

|            |                                                                                                                                                                |                                                |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|
| <b>STN</b> | <b>Systémy na akumuláciu elektrickej energie (EES)<br/>Časť 5-1: Bezpečnostné hľadiská pre systémy<br/>EES integrované do siete<br/>Všeobecná špecifikácia</b> | <b>STN<br/>EN IEC 62933-5-1</b><br><br>36 4400 |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|

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

Táto norma obsahuje anglickú verziu európskej normy.

This standard includes the English version of the European Standard.

Táto norma bola oznámená vo Vestníku ÚNMS SR č. 11/24

Obsahuje: EN IEC 62933-5-1:2024, IEC 62933-5-1:2024

139563



EUROPEAN STANDARD  
NORME EUROPÉENNE  
EUROPÄISCHE NORM

**EN IEC 62933-5-1**

September 2024

ICS 13.020.30

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**

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

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

|                    |      |                                                          |
|--------------------|------|----------------------------------------------------------|
| 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)             |

**EN IEC 62933-5-1:2024 (E)****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](http://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        |

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

| <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 | -           |

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

| <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 | -            | -           |





IEC 62933-5-1

Edition 1.0 2024-07

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE



**Electrical energy storage (EES) systems –  
Part 5-1: Safety considerations for grid-integrated EES systems – General  
specification**

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

**THIS PUBLICATION IS COPYRIGHT PROTECTED****Copyright © 2024 IEC, Geneva, Switzerland**

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Secretariat  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

**About the IEC**

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

**About IEC publications**

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

**IEC publications search - [webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)**

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

**IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)**

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

**IEC Customer Service Centre - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)**

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: [sales@iec.ch](mailto:sales@iec.ch).

**IEC Products & Services Portal - [products.iec.ch](http://products.iec.ch)**

Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

**Electropedia - [www.electropedia.org](http://www.electropedia.org)**

The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

**A propos de l'IEC**

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

**A propos des publications IEC**

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

**Recherche de publications IEC -****[webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)**

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, ...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

**IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)**

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

**Service Clients - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)**

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: [sales@iec.ch](mailto:sales@iec.ch).

**IEC Products & Services Portal - [products.iec.ch](http://products.iec.ch)**

Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications, symboles graphiques et le glossaire. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

**Electropedia - [www.electropedia.org](http://www.electropedia.org)**

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 500 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 25 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.



IEC 62933-5-1

Edition 1.0 2024-07

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE



**Electrical energy storage (EES) systems –  
Part 5-1: Safety considerations for grid-integrated EES systems – General  
specification**

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

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

COMMISSION  
ELECTROTECHNIQUE  
INTERNATIONALE

ICS 13.020.30

ISBN 978-2-8322-9374-4

**Warning! Make sure that you obtained this publication from an authorized distributor.  
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

## 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<br>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,<br>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<br>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<br>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<br>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](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/publications](http://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](http://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*

**koniec náhľadu – text ďalej pokračuje v platenej verzii STN**