JOINT CANADA-UNITED STATES
NATIONAL STANDARD

ANSI/CAN/UL 9540:2025

STANDARD FOR SAFETY

Energy Storage Systems and Equipment

ULNORM.COM : Click to view the full PDF of UL 9540 2021

ANSI/UL 9540-2025

Copyright Underwriters Laboratories Inc.

SCC FOREWORD

National Standard of Canada

A National Standard of Canada is a standard developed by a Standards Council of Canada (SCC) accredited Standards Development Organization, in compliance with requirements and guidance set out by SCC. More information on National Standards of Canada can be found at www.scc.ca.

SCC is a Crown corporation within the portfolio of Innovation, Science and Economic Development (ISED) Canada. With the goal of enhancing Canada's economic competitiveness and social well-being, SCC leads and facilitates the development and use of national and international standards. SCC also coordinates Canadian participation in standards development, and identifies strategies to advance Canadian standardization efforts.

Accreditation services are provided by SCC to various customers, including product certifiers, testing laboratories, and standards development organizations. A list of SCC programs and accredited bodies is publicly available at www.scc.ca.

ULNORM.COM : Click to view the full PDF of UL 9540 2021

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

Copyright Underwriters Laboratories Inc.

UL Standard for Safety for Energy Storage Systems and Equipment, ANSI/CAN/UL 9540

Third Edition, Dated June 28, 2023

Summary of Topics

This revision of ANSI/CAN/UL 9540 dated March 7, 2025 includes the addition of new Annex H to help clarify required manufacturer's installation instructions for residential ESS.

Text that has been changed in any manner or impacted by ULSE's electronic publishing system is marked with a vertical line in the margin.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated November 1, 2024.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form by any means, electronic, mechanical photocopying, recording, or otherwise without prior permission of ULSE Inc. (ULSE).

ULSE provides this Standard "as is" without warranty of any kind, either expressed or implied, including but not limited to, the implied warranties of merchantability or fitness for any purpose.

In no event will ULSE be liable for any special, incidental, consequential, indirect or similar damages, including loss of profits, lost savings, loss of data, or any other damages arising out of the use of or the inability to use this Standard, even if ULSE or an authorized ULSE representative has been advised of the possibility of such damage. In no event shall ULSE's liability for any damage ever exceed the price paid for this Standard, regardless of the form of the claim.

Users of the electronic versions of UL's Standards for Safety agree to defend, indemnify, and hold ULSE harmless from and against any loss, expense, liability, damage, claim, or judgment (including reasonable attorney's fees) resulting from any error or deviation introduced while purchaser is storing an electronic Standard on the purchaser's computer system.

ULNORM.COM : Click to view the full PDF of UL 9540 2021

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

Copyright Underwriters Laboratories Inc.

No Text on This Page

ULNORM.COM : Click to view the full PDF of UL 9540 2021

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

Copyright Underwriters Laboratories Inc.

JUNE 28, 2023
(Title Page Reprinted: March 7, 2025)

ANSI/UL 9540-2025

ANSI/CAN/UL 9540:2025

Standard for Energy Storage Systems and Equipment

First Edition – November, 2016
Second Edition – February, 2020

Third Edition

June 28, 2023

This ANSI/CAN/UL Safety Standard consists of the Third Edition including revisions through March 7, 2025.

The most recent designation of ANSI/UL 9540 as an American National Standard (ANSI) occurred on March 7, 2025. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, Preface or SCC Foreword.

This Standard has been designated as a National Standard of Canada (NSC) on March 7, 2025.

© 2025 ULSE Inc. All rights reserved.

ULNORM.COM : Click to view the full PDF of UL 9540 2021

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

Copyright Underwriters Laboratories Inc.

No Text on This Page

ULNORM.COM : Click to view the full PDF of UL 9540 2021

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

Copyright Underwriters Laboratories Inc.

CONTENTS

Preface (UL) **7**

INTRODUCTION

1 Scope 13
2 Components 14
3 Units of Measurement 14
4 Undated References 14
5 Normative References 14
6 Glossary 21

CONSTRUCTION

7 Non-Metallic Materials 27
8 Metallic Enclosures and Parts Resistance to Corrosion 28
9 Enclosures and Guarding of Hazardous Parts 29
10 General Electrical Safety of Systems and Additional Requirements for Walk-in Units 29
11 Wiring and Electrical Supply Connections 31
12 General Electrical Equipment 32
13 Electrical Spacings and Separation of Circuits 33
14 Insulation Levels and Protective Grounding 34
15 Safety Analysis and Control Systems 36
16 Remote Software Update Enabled ESS 37
16.1 Critical and/or critical supervisory software (UL 1998) 37
16.2 Class B software (UL 60730-1 or CSA E60730-1) 38
17 Remote Controls 39
18 Communication Systems 40
18.1 General 40
18.2 External warning communication system (EWCS) 40
19 Heating and Cooling Systems 41
20 Piping Systems, Pressure Vessels, Fuel and Other Fluid Supply Connections and Controls 41
21 Containment of Moving Parts in Mechanical ESS 42
22 Noise Levels 42
23 Hazardous Fluid Control 42
24 Combustible Vapor Concentrations 43
25 Flammable Solids 44
26 Fire Detection, Suppression and Propagation 44
26.1 General 44
26.2 Large scale fire testing 45
27 Power Conversion Equipment 45
27.1 General 45
27.2 Utility grid interaction 45
27.3 Utility grid interactive inverter 46
27.4 Standalone and multi-mode power conditioning systems 46
28 Energy Storage System Technologies 46
28.1 Electrochemical ESS 46
28.2 Chemical ESS 46
28.3 Mechanical ESS 46
28.4 Thermal ESS 47

PERFORMANCE

29 General 48

ULNORM.COM : Click to view the full PDF of UL 9540 2021

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

Copyright Underwriters Laboratories Inc.

ELECTRICAL TESTS

30 Normal Operations Test 48
31 Abnormal Operation Tests for Thermal Energy Storage Systems 50
31.1 General....50
31.2 Failure of thermal controls 50
31.3 Exposure to out of specification thermal conditions....50
31.4 Failure of pressure controls 50
31.5 Failure of fluid controls 50
32 Dielectric Voltage Withstand Test....51
33 Impulse Test 52
34 Equipment Grounding and Bonding Test 52
35 Insulation Resistance Test 53
36 Electromagnetic Immunity Tests 53
36.1 General....53
36.2 Electrostatic discharge 54
36.3 Radio-frequency electromagnetic field....54
36.4 Fast transient/burst immunity....54
36.5 Surge immunity 55
36.6 Radio-frequency common mode 55
36.7 Power-frequency magnetic field 56
36.8 Operational verification 56
36.9 Operational verification of remote software update capability 56

MECHANICAL TESTS

37 Containment of Moving Parts 56
37.1 Control system fault overspeed test....56
37.2 Faulted securement test....57
37.3 Blocked shaft test 57
37.4 Mechanical integrity test....58
37.5 Bearing failure test....59
38 Leakage Tests....59
39 Strength Tests....60
39.1 General....60
39.2 Hydrostatic strength test....60
39.3 Pneumatic strength test....60
40 Enclosure and Mounting Tests....60
40.1 Wall mount fixture/test....60
40.2 Enclosure impact 61
40.3 Enclosure steady force....61
40.4 Mold stress 62

ENVIRONMENTAL TESTS

41 Special Environment Installations 62
41.1 General....62
41.2 Outdoors installations subject to moisture exposure 62
41.3 Outdoor installation in marine environments....63
41.4 Installation in seismic environments 63

MANUFACTURING AND PRODUCTION TESTS

42 Electrical Production Tests 64
42.1 Dielectric voltage withstand test 64

ULNORM.COM : Click to view the full PDF of UL 9540 2021
ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.
Copyright Underwriters Laboratories Inc.

42.2 Grounding and bonding system check 64
42.3 Check of safety controls 64
43 Mechanical Production Tests 65
43.1 Integrity at maximum abnormal operating speed 65
43.2 Production screening of rotors 65
43.3 Leak check of hazardous fluid systems 65
44 Production Quality Control 65

MARKINGS

45 General 65

INSTRUCTIONS

46 General 68

ANNEX A (Normative)

A1 Standards for Components 72

ANNEX B (Informative) – GENERAL BATTERY SAFETY CONSIDERATIONS

B1 General 74
B2 Design Recommendations 74

ANNEX C (Normative for Canada and Informative for the US) – SAFETY MARKING TRANSLATIONS

ANNEX D (Normative) – APPROACH FOR EVALUATING VALVE REGULATED OF VENTED LEAD ACID OR NICKEL CADMIUM BATTERY ENERGY STORAGE SYSTEMS

D1 General 78
D2 Construction 78
D3 Performance 79
D3.1 General 79

ANNEX E (Informative) – GUIDANCE ON CAPACITY AND SEPARATION DISTANCE LIMITS FOR ELECTROCHEMICAL ESS

E1 General 81

ANNEX F (Normative) – METAL COMPATIBILITY TABLE

ANNEX G (Normative) – CLEAN AGENT DIRECT INJECTION BATTERY RACK COOLANT SYSTEM UNITS

G1 General 84
G2 Glossary 84
G3 Construction 84
G3.1 Piping 84
G3.2 Pressure relief valves 85
G3.3 Pressure regulators 85

ULNORM.COM : Click to view the full PDF of UL 9540 2021

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

Copyright Underwriters Laboratories Inc.

G3.4 Solenoid valves 85
G3.5 Electrical controls 85
G3.6 Input sensors and detectors 85
G3.7 Alarms 86
G3.8 Wiring and terminals 86
G3.9 Clean agent assembly component requirements 86
G4 Performance 87
G4.1 General 87
G4.2 Clean agent assembly tests (UL/ULC 2166 Tests) 87
G4.3 Start to discharge test 88
G4.4 Direct injection coolant system tests 88
G5 Production Tests 88
G6 Markings 89
G7 Instructions 90

ANNEX H (Normative) – MANUFACTURER'S INSTALLATION INSTRUCTIONS TEMPLATE FOR RESIDENTIAL ESS

H1 Manufacturer's Installation Instructions Template Instructions 93

ULNORM.COM : Click to view the full PDF of UL 9540 2021

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

Copyright Underwriters Laboratories Inc.

Preface (UL)

This is the Third Edition of ANSI/CAN/UL 9540 Standard for Safety for Energy Storage Systems and Equipment.

ULSE is accredited by the American National Standards Institute (ANSI) and the Standards Council of Canada (SCC) as a Standards Development Organization (SDO).

This Standard has been developed in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization.

This ANSI/CAN/UL 9540 Standard is under continuous maintenance, whereby each revision is approved in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization. In the event that no revisions are issued for a period of four years from the date of publication, action to revise, reaffirm, or withdraw the standard shall be initiated.

In Canada, there are two official languages, English and French. All safety warnings must be in French and English. Attention is drawn to the possibility that some Canadian authorities may require additional markings and/or installation instructions to be in both official languages.

Comments or proposals for revisions on any part of the Standard may be submitted at any time. Proposals should be submitted via a Proposal Request in the Collaborative Standards Development System (CSDS) at https://csds.ul.com.

Our Standards for Safety are copyrighted by ULSE Inc. Neither a printed nor electronic copy of a Standard should be altered in any way. All of our Standards and all copyrights, ownerships, and rights regarding those Standards shall remain the sole and exclusive property of ULSE Inc.

This Edition of the Standard has been formally approved by the Technical Committee (TC) on Energy Storage Systems and Equipment, TC 9540.

This list represents the TC 9540 membership when the final text in this Standard was balloted. Since that time, changes in the membership may have occurred.

ULNORM.COM : Click to view the full PDF of Ul 9540 2021

TC 9540 Membership

Name	Representing	Interest Category	Region
Accosta, Robert Jr.	Arup	General Interest	USA
Allen, Matt	County Fire Authority	Authorities Having Jurisdiction	Australia
Amin, Anujkumar	CSA Group	Testing & Standards Org.	Ontario, Canada
Balash, Gary	East Penn Manufacturing Co.	Producer	USA
Baldassari, Mark	Enphase Energy	Producer	USA
Barrett, Jim	Enel-X	Producer	USA
Barry, Michael	Exponent Inc.	General Interest	USA
Bartlett, Nicholas	National Renewable Energy Lab	Government	USA
Bhattarai, Arjun	VFlowTech Pte Ltd	Producer	Singapore
Boone, Mark	AEGIS	General Interest	USA

TC 9540 Membership Continued on Next Page

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

Copyright Underwriters Laboratories Inc.

TC 9540 Membership Continued

Name	Representing	Interest Category	Region
Bower, Ward	Ward Bower Innovations LLC	General Interest	USA
Brooks, William	Brooks Engineering LLC	General Interest	USA
Chatwin, Troy	GE Transportation a Wabtec Company	Producer	USA
Cheddi, Dan	Electrical Safety Authority	Authorities Having Jurisdiction	Ontario, Canada
Chen, Among	DEKRA	Testing & Standards Org.	China
Chen, Benjamin	Standards Individual	General Interest	Taiwan
Chen, Kristy	Institution of Fire Engineers (Singapore)	General Interest	Singapore
Chen, Man	CSG Power Generation Company	Commercial/Industrial User	China
Chen, Sicong	Shanghai Testing & Inspection Institute of Electrical Equipment Co., Ltd.	Testing & Standards Org.	China
Ching, Yonghan	Cummins Power Generation	Producer	USA
Cho, Seong Il	Samsung SDI	Producer	Republic of Korea
Connell, Christopher	Fronius USA LLC	Supply Chain	USA
Costello, Joshua	County of Los Angeles Fire Department	Authorities Having Jurisdiction	USA
Daniels, Scott	Blackteal Energy	Supply Chain	USA
De Lucia, Tom	American Energy Storage Innovations (AESI)	Producer	USA
DiGenova, Kevin	Nova Quest, LLC	General Interest	USA
Ditch, Benjamin	FM Global	Testing & Standards Org.	USA
Douglas, Steve	QPS Evaluation Services Inc.	Testing & Standards Org.	Ontario, Canada
Echeverria, Ben	Burns & McDonnell	Supply Chain	USA
Edley, Steve	Atlas Power Technologies	Producer	British Columbia, Canada
Eslik, Erinc	Wartsila	Producer	USA
Feng, Zhu (Drew)	Xiamen Ampace Technology Limited	Producer	China
Ferlitch JR, Carl	Chubb Insurance	General Interest	USA
Fink, Brian	Fire & Risk Alliance, LLC	General Interest	USA
Fisher, Jason	Solar Technical Consulting LLC	General Interest	USA
Fok, Kevin	LG Energy Solution Vertech	Supply Chain	USA
Frasca, John	Zurich Insurance PLC	General Interest	USA
Gandhi, Pravinray	self	General Interest	USA
Gass, Philip	IISD	General Interest	USA
Gerczynski, Kara	Elizabeth Fire Protection District	Authorities Having Jurisdiction	USA
Ginder, David	Acculon Energy	Producer	USA
Glubrecht, Kevin	Alberta Municipal Affairs	Government	Alberta, Canada
Goshia, Keith	EOS Energy	Producer	USA
Haer, Jason	Lunar Energy	Producer	USA
Hardman, Bryan	TMEIC Corp	Producer	USA
Hattier, Robert	IBEW LOCAL 134	General Interest	USA
Hayes, Paul	American Fire Technologies Inc.	General Interest	USA

TC 9540 Membership Continued on Next Page

ULNORM.COM : Click to view the full PDF of UL 9540 2021
ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.
Copyright Underwriters Laboratories Inc.

TC 9540 Membership Continued

Name	Representing	Interest Category	Region
He, Sha	self	General Interest	Quebec, Canada
Hernandes, Manuel	National Research Council Canada	Government	British Columbia, Canada
Herzfeld, Martin	California Contractors	Supply Chain	USA
Hidayat, Asep	PT International Chemical Industry (Representing BSN)	Testing & Standards Org.	Indonesia
Higgins, Steven	Surrette Battery	Supply Chain	Nova Scotia, Canada
Hill, Ken	EnerSys Delaware Inc.	Producer	USA
Holmes, John	American Honda Motor Co Inc	General Interest	USA
Hren, Rebekah	Ippnc LLC	General Interest	USA
Ilkiv, Vitaliy	TUV CUD Canada	Testing & Standards Org.	Ontario, Canada
Jackson, Pete	City of Bakersfield	Authorities Having Jurisdiction	USA
Jayanath, Vikram	Rolls-Royce Power Systems – Rolls-Royce Solutions America Inc.	Producer	USA
Johnson, Tracy	Zarges, Inc	Supply Chain	USA
Jolissaint, Vincent	Cobalt Power Systems	Supply Chain	USA
Kadiwala, Jay	US Consumer Product Safety Commission	Non-Voting	USA
Kalim Vazquez, Omar	SGS	Testing & Standards Org.	USA
Kane, Larry	IHI Energy Storage	Producer	USA
Kennedy, Chad	Schneider Electric USA Inc.	Producer	USA
Kluge, Richard	NEBScore Inc.	Commercial/Industrial User	USA
Knedlhans, Jason	Peregrine Energy Solutions LLC	Commercial/Industrial User	USA
Koffel, William	Koffel Associates Inc	General Interest	USA
Laib, Andrew	Safe Labs	General Interest	USA
Lang, Scott	Honeywell International LLC	Supply Chain	USA
Laoonual, Yossapong	King Mongkut University of Technology Thonburi (KMUTT)	General Interest	Thailand
Li, Yan	State Grid Jiangsu Electric Power Co. Ltd.	Commercial/Industrial User	China
Liu, Haiwen	TUV Rheinland of North America Inc.	Testing & Standards Org.	USA
Mak, Shu Lun	Vocational Training Council	General Interest	China
McCormick, Jonathan	Tesla Motors Inc.	Producer	USA
McFadden, Adam	Firehouse Training	General Interest	Ontario, Canada
McKean, Colin	Canadian Battery Association	General Interest	Ontario, Canada
Meier, Pierce	Vistra Corporation	Commercial/Industrial User	USA
Miraldi, Andrew	Miraldi Engineering	Producer	USA
Mitchell, Alena	Powin	Producer	USA
Moradi, Kamran	8minute Solar Energy	Commercial/Industrial User	USA
Mueller, Juergen	Kulr Technology	Supply Chain	USA
Myers, Randi K.	UL Standards & Engagement	TC Chair – Non-voting	USA
Nabavi, Ali	Powersmiths	Producer	Ontario, Canada
Nansel, Alli	Form Energy	Producer	USA

TC 9540 Membership Continued on Next Page

ULNORM.COM : Click to view the full PDF of UL 9540 2021

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

Copyright Underwriters Laboratories Inc.

TC 9540 Membership Continued

Name	Representing	Interest Category	Region
Narine, Randy	Clean Energy Safety and Training Council of Canada	General Interest	Ontario, Canada
O'Connor, Brian	National Fire Protection Association	Testing & Standards Org.	USA
Onnerud, Per	Cadenza Innovations Inc	Supply Chain	USA
Onovakpuri, Lunar	Qcells	Producer	USA
Orlowski, Steve	Sundowne Building Code Consultants, LLC	General Interest	USA
Paiss, Matthew	Pacific Northwest National Laboratory	Government	USA
Patel, Dipesh	Intertek Testing Services	Testing & Standards Org.	USA
Patel, Radhe	Bureau Veritas	Testing & Standards Org.	USA
Perry, Justin	Dominion Energy	Commercial/Industrial User	USA
Phool, Sunil	R Safety and Consulting	General Interest	Alberta, Canada
Picard, Charles	Solar Energy Industries Association	General Interest	USA
Pomerleau, Guy	Blue Solutions Canada	Producer	British Columbia, Canada
Powell, Douglas	Microvast / Energy Division	Producer	USA
Richard, Robert	Hazmat Safety Consulting LLC	General Interest	USA
Riley, Richard	Sonnen Inc.	Producer	USA
Rispoli, Ronald	Entergy Services	Commercial/Industrial User	USA
Rogers, James	Town of Oak Bluffs	Authorities Having Jurisdiction	USA
Rogers, Paul	International Association of Fire Fighters	General Interest	USA
Rosewater, David	Sandia National Laboratories	Government	USA
Sanders, Seth	Amber Kinetics Inc.	Producer	USA
Sappington, Steve	Caterpillar Inc.	Producer	USA
Savage, Michael	Marion County, FL	Authorities Having Jurisdiction	USA
Schimanek, Ralf	Fluence Energy LLC	Producer	Germany
Schneider, Timm	Northvolt Systems AB	Producer	Sweden
Schuetze, Karl	Active Power Inc.	Producer	USA
Schwalb, LaTanya	UL Solutions	Testing and Standards Org.	USA
Shaw-Stewart, James	Everoze Partners	General Interest	United Kingdom
Shinde, Mayur	Rivian Automotive LLC	Producer	USA
Skutt, Glenn	Fermata Energy	Supply Chain	USA
Slish, Jessica	Vertiv	Producer	USA
Smith, Douglas	West Coast Code Consultants (WC3)	General Interest	USA
Smith, Parker	Southwest Research Institute	Testing and Standards Org.	USA
Soares, Gabriel	Moment Energy	Producer	British Columbia, Canada
Song, Tony	Invenergy	Commercial/Industrial User	USA
Spies, Jeffrey	Planet Plan Sets	General Interest	USA
Staples, Mike	City of Victoria	Non-voting	British Columbia, Canada
Steele, Robert	Columbia Power Systems Inc.	Commercial/Industrial User	USA

TC 9540 Membership Continued on Next Page

ULNORM.COM : Click to view the full PDF of UL 9540 2021

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

Copyright Underwriters Laboratories Inc.

TC 9540 Membership Continued

Name	Representing	Interest Category	Region
Stevens, Daniel	Axis Capital	General Interest	United Kingdom
Subbarao, Leo	Subbarao Technologies LLC	General Interest	USA
Sudler III, Samuel	SEA LTD	General Interest	USA
Suzuki, Jin	Tohoku Murata Manufacturing Co. Ltd.	Producer	Japan
Tang, Liang	China Energy Storage Alliance (CNESA)	General Interest	China
Thakkar, Neelesh	ZincFive Inc	Producer	USA
Thompson, Christopher	Solaredge Technologies Inc.	Producer	USA
Thompson, Gary	TUREYCU	General Interest	Ontario, Canada
Towski, Chris	Cambridge Fire Department	Authorities Having Jurisdiction	USA
Valentin, Jordan	Nuvation	Supply Chain	Ontario, Canada
VanHeirseele, Megan	UL Standards & Engagement	TC Project Manager – Non-voting	USA
Wang, Jinze	Fortress Power	Producer	USA
Wang, Lee	Carrier	Producer	USA
Wang, Qingsong	University of Science and Technology of China (USTC)	General Interest	China
Warfield, Don	Ameresco Solar	Producer	USA
Warner, Nicholas	Energy Storage Response Group	General Interest	USA
Weimin, Jia	Beijing Much Fireproof & Insulation Materials Co. Ltd.	Supply Chain	China
Wellman, Zak	Simpliphi Power	Producer	USA
Wiese, Angie	City of St. Paul	Authorities Having Jurisdiction	USA
Wilkie, Steven	New York Power Authority	Government	USA
Wills, Robert	Integrid, LLC	Producer	USA
Wong, Siew Yuan	Power Automation PTE LTD	General Interest	Singapore
Woo, Minje	LG Energy Solution	Producer	Republic of Korea
Wurmlinger, Steve	SMA Solar Technology AG	Supply Chain	USA
Xiaohe, Zhang	Chuweineng Testing Technology (Shanghai) Co Ltd	Testing and Standards Org.	China
Xie, Jing	GoodWe Technologies Co Ltd	Producer	China
Xu, Hongbin	Guangzhou MCM Certification and Testing Co. Ltd.	Testing and Standards Org.	China
Yan, Xiao	Volta Institute of Digital Battery Energy Storage	General Interest	China
Yavari, Iman	SenezCo – Fire Science & Engineering	General Interest	Ontario, Canada
Yunzheng, Zhu	ZHEJIANG LAB/Intelligent Robot Research Center	General Interest	China

ULNORM.COM : Click to view the full PDF of UL 9540 2021

International Classification for Standards (ICS): 27.100; 29.220

For information on ULSE Standards, visit https://www.shopulstandards.com, call toll free 1-888-853-3503 or email us at ClientService@shopULStandards.com.

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

Copyright Underwriters Laboratories Inc.

This Standard is intended to be used for conformity assessment.

The intended primary application of this standard is stated in its scope. It is important to note that it remains the responsibility of the user of the standard to judge its suitability for this particular application.

CETTE NORME NATIONALE DU CANADA EST DISPONIBLE EN VERSIONS FRANÇAISE ET ANGLAISE

ULNORM.COM : Click to view the full PDF of UL 9540 2021

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

Copyright Underwriters Laboratories Inc.

INTRODUCTION

1 Scope

1.1 These requirements cover an energy storage system (ESS) that is intended to receive and store energy in some form so that the ESS can provide electrical energy to loads or to the local/area electric power system (EPS) when needed. Electrochemical, chemical, mechanical, and thermal ESS are covered by this Standard. The ESS shall be constructed either as one unitary complete piece of equipment or as matched assemblies, that when connected, in accordance with the manufacturer's installation instructions, form the ESS. An ESS consists of at least an energy storage function and energy storage protective function. If the ESS includes multiple parts that are housed in separate enclosures, it shall be considered as a multi-part ESS covered by this Standard. Individual parts (e.g. power conversion equipment, a battery, etc.) of an ESS are not considered an ESS on their own. This Standard evaluates the compatibility and safety of these various components and parts integrated into an ESS. The ESS can be an AC ESS or a DC ESS as defined in this Standard.

1.2 The systems covered by this Standard include those intended to be used in a standalone mode (e.g. islanded) including "self-supply" systems to provide electrical energy and those used in parallel with an electric power system or electric utility grid such as "grid-supply" systems, or applications that perform ancillary operational modes associated with power generation such as voltage support and regulation, frequency support and regulation, volt-var, capacity reserve, energy shifting or other utility grid support services.

1.3 Energy storage systems are intended for installation and use in accordance with the National Electrical Code, NFPA 70, the Canadian Electrical Code, Part I Safety Standard for Electrical Installations, CSA C22.1, the National Electrical Safety Code, IEEE C2, the International Fire Code, ICC IFC, the International Residential Code, ICC IRC, the National Fire Code of Canada, NRC NFC, the Fire Code, NFPA 1, and the Standard for the Installation of Stationary Energy Storage Systems, NFPA 855. Requirements for installation, with the exception of installation manuals and documents for installation provided with the system are outside the scope of this Standard.

1.4 This Standard covers energy storage systems for stationary indoor and outdoor installations. This Standard also covers mobile energy storage systems as defined by this Standard. This Standard includes requirements for energy storage systems used in residential and non-residential installations.

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.

NOTE: UL 1778/CSA C22.2 No. 107.3 is applicable to UPS that employ chemistries other than lead acid or Ni-cad, but the fire codes and the ESS installation standard do not exclude UPS applications from ESS criteria including compliance to this Standard for these other chemistries.

1.6 The maximum energy capacity of individual electrochemical ESS shall be determined by the following in (a) – (d). Where the results of testing are used, the results shall be determined in accordance with the Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems, UL 9540A:

a) The maximum energy capacity of residential use electrochemical ESS shall not exceed 20 kWh (72 MJ). This value shall be permitted to be increased to the value of the unit which meets the performance criteria of the UL 9540A Unit Level test;

b) The maximum energy capacity of non-residential use electrochemical ESS shall not exceed 50 kWh (180 MJ). This value shall be permitted to be increased to the value of the unit which meets

ULNORM.COM : Click to view the full PDF of UL 9540 2021

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

Copyright Underwriters Laboratories Inc.

the performance criteria of the UL 9540A Installation Level test, provided the ESS is marked in accordance with 45.20;

c) There is no maximum energy capacity limit for non-residential use electrochemical ESS that are tested in accordance with UL 9540A in which the performance level criteria of the cell level test have been met; and

d) There is no maximum energy capacity limit for non-residential use electrochemical ESS intended for use in remote outdoor locations as defined in the applicable installation code, provided they are marked in accordance with 45.21.

NOTE 1: The Standard for the Installation of Stationary Energy Storage Systems, NFPA 855 defines outdoor remote locations as being located more than 30.5 m (100 ft) from exposures.

NOTE 2: Lead acid, Ni-Cad, Ni-MH, and Ni-Zn ESS have exceptions to the capacity energy limits including, in some cases, no limits based upon specific telecom and utility installations as outlined in NFPA 855.

2 Components

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 Annex A for a list of standards covering components generally used in the energy storage systems covered by this Standard. Components and equipment shall comply with the CSA and/or UL standards as appropriate for the country or countries where the energy storage system is to be installed.

3 Units of Measurement

3.1 Values and their respective units of measurement that are stated without parentheses constitute the requirement of the standard and those in parentheses constitute explanatory or approximate information.

4 Undated References

4.1 Any undated reference appearing in the requirements of this Standard shall be interpreted as referring to the latest edition of the reference, including all revisions and amendments.

5 Normative References

5.1 The following standards are referenced in this Standard, and portions of these referenced standards may be essential for compliance. Energy storage systems covered by this Standard shall comply with the referenced installation codes and standards as appropriate for the country where the energy storage system is to be installed. When the energy storage system is intended for use in more than one country, the energy storage system shall comply with the installation codes and standards for all countries where it is intended to be used.

ASME B31 (all applicable parts), *Power Piping*

ASME BPVC, *Boiler and Pressure Vessel Code*

ASTM D412, *Standard Test Method for Vulcanized Rubber and Thermoplastic Elastomers – Tension*

ASTM D4169, *Standard Practice for Performance Testing of Shipping Containers and Systems*

ASTM E136, *Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C*

ULNORM.COM : Click to view the full PDF of UL 9540 2021

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

Copyright Underwriters Laboratories Inc.

29 CFR 1910.95, *Occupational Noise Exposure*

29 CFR 1910.1200, *Toxic and Hazardous Substances*

CSA C22.1, *Canadian Electrical Code, Part I Safety Standard for Electrical Installations*

CSA C22.2 No. 0, *General Requirements – Canadian Electrical Code, Part II*

CSA C22.2 No. 0.15, *Adhesive Labels*

CSA C22.2 No. 0.17, *Evaluation of Properties of Polymeric Materials*

CSA C22.2 No. 0.2, *Insulation Coordination*

CSA C22.2 No. 0.8, *Safety Functions Incorporating Electronic Technology*

CSA C22.2 No. 41, *Grounding and Bonding Equipment*

CSA C22.2 No. 94.2, *Enclosures for Electrical Equipment, Environmental Considerations*

CSA C22.2 No. 100, *Motors and Generators*

CSA C22.2 No. 107.1, *Power Conversion Equipment*

CSA C22.2 No. 107.3, *Uninterruptible Power Systems*

CSA C22.2 No. 139, *Electrically Operated Valves*

CSA C22.2 No. 286, *Industrial Control Panels and Assemblies*

CSA C22.2 No. 301, *Industrial Electrical Machinery*

CSA C22.2 No. 60079-2, *Explosive Atmospheres – Part 2: Equipment Protection By Pressurized Enclosure "p"*

CSA C22.2 No. 60529, *Degrees of Protection Provided By Enclosures (IP Code)*

CSA C22.2 No. 61800-5-1, *Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal, and Energy*

CSA C22.2 No. 62109-1, *Safety of Power Converters for Use in Photovoltaic Power Systems – Part 1: General Requirements*

CSA C22.2 No. 62368-1, *Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements*

CSA B51, *Boiler, Pressure Vessel, and Pressure Piping Code*

CSA B52, *Mechanical Refrigeration Code*

CSA B149.1, *Natural Gas and Propane Installation Code*

ULNORM.COM : Click to view the full PDF of UL 9540 2021

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

Copyright Underwriters Laboratories Inc.

CSA FC 1, *Fuel Cell Technologies – Part 3-100: Stationary Fuel Cell Power Systems – Safety*

CSA Z462, *Workplace Electrical Safety*

CSA Z662, *Oil and Gas Pipeline Systems*

CSA E60730-1, *Automatic Electrical Controls for Household and Similar Use – Part 1: General Requirements*

ICC IBC, *International Building Code*

ICC IFC, *International Fire Code*

ICC IRC, *International Residential Code*

IEC 60068-2-52, *Environmental Testing Part 2: Tests – Tests Kb, Salt Mist, Cyclic (Sodium Chloride Solution)*

IEC 60364-4-41, *Low-Voltage Electrical Installations – Part 4-41: Protection for Safety – Protection Against Electric Shock*

IEC 60364-6, *Low-Voltage Electrical Installations – Part 6: Verification*

IEC 60417 Database, *Graphical Symbols for Use on Equipment*

IEC 60529, *Degrees of Protection Provided by Enclosures (IP Code)*

IEC 60664-1, *Insulation Coordination for Equipment Within Low-Voltage Systems – Part 1: Principles, Requirements and Tests*

IEC 60812, *Failure modes and effects analysis (FMEA and FMECA)*

IEC 60980, *Recommended Practices for Seismic Qualification of Electrical Equipment of the Safety System for Nuclear Generating Stations*

IEC 61000-4-2, *Electromagnetic Compatibility (EMC) – Part 4-2: Testing and Measurement Techniques – Electrostatic Discharge Immunity Test*

IEC 61000-4-3, *Electromagnetic Compatibility (EMC) – Part 4-3: Testing and Measurement Techniques – Radiated, Radio-Frequency, Electromagnetic Field Immunity Test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and Measurement Techniques – Electrical Fast Transient/Burst Immunity Test*

IEC 61000-4-5, *Electromagnetic Compatibility (EMC) – Part 4-5: Testing and Measurement Techniques – Surge Immunity Test*

IEC 61000-4-6, *Electromagnetic Compatibility (EMC) – Part 4-6: Testing and Measurement Techniques – Immunity to Conducted Disturbances, Induced by Radio-Frequency Fields*

IEC 61000-4-8, *Electromagnetic Compatibility (EMC) – Part 4-8: Testing and Measurement Techniques – Power Frequency Magnetic Field Immunity Test*

ULNORM.COM : Click to view the full PDF of UL 9540 2021

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

Copyright Underwriters Laboratories Inc.