 864 or ULC S527 and shall have sufficient input and output channels for the system. The input signals to the fire control panel shall be compatible with the panel.		N/A
G3.5.3	Manual pull switches shall comply with UL 38 or ULC S528 and be compatible with the fire alarm control panel and rated for the circuit. The manual pull switch shall be located where it is accessible.		N/A
G3.6	Input sensors and detectors		N/A
G3.6.1	Detectors and other input sensors to the fire alarm control panel shall be evaluated in accordance with the appropriate standard for that device.		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
G3.6.2	The signals from these various detection devices shall be compatible with the fire control panel in accordance with G3.5.		N/A
G3.6.3	If input signals from the battery management system (BMS) to the fire control panel are relied upon for the operation of the direct injection coolant system, these communication signals shall be determined compatible with the fire control panel in accordance with G3.5.		N/A
G3.7	Alarms		N/A
G3.7.1	A visual and audio alarm shall be provided with the direct injection coolant system and they shall operate when the direct injection coolant system operates.		N/A
G3.7.2	Visual alarms shall be in accordance with UL 1638 or ULC 526, and audio alarms shall be in accordance with UL 464/ULC 525.		N/A
G3.8	Wiring and terminals		N/A
G3.8.1	Wiring within the direct injection coolant system shall be in accordance with NFPA 70, NFPA 72 or CSA C22.1 and this Standard.		N/A
G3.8.2	The wiring and connections between parts of a direct injection coolant system shall be protected or enclosed, or they shall be in a cord or cable that has been evaluated and determined to be rated for the application.		N/A
G3.8.3	Internal wiring shall be routed and secured so that the wires and electrical connections are not subjected to stress or mechanical damage in accordance with this Standard.		N/A
G3.8.4	Internal wiring of circuits that operate at different potentials shall be separated by barriers or shall be segregated, unless the conductors of the circuits of lower voltage are provided with insulation for the highest voltage in accordance with this Standard.		N/A
G3.8.5	Duplicate terminals or leads, or an equivalent arrangement, shall be provided for circuits of devices intended to be connected to initiating-device circuits of the fire control unit; one for each incoming and one for each outgoing wire.		N/A
G3.9	Clean agent assembly component requirements		N/A
G3.9.1	The clean agent tank assembly shall be located where it can be inspected, recharged and subjected to any other specified maintenance activities without impacting its ongoing protection functions.		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
G3.9.2	The requirements of UL/ULC 2166 summarized in Table G3.1 shall apply. Where UL/ULC 2166 references "extinguishing system unit", it shall be replaced with "direct injection battery rack coolant system unit".		N/A
G4	Performance		N/A
G4.1	General		N/A
G4.1.1	The direct injection coolant systems shall be subjected to the applicable performance tests as noted in this Annex.		N/A
G4.2	Clean agent assembly tests (UL/ULC 2166 Tests)		N/A
G4.2.1	The requirements of UL/ULC 2166 summarized in Table G4.1 shall apply. Where UL/ULC 2166 references "extinguishing system unit", it shall be replaced with "direct injection battery rack coolant system unit".		N/A
G4.3	Start to discharge test		N/A
G4.3.1	The start to discharge test shall be conducted on relief valves other than those employed on the clean agent cylinder assembly in accordance with UL 1973.		N/A
	<i>Exception: This test may be waived on relief valves that comply with ASME BPVC and that are used within their ratings.</i>		N/A
G4.4	Direct injection coolant system tests		N/A
G4.4.1	Large scale fire test		N/A
G4.4.1.1	The direct injection coolant system shall be tested in accordance with the unit level test of UL 9540A when installed in the specific battery rack assembly with intended modules that the system is designed to protect.		N/A
G5	Production Tests		N/A
G5.1	The applicable production tests of the Manufacturing and Production Tests, General section of UL/ULC 2166 shall apply.		N/A
G5.2	The start-to-discharge production line test of the Manufacturing and Production Line Tests, General section of UL 1973 shall apply to relief valves that have not been determined to comply with the ASME BPVC and are used in the system.		N/A
G5.3	The requirements of UL/ULC 2166 summarized in Table G5.1 shall apply. Where UL/ULC 2166 references "extinguishing system unit", it shall be replaced with "direct injection battery rack coolant system unit".		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
G6	Markings		N/A
G6.1	Each direct injection battery rack coolant system unit shall be marked with an identifying part or model number and the manufacturer's or private labeler's name or other equivalent designation.		N/A
G6.2	A cylinder/valve assembly, in addition to being marked with operating, recharging, inspection and maintenance instructions (see G7.3), shall be marked with the year of manufacture, or the last two digits of the year of manufacture.		N/A
G6.3	Operating, recharging, inspection and maintenance instructions and other relevant information shall be marked on the cylinder/valve assembly.		N/A
G6.4	Each clean agent container shall be legibly marked in accordance with UL/ULC 2166.		N/A
G6.5	The requirements of UL/ULC 2166 summarized in Table G6.1 shall apply. Where UL/ULC 2166 references "extinguishing system unit", it shall be replaced with "direct injection battery rack coolant system unit".		N/A
G7	Instructions		N/A
G7.1	A copy of the installation, operating, recharging, inspection, and maintenance instruction manual is to be furnished for the direct injection coolant system. These instructions shall also be provided for the evaluation and testing of the system.		N/A
G7.2	The instructions shall reference the limitations of each direct injection coolant system and shall include operating detail, schedule of pipe, installation, maintenance, and testing requirements and so on.		N/A
G7.3	Routine maintenance of the system shall be outlined in the maintenance manual and shall include the maintenance procedures to be conducted and the frequency with which the maintenance procedures are conducted on the system. The maintenance schedule shall consist of monthly, semi-annual and annual intervals of routine inspection and maintenance in accordance with the manufacturer's specifications.		N/A
G7.4	The requirements of UL/ULC 2166 summarized in Table G7.1 shall apply. Where UL/ULC 2166 references the "extinguishing system unit", it shall be replaced with "direct injection battery rack coolant system unit".		N/A
ANNEX H (Normative) – Manufacturer's Installation Instructions Template For Residential Ess			N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict
H1	Manufacturer's Installation Instructions Template Instructions		N/A
H1.1	The first four columns in Table H.1 is the template that shall be used and filled in with the manufacturer's installation instructions information that is required to be provided with each ESS in accordance with this Standard.		N/A
H1.2	If there are multiple units referenced in the manufacturer's installation instructions, use a separate table for each separate unit, or add additional columns to the table to address the information for multiple units.		N/A
H1.3	No value shall be left blank. If a parameter was not evaluated, then the value shall be "N/E" for "Not Evaluated." If a parameter is not applicable, then the value shall be "N/A" for "Not Applicable."		N/A

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict

CI.13	TABLE: Electrical Spacings and Separation of Circuits						P
Clearance cl and creepage distance dcr at/of:	System / Impulse voltage (V)	U r.m.s. (V)	Required cl (mm)	cl (mm)	Required dcr (mm)	dcr (mm)	
Battery Module							
Between + and – (FI)	800	57.6	0.2x1.14=0.228	See below	0.8	See below	
P+ to P-	-	-	-	50.16	-	>50.16	
B+ to B-	-	-	-	59.69	-	>59.69	
Between live part and enclosure (BI)	800	57.6	0.2x1.14=0.228	See below	0.8	See below	
B+ to enclosure	-	-	-	8.54	-	>8.54	
BMS Board							
Between live part and enclosure (BI)	800	57.6	0.2x1.14=0.228	See below	0.8	See below	
DX5 to PE(H1)	-	-	-	3.14	-	3.14	
DX13 to PE(H5)	-	-	-	3.14	-	3.14	
Between hazard parts and communication (RI)	1500	57.6	0.4x1.14=0.456	See below	1.5	See below	
Digital Isolators (U18)	-	-	-	5.45	-	5.45	
Digital Isolators (U20)	-	-	-	5.45	-	5.45	
Energy Source Definition:							
The Product provides Protective grounding for enclosure.							
Supplementary information:							
Battery VMAX (DC side) = 57.6Vd.c							
OCV II evaluated battery circuit. General MG IIIb evaluated for creepage distances except PCB board.							
*Coated printed boards used for BMU and CMU board according to UL 62368-1 Table G.13.							

CI.30	TABLE: Normal Operation Test						P
AC				Battery system			
Rated Voltage (V)	Rated Current (A)	Rated Power (kW)	Measured Voltage (Vdc)	Measured Current (A)	Measured Power (kW)	Comments	
-	-	-	-	38.1	16	N/A	
Work condition ¹⁾			Rated Battery System voltage		Battery System current		

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict

Charging and discharging	57.6V		According to the PCS Charging and discharging map
Measuring location:	Max. measured Temp. [°C]	Max. measured Temp. correct to T _{MA} ²⁾ [°C]	Max. Temp. limit ³⁾ [°C]
Battery module			
External surface	55.05	--	70
Internal surface	55.17	--	70
Screen surface	55.17	--	80
Cell 1	57.98	--	65
Cell 2	58.44	--	65
Cell 3	57.47	--	65
Cell 4	58.31	--	65
Cell 5	58.38	--	65
Internal side of handle	55.62	--	65
Plastic cover (P+)	59.19	--	85
Plastic cover (P-)	57.10	--	85
Circuit breaker	56.03	--	85
P+ busbar	57.59	--	80
B+ busbar	58.12	--	80
Wire harness	57.70	--	85
Temperature sampling Terminal	57.70	--	105
BMS board			
Terminal surface	61.34	--	105
MCU (U5)	63.20	--	85
Isolated IC (U18)	61.55	--	125
Relay (U73)	58.98	--	85
Relay (U14)	60.02	--	85
Pre-charging relay (Q45)	57.70	--	150
Fuse near PCB	57.48	--	130
Ambient	55.00	--	--

Supplementary information:

The test was conducted at ambient temperature of 55°C, Operation mode: Constant current: 31.4A, run the product until finishing three complete charging and discharging cycles, 30 min rest between single cycles, 16 h rest between two cycles.

UL 9540			
Clause	Requirement + Test	Result - Remark	Verdict

CI.32&33	TABLE: Dielectric Strength and Impulse			P
Test Location:		Dielectric Voltage	Impulse Voltage	Pass / Fail
Battery system P (+) to PE (BI)		110	800	Pass
Battery system P (-) to PE (BI)		110	800	Pass
Battery power circuit (+) to Communication circuit (RI)		220	1500	Pass
Battery power circuit (-) to Communication circuit (RI)		220	1500	Pass
Supplementary information: Battery system max. Voltage: 57.6 Vdc.				

CI.34	TABLE: Equipment Grounding and Bonding Test			P
Tested between:		Voltage	Current	Resistance
Battery enclosure to PE terminal		--	25A	28mΩ
Battery farthest cabinet to PE terminal		--	25A	28mΩ
Supplementary information: Measurements should not exceed 0.1Ω / 2.5V.				

CI.35	TABLE: Insulation Resistance Test		P
Tested between:		Measure Resistance (MΩ)	Comments
Battery + to PE		1222	>1MΩ
Battery - to PE		1174	>1MΩ
Supplementary information:			

--The end of test report--

PHOTO DOCUMENTATION

CN26SVV2 001 attachment 1

for

Rechargeable Li-ion Battery System

SE-FX Max-6 (X=16, 32, 48, 64, 80, 96, 112, 128, 144, 160, 176, 192, 208, 224, 240, 256, 272, 288, 304, 320, 336, 352, 368, 384, 400, 416, 432, 448, 464, 480, 496, 512, which represents the total energy (kWh) of the parallel battery module)

NINGBO DEYE ESS TECHNOLOGY CO., LTD.



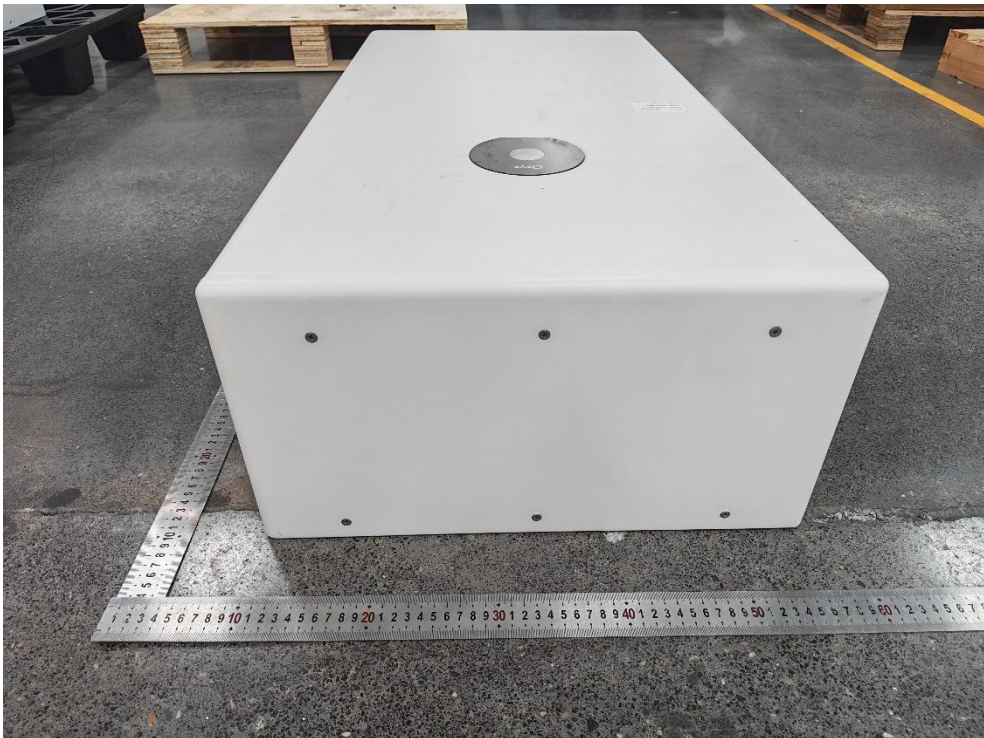
This documentation consists of 7 pages (excluding this cover page)

Report Number: CN26SVV2 001 attachment 1

Model: See cover page



Top view of battery module



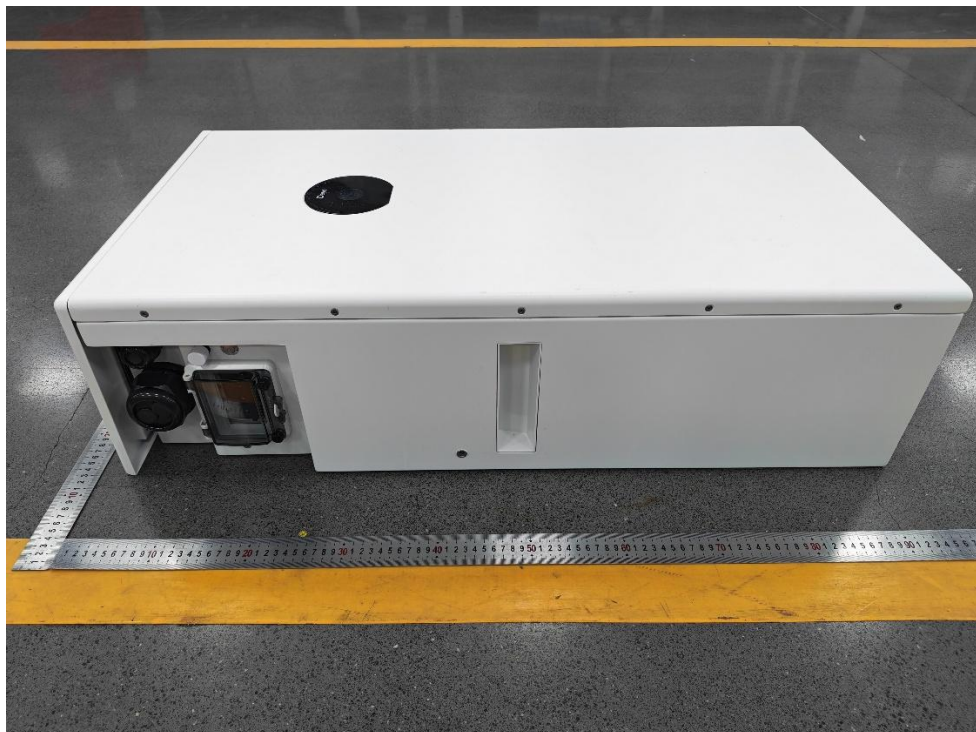
Front view of battery module

Report Number: CN26SVV2 001 attachment 1

Model: See cover page



Back view of battery module



Left view of battery module for AU version

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Model: See cover page



Right view of battery module for AU version



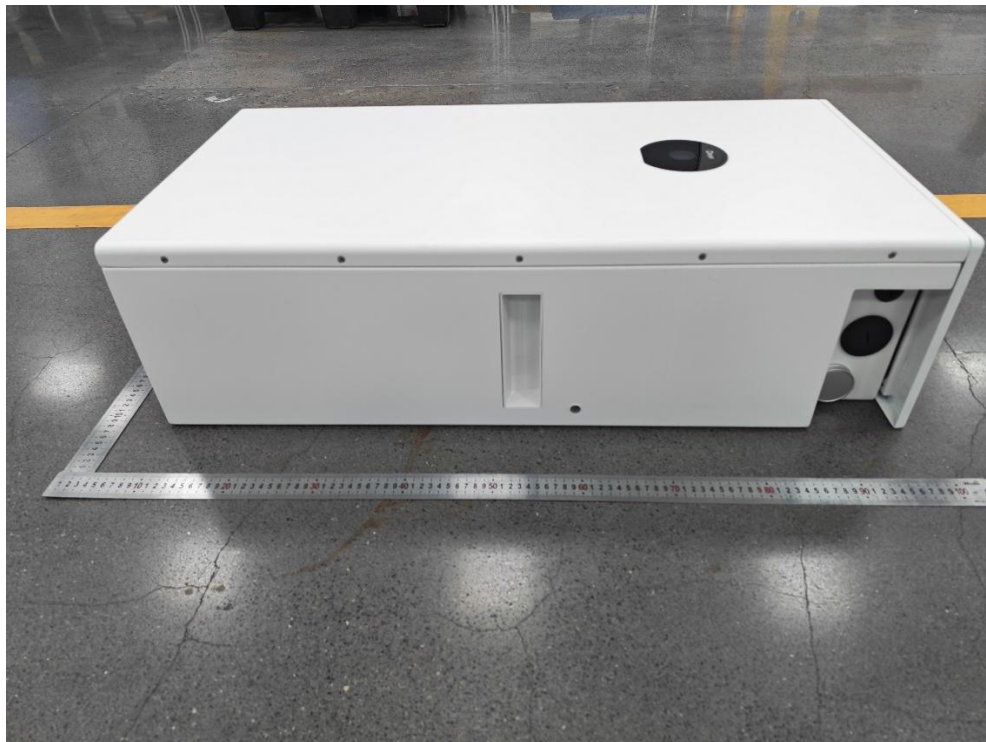
External view of blanking plug for AU version

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Model: See cover page



Left view of battery module for US version



Right view of battery module for US version

Report Number: CN26SVV2 001 attachment 1

Model: See cover page



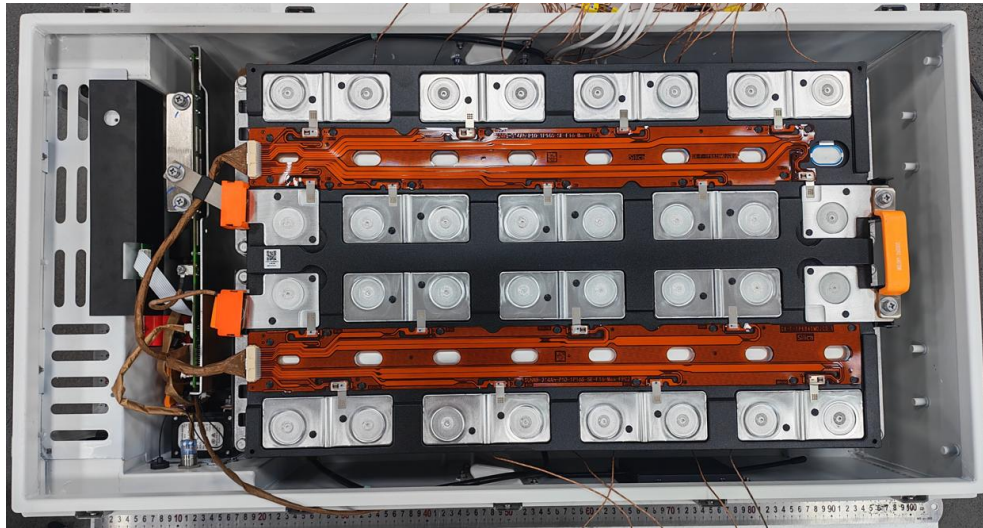
External view of blanking plug for US version



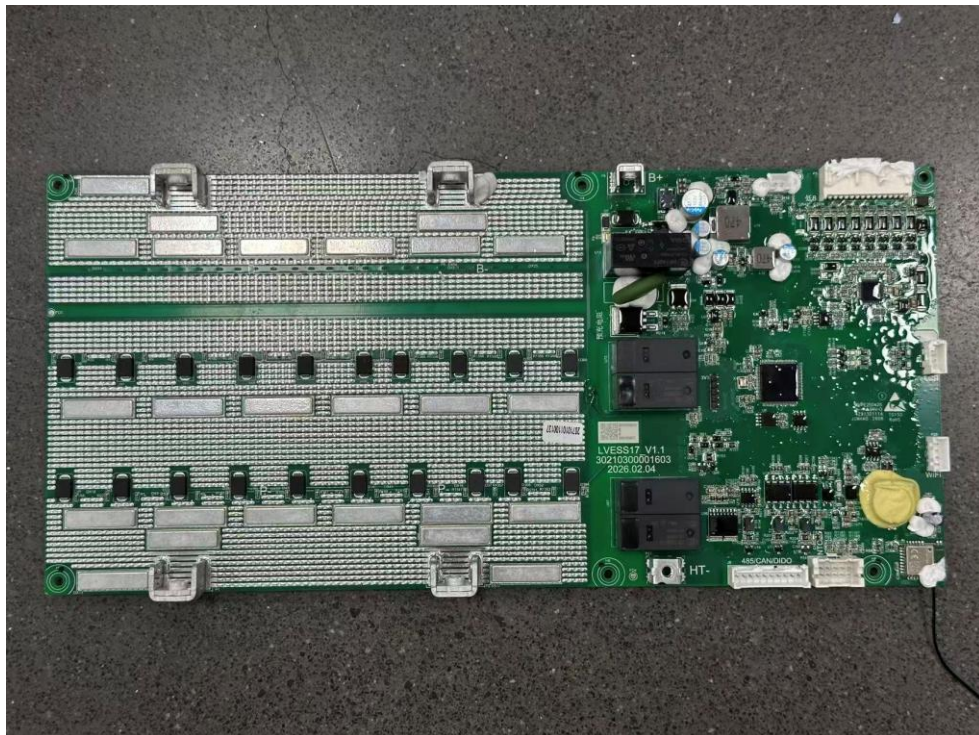
External view of module fitted with metal junction box

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Internal view



Top view of BMS board

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Model: See cover page



Back view of BMS board



Cell view