



BSI Standards Publication

Electrical energy storage (EES) systems

Part 5-1: Safety considerations for grid-integrated
EES systems — General specification

National foreword

This British Standard is the UK implementation of EN IEC 62933-5-1:2024. It is identical to IEC 62933-5-1:2024.

The UK participation in its preparation was entrusted to Technical Committee ESL/120, Electrical Energy Storage.

A list of organizations represented on this committee can be obtained on request to its committee manager.

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

© The British Standards Institution 2024
Published by BSI Standards Limited 2024

ISBN 978 0 539 20267 0

ICS 13.020.30; 13.020.30; 29.020

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 September 2024.

Amendments/corrigenda issued since publication

Date	Text affected
------	---------------

English Version

Electrical energy storage (EES) systems - Part 5-1: Safety considerations for grid-integrated EES systems - General specification
(IEC 62933-5-1:2024)

Systèmes de stockage de l'énergie électrique (EES) - Partie 5-1: Considérations de sécurité pour les systèmes EES intégrés au réseau - Spécifications générales
(IEC 62933-5-1:2024)

Elektrische Energiespeichersysteme (EES-Systeme) - Teil 5-1: Sicherheitserwägungen für netzintegrierte EES-Systeme - Allgemeine Spezifikation
(IEC 62933-5-1:2024)

This European Standard was approved by CENELEC on 2024-09-03. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.



European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

The text of document 120/368/FDIS, future edition 1 of IEC 62933-5-1, prepared by TC 120 "Electrical Energy Storage (EES) systems" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 62933-5-1:2024.

The following dates are fixed:

- latest date by which the document has to be implemented at national (dop) 2025-06-03 level by publication of an identical national standard or by endorsement
- latest date by which the national standards conflicting with the (dow) 2027-09-03 document have to be withdrawn

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

Endorsement notice

The text of the International Standard IEC 62933-5-1:2024 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standard indicated:

IEC 60079-0	NOTE	Approved as EN IEC 60079-0
IEC 60079-10-1	NOTE	Approved as EN IEC 60079-10-1
IEC 60079-10-2	NOTE	Approved as EN 60079-10-2
IEC 60085	NOTE	Approved as EN 60085
IEC 60127-1	NOTE	Approved as EN 60127-1
IEC 60309 series	NOTE	Approved as EN IEC 60309 series
IEC 60317 series	NOTE	Approved as EN IEC 60317 series
IEC 60335-2-40	NOTE	Approved as EN IEC 60335-2-40
IEC 60691	NOTE	Approved as EN IEC 60691
IEC 60730-1	NOTE	Approved as EN 60730-1
IEC 60730-2-8	NOTE	Approved as EN IEC 60730-2-8
IEC 60738-1	NOTE	Approved as EN IEC 60738-1
IEC 60812:2018	NOTE	Approved as EN IEC 60812:2018 (not modified)
IEC 60896-11	NOTE	Approved as EN 60896-11
IEC 60896-21	NOTE	Approved as EN 60896-21
IEC 60896-22	NOTE	Approved as EN 60896-22

IEC 60947-1	NOTE	Approved as EN IEC 60947-1
IEC 60947-7 series	NOTE	Approved as EN IEC 60947-7 series
IEC 60999-1	NOTE	Approved as EN 60999-1
IEC 60999-2	NOTE	Approved as EN 60999-2
IEC 61000 series	NOTE	Approved as EN IEC 61000 series
IEC 61025:2006	NOTE	Approved as EN 61025:2007 (not modified)
IEC 61058-1	NOTE	Approved as EN IEC 61058-1
IEC 61140	NOTE	Approved as EN 61140
IEC 61204-7	NOTE	Approved as EN IEC 61204-7
IEC 61508-1	NOTE	Approved as EN 61508-1
IEC 61508-4:2010	NOTE	Approved as EN 61508-4:2010 (not modified)
IEC 61558-1	NOTE	Approved as EN IEC 61558-1
IEC 61558-2-16	NOTE	Approved as EN 61558-2-16
IEC 61643-11	NOTE	Approved as EN 61643-11
IEC 61643-331	NOTE	Approved as EN IEC 61643-331
IEC 61810-1	NOTE	Approved as EN 61810-1
IEC 61882:2016	NOTE	Approved as EN 61882:2016 (not modified)
IEC 61984	NOTE	Approved as EN 61984
IEC 62271 series	NOTE	Approved as EN IEC 62271 series
IEC 62282-3-100	NOTE	Approved as EN IEC 62282-3-100
IEC 62351 series	NOTE	Approved as EN IEC 62351 series
IEC 62368-1:2018	NOTE	Approved as EN IEC 62368-1:2020 (not modified) +A11:2020
IEC 62485-1:2015	NOTE	Approved as EN IEC 62485-1:2018 (not modified)
IEC 62619	NOTE	Approved as EN IEC 62619
IEC 62932-2-2	NOTE	Approved as EN IEC 62932-2-2
IEC 62984-2	NOTE	Approved as EN IEC 62984-2
IEC 62990-2	NOTE	Approved as EN IEC 62990-2
IEC 63056	NOTE	Approved as EN IEC 63056
IEC 63115-2	NOTE	Approved as EN IEC 63115-2
ISO 12944 series	NOTE	Approved as EN ISO 12944 series
ISO 13732-1:2006	NOTE	Approved as EN ISO 13732-1:2008 (not modified)
ISO 13850:2015	NOTE	Approved as EN ISO 13850:2015 (not modified)
ISO 13857:2019	NOTE	Approved as EN ISO 13857:2019 (not modified)
ISO 19353:2019	NOTE	Approved as EN ISO 19353:2019 (not modified)

Annex ZA

(normative)

Normative references to international publications with their corresponding European publications

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60068-2-52	-	Environmental testing - Part 2-52: Tests - Test Kb: Salt mist, cyclic (sodium chloride solution)	EN IEC 60068-2-52	-
IEC 60079-2	2014	Explosive atmospheres - Part 2: Equipment protection by pressurized enclosure "p"	EN 60079-2	2014
IEC 60204-1	-	Safety of machinery - Electrical equipment of machines - Part 1: General requirements	EN 60204-1	-
IEC 60204-11	-	Safety of machinery - Electrical equipment of machines - Part 11: Requirements for equipment for voltages above 1 000 V AC or 1 500 V DC and not exceeding 36 kV	EN IEC 60204-11	-
IEC 60364	series	Low-voltage electrical installations	HD 60364	series
IEC 60364-4-41	2005	Low-voltage electrical installations - Part 4-41: Protection for safety - Protection against electric shock	HD 60364-4-41	2017
+ A1	2017		-	-
-	-		+ A11	2017
-	-		+ A12	2019
IEC 60364-4-43	-	Low-voltage electrical installations - Part 4-43: Protection for safety - Protection against overcurrent	HD 60364-4-43	-
IEC 60364-4-44	-	Low-voltage electrical installations - Part 4-44: Protection for safety - Protection against voltage disturbances and electromagnetic disturbances	HD 60364-4-442	-
IEC 60364-6	2016	Low voltage electrical installations - Part 6: Verification	HD 60364-6	2016
-	-		+ A11	2017
-	-		+ A12	2017

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
-	-		+ AC	2017-11
IEC 60529	-	Degrees of protection provided by enclosures (IP Code)	EN 60529	-
IEC 60664-1	2020	Insulation coordination for equipment within low-voltage supply systems - Part 1: Principles, requirements and tests	EN IEC 60664-1	2020
IEC 60695-11-10	-	Fire hazard testing - Part 11-10: Test flames - 50 W horizontal and vertical flame test methods	EN 60695-11-10	-
IEC 60730-1	2022	Automatic electrical controls - Part 1: General requirements	EN IEC 60730-1	2024
IEC 60730-2-9	-	Automatic electrical controls - Part 2-9: Particular requirements for temperature sensing control	EN IEC 60730-2-9	-
IEC 60947-5-1	-	Low-voltage switchgear and controlgear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices	EN 60947-5-1	-
IEC 61000-1-2	-	Electromagnetic compatibility (EMC) - Part 1-2: General - Methodology for the achievement of functional safety of electrical and electronic systems including equipment with regard to electromagnetic phenomena	EN 61000-1-2	-
IEC 61000-6-1	-	Electromagnetic compatibility (EMC) - Part 6-1: Generic standards - Immunity standard for residential, commercial and light-industrial environments	EN IEC 61000-6-1	-
IEC 61000-6-2	-	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments	EN IEC 61000-6-2	-
IEC 61000-6-3	-	Electromagnetic compatibility (EMC) - Part 6-3: Generic standards - Emission standard for equipment in residential environments	EN IEC 61000-6-3	-
IEC 61000-6-4	-	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments	EN IEC 61000-6-4	-
IEC 61000-6-5	-	Electromagnetic compatibility (EMC) - Part 6-5: Generic standards - Immunity for equipment used in power station and substation environment	EN 61000-6-5	-
IEC 61000-6-7	-	Electromagnetic compatibility (EMC) - Part 6-7: Generic standards - Immunity requirements for equipment intended to perform functions in a safety-related system (functional safety) in industrial locations	EN 61000-6-7	-
IEC/TR 61340-1	-	Electrostatics - Part 1: Electrostatic phenomena - Principles and measurements	-	-

EN IEC 62933-5-1:2024 (E)

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 61439-1	-	Low-voltage switchgear and controlgear assemblies - Part 1: General rules	EN IEC 61439-1	-
IEC 61508	series	Functional safety of electrical/electronic/programmable electronic safety-related systems	EN 61508	series
IEC 61511	series	Functional safety - Safety instrumented systems for the process industry sector	EN 61511	series
IEC 61936-1	-	Power installations exceeding 1 kV AC and 1,5 kV DC - Part 1: AC	EN IEC 61936-1	-
IEC/TS 61936-2	-	Power installations exceeding 1 kV a.c. and 1,5 kV d.c. - Part 2: d.c.	-	-
IEC 62061	-	Safety of machinery - Functional safety of safety-related control systems	EN IEC 62061	-
IEC 62109-1	-	Safety of power converters for use in photovoltaic power systems - Part 1: General requirements	EN 62109-1	-
IEC 62109-2	-	Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters	EN 62109-2	-
IEC 62116	2014	Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures	EN 62116	2014
IEC 62305-2	-	Protection against lightning - Part 2: Risk management	EN 62305-2	-
IEC 62443-3-3	-	Industrial communication networks - Network and system security - Part 3-3: System security requirements and security levels	EN IEC 62443-3-3	-
IEC 62477-1	2022	Safety requirements for power electronic converter systems and equipment - Part 1: General	EN IEC 62477-1	2023
IEC 62477-2	-	Safety requirements for power electronic converter systems and equipment - Part 2: Power electronic converters from 1 000 V AC or 1 500 V DC up to 36 kV AC or 54 kV DC	EN IEC 62477-2	-
IEC 62689-2	-	Current and voltage sensors or detectors, to be used for fault passage indication purposes - Part 2: System aspects	EN 62689-2	-
IEC 62909-1	-	Bi-directional grid connected power converters - Part 1: General requirements	EN IEC 62909-1	-
IEC 62909-2	-	Bi-directional grid-connected power converters - Part 2: Interface of GCPC and distributed energy resources	EN IEC 62909-2	-
IEC 62933-1	-	Electrical energy storage (EES) systems - Part 1: Vocabulary	EN IEC 62933-1	-
IEC 62933-5-2	-	Electrical energy storage (EES) systems - Part 5-2: Safety requirements for grid-integrated EES systems - Electrochemical-	EN IEC 62933-5-2	-

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
		based systems		
ISO 1182	-	Reaction to fire tests for products - Non-combustibility test	EN ISO 1182	-
ISO 7010	-	Graphical symbols - Safety colours and safety signs - Registered safety signs	-	-
ISO 12100	2010	Safety of machinery - General principles for design - Risk assessment and risk reduction	EN ISO 12100	2010
ISO 13849	series	Safety of machinery - Safety-related parts of control systems	EN ISO 13849	series
ISO 15649	-	Petroleum and natural gas industries - Piping	-	-
ASME B31.1	-	Code for Pressure Piping, Section 1: Power Piping	-	-
ASME B31.3	-	Code for Pressure Piping, Section 3: Process piping	-	-
IEEE Std 1547.1	2020	Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces	-	-

CONTENTS

FOREWORD.....	6
INTRODUCTION.....	8
1 Scope.....	9
2 Normative references	9
3 Terms and definitions	12
4 Basic approach for safety considerations of EES systems	16
5 Hazard considerations for EES systems	17
5.1 Electrical hazards	17
5.2 Mechanical hazards	17
5.3 Energy hazards.....	17
5.3.1 Explosion hazards	17
5.3.2 Hazards arising from electrical, magnetic, and electromagnetic fields	18
5.4 Fire hazards.....	18
5.5 Temperature hazards.....	18
5.6 Chemical hazards	18
5.7 Unsuitable working conditions	18
6 EESS risk assessment.....	19
6.1 EESS structure	19
6.1.1 General characteristics	19
6.1.2 Specific characteristics	19
6.2 Description of storage conditions	20
6.2.1 Types of grids, applications and locations.....	20
6.2.2 Vulnerable elements	20
6.2.3 Special provisions for EES systems in generally accessible locations	21
6.2.4 Sources of external aggression.....	21
6.2.5 Unattended operation	21
6.2.6 Unintentional islanding	21
6.3 Risk analysis	21
6.3.1 General	21
6.3.2 Components	22
6.3.3 Risk considerations	22
6.3.4 System level risk analysis.....	23
7 Requirements necessary to reduce risks	24
7.1 General measures to reduce risks.....	24
7.2 Preventive measures against damage to neighbouring inhabitants.....	26
7.3 Safety-related design review	26
7.3.1 General	26
7.3.2 Initial safety design review.....	27
7.3.3 Subsequent design revisions	27
7.4 Preventive measures against damage to workers and other persons at risk	27
7.4.1 Protection from electrical hazards.....	27
7.4.2 Protection from mechanical hazards	30
7.4.3 Protection from high pressure hazards.....	30
7.4.4 Protection from explosive atmosphere hazards	31
7.4.5 Protection from hazards arising from electric, magnetic, and electromagnetic fields.....	32

7.4.6	Protection from fire hazards.....	32
7.4.7	Protection from thermal hazards	33
7.4.8	Protection from chemical hazards	34
7.4.9	Protection from workplace hazards	35
7.4.10	Staff training.....	36
7.5	EESS disconnection and shutdown	36
7.5.1	General	36
7.5.2	Grid-disconnected state	37
7.5.3	Stopped state	38
7.5.4	EESS shutdown.....	38
7.5.5	Partial disconnection	38
7.5.6	Equipment guidelines for emergency shutdown	38
7.6	Cyber security.....	39
7.7	Remote monitoring and unattended operation	39
8	System testing.....	40
8.1	General.....	40
8.2	Validation and testing of EESS – Electrical hazards	42
8.2.1	General	42
8.2.2	Accessibility to hazardous live parts	42
8.2.3	Protection from exposure to moisture and pollution.....	42
8.2.4	Electrical insulation and protection against electrical shock tests	43
8.2.5	Protection against out of normal operation range tests	45
8.2.6	Anti-islanding.....	47
8.3	Validation and testing of EESS – Mechanical hazards.....	47
8.3.1	Enclosure strength against impact	47
8.3.2	Enclosure strength against static force	48
8.3.3	Containment of hazardous moving parts	48
8.3.4	Mounting means and handle robust test.....	48
8.3.5	Impact and vibration during transportation and seismic events	49
8.4	Validation and testing of EESS – Fluid hazards (high or low temperature, high pressure, flammable, corrosive, caustic, or toxic)	49
8.4.1	General	49
8.4.2	Hazardous fluid containing parts strength test	49
8.4.3	Hazardous fluid containing parts leakage test.....	50
8.4.4	Start-to-discharge pressure test.....	51
8.5	Validation and testing of EESS – Explosion and combustible concentrations hazards.....	52
8.5.1	Gas detection and off-gas detection	52
8.5.2	Mechanical ventilation evaluation	52
8.6	Validation and testing of EESS – Hazards arising from electric, magnetic and electromagnetic fields	52
8.7	Validation and testing of EESS – Fire propagation hazards.....	53
8.8	Validation and testing of EESS – Temperature hazards	53
8.8.1	General	53
8.8.2	Containment of hazardous temperature (low or high) fluids.....	53
8.8.3	Temperature under normal operation tests	53
8.9	Validation and testing of EESS – Chemical effects.....	53
8.9.1	Strength tests	53
8.9.2	Leakage tests	53

8.10	Validation and testing of EESS – Hazards arising from the environment	54
8.10.1	General	54
8.10.2	Ingress of moisture	54
8.10.3	Exposure to marine environments	54
8.11	Validation and testing of EESS – Hazards arising from auxiliary, control and communication subsystem malfunctions	54
8.11.1	General	54
8.11.2	Auxiliary system malfunction	55
8.11.3	EES control subsystem malfunction	57
8.11.4	EESS internal communication malfunction	58
8.11.5	EESS external communication malfunction	59
9	Instruction manuals and guidelines	59
9.1	General	59
9.2	Installation manual	60
9.3	Maintenance manual	61
9.3.1	General	61
9.3.2	Personal protective equipment (PPE) guidelines	61
9.4	Operator manual	61
9.5	Emergency procedure manual	62
9.6	First response manual	62
10	Markings and signage	63
10.1	General	63
10.2	Nameplate	63
10.3	Cautionary markings and signage	63
Annex A (informative)	Main risks of different storage technologies	64
A.1	General	64
A.2	Pumped hydro storage	64
A.3	Flywheel	65
A.4	Gravitational EESS	65
A.5	Battery energy storage systems	66
A.6	Hydrogen and synthetic natural gas	66
A.7	Thermal EESS technologies	67
A.8	Other EESS technologies	68
Annex B (informative)	Safety considerations	69
B.1	General	69
B.2	Electrical hazards	69
B.3	Mechanical hazards	70
B.4	Energy hazards	70
B.4.1	Explosion hazards	70
B.4.2	Hazards arising from electrical, magnetic, and electromagnetic fields	71
B.5	Fire hazards	71
B.6	Temperature hazards	72
B.7	Chemical hazards	73
B.8	Unsuitable working conditions	73
Annex C (normative)	Test methods for mechanical EESS using a flywheel accumulation subsystem	74
C.1	General	74
C.2	Purpose	74
C.3	Requirement	74

C.4 Method	74
Annex D (informative) Component safety standards	75
Bibliography	78
Figure 1 – General description of the approach to address hazards in EES systems	17
Figure 2 – Iterative checking sequence in general risk assessment procedures	24
Figure 3 – General risk reduction measures to minimize hazards	25
Figure 4 – Damage propagation from a contained incident to a major incident, and layered measures to minimize damage	25
Figure 5 – Initial safety design review and design revision	27
Figure 6 – Examples of different EESS architectures	37
Figure 7 – EESS architecture in the two main EESS configurations	41
Figure B.1 – Islanding of the EESS	70
Table 1 – EESS characteristics for risk assessment consideration	20
Table 2 – Test parameters for the strength test	50
Table 3 – Test parameters for the leakage test	51
Table A.1 – Main risk scenarios for pumped hydro storage	64
Table A.2 – Main risk scenarios for flywheel	65
Table A.3 – Main risk scenarios for gravitational EESS	66
Table A.4 – Main risk scenarios for hydrogen storage	67
Table A.5 – Main risk scenarios for thermal EESS storage	68
Table D.1 – Examples of component safety standards for use in EESS	75

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRICAL ENERGY STORAGE (EES) SYSTEMS –**Part 5-1: Safety considerations for grid-integrated EES systems –
General specification**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 62933-5-1 has been prepared by IEC technical committee TC 120: Electrical Energy Storage (EES) systems. It is an International Standard.

This first edition cancels and replaces the first edition of IEC TS 62933-5-1 published in 2017. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to IEC TS 62933-5-1:2017:

- a) Revising "should" statements to "shall" statements for all requirements and move some "should" statements clauses to Annex B for informative purposes.
- b) Update standard references (normative).
- c) Update definitions and add or remove definitions where necessary.

- d) Revise criteria in Clause 6 and Clause 7 to be actionable and add standard references where necessary.
- e) Revise Clause 8 for more thorough test method and criteria, add tests where necessary.
- f) Add markings and instruction criteria.
- g) Revise Annex A to add technology safety information on gravitational and thermal EESS.
- h) Add Annex B and Annex C for safety considerations for EESS and test method for mechanical EESS.
- i) Add informative list of standards and update bibliography.

The text of this International Standard is based on the following documents:

Draft	Report on voting
120/368/FDIS	120/377/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 62933 series, published under the general title *Electrical energy storage (EES) systems*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

Many governments' plans for how electricity will be generated and managed in the future have been determined. Such current plans cannot be implemented without long-term storage with capacities in the large scale range.

There are a number of types of storage technologies that have emerged. Examples of these technologies are pumped hydro storage (PHS), electrochemical batteries, flywheel storage systems and hydrogen and synthetic natural gas (SNG). Pumped hydro storage has been widely used in terms of the total amount of stored energy. A flywheel is a model of kinetic energy storage with a high power density, excellent cycle stability and long life. While some flywheels are intended for short term operation, others can operate over longer periods of time of up to a few hours. Batteries require development primarily to decrease cost, and for some technologies to increase energy density as well. Hydrogen and synthetic natural gas (SNG) added to natural gas are likely to be essential elements of future electric grids because of their energy storage duration and capacity. Hydrogen and SNG should be further researched and developed across a broad front, including physical facilities, interactions with existing uses of gas for supply and distribution network, optimal chemical processes, safety, reliability and efficiency. The IEC White Paper on electrical energy storage can provide further background information concerning EES systems.

For mature EES systems, various IEC standards exist, covering technical features, testing and system integration. For other technologies, there are only a few standards, covering special topics.

Up to now no general standard addressing safety for EESS integration into an electrical grid has been developed.

The rapid growth and the new technologies involved in electrical energy storage in the near future, as well as their installation by consumers will impose particular requirements for safety. At the same time, society and governments will need assurance of safety before the much-needed systems can be deployed.

This document stands as a decisive step towards the gradual alignment with specific technologies and applications concerning the safety of packaged or site-assembled grid-integrated EESS.

Additional criteria specific to electrochemical type electrical energy storage (EES) systems are given in IEC 62933-5-2.

ELECTRICAL ENERGY STORAGE (EES) SYSTEMS –

Part 5-1: Safety considerations for grid-integrated EES systems – General specification

1 Scope

This part of IEC 62933 specifies safety considerations (e.g. hazards identification, risk assessment, risk mitigation) applicable to EES systems integrated with the electrical grid.

This document provides criteria to enable the safe application and use of electrical energy storage systems of any type or size intended for grid-integrated applications.

This document can be applied to all EESS technologies, but for requirements specific to electrochemical EES systems, reference is also made to IEC 62933-5-2.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-2-52, *Environmental testing – Part 2-52: Tests – Test Kb: Salt mist, cyclic (sodium chloride solution)*

IEC 60079-2:2014, *Explosive atmospheres – Part 2: Equipment protection by pressurized enclosure "p"*

IEC 60204-1, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

IEC 60204-11, *Safety of machinery – Electrical equipment of machines – Part 11: Requirements for equipment for voltages above 1 000 V AC or 1 500 V DC and not exceeding 36 kV*

IEC 60364 (all parts), *Low-voltage electrical installations*

IEC 60364-4-41:2005, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*
IEC 60364-4-41:2005/AMD1:2017

IEC 60364-4-43, *Low-voltage electrical installations – Part 4-43: Protection for safety – Protection against overcurrent*

IEC 60364-4-44, *Low-voltage electrical installations – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*

IEC 60364-6:2016, *Low voltage electrical installations – Part 6: Verification*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60664-1:2020, *Insulation coordination for equipment within low-voltage supply systems – Part 1: Principles, requirements and tests*

IEC 60695-11-10, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*

IEC 60730-1:2020, *Automatic electrical controls – Part 1: General requirements*

IEC 60730-2-9, *Automatic electrical controls – Part 2-9: Particular requirements for temperature sensing controls*

IEC 60947-5-1, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC 61000-1-2, *Electromagnetic compatibility (EMC) – Part 1-2: General – Methodology for the achievement of functional safety of electrical and electronic systems including equipment with regard to electromagnetic phenomena*

IEC 61000-6-1, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity standard for residential, commercial and light-industrial environments*

IEC 61000-6-2, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments*

IEC 61000-6-3, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for equipment in residential environments*

IEC 61000-6-4, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*

IEC 61000-6-5, *Electromagnetic compatibility (EMC) – Part 6-5: Generic standards – Immunity for equipment used in power station and substation environment*

IEC 61000-6-7, *Electromagnetic compatibility (EMC) – Part 6-7: Generic standards – Immunity requirements for equipment intended to perform functions in a safety-related system (functional safety) in industrial locations*

IEC TR 61340-1, *Electrostatics – Part 1: Electrostatic phenomena – Principles and measurements*

IEC 61439-1, *Low voltage switchgear and control gear assemblies – Part 1: General rules*

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC 61511 (all parts), *Functional safety – Safety instrumented systems for the process industry sector*

IEC 61936-1, *Power installations exceeding 1 kV AC and 1,5 kV DC – Part 1: AC*

IEC TS 61936-2, *Power installations exceeding 1 kV AC and 1,5 kV DC – Part 2: DC*

IEC 62061, *Safety of machinery – Functional safety of safety-related control systems*

IEC 62109-1, *Safety of power converters for use in photovoltaic power systems – Part 1: General requirements*

IEC 62109-2, *Safety of power converters for use in photovoltaic power systems – Part 2: Particular requirements for inverters*

IEC 62116:2014, *Utility-interconnected photovoltaic inverters – Test procedure of islanding prevention measures*

IEC 62305-2, *Protection against lightning – Part 2: Risk management*

IEC 62443-3-3, *Industrial communication networks – Network and system security – Part 3-3: System security requirements and security levels*

IEC 62477-1:2022, *Safety requirements for power electronic converter systems and equipment – Part 1: General*

IEC 62477-2, *Safety requirements for power electronic converter systems and equipment – Part 2: Power electronic converters from 1 000 V AC or 1 500 V DC up to 36 kV AC or 54 kV DC*

IEC 62689-2, *Current and voltage sensors or detectors, to be used for fault passage indication purposes – Part 2: System aspects*

IEC 62909-1, *Bi-directional grid-connected power converters – Part 1: General requirements*

IEC 62909-2, *Bi-directional grid-connected power converters – Part 2: Interface of GCPC and distributed energy resources*

IEC 62933-1, *Electrical energy storage (EES) systems – Part 1: Vocabulary*

IEC 62933-5-2, *Electrical energy storage (EES) systems – Part 5-2: Safety requirements for grid-integrated EES systems – Electrochemical-based systems*

ISO 1182, *Reaction to fire tests for products – Non-combustibility test*

ISO 7010, *Graphical symbols – Safety colours and safety signs – Registered safety signs*

ISO 12100:2010, *Safety of machinery – General principles for design – Risk assessment and risk reduction*

ISO 13849 (all parts), *Safety of machinery – Safety-related parts of control systems*

ISO 15649, *Petroleum and natural gas industries – Piping*

ASME B31.1, *ASME B31 Code for Pressure Piping, Section 1: Power Piping*

ASME B31.3, *ASME B31 Code for Pressure Piping, Section 3: Process piping*

IEEE Std 1547.1-2020, *Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62933-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

access to EESS

3.1.1

restricted access area

area to which only skilled persons with the proper authorization have access

[SOURCE: IEC 60050-195:2021, 195-04-04, modified – the words "electrically" and "and electrically instructed persons" have been removed.]

3.1.2

unrestricted access area

area that is not a restricted access area

3.2

operation status

3.2.1

commissioning

activities undertaken to prepare a system or product prior to demonstrating that it meets its specified requirements

[SOURCE: IEC 60050-821:2017, 821-12-09]

3.2.2

decommissioning

administrative and technical actions taken to allow the removal of some or all of the EESS regulatory controls from a facility

Note 1 to entry: These actions can include the processes of discharging and dismantling.

[SOURCE: IEC 60050-395: 2014, 395-08-28, modified – the term "regulatory controls" is replaced with "EESS" and the term "decontamination" with "discharging"]

3.3

EESS

3.3.1

hybrid EESS

EESS that incorporates multiple storage technologies into one system

EXAMPLE: Hybrid EESS that incorporates batteries and electric double layer capacitors in one EESS.

3.3.2

multi-part EESS

electrical energy storage system consisting of assemblies or equipment interconnected in the field to comprise a complete system

3.4

electrical installation

assembly of electrical equipment which is used for the generation, transmission, conversion, distribution and/or use of electric energy

Note 1 to entry: The electrical installation includes energy sources such as batteries, capacitors and all other sources of stored electric energy.

[SOURCE: IEC 60050-651:2014, 651-26-01]

3.5

energized, adj.

live, adj.

at an electric potential different from that of earth at the worksite and which presents an electrical hazard

Note 1 to entry: A part is energized when it is electrically connected to a source of electric energy. It can also be energized when it is electrically charged and/or under the influence of an electric or magnetic field.

[SOURCE: IEC 60050-651:2014, 651-21-08]

3.5.1

hazardous live part

live part that, under certain conditions, can give a harmful electric shock

Note 1 to entry: A hazardous voltage can be present on the accessible surface of solid insulation. In such a case, this surface is considered to be a hazardous live part.

[SOURCE: IEC 60050-195:2021, 195-06-05]

3.6

harm

physical injury or damage to persons, property, and livestock

[SOURCE: IEC 60050-903:2013, 903-01-01]

3.7

hazard

potential source of harm

Note 1 to entry: In English, the term "hazard" can be qualified in order to define the origin of the hazard or the nature of the expected harm (e.g. "electric shock hazard", "crushing hazard", "cutting hazard", "toxic hazard", "fire hazard", "drowning hazard").

Note 2 to entry: In French, the synonym "risque" is used together with a qualifier or a complement to define the origin of the hazard or the nature of the expected harm (e.g. "risque de choc électrique", "risque d'écrasement", "risque de coupure", "risque toxique", "risque d'incendie", "risque de noyade").

Note 3 to entry: In French, the term "risque" also denotes the combination of the probability of occurrence of harm and the severity of that harm, in English "risk" (see 3.9).

[SOURCE: IEC 60050-903:2013, 903-01-02]

3.8

major incident

event or situation resulting from uncontrolled developments in the course of the operation of the EESS and leading to serious harm to human health or the environment, immediate or delayed, inside or outside the establishment, which requires special arrangements to be implemented by one or more emergency responder agency

3.9 protective measures and safeguards

3.9.1 personal protective equipment PPE

device or appliance designed to be worn or held by an individual for protection against one or more health and safety hazards whilst performing live working

[SOURCE: IEC 60050-651:2014, 651-23-01, modified – “or held” has been added to the definition.]

3.9.2 protective measure

measure intended to achieve adequate risk reduction, implemented by the designer (inherent design, safeguarding and complementary protective measures, information for use) and by the user (organization: safe working procedures, supervision, training; permit-to-work systems; provision and use of additional safeguards; use of personal protective equipment)

[SOURCE: IEC 60050-903:2013, 903-01-17]

3.10 risk

combination of the probability of occurrence of harm and the severity of that harm

Note 1 to entry: In French, the term "risque" also denotes the potential source of harm, in English "hazard" (see 3.7).

[SOURCE: IEC 60050-903:2013, 903-01-07]

3.10.1 tolerable risk

risk which is accepted in a given context based on the current values of society

[SOURCE: IEC 60050-903:2013, 903-01-12]

3.11 risk and hazard analysis

3.11.1 failure mode

manner in which failure occurs

Note 1 to entry: A failure mode may be defined by the function lost or other state transition that occurred.

[SOURCE: IEC 60050-192:2015, 192-03-17]

3.11.2 failure modes and fault tree analysis FMEA

qualitative method of analysis that involves the study of possible failure modes and faults in sub items, and their effects at various system and subsystem levels

[SOURCE: IEC 60050-192:2015, 192-11-05, modified – the term “indenture” has been replaced with “system and subsystem” and the note has been removed.]

3.11.3**failure modes, effects and criticality analysis****FMECA**

quantitative or qualitative method of analysis that involves failure modes and effects analysis together with a consideration of the probability of the failure mode occurrence and the severity of the effects

[SOURCE: IEC 60050-192:2015, 192-11-06, modified – the note has been removed.]

3.11.4**fault tree analysis****FTA**

deductive analysis using fault trees

[SOURCE: IEC 60050-192:2015, 192-11-08]

3.11.5**hazard and operability studies****HAZOP studies**

structured and systematic technique for examining a defined system with the objective of identifying potential hazards in the system and identifying potential operability problems with the system and, in particular, identifying causes of operational disturbances and production deviations likely to lead to non-conforming products

Note 1 to entry: The hazards involved can include both those essentially relevant only to the immediate area of the system and those with a much wider sphere of influence, for example some environmental hazards

3.11.6**risk analysis**

systematic use of available information to identify hazards and to estimate the risk

[SOURCE: IEC 60050-903:2013, 903-01-08]

3.11.7**risk assessment**

overall process comprising a risk analysis and a risk evaluation

[SOURCE: IEC 60050-903:2013, 903-01-10]

3.11.8**risk evaluation**

procedure based on the risk analysis to determine whether the tolerable risk has been achieved

[SOURCE: IEC 60050-903:2013, 903-01-09]

3.12**reasonably foreseeable misuse**

use of a product, process or service in a way not intended by the supplier, but which can result from readily predictable human behaviour

[SOURCE: IEC 60050-903:2013, 903-01-14]

3.13

safety-related system

designated control system that implements the required safety functions necessary to achieve or maintain a safe state for the EESS; and is intended to achieve, on its own or with other risk reduction measures, the necessary risk reduction in order to meet the required tolerable risk

[SOURCE: IEC 61508-4:2010, 3.4.1, modified – revise “EUC” to “EESS”, delete “other E/E/PE safety-related systems and”, revise “the necessary safety integrity for the required safety functions” to “the necessary risk reduction in order to meet the required tolerable risk”.]

3.14

shutdown

transitional state of an EESS from operational state (either charging from the grid or output power to the grid) to standstill or idling state

[SOURCE: IEC 60050-415:1999, 415-01-09, modified – revise “a wind turbine between power production and” to “an EESS from operational state (either charging from the grid or output power to the grid) to”.]

3.14.1

emergency shutdown

rapid shutdown of EESS triggered by a protection system or by manual intervention to avoid equipment damage, or personnel hazards or both

[SOURCE: IEC 60050-415:1999, 415-01-11, modified – revise “the wind turbine” to “EESS”, and add “intervention to avoid equipment damage, or personnel hazards or both”.]

3.14.2

normal shutdown

shutdown of EESS in which all stages of the shutdown are under the control of the control system

[SOURCE: IEC 60050-415:1999, 415-01-10, modified – add “of EESS”]

3.15

skilled person

qualified person

person with relevant education, training, knowledge and experience to enable him or her to perceive risks and to avoid danger which electricity can create

[SOURCE: IEC 60050-651:2014, 651-26-11]

4 Basic approach for safety considerations of EES systems

The approach taken in this document is shown in Figure 1. The first aspect covered in Clause 5 is the identification of the different hazards associated with an EESS based on its system type, location, size and how it can impact or be impacted by its surroundings. The second aspect, covered in Clause 6 is the conduct of a risk assessment that is determined based upon considerations identified in Clause 5, according to operational use. The third aspect covered in Clause 7 deals with the measures to implement to reduce the risk based on the assessment conducted under Clause 6.

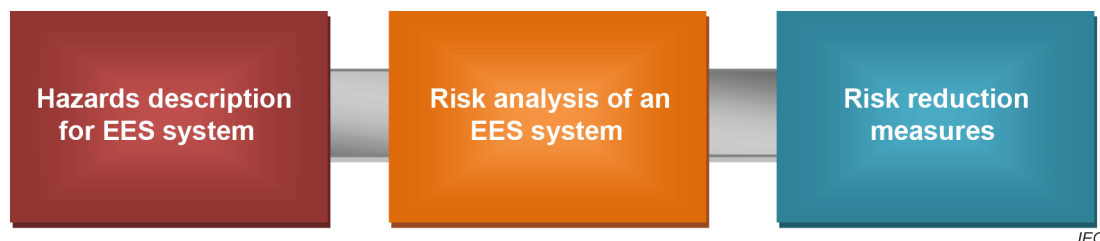


Figure 1 – General description of the approach to address hazards in EES systems

5 Hazard considerations for EES systems

5.1 Electrical hazards

EES systems that contain hazardous voltage levels can pose an electric shock hazard to persons. Voltage limits above 30 V AC RMS/42,4 V AC peak or 60 V DC are considered hazardous voltage.

NOTE 1 In IEC 62477-1 DVC As levels are 30 V AC RMS/42,4 V AC peak or 60 V DC for dry condition. Voltages above these levels are considered as hazardous voltage.

Arc flash boundaries shall be determined to establish appropriate levels of personal protective equipment for workers involved in maintenance and other actions on energized equipment. The arc flash boundary shall be the distance at which the incident energy equals 5 J/cm².

NOTE 2 NFPA 70E provides guidance on worker electrical safety including electric shock and arc flash hazards associated with work on electrically live parts. The arc flash boundary of 5 J/cm² is noted in this document.

The EESS shall also be evaluated for potential hazards due to static electricity, which can lead to hazardous conditions especially within areas of flammable or explosive concentrations of gases or dust.

Electric hazards can also arise from inappropriate electric firefighting procedures. Emergency response guidelines for the EESS shall address appropriate firefighting procedures applicable to that EESS technology.

5.2 Mechanical hazards

Moving parts that present potentially hazardous kinetic energy shall be enclosed or contained to prevent exposure to the moving parts during operation or as a result of a fault in the system, such as worn bearings, loss of vacuum, overspeed conditions, and damaged or blocked rotors.

Parts containing hazardous pressure shall have sufficient strength to safely withstand those pressures. Local regulations for design of parts containing hazardous pressure can apply. Pressure relief devices shall be provided to prevent an overpressure condition.

5.3 Energy hazards

5.3.1 Explosion hazards

Explosions endanger the lives and health of those exposed as a result of the uncontrolled effects of flame and pressure, the presence of noxious reaction products, the discharge of shrapnels, and the consumption of oxygen in the ambient air.

The hazardous risk assessment of the EESS shall determine if there is a potential for an explosion hazard from the EESS during normal and abuse conditions.

5.3.2 Hazards arising from electrical, magnetic, and electromagnetic fields

Exposure to radio frequency energy of sufficient intensity at frequencies between 3 kHz and 300 GHz that can adversely affect personnel working around the EESS shall be prevented.

Risks caused by radioactive substances (radiation and ingestion) are out of the scope of this document.

5.4 Fire hazards

It shall be determined whether combustible materials exist or can exist in the EESS, and in what quantity and distribution.

In assessing the fire hazard, the existence and quantity of fire supporting substances, for example oxygen producing substances, and the potential for their occurrence shall be determined.

Ignition sources, for example hot wires, electrical arcs, friction between moving parts (see Annex B for more information of ignition sources), that exist in EESS or in the vicinity of the EESS or that can occur under some circumstances shall be determined.

5.5 Temperature hazards

EESS shall be designed to prevent inadvertent exposure of persons to hot or cold parts or fluids that can result in an injury.

Emergency response guidelines shall provide instructions to avoid the potential for exposure to excessive heat or hot smoke.

5.6 Chemical hazards

The EESS can contain chemicals that are hazardous to persons if they are exposed to these chemicals. Chemical hazards associated with the EESS shall be identified.

5.7 Unsuitable working conditions

All EES systems shall be arranged to facilitate access to and egress from the area in which the system is installed or enclosed to prevent persons from becoming trapped. Working space and conditions shall be adapted to prevent the risk of musculoskeletal disorders (MSD) injury (see Annex B) which depends on work positions and postures, how often the task is performed, the level of required effort and how long the task lasts.

When evaluating working space for electrical installation and maintenance work, there shall be sufficient space to safely work on the system without the risk of electrical hazards to personnel performing the installation or maintenance. Local regulations can apply.

NOTE 1 Article 110 of NFPA 70:2023 has specific criteria for safe electric working space that are voltage dependent.

Noise from the EESS shall be within specified limits of safety by protective measures including warning markings, and the wearing of hearing protection shall be implemented as determined necessary based upon the limits of the installation. Local regulations can apply.

NOTE 2 Examples of limits imposed in the workplace are: the NIOSH sound level limit for 8 h exposure is 85 dB; the EU sound level limit for 8 h exposure is 87 dB; the OSHA sound level limit for 8 h exposure is 90 dB.

The EESS shall not have sharp edges that can cause a physical injury to personnel.

6 EESS risk assessment

6.1 EESS structure

6.1.1 General characteristics

A risk assessment that includes measures for risk reduction shall be conducted on the EESS. The principles and methodology of ISO 12100 can be used for the risk assessment. IEC/ISO 31010 documents many different techniques that can be used for the risk assessment and provides guidance on their applicability as well as the applicable reference documents for each technique.

NOTE 1 This document covers gravity energy storage systems, which can be considered as a machine. For other EESS, ISO 12100 can also be used as a reference standard for risk assessment.

NOTE 2 Some of the methods covered in IEC/ISO 31010 include primary hazard analysis, structured what if technique (SWIFT), failure modes and effects analysis (FMEA), failure modes, effects and criticality analysis (FMECA), hazard and operability studies (HAZOP studies) and fault tree analysis (FTA).

NOTE 3 In many cases, for example for V-L type EESS that are connected to LV grid with limited power and energy, a risk assessment based on a risk analysis limited to single-fault conditions will be sufficient. In other cases, for example for V-H type EESS that are connected to HV grid with high power and energy, in order to provide a comprehensive evaluation of specific and overall aspects of the EESS and the surrounding environment, if a risk assessment based on a risk analysis limited to single-fault condition is insufficient, a double-fault analysis can be done.

To conduct the risk assessment, a description of the EESS is required. The following general characteristics shall be noted:

- type, power, energy, rated life according to calendar or cycling ageing (guaranteed lifetime, number of cycles),
- application type,
- hazardous materials contained (formulas, physical state, quantities, safety data sheets),
- general functions, safety and security functions, programming functions,
- self-test functions, remote control, staff presence,
- auxiliary devices included in the system,
- measures taken to ensure the design safety and the reliability of the system,
- measures available to mitigate the risks,
- operating parameters,
- known hazards associated with any components of the EESS,
- instructions for use and maintenance.

6.1.2 Specific characteristics

Table 1 lists specific characteristics that shall be considered during the risk assessment.

Table 1 – EESS characteristics for risk assessment consideration

Type of EESS ^a	Grid connection type	Application	Location	Voltage at point of connection
mechanical – pumped hydro (PHS) – compressed air (CAES) – flywheel (FES) – gravitational (GES) electrochemical – secondary batteries – flow batteries – supercapacitors (generally combined with batteries in a hybrid EES) thermal – latent heat storage – sensible heat storage – thermochemical storage (adsorption and absorption) chemical – hydrogen	– transmission grids – distribution grids – commercial grids – industrial grids – residential grids – islanded grids	– peak shaving (long duration application) – load levelling (long duration application) – frequency regulation (short duration application) – stabilizing renewable energy (short duration application) – backup power – combined applications (multiple use applications)	– residential including group of households – commercial and public access buildings – industrial – utility – outdoor enclosed or unenclosed, or both – indoor enclosed or unenclosed, or both – underground	V-L: $\leq 1\,000$ V AC or $\leq 1\,500$ V DC V-H: $>1\,000$ V AC or $> 1\,500$ V DC
^a Annex A gives a short description of the main risks of different mechanical, electrochemical and chemical storage technologies. Some EESS can be a combination of the different types of technologies in one system as a type of hybrid system.				

6.2 Description of storage conditions

6.2.1 Types of grids, applications and locations

Refer to Table 1 for types of grids, for EESS applications and locations that will impact the risk assessment.

6.2.2 Vulnerable elements

To assess the severity of a potential accident or incident, it is essential to clearly identify the elements of the environment that could be affected. Generally, the following elements shall be considered:

- people (e.g. site staff concerned, resident populations or people working around the site, including number, time of presence, distance from the plant and type of persons and their limitations);
- facilities and equipment not directly in the field of study;
- essential safety equipment;
- devices relying on the EESS;
- properties and structures;
- natural environment (e.g. groundwater, rivers, soil, atmosphere, wind direction, seismic levels, lightning levels, and altitude).