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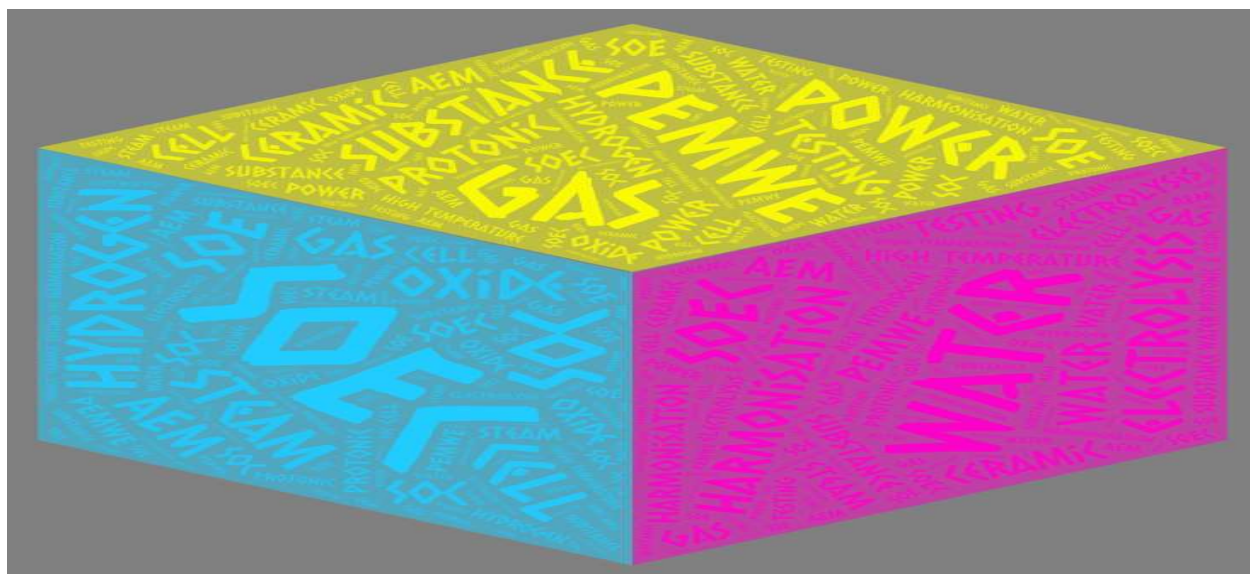
JRC VALIDATED METHODS, REFERENCE METHODS AND MEASUREMENTS REPORT

EU harmonised terminology for hydrogen generated by electrolysis

*An open and comprehensive
compendium*

Malkow, K T, Pilenga, A , Blagoeva, D

2020



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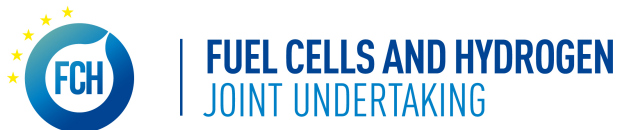
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56 **Foreword**

57 This report was carried out under the framework contract (FWC) between the Directorate-General (DG) Joint
58 Research Centre (JRC) of the European Commission and the Fuel Cells and Hydrogen second Joint Under-
59 taking (FCH2JU), Rolling Plan 2020 deliverable B.2.2.¹

60



61

¹See FCH2JU ANNUAL WORK PLAN (AWP) 2020, p. 83 online at <https://www.fch.europa.eu/page/call-2020>

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68
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71 and Bureau International des Poids et Mesures (BIPM) Joint Committee for Guides in Metrology (JCGM)⁶ for
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76
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²For more information on FCH2JU, see online at <http://fch.europa.eu>

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Abstract

This report entitled EU HARMONISED TERMINOLOGY FOR HYDROGEN GENERATED BY ELECTROLYSIS is prepared under the FWC between JRC and FCH2JU. It is the result of a collaborative effort between European partners from industry, research and development (R&D) organisations and academia participating to FCH2JU funded R&D projects⁷ in electrolysis applications.⁸

The objective of this pre-normative research (PNR) document is to present an open and comprehensive compendium of harmonised terminology which are encountered in electrolysis applications. As means of ordered knowledge representation, clarity of communication and open access to technical information, the commonly accepted terms and definitions of this compendium cover many aspects of electrolysis. They are materials research, modelling, design & engineering, analysis, characterisation, measurements, laboratory testing, prototype development and field tests including demonstration as well as quality assurance (QA).

The commonly accepted definitions of terms and phrases may be used in RD&D project documents, test and measurement methods, test procedures and test protocols, scientific publications, and technical documentation. This compendium is primarily intended for use by those involved in conducting RD&D as well as in drafting and evaluating R&I programme. But, it also contains information useful for others, e. g. auditors, manufacturer, designers, system integrators, testing centres, service providers and educators. Note, it is expandable to account for future power-to-hydrogen (P2H2) developments in energy storage (ES) particularly electrical energy storage (EES), hydrogen-to-power (H2P), hydrogen-to-industry (H2I) and hydrogen-to-substance (H2X) applications.

⁷For a list of FCH2JU funded research, development and demonstration (RD&D) projects, see at <https://www.fch.europa.eu/page/fch-ju-projects>.

⁸RD&D projects funded by Horizon 2020, the European Union (EU)'s Research and innovation (R&I) programme of which the FCH2JU is part of, can be found at <https://ec.europa.eu/programmes/horizon2020/en/h2020-sections-projects>.

1 Introduction

HYDROGEN generation by electrolysis using renewable energy sources (RESs) particularly variable renewable energy (VRE) such as ocean energy, solar energy, tidal energy, and wind energy can be divided into two major categories:

- Low temperature water electrolysis (LTWE) and
- High temperature electrolysis (HTEL) also known as high temperature steam electrolysis (HTSEL) with LTWE subdivided into three main technologies,
 - Alkaline water electrolyser (AWE),
 - Proton exchange membrane water electrolyser (PEMWE) and
 - Anion exchange membrane water electrolyser (AEMWE).

Based on these technologies, water electrolyzers (WEs) usually operate similar to proton exchange membrane fuel cells (PEFCs) at temperatures below 100 °C when water is in liquid state. At elevated temperatures (usually below 200 °C), WE utilise water vapour under atmospheric conditions. High-pressure electrolyser (HPE) operated at higher than atmospheric pressure typically upto $4 \cdot 10^6$ MPa ($4 \cdot 10^3$ kPa, 40 bar) where water remains in liquid state.

The most mature LTWE technology is alkaline electrolysis (AEL) followed by proton exchange membrane electrolysis (PEMEL) being also increasingly demonstrated at technology readiness levels (TRLs) from medium to high. Yet at low TRL that is, in an early stage of R&D, are anion exchange membrane electrolysis (AEMEL) and bipolar membrane electrolysis (BPMEEL). The latter combines PEMEL and AEMEL in a single device.

Remark, hydrogen can also be generated by water electrolysis in regenerative fuel cells (RFCs) particularly proton exchange membrane (PEM) based unitised regenerative fuel cells (URFCs) when operated in regenerative (electrolysis) mode using the same fuel cell stack, seawater (saline surface water) electrolysis and chlor-alkali electrolysis.

The less mature HTEL also known as solid oxide electrolysis (SOEL) can be subdivided into two main technologies namely

- oxygen ion conducting solid oxide electrolyser (O-SOE) which similar to solid oxide fuel cells (SOFCs) or oxide ion conducting solid oxide fuel cell (O-SOFC), operate at high temperatures (HTs) usually in the range of 700 °C to 900 °C, and

- proton conducting solid oxide electrolyser (P-SOE), proton ceramic electrolyser (PCE), or hydrogen ion (proton) conducting solid oxide electrolyser (H-SOE) which similar to proton conducting ceramic fuel cells (PCFCs) or hydrogen ion (proton) conducting solid oxide fuel cell (H-SOFC), operate at intermediate temperatures (ITs) commonly between 400 °C and 650 °C.

Besides these two solid oxide electrolyser (SOE) technologies, reversible solid oxide electrolyser (rSOE) based on reversible solid oxide cells (rSOCs) and reversible proton ceramic conducting electrolyser (rPCE) based on reversible proton conducting ceramic cells (rPCCs) are electrolyser made up of respectively oxygen ion conducting electrolysis cells (OCECs), also known as oxygen ion (proton) conducting solid oxide electrolysis cells (O-SOECs) and proton conducting ceramic electrolysis cells (PCECs), also known as hydrogen ion (proton) conducting solid oxide electrolysis cells (H-SOECs). At any given time, rSOCs operate either in fuel cell (FC) mode, also known as SOFC/PCFC (O-SOFC/H-SOFC) mode, or in electrolysis mode, also known as solid oxide electrolysis cell (SOEC)/PCEC (O-SOEC/H-SOEC) mode.

Another not yet mature HTEL technology based on molten carbonate electrolysis cells (MCECs) are molten carbonate electrolyzers (MCEs) which similar to molten carbonate fuel cells (MCFCs) operate at ITs usually in the range of 450 °C to 650 °C. This includes reversible molten carbonate electrolyser (rMCE) based on reversible molten carbonate cells (rMCCs).

The common use of hydrogen is either as compressed gaseous hydrogen (CGH₂) or liquefied hydrogen (LH₂). The hydrogen generated by electrolysis in hydrogen refueling stations (HRSs), a power-to-fuel (P2F) application, may be used as fuel in fuel cell electric vehicles (FCEVs) and other power-to-mobility (P2M) applications (aviation, maritime, off-road, rail, etc). It may also be stored in vessels and caverns for later energy use including H2P conversion processes such as micro-scale combined heat and power (mCHP) in domestic and commercial buildings employing FCs to generate electricity, heat and hot water.

In addition, hydrogen can be fed to existent natural gas (NG) pipeline networks yielding blends of natural gas and hydrogen (NGH₂), a technology application known as power-to-gas (P2G). Indirectly, hydrogen generated

153 by electrolysis in a P2H2 process⁹ may be converted first to syngas produced in power-to-syngas (P2SG)
154 installations before feeding it into a network of NG pipes. It may also be used in downstream power-to-
155 industry (P2I) processes such as power-to-chemical (P2C), power-to-liquid (P2L) and power-to-refinery (P2R)
156 providing various industries with hydrogen (chemical, beverage/food, electronics/semiconductor, fertiliser,
157 glass, metallurgical/steel, pharmaceutical, refineries, etc) either as a fuel or feedstock in power-to-X (P2X)
158 applications also known as power-to-substance (P2S).

159 This includes H2X conversion processes particularly power-to-methane (P2CH4), power-to-ethanol (P2EtOH),
160 power-to-methanol (P2MeOH), and power-to-ammonia (P2NH3).

161 In power-to-power (P2P) applications, hydrogen serves as a storage medium and subsequently as a fuel
162 for power generation (PG) whether electricity or heat including combined heat and power (CHP), using, for
163 example, fuel cell power systems (FCSs) which may comprise alkaline fuel cells (AFCs), phosphoric acid fuel
164 cells (PAFCs), PEFCs, MCFCs, or SOFCs.

165 Besides WE, hydrogen can also be generated by electrolysis in hybrid redox flow batteries (HRFBs) and
166 microbial electrolysis cells (MECs), or by photoelectrolysis in photoelectrolytic cells (PECs). These technolo-
167 gies are at their early R&D stages and have yet to progress from low to medium TRLs.

168
169 As means of ordered knowledge representation, clarity of communication and facilitation of access to technical
170 information, this reference document provides, in alphabetical order, an open and comprehensive compendium
171 of appropriate EU harmonised water electrolysis terminology expressions in section 2. These conceptually
172 consistent expressions primarily regard hydrogen generated by electrolysis.

173
174 The prime objective of this PNR document is to list commonly accepted definitions of terms and phrases
175 covering a broad and conscious range of water electrolysis and HTSEL R&I aspects concerning materials
176 research, modelling (i. e. atomistic, molecular dynamics (MD), Monte Carlo (MC), and computational fluid
177 dynamics (CFD) simulations), design & engineering, analysis, characterisation & measurements, laboratory
178 testing, prototype development, and field tests including demonstration as well as QA.

179
180 The terms & phrases are recommended for use in the drafting and application of test & measurement methods,
181 test procedures and test protocols including the unambiguous reporting of test results as well as in drafting
182 R&D project deliverable, R&I programme documents and other scientific and technical (S&T) documentation
183 dealing with hydrogen generated by electrolysis.

184
185 This compendium is primarily intended for use by those involved in conducting RD&D as well as in drafting,
186 monitoring and evaluating R&I programme. Prototype examples of such documents are the FCH2JU Multi-
187 Annual Work Programme 2014-2020 (FCH2JU, 2014), the recently published Hydrogen Roadmap Europe
188 (FCH2JU, 2019) and the very recently drafted Strategic research and innovation agenda (SRIA)¹⁰ (Hydrogen
189 Europe and Hydrogen Europe Research, 2020) which use but define many of the terms defined herein including
190 key performance indicators (KPIs) for electrolysis technologies (AEL, PEMEL, SOEL and PCCEL) for both,
191 stacks and systems.¹¹ Also, this compendium contains information useful for others, e. g. auditors, manufac-
192 turer, designers, system integrators, testing centres, service providers and educators. It is readily expandable
193 to account for future P2H2 developments in ES particularly EES, H2P, H2I and H2X applications.

⁹Sometimes PtH is used to denote P2H2. But, PtH can easily be confused with platinum hydride having PtH as chemical formula. PtH could also mean power-to-heat.

¹⁰It is made up of 20 roadmaps as major contribution to develop the Multi-annual work plan (MAWP) of the Clean Hydrogen for Europe institutional public private partnership (IPPP) proposed to succeed FCH2JU under the EU R&I framework Programme Horizon Europe which is to focus on renewable hydrogen production, transmission, distribution and storage, alongside selected FC end-use technologies (European Commission, 2020).

¹¹KPIs for Fuel Cells and Hydrogen (FCH) R&I are listed in another recently updated document (EERA JP FCH and Hydrogen Europe Research, 2020).

2 Terms and definitions

In the compilation of terms and definitions listed herein, we draw on those provided in International Standards including Publicly Available Specifications (PASs), Technical Specifications (TSs), Technical Reports (TRs), guides, and vocabularies developed by standards developing organisations (SDOs) such as

- American Society for Testing and Materials (ASTM),
- Institute of Electrical and Electronics Engineers (IEEE),
- IEC which maintains the IEC 60050 Electropedia terminological database International Electrotechnical Vocabulary (IEV) (IEC, 2020a), and
- ISO which maintains the ISO online browsing platform (ISO, 2020).

Also, we use terms and definitions provided in the JRC technical report EUR 29300 EN (Tsoitridis and Pilenga, 2018), the predecessor to this PNR document, and those compiled in guides and glossaries by organisations such as

- BIPM,
- IUPAC, and
- JCGM.

We also searched databases such as CIPedia[®] (IAIS, 2020), European Environmental Agency (EEA) Glossary (EEA, 2020), International Renewable Energy Agency (IRENA) Glossaries (Richards and Boo, 2013, Ackermann et al., 2016), Interactive terminology for Europe (IATE) (CdT, 2020) and United Nations Terminology Database (UNTERM) (UN Publications, 2020).

This PNR document uses appropriate terms and definitions as agreed or stem from the following sources:

- IEC 62282-8-101:2020 Energy storage systems (ESSs) using fuel cell modules in reverse mode - Test procedures for the performance of solid oxide single cells and stacks, including reversible operation (IEC, 2020b),
- IEC 62282-8-201:2020 Energy storage systems (ESSs) using fuel cell modules in reverse mode - Test procedures for the performance of power-to-power (P2P) systems (IEC, 2020c),
- IEC 62282-8-102:2019 Energy storage systems (ESSs) using fuel cell modules in reverse mode - Test procedures for the performance of single cells and stacks with proton exchange membrane, including reversible operation (IEC, 2019),
- IEC 62933-1:2018 Electrical energy storage systems (EESSs) - Part 1: Vocabulary (IEC, 2018),
- IEC TS 62282-7-2:2014 Test methods - Single cells and stacks performance tests for solid oxide fuel cell (SOFC) (IEC, 2014),
- IEC 88528-11:2004 Reciprocating internal combustion engine driven alternating current generating sets — Part 11: Rotary uninterruptible power systems - Performance requirements and test methods (IEC, 2004),
- ISO/IEC Directives, Part 2 Principles and rules for the structure and drafting of ISO and IEC documents (ISO and IEC, 2018b),
- ISO 1382:2020 Rubber - Vocabulary (ISO, 2020l),
- ISO 1942:2020 Dentistry - Vocabulary (ISO, 2020e),
- ISO 8044:2020 Corrosion of metals and alloys — Vocabulary (ISO, 2020c),
- ISO 12749-1:2020 Nuclear energy - Vocabulary - Part 1: General terminology (ISO, 2020j),
- ISO 14907-1:2020 Electronic fee collection — Test procedures for user and fixed equipment — Part 1: Description of test procedures (ISO, 2020f),
- ISO/GIsacr:IEC 15944-12:2020 Information technology - Business operational view - Part 12: Privacy protection requirement (PPR) on information life cycle management (ILCM) and EDI of PI (ISO and IEC, 2020),
- ISO 19880-1:2020 Gaseous hydrogen — Fuelling stations — Part 1: General requirements (ISO, 2020g),

- 239 ▪ ISO 20024:2020 Solid biofuels — Safe handling and storage of solid biofuel pellets in commercial and
240 industrial applications (ISO, 2020m),
- 241 ▪ ISO 27186:2020 Active implantable medical devices - Four-pole connector system for implantable cardiac
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249 (ISO, 2020b),
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251 fluoride used in the infrared spectrum (ISO, 2020k),
- 252 ▪ ISO 22932-2:2020 Mining - Vocabulary - Part 2: Geology (ISO, 2020i),
- 253 ▪ ISO/IEC Guide 63:2019 Guide to the development and inclusion of aspects of safety in International
254 Standards for medical devices (ISO and IEC, 2019),
- 255 ▪ ISO Guide 82:2019 Guide to the development and inclusion of aspects of safety in International Standards
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339 (ISO and IEC, 2017a),
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354 the energy utility industry (ISO and IEC, 2017b),
- 355 ▪ ISO 29464:2017 Cleaning of air and other gases - Terminology (ISO, 2017d),
- 356 ▪ ISO 52000-1:2017 Energy performance of buildings - Overarching EPB assessment - Part 1: General
357 framework and procedures (ISO, 2017e),
- 358 ▪ ISO/TS 80004-13:2017 Nanotechnologies - Vocabulary - Part 13: Graphene and related two dimensional
359 (2D) materials (ISO, 2017k),
- 360 ▪ ISO 6976:2016 Natural gas - Calculation of calorific values, mass density, relative density and Wobbe
361 indices from composition (ISO, 2016g),
- 362 ▪ ISO 15901-1:2016 Evaluation of pore size distribution and porosity of solid material by mercury porosi-
363 metry and gas adsorption - Part 1: Mercury porosimetry (ISO, 2016d),
- 364 ▪ ISO/TR 16196:2016 Nanotechnologies - Compilation and description of sample preparation and dosing
365 methods for engineered and manufactured nanomaterials (ISO, 2016f),
- 366 ▪ ISO 16315:2016 Small craft - Electric propulsion system (ISO, 2016i),
- 367 ▪ ISO 16577:2016 Molecular biomarker analysis - Terms and definitions (ISO, 2016e),
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369 specimens - Part 1: Terms and definitions (ISO, 2016c),

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- 387 and measuring equipment - Part 5: Uncertainty in verification testing of indicating measuring instruments (ISO,
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- 389 ▪ ISO 14456:2015 Gas cylinders - Gas properties and associated classification (FTSC) codes (ISO, 2015e),
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- 391 ▪ ISO/TS 16901:2015 Guidance on performing risk assessment in the design of onshore LNG installations
- 392 including the ship/shore interface (ISO, 2015h),
- 393 ▪ ISO 18875:2015 Coalbed methane exploration and development - Terms and definitions (ISO, 2015b),
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- 396 ▪ ISO/IEC 29197:2015 Information technology - Evaluation methodology for environmental influence in
- 397 biometric system performance (ISO and IEC, 2015c),
- 398 ▪ ISO/ASTM 52900:2015 Additive manufacturing - General principles - Terminology (ISO and ASTM,
- 399 2015),
- 400 ▪ ISO 6932:2014 Cold-reduced carbon steel strip with a maximum carbon content of 0,25 % (ISO, 2014b),
- 401 ▪ ISO 11358-2:2014 Plastics - Thermogravimetry (TG) of polymers - Part 2: Determination of activation
- 402 energy (ISO, 2014j),
- 403 ▪ ISO 12619-1:2014 Road vehicles - Compressed gaseous hydrogen (CGH₂) and hydrogen/Natural gas
- 404 blend fuel system components - Part 1: General requirements and definitions (ISO, 2014k),
- 405 ▪ ISO 13099-3:2014 Colloidal systems - Methods for zeta potential determination - Part 3: Acoustic
- 406 methods (ISO, 2014c),
- 407 ▪ ISO 13315-2:2014 Environmental management for concrete and concrete structures - Part 2: System
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- 411 ▪ TR 14639-2:2014 Health informatics - Capacity-based eHealth architecture roadmap - Part 2: Archi-
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- 415 ▪ ISO/TR 16208:2014 Corrosion of metals and alloys - Test method for corrosion of materials by electro-
416 chemical impedance measurements (ISO, 2014d),
- 417 ▪ ISO 20507:2014 Fine ceramics (advanced ceramics, advanced technical ceramics) - Vocabulary (ISO,
418 2014f),
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- 420 ▪ ISO 472:2013 Plastics - Vocabulary (ISO, 2013g),
- 421 ▪ ISO/TS 80004-8:2013 Nanotechnologies - Vocabulary - Part 8: Nanomanufacturing processes (ISO,
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- 436 ▪ ISO 18924:2013 Imaging materials - Test method for Arrhenius-type predictions (ISO, 2013c),
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570 This compendium numbers all terms sequentially in uniform entry layout as follows:

571 **number. name (abbreviation, if any)**

572 term definition

573 Example(s): examples, if any

574 Note(s) to entry: including numbered figure(s) and table(s), if any

575 [Source: reference], if any

576 Note(s) to entry: including numbered figure(s) and table(s), if any.

577 in the following sections,

578 section 2.1 General terms particularly

579 - methodological concepts regarding terminology, metrology, quality, and safety common to LTWE and

580 HTEL alike (section 2.1.1),

581 - electrical & electrochemical (section 2.1.2),

582 - methods, characterisation, measurements and testing (section 2.1.4),

583 - components, materials & substances (section 2.1.3), and

584 - phenomena & properties (section 2.1.5);

585 section 2.2 Terms related to LTWE including

586 - physico-chemical & electrochemical concepts, phenomena and devices (section 2.2.1),

587 - materials & properties (section 2.2.2),

- 588 - manufacture, processing & assembly (section 2.2.3), and
 589 - testing terminus (section 2.2.4);
- 590 section 2.3 Terms related to HTEL including
- 591 - electrochemical concepts, phenomena and devices (section 2.3.1),
 592 - materials & processing (section 2.3.2),
 593 - manufacture & processing (section 2.3.3), and
 594 - testing (section 2.3.4);
- 595 section 2.4 Terms of parameters and quantities regarding particularly
- 596 - efficiency terminus (section 2.4.1),
 597 - electrical expressions (section 2.4.2), and
 598 - physical, physico-chemical & technological expressions (section 2.4.3);
- 599 section 2.5 Terms used in electrolysis applications particularly
- 600 - electrical terminus and related expressions (section 2.5.1),
 601 - devices, components and systems (section 2.5.2),
 602 - energy conversion and storage technologies and cost (section 2.5.3), and
 603 - system operation and testing (section 2.5.4).

604 Informatively, we complement this compendium with lists of abbreviations and acronyms,¹² figures, symbols,
 605 and tables along with annexes on several formulas and derivations important for comprehension, guidance,
 606 performance assessment and cost benefit analysis (CBA) of electrolysis technologies in general and devices in
 607 particular.

608 At the end of the document, a subject index on used abbreviations and acronyms and an index of all listed
 609 terms is included.

610 Similar to standards, the following verbal forms are principally used as follows:

- 611 "shall" indicates a requirement,
 612 "should" indicates a recommendation,
 613 "may" indicates a permission and
 614 "can" indicates a possibility or a capability.

615 Note, reference herein to Système International d'Unités (SI) coherent (derived) units (see Table 2 & Table 3)
 616 include, as appropriate, metric prefixes (see Table 5) whether decimal multiples or decimal fractions (sub-
 617 multiples) of the concerned unit. Alongside SI units, non-SI units (see Table 4) are used as customary.
 618

619 **2.1 General terms**

620 **1. affinity**

621 tendency of substances to react with each other

622

623 Note to entry: Also defined as the decrease in Gibbs energy on going from the reactants to the products
 624 of a chemical reaction.

625

626 [Source: ISO/TR 27912:2016 3.2]

627 **2. alkaline fuel cell (AFC)**

628 fuel cell that employs an alkaline electrolyte

629

630 [Source: IEV 485-08-03]

631 **3. anion exchange membrane fuel cell (AEMFC)**

632 fuel cell that employs an anion exchange membrane as electrolyte

¹²Note, country names are abbreviated following the three-letter codes defined in ISO 3166-1:2013 (ISO, 2013a).

633 **4. applied research**

634 research directed toward using knowledge gained by basic scientific research to make things or to create
635 situations that will serve a practical or utilitarian purpose

636

637 [Source: IATE 45197]

638 **5. basic scientific research**

639 experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying found-
640 ation of phenomena and observable facts, without any particular application or use in view

641

642 [Source: IATE 1568516]

643 **6. bipolar**

644 having two poles or electrode

645

646 [Source: ISO 27186:2020 3.2]

647 **7. capacity**

648 capability of a system, subsystem or resource to perform its expected function from a quantitative point
649 of view

650

651 Example: The capacity of a system or a resource to produce a given quantity of output in a par-
652 ticular time period.

653

654 Note to entry: For a given system or resource the distinction between capacity available and capa-
655 city requested may be useful.

656

657 [Source: ISO 15531-1:2004 3.6.4]

658 **8. co-electrolysis**

659 intended simultaneous electrolysis of water (steam) and another reducible substance

660 **9. coating process**

661 process of applying a thin layer of a material in the form of a fluid or powder to a substrate

662

663 [Source: ISO 472:2013 2.154]

664 **10. cold state**

665 non-operative state of a cell/stack/system when it is at ambient temperature with no power input or
666 output

667

668 [Source: JRC EUR 29300 EN report 3.17.2]

669 **11. compendium**

670 publication consisting of summaries of information on a single topic, or on a number of related topics

671

672 [Source: IATE 1390906]

673 **12. compressed gaseous hydrogen (CGH₂)**

674 gaseous hydrogen which has been compressed and stored for use as a vehicle fuel

675

676 [Source: ISO 12619-1:2014 3.3]

677 **13. computational fluid dynamics (CFD)**

678 numerical methods and algorithms to solve and analyse problems that involve fluid flows

679

680 [Source: ISO/TS 16901:2015 3.5]

681 **14. computer aided design (CAD)**

682 use of a computer for design and drafting

683

684 [Source: ISO 6707-2:2017 3.3.1]

- 685 **15. computer aided manufacturing (CAM)**
686 fabrication that involves the use of digitalized data
687
688 [Source: ISO 1942:2020 3.8]
- 689 **16. concentration**
690 mass of a dispersed or dissolved material in a given volume
691
692 [Source: ISO 13943:2017 3.62]
- 693 **17. counter flow**
694 fluid flow in opposite directions through adjacent parts
- 695 **18. demonstration**
696 application and integration of a new product or service into an existing or new system
697
698 [Source: IATE 1691309]
- 699 **19. design**
700 process used to generate the set of information defining the characteristics of a product
701
702 [Source: ISO 10795:2019 3.83]
- 703 **20. development**
704 process by which the capability to adequately implement a technology or design is established before
705 manufacture
706
707 Note 1 to entry: This process can include the building of various partial or complete models of the
708 products and assessment of their performance.
709
710 [Source: ISO 10795:2019 3.85]
711
712 Note 2 to entry: In development, research findings or other knowledge is applied to plan or design
713 for the production of new or substantially improved materials, devices, products, processes, systems or
714 services prior to commencement of their commercial production or use.
- 715 **21. diluent**
716 inert component within a gas mixture that reduces the concentration of the remaining (active) materials
717
718 [Source: ISO/TR 15916:2015 3.30]
- 719 **22. dry gas**
720 fluid that is solely in gaseous phase in which the partial pressure of water is negligible
- 721 **23. electrical energy**
722 active electrical power integrated over a given period of time
723
724 [Source: ISO 14955-2:2018 3.2]
- 725 **24. electrochemical system (ECS)**
726 system consisting of one or more electrochemical cells which are connected to one or more peripheral
727 components which have themselves different functions
- 728 **25. exhaust**
729 gas flow to atmosphere
730
731 [Source: ISO 5598:2019 3.2.262]
- 732 **26. footprint**
733 2D extent or projection of a 3D object on a horizontal surface
734
735 [Source: ISO 19107:2019 3.40]

736 **27. fresh water**

737 water with a conductivity not greater than 1,800 μS

738

739 [Source: ISO 24408:2005 3.3]

740

741 Note to entry: Originally, fresh water is intended for human consumption but also used for certain
742 technical purposes such as water electrolysis and for sanitary hygienic need.

743 **28. fuel cell (FC)**

744 electrochemical device that converts the chemical energy of a fuel and an oxidant to electrical energy
745 (DC power), heat and other reaction products

746

747 [Source: ISO 14687:2019 3.7]

748

749 Note to entry: The FC was first demonstrated in 1802 by English chemist Humphry Davy (1778-1829).
750 The FC principle was invented in 1838 by German chemist Christian Friedrich Schönbein (1799-1868)
751 and developed in 1839 by Welsh scientist William Robert Grove (1811-1896).

752 **29. function**

753 intended effect of a system, subsystem, product or part

754

755 Note to entry: Functions should have a single definite purpose.

756

757 [Source: ISO 10795:2019 3.110]

758 **30. gas**

759 gaseous phase of a substance that cannot reach equilibrium with its liquid or solid state in the temper-
760 ature and pressure range of interest

761

762 Note to entry: This definition is a simplification of the scientific definition, and merely requires that the
763 substance is at a temperature above its boiling point or sublimation point at the ambient temperature
764 and pressure.

765

766 [Source: IEV 426-02-26]

767 **31. greenhouse gas (GHG)**

768 natural or anthropogenic gaseous constituent of the atmosphere that absorbs and emits radiation at
769 specific wavelengths within the spectrum of infrared radiation emitted by the earth's surface, the atmo-
770 sphere, and clouds

771

772 Note to entry: Water vapour and ozone are anthropogenic as well as natural greenhouse gases but
773 are not included as recognised greenhouse gases due to difficulties, in most cases, in isolating the
774 human-induced component of global warming attributable to their presence in the atmosphere.

775

776 [Source: ISO 13065:2015 3.21]

777 **32. high-temperature proton exchange membrane fuel cell (HT-PEMFC)**

778 proton exchange membrane fuel cell operating at temperatures above 100 °C

779 **33. hybrid redox flow battery (HRFB)**

780 redox flow battery where electrolysis intentionally occurs to generate hydrogen

781 **34. idle**

782 pertaining to a resource that is not being used, but is not faulty

783

784 Note to entry: An idle resource may be either free or busied out.

785

786 [Source: IEV 715-02-06]

787 **35. idle time**

788 period of time during which a system or component is operational and in service, but not in use

789

790 [Source: ISO/IEC/IEEE 24765:2017 3.1869]

791 **36. information**

792 representation of the state or events of a process, in a form understood by the process

793

794 [Source: IEC 821-11-24]

795

796 Note to entry: Information may also represent, in forms suitable for communication, storage or pro-
797 cessing, intelligence or knowledge concerning objects, such as facts, events, things, processes, or ideas
798 (including concepts) that, within a certain context, have a particular meaning.

799 **37. innovation**

800 action or process of making changes in something established, especially by introducing new methods,
801 ideas, or products

802

803 [Source: IATE 1475993]

804 **38. isostatic pressing**

805 application of a hydrostatic pressure through a liquid to achieve densification prior to the production of
806 a uniform compact monolith through ceramisation of the densified liquid

807

808 [Source: IUPAC Gold Book IT07625]

809 **39. leak-tight**

810 leakage that is acceptable for a particular component

811

812 [Source: ISO 13628-7:2005 3.1.78]

813 **40. limiting operating condition**

814 extreme operating condition that a device or system is required to withstand without damage or degrad-
815 ation when it is subsequently operated under its rated operating conditions

816 **41. load following**

817 operation mode of a device or system set to closely follow a given load profile (i. e. demand pattern)

818 **42. metal-supported solid oxide fuel cell (MSOFC)**

819 solid oxide fuel cell that is mechanically supported by a metallic interconnect or porous substrate

820 **43. modelling**

821 use of analytical or digital representation to facilitate design, construction, or modification of an abstract
822 or a computational model to form a reliable basis for conclusive decisions

823 **44. molecular dynamics (MD) simulation**

824 computational method analysing the physical movements of interacting particles (atoms and molecules)
825 by calculating the time dependent behavior (dynamic evolution) of a molecular system using descriptions
826 of inter-atomic potentials or molecular mechanics force fields

827 **45. molten carbonate fuel cell (MCFC)**

828 fuel cell that employs molten carbonate electrolyte

829

830 [Source: IEC 485-08-06]

831 **46. Monte Carlo (MC) simulation**

832 simulation having many repeats, each time with a different starting value, to obtain distribution function

833

834 [Source: ISO/TS 16901:2015 3.19]

835 **47. Newtonian fluid**

836 fluid that has a viscosity that is independent of the rate of shear

837
838 [Source: ISO 5598:2019 3.2.476]

839 **48. normal condition**

840 condition in which all means of protection are intact

841
842 [Source: IEC 60364-4-41:2017 411.01]

843 **49. normal operation**

844 situation when the equipment is operating within its design parameters

845
846 [Source: ISO 16924:2016 3.55]

847 **50. operating condition**

848 conditions at which the tested system, more specifically each equipment of the tested system, is oper-
849 ated, as well as physical conditions such as range of ambient temperatures, pressure, radiation levels,
850 humidity and atmosphere are included

851
852 [Source: IEC 62282-8-201:2020 3.1.13]

853 **51. oxygen production rate**

854 amount of oxygen produced by electrolysis

855 **52. phosphoric acid fuel cell (PAFC)**

856 fuel cell that uses an aqueous solution of phosphoric acid (H_3PO_4) as the electrolyte

857
858 [Source: IEC 60851-1:2011 3.1.1]

859 **53. photoelectrochemical cell (PECC)**

860 electrochemical cell in which current and a voltage are simultaneously produced upon absorption of light
861 by one or more of the electrodes

862
863 Note to entry: Usually at least one of the electrodes is a semiconductor.

864
865 [Source: IUPAC P04606]

866 **54. policy**

867 rule or set of rules that speak to one or more legal, political, organisational, functional, business, tech-
868 nical, or related matters that may be expressed as obligations, permissions, or prohibitions

869
870 [Source: ISO/TR 14639-2:2014 2.61]

871 **55. potable water**

872 water suitable for human consumption and use in compliance with the quality requirement laid down in
873 the applicable statutory provisions, defined in this part of ISO 15748 as:

- 874 a) water from a central public potable water supply;
- b) water converted from seawater by evaporation at temperatures exceeding 80 °C;
- c) water converted from seawater by evaporation at temperatures below 80 °C, and which has ad-di-tion-
al-ly been sterilised;
- d) water generated by reverse osmosis;
- e) hot potable water heated in suitable water heaters

875
876
877 [Source: ISO 15748-1:2002 3.8]

878 **56. pre-normative research (PNR)**

879 non-competitive research and development having the objective of creating common functional specifica-
880 tions, developing open systems concepts and their prototype realisation, essential for creating conditions
881 where competition can take place

882
883 [Source: IATE 1492324]

884 **57. pressure loss**

885 reduction in pressure caused by any extraction of energy that is not converted into useful work

886
887 [Source: ISO 5598:2019 3.2.576]

888 **58. principle of superposition**

889 principle that the time response to the sum of several input variables is the same as the sum of the time
890 responses caused by the individual input variables

891
892 Note to entry: The principle of superposition includes the special case, that at multiplication of an
893 input variable by a constant factor the accompanying time response is multiplied by the same factor
894 (often called "principle of amplification").

895
896 [Source: IEV 351-45-01]

897 **59. product**

898 thing or substance produced by a natural or artificial process

899
900 Note 1 to entry: In ISO/IEC Guide 77, the term "product" is taken in its broadest sense to include
901 devices, systems and installations, as well as material, software and services.

902
903 [Source: ISO/IEC Guide 77-2:2008 2.12]

904
905 Note 2 to entry: The dominant element of a product is that it is generally tangible.

906 **60. project**

907 unique process, consisting of a set of coordinated and controlled activities with start and finish dates,
908 undertaken to achieve an objective conforming to specific requirements, including the constraints of
909 time, cost and resources

910
911 Note 1 to entry: An individual project can form part of a larger project structure and generally has
912 a defined start and finish date.

913 Note 2 to entry: In some projects the objectives and scope are updated and the product or service
914 characteristics defined progressively as the project proceeds.

915 Note 3 to entry: The output of a project can be one or several units of product or service.

916 Note 4 to entry: The project's organization is normally temporary and established for the lifetime of the
917 project.

918 Note 5 to entry: The complexity of the interactions among project activities is not necessarily related
919 to the project size.

920
921 [Source: ISO 10795:2019 3.178]

922 **61. proton exchange membrane fuel cell (PEFC)**

923 fuel cell that employs a polymer membrane with (proton) ion exchange capability as the electrolyte

924
925 [Source: IEV 485-08-08]

926
927 Note to entry: Proton exchange membrane fuel cell is also known as polymer electrolyte membrane
928 fuel cell (PEMFC).

929 **62. proton conducting ceramic fuel cell (PCFC)**

930 fuel cell that employs a proton conducting oxide as the electrolyte also abbreviated as H-SOFC

931 **63. Raman effect**

932 emitted radiation, associated with molecules illuminated with monochromatic radiation, characterized
933 by an energy loss or gain arising from rotational or vibrational excitations

934
935 [Source: ISO 18115-2:2013 5.128]

936 **64. rated condition**

937 conditions that are indicated by the highest and, where necessary, lowest numerical values of essential
938 characteristics, confirmed through testing, at which a component or piping is designed to ensure ad-
939 equate service life

940
941 [Source: ISO 5598:2019 3.2.617]

942 **65. rated value**

943 quantity value assigned, generally by a manufacturer, for a specified operating condition of a component,
944 device or equipment

945
946 [Source: IEV 442-01-01]
947 [Source: IEV 441-18-35]

948 **66. regenerative fuel cell (RFC)**

949 electrochemical cell able to produce electric energy from a fuel and an oxidant, and to produce the fuel
950 and oxidant in an electrolysis process from electric energy

951
952 [Source: IEV 485-08-09]

953 **67. relief valve**

954 safety device used for over-pressure protection and which does not operate under normal running con-
955 ditions

956
957 [Source: ISO 21789:2009 3.12]

958 **68. renewable**

959 replenishable naturally at source at a rate at least the same as consumption

960
961 Note to entry: This can apply to materials and energy.

962
963 [Source: ISO 8887-1:2017 3.1.7]

964 **69. renewable electrolyser**

965 electrolyser that uses electricity produced from renewable energy sources

966
967 [Source: IATE 3590390]

968 **70. renewable hydrogen**

969 hydrogen produced by electrolysis of water using energy generated by renewable energy sources

970
971 [Source: IATE 3589536]

972
973 Note 1 to entry: Using renewable resources means both as the source for the hydrogen and the source
974 for the energy input into the production process. Hydrogen produced by electrolysis in an electrolyser
975 from (surplus) renewable electricity obtained from periodically available wind energy and solar energy, a
976 process in which the full life cycle greenhouse gas (GHG) emissions are close to zero. Renewable hydro-
977 gen may also be produced through the reforming of biogas (instead of NG) or biochemical conversion
978 of biomass, if in compliance with sustainability requirements.

979 Note 2 to entry: Clean hydrogen refers to renewable hydrogen (European Commission, 2020).

980 **71. renewables**

981 energy sources that are inherently renewable

- 982 **72. research**
983 systematic investigation into and study of materials and sources in order to establish facts and reach
984 new conclusions
985
986 [Source: IATE 48669]
- 987 **73. roadmap**
988 detailed plan to guide progress towards a goal
989
990 [Source: ISO/TR 14639-2:2014 2.68]
- 991 **74. seawater**
992 artificial seawater made up to a dilution of 3,5 % by volume of dissolved sodium chloride and fresh water
993
994 [Source: ISO 24408:2005 3.4]
- 995 **75. service**
996 result of activities between a supplier and a customer, and the internal activities carried out by the
997 supplier to meet the requirements of the customer
998
999 [Source: ISO/TR 21245:2018 3.21]
- 1000 **76. shelf life**
1001 length of time a product can be stored at specified conditions and still be expected to perform to spec-
1002 ification and have adequate service life
1003
1004 [Source: ISO 5598:2019 3.2.681]
- 1005 **77. shutdown**
1006 sequence of operations, specified by the manufacturer, that occurs to stop the system and all its reac-
1007 tions in a safe and controlled manner
1008
1009 [Source: JRC EUR 29300 EN report 3.17.6]
- 1010 **78. signal**
1011 physical phenomenon one or more of whose characteristics may vary to represent information
1012
1013 [Source: IEV 702-04-01]
1014
1015 Note 1 to entry: The physical phenomenon may be an electromagnetic wave and the characteristic
1016 may be an electric field, a voltage.
1017 Note 2 to entry: The information is generally represented by one or more quantities.
- 1018 **79. single cell**
1019 basic unit of a fuel cell (FC) or an electrolysis cell
- 1020 **80. solid oxide fuel cell (SOFC)**
1021 fuel cell that uses an ion-conducting oxide as the electrolyte
1022
1023 [Source: IEV 485-08-10]
- 1024 **81. solid polymer fuel cell (SPFC)**
1025 fuel cell that employs a solid polymer membrane with ion exchange capability as the electrolyte
- 1026 **82. sorbent**
1027 material that sorbs another
- 1028 **83. specification**
1029 document that prescribes requirements with which the product or service has to conform
1030
1031 [Source: ISO 7348:1992 05.01.02]

- 1032 **84. specified requirement**
1033 need or expectation that is stated
1034
1035 Note 1 to entry: Specified requirements may be stated in normative documents such as regulations,
1036 standards and technical specifications.
1037
1038 [Source: ISO/IEC 17007:2009 3.4]
- 1039 **85. stack arrays**
1040 number of stack arrays within the system that can be operated independently
1041
1042 [Source: JRC EUR 29300 EN report 3.18.11.3]
- 1043 **86. supplier**
1044 person or organization supplying materials or products
1045
1046 [Source: ISO 6707-2:2017 3.8.30]
- 1047 **87. unitised regenerative fuel cell (URFC)**
1048 fuel cell which can perform water electrolysis using DC power to generate hydrogen and oxygen (regen-
1049 erative mode) as well as can function in fuel cell mode to recombine hydrogen and oxygen to produce
1050 DC electricity
1051
1052 Note to entry: The same fuel cell stack is used in both modes.
- 1053 **88. user**
1054 any entity other than a supplier
1055
1056 [Source: ISO 11625:2007 3.8]
- 1057 **89. vacuum**
1058 condition associated with a pressure or mass density below the prevailing atmospheric level
1059
1060 Note to entry: This is expressed in absolute pressure or negative gauge pressure.
1061
1062 [Source: ISO 5598:2019 3.2.785]
- 1063 **90. venting**
1064 release of excessive pressure intended by design
1065
1066 [Source: ISO/TR 8713:2019 3.156]
- 1067 **91. water**
1068 collective term for all types of water used for water supply
1069
1070 [Source: ISO 15748-1:2002 3.5]
- 1071 **92. water vapour**
1072 moisture in the gaseous phase
1073
1074 [Source: ISO 9346:2007 2.3]
- 1075 **93. water vapour partial pressure**
1076 pressure which the water vapour would exert if it alone occupied the volume occupied by the humid air
1077 at the same temperature
1078
1079 [Source: ISO 13731:2001 2.120]

2.1.1 Methodological concepts and expressions

94. acceptance criteria

defined limits placed on characteristics of materials, products or service

[Source: ISO 13533:2001 3.1]

95. accreditation

third-party attestation related to a conformity assessment body conveying formal demonstration of its competence, consistent operation and impartiality in performing specific conformity assessment activities

[Source: ISO 14907-1:2020 3.2]

96. accuracy

quality of freedom from mistake or error; the degree of correctness with which a measured value agrees with the true value

[Source: ISO/IEC 14776-121:2010 3.1.1]

97. ambient conditions

common, prevailing, and uncontrolled atmospheric and weather conditions in a room or place

Note to entry: A test described as "conducted at ambient conditions" was performed at whatever conditions were prevailing at that time on that day.

[Source: ISO/IEC 29197:2015 4.1]

98. Arrhenius equation

formula representing the temperature dependence of the rate constant of a reaction

Note to entry: The rate constant, k , of a reaction is expressed by the Arrhenius formula, as follows:

$$k = Ae^{-\frac{E_a}{R_g T}}$$

where

R_g is the universal gas constant (= 8.314 J K⁻¹ mol⁻¹);

T is the thermodynamic temperature, in kelvin (K);

A is the pre-exponential factor, in reciprocal seconds (s⁻¹);

E_a is the activation energy, in J mol⁻¹;

k is the rate of reaction (= $d\alpha/dt$), in reciprocal seconds (s⁻¹).

[Source: ISO 11358-2:2014 3.1]

Note to entry: This equation is named after Swedish physicist Svante August Arrhenius (1859-1927).

99. assessment

systematic process of collecting and analysing data to determine the current status of a product, a process, a system, a person or an organization

[Source: ISO 10795:2019 3.24]

100. availability

ability of an item to be in a state to perform a required function under given conditions at a given instant of time or over a given time interval, assuming that the required external resources are provided

Note 1 to entry: This ability depends on the combined aspects of the reliability performance, the maintainability performance and the maintenance support performance.

1126 Note 2 to entry: Required external resources, other than maintenance resources, do not affect the avail-
1127 ability performance of the item.
1128 Note 3 to entry: When referring to the measure for availability, the preferred term is "instantaneous
1129 availability".
1130
1131 [Source: ISO 10795:2019 3.28]
1132
1133 Note 3 to entry: Operational availability is determined considering down time due to failures and
1134 associated delays, but excluding external causes.

1135 **101. beginning of life (BoL)**
1136 start of the life cycle of a device, product or system

1137 **102. best practice**
1138 processes, methods, or procedures that, at any known time, are generally considered as superior practice
1139 that delivers optimal outcome(s), such that they are proven worthy to be adopted

1140 **103. calibration**
1141 operation that, under specified conditions, in a first step, establishes a relation between the quantity val-
1142 ues with measurement uncertainties provided by measurement standards and corresponding indications
1143 with associated measurement uncertainties and, in a second step, uses this information to establish a
1144 relation for obtaining a measurement result from an indication
1145
1146 Note 1 to entry: A calibration may be expressed by a statement, calibration function, calibration dia-
1147 gram, calibration curve, or calibration table. In some cases, it may consist of an additive or multiplicative
1148 correction of the indication with associated measurement uncertainty.
1149 Note 2 to entry: Calibration should not be confused with adjustment of a measuring system, often
1150 mistakenly called "self-calibration", nor with verification of calibration.
1151 Note 3 to entry: Often, the first step alone in the above definition is perceived as being calibration.
1152
1153 [Source: ISO/TS 20460:2015 3.1]

1154 **104. calibration interval**
1155 period between routine calibrations over which the performance of the analyser meets specified require-
1156 ments
1157
1158 [Source: ISO 14532:2014 2.5.1.6]

1159 **105. certificate of conformity (CoC)**
1160 documented information that attests to product conformity, conformance to defined process, design,
1161 and specification requirements
1162
1163 [Source: ISO 10795:2019 3.38]

1164 **106. certification**
1165 procedure by which a third party or manufacturer gives written assurance that a product, process or
1166 service conforms to specified requirements
1167
1168 [Source: ISO 16528-1:2007 2.3]

1169 **107. Conformité Européene (CE) mark**
1170 compliance symbol indicating that a product meets the requirements of the EU legislation that applies
1171 to that product (EU product conformity mark)

1172 **108. criterion**
1173 requirement that describes what is to be assessed
1174
1175 Note 1 to entry: A criterion adds meaning and operability to a principle without itself being a dir-
1176 ect measure of performance.
1177 Note 2 to entry: A criterion is characterized by a set of related indicators.
1178
1179 [Source: ISO 13065:2015 3.11]

- 1180 **109. critical raw material (CRM)**
1181 raw material or substance which under a given classification is crucial due to its economic, societal or
1182 strategic importance and carries a significant risk of supply
1183
1184 Note to entry: Here "critical" is not meant as being "rare".
- 1185 **110. data**
1186 representation of information in a formalised manner suitable for human or automatic processing
1187
1188 Note to entry: Processing includes communication and interpretation.
1189
1190 [Source: IEV 171-01-02]
- 1191 **111. default**
1192 pertaining to an attribute, a value, or an option that is assumed when none is explicitly specified
1193
1194 [Source: IEV 171-05-66]
- 1195 **112. definition**
1196 representation of a concept by a descriptive statement which serves to differentiate it from related con-
1197 cepts
1198
1199 [Source: ISO/IEC 15944-12:2020 3.37]
- 1200 **113. demand**
1201 requirement for functional performance
1202
1203 [Source: ISO/TR 15686-11:2014 3.1.19]
- 1204 **114. derived quantity**
1205 quantity that can be derived or calculated from test input parameters, and/or test output parameters
1206 (e. g. current density, reactant utilisation, electric efficiency)
1207
1208 Note 1 to entry: In comparison to test output parameters, derived quantities are not directly measurable.
1209
1210 [Source: IEC 62282-8-101 3.1.12]
1211
1212 Note 2 to entry: In comparison to base quantities, derived quantities are not directly measurable but
1213 calculated from base quantities.
- 1214 **115. designation**
1215 representation of a concept by a sign which denotes it in a domain or subject
1216
1217 Note 1 to entry: A designation can be linguistic or non-linguistic. It can consist of various types of
1218 characters, but also punctuation marks such as hyphens and parentheses, governed by domain-, subject-,
1219 or language-specific conventions.
1220 Note 2 to entry: A designation can be a term including appellations, a proper name, or a symbol.
1221
1222 [Source: ISO 1087:2019 3.4.1]
- 1223 **116. device**
1224 material element or assembly of such elements intended to perform a required function
1225
1226 [Source: IEV 151-11-20]
- 1227 **117. discrete Fourier transform (DFT)**
1228 discrete transform in time and frequency, based on the Fourier integral transform, used to obtain a
1229 spectral estimation of N uniformly time-spaced samples of a signal observed over a finite duration

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[Source: ISO 18431-2:2004 3.1]

$$DFT\{f[k]\}(n) = \sum_{k=0}^{N-1} f[k] e^{-\frac{2\pi i k}{N}n}, n \in [0, N - 1]$$
$$F[n] = \sum_{k=0}^{N-1} f[k] (\cos -i \sin) \left(\frac{2\pi k}{N}n \right)$$

where i is the imaginary unit with property $(\pm i)^2 = -1$

118. documentation

one mode of information communication

Note to entry: This includes management and technical data current as of a given point in time and may be used to reflect contractor to customer and/or contractor to contractor agreements and procedures. This includes such item as program plans, procedures, specifications, reports, technical publications, training documentation.

[Source: ISO 10795:2019 3.89]

119. down time

time interval during which an item is in a down state

Note 1 to entry: The down time includes all the delays between the item failure and the restoration of its service. Down time can be either planned or unplanned.

[Source: ISO 20815:2018 3.1.11]

120. end of life (EoL)

life cycle stage of a product such as a device, equipment or system starting when it is removed from its intended use phase

Note to entry: The phrase "removed from its intended use" does not necessarily mean "dismantled". In fact, the product can either be reused/recovered or disposed of, possibly after dismantling and further recycling processes.

121. environment

natural conditions and induced conditions that constrain the design definitions or operations of a product

Note 1 to entry: Examples of natural conditions are weather, climate, ocean conditions, terrain, vegetation, dust, light and radiation.

Note 2 to entry: Examples of induced conditions are electromagnetic interference, heat, vibration, pollution and contamination.

[Source: ISO 10795:2019 3.92]

122. environmental condition

characteristic of the environment which may affect performance of a device or system

[Source: IEC 60050-101 161-03]

123. environmental impact

any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organisation's environmental aspects

[Source: ISO/TR 15686-11:2014 3.1.32]

124. European standard

standard adopted by a European Standards Organisation

[Source: IATE 850351]

- 1281 **125. explosive atmosphere**
1282 mixture with air, under atmospheric conditions, of flammable substances in the form of gas, vapour, or
1283 dust, which, after ignition, permits self-sustaining propagation
1284
1285 [Source: IEV 426-01-06]
- 1286 **126. explosive gas atmosphere**
1287 mixture with air, under atmospheric conditions, of flammable substances in the form of gas or vapour,
1288 which, after ignition, permits self-sustaining flame propagation
1289
1290 Note to entry: Although a mixture which has a concentration above the upper flammability limit
1291 (UFL) is not an explosive gas atmosphere, it can readily become so and, generally for area classification
1292 purposes, it is advisable to consider it as an explosive gas atmosphere.
1293
1294 [Source: ISO 19880-1:2020 3.20]
- 1295 **127. fail-safe**
1296 equipment or a system so designed that, in the event of failure or malfunction of any part of the system,
1297 devices are automatically activated to stabilise or secure the safety of the operation
1298
1299 [Source: ISO 20024:2020 3.2.3]
- 1300 **128. feasibility study**
1301 study to identify and analyse a problem and its potential solutions in order to determine their viability,
1302 costs, and benefits
1303
1304 [Source: ISO/TR 21245:2018 3.7]
- 1305 **129. fitness for purpose**
1306 ability of a product, process or service to serve a defined purpose under specific conditions
1307
1308 [Source: ISO 21927-1:2008 3.8]
- 1309 **130. glossary**
1310 terminological dictionary that contains designations from one or more domains or subjects together with
1311 equivalents in one or more natural languages
1312
1313 Note 1 to entry: In English common language usage, glossary can refer to a monolingual list of desig-
1314 nations and definition in a domain or subject.
1315
1316 [Source: ISO 1087:2019 3.7.6]
- 1317 **131. good laboratory practice (GLP)**
1318 set of rules and regulations issued by an authoritative body or standards organisation, or generally agreed
1319 upon best practices for laboratory operation, that establishes broad methodological guidelines for pro-
1320 cedures and record keeping
1321
1322 [Source: ISO 16577:2016 3.74]
- 1323 **132. good practice**
1324 method that has been proven to work well and produce good results, and is therefore recommended as
1325 a model
1326
1327 Note to entry: Methods or techniques described as good practice have usually been tested over time
1328 and validated, in the broad sense, through repeated trials before being accepted as worthy of adoption
1329 more broadly.
1330
1331 [Source: ISO 14055-1:2017 3.1.3]

1332 **133. harmonisation**

1333 activity to establish correspondence between two or more closely related or overlapping matters of com-
1334 mon or joint interest and subjects such as concepts, terms, definitions, standards, measurement methods,
1335 test methods, test procedures, and test protocols including data reporting format which have differences
1336 in nature, kind, or type, in order to eliminate or reduce the differences between them

1337

1338 Note to entry: Harmonisation may include an element of full or partial agreement on the content
1339 and/or the application of one or more subjects. A minimum of harmonisation is by a uniform data
1340 reporting format and the approximation of common terms and definitions.

1341 **134. harmonised standard**

1342 European standard developed by a recognised European Standards Organisation (CEN, CENELEC, or
1343 ETSI), in line with a European Directive

1344

1345 [Source: ISO 19880-1:2020 3.35]

1346 **135. hazard**

1347 potential source of harm

1348

1349 [Source: ISO/TR 21245:2018 3.8]

1350

1351 Note to entry: This can be associated with the design, fabrication, operation or environment of an
1352 equipment or a system.

1353 **136. hazardous area**

1354 area in which an explosive atmosphere is present, or may be expected to be present, in quantities such
1355 as to require special precautions for the construction, installation and use of electrical apparatus

1356

1357 [Source: ISO 22734:2019 3.2]

1358 **137. impact**

1359 change, adverse or beneficial, caused by the process being assessed

1360

1361 [Source: ISO 13065:2015 3.26]

1362 **138. incident**

1363 any unplanned event that resulted in injury or ill health of people, or damage or loss to property, plant,
1364 materials or the environment or a loss of business opportunity

1365

1366 Note 1 to entry: The use of the term incident is intended to include the term accident.

1367

1368 [Source: ISO 19880-1:2020 3.43]

1369 **139. indicator**

1370 quantitative, qualitative or binary variable that can be measured or described, in response to a defined
1371 criterion

1372

1373 [Source: ISO 13065:2015 3.27]

1374 **140. innovation readiness level (IRL)**

1375 quantitative measures on an integer scale of maturity from 1 (basic) to 10 (most mature) for assessing
1376 the level of maturity of an innovative product, service, or emerging business analysed along five dimen-
1377 sions (TRL, intellectual property readiness level (IPRL), market readiness level, consumer readiness level
1378 (CRL), and societal readiness level (SRL)) that can influence its innovation process on a scale

1379

1380 Note 1 to entry: is intended to depict the development of innovation and may help to implement
1381 an innovation over the life cycle of a product or service more effectively.

1382 Note 2 to entry: The maturity levels are

1383 Level 1: **Unsatisfied needs identified**

1384 Level 2: **Potential business opportunities identified**

- 1385 Level 3: **System analysis performed and general environment analysed**
 1386 Level 4: **Market research performed**
 1387 Level 5: **Target defined**
 1388 Level 6: **Industry analysis performed**
 1389 Level 7: **Competitors analysis and positioning performed**
 1390 Level 8: **Value proposition defined**
 1391 Level 9: **Product/service/business defined**
 1392 Level 10: **Business model coherently defined.**

1393 **141. instruction**

1394 provision that conveys an action to be performed

1395 [Source: IEV 901-05-03]

1397 **142. integrity**

1398 ability of a barrier to function as required when needed

1399 [Source: ISO 20815:2018 3.1.22]

1401 **143. intended use**

1402 use for which a product, process or service is intended according to the specifications, instructions and
 1403 information provided by the manufacturer

1404 [Source: ISO/IEC Guide 63:2019 3.4]

1406 **144. International System of Quantities (ISQ)**

1407 system of quantities based on the seven base quantities: length, mass, time, electric current, thermody-
 1408 namic temperature, amount of substance, and luminous intensity

1409 Note 1 to entry: This system of quantities is published in the ISO 80000 and IEC 80000 series Quantity
 1410 and units.

1411 Note 2 to entry: The Système International d'Unités (SI) is based on the ISQ.

1412 [Source: ISO/IEC Guide 99:2007 1.6]

1415 **145. inverse discrete Fourier transform (IDFT)**

1416 inverse of the discrete Fourier transform

$$1417 \mathcal{DFT}^{-1}\{F[n]\}(k) = \frac{1}{N} \sum_{n=0}^{N-1} F[n] e^{\frac{2\pi i n}{N} k}, \quad k \in [0, N-1]$$

$$1418 f[k] = \frac{1}{N} \sum_{n=0}^{N-1} F[n] (\cos -i \sin) \left(\frac{2\pi n}{N} k \right)$$

1419 where i is the imaginary unit with property $(\pm i)^2 = -1$

1421 **146. item**

1422 subject being considered

1423 Note 1 to entry: The item may be an individual part, component, device, functional unit, equipment,
 1424 subsystem, or system.

1425 Note 2 to entry: The item may consist of hardware, software, people or any combination thereof.

1426 Note 3 to entry: The item is often comprised of elements that may each be individually considered.

1427 [Source: IEV 192-01-01]

1430 **147. key performance indicator (KPI)**

1431 quantifiable measure that an organization uses to gauge or compare performance in terms of meeting
 1432 its strategic and operational objectives

1433 [Source: ISO 22300:2018 3.131]

1435 **148. Kramers-Kronig relations (KKR)**

1436 relation connecting the real and imaginary parts of any complex function which is analytic (complex
1437 differentiable) in the upper half of the complex frequency plane (UHP)

1438
1439 Note 1 to entry: These relations are often used to relate the real and imaginary parts of response
1440 functions in physical systems because causality implies that the analyticity condition is satisfied, and
1441 conversely, analyticity implies causality of the corresponding physical system.

1442 [Source: ISO/TR 16208:2014 3.15]
1443

1444
$$\Re I(\omega) = \frac{2}{\pi} \int_0^{\infty} \frac{\nu \Im I(\nu)}{\nu^2 - \omega^2} d\nu = \frac{2}{\pi} \int_0^{\infty} \frac{\nu \Im I(\nu) - \omega \Im I(\omega)}{\nu^2 - \omega^2} d\nu$$

1445
$$\Im I(\omega) = \frac{2}{\pi} \int_0^{\infty} \frac{\omega \Re I(\nu)}{\omega^2 - \nu^2} d\nu = \frac{2\omega}{\pi} \int_0^{\infty} \frac{\Re I(\nu) - \Re I(\omega)}{\omega^2 - \nu^2} d\nu$$

1446

1447 for all $\omega, \nu \in \mathbb{R}$ where the dash in the integral sign signifies principal value (Bohren, 2010, (de Laer)
1448 Kronig, 1926, Kramers, 1927)

1449 Note 2 to entry: The Kramers-Kronig relations (KKRs) also hold when the UHP is substituted by the
1450 lower half of the complex frequency plane (LHP) provided both integrals are negated.

1451 Note 3 to entry: These relations are named after Dutch physicist Hendrik Anthony Kramers (1894-1952)
1452 and German physicist Ralph (de Laer) Kronig (1904-1995).

1453 **149. laboratory**

1454 designated area containing instruments and equipments used for scientific research, analyses, measure-
1455 ment and testing

1456
1457 Note to entry: This term can be also used in the sense of a legal entity, a technical entity or both.

1458 **150. life cycle**

1459 series of identifiable stages through which an item goes, from its conception to disposal

1460
1461 Example: A typical system life cycle consists of: concept and definition; design and development;
1462 construction, installation and commissioning; operation and maintenance; mid-life upgrading, or life
1463 extension; and decommissioning and disposal.

1464
1465 Note to entry: The stages identified will vary with the application.

1466 [Source: IEV 192-01-09]
1467

1468 **151. life cycle assessment (LCA)**

1469 method of measuring and evaluating the environmental impacts associated with a product, system or
1470 activity, by describing and assessing the energy and materials used and released to the environment over
1471 the life cycle

1472
1473 [Source: ISO/TR 15686-11:2014 3.1.60]

1474 **152. life cycle cost**

1475 cost of an asset or its parts throughout its life cycle, while fulfilling its performance requirement

1476
1477 [Source: ISO 15686-1:2011 3.11]

1478 **153. lifetime**

1479 period over which any of the item properties are required to be within defined limits

1480
1481 [Source: ISO 10795:2019 3.143]

1482 **154. manufacturing readiness level (MRL)**

1483 quantitative measures on an integer scale from 1 (basic: implications identified) to 10 (most mature: full
1484 operation demonstrated) for assessing the maturity of a manufacturing process or a given technology,
1485 component, product or system from a manufacturing perspective as well as the capabilities of possible
1486 suppliers and potential contractors including the identification of associated risks

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Note to entry: These levels are

Level 1: **Basic manufacturing implications identified**

Level 2: **Manufacturing concepts identified**

Level 3: **Manufacturing proof of concept developed**

Level 4: **Manufacturing capability for technology developed in laboratory environment**

Level 5: **Manufacturing capability developed for prototype components in relevant production environment**

Level 6: **Manufacturing capability developed for prototype system or subsystem in relevant production environment**

Level 7: **Manufacturing capability developed for systems, subsystems or components in representative production environment**

Level 8: **Manufacturing pilot line capability demonstrated]**

Level 9: **Low rate production demonstrated**

Level 10: **Full rate production demonstrated.**

155. material safety data sheet (MSDS)

document specifying the properties of a substance, its potential hazardous effects for humans and the environment, and the precautions necessary to handle and dispose of the substance safely

[Source: ISO 14937:2009 3.12]

156. measurement error

measured quantity value minus a reference quantity value

Note 1 to entry: The concept of 'measurement error' can be used both
 F is Faraday constant,

a) when there is a single reference quantity value to refer to, which occurs if a calibration is made by means of a measurement standard with a measured quantity value having a negligible measurement uncertainty or if a conventional quantity value is given, in which case the measurement error is known, and

b) if a measurand is supposed to be represented by a unique true quantity value or a set of true quantity values of negligible range, in which case the measurement error is not known.

Note 2 to entry: Measurement error should not be confused with production error or mistake.

[Source: ISO 12749-1:2020 3.4.6]

157. measurement method

generic description of a logical organisation of operations used in a measurement

Note to entry: Measurement methods may be qualified in various ways such as: substitution measurement method, differential measurement method, and null measurement method; or direct measurement method and indirect measurement method.

[Source: IEV 112-04-04]

158. milestone

designated project status that indicates the amount of progress made toward project completion, or that should be achieved before the project proceeds to a new phase

[Source: ISO 10795:2019 3.153]

159. model

approximation, representation or idealization of selected aspects of the structure, behavior, operation or other characteristics of a real-world process, concept or system; models may have other models as

1533 components
1534
1535 [Source: ISO/IEC 14776-121:2010 3.1.58]
1536
1537 Note to entry: Based with sufficient precision upon known laws, identification or specified supposi-
1538 tions, a model is used to form as basis for calculations, predictions, or further assessment and identify
1539 particular instances of the process, concept or system.

1540 **160. modification**
1541 combination of all technical and administrative actions intended to change an item
1542
1543 [Source: ISO 20815:2018 3.1.36]

1544 **161. need**
1545 prerequisite identified as necessary to achieve an intended outcome, implied or stated
1546
1547 [Source: ISO/TR 21245:2018 3.15]

1548 **162. network**
1549 arrangement of nodes and interconnecting branches
1550
1551 [Source: IEV 732-01-01]

1552 **163. nomenclature**
1553 terminology resource structured systematically according to pre-established naming rules
1554
1555 [Source: ISO 1087:2019 3.7.7]

1556 **164. nominal condition**
1557 approximate value of a characterising quantity of a device or system that provides guidance for its
1558 appropriate use

1559 **165. operation**
1560 combination of activities (switching, controlling, monitoring and maintenance) necessary to permit a
1561 device, system or installation to function

1562 **166. operational performance requirement**
1563 subset of the performance requirements of an element specifying the element functions in its operational
1564 environment
1565
1566 Note 1 to entry: The operational performance requirements are expressed through technical specifica-
1567 tions covering all engineering domains. Note 2 to entry: The full set of performance requirements of an
1568 element consists of the operational performance requirements and the performance requirements for the
1569 use of the element.
1570
1571 [Source: ISO 16290:2013 2.12]

1572 **167. performance requirement**
1573 set of parameters that are intended to be satisfied by the element
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1575 [Source: ISO 16290:2013 2.14]

1576 **168. precision**
1577 degree of exactness or discrimination with which a quantity is stated
1578
1579 [Source: ISO/IEC 14776-121:2010 3.1.74]

1580 **169. procedure**
1581 specified way to carry out an activity or a process
1582
1583 [Source: ISO 22300:2018 3.179]

1584 [Source: IEV 902-02-02]

1585

1586 Note to entry: Procedures should be documented.

1587 **170. process**

1588 set of interrelated or interacting activities that use inputs to deliver an intended result

1589

1590 Note 1 to entry: Whether the "intended result" of a process is called output, product or service depends
1591 on the context of the reference.

1592 Note 2 to entry: Inputs to a process are generally the outputs of other processes and outputs of a process
1593 are generally the inputs to other processes.

1594 Note 3 to entry: Two or more interrelated and interacting processes in series can also be referred to as
1595 a process.

1596 Note 4 to entry: Processes in an organization are generally planned and carried out under controlled
1597 conditions to add value.

1598 Note 5 to entry: A process where the conformity of the resulting output cannot be readily or econom-
1599 ically validated is frequently referred to as a "special process".

1600

1601 [Source: ISO 10795:2019 3.171]

1602 **171. qualification**

1603 demonstration of physical attributes, knowledge, skill, training and experience required to properly per-
1604 form tasks

1605

1606 [Source: ISO 9712:2012 3.23]

1607

1608 Note to entry: A qualification may be implemented by analysis, test, or inspection.

1609

1610 [Source: ISO 10795:2019 3.183]

1611 **172. quality**

1612 degree to which a set of inherent characteristics of an object fulfills requirement

1613

1614 Note 1 to entry: The term "quality" can be used with adjectives such as poor, good or excellent.

1615 Note 2 to entry: "Inherent", as opposed to "assigned", means existing in the object.

1616

1617 [Source: ISO 10795:2019 3.188]

1618 **173. quality assurance (QA)**

1619 planned and systematic actions necessary to provide adequate confidence that a process, measurement
1620 or service will satisfy given requirements for quality, for example, those specified in a licence

1621

1622 [Source: ISO 20553:2006 3.17]

1623

1624 Note to entry: It is not synonymous with quality control but meant to protect against failures of
1625 quality control.

1626 **174. quality control (QC)**

1627 operational techniques and activities that sustain the product or service quality to specified requirements

1628

1629 [Source: ISO 7348:1992 05.01.01]

1630 **175. real-time**

1631 pertaining to the processing of data by a computer in connection with another process outside the com-
1632 puter according to time requirements imposed by the outside process

1633

1634 [Source: IEV 171-05-53]

1635 **176. recommendation**

1636 expression, in the content of a document, that conveys a suggested possible choice or course of action
1637 deemed to be particularly suitable without necessarily mentioning or excluding others

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[Source: ISO/IEC Directives, Part 2 3.3.3]

177. record

retrievable information

[Source: ISO 13533:2001 3.60]

178. recyclability

ability of waste material to be processed for the original purpose or other purposes, excluding energy recovery

[Source: IEV 901-07-11]

179. recycling

recovery operation by which waste material are reprocessed into product, materials or substances whether for the original or other purposes

Note to entry: It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are used as fuels or for back filling operations.

[Source: ISO 6707-3:2017 3.4.22]

180. reference condition

set of specified values and/or ranges of values of influence quantities under which the uncertainties, or limits of error, admissible for a measuring instrument are the smallest

[Source: IEV 311-06-02]

181. reliability

ability of an item to perform a required function under given conditions for a given time interval

Note 1 to entry: It is generally assumed that the item is in a state to perform this required function at the beginning of the time interval.

Note 2 to entry: Generally, reliability performance is quantified using appropriate measures. In some applications these measures include an expression of reliability performance as a probability, which is also called reliability.

[Source: ISO 10795:2019 3.198]

Note 3 to entry: Given conditions include aspects that affect reliability, such as mode of operation, stress levels, environmental conditions, and maintenance.

182. requirement

need or expectation that is stated, generally implied or obligatory

Note 1 to entry: "Generally implied" means that it is custom or common practice for the organisation and interested parties, that the need or expectation under consideration is implied.

Note 2 to entry: A specified requirement is one that is stated, for example in documented information.

Note 3 to entry: A qualifier can be used to denote a specific type of requirement, e.g. product requirement, quality management requirement, customer requirement, quality requirement.

Note 4 to entry: Requirements can be generated by different interested parties or by the organisation itself.

Note 5 to entry: It can be necessary for achieving high customer satisfaction to fulfill an expectation of a customer even if it is neither stated nor generally implied or obligatory.

[Source: ISO 10795:2019 3.201]

183. resolution

smallest change in a quantity being measured that causes a perceptible change in the corresponding indication

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Note to entry: Resolution can depend on, for example, noise (internal or external) or friction. It may also depend on the value of a quantity being measured.

[Source: BIPM JCGM VIM 4.14]

184. risk

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

Note 1 to entry: The probability of occurrence includes the exposure to a hazardous situation, the occurrence of a hazardous event and the possibility to avoid or limit the harm.

[Source: ISO 20024:2020 3.2.14]

Note 2 to entry: Risks arise from uncertainty due to a lack of predictability or control of events.

Note 3 to entry: Risk is often characterised by reference to potential events and consequences (including changes in circumstances), or a combination of these.

185. risk assessment (RA)

overall process of risk identification, risk analysis, risk evaluation, and risk mitigation

[Source: ISO 22734:2019 3.30]

186. routine

ordered set of instructions that can have some general or frequent use

[Source: IEV 171-05-42]

187. safety

state where an acceptable level of risk is not exceeded

Note to entry: Risk relates to:

- fatality,
- injury or occupational illness,
- damage to hardware or site facilities,
- damage to an element of a system,
- the main functions of a system,
- pollution of the environment, atmosphere and
- damage to public or private property.

[Source: ISO 10795:2019 3.210]

188. societal readiness level (SRL)

way of assessing the level of societal adaptation of a particular development, infrastructure, innovation, intervention, policy, process, product, project, system, or technology for acceptance by and useful application for and within society

Note 1 to entry: When societal readiness is expected to be low (SRL 1-3), suggestions for a realistic transition towards societal adaptation (SRL 7-9) are required.

Note 2 to entry: These levels are

Level 1: **Problem and societal readiness identified**

Level 2: **Proposed solution(s) and potential impact, expected societal readiness as well as relevant stakeholders from the project identified**

Level 3: **Initial testing of proposed solution(s) jointly with relevant stakeholders]**

Level 4: **Problem validated through pilot testing in relevant environment to substantiate proposed impact and societal readiness**

- 1738 Level 5: **Proposed solution(s) validated with relevant stakeholders]**
- 1739 Level 6: **In cooperation with relevant stakeholders to gain initial feedback on potential im-**
- 1740 **pact, solution(s) in relevant environment demonstrated**
- 1741 Level 7: **Refinement of project and/or solution(s) in relevant environment with relevant**
- 1742 **stakeholders retesting as needed**
- 1743 Level 8: **Proposed solution(s) as well as a plan for societal adaptation completed and quali-**
- 1744 **fied]**
- 1745 Level 9: **actual project solution(s) in relevant environment proven.**

1746 **189. software**

1747 programs, procedures, rules and any associated documentation pertaining to the operations of a com-

1748 puter system

1749 [Source: ISO 10795:2019 3.217]

1751 **190. stakeholder**

1752 person or organisation that can affect, be affected by, or perceive itself to be affected by a decision or

1753 activity

1754 [Source: ISO 21931-2:2019 3.29]

1755 Note to entry: Decision makers can be a stakeholders.

1758 **191. standard**

1759 document, established by consensus and approved by a recognised body, that provides, for common and

1760 repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement

1761 of the optimum degree of order in a given context

1762 Note to entry: Standards should be based on the consolidated results of science, technology and exper-

1763 ience, and aimed at the promotion of optimum community benefits.

1764 [Source: IEV 901-02-02]

1767 **192. standard conditions**

1768 test or operating conditions that have been predetermined to be the basis of the test in order to have

1769 reproducible and comparable sets of test data

1770 [Source: IEV 485-22-08]

1771 Note 1 to entry: Standard conditions may be defined by specification, regulation or contract.

1772 Note 2 to entry: Not preferred alternatives are base conditions, normal conditions, rated operating

1773 conditions, reference conditions, etc.

1776 **193. standard tap water**

1777 distilled, deionised or tap water, having a conductivity between 40 mS/m and 150 mS/m achieved by

1778 adding a magnesium salt to the water, and having concentrations of iron, manganese and/or aluminium

1779 not exceeding 1 mg/l

1780 [Source: ISO 14436:2010 3.1]

1782 **194. state of the art (SoA)**

1783 developed stage of technical capability at a given time as regards products, processes and services, based

1784 on the relevant consolidated findings of science, technology and experience

1785 Note to entry: The state of the art embodies what is currently and generally accepted as good practice in

1786 technology. The state of the art does not necessarily imply the most technologically advanced solution.

1787 The state of the art described here is sometimes referred to as the "generally acknowledged state of the

1788 art".

1789 [Source: ISO/IEC Guide 63:2019 3.18]

1790

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- 1792 **195. sustainability**
1793 state of the global system, including environmental, social and economic aspects, in which the needs of
1794 the present are met without compromising the ability of future generations to meet their own needs
1795
1796 Note 1 to entry: The environmental, social and economic aspects interact, are interdependent and
1797 are often referred to as the three dimensions of sustainability.
1798 Note 2 to entry: Sustainability is the goal of sustainable development.
1799
1800 [Source: ISO Guide 82:2019 3.1]
- 1801 **196. system**
1802 series of subsystems joined together to perform a definite function
1803
1804 [Source: ISO 14952-1:2003 2.30]
- 1805 **197. system boundary**
1806 boundary between the system under assessment and the outer region, specifying which unit processes
1807 are part of a product system
1808
1809 [Source: ISO 13315-2:2014 3.6]
- 1810 **198. Système International d'Unités (SI)**
1811 system of units, based on the International System of Quantities, their names and symbols, including a
1812 series of prefixes and their names and symbols, together with rules for their use, adopted by the General
1813 Conference on Weights and Measures (CGPM)
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1815 Note 1 to entry: The SI is founded on the seven base quantities of the ISQ and the names and symbols
1816 of the corresponding base units.
1817 Note 2 to entry: The base units and the coherent derived units of the SI form a coherent set, designated
1818 the "set of coherent SI units".
1819 Note 3 to entry: For a full description and explanation of the Système International d'Unités, see the
1820 current edition of the SI brochure published by the Bureau International des Poids et Mesures (BIPM)
1821 and available on the BIPM website.
1822 Note 4 to entry: In quantity calculus, the quantity 'number of entities' is often considered to be a base
1823 quantity, with the base unit one, symbol 1.
1824
1825 [Source: ISO/IEC Guide 99:2007 1.16]
- 1826 **199. technical regulation**
1827 regulation that provides technical requirements, either directly or by referring to or incorporating the
1828 content of a standard, Technical Specification or code of practice
1829
1830 Note to entry: A technical regulation may be supplemented by technical guidance that outlines some
1831 means of compliance with the requirements of the regulation, i. e. deemed-to-satisfy provision.
1832
1833 [Source: IEV 901-02-11]
- 1834 **200. technical specification**
1835 specification expressing technical requirements for designing and developing the solution to be imple-
1836 mented
1837
1838 Note to entry: The Technical Specification evolves from the functional specification and defines the
1839 technical requirements for the selected solution as part of a business agreement.
1840
1841 [Source: ISO 10795:2019 3.238]
- 1842 **201. technology readiness level (TRL)**
1843 method for estimating through assessment of the maturity of an evolving technology prior to using this
1844 technology in a product or system according to an integer scale from 1 (basic) to 9 (most mature:
1845 system proven and market ready)

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Note to entry: can be categories as follows:

Level 1: **Basic scientific research - basic principles observed and reported** Scientific research begins to be translated into applied research and development which may include fundamental investigations and desktop (paper) studies.

Level 2: **Applied research - technology concept and/or applications formulated** Once basic principles are observed, practical applications can be formulated which may include analytic studies and experimentation.

Level 3: **Critical function, proof of concept established** Active research and development is initiated. Laboratory studies aim to validate analytic predictions of separate components of the technology which may include components that are not yet integrated or representative.

Level 4: **Laboratory testing of prototype component or process** Design, development and laboratory testing of technological components are performed, basic technological components are integrated to establish that they will work together which represents a relatively low fidelity prototype in comparison to the eventual system.

Level 5: **Laboratory testing of integrated system** The basic technological components are integrated together with realistic supporting elements to be tested in a simulated environment which is a high fidelity prototype compared to the eventual system.

Level 6: **Prototype system verified** The prototype is tested in a relevant environment and the system or process demonstration is carried out in an operational environment.

Level 7: **Integrated pilot system demonstrated** The prototype is near, or at, planned operational system level with final design completed aiming at removing engineering and manufacturing risks.

Level 8: **System incorporated in commercial design** The technology is proven to work in its final form under the expected conditions representing in most of the cases end of system development.

Level 9: **System ready for full scale deployment** The technology in its final form is ready for commercial deployment.

Level beyond 9: **Market introduction** The product, process or service is launched commercially, marketed to and adopted by customers.

202. term

designation of a defined concept in a special language by a linguistic expression

Note to entry: A term may consist of one or more words (simple term or complex term) or even contain symbols.

[Source: ISO/IEC 15944-12:2020 3.138]

203. terminology

set of designations and concepts belonging to one domain or subject

[Source: ISO 1087:2019 3.1.11]

204. test method

specified technical procedure for performing a test

[Source: ISO/IEC Guide 2:2004]

205. thermodynamic temperature

temperature measured on the absolute scale which is based on absolute zero ($-273,15\text{ }^{\circ}\text{C}$) and having an interval of measurement that is equivalent to degrees Celsius

[Source: ISO 18924:2013 2.6]

Note 2 to entry: The coherent SI unit of thermodynamic temperature is kelvin, K.

- 1896 **206. useful life**
- 1897 time interval, from first use until user requirements are no longer met, due to economics of operation
1898 and maintenance, or obsolescence
1899
- 1900 Note to entry: In this context, "first use" excludes testing activities prior to hand-over of the item
1901 to the end-user.
1902
- 1903 [Source: IEV 192-02-27]
- 1904 **207. validation**
- 1905 confirmation, through the provision of objective evidence, that the requirements for a specific intended
1906 use or application have been fulfilled
1907
- 1908 Note 1 to entry: The term "validated" is used to designate the corresponding status.
1909 Note 2 to entry: The use conditions for validation can be real or simulated.
1910 Note 3 to entry: In design and development, validation concerns the process of examining an item to
1911 determine conformity with user needs.
1912 Note 4 to entry: Validation is normally performed during the final stage of development, under defined
1913 operating conditions, although it may also be performed in earlier stages.
1914 Note 5 to entry: Multiple validations may be carried out if there are different intended uses.
1915 [Source: IEV 192-01-18]
- 1916 **208. verification**
- 1917 provision of objective evidence that a given item fulfils specified requirements
1918
- 1919 [Source: ISO/TS 20460:2015 3.14]
1920
- 1921 Note to entry: Verification does not establish traceability. It should not be confused with calibra-
1922 tion. Not every verification is a validation. When applicable, measurement uncertainty should be taken
1923 into consideration. The activities carried out for verification are sometimes called a qualification process.
- 1924 **209. vocabulary**
- 1925 representation of a concept by a descriptive statement which serves to differentiate it from related con-
1926 cepts
1927
- 1928 [Source: ISO/IEC 15944-12:2020 3.144]
1929
- 1930 Note to entry: It is a terminological dictionary containing designations and definitions from one or
1931 more specific subject areas/fields/domains. A vocabulary may also be bi- or multilingual.
- 1932 **2.1.2 Electrical & electrochemical**
- 1933 **210. activation polarisation**
- 1934 part of the electrode polarisation arising from a charge-transfer step of the electrode reaction
1935
- 1936 [Source: IEV 482-03-05]
- 1937 **211. alternating current (AC)**
- 1938 electric current that is a periodic function of time with a zero direct component or, by extension, a
1939 negligible direct component
1940
- 1941 [Source: IEV 131-11-24]
- 1942 **212. anion**
- 1943 negatively charged ion
- 1944 **213. anode**
- 1945 by convention, cell electrode at which an oxidation reaction occurs
1946
- 1947 [Source: IEV 482-02-27]

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Note 1 to entry: At an anode, electrons are produced in a galvanic cell or extracted in an electrolytic cell.

Note 2 to entry: The concepts of “anode” and “cathode” are related only to the direction of electron flow, not to the polarity of the electrodes.

[Source: IUPAC Recommendations 2019 3.1]

214. anodic polarisation

electrode polarisation associated with an electrochemical oxidation reaction

[Source: IEV 482-03-06]

215. anodic reaction

electrode reaction involving an electrochemical oxidation

[Source: IEV 482-03-11]

216. bipolar electrode

electrode that is not directly connected to the power supply but is so placed in the solution between the anode and the cathode that the part nearest to the anode becomes cathodic and the part nearest to the cathode becomes anodic

[Source: ISO 2080:2008 3.23]

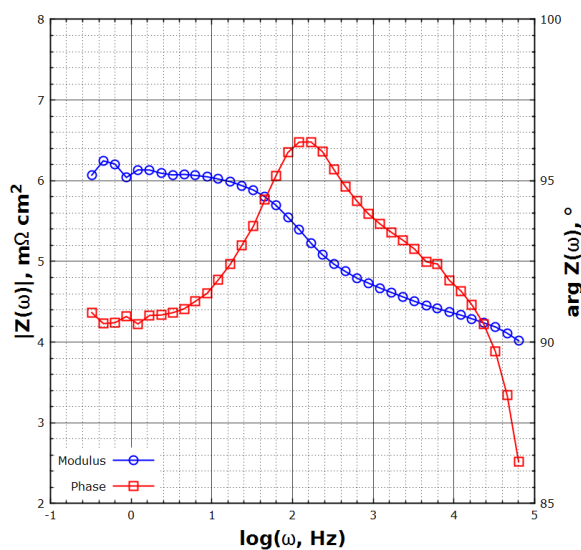
217. Bode plot

diagram showing the immittance, $I(\omega)$ (i. e. impedance, $Z(\omega)$) by plotting the absolute value (magnitude), real part and/or imaginary part of immittance and the phase (argument) of immittance on the ordinate (in logarithmic scale) as a function of (angular) frequency f ($\omega = 2\pi f$) on the abscissa (in logarithmic scale)

Note 1 to entry: For the phase the principal value may be taken. Instead of phase, either the loss tangent (dissipation factor), which is the tangent of the phase, or the quality factor, being the inverse of the loss tangent, may be displayed.

Note 2 to entry: Bode plot is named after the US engineer and scientist Hendrik Wade Bode (1905-1982).

Figure 1: Schematic Bode plot (see Figure 3 for the corresponding Nyquist plot)



218. capacitor

two-terminal device characterized essentially by its capacitance

[Source: IEV 151-13-28]

- 1985 **219. cathode**
 1986 by convention, cell electrode at which, a reduction reaction occurs
 1987
 1988 [Source: IEV 482-02-28]
 1989
 1990 Note to entry: The concepts of “anode” and “cathode” are related only to the direction of electron flow,
 1991 not to the polarity of the electrodes.
 1992
 1993 [Source: IUPAC Recommendations 2019 3.4]
- 1994 **220. cathodic polarisation**
 1995 electrode polarisation associated with an electrochemical reduction reaction
 1996
 1997 [Source: IEV 482-03-07]
- 1998 **221. cathodic reaction**
 1999 electrode reaction involving an electrochemical reduction
 2000
 2001 [Source: IEV 482-03-12]
- 2002 **222. cation**
 2003 positively charged ion
- 2004 **223. charge carrier**
 2005 particle such as an electron, proton, ion, or, by extension, entity with particle-like characteristics, such
 2006 as a hole, having non-zero electric charge
 2007
 2008 Note to entry: The electric charge of a charge carrier is always an integral multiple, positive or negative,
 2009 of the elementary electric charge.
 2010
 2011 [Source: IEV 113-06-25]
- 2012 **224. charge transfer**
 2013 transfer of charge from an atom, molecule or ion to another atom, molecule or ion
 2014
 2015 [Source: ISO 18115-1:2013 4.100]
 2016
 2017 Note 1 to entry: Charge transfer can be electronic or ionic in nature.
 2018 Note 2 to entry: Charge transfer involving the same (different) chemical species is symmetric (asym-
 2019 metric).
- 2020 **225. circuit element**
 2021 basic constituent part of a circuit, exclusive of interconnections
 2022
 2023 [Source: ISO/IEC 14776-121:2010 3.1.16]
- 2024 **226. concentration polarisation**
 2025 part of the electrode polarisation arising from concentration gradients of electrode reactants and products
 2026
 2027 [Source: IEV 482-03-08]
 2028
 2029 Note to entry: Concentration polarisation is more important at high current densities and can result
 2030 in a sharp decrease in the cell voltage.
- 2031 **227. constant phase element (CPE)**
 2032 equivalent circuit component that models the behaviour of an imperfect capacitor representing a con-
 2033 stant phase shift through the whole frequency range
 2034
 2035 Note 1 to entry: A capacitor has a phase shift of -90° ; for a constant phase element, the abso-
 2036 lute value is smaller.
 2037
 2038 [Source: ISO/TR 16208:2014 3.2]

- 2039 **228. counter electrode**
2040 electrode commonly used in applied polarisation to balance the current passing to the working working
2041 electrode
2042
2043 Note to entry: It is usually made from a non-corroding material.
2044
2045 [Source: ISO 8044:2020 7.1.39]
- 2046 **229. Debye length**
2047 characteristic length of the electric double layer in an electrolyte solution
2048
2049 [Source: ISO 13099-3:2014 3.1.2]
2050
2051 Note to entry: The coherent SI unit of Debye length is meter, m.
- 2052 **230. Debye-Hückel approximation**
2053 model assuming small electric potentials in the electric double layer
2054
2055 [Source: ISO 13099-3:2014 3.1.1]
2056
2057 Note to entry: This model is named after Dutch chemist and physicist Petrus Josephus Wilhelmus
2058 Debije (1884-1966) who won in 1936 the Nobel Prize in Chemistry and German chemist and physicist
2059 Erich Armand Arthur Joseph Hückel (1896-1980).
- 2060 **231. direct current (DC)**
2061 electric current that is time-independent or, by extension, periodic current the direct component of which
2062 is of primary importance
2063
2064 [Source: IEV 131-11-22]
- 2065 **232. electric circuit**
2066 circuit consisting of electric circuit elements only
2067
2068 [Source: IEV 131-11-07]
- 2069 **233. electric circuit element**
2070 circuit element for which only relations between electric integral quantities are considered
2071
2072 [Source: IEV 131-11-04]
- 2073 **234. electric circuit model**
2074 representation of an electric or magnetic device by means of a circuit composed of ideal elements
2075
2076 [Source: IEV 131-15-06]
- 2077 **235. electric double layer (EDL)**
2078 model representing the structure of an electrolyte at an electrode-electrolyte interface by a rigid layer
2079 formed by the charge carriers on the surface of the electrode and a diffuse layer formed by mobile ions
2080 in the electrolyte
2081
2082 [Source: IEV 114-02-19]
2083
2084 Note to entry: Complex interfacial profiles that can be approximated by two distinct sub-layers with
2085 different physical properties (e. g. structure and/or nature and/or composition), are referred to as in-
2086 terfacial double-layers. Examples of such approximated complex profiles are: the electric double layer
2087 consisting of a surface charge layer (i. e. a two dimensional distribution of one type of ions) and a diffuse
2088 charge layer (counter-ions distributed over the space region next to the surface); the approximated profile
2089 of the orientation angle of anisotropic liquid molecules within a 'double-layer' consisting of a distribution
2090 of so-called anchored molecules which are perturbed (strongly bound and orientated) by the surface,
2091 and the adjacent, so-called, transition layer, i. e. the region where the surface perturbation is damped.
2092
2093 [Source: IUPAC Gold Book I03084]

- 2094 **236. electricity**
 2095 set of the phenomena associated with electric charges and electric currents
 2096
 2097 [Source: IEV 121-11-76]
- 2098 **237. electro-migration**
 2099 transport of ions in an electrolyte due to an electric field
 2100
 2101 [Source: IEV 113-04-06]
- 2102 **238. electrocatalysis**
 2103 increasing the rate of an electrode reaction by adding specific material to the electrode
 2104
 2105 [Source: IEV 113-04-15]
- 2106 **239. electrochemical cell (EC)**
 2107 system consisting of at least two electrodes in an electrolyte
 2108
 2109 [Source: ISO 16773-1:2016 2.15]
- 2110 **240. electrochemical reaction**
 2111 chemical reaction involving oxidation or reduction of chemical components with a transfer of electrons
 2112 to or from the active material
 2113
 2114 Note to entry: The electrochemical reaction can also involve other chemical reactions including subre-
 2115 actions on a cell electrode.
 2116
 2117 [Source: IEV 482-03-01]
- 2118 **241. electrode**
 2119 conductive part in electric contact with a medium of lower conductivity and intended to perform one or
 2120 more of the functions of emitting charge carriers to or receiving charge carriers from that medium or to
 2121 establish an electric field in that medium
 2122
 2123 [Source: IEV 114-02-03]
 2124
 2125 Note to entry: An electrode is either a positive electrode or a negative electrode.
 2126
 2127 [Source: IEC 62282-8-102:2019 3.1.8]
- 2128 **242. electrode polarisation**
 2129 accumulation or depletion of electric charges at an electrode, resulting in a difference between the elec-
 2130 trode potential with current flow, and the potential without current flow or equilibrium electrode potential
 2131
 2132 [Source: IEV 114-02-15]
- 2133 **243. electrode reaction**
 2134 electrochemical reaction involving the transfer of electrons between electrolyte and electrode
 2135
 2136 [Source: IEV 114-02-04]
- 2137 **244. electrolyser**
 2138 electrochemical device that converts water/steam and/or CO₂ to hydrogen and oxygen by electrolysis
 2139 reaction
 2140
 2141 Note to entry: These devices include AWE device, PEMEL device, SOEC device, and other devices
 2142 of similar type.
- 2143 **245. electrolysis**
 2144 use of direct current to drive an otherwise non-spontaneous (endergonic) electrochemical reaction
 2145

2146 Note to entry: Besides water electrolysis for the production of hydrogen and oxygen, electrolysis has
2147 other applications most notably in chlor-alkali electrolysis to produce chlorine for use in chemical in-
2148 dustry and hydrogen as by-product, photoelectrolysis using directly solar energy to produce hydrogen
2149 and oxygen, carbon dioxide capture by electrolytic carbonate formation, waste water treatment (i.e.
2150 electro-chlorination), and molten (fused) salt electrolysis used in (hydro-)metallurgical industry to pro-
2151 duce (recover) metals.

2152 **246. electrolyte**

2153 liquid or solid substance containing mobile ions which render it ionically conductive

2154

2155 Note to entry: The electrolyte may be liquid, solid or a gel.

2156

2157 [Source: IEV 482-02-29]

2158 **247. electrolytic cell**

2159 electrochemical cell intended to produce chemical reactions

2160

2161 [Source: IEV 114-03-06]

2162 **248. electron**

2163 stable elementary particle having an electric charge of $\pm 1.60219 \times 10^{-19}$ C and a rest mass of 9.1095
2164 $\times 10^{-31}$ kg

2165

2166 [Source: IEV 881-02-57]

2167

2168 Note 1 to entry: Electrons are constituents of all atomic orbits.

2169 Note 2 to entry: Protons have charge number -1.

2170 **249. electron hole**

2171 vacancy appearing in an almost filled energy band, behaving like a carrier of one positive elementary
2172 charge

2173

2174 [Source: IEV 113-06-23]

2175

2176 Note to entry: An electron hole due to an electron is also known as a defect electron, an imagin-
2177 ary particle of positive charge which fills all those levels in the valence band that are not occupied by
2178 electrons. In this sense, an electron can be viewed as a defectproton or proton hole.

2179 Note 2 to entry: The term hole (German: "Loch") was introduced by Swiss physicist Gregory Hugh
2180 Wannier (1911-1983).

2181 **250. endothermic reaction**

2182 chemical or electrochemical reaction requiring energy, usually in the form of heat, to be absorbed from
2183 the surroundings (environment)

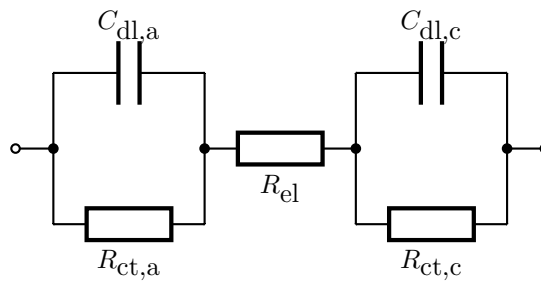
2184 **251. equivalent electric circuit (EEC)**

2185 model of a device or system to capture the equivalence to an electric circuit when simulating its beha-
2186 viour under the flow of an electric current

2187

2188 Note to entry: This could be a network, consisting of elements such as a resistor, a capacitor and
2189 an inductor, which has the same impedance spectrum (i. e. the same response to a perturbation) as the
2190 electrochemical system under test.

Figure 2: Example of an EEC model of an electrochemical cell (EC) (anode, electrolyte and cathode)



2191

$$Z(\omega) = R_{ct,a} \frac{1 - i\omega\tau_a}{1 - (\omega\tau_a)^2} + R_{el} + R_{ct,c} \frac{1 - i\omega\tau_c}{1 - (\omega\tau_c)^2}$$

where

Z is impedance,

i is imaginary unit with property $(\pm i)^2 = -1$,

ω is angular frequency,

R_{el} is electrolyte electrical resistance,

$R_{ct,a}$ & $R_{ct,c}$ is charge transfer electrical resistance of respectively anode and cathode,

$C_{dl,a}$ & $C_{dl,c}$ is electric double layer (EDL) capacitance of respectively anode and cathode, and

$\tau_a = R_{ct,a} \cdot C_{dl,a}$ & $\tau_c = R_{ct,c} \cdot C_{dl,c}$ is time constant related to respectively anode and cathode.

2192 **252. exothermic reaction**

2193 chemical or electrochemical reaction where energy, usually in the form of heat, is released

2194 **253. Faraday's laws of electrolysis**

2195 two laws stating that the amount of substance (number of moles, n) produced at/extracted from each
 2196 electrode is directly proportional to the quantity of electric charge (constant current, I times electrolysis
 2197 time, t) which has flown through the cell during electrolysis

2198
$$n = \frac{I \cdot t}{F \cdot \sum_i \frac{z_i m_i}{M_i}}$$

F is Faraday constant,

m_i is mass fraction of species i produced at/extracted from an electrode,

2199 where

z_i is valence of that species i , and

M_i is molar mass of that species i .

2200

2201

2202

Note to entry: These laws are named after English scientist Michael Faraday (1791-1867).

2203 **254. galvanic cell**

2204 combination of different electrodes connected in series with an electrolyte

2205

2206

Note to entry: The galvanic cell is an electrochemical source of electrical current and will produce
 2207 a current when the electrodes are connected by an external electronic conductor.

2208

2209

[Source: ISO 8044:2020 7.1.12]

2210 **255. Gouy-Chapman-Stern model**

2211 model describing the electric double layer

2212

2213 [Source: ISO 13099-3:2014 3.1.9]
2214
2215 Note to entry: This model is named after French physicist Louis Georges Gouy (1854-1926), Eng-
2216 lish chemist David Leonard Chapman (1869-1958) and German physicist Otto Stern (1888-1969) who
2217 won in 1943 the Nobel Prize in Physics.

2218 **256. half cell**

2219 theoretical single oxidation or reduction half reaction occurring on an electrode

2220

2221 Note to entry: Two half cells connected form an electrochemical cell.

2222

2223 [Source: ISO 8044:2020 7.1.40]

2224 **257. high-pressure electrolyser (HPE)**

2225 WE operating at higher than atmospheric pressure

2226 **258. hydrogen electrode**

2227 platinised platinum electrode saturated by a stream of pure gaseous hydrogen

2228

2229 Note to entry: A platinized platinum electrode consists of a platinum rod covered by compact plat-
2230 inum powder called platinum black.

2231

2232 [Source: IEV 113-03-16]

2233 **259. inductor**

2234 two-terminal device characterised essentially by its inductance

2235

2236 [Source: IEV 151-13-25]

2237 **260. inner Helmholtz plane (IHP)**

2238 locus of the electrical centres of specifically adsorbed ions

2239

2240 [Source: IUPAC Gold Book I03048]

2241

2242 Note to entry: This layer and the outer Helmholtz plane (OHP) are named after German physicist
2243 Hermann Ludwig Ferdinand von Helmholtz (1821-1894).

2244 **261. ion**

2245 atom or molecule with acquired unbalanced electric charge due to valence electron gain or loss

2246 **262. lattice interstitial**

2247 defect where atoms assume a normally unoccupied site in a lattice

2248 **263. lattice vacancy**

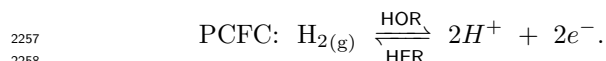
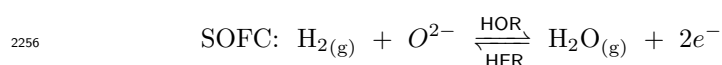
2249 defect due to one or more missing atoms in a normally occupied site of a lattice

2250 **264. negative electrode**

2251 electrode at which fuel (hydrogen) gas is consumed (FC mode) or produced (electrolysis mode)

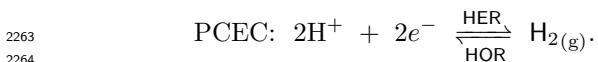
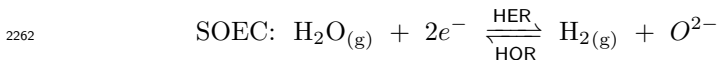
2252

2253 Note 1 to entry: A negative electrode may also be called fuel (hydrogen) electrode or negatrode.
2254 In FC mode, it is called anode, where fuel (hydrogen) is oxidised producing water (steam) in a solid
2255 oxide fuel cell and protons in a proton conducting ceramic fuel cell. The electrode reactions are



2259 In electrolysis mode, it is called cathode, where hydrogen is produced by reducing water (steam) in a
2260 solid oxide electrolysis cell and protons in a proton conducting ceramic electrolysis cell. The electrode

2261 reactions are



2265 Note 2 to entry: The negative electrode gas is usually hydrogen or a mixture which contains hydrogen
2266 as a principal component mixed with water (steam) and/or inert gas.

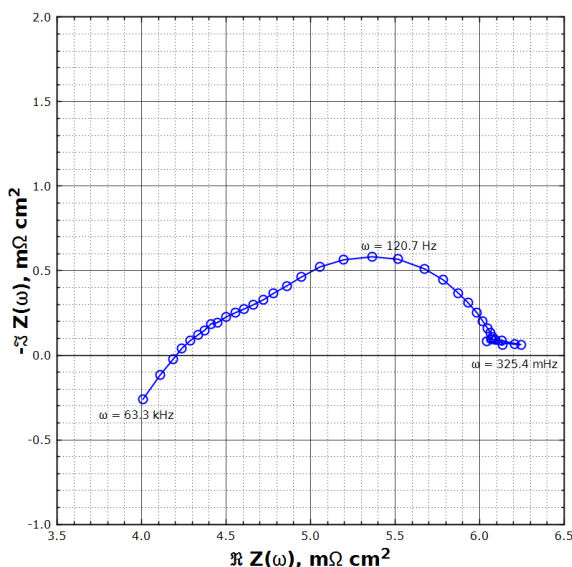
2267 **265. Nyquist plot**

2268 diagram showing the immittance, $I(\omega)$ (i.e. impedance, $Z(\omega)$) over a range of measured frequencies
2269 by plotting the imaginary part of the (conjugate) immittance on the ordinate as a function of the real
2270 part of the immittance on the abscissa

2271
2272 Note 1 to entry: Nyquist plots should be plotted in same scale on ordinate and abscissa as to properly
2273 identify "depressed semi-arcs".

2274 Note 2 to entry: Nyquist plot is named after the US engineer Harry Nyquist (1889-1976).

Figure 3: Schematic Nyquist plot (see Figure 1 for the corresponding Bode plot)



2275
2276 **266. ohmic overvoltage**

2277 overvoltage arising from the flow of electric current through the ohmic electrical resistance of the cell
2278 components

2279
2280 Note to entry: The term "ohmic" refers to the fact that following Ohm's law,¹³ the overvoltage is
2281 proportional to the flow of the electric current with the ohmic electrical resistance as the proportionality
2282 constant.

2283 **267. outer Helmholtz plane (OHP)**

2284 electrified interface, the locus of the electrical centres of non-specifically adsorbed ions in their position
2285 of closest approach

2286
2287 [Source: IUPAC Gold Book O04350]

2288 **268. photoelectrolysis**

2289 photo-electrochemical process which uses optical (light) radiation as source of energy to generate a
2290 photo-current to eventually split, for example, water into hydrogen and oxygen by electrolysis

2291 **269. photoelectrolytic cell (PEC)**

2292 cell in which radiant energy causes a net chemical conversion in the cell, e. g. so as to produce hydrogen
2293 as a useful fuel

¹³This law is named after German physicist and mathematician Georg Simon Ohm (1789-1854).

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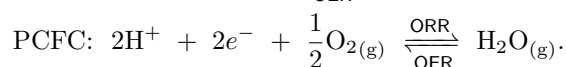
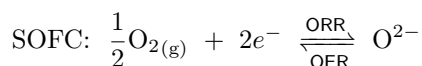
Note to entry: These cells can be classified as photosynthetic or photocatalytic. In the former case, radiant energy provides a Gibbs free energy to drive a reaction such as $\text{H}_2\text{O} \rightarrow \text{H}_2 + 0.5 \text{O}_2$, and electrical or thermal energy may be later recovered by allowing the reverse, spontaneous reaction to proceed. In a photocatalytic cell the photon absorption promotes a reaction with $\Delta G < 0$ so there is no net storage of chemical energy, but the radiant energy speeds up a slow reaction.

[Source: IUPAC P04608]

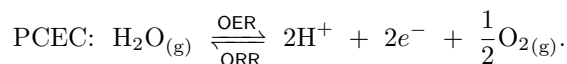
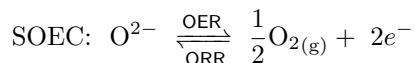
270. positive electrode

electrode at which oxidant (oxygen) is consumed (FC mode) or produced (electrolysis mode)

Note 1 to entry: A positive electrode may also be called oxygen electrode or positrode. In FC mode, it is called cathode, where oxygen is reduced forming oxide ions in a solid oxide fuel cell and producing water (steam) in a proton conducting ceramic fuel cell. The electrode reactions are



In electrolysis mode, it is called the anode, where oxygen is formed by oxidising oxide ions in a solid oxide electrolysis cell and water (steam) in a proton conducting ceramic electrolysis cell. The electrode reactions are



Note 2 to entry: The positive electrode gas is usually air or a mixture which contains air as a principal component mixed with water (steam) and/or inert gas.

271. reaction

chemical change in which a substance decomposes, combines with other substances, or interchanges constituents with other substances

[Source: ISO 14624-6:2006 3.7]

272. reaction polarisation

part of the electrode polarisation arising from a chemical reaction impeding the electrode reaction

[Source: IEV 482-03-10]

273. reference electrode

electrode having a stable and reproducible potential that is used as a reference in the measurement of electrode potentials

Note 1 to entry: This electrode has to have a potential which is thermodynamically stable with respect to that of the standard hydrogen electrode (SHE).

[Source: ISO 16773-1:2016 2.39]

Note 2 to entry: Some reference electrodes use the electrolyte in which the measurement is carried out. Their potential varies according to the composition of this electrolyte.

[Source: ISO 12473:2017 3.23]

274. resistivity

inverse of the conductivity when this inverse exists

[Source: IEV 121-12-04]

Note to entry: The coherent SI unit of resistivity is ohm meter, $\Omega \text{ m}$.

2347 **275. resistor**

2348 two-terminal device characterised essentially by its electrical resistance

2349

2350 [Source: IEC 151-13-19]

2351 **276. reversible mode**

2352 operation mode of a cell or a stack which alternates between fuel cell mode and electrolysis mode, also
2353 known as regenerative mode

2354

2355 Note to entry: In this context, the term "reversible" does not refer to the thermodynamic principle
2356 of an ideal process. It includes evacuation of reactants and/or products from and purging of electrode
2357 compartments as necessary before switching to either mode.

2358 **277. Tafel equation**

2359 equation in electrochemical kinetics relating the rate of an electrochemical reaction to the overvoltage

2360
$$\eta = \pm A \cdot \log_{10} \frac{i}{i_0}$$

η is overvoltage,

\log_{10} is logarithm to base 10 (decade),

2361 where A is Tafel slope for an anodic reaction (+) or a cathodic reaction (-),

i is current density, and

2362

i_0 is exchange current density.

2363

2364 Note to entry: This equation is named after Swiss chemist Julius Tafel (1892-1918).

2365 **278. Tafel slope**

2366 slope of the straight-line portion of an electrochemical current density/potential curve [plotted in terms
2367 of logarithm of the current density versus overvoltage] corresponding to an activation-controlled reaction

2368

2369 [Source: ISO 8044:2020 7.1.42]

2370

2371 Note 1 to entry: The unit of Tafel slope is volt per decade, V dec⁻¹.

2372 Note 2 to entry: This slope is named after Swiss chemist Julius Tafel (1892-1918).

2373 **279. transmission line (TL)**

2374 structure designed to guide the propagation of electromagnetic energy in a well-defined direction

2375

2376 [Source: ISO/IEC 14776-121:2010 3.1.96]

2377 **280. working electrode**

2378 test electrode in an electrochemical cell, designed for electrochemical tests

2379

2380 [Source: ISO 8044:2020 7.1.45]

2381 **2.1.3 Components, materials & substances**

2382 **281. agglomerate**

2383 collection of weakly bound particles or aggregates or mixtures of the two where the resulting external
2384 surface area is similar to the sum of the surface areas of the individual components

2385

2386 Note 1 to entry: The forces holding an agglomerate together are weak forces, for example, van der
2387 Waals forces, or simple physical entanglement.

2388 Note 2 to entry: Agglomerates are also termed secondary particles and the original source particles are
2389 termed primary particles.

2390

2391 [Source: ISO/TS 80004-6:2013 2.10]

- 2392 **282. amorphous**
2393 solid structure where its ions, molecules, or atoms are oriented randomly, lacking any order
2394
2395 [Source: ISO/TS 20477:2017 3.2.2]
- 2396 **283. assembly**
2397 combination of parts, components and units which forms a functional entity
2398
2399 [Source: ISO 10786:2011 3.5]
2400 [Source: ISO 10795:2019 3.23]
- 2401 **284. austenitic steel**
2402 steel in which the structure consists of austenite at ambient temperature
2403
2404 Note 1 to entry: Cast austenitic steels can contain up to about 20 % of ferrite.
2405 Note 2 to entry: Austenite (γ -iron or γ -Fe) has a face centred cubic crystal structure.
- 2406 **285. binder**
2407 material serving to coat the particles of an aggregate and to assure its cohesion
2408
2409 [Source: ISO 1998-1:1998 1.40.250]
- 2410 **286. by-pass**
2411 passage conveying fluid from the upstream side to the downstream side of a pipework component so as
2412 to be independent of the action of the pipework component
2413
2414 [Source: ISO 13574:2015 2.26]
- 2415 **287. by-product**
2416 co-product from a process that is incidental or not intentionally produced and which cannot be avoided
2417
2418 Note to entry: Wastes are not by-products.
2419
2420 [Source: ISO 6707-3:2017 3.3.1]
- 2421 **288. catalyst**
2422 substance that increases the rate of a reaction without being consumed itself
2423
2424 Note to entry: The catalyst lowers the activation energy of the reaction, allowing for an increase in
2425 the reaction rate, or allowing it to proceed at a lower temperature or overpotential. A catalyst that
2426 promotes an electrochemical reaction is termed an 'electro-catalyst'.
2427
2428 [Source: JRC EUR 29300 EN report 3.3.2]
- 2429 **289. cell**
2430 basic functional unit, consisting of an assembly of electrodes, electrolyte, terminals and usually separa-
2431 tors, that is a sink or source of electrical energy
- 2432 **290. check valve**
2433 valve that operates on differential pressure and allows flow in one direction only
2434
2435 [Source: ISO/TR 15916:2015 3.13]
- 2436 **291. circuit**
2437 interconnection of electrical components
2438
2439 [Source: ISO/IEC 14776-121:2010 3.1.15]

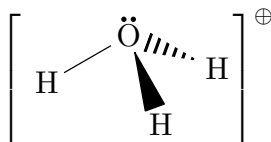
- 2440 **292. co-product**
2441 any of one or more products from the same unit process, but which is not the object of the assessment
2442
2443 Note to entry: Co-product and product have the same status and are used for identification of several
2444 distinguishable flows of products from the same unit process. Where one of two or more co-products
2445 is the object of assessment of the environmental product declaration, this is normally considered the
2446 product, and the other output(s) the co-product(s). Where one of the co-products is an input to a
2447 process, this is normally considered as a product input. From co-product and product, waste is the only
2448 output to be distinguished as a non-product.
2449
2450 [Source: ISO 6707-3:2017 3.3.2]
- 2451 **293. component**
2452 set of materials, assembled according to defined and controlled processes, which cannot be disassembled
2453 without destroying its capability and which performs a simple function that can be evaluated against
2454 expected performance requirements
2455
2456 [Source: ISO 10795:2019 3.48]
- 2457 **294. composite**
2458 multicomponent material comprising multiple, different (non-gaseous) phase domains in which at least
2459 one type of phase domain is a continuous phase
2460
2461 Note to entry: A foamed substance, which is a multiphase material that consists of a gas dispersed
2462 in a liquid or solid, is not normally considered to be a composite.
2463
2464 [Source: IUPAC Purple Book Chapter 11 4.1.6]
- 2465 **295. condensate drain**
2466 pipe designed to collect and drain condensates from a low point in the gas circuit
2467
2468 [Source: ISO 13574:2015 2.40]
- 2469 **296. conductor**
2470 conductive part intended to carry a specified electric current
2471
2472 [Source: IEV 195-01-07]
2473 [Source: IEV 826-14-06]
- 2474 **297. constituent**
2475 substance present within a specified substance or a parent substance
2476
2477 [Source: ISO 11238:2018 3.17]
- 2478 **298. contaminant**
2479 foreign substance or material in a liquid, gas or solid, which usually has deleterious effect on one or more
2480 properties
- 2481 **299. coolant**
2482 medium, liquid or gas, by means of which heat is transferred
2483
2484 [Source: IEV 411-44-02]
- 2485 **300. corrosion effect**
2486 change in any part of the corrosion system caused by corrosion
2487
2488 [Source: ISO 8044:2020 3.5]
- 2489 **301. corrosion product**
2490 substance formed as a result of corrosion
2491
2492 [Source: ISO 8044:2020 3.8]

2493	302. corrosion rate
2494	corrosion effect on a metal per unit time
2495	
2496	Note to entry: The unit used to express the corrosion rate depends on the technical system and on
2497	the type of corrosion effect. Thus, corrosion rate is typically expressed as an increase in corrosion depth
2498	per unit time, or the mass of metal turned into corrosion products per area of surface and per unit time,
2499	etc. The corrosion effect may vary with time and may not be the same at all points of the corroding
2500	surface. Therefore, reports of corrosion rates are typically accompanied by information on the type, time
2501	dependency and location of the corrosion effect.
2502	
2503	[Source: ISO 8044:2020 3.12]
2504	303. corrosion system
2505	system consisting of one or more metals and those parts of the environment that influence corrosion
2506	
2507	Note to entry: Parts of the environment may be, for example, coatings, surface layers or additional
2508	electrodes.
2509	
2510	[Source: ISO 8044:2020 3.4]
2511	304. crystalline
2512	solid structure where its ions, molecules, or atoms are in an ordered, three dimensional arrangement
2513	
2514	[Source: ISO/TS 20477:2017 3.2.1]
2515	305. current collector
2516	electronically conductive material in a cell/stack assembly unit that collects/conducts electrons from/to
2517	the electrodes
2518	
2519	[Source: IEC 62282-8-101:2020 3.1.10]
2520	306. current connector
2521	conductor of electricity used for carrying current between components in an electric circuit
2522	
2523	[Source: IEC 482-02-37]
2524	307. de-mineralised water
2525	water of which the mineral matter or salts have been removed
2526	
2527	[Source: ISO/TR 27912:2016 3.24]
2528	308. detector
2529	device or substance that indicates the presence of a phenomenon, body, or substance when a threshold
2530	value of an associated quantity is exceeded
2531	
2532	Examples: Halogen leak detector, litmus paper.
2533	
2534	Note 1 to entry: In some fields, the term "detector" is used for the concept of sensor.
2535	Note 2 to entry: In chemistry, the term "indicator" is frequently used for this concept.
2536	
2537	[Source: BIPM JCGM VIM 3.9]
2538	309. deuterium
2539	isotope of hydrogen having a nucleus containing one neutron and one proton
2540	
2541	[Source: ISO/TR 15916:2015 3.84]
2542	
2543	Note to entry: The cation ${}^2\text{H}^+$ is a deuteron, the species ${}^2\text{H}^-$ is a deuteride anion, and ${}^2\text{H}$ is the
2544	deuterio group.
2545	
2546	[Source: IUPAC Gold Book D01648]

- 2547 **310. diffusion layer**
2548 electrolyte layer at the electrode surface with a different concentration of a given species than that in
2549 the bulk of the solution
2550
2551 [Source: ISO 8044:2020 7.2.11]
- 2552 **311. electrochemical separator**
2553 in an electrochemical cell, device made of insulating material permeable to the ions of the electrolyte
2554 and prohibiting totally or partially the mixing of the substances on both sides
2555
2556 Note to entry: Membranes and diaphragms are special forms of electrochemical separators.
2557
2558 [Source: IEC 60076-3:2013 3.1.1]
- 2559 **312. end plate**
2560 component located on either end of the electrolysis cell or stack to transmit the required compression
2561 to the stacked cells to allow proper electrical contact and to avoid fluid leaks
2562
2563 Note to entry: The end plate may comprise ports, ducts or manifolds for the conveyance of fluids
2564 (reactants, coolant, cable wiring) to/from the cell or stack.
2565
2566 [Source: JRC EUR 29300 EN report 3.3.8]
- 2567 **313. equipment**
2568 machine or group of machines including all machine or process control components
2569
2570 [Source: ISO 17359:2018 3.1]
- 2571 **314. ferritic steel**
2572 steel in which the structure consists of ferrite at ambient temperature
2573
2574 Note to entry: Ferrite (α -iron or α -Fe) has a body centred cubic crystal structure with maximum carbon
2575 solubility of 0.001 wt-% at 0 °C and 0.02 wt-% at 727 °C (eutectic temperature).
- 2576 **315. flow meter**
2577 device that directly measures and indicates the flow rate of a fluid
2578
2579 [Source: ISO 5598:2019 3.2.315]
- 2580 **316. flow plate**
2581 electronically conductive plate that incorporates channels for fluid transport and which comprises an
2582 electric contact with an electrode
- 2583 **317. fuel cell stack**
2584 assembly of cells, interconnects or bipolar plate, cooling plates, manifolds and a supporting structure
2585 that electrochemically converts reactants typically hydrogen-rich gas and air to direct current electricity,
2586 heat and other reaction products
2587
2588 Note to entry: Fuel cell stacks with low number of cells are called short stacks.
- 2589 **318. gas mixture**
2590 combination of different single gases deliberately mixed in specified proportions
2591
2592 [Source: ISO 14456:2015 3.1]
- 2593 **319. gas pressure regulator**
2594 device that maintains the downstream pressure constant to within fixed limits, independent of variations,
2595 within a given range, of the upstream pressure and/or flow rate
2596
2597 [Source: ISO 13574:2015 2.74]

- 2598 **320. gas seal**
 2599 air-tight mechanism that prevents gas from leaking out of a prescribed flow path
- 2600 **321. gasket**
 2601 component that prevents the exchange of fluids between two or more compartments of a device or the
 2602 leakage of fluids from a device to the outside
 2603
 2604 [Source: JRC EUR 29300 EN report 3.3.9]
- 2605 **322. grade**
 2606 set of specifications indicating the quality of a substance or specified substance
 2607
 2608 [Source: ISO 11238:2018 3.33]
- 2609 **323. hardware**
 2610 items of identifiable equipment including piece parts, components, assemblies, subsystems and systems
 2611
 2612 [Source: ISO 10795:2019 3.119]
- 2613 **324. heat transfer medium**
 2614 medium (water, air, etc) used for the transfer of the heat without change of state
 2615
 2616 [Source: ISO 22449-1:2020 3.1.7]
 2617
 2618 Note to entry: The fluid cooled by the evaporator, the fluid heated by the condenser, and the fluid
 2619 circulating in the heat recovery heat exchanger.
- 2620 **325. hydrocarbon**
 2621 organic compound consisting exclusively of the elements of carbon and hydrogen
 2622
 2623 [Source: ISO 14952-1:2003 2.14]
- 2624 **326. hydrogen**
 2625 chemical element, H with atomic number 1, usually occurring as a diatomic molecule, H₂ which is a
 2626 highly flammable, colourless, odourless and tasteless gas at standard ambient temperature and pressure
- 2627 **327. hydrogen sensing element**
 2628 component that provides a measurable, continuously changing physical quantity in correlation to the
 2629 surrounding hydrogen volume fraction
 2630
 2631 [Source: ISO 26142:2010 3.11]
- 2632 **328. hydrogen sensor**
 2633 assembly, which contains one or more hydrogen sensing elements and may also contain circuit com-
 2634 ponents associated with the hydrogen sensing elements, that provides a continuously changing physical
 2635 quantity or signal in correlation to the physical quantity provided by the hydrogen sensing element(s)
 2636
 2637 [Source: ISO 26142:2010 3.12]
- 2638 **329. hydronium**
 2639 aqueous cation H₃O⁺ of molecular weight 19.023 g mol⁻¹ which is the type of oxonium ion produced by
 2640 protonation of water (as a prototype reaction):
 2641
 2642
$$2\text{H}_2\text{O}_{(l)} \rightleftharpoons \text{OH}^-_{(aq)} + \text{H}_3\text{O}^+_{(aq)}$$

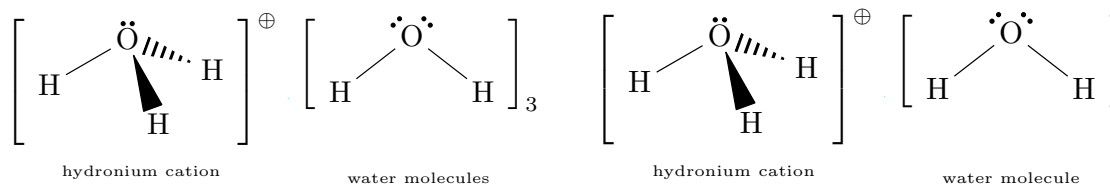
Figure 4: Schematic pyramidal structure of hydronium (oxonium) cation



Note 1 to entry: The hydronium cation may be idealised by two main forms: Eigen cation, H₉O₄⁺

(protonated tetramer, $H^+(H_2O)_4$ or triply coordinated hydronium cation, $H_3O^+(H_2O)_3$) and Zundel cation, $H_5O_2^+$ (protonated dihydronium cation, $H^+(H_2O)_2$ or singly coordinated hydronium cation, $H_3O^+(H_2O)$). Due to hydrogen bonding in bulk water and/or aqueous solutions including hydrated ionomers such as ion exchange membranes (IEMs) and ionomer solutions, higher coordinated proton complexes (clusters) with multiple solvation shells ($H_3O^+(H_2O)_n$) may coexist with Eigen and Zundel cations.

Figure 5: Schematic pyramidal structure of Eigen cation (left) and Zundel cation (right)



Note 2 to entry: The Eigen and Zundel cations are named after respectively German chemists Manfred Eigen (1927-2019) who won in 1967 the Nobel Prize in Chemistry, and Georg Zundel (1931-2007).

Note 3 to entry: Proton solvation results in the concomitant transport of water across cation exchange membranes (CEMs) in, for example, FCs such as PEFC and high-temperature proton exchange membrane fuel cell (HT-PEMFC) as well as water electrolysis cells (WECs), i. e. proton exchange membrane electrolysis cells (PEMECs).

330. hydroxide

aqueous anion OH^- of molecular weight $17.007 \text{ g mol}^{-1}$ which is produced by protonation of water (as a prototype reaction):

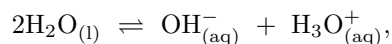
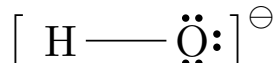


Figure 6: Schematic structure of hydroxide anion



Note 1 to entry: By intuitive analogy to the hydronium cation, the hydroxide anions namely $H_7O_4^-$ (deprotonated water tetramer or triply coordinated hydroxide anion, $OH^-(H_2O)_3$) and $H_3O_2^-$ (deprotonated water dimer or singly coordinated hydroxide anion, OH^-H_2O) may be viewed as mirror images of respectively the Eigen and Zundel cations. Beside these two types of hydroxide anions, higher coordinated hydroxide anion complexes (clusters) with multiple solvation shells ($OH^-(H_2O)_n$) may coexist due to hydrogen bonding in bulk water and/or aqueous solutions including hydrated ionomers such as IEMs and ionomer solutions.

Note 2 to entry: The solvation of hydroxide anions results in the concomitant transport of water across anion exchange membranes (AEMs) in, for example, FCs such as AFCs and alkaline anion exchange membrane fuel cells (AAEMFCs) as well as WECs, i. e. alkaline anion exchange membrane electrolysis cells (AAEMECs).

331. impurity

foreign species present but which is not intentionally added to or retained by a substance

332. inert gas

gas which does not readily react chemically with other substances

[Source: ISO 10286:2015 712]

333. interlock

mechanical, electrical or other type of device, the purpose of which is to prevent the operation of machine elements under specified conditions by an inhibit command from the interlocking device that a) directly interrupts the energy supply or directly disconnects parts from the equipment, or

b) is introduced into the control system so that interruption of the energy or disconnection of parts from the equipment is triggered by the control system

[Source: ISO 21789:2009 3.6]

- 2689 **334. isotope**
2690 variants of a chemical element that differ by atomic mass, having the same number of protons and
2691 differing in the number of neutrons in the nucleus
2692
2693 [Source: ISO 11238:2018 3.37]
- 2694 **335. layer**
2695 any conceptual region of space restricted in one dimension, within or at the surface of a condensed phase
2696 or a film
2697
2698 Note to entry: The usage of the term 'film' for an adsorption layer is confusing and is discouraged.
2699 The term double-layer applies to layers approximated by two 'distinct' sublayers.
2700
2701 [Source: IUPAC Gold Book L03488]
- 2702 **336. liquefied hydrogen (LH₂)**
2703 hydrogen that has been liquefied, i. e. brought to a liquid state
2704
2705 [Source: ISO 14687:2019 3.15]
- 2706 **337. load**
2707 device, system or process that consumes electrical energy
2708
2709 [Source: ISO 17800:2017 3.2]
- 2710 **338. material**
2711 raw, semi-finished or finished purchased item (gaseous, liquid, solid) of given characteristics from which
2712 processing into a functional element of the product is undertaken
2713
2714 [Source: ISO 10795:2019 3.148]
- 2715 **339. membrane**
2716 material that provides separation between oxygen and hydrogen product gases while allowing ionic trans-
2717 port within the cell
2718
2719 [Source: ISO 22734:2019 3.19]
- 2720 **340. metal-matrix composite (MMC)**
2721 material consisting of a metal matrix and a dispersed second phase (and possibly other dispersed phases)
2722 which is (are) essentially insoluble in the matrix
- 2723 **341. moiety**
2724 entity within a substance that has a complete and continuous molecular structure
2725
2726 [Source: ISO 11238:2018 3.45]
- 2727 **342. mounting**
2728 method by which a component, piping or system is fastened
2729
2730 [Source: ISO 5598:2019 3.2.463]
- 2731 **343. nano particle**
2732 nano-object with all three external dimensions in the nano scale
2733
2734 Note to entry: If the lengths of the longest to the shortest axes of the nano-object differ signific-
2735 antly (typically by more than three times), the terms nanofibre or nanoplate are intended to be used
2736 instead of the term nano particle.
2737
2738 [Source: ISO/TS 80004-6:2013 2.3]

- 2739 **344. nanocomposite**
2740 solid comprising a mixture of two or more phase-separated materials, one or more being nanophase
2741
2742 Note 1 to entry: Gaseous nanophases are excluded (they are covered by nanoporous material).
2743 Note 2 to entry: Materials with nano scale phases formed by precipitation alone are not considered to
2744 be nanocomposite materials.
2745
2746 [Source: ISO/TS 80004-8:2013 2.2]
- 2747 **345. normal hydrogen**
2748 75 % ortho hydrogen and 25 % para hydrogen
2749
2750 [Source: ISO/TR 15916:2015 3.70]
- 2751 **346. O-ring**
2752 moulded elastomeric seal that has a round cross-section in the free state
2753
2754 Note to entry: Another name for an O-ring is "toroidal sealing ring".
2755
2756 [Source: ISO 5598:2019 3.2.507]
- 2757 **347. ortho-hydrogen**
2758 hydrogen molecule in which the rotation of the nuclear spin of the individual atoms in the molecule is
2759 in the same direction (parallel)
2760
2761 [Source: ISO/TR 15916:2015 3.73]
- 2762 **348. oxidant**
2763 chemical, such as oxygen, that consumes one or more electrons in an electrochemical reaction
- 2764 **349. para-hydrogen**
2765 hydrogen molecule in which the rotation of the nuclear spin of the individual atoms in the molecule is
2766 in the opposite direction (antiparallel)
2767
2768 [Source: ISO/TR 15916:2015 3.78]
- 2769 **350. particle**
2770 small discrete mass of solid or liquid matter
2771
2772 [Source: ISO 3857-4:2012 2.51]
- 2773 **351. plate separator**
2774 component of a cell, made up of material permeable for ions, which prevents electric contact between
2775 cell plates of opposite polarity within a cell
2776
2777 [Source: IEC 482-02-11]
- 2778 **352. pore**
2779 inherent or induced cavity within a particle or within an object
2780
2781 [Source: ISO 3252:2019 3.3.44]
- 2782 **353. porosity**
2783 property of a material that contains very fine continuous holes which when connected allow the passage
2784 of gases, liquids and solids in through one surface and out at another surface
2785
2786 Note to entry: It is also a measure for the amount of pore volume in an otherwise solid material expressed
2787 as the ratio of the volume of all voids/pores to the total volume of the porous object consisting of solid
2788 and void components.

- 2789 **354. porous layer**
2790 permeable layer of solid material in any form having interstices of small size, generally known as "pores"
2791
2792 [Source: ISO 29464:2017 3.2.144]
- 2793 **355. porous medium**
2794 medium which is heterogeneous due to the presence of finely divided solid phases and voids
2795
2796 [Source: ISO 9251:1987 3.3]
- 2797 **356. porous solid**
2798 solid with cavities or channels which are deeper than they are wide
2799
2800 [Source: ISO 15901-1:2016 3.3]
- 2801 **357. porous structure**
2802 pattern of the pores in a material, characterized by the shape, size and distribution of the pores
2803
2804 [Source: ISO 3252:2019 3.3.49]
- 2805 **358. pressure reducer**
2806 device used to reduce gas pressure immediately downstream of its installed position
2807
2808 [Source: ISO 14532:2014 2.3.3.3]
- 2809 **359. protium**
2810 isotope of hydrogen having a nucleus containing one proton
2811
2812 Note 1 to entry: Protium is the most common constituent of molecular hydrogen.
2813
2814 [Source: ISO/TR 15916:2015 3.84]
2815
2816 Note 2 to entry: The cation ${}^1\text{H}^+$ is a proton, the species ${}^1\text{H}^-$ is a protide anion, and ${}^1\text{H}$ is the
2817 protio group.
2818
2819 [Source: IUPAC Gold Book P04903]
- 2820 **360. proton**
2821 stable elementary particle having a positive charge of 1.60219×10^{-19} C and a rest mass of 1.672621637
2822 $\times 10^{-27}$ kg
2823
2824 [Source: IEC 881-02-51]
2825
2826 Note to entry: Protons are constituents of all atomic nuclei with charge number +1.
- 2827 **361. prototype**
2828 equipment item, used for type testing, considered to be representative of the product for which con-
2829 formity is being assessed
2830
2831 Note to entry: It may be either fabricated especially for type testing or selected at random from a
2832 production series.
2833
2834 [Source: ISO 10855-1:2018 3.5]
- 2835 **362. purge flow**
2836 fluid flow designed to remove a contaminant from a filtration or separation device
2837
2838 [Source: ISO 3857-4:2012 2.59]

- 2839 **363. quick connector**
2840 pair of type-specific component which can be easily and rapidly joined together by a single action of one
2841 or both hands without the use of tools
2842
2843 [Source: ISO 7396-2:2007 3.26]
- 2844 **364. reactant**
2845 chemical substance that is present at the beginning of a electrochemical reaction
- 2846 **365. repair**
2847 return a product, component, assembly or system to an acceptable condition by renewal, replacement
2848 or mending of worn, damaged or degraded parts
2849
2850 [Source: ISO/TR 15686-11:2014 3.1.107]
- 2851 **366. replacement**
2852 change of parts of an existing item to regain its functionality
2853
2854 [Source: ISO/TR 15686-11:2014 3.1.108]
- 2855 **367. safety device**
2856 all elements that are used to measure, limit or control safety relevant process variables, for processing
2857 safety relevant signals or for activation of automatic or manual safety related interventions
2858
2859 [Source: ISO 21789:2009 3.13]
- 2860 **368. seal**
2861 component providing a barrier to prevent the passage of fluids, transmitting no significant loads between
2862 the flanges
2863
2864 [Source: ISO 27509:2012 3.1.5]
- 2865 **369. sealant**
2866 adhesive material used to fill gaps where movement can occur in service and which, when set, has elastic
2867 properties
2868
2869 Note to entry: The term "sealant" is also used for a material filling a void against the ingress or
2870 egress of a fluid under pressure.
2871
2872 [Source: ISO 472:2013 2.1524]
- 2873 **370. selective laser sintering (SLS)**
2874 additive manufacturing (AM) technique that uses one or more lasers as power source(s) to selectively
2875 fuse (sinter) powdered material (tiny particles of plastic, ceramic or glass) into a solid structure layer
2876 upon layer based on a three dimensional model
- 2877 **371. sensor**
2878 device or instrument designed to detect or measure a variable
2879
2880 Note 1 to entry: There are passive, active, and binary sensors, also for network connection.
2881 Note 2 to entry: A sensor is a field device for providing the necessary information (signal) about the
2882 physical conditions, states, and values of the processing functions to enable the processing functions to
2883 perform the programmed operations.
2884 Note 3 to entry: The term sensor does not provide a differentiation between a binary or analog type.
2885 The distinctive feature should be stated, e. g., switch/push button sensor (binary), thermostat (binary),
2886 temperature sensor (analog).
2887 Note 4 to entry: Sensors also are differentiated by their housing and mounting type (e. g. surface type)
2888 and by their purpose.
2889
2890 [Source: ISO 16484-2:2004 3.178]

- 2891 **372. short stack**
2892 stack with a number of cells that is significantly smaller than the designed stack with rated power, but
2893 is sufficiently large to represent the scaled characteristics of the full stack
- 2894 **373. shunt**
2895 resistor connected in parallel with the current circuit of a measuring instrument in order to extend its
2896 measuring range
2897
2898 Note to entry: A shunt is generally intended to provide a voltage proportional to the current to be
2899 measured.
2900
2901 [Source: IEC 313-09-04]
- 2902 **374. solvent**
2903 liquid or mixture of liquids that is used to dissolve a substance or to dilute a solution without causing
2904 any chemical change
2905
2906 Note to entry: In the adhesives field, solvents are used to control the consistency and character of
2907 the adhesive and to regulate the application properties.
2908
2909 [Source: ISO 472:2013 2.1550]
- 2910 **375. stack**
2911 assembly of two and more electrochemical cells, separators, manifolds and a supporting structure as well
2912 as cooling plates where applicable
2913
2914 Note to entry: Stacks with low number of cells are called short stacks.
- 2915 **376. stainless steel**
2916 steel whose most characterising element is chromium of at least 10,5 % (mass fraction) Cr and maximum
2917 1,2 % (mass fraction) C, and the primary importance of which is its resistance to corrosion
2918
2919 [Source: ISO 21850-1:2020 3.2]
- 2920 **377. substance**
2921 matter of defined composition that has discrete existence, whose origin may be biological, mineral or
2922 chemical
2923
2924 [Source: ISO 11238:2018 3.84]
- 2925 **378. substrate**
2926 surface or material upon which a substance is deposited
2927
2928 [Source: ISO 21043-1:2018 3.31]
- 2929 **379. thermocouple**
2930 temperature sensor that consists of two different types of metal wire that are bonded at both ends and
2931 generates electromotive force that is caused by the difference of temperature between hot junction and
2932 cold junction
2933
2934 [Source: ISO 13574:2015 2.189]
- 2935 **380. tritium**
2936 isotope of hydrogen having two neutrons and a mass number of three
2937
2938 [Source: ISO/TR 15916:2015 3.106]
2939
2940 Note to entry: The cation ${}^3\text{H}^+$ is a triton, the species ${}^3\text{H}^-$ is a tritide anion, and ${}^3\text{H}$ is the tritio
2941 group.
2942
2943 [Source: IUPAC Gold Book T06513]

- 2944 **381. vent**
2945 opening intended to discharge gases, fumes or mists except the exhaust gas of the gas turbine, the latter
2946 being called the exhaust system
2947
2948 [Source: ISO 21789:2009 3.18]
- 2949 **2.1.4 Methods, measurements and testing**
- 2950 **382. abnormal operating condition**
2951 temporary operating condition other than transient that is not a normal operating condition
2952
2953 Note to entry: An abnormal operating condition may not necessarily be due to a fault condition of
2954 the device or system itself.
- 2955 **383. accelerated stress testing (AST)**
2956 applying for shorter periods more extreme levels of stress to a device, product or system than would
2957 usually occur under normal conditions assuming it will exhibit the same failure mechanisms as it would
2958 experience at longer exposures with less extreme stress levels
- 2959 **384. accelerated test**
2960 test in which the stress level, or rate of stress application, exceeds that occurring under specified oper-
2961 ational conditions, to reduce the duration required to produce a stress response
2962
2963 Note to entry: The test should not alter the basic failure modes or failure mechanisms, or their re-
2964 lative prevalence.
2965
2966 [Source: IEV 192-09-08]
- 2967 **385. accelerated testing**
2968 test in which the applied stress level is chosen to exceed that stated in the reference conditions in order
2969 to shorten the duration required to observe the stress response of the item, or to magnify the response
2970 in a given time duration
2971
2972 Note to entry: To be valid, an accelerated test shall not alter the basic failure modes and failure
2973 mechanisms, or their relative prevalence.
2974
2975 [Source: ISO 11462-1:2001 A.1]
- 2976 **386. acceptance test**
2977 contractual procedure to demonstrate, to the customer, that acceptance criteria are met
2978
2979 [Source: IEV 192-09-03]
- 2980 **387. actual value**
2981 value of a quantity determined by measurement on a specific relay, during performance of a specified
2982 function
2983
2984 [Source: IEV 444-02-21]
- 2985 **388. alternating**
2986 pertaining to a periodic quantity of zero mean value
2987
2988 [Source: IEV 103-06-03]
- 2989 **389. amperometry**
2990 electrochemical measurement principle based on measurement of current at a controlled applied potential
2991
2992 Note 1 to entry: The current is usually faradaic and the applied potential is usually constant.
2993 Note 2 to entry: Amperometry can be distinguished from voltammetry by the parameter being controlled
2994 (electrode potential) and the parameter being measured (electrode current which is usually a function

2995 of time).

2996 Note 3 to entry: The integral of current with time is the electric charge, which may be related to the

2997 amount of substance reacted by Faraday's laws of electrolysis.

2998 [Source: IUPAC Recommendations 2019 6.2.1]

2999

3000 **390. atomic force microscopy (AFM)**

3001 method for imaging surfaces by mechanically scanning their surface contours, in which the deflection of

3002 a sharp tip sensing the surface forces, mounted on a compliant cantilever, is monitored

3003

3004 Note 1 to entry: Atomic force microscopy can provide a quantitative height image of both insulat-

3005 ing and conducting surfaces.

3006 Note 2 to entry: Some Atomic force microscopy instruments move the sample in the x-, y- and z-

3007 directions while keeping the tip position constant and others move the tip while keeping the sample

3008 position constant.

3009 Note 3 to entry: Atomic force microscopy can be conducted in vacuum, a liquid, a controlled atmo-

3010 sphere or air. Atomic resolution may be attainable with suitable samples, with sharp tips and by using

3011 an appropriate imaging mode.

3012 Note 4 to entry: Many types of force can be measured, such as the normal forces or the lateral, friction

3013 or shear force. When the latter is measured, the technique is referred to as lateral, frictional or shear

3014 force microscopy. This generic term encompasses all of these types of force microscopy.

3015 Note 5 to entry: Atomic force microscopy can be used to measure surface normal forces at individual

3016 points in the pixel array used for imaging.

3017 Note 6 to entry: For typical atomic force microscopy tips with radii < 100 nm, the normal force should

3018 be less than about $0.1 \mu\text{N}$, depending on the sample material, or irreversible surface deformation and

3019 excessive tip wear occurs.

3020

3021 [Source: ISO/TS 80004-6:2013 3.5.2]

3022 **391. Auger electron spectroscopy (AES)**

3023 any technique in which a specimen is bombarded with keV-energy electrons or X-rays, and the energy

3024 distribution of the electrons produced through radiationless de-excitation of the atoms in the sample

3025 (Auger electrons) is recorded

3026

3027 [Source: IUPAC Gold Book A00522]

3028

3029 Note 1 to entry: An electron beam in the energy range 2 keV to 30 keV is often used for excita-

3030 tion of the Auger electrons. Auger electrons can also be excited with X-rays, ions and other sources

3031 but the term Auger electron spectroscopy, without additional qualifiers, is usually reserved for electron-

3032 beam-induced excitation. Where an X-rays source is used, the Auger electron energies are referenced to

3033 the Fermi level but, where an electron beam is used, the reference may either be the Fermi level or the

3034 vacuum level. Spectra conventionally may be presented in the direct or differential forms.

3035

3036 [Source: ISO/TS 80004-6:2013 4.16]

3037

3038 Note 2 to entry: AES is named after French physicist Pierre Victor Auger (1899-1993).

3039 **392. back-pressure regulator**

3040 device used to control/maintain gas pressure immediately upstream of its installed position

3041

3042 [Source: ISO 14532:2014 2.3.3.4]

3043 **393. beginning of test (BoT)**

3044 time when test starts

3045 **394. breadboard**

3046 physical model designed to test functionality and tailored to the demonstration need

3047

3048 [Source: ISO 10795:2019 3.29]

3049 **395. Brunauer-Emmett-Teller (BET)**

3050 method for the determination of the total specific external and internal surface area of disperse powders
3051 and/or porous solids by measuring the amount of physically adsorbed gas utilizing the model developed
3052 by Brunauer, Emmett and Teller for interpreting gas adsorption isotherms

3053
3054 Note 1 to entry: Method originates from (Brunauer et al., 1938).

3055 Note 2 to entry: The BET method is applicable only to adsorption isotherms of type II (disperse, non-
3056 porous or macroporous solids) and type IV (mesoporous solids, pore diameter between 2 nm and 50
3057 nm). Inaccessible pores are not detected. The BET method cannot reliably be applied to solids which
3058 absorb the measuring gas.

3059
3060 [Source: ISO/TS 80004-6:2013 3.6.3]

3061 **396. chronoamperometry**

3062 amperometry in which the current is measured as a function of time after a change in the applied potential

3063
3064 Note to entry: If the potential step is from a potential at which no current flows (i.e., at which
3065 the oxidation or reduction of the electrochemically active species does not take place) to one at which
3066 the current, i (ampere, A) is limited by diffusion, the current obeys the Cottrell equation:

3067
$$i = \frac{nF A c_j^0 \sqrt{D_j}}{\sqrt{\pi t}}$$

3068 where

3069 n is number of electrons (to reduce/oxidise one molecule of species j , for example);

F is Faraday's constant (C mol⁻¹);

A is area of the (planar) electrode (cm²);

3070 c is initial concentration of the reducible species j (mol cm⁻³);

D_j is diffusion coefficient for species j (cm² s⁻¹);

3071 t is time.

3072
3073 [Source: IUPAC Recommendations 2019 6.2.2]

3074 **397. confocal optical microscopy (COM)**

3075 method for microscopy in which, ideally, a point in the object plane is illuminated by a diffraction-limited
3076 spot of light, and light emanating from this point is focused upon and detected from an area smaller
3077 than the central area of the diffraction disc situated in the corresponding position in a subsequent field
3078 plane

3079
3080 Note 1 to entry: An image of an extended area is formed either by scanning the object, or by scanning
3081 the illuminated and detected spots simultaneously.

3082 Note 2 to entry: The confocal principle leads to improved contrast and axial resolution by suppression
3083 of light from out-of-focus planes.

3084
3085 [Source: ISO/TS 80004-6:2013 3.5.10]

3086 **398. constant current operation**

3087 operational mode when the electrolyser or the fuel cell is operated at constant current (galvanostatic
3088 mode)

3089 **399. constant voltage operation**

3090 operational mode when the electrolyser or the fuel cell is operated at constant voltage (potentiostatic
3091 mode)

3092 **400. cost benefit analysis (CBA)**

3093 means used to assess the relative cost and benefit of a number of risk reduction alternatives

3094

3095 Note to entry: The ranking of the risk reduction alternatives evaluated is usually shown graphically.

3096

3097 [Source: ISO/TS 16901:2015 3.7]

3098 **401. current interrupt (CI)**

3099 method of measuring the change in voltage of a cell or a stack by interrupting the drawn current (fuel
3100 cell) or the supplied current (electrolysis) for a brief period, typically an interval of a few milliseconds
3101 while recording the resulting voltage

3102

3103 Note to entry: The difference between the voltage before and after current interrupt, divided by the
3104 current before current interrupt, is the sought electrical resistance. The transient voltage as a function
3105 of time may be monitored in real time using, for example, an oscilloscope.

3106 **402. cyclic voltammetry**

3107 voltammetry in which the electric current is recorded as the electrode potential is varied with time cyc-
3108 lically between two potential limits, normally at a constant scan rate

3109

3110 Note 1 to entry: The initial potential is usually the negative or positive limit of the cycle but can
3111 have any value between the two limits, as can the initial scan direction. The limits of the potential are
3112 known as the switching potentials.

3113 Note 2 to entry: Normally the initial potential is chosen where no electrode reaction occurs and the
3114 switching potential is greater (more positive for an oxidation or more negative for a reduction) than the
3115 peak potential of the analyte reaction.

3116 Note 3 to entry: The plot of current against potential is termed a cyclic voltammogram. Usually peak-
3117 shaped responses are obtained for scans in both directions.

3118 Note 4 to entry: Cyclic voltammetry is frequently used for the investigation of mechanisms of electro-
3119 chemical/electrode reactions. The current-potential curve may be modelled to obtain reaction mechan-
3120 isms and electrochemical parameters.

3121

3122 [Source: IUPAC Recommendations 2019 6.3.5]

3123 **403. data processing**

3124 systematic performance of operations upon data

3125

3126 [Source: IEC 171-01-17]

3127 **404. data reporting format (DRF)**

3128 set of specified characteristics of data compiled into a prescribed format for reporting

3129 **405. design of experiment (DoE)**

3130 efficient procedure for planning combinations of values of factors in experiments so that the data ob-
3131 tained can be analysed to yield valid and objective conclusions

3132

3133 Note 1 to entry: Experimental design is applied to determine the set of conditions that are required to
3134 obtain a product or process with desirable, often optimal properties. A characteristic of experimental
3135 design is that these conditions are determined in a statistically-optimal way.

3136 Note 2 to entry: Response surface methodology is considered an important part of experimental design.

3137 Note 3 to entry: An 'experimental design' (noun) usually refers to a table giving the levels of each factor
3138 for each run.

3139

3140 [Source: IUPAC Recommendations 2016 4.7]

3141 **406. device under test (DUT)**

3142 device subject to a test

3143 **407. analysis of difference in impedance spectra (ADIS)**

3144 electrochemical impedance spectroscopy analysis technique by which spectra recorded under different
3145 conditions are subtracted from another (upon logarithmic differentiation with respect to frequency) for
3146 identifying features in the resultant spectra pertaining to physico-electrochemical processes otherwise
3147 difficult to be exhibited

3148 **408. differential immittance analysis (DIA)**

3149 advanced immittance data processing and analysis technique based on equivalent electric circuit (EEC)
3150 parametric model to identify through numerical differentiation with respect to (angular) frequency struc-
3151 tural information of the studied object extractable from its measured data without requiring an initial
3152 working hypothesis

3153 **409. differential scanning calorimetry (DSC)**

3154 technique in which the the difference between the heat flow rate into a test specimen and that into
3155 a reference specimen is measured as a function of temperature and/or time while the test specimen
3156 and the reference specimen are being subjected to the same controlled temperature programme under a
3157 specified atmosphere

3158
3159 Note to entry: A distinction is made between two modes, power-compensation differential scanning
3160 calorimetry (power-compensation DSC) and heat-flux differential scanning calorimetry (heat-flux DSC),
3161 depending on the principle of measurement used.

3162 [Source: ISO 472:2013 2.278]
3163

3164 **410. distribution of relaxation times (DRT)**

3165 theoretical concept of electrochemical impedance spectroscopy (EIS) based on the fundamental principle
3166 of superposition of suitable combination of a large but finite number of branches of one homogeneous
3167 and at least one additional electric circuit (lumped) element infinitesimal small in magnitude which
3168 form a one-port electrical network, the total immittance of which adheres in the continuous limit to all
3169 principles of linear, time invariant (LTI) systems and as such, the DRT is a numerical approach for the
3170 better resolved analysis of (measured) immittance spectroscopy (IS) data
3171

3172 Note 1 to entry: The DRT spectrum (intensity (magnitude) versus relaxation time) which is not directly
3173 measurable, represents a discrete, continuous, or mixed (discrete and continuous) function (distribution)
3174 of time constants, τ (relaxation times) attributable to separable relaxation phenomena stemming from
3175 one or more physico-electrochemical process (conduction, convection, diffusion, electro-migration, re-
3176 action, etc) occurring in the studied device under test (DUT), an EC or electrochemical system (ECS)
3177 which is excited, for example, by small alternating current (AC) signals. Besides the total number of
3178 distinguishable DRT peaks linked to individual time constants, it provides additional information (peak
3179 position, height, orientation and area, full width at half maximum (FWHM)) usually not or not readily
3180 accessible by other means. DRT analysis supplements and complements parameter identification, for
3181 example, by complex nonlinear least squares (CNLS) fitting of the measured data to an EEC model
3182 starting with initial parameter estimates stemming from the additional information. Remark, real valued
3183 DRT have the disadvantage that they apply to immittance spectroscopy data of an ECS which must
3184 either be exclusively resistive-capacitive or resistive-inductive. This is resolved by generalising the DRT
3185 to be complex valued using the Hilbert integral transform (HIT)¹⁴ (King, 2008 & 2009) making it com-
3186 pliant with the LTI principles (Malkow, 2019). This allows DRT analysis of any Kramers-Kronig (KK)
3187 compliant IS data (Malkow, 2017).

3188 Note 2 to entry: Software to estimate real valued DRT is freely available (for non-commercial use) such
3189 as DRTtools (Wan, 2018), LEVMW (Macdonald, 2015), ec-idea (Danzer, 2020), DP-DRT (Liu and
3190 Ciucci, 2020), GP-DRT (Liu and Ciucci, 2019) and GENEREG (Roths et al., 2001).

3191 **411. durability test**

3192 test conducted to estimate or verify durability

3193 [Source: IEV 192-09-17]
3194

3195 **412. duty cycle**

3196 specified sequence of operating conditions

3197 [Source: IEV 151-16-02]
3198

3199
3200 repetitive variation of load in which the cycle time is too short for thermal equilibrium to be attained in
3201 the first cycle

3202 [Source: IEV 426-04-11]
3203

¹⁴This integral transform is named after German mathematician David Hilbert (1862-1943).

- 3204 **413. elastic peak electron spectroscopy (EPES)**
- 3205 measurement method in which an electron spectrometer is used to measure the energy, intensity, and/or
- 3206 energy broadening distribution of quasi-elastically scattered electrons from a solid or liquid surface
- 3207
- 3208 Note 1 to entry: An electron beam in the energy range 100 eV to 3 keV is often used for this kind
- 3209 of spectroscopy.
- 3210 Note 2 to entry: In general, electron sources with energy spreads that are less than 1 eV are required to
- 3211 provide adequate information.
- 3212 Note 3 to entry: EPES is often an auxiliary method of Auger electron spectroscopy (AES) and reflection
- 3213 electron energy loss spectroscopy (REELS), providing information on the composition of the surface
- 3214 layer. EPES is suitable for the experimental determination of the electron inelastic mean free path, the
- 3215 electron differential elastic scattering cross section, and the surface excitation parameter.
- 3216
- 3217 [Source: IUPAC Recommendations 2020 (Takeuchi et al., 2020) 3]
- 3218 **414. electrochemical atomic force microscopy (EC-AFM)**
- 3219 AFM mode in which a conductive probe is used in an electrolyte solution to measure both topography
- 3220 and electrochemical current
- 3221
- 3222 [Source: ISO 18115-2:2013 3.8]
- 3223 **415. electrochemical impedance spectroscopy (EIS)**
- 3224 electrochemical technique which allows the impedance spectrum of an electrochemical system to be
- 3225 recorded as a function of the frequency of the applied voltage signal (potentiostatic mode) or AC signal
- 3226 (galvanostatic mode), and the spectrum thus obtained to be represented as Nyquist plots and/or Bode
- 3227 plots
- 3228
- 3229 Note 1 to entry: EIS analysis may be performed, for example, by distribution of relaxation times analysis
- 3230 and CNLS fitting of the measured data to the chosen equivalent electric circuit model to eventually
- 3231 reveal meaningful values of microscopic quantities sought from model parameters estimated (charge
- 3232 transfer resistance, polarisation resistance, double layer capacitance, etc).
- 3233 Note 2 to entry: EIS software to present and analyse EIS data is freely available (for non-commercial
- 3234 use) such as Elchemea Analytical (Koch et al., 2020), EIS simulation software (Srinivasan, 2019), EIS
- 3235 Spectrum Analyser (Bandarenka and Ragoisha, 2013), Impedance Analyzer (Murbach, 2017), imped-
- 3236 ance.py (Murbach, 2020), LEVMW (Macdonald, 2015), ECIF (Plymill and Huang, 2019), FittingGUI
- 3237 (Witzenhausen, 2017), MVCNLS (Hilpert, 2011), MEISP (Barsoukov, 2011), PyEIS (Knudsen, 2019),
- 3238 Zfit (Barrere, 2019) and ZMAN (ZIVE LAB, 2017) as well as the Lin-KK Tool (Schönleber, 2015) for
- 3239 KK testing of IS data.
- 3240 Note 3 to entry: EIS variants may use multi-sinusoidal excitation as well as non-electrical stimuli. Also,
- 3241 nonlinear EIS is nowadays increasingly applied to study ECSs.
- 3242 **416. electrochemical scanning tunneling microscopy (EC-STM)**
- 3243 STM mode in which a coated tip is used in an electrolyte solution to measure both topography and
- 3244 electrochemical current
- 3245
- 3246 [Source: ISO 18115-2:2013 3.9]
- 3247 **417. electron energy loss spectroscopy (EELS)**
- 3248 method in which an electron spectrometer measures the energy spectrum of electrons from a nominally
- 3249 monoenergetic source emitted after inelastic interactions with the sample, often exhibiting peaks due to
- 3250 specific inelastic loss processes
- 3251
- 3252 Note 1 to entry: The spectrum obtained using an incident-electron beam of about the same energy
- 3253 as in Auger electron spectroscopy or X-ray photoelectron spectroscopy peak approximates to the energy
- 3254 loss spectrum associated with that peak.
- 3255 Note 2 to entry: The electron energy loss spectroscopy, measured with an incident-electron beam, is a
- 3256 function of the beam energy, the angle of incidence of the beam, the angle of emission and the electronic
- 3257 properties of the sample.
- 3258
- 3259 [Source: ISO/TS 80004-6:2013 4.14]

- 3260 **418. electron probe microanalysis (EPMA)**
3261 method using bombardment of a solid specimen by electrons which generate a variety of signals providing
3262 the basis for a number of different analytical techniques
3263
3264 [Source: IUPAC Gold Book E02006]
- 3265 **419. electron spin resonance spectroscopy (ESR)**
3266 method for studying chemical species that have one or more unpaired electrons through resonant excit-
3267 ation of electron spin
3268
3269 Note to entry: Similar to NMR but measuring electron spin.
3270
3271 [Source: ISO/TS 80004-6:2013 4.27]
- 3272 **420. end of test (EoT)**
3273 time when test ends
- 3274 **421. endurance test**
3275 test carried out over a time interval to investigate how the properties of an item are affected by the
3276 application of stated stresses and by their duration or repeated application
3277
3278 [Source: IEV 151-16-22]
- 3279 **422. energy disperse X-ray spectroscopy (EDS)**
3280 analytical technique which enables the elemental analysis or chemical characterisation of a specimen by
3281 analysing characteristic X-rays emitted by the matter in response to electron irradiation
3282
3283 [Source: ISO 15932:2013 6.6]
- 3284 **423. equipment under test (EUT)**
3285 equipment other than an item or a device subject to a test
- 3286 **424. evaluation**
3287 systematic process that compares the result of measurement to recognised criteria to determine the
3288 discrepancies between intended and actual performance
3289
3290 [Source: ISO 22300:2018 3.81]
- 3291 **425. evolved gas analysis (EGA)**
3292 method in which the nature and/or amount of volatile product(s) released by a substance is (are) meas-
3293 ured as a function of temperature while the substance is subjected to a controlled temperature programme
3294
3295 [Source: ISO/TS 80004-6:2013 4.25]
- 3296 **426. ex-situ**
3297 describing the way a measurement or test is taken or an analyses is performed "off-place", that is, out-
3298 side the place (location) the phenomenon or process investigated would occur by isolating it from other
3299 systems or by altering the measurement or test conditions being different from the operating conditions
3300 of the studied item or system
3301
3302 Note to entry: For an electrochemical cell, it is not tested using the same apparatus or hardware
3303 when tested in-situ.
- 3304 **427. experimental validation**
3305 validation achieved through means of experiments and testing whether at laboratory scale or in the field
- 3306 **428. failure**
3307 termination of the ability of an item to perform a required function
3308
3309 [Source: ISO 10795:2019 3.98]

3310 **429. failure mode and effects analysis (FMEA)**

3311 analytically derived identification of the conceivable equipment failure modes and the potential adverse
3312 effects of those modes on the system and mission

3313

3314 Note to entry: It is primarily used as a design tool for review of critical components.

3315

3316 [Source: ISO/TS 16901:2015 3.11]

3317 **430. fast Fourier transformation (FFT)**

3318 efficient algorithm to compute the discrete Fourier transform

3319

3320 [Source: ISO 15932:2013 5.4.1]

3321

3322 Note 1 to entry: While several other algorithms exists, it is typically the Cooley-Tukey (divide-and-
3323 conquer) decimation in time algorithm (Cooley and Tukey, 1965) named after US mathematicians
3324 James William Cooley (1926-2016) and John Wilder Tukey (1915-2000), which is used to compute the
3325 FFT. Conceptually, this algorithm can be traced to the original idea by German mathematician and
3326 physicist Johann Carl Friedrich Gauß (1777-1855).

3327 Note 2 to entry: In FFT and IFFT, the discrete signal whether numerically generated or experimentally
3328 measured, being inevitably of finite duration represents the continuous signal to be transformed to the
3329 angular frequency domain. Such periodised signals is localised in the time domain (TD) which is equi-
3330 valent to the same signal but of infinite duration times a rectangular time window. This multiplication
3331 corresponds to a convolution in the angular frequency domain of the Fourier integral transforms (FITs) of
3332 the continuous signal and the time window. The latter is the $\text{sinc}(\omega) = \frac{\sin(\omega)}{\omega}$ function which has infinite
3333 bandwidth and so has the convolved signal resulting in spectral leakage. That is, the appearance in the
3334 angular frequency spectrum of additional non-zero peaks at other angular frequencies than but adjacent
3335 to the main peak which is not an artifact of discrete Fourier transform (DFT) but of the finite duration
3336 signal caused by discrete data sampling (aliasing). Also, due attention should be paid to discontinuities
3337 present in the discrete signal to be transformed in order not to unintentionally alter information in the
3338 data.

3339 Note 3 to entry: Besides the transformation of TD immittance data into the angular frequency domain
3340 and *vice versa*, FFT and its inverse (IFFT) can be used to numerically validate measured immittances
3341 $I(\omega)$ for conformity with the HIT (and equivalently, the Kramers-Kronig relations (KKR)) using the
3342 convolution property of FIT (see Table 8) to reject non-conform frequency data. Several software im-
3343 plementation including open source codes generalise ubiquitous FFT (an orthogonal transform) and its
3344 inverse (IFFT) from equally spaced sampling points (nodes) to arbitrary spaced nodes (Boyd, 1992, Dutt
3345 and Rokhlin, 1993, Keiner et al., 2009).

3346 **431. fault tree**

3347 logic diagram showing the faults of sub items, external events, or combinations thereof, which cause a
3348 predefined, undesired event

3349

3350 [Source: IEV 192-11-07]

3351 **432. fault tree analysis (FTA)**

3352 analysis using logic diagram showing the faults of sub-items, external events, or combinations thereof,
3353 that result in a predefined, undesired event

3354

3355 [Source: ISO 10795:2019 3.104]

3356 **433. field test**

3357 test carried out under user operational conditions

3358

3359 Note to entry: The operating, environmental, maintenance and measurement conditions present at
3360 the time of the test may be monitored or recorded.

3361

3362 [Source: IEV 192-09-06]

3363 **434. Fourier integral transform (FIT)**

3364 for a real or complex function $f(t)$ of the real variable t , complex function $F(\omega)$ of the real variable ω ,
 3365 given by the integral transformation

$$3366 \quad F(\omega) = \int_{-\infty}^{\infty} f(t) e^{-i\omega t} dt$$

3367
 3368 where i is the imaginary unit with property $(\pm i)^2 = -1$

3369
 3370 Note 1 to entry: If t is time, the variable ω represents angular frequency.

3371 [Source: IEV 103-04-01]

3372
 3373 Note 2 to entry: FIT of $f(t)$ only exists when $f(t) = \mathcal{F}^{-1}\{F(\omega)\}(t)$ (IFIT of $F(\omega) = \mathcal{F}\{f(t)\}(\omega)$)
 3374 has utmost finite number of discontinuities, fulfills the Lipschitz condition¹⁵ of order α at $t = t'$,
 3375 $|f(t) - f(t')| \leq C|t - t'|^\alpha$, $t' \in \mathbb{R}$ where the constants, C and $\alpha > 0$ are independent of t , and is
 3376 absolutely integrable,
 3377

$$3378 \quad \int_{-\infty}^{+\infty} |f(t)| dt < \infty.$$

3379
 3380 For a jump discontinuity at t , $f(t)$ is replaced by the non-zero average $0.5(f(t_{\pm}) + f(t_{\mp}))$ when existing
 3381 where $f(t_{-})$ and $f(t_{+})$ are the limits of $f(t)$ at the left hand side (LHS) at $t = t_{-}$ and the right hand
 3382 side (RHS) at $t = t_{+}$, respectively. FIT and its inverse (IFIT) have different forms:

$$3383 \quad \mathcal{F}\{f(t)\}(\omega) = \sqrt{\frac{|b|}{(2\pi)^{1-a}}} \int_{-\infty}^{\infty} f(t) e^{ib\omega t} dt$$

$$3384 \quad = \sqrt{\frac{|b|}{(2\pi)^{1-a}}} \int_{-\infty}^{\infty} (f_e(t) \cos(b\omega t) + f_o(t) i \sin(b\omega t)) dt$$

$$3385 \quad \mathcal{F}^{-1}\{F(\omega)\}(t) = \sqrt{\frac{|b|}{(2\pi)^{1+a}}} \int_{-\infty}^{\infty} F(\omega) e^{-ib\omega t} d\omega$$

$$3386 \quad = \sqrt{\frac{|b|}{(2\pi)^{1+a}}} \int_{-\infty}^{\infty} (F_e(\omega) \cos(b\omega t) - F_o(\omega) i \sin(b\omega t)) d\omega$$

3387
 3388 where a and b are arbitrary constants, $f_e(t) = 0.5(f(t) + f(-t))$ and $f_o(t) = 0.5(f(t) - f(-t))$ are
 3389 the even and odd parts of $f(t) = (f_e + f_o)(t)$, respectively, and $F_e(\omega) = 0.5(F(\omega) + F(-\omega))$ and
 3390 $F_o(\omega) = 0.5(F(\omega) - F(-\omega))$ are the even and odd parts of $F(\omega) = (F_e + F_o)(\omega)$, respectively. Besides
 3391 the complex exponential kernels, $e^{\pm i\omega t} = \cos(\omega t) \pm i \sin(\omega t)$, other FIT forms use related kernel functions
 3392 or higher dimensional kernels.

3393 Note 3 to entry: FIT is used to analyse stable systems whether or not causal (non-anticipative). It is
 3394 related to its inverse (IFIT) by $\mathcal{F}\{\mathcal{F}^{-1}\{F(\omega)\}(t)\}(\omega) = f(t)$ and equivalently, $\mathcal{F}^{-1}\{\mathcal{F}\{f(t)\}(\omega)\}(t) =$
 3395 $f(t)$ that is, $\mathcal{F}^{\pm 1}\mathcal{F}^{\mp 1} = \mathcal{F}^{\mp 1}\mathcal{F}^{\pm 1}$ in general. FIT is related to the Laplace integral transform (LIT) by
 3396 $\mathcal{F}\{f(t)\}(\omega) = \mathcal{L}\{f(t)\}(-i\omega) + \mathcal{L}\{f(-t)\}(i\omega)$. This bilateral (two sided) FIT is related to the unilateral
 3397 (one sided) FIT by

$$3398 \quad \mathcal{F}\{f(t) h(t)\}(\omega) = \int_0^{\infty} f(t) e^{-i\omega t} dt$$

3399
 3400 where $h(t)$ is the unit step function, $h(t) = 0.5(1 + \text{sgn}(t))$ with signum function, $\text{sgn}(t) = \frac{t}{|t|}$ &
 3401 $\text{sgn}(0) = 0$ (Abramowitz and Stegun, 1972). This transform deals with causal systems, for example, to
 3402 derive lumped circuit elements (resistors, inductors and/or capacitors) including transmission lines (TLs)
 3403 from linear ordinary differential equations (ODEs) in TD to algebraic equations in angular frequency
 3404 (Fourier) domain.

3405 Note 4 to entry: FIT and IFIT are named after French mathematician and physicist Jean-Baptiste Joseph
 3406 Fourier (1768-1830).

3407 **435. Fourier transform infra-red spectroscopy (FTIR)**

3408 method in which a sample is subjected to excitation of molecular bonds by pulsed, broad-band infra-red
 3409 radiation, and the Fourier transform mathematical method is used to obtain an absorption spectrum

¹⁵This condition is named after German mathematician Rudolf Otto Sigmund Lipschitz (1832-1903).

- 3410
3411 [Source: ISO/TS 80004-6:2013 4.8]
- 3412 **436. Fourier transformation (FT)**
3413 transformation that assigns to a function of a real variable its Fourier transform
3414
3415 [Source: IEV 103-04-02]
- 3416 **437. galvanodynamic test**
3417 test in which the applied current is varied at a pre-programmed rate and the relationship between current
3418 and voltage is recorded
- 3419 **438. galvanostatic test**
3420 test in which the current is maintained constant and the voltage is recorded as a function of time
- 3421 **439. gas analysis**
3422 measurement methods and techniques for determining the gas composition
3423
3424 [Source: ISO 14532:2014 2.5.2.1.4]
- 3425 **440. gas chromatograph**
3426 device that physically separates components of a mixture in the gaseous phase and measures them in-
3427 dividually with a detector whose signal is processed
3428
3429 [Source: ISO 14532:2014 2.4.3]
- 3430 **441. gas chromatography (GC)**
3431 separation technique in which the mobile phase is a gas
3432
3433 Note to entry: Gas chromatography is always carried out in a column.
3434
3435 [Source: IUPAC Gold Book G02578]
- 3436 **442. gas-tight**
3437 capable of holding gas without leaking under the specified pressure for the specified length of time
3438
3439 [Source: ISO 10424-1:2004 4.1.19]
- 3440 **443. high-resolution transmission electron microscopy (HREM)**
3441 method for obtaining lattice and crystal structure images by interfering with a transmitted electron wave
3442 and diffracted electron waves using an electromagnetic lens with a small spherical aberration
3443
3444 [Source: ISO 15932:2013 2.5.1]
- 3445 **444. impulse**
3446 variation in the value of a magnitude, short in relation to the time schedule of interest, the final value
3447 being the same as the initial value
3448
3449 [Source: ISO/IEC 2382:2015 2121647]
- 3450 **445. in-operando**
3451 describing the way a measurement, test or analyses is performed under operating conditions
- 3452 **446. in-situ**
3453 describing the way a measurement or test is taken or an analyses is performed "in-place", that is, in
3454 the same place (location) the phenomenon or process investigated occurs or assumed to occur without
3455 isolating it from other systems, or altering the measurement or test conditions (operating conditions of
3456 the studied item or system)
3457
3458 Note to entry: For an electrochemical cell, it means that the cell experiences a potential.

3459 **447. inductively coupled plasma mass spectroscopy (ICP-MS)**

3460 method in which a high temperature discharge generated in flowing argon by an alternating magnetic
3461 field induced by a radio frequency load coil that surrounds the tube carrying the gas is detected using a
3462 mass spectrometer

3463
3464 [Source: ISO/TS 80004-6:2013 4.22]

3465 **448. input variable**

3466 variable quantity which is acting on a system from the outside and which is independent of the other
3467 variable quantities of the system

3468
3469 [Source: IEV 351-41-06]

3470 **449. interlaboratory comparison**

3471 organisation, performance and evaluation of measurements or tests on the same or similar items by two
3472 or more laboratories in accordance with predetermined conditions

3473
3474 [Source: ISO/IEC 17025:2017 3.3]

3475 **450. intralaboratory comparison**

3476 organization, performance and evaluation of measurements or tests on the same or similar items within
3477 the same laboratory in accordance with predetermined conditions

3478
3479 [Source: ISO/IEC 17025:2017 3.4]

3480 **451. inverse fast Fourier transformation (IFFT)**

3481 efficient algorithm to compute the inverse of the discrete inverse discrete Fourier transform

3482
3483 [Source: ISO 15932:2013 5.4.1]

3484 **452. inverse Fourier integral transform (IFIT)**

3485 representation of a real or complex function $f(t)$ of the real variable t by the integral transformation

3486
3487
$$f(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F(\omega) e^{i\omega t} d\omega$$

3488 where $F(\omega)$ is the Fourier integral transform of the function $f(t)$ and i is the imaginary unit with prop-
3489 erty $(\pm i)^2 = -1$

3490
3491 [Source: IEV 103-04-03]

3492
3493 Note to entry: If t is time, the variable ω represents angular frequency.

3494 **453. inverse Fourier transformation (IFT)**

3495 transformation that assigns to the Fourier integral transform of a function this function

3496
3497 [Source: IEV 103-04-04]

3498 **454. inverse Laplace integral transform (ILIT)**

3499 representation of a real or complex function $f(t)$ of the real variable t by the integral transformation

3500
3501
$$f(t) = \frac{1}{2\pi i} \int_{\sigma-i\infty}^{\sigma+i\infty} F(s) e^{st} ds$$

3502 where $F(s)$ is the Laplace integral transform of the function $f(t)$, σ is greater or equal to the abscissa
3503 of convergence of $F(s)$ and i is the imaginary unit with property $(\pm i)^2 = -1$

3504
3505 [Source: IEV 103-04-07]

3506
3507 Note to entry: If $f(t)$ had a nonzero negative time part, $f(t < 0) \neq 0$, it would not have been
3508 captured by the LIT and thus, the ILIT cannot bring it back. Then, ILIT is defined as

3509
3510
$$f(t) h(t) = \frac{1}{2\pi i} \int_{\sigma-i\infty}^{\sigma+i\infty} F(s) e^{st} ds.$$

3511 **455. inverse Laplace transformation (ILT)**

3512 transformation that assigns to the Laplace integral transform of a function this function

3513

3514 [Source: IEV 103-04-08]

3515 **456. item under test (IUT)**

3516 item subject to a test

3517 **457. laboratory test**

3518 test made under prescribed and controlled conditions that may or may not simulate field conditions

3519

3520 [Source: IEV 192-09-05]

3521 **458. laboratory testing**

3522 measurement of product performance quantified under controlled and documented conditions, where
3523 performance can be replicated by duplicating those conditions

3524

3525 [Source: ISO/TR 21276:2018 3.5.9]

3526 **459. Laplace integral transform (LIT)**

3527 for a real or complex function $f(t)$ of the real variable t , complex function $F(s)$ of a complex variable
3528 s , given by the integral transformation

3529
$$F(s) = \int_{0^-}^{+\infty} f(t) e^{-st} dt$$

3530

3531

3532 [Source: IEV 103-04-05]

3533

3534 Note 1 to entry: If t is time, s is complex angular frequency, $s = \sigma + i\omega$, $\sigma, \omega \in \mathbb{R}$.

3535 Note 2 to entry: $F(s) = \mathcal{L}\{f(t)\}(s)$, the LIT of $f(t)$, exists if and only if s is inside the region of
3536 convergence (RoC) which are strips parallel to the $i\omega$ axis in the complex angular frequency plane so
3537 that

3538
$$\int_{0^-}^{+\infty} |f(t)e^{-\sigma t}| dt < \infty;$$

3539

3540 holds for absolutely integrable functions $f(t) = \mathcal{L}^{-1}\{F(s)\}(t)$ (ILIT of $F(s)$). Then, the inherent
3541 attenuation parameter, $\sigma = \Re(s)$ solely determines whether or not $F(s)$ converges. Contrary to FIT,
3542 LIT can deal with locally integrable (bounded) functions $f(t)$ exhibiting

3543
$$\int_{0^-}^{+\infty} |f(t)| dt \rightarrow \infty$$

3544

3545 provided the Laplace integral exists. This conditionally convergent integral transform is used to analyse
3546 causal systems whether or not stable.

3547 Note 3 to entry: LIT is used to derive the immittance of distributed parameter circuit elements from TD
3548 partial differential equations (PDEs) of distributed parameter systems to the complex angular frequency
3549 (Laplace) domain. Applying the Plemelj-Sochocki formula (theorem)¹⁶ (Sochocki, 1873, Plemelj, 1908),
3550 the immittances are obtained in the angular frequency (Fourier) domain.

3551 Note 4 to entry: LIT is related to its inverse (ILIT) by $\mathcal{L}\{\mathcal{L}^{-1}\{F(s)\}(t)\}(s) = f(t)$ and FIT by
3552 $\mathcal{L}\{f(t)\}(s) = 2\pi\mathcal{F}\{f(t) h(t)\}(i\omega)$. This unilateral (one sided) LIT is related to the bilateral (two
3553 sided) LIT to deal with acausal systems, by

3554
$$\mathcal{L}\{f(t)\}(s) = \int_{-\infty}^{+\infty} f(t) h(t) e^{-st} dt.$$

3555

3556 Note 5 to entry: LIT and ILIT are named after French astronomer, mathematician and physicist Pierre-
3557 Simon de Laplace (1749-1827).

¹⁶This theorem is named after Slovene mathematician Josip Plemelj (1873-1967) and Polish mathematician Julian Karol Sochocki (1842-1927).

3558 **460. Laplace transformation (LT)**

3559 transformation that assigns to a function of a real variable its Laplace integral transform

3560 [Source: IECV 103-04-06]

3562 **461. linear sweep voltammetry (LSV)**

3563 measure of current as a function of time (and implicitly as a function of potential) when the potential
3564 of a working electrode is varied linearly with time in respect to the reference electrode with time

3565 [Source: IUPAC Orange Book 8.5.3]

3566 Note 1 to entry: The peak current, i_p (ampere, A) is expressed by the Randles-Ševčík equation:
3567

3568

$$3569 \quad i_p = 0.4463nFAc\sqrt{\frac{nFvD}{R_gT}}$$

3570 where

3571 n is number of electrons transferred in the redox reaction (i. e. 1);

F is Faraday's constant in (C mol⁻¹);

A is electrode area (cm²);

c is concentration in (mol cm⁻³);

3572 D is diffusion coefficient (cm² s⁻¹);

v is scan rate (V s⁻¹);

R_g is universal gas constant (J K⁻¹ mol⁻¹);

3573 T is thermodynamic temperature (K).

3574 Note 2 to entry: The scan is usually started at a potential where no electrode reaction occurs.

3575 Note 3 to entry: LSV corresponds to the first half cycle of cyclic voltammetry.

3576 [Source: IUPAC Recommendations 2019 6.3.14]

3577

3578

3579 **462. load cycle**

3580 repeated loading and unloading of a material such that it undergoes repeated stress

3581 Example: Repeated pressurisation and depressurization of a storage vessel.

3582 [Source: ISO/TR 15916:2015 3.62]

3583

3584

3585 **463. local electrochemical impedance spectroscopy (LEIS)**

3586 electrochemical impedance spectroscopy to probe (and map) the electrical impedance of an electro-
3587 chemical system at a confined active area involving the use of micro-electrodes and some cases, also
3588 nano-structured electrodes

3589 **464. low-energy electron microscopy (LEES)**

3590 method that examines surfaces where images and/or diffraction patterns of the surfaces are formed by
3591 low-energy elastically backscattered electrons generated by a non-scanning electron beam

3592 Note 1 to entry: The method is typically used for the imaging and analysis of very flat, clean sur-
3593 faces.

3594 Note 2 to entry: Low energy electrons have energy typically in the range 1 eV to 100 eV.

3595 [Source: ISO/TS 80004-6:2013 3.5.8]

3596

3597

3598 **465. low-energy ion scattering spectroscopy (LEISS)**

3599 measurement method to elucidate the composition and structure of the outermost atomic layers of a
3600 solid material, in which principally monoenergetic, singly-charged probe ions scattered from the surface

3601 are detected and recorded as a function of their energy, angle of scattering, or both

3602

3603 Note to entry: LEISS is a form of ion beam analysis in which the probe ions, typically He⁺ or Ne⁺, have
3604 energies in the range 0.1 keV to 10 keV.

3605

3606 [Source: IUPAC Recommendations 2020 (Takeuchi et al., 2020) 10]

3607 **466. measurement**

3608 process of experimentally obtaining one or more values that can reasonably be attributed to a quantity

3609

3610 Note 1 to entry: Measurement does not apply to nominal properties.

3611 Note 2 to entry: Measurement implies comparison of quantities, including counting of entities.

3612

3613 [Source: IEC 60050-401-01]

3614 **467. measurement accuracy**

3615 closeness of agreement between a measured quantity value and a true quantity value of a measurand

3616

3617 Note 1 to entry: The concept "measurement accuracy" is not a quantity and is not given a numer-
3618 ical quantity value. A measurement is said to be more accurate when it offers a smaller measurement
3619 error.

3620 Note 2 to entry: The term "measurement accuracy" should not be used for measurement trueness and
3621 the term "measurement precision" should not be used for "measurement accuracy", which, however, is
3622 related to both these concepts.

3623 Note 3 to entry: Measurement accuracy is sometimes under-stood as closeness of agreement between
3624 measured quantity values that are being attributed to the measurand.

3625

3626 [Source: BIPM JCGM VIM 2.13]

3627 **468. measurement procedure**

3628 detailed description of a measurement according to one or more measurement principles and to a given
3629 measurement method, based on a measurement model and including any calculation to obtain a meas-
3630 urement result

3631

3632 Note 1 to entry: A measurement procedure is usually documented in sufficient detail to enable an
3633 operator to perform a measurement.

3634 Note 2 to entry: A measurement procedure can include a statement concerning a target measurement
3635 uncertainty.

3636

3637 [Source: ISO 16577:2016 3.100]

3638 **469. medium-energy ion scattering spectroscopy (MEISS)**

3639 measurement method to elucidate the composition and structure of the very outermost atomic layers
3640 of a solid material, in which principally monoenergetic, singly-charged probe ions scattered from the
3641 surface are detected and recorded as a function of their energy, angle of scattering, or both

3642

3643 Note to entry: MEISS is a form of ion beam analysis in which the probe ions, typically protons, have
3644 energies in the range 100 keV to 200 keV. By using channelling and aligning the incident ion beam along
3645 a crystal axis, the scattering from the substrate can be suppressed, enhancing the signal quality and
3646 visibility obtained for amorphous overlayers. By further aligning the detector along a second crystal axis,
3647 the double alignment mode, the scattering from the substrate can be further suppressed, improving the
3648 signal quality and visibility for amorphous overlayers to a high level. In some cases, an angle sensitive
3649 detector is used that allows extensive structure and depth profile information to be obtained.

3650

3651 [Source: IUPAC Recommendations 2020 (Takeuchi et al., 2020) 11]

3652 **470. nominal operation mode**

3653 operation of the device using the parameter setting defined to obtain the nominal performances as
3654 defined in the Technical Specifications

3655

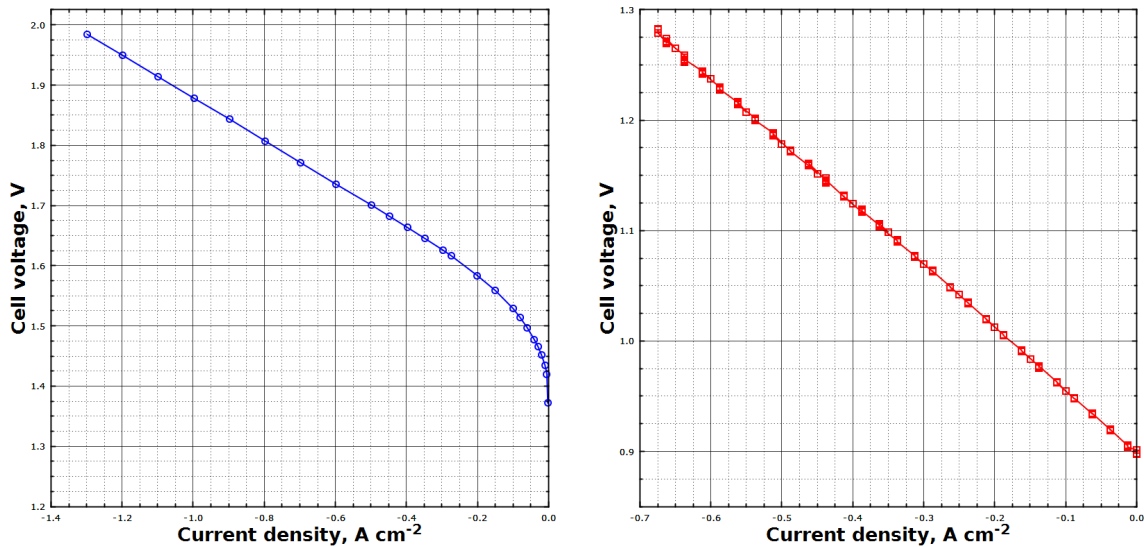
3656 [Source: JRC EUR 29300 EN report 3.17.3]

- 3657 **471. nominal value**
3658 value of a quantity used to designate and identify a component, device, equipment, or system
3659
3660 Note to entry: The nominal value is generally a rounded value.
3661
3662 [Source: IEV 482-03-43]
- 3663 **472. non-intrusive**
3664 describing the way a measurement is taken or an analyses is performed without interruption or with
3665 minimum disturbance which is often limited locally and/or limited in duration
- 3666 **473. nuclear magnetic resonance spectroscopy (NMR)**
3667 method where the resonance magnetic properties of atomic nuclei are used to determine physical and
3668 chemical properties of atoms and molecules
3669
3670 [Source: ISO/TS 80004-6:2013 4.26]
- 3671 **474. Nyquist frequency**
3672 maximum usable frequency available in data taken at a given sampling rate $f_N = \frac{f_s}{2}$ where f_N is the
3673 Nyquist frequency and f_s is the sampling frequency
3674
3675 [Source: ISO 18431-1:2005 3.7]
3676
3677 Note to entry: Nyquist frequency is named after the US engineer Harry Nyquist (1889-1976).
- 3678 **475. open circuit operation**
3679 no-load operation with zero output current
3680
3681 [Source: IEV 151-15-22]
- 3682 **476. operating mode**
3683 preset condition of functioning of the system
3684
3685 [Source: ISO 16110-1:2007 3.51]
- 3686 **477. operating state**
3687 state at which the tested system, more specifically each equipment of the tested system, is operated at
3688 specified conditions
3689
3690 [Source: IEC 62282-8-201:2020 3.1.14]
- 3691 **478. output variable**
3692 recordable variable quantity generated by a system, influenced only by the system and via the system by
3693 its input variables
3694
3695 [Source: IEV 351-41-07]
- 3696 **479. performance evaluation**
3697 process of determining measurable results
3698
3699 [Source: ISO 22300:2018 3.168]
- 3700 **480. polarisation curve**
3701 plot of the output voltage of a cell or a stack as a function of output current density at specified oper-
3702 ating conditions
3703
3704 Note to entry: The polarisation curve is expressed in volt versus ampere per square meter (or ampere per
3705 square centimetre), V versus A/m² (or A/cm²). The values of current density are positive and negative

3706

in fuel cell mode and electrolysis mode, respectively.

Figure 7: Examples of polarisation curves of a PEMEC (left) and a SOEC (right)



3707

3708 **481. post-mortem analysis**

3709 scientific approach for an analysis performed following exposure, measurement or testing to establish
3710 cause of failure or to characterise the state upon end of test or end of life

3711 **482. potentiodynamic test**

3712 test in which the voltage is varied at a pre-programmed rate and the relationship between current density
3713 and voltage is recorded

3714 **483. potentiometry**

3715 method of electroanalytical chemistry based on measurement of an electrode potential

3716

3717 [Source: IEV 114-04-12]

3718 **484. potentiostatic test**

3719 test in which the voltage is maintained constant and the current is recorded as a function of time

3720 **485. qualification test**

3721 procedure to verify conformance to the requirements of a specification

3722

3723 Note to entry: A qualification test is generally performed before starting production of an item on
3724 a larger scale.

3725

3726 [Source: IEV 192-09-04]

3727 **486. Raman spectroscopy**

3728 spectroscopy in which the Raman effect is used to investigate molecular energy levels

3729

3730 [Source: ISO 18115-2:2013 5.129]

3731 [Source: ISO/TS 80004-6:2013 4.10]

3732 **487. rated operating condition**

3733 conditions which are applied for standard operation of equipment and/or system

3734

3735 Note to entry: They are recommended by the equipment and/or system manufacturers considering
3736 the respective characteristics of the equipment/system.

3737

3738 [Source: IEC 62282-8-201:2020 3.1.20]

- 3739 **488. reference gas**
3740 gas with which appliances operate under nominal conditions when supplied at the corresponding normal
3741 pressure
3742
3743 [Source: ISO 14532:2014 2.7.3]
- 3744 **489. reference operating condition**
3745 operating condition prescribed for evaluating the performance of a measuring instrument or measuring
3746 system or for comparison of measurement results
3747
3748 Note to entry: Reference operating condition specify intervals of values of the measurand and of the
3749 influence quantities.
3750
3751 [Source: BIPM JCGM VIM 4.11]
- 3752 **490. reflection electron energy loss spectroscopy (REELS)**
3753 measurement method in which an electron spectrometer is used to measure the energy distribution of
3754 electrons quasi-elastically scattered by atoms at or in a surface layer and the associated electron energy
3755 loss spectrum
3756
3757 [Source: IUPAC Recommendations 2020 (Takeuchi et al., 2020) 5]
- 3758 **491. regulation mode**
3759 mode of operation where the device is working using a variable power, i. e. provided by the network to
3760 compensate for grid imbalances
3761
3762 [Source: JRC EUR 29300 EN report 3.17.4]
- 3763 **492. root cause analysis (RCA)**
3764 systematic process to identify the cause of a fault, failure or undesired event, so that it can be removed
3765 by design, process or procedure changes
3766
3767 [Source: IEC 60880-1-2:2005 3.1.7]
- 3768 **493. round robin testing**
3769 testing of identical materials at different test facilities for the comparison of results
3770
3771 [Source: ISO 14624-3:2005 3.7]
- 3772 **494. routine test**
3773 test made on each individual device during or after manufacture to check if it complies with the require-
3774 ments of the standard concerned or the criteria specified
3775
3776 [Source: IEC 60880-1-2:2005 3.1.7]
- 3777 **495. Rutherford backscattering spectroscopy (RBS)**
3778 measurement method to elucidate composition and structure of layers at the surface of a solid material,
3779 in which principally monoenergetic, singly charged probe ions scattered from the surface with a Ruther-
3780 ford cross section are detected and recorded as a function of their energy or angle of scattering, or both
3781
3782 Note 1 to entry: RBS is a form of ion beam analysis in which the probe ions, typically typically He^+
3783 but sometimes H^+ , have energies in the range 1 MeV to 2 MeV. In its traditional form, a solid-state
3784 energy-dispersive detector is used. In the form of high-resolution RBS, the energy can be reduced to
3785 300 keV and a high-resolution (ion optical) spectrometer can be used. By using channelling and aligning
3786 the incident ion beam along a crystal axis, the scattering from the substrate can be suppressed so that
3787 enhanced signal quality and visibility are obtained for amorphous overlayers.
3788
3789 [Source: IUPAC Recommendations 2020 (Takeuchi et al., 2020) 12]
- 3790
3791 Note 2 to entry: RBS is named after British physicist Ernest Rutherford (1871-1937) who won in
3792 1908 the Nobel Prize in Chemistry.

- 3793 **496. sample**
3794 amount of the material, product, or assembly, to be tested, which is representative of the item as a whole
3795
3796 [Source: ISO 13943:2017 3.334]
- 3797 **497. sampling frequency**
3798 number of samples per unit of time for uniformly sampled data
3799
3800 [Source: ISO 18431-1:2005 3.10]
- 3801 **498. scanning electrochemical microscopy (SECM)**
3802 SPM mode in which imaging occurs in an electrolyte solution with an electrochemically active tip
3803
3804 Note 1 to entry: In most cases, the SECM tip is an ultramicroelectrode and the tip signal is a Faradaic
3805 current from electrolysis of solution species. Note 2 to entry: The potential difference between the
3806 tip and either the sample or a reference electrode is usually monitored. Note 3 to entry: The liquid
3807 is usually an ionic or polar liquid in which an electric double layer exists at the sample surface. Note
3808 4 to entry: The surface may be scanned with the tip at a constant height in the instrument frame to
3809 measure the convolution of topography and electrochemical activity, or if the sample is electrochemically
3810 homogeneous, in a feedback mode so that the tip is at a constant distance from the sample surface and
3811 the topography of the surface is recorded.
3812
3813 [Source: ISO 22493:2014 3.22]
- 3814 **499. scanning electron microscopy (SEM)**
3815 method that examines and analyses the physical information (such as secondary electron, backscattered
3816 electron, absorbed electron and X-rays radiation) obtained by generating electron beams and scanning
3817 the surface of the sample in order to determine the structure, composition and topography of the sample
3818
3819 [Source: ISO/TS 80004-6:2013 3.5.5]
- 3820 **500. scanning ion microscopy (SIM)**
3821 method in which an ion beam focused into a sub-nanometre scale spot is scanned over a surface to
3822 create an image
3823
3824 Note to entry: A variety of different ion sources can be used for imaging, including helium, neon
3825 and argon.
3826
3827 [Source: ISO/TS 80004-6:2013 3.5.9]
- 3828 **501. scanning near field optical microscopy (SNOM)**
3829 method of imaging surfaces optically in transmission or reflection by mechanically scanning an optically
3830 active probe much smaller than the wavelength of light over the surface whilst monitoring the transmit-
3831 ted or reflected light or an associated signal in the near-field regime
3832
3833 Note 1 to entry: Topography is important and the probe is scanned at constant height. Usually the
3834 probe is oscillated in the shear mode to detect and set the height.
3835 Note 2 to entry: Where the extent of the optical probe is defined by an aperture, the aperture size is
3836 typically in the range 10 nm to 100 nm, and this largely defines the resolution. This form of instrument
3837 is often called an aperture scanning near field optical microscopy to distinguish it from a scattering scan-
3838 ning near field optical microscopy (previously called apertureless scanning near field optical microscopy)
3839 although, generally, the adjective "aperture" is omitted. In the apertureless form, the extent of the
3840 optically active probe is defined by an illuminated sharp metal or metal-coated tip with a radius typically
3841 in the range 10 nm to 100 nm, and this largely defines the resolution.
3842 Note 3 to entry: In addition to the optical image, scanning near field optical microscopy can provide a
3843 quantitative image of the surface contours similar to that available in atomic force microscopy and allied
3844 scanning-probe techniques.
3845
3846 [Source: ISO/TS 80004-6:2013 3.5.4]

3847 **502. scanning probe microscopy (SPM)**

3848 method of imaging surfaces by mechanically scanning a probe over the surface under study, in which
3849 the concomitant response of a detector is measured

3850

3851 Note 1 to entry: This generic term encompasses many methods including Atomic force microscopy,
3852 Scanning near field optical microscopy, Scanning ion conductance microscopy and Scanning tunnelling
3853 microscopy.

3854 Note 2 to entry: The resolution varies from that of Scanning tunnelling microscopy, where individual
3855 atoms can be resolved, to Scanning thermal microscopy in which the resolution is generally limited to
3856 around 1 μm .

3857

3858 [Source: ISO/TS 80004-6:2013 3.5.1]

3859 [Source: ISO 18115-2:2013 3.30]

3860 **503. scanning transmission electron microscopy (STEM)**

3861 method that produces magnified images or diffraction patterns of the sample by a finely focused electron
3862 beam, scanned over the surface and which passes through the sample and interacts with it

3863

3864 Note 1 to entry: Typically uses an electron beam with a diameter of less than 1 nm.

3865 Note 2 to entry: Provides high-resolution imaging of the inner microstructure and the surface of a thin
3866 sample [or small particles], as well as the possibility of chemical and structural characterisation of micro-
3867 metre and sub-micrometre domains through evaluation of the X-rays spectra and the electron diffraction
3868 pattern.

3869

3870 [Source: ISO/TS 80004-6:2013 3.5.7]

3871 **504. scanning tunnelling microscopy (STM)**

3872 scanning probe microscopy mode for imaging conductive surfaces by mechanically scanning a sharp,
3873 voltage-biased, conducting probe tip over their surface, in which the data of the tunnelling current and
3874 the tip-surface separation are used in generating the image

3875

3876 Note 1 to entry: Scanning tunnelling microscopy can be conducted in vacuum, a liquid or air. Atomic
3877 resolution can be achieved with suitable samples and sharp probes and can, with ideal samples, provide
3878 localised bonding information around surface atoms.

3879 Note 2 to entry: Images can be formed from the height data at a constant tunnelling current or the
3880 tunnelling current at a constant height or other modes at defined relative potentials of the tip and
3881 sample.

3882 Note 3 to entry: Scanning tunnelling microscopy can be used to map the densities of states at surfaces
3883 or, in ideal cases, around individual atoms. The surface images can differ significantly, depending on the
3884 tip bias, even for the same topography.

3885

3886 [Source: ISO/TS 80004-6:2013 3.5.3]

3887 **505. secondary ion mass spectroscopy (SIMS)**

3888 method in which a mass spectrometer is used to measure the mass-to-charge quotient and abundance
3889 of secondary ions emitted from a sample as a result of bombardment by energetic ions

3890

3891 Note 1 to entry: Secondary ion mass spectroscopy is, by convention, generally classified as dynamic,
3892 in which the material surface layers are continually removed as they are being measured, and static, in
3893 which the ion areic dose during measurement is restricted to less than 10^{16} ions/ m^2 in order to retain
3894 the surface in an essentially undamaged state.

3895

3896 [Source: ISO/TS 80004-6:2013 4.23]

3897

3898 Note 2 to entry: Static secondary ion mass spectroscopy (SSIMS) uses low current densities for analysis
3899 of sample surface components usually by time of flight mass spectrometer (TOF-SIMS), in contrast
3900 with dynamic secondary ion mass spectroscopy (DSIMS) which is used for analysis of components in
3901 the depth direction.

3902

3903 [Source: IUPAC Recommendations 2020 (Takeuchi et al., 2020) 29]

- 3904 **506. sensitivity analysis**
3905 test of the outcome of an analysis by altering one or more parameters from initial value(s)
3906
3907 [Source: ISO/TR 15686-11:2014 3.1.112]
- 3908 **507. set point**
3909 specific value for an environmental parameter that is being controlled
3910
3911 [Source: ISO/IEC 29197:2015 4.14]
- 3912 **508. short circuit operation**
3913 no-load operation with zero output voltage
3914
3915 [Source: IEC 60335-1:2015 23.1.1.1]
3916
3917 Note to entry: In short circuit operation, the positive and negative electrodes are connected directly
3918 leading to a maximum current.
- 3919 **509. short-stack test**
3920 electrolyser stack test with a significantly smaller number of cells than the designed stack with rated
3921 power, but with a high enough number of cells to represent the scaled characteristics of the full stack
3922
3923 [Source: JRC EUR 29300 EN report 3.24.10]
- 3924 **510. single cell test**
3925 parametric test for the assessment of performance and degradation behaviour performed on one single cell
3926
3927 [Source: JRC EUR 29300 EN report 3.24.11]
- 3928 **511. small-angle neutron scattering spectroscopy (SANS)**
3929 method in which a beam of neutrons is scattered from a sample and the scattered neutron intensity is
3930 measured for small angle deflection
3931
3932 Note to entry: The scattering angle is usually between 0.5° and 10° in order to study the structure
3933 of a material on the length scale of 1 nm to 100 nm. The method provides information on the sizes of
3934 the particles and to a limited extent the shapes of the particles dispersed in homogeneous medium.
3935
3936 [Source: ISO/TS 80004-6:2013 3.2.2]
- 3937 **512. small-angle X-ray scattering spectroscopy (SAXS)**
3938 method in which the elastically scattered intensity of X-rays is measured for small-angle deflections
3939
3940 Note 1 to entry: The angular scattering is usually measured within the range 0.1° to 10° . This provides
3941 structural information on macromolecules as well as periodicity on length scales typically larger than 5
3942 nm and less than 200 nm for ordered or partially ordered systems.
3943
3944 [Source: ISO/TS 80004-6:2013 3.2.4]
3945
3946 Note 2 to entry: Wide-angle X-ray scattering spectroscopy (WAXS) is an analogous technique, sim-
3947 ilar to X-rays crystallography, in which scattering at larger angles, which is sensitive to periodicity on
3948 smaller length scales, is measured.
3949 Note 3 to entry: The X-rays source can be a synchrotron, in which case the term synchrotron radiation
3950 small-angle X-ray scattering spectroscopy (SAXS) is occasionally encountered.
3951
3952 [Source: IUPAC Recommendations 2020 (Takeuchi et al., 2020) 48]
- 3953 **513. specified condition**
3954 conditions that are required to be met during operation or test
3955
3956 [Source: ISO 5598:2019 3.2.703]

- 3957 **514. sputtered neutral mass spectroscopy (SNMS)**
3958 method in which a mass spectrometer is used to measure the mass-to-charge quotient and abundance
3959 of secondary ionized neutral species emitted from a sample as a result of particle bombardment
3960
3961 [Source: ISO 18115-1:2013 3.19]
- 3962 **515. stabilisation**
3963 state when a specified number of successive readings taken in a measurement at a specified time interval
3964 indicate no substantial change given a defined range or limit of the measuring range
- 3965 **516. stack test**
3966 test of the fuel cell or electrolysis cell performance based on a stack
3967
3968 Note to entry: The stack test involves variables that can be related to individual cells (flow, pres-
3969 sure, temperature, voltage, etc) or the whole stack (flow rates, pressures, temperature, current density,
3970 etc) and adjusted in order to obtain data over a wide range of conditions. The outcome of a stack test
3971 can be a polarisation curve, a single cell's voltages stability plot, or other data related to performance.
- 3972 **517. standard operating procedure**
3973 documented procedure describing how to perform tests or activities normally not specified in detail in
3974 test plans or guidelines
- 3975 **518. steady state**
3976 state of a system at which all state and output variables remain constant in time while all input variables
3977 are constant
3978
3979 [Source: ISO/TR 8713:2019 3.138]
- 3980 **519. steady-state operating condition**
3981 operating conditions in which relevant parameters are in steady state after a period of stabilisation
3982
3983 [Source: ISO 5598:2019 3.2.726]
- 3984 **520. stress testing**
3985 type of performance efficiency testing conducted to evaluate a test item's behaviour under conditions of
3986 loading above anticipated or specified capacity requirements, or of resource availability below minimum
3987 specified requirements
3988
3989 [Source: ISO/IEC/IEEE 29119-1:2013 4.43]
- 3990 **521. surface enhanced ellipsometric contrast microscopy (SEEC)**
3991 method of optical imaging using the association of contrast-enhancing surfaces as sample slides and a
3992 reflected light optical microscope with crossed polarisers
3993
3994 Note to entry: The contrast-enhancing slides are designed to become anti-reflecting when used in
3995 these conditions, leading to an increase in the axial sensitivity of the optical microscope by a factor of
3996 around 100.
3997
3998 [Source: ISO/TS 80004-6:2013 3.5.11]
- 3999 **522. surface-enhanced Raman spectroscopy (SERS)**
4000 enhanced Raman effect observed for certain molecules or nano-objects adsorbed to particular metal sur-
4001 faces whose roughness is in the nano scale when illuminated with suitable light
4002
4003 Note to entry: The roughness of a surface is typically in the range of a few tens of nanometres for
4004 enhancement to occur.
4005
4006 [Source: ISO/TS 80004-6:2013 4.11]

- 4007 **523. system test**
4008 test of a complete system to detect instances of non-conformity with the respective functional specific-
4009 ation
4010
4011 Note to entry: System test is mainly for verification, but may include some validation.
4012
4013 [Source: IEV 192-09-25]
- 4014 **524. system testing**
4015 testing conducted on a complete, integrated system to evaluate the system's compliance with its spe-
4016 cified requirements
4017
4018 [Source: ISO/IEC/IEEE 26511:2018 3.1.31]
- 4019 **525. test**
4020 technical operation that consists of the determination of one or more characteristics or performance of
4021 a given product, material, equipment, organism, physical phenomenon, process, or service according to
4022 a specified procedure
4023
4024 [Source: ISO 16484-2:2004 3.190]
- 4025 **526. test condition**
4026 testable aspect of a component or system, such as a function, transaction, feature, quality attribute, or
4027 structural element identified as a basis for testing
4028
4029 Note to entry: Test conditions can be used to derive coverage items, or can themselves constitute
4030 coverage items.
4031
4032 [Source: ISO/IEC/IEEE 29119-1:2013 4.52]
- 4033 **527. test cycle**
4034 sequence of specific and reproducible operating, environmental and maintenance conditions that are
4035 repeated periodically during a test
4036
4037 Note to entry: The operating conditions are varied to simulate the time variation of operating and
4038 environmental conditions of intended use.
4039
4040 [Source: IEV 192-09-16]
- 4041 **528. test equipment**
4042 measuring system and its accessories used in a test, other than the indicating measuring instruments
4043 under test and its recognised accessories
4044
4045 [Source: ISO 14253-5:2015 3.10]
- 4046 **529. test instruction**
4047 distinct piece of information required within the framework of test execution
4048
4049 [Source: ISO/IEC 18745-1:2018 3.10]
- 4050 **530. test parameter**
4051 parameter that specifies one or more characteristics of a system to be tested
4052
4053 [Source: ISO 14907-1:2020 3.29]
- 4054 **531. test plan**
4055 list of test sequences and their specific test parameters and expected evaluation results
4056
4057 [Source: ISO/IEC 18745-1:2018 3.11]
4058
4059 Note 1 to entry: A project can have more than one test plan, for example there could be a project

4060 test plan (also known as a master test plan) that encompasses all testing activities on the project;
4061 further detail of particular test activities could be defined in one or more test sub-process plans (i.e. a
4062 system test plan or a performance test plan).

4063 Note 2 to entry: Typically a test plan is a written document, though other plan formats could be possible
4064 as defined locally within an organization or project.

4065 Note 3 to entry: Test plans could also be written for non-project activities, for example a maintenance
4066 test plan.

4067
4068 [Source: ISO/IEC/IEEE 29119-1:2013 4.75]

4069 **532. test procedure**

4070 set of instructions to be followed in order to obtain a test result

4071
4072 [Source: ISO/IEC 18745-1:2018 3.12]

4073
4074 Note to entry: Test procedures include detailed instructions for how to run a set of one or more test
4075 cases selected to be run consecutively, including set up of common preconditions, and providing input
4076 and evaluating the actual result for each included test case.

4077
4078 [Source: ISO/IEC/IEEE 29119-1:2013 4.78]

4079 **533. test protocol**

4080 list of the steps to be followed in the test

4081
4082 [Source: ISO/IEC/IEEE 26513:2017 3.41]

4083
4084 Note 1 to entry: The test protocol is defined either by relevant standards or - when none is avail-
4085 able - by the tester or the tester counterpart.

4086 Note 2 to entry: The tester and the tester counterpart are to agree upon the test protocol prior to the
4087 test.

4088 Note 3 to entry: An unambiguous test protocol is crucial for the effectiveness of a test. In particular,
4089 the definition of the set of permissible test instances constitutes a trade-off between thoroughness and
4090 practical and economical viability of the test.

4091
4092 [Source: ISO 14253-5:2015 3.5]

4093 **534. test report**

4094 document that presents the test results and other information relevant to the tests (e.g., configuration
4095 description and detected errors)

4096
4097 [Source: ISO/IEC 10641:1993 3.29]

4098 **535. test result**

4099 indication of whether or not a specific test case has passed or failed, i.e. if the actual result observed as
4100 test item output corresponds to the expected result or if deviations were observed

4101
4102 [Source: ISO/IEC/IEEE 29119-1:2013 4.82]

4103 **536. test sequence**

4104 test procedure that comprises a number of different methods in a defined order of execution

4105
4106 [Source: ISO/IEC 18745-1:2018 3.13]

4107 **537. test site**

4108 location of the system under test and its surroundings

4109 **538. test state**

4110 state of the tested system that is consistent with the objective of the evaluation

4111
4112 Note to entry: More specifically, it means the specific operating state for equipment of the tested system.

4113
4114 [Source: IEC 62282-8-201:2020 3.1.28]

- 4115 **539. test value**
4116 value of a quantity for which the relay shall comply with a specified action during a test
4117
4118 [Source: IEV 444-02-20]
4119
4120 value of a quantity for which the tested item shall comply with a specified action during a test
- 4121 **540. testing**
4122 activity carried out to determine, by specific procedures, that one or more characteristic of a product,
4123 process or service meet(s) one or more specified requirements
4124
4125 [Source: ISO 16528-1:2007 2.17]
- 4126 **541. thermogravimetric analysis (TGA)**
4127 method in which the change in mass of a sample is measured as a function of temperature while the
4128 sample is subjected to a controlled temperature programme
4129
4130 [Source: ISO/TS 80004-6:2013 5.1.2]
- 4131 **542. time window**
4132 weighting function applied to an ensemble of sampled data to reduce the amount of energy which flows
4133 into adjacent frequency (spectral leakage) caused by sampling a signal that is not periodic within the
4134 finite time record of the observation interval, i. e. that has truncated sinusoidal components
4135
4136 [Source: ISO 18431-2:2004 3.3]
4137
4138 Note to entry: Several time window (apodisation) functions exists (Harris, 1978, Gade and Herlufsen,
4139 1987a, Gade and Herlufsen, 1987b).
- 4140 **543. transfer function**
4141 for a LTI system, ratio of the LIT of a time varying output signal to the LIT of the corresponding time
4142 varying input signal
- 4143 **544. transmission electron microscopy (TEM)**
4144 method that produces magnified images or diffraction patterns of the sample by an electron beam which
4145 passes through the sample and interacts with it
4146
4147 [Source: ISO/TS 80004-6:2013 3.5.6]
- 4148 **545. type approval**
4149 process of testing a design (type of documents produced while using a common material and component
4150 basis and the same manufacturing processes, including same production quality assurance process) to
4151 ensure it is compliant-in-principle with the specifications
4152
4153 [Source: ISO/IEC 18745-1:2018 3.14]
- 4154 **546. type test**
4155 proof-of-design test, which is done once and is repeated only after change of design
4156
4157 [Source: ISO 7186:2011 3.34]
- 4158 **547. validation test**
4159 test performed to qualify a particular size, type and model of product for a specific grade of service
- 4160 **548. voltammetry**
4161 method of electroanalytical chemistry in which the electric current resulting from the application of an
4162 electric potential at an electrode is measured
4163
4164 [Source: IEV 114-04-11]

4165 **549. X-ray absorption fine structure spectroscopy (XAFS)**

4166 measurement method to measure the absorption of X-rays at energy near and above (typically several
4167 hundred eV greater) an absorption edge, over which fine structure (modulation of the X-rays absorption
4168 coefficient) can be detected

4169

4170 Note 1 to entry: XAFS includes both extended X-rays absorption fine structure spectroscopy and X-rays
4171 absorption near edge spectroscopy. It involves transitions from a core-level to an unoccupied orbital
4172 or band and mainly reflects the local atomic structure and bonding (SEXAFS) and the density of the
4173 unoccupied electronic states (XANES).

4174 Note 2 to entry: XAFS measurements usually start some 10 eV before the core-level binding energy (the
4175 absorption edge) of the emitting atoms, because in many cases pre-edge features are used to identify
4176 chemical bonds [example: π^* resonances (excitation into lowest unoccupied molecular orbitals) in C
4177 K-edge spectra of polymer samples].

4178 Note 3 to entry: Usefully sharp absorption edges are commonly observed in X-rays absorption spectra,
4179 although broader increases can be observed for some inner-shell excitations with short lifetimes.

4180 Note 4 to entry: XAFS spectra are best recorded when a highly intense beam of X-rays from a syn-
4181 chrotron is used along with a high resolution double crystal or curved crystal spectrometer. Detectors
4182 include ionisation chambers, scintillation counters, and solid state detectors.

4183

4184 [Source: IUPAC Recommendations 2020 (Takeuchi et al., 2020) 61]

4185

4186 Note 5 to entry: Related measurement method are extended X-ray absorption fine structure spectroscopy
4187 (EXAFS) and near-edge extended X-ray absorption fine structure spectroscopy (NEXAFS).

4188 **550. X-ray diffraction spectroscopy (XRD)**

4189 scattering in which the incident radiation is a beam of X-rays

4190

4191 Note to entry: The elastic scattering of the X-rays from the electron clouds of atoms in a system
4192 produces a diffraction pattern that gives information about the crystallographic structure.

4193

4194 [Source: ISO/TS 11937:2012 3.2]

4195 **551. X-ray absorption spectroscopy (XAS)**

4196 method in which the absorption of X-rays passing through matter is measured as a function of X-rays
4197 energy

4198

4199 Note 1 to entry: The method is used to determine local geometric and/or electronic structure of
4200 matter.

4201 Note 2 to entry: X-RAY absorption fine structure spectroscopy, X-ray absorption near edge spectroscopy,
4202 near-edge extended X-ray absorption fine structure spectroscopy are all types of X-rays absorption spec-
4203 troscopy.

4204

4205 [Source: ISO/TS 80004-6:2013 4.19]

4206 **552. X-ray fluorescence spectroscopy (XRF)**

4207 secondary radiation occurring when a high intensity incident X-rays beam impinges upon a material
4208 placed in the path of the incident beam

4209

4210 Note 1 to entry: The secondary emission has wavelengths and energies characteristic of that mater-
4211 ial.

4212

4213 [Source: ISO/TS 80004-6:2013 4.20]

4214 **553. X-ray photoelectron spectroscopy (XPS)**

4215 measurement method in which an electron spectrometer is used to measure the energy distribution of
4216 photoelectrons and Auger electrons emitted from a surface irradiated by X-rays photons

4217

4218 Note 1 to entry: X-rays sources in common use are unmonochromated Al K α and Mg K α X-rays at
4219 1,486.6 eV and 1,253.6 eV, respectively. Modern instruments also use monochromated Al K α X-rays.
4220 Some instruments make use of various X-rays sources with other anodes or of synchrotron radiation.

4221

4222 [Source: ISO/TS 80004-6:2013 4.18]

4223

4224 Note 2 to entry: Synchrotron X-ray XPS can be performed under vacuum, ambient, or high pressure,
4225 enabling investigations of surfaces under ambient and extreme conditions. Emitted electrons include
4226 photoelectrons and Auger electrons.

4227

4228 [Source: IUPAC Recommendations 2020 (Takeuchi et al., 2020) 7]

4229 **2.1.5 Phenomena & properties**

4230 **554. abnormal operation**

4231 process-linked malfunction that occurs infrequently

4232

4233 [Source: IEV 426-03-29]

4234 **555. absorption**

4235 process of one material (absorbate) being retained by another (absorbent); this may be the physical
4236 solution of a gas, liquid, or solid in a liquid, attachment of molecules of a gas, vapour, liquid, or dis-
4237 solved substance to a solid surface by physical forces, etc

4238

4239 [Source: IUPAC Gold Book A00036]

4240 **556. activation**

4241 final process by which electrochemical active components of a cell are brought to functional completion
4242 in order to deliver electrical energy

4243

4244 [Source: IEV 482-01-19]

4245 **557. activation losses**

4246 overpotential contribution due to catalyst material electrodes properties and related activation energy
4247 requirements

4248

4249 [Source: JRC EUR 29300 EN report 3.24.7.1]

4250 **558. adsorption**

4251 process in which the molecules of a gas adhere by physical or chemical processes to the exposed surfaces
4252 of solid substances, both the outer surface and inner pore surface, with which they come into contact

4253

4254 [Source: ISO 10121-2:2013 3.4]

4255 **559. all-pass system**

4256 system the transfer function of which has as many poles as zeros with the property that all its zeros
4257 have positive real parts and are situated in the right half plane as reflections at the imaginary axis of
4258 the poles in the left half plane

4259

4260 [Source: IEV 351-42-18]

4261 **560. anisotropy**

4262 pertaining to a material whose specified property is spatial direction (orientation) dependent

4263 **561. artefact**

4264 unwanted distortion or added feature in measured data arising from lack of idealness of equipment

4265

4266 [Source: ISO 18115-2:2013 5.6]

4267 **562. Bjerrum length**

4268 separation at which the electrostatic interaction between two elementary charges, e is comparable in
4269 magnitude to the thermal energy, $k_B T$ while given by

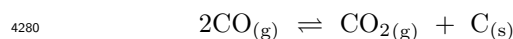
4270
$$\lambda_B = \frac{e^2}{4\pi\epsilon_0\epsilon_r k_B T}$$

4271 where e is the elementary charge, ε_0 and ε_r are the vacuum permittivity and the relative dielectric
4272 constant of the medium, respectively while k_B is the Boltzmann constant¹⁷ and T is the thermodynamic
4273 temperature

4274
4275 Note to entry: This length scale is named after Danish chemist Niels Janniksen Bjerrum (1879-1958).

4276 **563. Boudouard reaction**

4277 redox reaction of a chemical equilibrium mixture of carbon monoxide and carbon dioxide at a given
4278 temperature that is, carbon monoxide disproportionates exothermically into carbon dioxide and carbon
4279 or *vice versa*:



4281 Note to entry: This reaction is named after the French chemist Octave Leopold Boudouard (1872-1923).

4282 **564. boundary layer**

4283 region in the immediate vicinity of a bounding surface in which the velocity of a flowing fluid increases
4284 rapidly from zero and approaches the velocity of the main stream

4285
4286 [Source: ISO/IEC TR 22560:2017 3.3]

4287 **565. bubble coverage**

4288 percentage of the electrode active area covered by gas bubbles

4289
4290 [Source: JRC EUR 29300 EN report 3.24.7.2.1]

4291 **566. bubble losses**

4292 overpotential contribution due to the reduction of the effective active area available for the electrolysis
4293 reaction where the produced gas bubbles remain in contact with electrodes' surfaces

4294
4295 Note to entry: A second phenomenon owing to the presence of gas bubbles is the reduction of electrolyte
4296 conductivity.

4297
4298 [Source: JRC EUR 29300 EN report 3.24.7.2]

4299 **567. bubble void fraction**

4300 gas volume fraction present in the electrolyte solution

4301
4302 [Source: JRC EUR 29300 EN report 3.24.7.2.2]

4303 **568. capacitive**

4304 qualifies an electric device or an electric circuit the predominant quantity of which, under given condi-
4305 tions, is a capacitance

4306
4307 [Source: IEV 151-15-54]

4308 **569. co-flow**

4309 fluid flow in the same direction through adjacent parts of an apparatus

4310
4311 [Source: IEV 485-06-17]

4312 **570. coloured noise**

4313 random noise which has a continuous spectrum and a varying Power spectral density (PSD) in the
4314 frequency band considered

4315
4316 [Source: IEV 702-08-40]

4317 **571. compressibility**

4318 capacity of a substance or item to be densified (compacted) under an uni-axially applied pressure

¹⁷This constant is named after Austrian physicist Ludwig Eduard Boltzmann (1844-1906).

- 4319 **572. concentration losses**
4320 overpotential contribution due to transport reactants or diffusion limitations
4321
4322 [Source: JRC EUR 29300 EN report 3.24.7.7]
- 4323 **573. condensation**
4324 process of changing a vapour into liquid
4325
4326 [Source: ISO 3857-4:2012 2.19]
- 4327 **574. conducting**
4328 qualifies a device or an electric circuit to indicate that it is carrying electric current
4329
4330 [Source: IEC 60050-421-10:2004 421-10-01]
- 4331 **575. conduction**
4332 mass or heat transfer by interaction of a species with matter
- 4333 **576. conductive**
4334 qualifies a medium to indicate that it can carry electric current
4335
4336 [Source: IEC 60050-421-10:2004 421-10-02]
- 4337 **577. convection**
4338 transfer of amount of heat by a moving fluid
4339
4340 Note 1 to entry: Convection can be natural or forced.
4341 Note 2 to entry: Convection is always associated with thermal conduction.
4342 Note 3 to entry: The state of the moving fluid may change by phase transition or chemical reaction.
4343
4344 [Source: IEC 60050-421-10:2004 421-10-03]
- 4345 **578. convective heat transfer**
4346 transfer of heat to a surface from a surrounding fluid by convection
4347
4348 Note 1 to entry: The amount of heat transfer depends on the temperature difference between the
4349 fluid and the surface, the fluid properties and the fluid velocity and direction.
4350 Note 2 to entry: The fundamental modes of heat transfer are conduction or diffusion, convection and
4351 radiation.
4352
4353 [Source: ISO 13943:2017 3.68]
4354
4355 Note to entry: The coherent SI unit of convective heat transfer is watt per square meter, $W m^{-2}$.
- 4356 **579. cooling**
4357 process whereby heat is removed from a material, fluid or atmosphere
4358
4359 [Source: ISO 13574:2015 2.43]
- 4360 **580. cross flow**
4361 fluid flow crossing at an angle essentially perpendicular to another fluid flow through adjacent parts
- 4362 **581. crossover**
4363 leakage between the two electrode sides of an electrochemical cell, in either direction, generally through
4364 the electrolyte
4365
4366 Note to entry: Crossover is due to different transport mechanisms: differential pressure, diffusion,
4367 electro-osmotic drag and electro-migration.

- 4368 **582. cryogenic**
4369 condition involving very low temperatures in the vicinity of the normal boiling point
4370
4371 [Source: ISO/TR 15916:2015 3.20]
- 4372 **583. cycle**
4373 one complete set of events or conditions which repeats in a periodical or cyclic manner
4374
4375 [Source: ISO 5598:2019 3.2.157]
- 4376 **584. degradation**
4377 irreversible process leading to a significant change in the structure of a material, typically characterized
4378 by a change of properties (e. g. integrity, molecular mass or structure, mechanical strength) and/or by
4379 fragmentation, affected by environmental conditions, proceeding over a period of time and comprising
4380 one or more steps
4381
4382 [Source: ISO 472:2013 2.262]
- 4383 **585. desorption**
4384 physical process in which the molecules of a gas, vapour or liquid are removed from the surface of a
4385 solid
4386
4387 [Source: ISO 3857-4:2012 2.27]
- 4388 **586. diffuse layer**
4389 region in which non-specifically adsorbed ions are accumulated and distributed by the contrasting action
4390 of the electric field and thermal motion
4391
4392 Note to entry: Counter and co-ions in immediate contact with the surface are said to be located in
4393 the Stern layer. Ions farther away from the surface form the diffuse layer or Gouy layer.
4394
4395 [Source: IUPAC Gold Book D01714]
- 4396 **587. diffusion**
4397 irregular spreading or scattering of a gaseous or liquid material
4398
4399 Note 1 to entry: Eddy diffusion is the process of transport of gases due to turbulent mixing in the
4400 presence of a composition gradient. Molecular diffusion is the net transport of molecules that results
4401 from their irregular molecular motions alone in the absence of turbulent mixing; it occurs when the
4402 concentration gradient of a particular gas in a mixture differs from its equilibrium value.
4403
4404 [Source: IUPAC Recommendation 2020 (Jones et al., 2020) AL-2.32]
4405
4406 Note 2 to entry: Diffusion coefficient is mass of species diffusing across a unit of area in a unit of
4407 time at a unit gradient.
- 4408 **588. dilution**
4409 continuous supply of a protective gas, after purging, at such a rate that the concentration of a flammable
4410 substance inside the pressurised enclosure is maintained at a value outside the flammable limits at any
4411 potential ignition source (that is to say, outside the dilution area)
4412
4413 Note to entry: Dilution of oxygen by inert gas can result in a concentration of flammable gas or
4414 vapour above the upper flammability limit.
4415
4416 [Source: IEC 426-09-07]
- 4417 **589. discrete signal**
4418 signal composed of successive elements in time, each element having one or more characteristic quantities which can represent data
4419
4420

4421 Note to entry: Examples of characteristic quantities are amplitude, wave-form, duration, and position in time.
4422
4423
4424 [Source: ISO/IEC 2382:2015 2124353]

4425 **590. distortion**
4426 rms value of the AC waveform exclusive of the fundamental component in an AC system, or the rms
4427 value of the alternating (ripple) component on the DC level in a DC system
4428
4429 Note to entry: AC system distortion can include harmonic and non-harmonic components. Harmonics
4430 are sinusoidal distortion components which occur at integer multiples of the fundamental frequency.
4431 Interharmonics are distortion components which occur at non-integer multiples of the fundamental frequency. These and all other elements of waveform distortion are included in this general definition of distortion.
4432
4433
4434
4435 [Source: ISO 1540:2006 3.5]

4436 **591. distributed**
4437 qualifies a circuit element for which the relations between integral quantities contain derivatives with
4438 respect to space coordinates
4439
4440 [Source: IEC 131-11-10]

4441 **592. distributed parameter system**
4442 system mathematically described by partial differential equations in order to represent its distribution in
4443 space
4444
4445 [Source: IEC 351-42-16]

4446 **593. down state**
4447 state of being unable to perform as required including due to preventive maintenance

4448 **594. downstream**
4449 away from a component in the direction of flow
4450
4451 [Source: ISO 13628-6:2006 3.8]

4452 **595. drag**
4453 force acting opposite to the relative motion of any object moving with respect to a surrounding fluid
4454
4455 [Source: ISO/IEC TR 22560:2017 3.7]

4456 **596. durability**
4457 ability of an item to perform a required function under given conditions of use and maintenance, until
4458 a limiting state is reached
4459
4460 Note to entry: A limiting state of an item should be characterised by the end of the useful life, unsuitability for any economic or technological reasons, or other relevant factors.
4461
4462
4463 [Source: ISO 14708-5:2010 3.112]

4464 **597. electrolyte leakage**
4465 undesired escape of liquid electrolyte from a cell/stack
4466
4467 [Source: JRC EUR 29300 EN report 2.4]

4468 **598. electronic conduction**
4469 electrical conduction where electrons (or holes) carry the electrical charges
4470
4471 [Source: ISO 11894-1:2013 3.2]

4472 **599. endurance**

4473 ability to withstand the action of aging factors

4474

4475 Note to entry: The endurance may be characterized by the results of accelerated ageing tests.

4476

4477 [Source: IEV 212-12-08]

4478 **600. equation of state (EoS)**

4479 equations that relate the properties of a given substance to its thermodynamic condition

4480

4481 [Source: ISO/TR 12748:2015 2.9]

4482 **601. equilibrium**

4483 state of balance between opposing forces or actions that is either static or dynamic

4484

4485 [Source: ISO/TR 27912:2016 3.29]

4486 **602. external leakage**

4487 leakage from the interior of a component or piping to the surrounding environment

4488

4489 [Source: ISO 5598:2019 3.2.266]

4490 **603. Fick's first law**

4491 non-relativistic first-order ODE relating the diffusive flux of a species to its instantaneous spatial change
4492 in concentration $c(\mathbf{x}, t)$ as a function of spatial position, x_i and time, t , within a medium generally
4493 expressed as

4494
$$\mathbf{J}(\mathbf{x}, t) = D \nabla c(\mathbf{x}, t), \mathbf{x} \in \mathbb{R}^n, t \in \mathbb{R}$$

4495 where the scalar, D is the diffusion coefficient of the species in the medium and $\nabla = \sum_{i=1}^n \partial_{x_i}$
4496 is the gradient operator acting on the n space variables which form the real valued vector space,
4497 $\mathbf{x} = (x_1, \dots, x_n)$, $n \in \mathbb{N} \setminus \{0\}$

4498

4499 Note 1 to entry: In one spatial dimension, $x_1 = x$, this law reduces in planar geometry to

4500
$$J(x, t) = D \partial_x c(x, t), x, t \in \mathbb{R}.$$

4501 Note 2 to entry: In a non-homogeneous medium, the scalar, D may vary in space while in an anisotropic
4502 medium, D becomes a tensor. In case of anomalous diffusion also known as sub-diffusion or super-
4503 diffusion particular in porous media with variable degrees of tortuosity, the spatial derivative is replaced
4504 by the fractal or fractional pendant to result in a integro-differential diffusion equation.

4505 Note 3 to entry: Fick's first law combined with the continuity equation, $\partial c(\mathbf{x}, t) = \nabla \cdot \mathbf{J}(\mathbf{x}, t)$, yields
4506 Fick's second law.

4507 Note 4 to entry: This law and Fick's second law are named after German physiologist Adolf Eugen Fick
4508 (1829-1901).

4509 **604. Fick's second law**

4510 non-relativistic second-order PDE relating the temporal change in the concentration of a species, $c(\mathbf{x}, t)$
4511 as a function of spatial position, x_i and time, t , within a medium to the instantaneous spatial change
4512 of its concentration gradient generally expressed as

4513
$$\partial_t c(\mathbf{x}, t) = D \nabla^2 c(\mathbf{x}, t), \mathbf{x} \in \mathbb{R}^n, t \in \mathbb{R}$$

4514 where the scalar, D is the diffusion coefficient of the species in the medium and $\nabla^2 = \sum_{i=1}^n \partial_{x_i}^2$
4515 is the Laplacian operator acting on the n space variables which form the real valued vector space,
4516 $\mathbf{x} = (x_1, \dots, x_n)$, $n \in \mathbb{N} \setminus \{0\}$

4517

4518 Note 1 to entry: In one spatial dimension, $x_1 = x$, this law reduces in planar geometry to

4519
$$\partial_t c(x, t) = D \partial_x^2 c(x, t), x, t \in \mathbb{R}.$$

4520 Note 2 to entry: In a non-homogeneous medium, the scalar, D may vary in space while in an anisotropic
4521 medium, D becomes a tensor. In these cases, the Laplacian is modified to $\nabla^2 = \nabla \cdot (D(\mathbf{x}) \nabla)$. In

4522 case of anomalous diffusion also known as sub-diffusion or super-diffusion particular in porous media
4523 with variable degrees of tortuosity, the spatial and/or time derivatives are replaced by their fractal or
4524 fractional pendants to result in a integro-differential diffusion equation.

4525 **605. flatness**

4526 minimum distance between two parallel planes that contain the surface

4527

4528 [Source: ISO 18115-2:2013 5.50]

4529 **606. flow**

4530 movement of fluid generated by differential pressure and defined by either volumetric or mass flow rates,
4531 such as litres per second or kilograms per second

4532

4533 [Source: ISO 8625-2:2018 3.3]

4534 **607. fluid**

4535 gases, liquids and vapour in pure phases as well as mixtures thereof

4536

4537 [Source: ISO 13628-7:2005 3.1.57]

4538 **608. fraction**

4539 distinct portion of material derived from a complex matrix, the composition of which differs from ante-
4540 cedent material

4541

4542 Note to entry: This concept is used to describe source material and is recursive in that a subsequent
4543 fraction can be derived from an antecedent fraction.

4544

4545 [Source: ISO 11238:2018 3.28]

4546 **609. frequency response**

4547 for a linear, time invariant system with a sinusoidal input variable in steady state of the output variable
4548 the ratio of the phasor of the output variable to the phasor of the corresponding input variable, repres-
4549 ented as a function of the angular frequency

4550

4551 Note to entry: The frequency response coincides with the transfer function taken on the imaginary
4552 axis of the complex plane.

4553

4554 [Source: IEV 351-45-41]

4555 **610. gain**

4556 increase in signal magnitude from one point to another (reciprocal of attenuation)

4557

4558 Note to entry: Gain may be expressed as a scalar ratio of the input magnitude to the output mag-
4559 nitude.

4560 **611. gas absorption**

4561 amount of gas absorbed by a liquid or adsorbed by a solid in contact with the gas under specified con-
4562 ditions

4563

4564 [Source: IEV 212-12-25]

4565 **612. gas leakage**

4566 collectively for all gases leaving the cell or stack, except those who are intended to leave

4567 **613. gas tightness**

4568 system characteristic that ensures that no exchange of fluids and gases between two or more compart-
4569 ments of a device occurs, i. e. between anode and cathode or the surrounding space

4570

4571 [Source: JRC EUR 29300 EN report 3.11]

4572 **614. Gaussian noise**

4573 random noise the values of which over any number n of arbitrary instants are distributed in accordance
4574 with an n -variable Gaussian probability law

4575

4576 Note 1 to entry: Gaussian noise is entirely defined by its time varying mean and by a covariance
4577 function of two instants. If the noise is stationary the mean is independent of time, the covariance
4578 becomes a correlation function depending only on the difference between the two instants considered
4579 and the knowledge of this correlation function is equivalent to that of the PSD.

4580 Note 2 to entry: Gaussian noise may be produced by a large number of independent pulses such that in
4581 any finite time interval each has a negligible value compared to that of the sum of the pulses.

4582 Note 3 to entry: In practice thermal noise, shot noise and quantum noise are Gaussian noises.

4583

4584 [Source: IEC 702-08-50]

4585 **615. harmonic**

4586 sinusoidal voltage or current components (distortion) of a periodic waveform which occur at a frequency
4587 that is an integer multiple of the fundamental frequency

4588

4589 Note 1 to entry: Most nonlinear loads generate odd-numbered harmonics; for example, as a result
4590 of full wave rectification of the input power.

4591 Note 2 to entry: The frequencies at which these 'characteristic harmonics' are produced by a user with
4592 a diode-type input rectifier are determined by the following equation:

4593
$$f_H = (k \times q \pm 1) \times f_1$$

4594 where

4595 H is the number of the harmonic;

k is an integer, beginning with 1;

4596

q is an integer, representing the number of rectifier commutations per cycle;

4597 f_1 is the fundamental frequency.

4598 Note 3 to entry: Half wave rectification produces even-numbered harmonics, which cause very un-
4599 desirable results (e.g. DC content) in the AC power system. Full wave rectification at the input of
4600 single-phase power users results in 'triplen' harmonics at odd multiples of three times the fundamental
4601 frequency. These are also very undesirable given the potential quantity of single-phase users and the fact
4602 that these harmonics interact with the distribution system's normally high (zero sequence) impedance
4603 to this frequency. User distortion current requirements are therefore intentionally restrictive for even and
4604 triplen harmonics.

4605

4606 [Source: ISO 1540:2006 3.23]

4607 **616. heat conduction**

4608 transfer of heat resulting from the interaction between adjacent molecules, within an entity consisting
4609 of solids or fluids

4610

4611 [Source: IEC 841-21-05]

4612 **617. heat convection**

4613 transfer of heat resulting from the motion of a material, within an entity consisting of a fluid

4614

4615 [Source: IEC 841-21-06]

4616 **618. heat transfer**

4617 exchange of thermal energy within a physical system or between physical systems, depending on the
4618 temperature and pressure, by dissipating heat

4619

4620 [Source: ISO 13943:2017 3.209]

4621

4622 Note to entry: The coherent SI unit of heat transfer is watt per square meter, $W m^{-2}$.

4623 **619. heating**

4624 process of supplying heat into an entity to raise or maintain its temperature

4625

4626 [Source: IEV 841-22-13]

4627 **620. homogeneous**

4628 uniform in structure and composition

4629

4630 [Source: ISO 20184-1:2018 3.11]

4631 **621. hysteresis**

4632 phenomenon represented by a characteristic curve which has two distinct branches, one branch, called
4633 the ascending branch, for increasing values of the input variable, and a second branch, called the des-
4634 cending branch, for decreasing values of the input variable

4635

4636 [Source: ISO 5598:2019 3.2.383]

4637 **622. ideal gas**

4638 gas that obeys the ideal gas law:

4639
$$pV_m = R_g T$$

4640 where

4641

p is absolute pressure;

V_m is molar volume (volume occupied by one mole of ideal gas);

4642

R_g is molar gas constant (= 8.314 J K⁻¹ mol⁻¹);

4643

T is thermodynamic temperature.

4644

4645 [Source: ISO 14532:2014 2.6.2.1]

4646 **623. idle mode**

4647 condition during which the equipment can promptly provide a primary function but is not doing so

4648

4649 [Source: IEV 904-03-14]

4650 **624. impulse response**

4651 time signal at the output of a system when a Dirac function is applied to the input

4652

4653 Note 1 to entry: The Dirac function, also called δ function, is the mathematical idealisation of a
4654 signal infinitely short in time which carries a unit amount of energy.

4655

4656 [Source: ISO 13472-1:2002 3.10]

4657

4658 Note 2 to entry: The impulse response contains all properties of the system. It is the inverse Laplace or
4659 Fourier transform of the transfer function and its convolution with the input function gives the output
4660 function.

4661 Note 3 to entry: The Dirac δ function (distribution) is named after English physicist Paul Adrien Maurice
4662 Dirac (1902-1984) who won in 1933 the Nobel Prize in Physics.

4663 **625. inductive**

4664 qualifies an electric device or an electric circuit the predominant quantity of which, under given condi-
4665 tions, is an inductance

4666

4667 [Source: IEV 151-15-53]

4668 **626. instantaneous value**

4669 value of a variable quantity at a given instant

4670

4671 [Source: ISO 2041:2018 3.2.49]

4672 **627. internal leakage**

4673 leakage between internal cavities of a component

4674

4675 [Source: ISO 5598:2019 3.2.408]

4676 **628. ionic conduction**

4677 electrical conduction where ions carry the electrical charges

4678

4679 [Source: ISO 11894-1:2013 3.1]

4680 **629. irreversible**

4681 lack of ability to return to the original state

4682 **630. isotropic**

4683 pertaining to a material whose specified property is spatial direction (orientation) independent

4684 **631. laminar flow**

4685 fluid flow characterised by the sliding of fluid layers (laminae) past one another in an orderly fashion

4686

4687 Note to entry: With this type of flow, friction is minimised.

4688

4689 [Source: ISO 5598:2019 3.2.411]

4690 **632. leakage**

4691 fluid flow of a relatively small quantity that does no useful work and causes energy losses

4692

4693 [Source: ISO 5598:2019 3.2.414]

4694 **633. linear**

4695 qualifies a circuit element or a circuit for which the integral quantities are linearly related

4696

4697 [Source: IEC 60050-101-11-18]

4698

4699 Note to entry: A relation $y = F(x)$ between two quantities x and y , where F is an operator, is
4700 linear if and only if,

4701
$$F\left(\sum_i a_i x_i\right) = \sum_i a_i F(x_i)$$

4702 where a_i are arbitrary constants.

4703 **634. linear system**

4704 system the behaviour of which obeys the principle of superposition

4705

4706 Note 1 to entry: The principle of superposition implies that such a system may be described by a
4707 set of linear equations.

4708 Note 2 to entry: A system, which does not have this property, is called non-linear system.

4709

4710 [Source: IEC 60050-101-42-11]

4711 **635. linear, time invariant (LTI)**

4712 property (additivity, homogeneity, and translation) of a device or system of finite dimension having pro-
4713 portional (linear) response (output) to an arbitrary input signal independent of the instant the signal is
4714 applied

4715

4716 Note to entry: The output of a physically realisable LTI system is for a linear combination of input
4717 signals the same as a linear combination of individual responses (outputs) to those inputs and where the
4718 output does not depend on when the input is applied. Often, an electrochemical system is intrinsically
4719 non-linear. Also, such systems commonly vary with time as the frequency range is scanned in traditional
4720 small AC signal electrochemical impedance spectroscopy measurements. That is, these systems may
4721 at best be viewed as quasi-LTI systems during a conventional electrochemical impedance spectroscopy
4722 measurement.

- 4723 **636. lumped**
4724 qualifies a circuit element for which the relations between integral quantities can be expressed by func-
4725 tions, or by derivatives or integrals with respect to time, or combinations thereof
4726
4727 Note to entry: A lumped circuit element is considered to have dimensions negligible with respect to the
4728 pertinent wavelengths of the electromagnetic field.
4729
4730 [Source: IEV 131-11-09]
- 4731 **637. mass transfer**
4732 transmission of mass by various mechanisms
4733
4734 [Source: ISO 9346:2007 2.1]
- 4735 **638. maximum-phase system**
4736 system the transfer function of which has the property that its real parts of some zeros are negative and
4737 others are positive
4738
4739 Note to entry: This definition applies to continuous time systems. For discrete time systems, neg-
4740 ative (positive) zeros mean zeros inside (outside) the unit circle.
- 4741 **639. Maxwell-Stefan (M-S) diffusion**
4742 generalised diffusion equation describing steady state mass transfer in a multi-component fluid by re-
4743 lating the molar fluxes, N_i and N_j of species i and j , respectively with the spatial gradient ∇ of the
4744 chemical potential, μ_i of species i , $\nabla\mu_i$ (driving force) under isothermal and isobaric conditions by
4745 separating ideal from non-ideal (correlation) effects of binary non-reacting species diffusion considering
4746 inter-molecular interactions (molecule collisions) between species i and j
4747
4748 Note to entry: Maxwell-Stefan (M-S) diffusion is named after Scottish scientist James Clerk Maxwell
4749 (1831-1879) and Slovene physicist, mathematician and poet Jožef Štefan (1835-1893).
- 4750 **640. minimal-phase system**
4751 system the transfer function of which has the property that its real parts of all poles and zeros are negative
4752
4753 Note 1 to entry: A minimal-phase system does not include dead-time elements or all-pass elements.
4754
4755 [Source: IEV 351-42-17]
4756
4757 Note 2 to entry: This definition applies to continuous time systems. For discrete time systems, all
4758 poles and zeros are outside the unit circle.
- 4759 **641. mixed-phase system**
4760 system the transfer function of which has the property that its real parts of zeros are negative
4761
4762 Note to entry: This definition applies to continuous time systems. For discrete time systems, all zeros
4763 are outside the unit circle.
- 4764 **642. mode**
4765 distinct status or distinct operating condition of a system
4766
4767 Note to entry: Any transition of equipment from or towards a neighbouring mode, either through
4768 user intervention or automatically initiated, should not be considered to form part of either mode.
4769
4770 [Source: IEV 904-03-09]
- 4771 **643. molar**
4772 qualifies the name of a quantity to indicate the quotient of that quantity by the amount of substance
4773
4774 [Source: IEV 112-03-15]

4775 **644. molar mass**

4776 mass of one mole of a substance

4777

4778 [Source: ISO 472:2013 2.597]

4779 **645. molecular mass**

4780 sum of the masses of the atoms making up a molecule

4781

4782 [Source: ISO 472:2013 2.1818]

4783 **646. nano scale**

4784 size range from approximately 1 nm to 100 nm

4785

4786 Note 1 to entry: Properties that are not extrapolations from a larger size will typically, but not ex-

4787

4788 clusively, be exhibited in this size range. For such properties the size limits are considered approximate.
4789 Note 2 to entry: The lower limit in this definition (approximately 1 nm) is introduced to avoid single
4790 and small groups of atoms from being designated as nano-objects or elements of nanostructures, which
4791 might be implied by the absence of a lower limit.

4791

4792 [Source: ISO/TS 80004-6:2013 2.1]

4793 **647. natural convection**

4794 motion of fluid particles caused by the buoyancy forces that arise when a hot body creates temperature
4795 and density gradients within a fluid

4796

4797 [Source: ISO TR 15916:2015 3.68]

4798 **648. Navier-Stokes (N-S) equation**

4799 parabolic PDE describing motion of fluid (continuum) mathematically as conservation of momentum

4800

4801 Note 1 to entry: The Navier-Stokes (N-S) equation is commonly accompanied by PDEs for conservation
4802 of mass and energy along with an equation of state (EoS) relating density, pressure and temperature.

4803

4804 Note 2 to entry: This equation is named after French engineer and physicist Claude Louis Marie Henri
Navier (1785-1836) and Irish physicist and mathematician George Gabriel Stokes (1819-1903).

4805 **649. Nernst-Einstein relation**

4806 equation relating the limiting molar conductivity, Λ_m^0 to the ionic diffusion coefficients, D_+ and D_- of
4807 the cation and anion, respectively by

4808
$$\Lambda_m^0 = \frac{F^2}{R_g T} (n_+ z_+^2 D_+ + n_- z_-^2 D_-)$$

4809 where F is Faraday constant, R_g is universal gas constant, T is thermodynamic temperature, n_+ and
4810 n_- are number of cations and anions per formula unit of electrolyte, respectively while z_+ and z_- are
4811 their respective valences

4812

4813 Note to entry: This relation is named after German physicist and chemist Walther Hermann Nernst
4814 (1864-1941) who won in 1920 the Nobel prize for Chemistry and German physicist Albert Einstein
4815 (1879-1955) who won in 1921 the Nobel prize for Physics while the constant F is named after English
4816 scientist Michael Faraday (1791-1867).

4817 **650. Nernst-Planck flux**

4818 ionic flux accounting for diffusion of charged species due to their spatial concentration gradient by Fick's
4819 second law, electro-migration (electrophoresis) due to a spatial potential gradient and convection due
4820 to the solvent flow (i. e. pumping, stirring, etc)

4821

4822 Note to entry: This flux is named after German physicist and chemist Walther Hermann Nernst (1864-
4823 1941) who won in 1920 the Nobel Prize in Chemistry and physicist Max Karl Ernst Ludwig Planck
4824 (1858-1947) who won in 1918 the Nobel Prize in Physics.

- 4825 **651. noise**
4826 any undesired signal or response that tends to interfere with the reception, interpretation or processing
4827 of the desired signal or response
4828
4829 [Source: ISO/TS 18173:2005 2.16]
- 4830 **652. ohmic losses**
4831 overpotential contribution due to the properties of electrolysis cell materials, i.e. ionic conduction in
4832 the electrolyte, separator/contact electrical resistance, electronic conduction and bubble effect
4833
4834 [Source: JRC EUR 29300 EN report 3.24.7.8]
- 4835 **653. operation mode**
4836 any combination of operating conditions
4837
4838 [Source: JRC EUR 29300 EN report 3.17]
- 4839 **654. oxidation**
4840 process in which a reactant loses one or more electrons
4841
4842 [Source: ISO 8044:2020 7.1.10]
4843
4844 Note 1 to entry: Electrons are generally transferred to another substance by a reduction reaction.
4845 Note 2 to entry: Oxidation results in an increase in the oxidation number of any atom within the
4846 reactant.
- 4847 **655. oxidation number**
4848 charge number that an atom within a molecule would have if all the ligands were removed along with
4849 the electron pairs that were shared
4850
4851 [Source: IEV 114-01-25]
- 4852 **656. oxidising atmosphere**
4853 gas medium containing oxidising components of the quantity necessary to perform oxidation processes
4854
4855 [Source: IEV 841-22-57]
- 4856 **657. percolation**
4857 flow of liquid through a stationary solid phase
4858
4859 [Source: IEV 212-19-08]
- 4860 **658. performance**
4861 qualitative level of a critical property at any point in time considered
4862
4863 [Source: ISO 15686-1:2011 3.15]
- 4864 **659. permeation**
4865 passage of a fluid through a permeable membrane
4866
4867 Note to entry: The process involves diffusion and may involve surface phenomena such as adsorption
4868 and desorption.
- 4869 **660. polarisation**
4870 change of an electrode potential caused by current flow
4871
4872 Note to entry: Current flow results in concentration polarisation and activation polarisation.
4873
4874 [Source: ISO 22426:2020 3.3]

- 4875 **661. pole**
4876 value of s that makes a transfer function in the complex variable infinity (∞), or its corresponding point
4877 in the s plane
4878
4879 [Source: ISO/IEC 14776-121:2010 3.1.72]
- 4880 **662. porous**
4881 describing a material having voids (rounded, tiny holes) throughout, that is, in all spatial dimensions
- 4882 **663. power spectral density (PSD)**
4883 distribution as a function of frequency of the power per unit bandwidth of the spectral components of
4884 a signal or a noise having a continuous spectrum and a finite mean power
4885
4886 Note 1 to entry: The instantaneous power of a signal or a noise is by convention equal to the square of
4887 its instantaneous value. This square is proportional to a physical power if the characteristic quantity is
4888 a field quantity.
4889 Note 2 to entry: The Power spectral density is the Fourier integral transform of the autocorrelation
4890 function of the signal or noise. The autocorrelation function of a deterministic signal exists if the signal
4891 has a finite mean power. The autocorrelation function of a random signal or random noise exists if it is
4892 represented by a second order random stationary function.
4893
4894 [Source: IEV 702-04-50]
- 4895 **664. purge**
4896 forced introduction of a fluid into a pre-determined area, in order to cleanse, by displacement, the ex-
4897 isting fluid
4898
4899 [Source: ISO 13574:2015 2.141]
- 4900 **665. purging**
4901 in a pressurised enclosure, the operation of passing a quantity of protective gas through the enclosure
4902 and ducts, so that the concentration of the explosive gas atmosphere is brought to a safe level
4903
4904 [Source: IEV 426-09-03]
- 4905 **666. pyrolysis**
4906 irreversible chemical decomposition of a material due to an increase in temperature without oxidation
4907
4908 [Source: ISO 4880:1997 53]
- 4909 **667. radiation**
4910 heat transfer by way of electromagnetic energy
4911
4912 Note to entry: Absorbed heat radiation is radiative heat absorbed by a surface and emitted heat radiation
4913 is radiant heat emitted from a surface. Incoming radiative heat is incident heat radiation.
4914
4915 [Source: ISO 13943:2017 3.320]
- 4916 **668. radiative heat transfer**
4917 transmission of heat by electromagnetic radiation or heat transfer by radiation
4918
4919 [Source: ISO 13943:2017 3.322]
4920
4921 Note to entry: The coherent SI unit of radiative heat transfer is watt per square meter, W m^{-2} .
- 4922 **669. random noise**
4923 noise for which the instantaneous value cannot be predicted
4924
4925 [Source: ISO 2041:2018 3.2.13]

4926 **670. reactive device/circuit**

4927 qualifies an inductive as well as a capacitive device or circuit

4928

4929 [Source: IEV 151-15-55]

4930 **671. real gas**

4931 gas that deviates from volumetric ideality

4932

4933 Note 1 to entry: No real gas obeys the ideal gas law. Deviations from volumetric ideality can be
4934 written in terms of the equation of state

4935
$$pV = Z(p, T)R_gT$$

4936 where

4937

p is absolute pressure;

V is volume occupied by one mole of the real gas (real molar volume);;

4938

$Z(p, T)$ is a variable, often close to unity, and is known as the compression factor;

R_g is the molar gas constant ($= 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$);

4939

T is thermodynamic temperature.

4940

4941 [Source: ISO 6976:2016 3.9]

4942 **672. reducing atmosphere**

4943 gas medium containing reduction components of the quantity necessary to perform the reduction pro-
4944 cesses

4945

4946 [Source: IEV 841-22-56]

4947 **673. reduction**

4948 process in which a reactant accepts one or more electrons

4949

4950 [Source: ISO 8044:2020 7.1.7]

4951

4952 Note 1 to entry: Electrons are generally transferred from another substance by an oxidation reaction.

4953

Note 2 to entry: Reduction results in a decrease in the oxidation number of any atom within the reactant.

4954 **674. resistive**

4955 qualifies an electric device or an electric circuit the predominant quantity of which, under given condi-
4956 tions, is a electrical resistance

4957

4958 [Source: IEV 151-15-52]

4959 **675. reversibility**

4960 ability to be returned to the original state without consumption of free energy and increase of entropy

4961 **676. reversible**

4962 ability to return to the original state

4963 **677. sealed**

4964 protected against escape or penetration of gas, liquids or dust

4965

4966 Note to entry: A safety device may be included for escape when internal pressure exceeds a specified
4967 value.

4968

4969 [Source: IEV 151-16-38]

4970 **678. short-circuit**

4971 accidental or intentional conductive path between two or more conductive parts forcing the electric po-
4972 tential differences between these conductive parts to be equal to or close to zero

4973
4974 [Source: IEV 151-12-04]

4975 **679. side reaction**

4976 additional and unwanted reaction in a cell that causes charging inefficiencies and loss of capacity, service
4977 life or performance

4978
4979 [Source: IEV 482-03-13]

4980 **680. side-lobes**

4981 sequence of peaks in the frequency domain caused by the use of a finite time window with the Fourier
4982 integral transform

4983
4984 [Source: ISO 18431-1:2005 3.14]

4985 **681. signal-to-noise ratio**

4986 ratio of the wanted signal level to the electromagnetic noise level as measured under specified conditions

4987
4988 [Source: IEV 161-06-04]

4989
4990 Note 1 to entry: The signal cannot generally be separated from noise, and in practice the ratio (signal
4991 + noise) to noise is measured.

- the nature and characteristics of the measurement po

- the nature and characteristics of the wanted signal,

4992 Note 2 to entry: The specified conditions comprise among others:

- the nature and characteristics of the noise, and

- the nature and characteristics of the measurement po

4993

4994 Note 3 to entry: The signal-to-noise ratio is generally expressed in decibels.

4995 **682. signal-to-noise ratio**

4996 difference, in decibels, between the level of the nominal useful signal and the level of the background
4997 noise at the moment of detection of the useful event

4998
4999 [Source: ISO 13472-1:2002 3.9]

5000 **683. sinusoidal**

5001 pertaining to an alternating quantity represented by the product of a real constant and a sine or cosine
5002 function whose argument is a linear function of the independent variable

5003
5004 Note to entry: The real constant may be a scalar, vector or tensor quantity.

5005
5006 [Source: IEV 103-07-01]

5007 **684. sorption**

5008 process by which one substance takes up or retains another given its capacity or tendency to take it up
5009 either by adsorption or absorption

5010 **685. spectral leakage**

5011 width of the peak in the power spectrum due to a single spectral component caused by using a finite
5012 window with the Fourier integral transform

5013
5014 [Source: ISO 18431-1:2005 3.16]

5015 **686. spectrum**

5016 description of a quantity as a function of frequency or wavelength

5017
5018 [Source: ISO 2041:2018 3.1.61]

- 5019 **687. stability**
5020 property of a system which implies that for a sufficiently small initial displacement from the rest position
5021 or for a sufficiently small disturbance the state variables remain within a sufficiently small neighbourhood
5022 of the rest position
5023
5024 [Source: IEV 351-42-20]
- 5025 **688. sterically modified Poisson-Boltzmann equation**
5026 within mean field theory (MFT), an inhomogeneous second order non-linear ODE relating the electro-
5027 static potential to the charge density as a function of spatial position in a system of spherical charges
5028 while considering steric (ion size) effects (exclusion volume corrections)
5029
5030 Note 1 to entry: This sterically modified Poisson-Boltzmann equation does not account for like charge
5031 attractions, molecular interactions and solvent structure.
5032 Note 2 to entry: This non-linear ODE is named after French mathematician, engineer and physicist
5033 Siméon Denis Poisson (1781-1840) and Austrian physicist and philosopher Ludwig Eduard Boltzmann
5034 (1844-1906).
- 5035 **689. Stern layer**
5036 counter and co-ions in immediate contact with a surface are said to be located in the Stern layer, and
5037 form with the fixed charge a molecular capacitor
5038
5039 [Source: IUPAC Gold Book S06003]
5040
5041 Note to entry: This layer is named after German physicist Otto Stern (1888-1969) who won in 1943 the
5042 Nobel Prize in Physics.
- 5043 **690. stimulus**
5044 external input acting on a system and capable in principle of provoking a response from that system
5045
5046 [Source: IEV 891-01-04]
- 5047 **691. stoichiometric**
5048 involving chemical combination in simple integral ratios
5049
5050 Note to entry: Characterized by having no excess of reactants or products over that required to satisfy
5051 the balanced chemical equation representing the given chemical reaction.
5052
5053 [Source: IUPAC Gold Book S06021]
- 5054 **692. stoichiometry**
5055 mass ratio of a substance (oxygen or fuel) to a reactant assuming that the (reduction respectively
5056 oxidation) reaction proceeds to completion
- 5057 **693. surface finish**
5058 measurement of the average roughness of a surface
5059
5060 [Source: ISO 13533:2001 3.72]
5061
5062 Note to entry: The coherent SI unit of surface finish is meter, m.
- 5063 **694. thermal conductance**
5064 reciprocal of the thermal resistance
5065
5066 [Source: IEV 113-04-46]
5067
5068 Note to entry: The coherent SI unit of thermal resistance is watt per kelvin, $W K^{-1}$.
- 5069 **695. thermal conduction**
5070 transfer of amount of heat through direct interaction within a medium or between mediums in direct
5071 physical contact without a flow of material

5072

5073

[Source: IEV 113-04-33]

5074

5075

Note to entry: The transfer of heat occurs usually from a region of higher temperature to a region of lower temperature. In the case of phase transition, it may occur even with equal temperatures.

5076

5077 **696. thermal equilibrium**

5078

state reached when the temperature of the parts of a component or equipment operating in a given environment no longer varies faster than a specified limit

5079

5080

5081

[Source: IEV 151-16-33]

5082

5083

Note to entry: The specified limit may be a temperature difference for a given duration at a fixed point.

5084

5085 **697. thermal power**

5086

quotient of the quantity of heat transferred or generated in a process by the time duration of this process

5087

5088

[Source: IEV 841-21-21]

5089

5090

Note to entry: The coherent SI unit of thermal power is watt, W.

5091 **698. thermal resistance**

5092

thermodynamic temperature difference divided by heat flow rate

5093

5094

[Source: IEV 113-04-45]

5095

5096

Note 1 to entry: Thermal resistance may be calculated as the quotient of the difference in temperature between two points and the associated steady state power dissipated under steady state conditions.

5097

5098

Note 2 to entry: The coherent SI unit of thermal resistance is kelvin per watt, K W^{-1} .

5099 **699. time-invariant system**

5100

system the behaviour of which obeys the principle of shifting

5101

5102

Note 1 to entry: The principle of shifting implies that the set of equations describing the system and their coefficients are time-invariant.

5103

5104

Note 2 to entry: A system, which does not have this property, is called time-invariant system.

5105

5106

[Source: IEV 351-42-14]

5107 **700. tortuosity**

5108

dimensionless measure of the geometric complexity of a porous medium commonly expressed as the ratio of the average length of all stream lines of a fluid that its convoluted path lines between two points for a given cross section of a porous space (void volume) to the straight line distance between these two points in such cross section

5109

5110

5111

5112 **701. transient**

5113

momentary variation of a characteristic from its steady state limits, and back to its steady state limits, as a result of a system disturbance

5114

5115

[Source: ISO 1540:2006 3.44]

5116

5117

Note to entry: The term "transient" is also used as a noun to mean a transient phenomenon or quantity.

5118

5119 **702. triple point**

5120

point in a one-component system at which the temperature and pressure of three phases are in equilibrium

5121

5122

[Source: IUPAC Gold Book T06502]

5123

5124

Note to entry: With p possible phases (i.e. gas, liquid, solid and plasma), $\frac{p!}{(p-3)!3!}$ triple point(s) exist; $p \geq 3$, $p \in \mathbb{N}$.

5125

5126 **703. turbulent flow**

5127 type of flow where the paths of individual particles of fluid are no longer everywhere straight (as in
5128 laminar flow) but are sinuous, intertwining and crossing one another in a disorderly manner so that a
5129 thorough mixing of fluid takes place

5130

5131 [Source: ISO/IEC TR 5598:2019 3.16]

5132

5133 Note to entry: Turbulent flow is characterised by random movement of particles of the fluid.

5134 **704. two-phase flow**

5135 flow of a gas phase with a liquid phase

5136

5137 Note to entry: In the definition of two-phase flow the liquid is considered a single phase regardless
5138 of its composition. In the definition of multi-phase flow the different liquid components (e. g. hydrocar-
5139 bon liquid, water, chemical inhibitor etc.) are considered different phases.

5140

5141 [Source: ISO/TR 12748:2015 2.58]

5142 **705. unit step response**

5143 quotient step response $\Delta v_{\epsilon}(t)$ divided by the step height K_{ϵ} of the step function, the quotient described
5144 by

5145
$$h(t) = \frac{\Delta v_{\epsilon}(t)}{K_{\epsilon}}.$$

5146 Note 1 to entry: The unit step response may be calculated from the unit impulse response by

5147
$$h(t) = \int_{-\infty}^t \delta(\tau) \, d\tau$$

5148 Note 2 to entry: The unit step response of a system mathematically may be considered to result from
5149 application of a unit step to an input variable.

5150

5151 [Source: IECV 351-45-30]

5152

5153 Note 3 to entry: The unit step response is also known as Heaviside function named after English
5154 engineer, mathematician and physicist Oliver Heaviside (1850-1925).

5155 **706. upstream**

5156 away from a component against the direction of flow

5157

5158 [Source: ISO 13628-6:2006 3.25]

5159 **707. van der Waals force**

5160 attractive or repulsive force between molecular entities (or between groups within the same molecular
5161 entity) other than those due to bond formation or to the electrostatic interaction of ions or ionic groups
5162 with one another or with neutral molecules

5163

5164 Note 1 to entry: The term includes dipole-dipole, dipole-induced dipole, and London (instantaneous
5165 induced dipole-induced dipole) forces. The term is sometimes used loosely for the totality of non-
5166 specific attractive or repulsive intermolecular forces.

5167

5168 [Source: ISO 18115-2:2013 5.171]

5169 [Source: IUPAC Gold Book V06597]

5170

5171 Note 2 to entry: This force is named after Dutch physicist Johannes Diderik van der Waals (1837-
5172 1923) who won in 1910 the Nobel Prize in Physics.

5173 **708. vapour**

5174 gaseous phase of a substance that can reach equilibrium with its liquid or solid state in the temperature
5175 and pressure range of interest

5176

5177 Note to entry: This definition is a simplification of the scientific definition, and merely requires that the
5178 substance is at a temperature below its boiling point or sublimation point at the ambient temperature
5179 and pressure.

5180
5181 [Source: IEV 426-02-31]

5182 **709. voltage fluctuation**

5183 series of voltage changes or a continuous variation of the rms or peak value of the voltage

5184
5185 Note to entry: Whether the rms or peak value is chosen depends upon the application, and which
5186 is used should be specified.

5187
5188 [Source: IEV 161-08-05]

5189 **710. wettability**

5190 ability of a solid material surface to adsorb a liquid

5191
5192 Note 1 to entry: A measure of the wettability is the contact angle between the solid surface and
5193 the liquid surface of a drop of the liquid on the solid.

5194 Note 2 to entry: The liquid for which the wettability is determined is not necessarily water.

5195
5196 [Source: IEV 212-12-21]

5197 **711. white noise**

5198 random noise which has a continuous spectrum and a constant PSD in the frequency band considered

5199
5200 [Source: IEV 702-08-39]

5201 **712. X-rays**

5202 electromagnetic radiation of a kind arising from the electrons outside the nucleus

5203
5204 [Source: ISO/TR 12748:2015 2.60]

5205
5206 Note 1 to entry: X-rays are used in spectroscopic techniques such as X-ray diffraction spectroscopy,
5207 energy disperse X-ray spectroscopy X-ray photoelectron spectroscopy, X-ray fluorescence spectroscopy,
5208 X-ray absorption spectroscopy, extended X-ray absorption fine structure spectroscopy and X-ray absorp-
5209 tion near edge spectroscopy to study especially the crystal structure of materials and their chemical
5210 constituents.

5211 Note 2 to entry: X-rays (German: Röntgenstrahlung) were named by German physicist Wilhelm Conrad
5212 Röntgen (1845-1923).

5213 **2.2 Low temperature water electrolysis terms**

5214 **713. alkaline electrolysis (AEL)**

5215 electrolysis that employs an alkaline solution as electrolyte

5216 **714. alkaline electrolysis cell (AEC)**

5217 electrolytic cell using an alkaline solution as electrolyte for water electrolysis

5218 **715. alkaline water electrolyser (AWE)**

5219 water electrolyser using alkaline solution as electrolyte

5220 **716. anion exchange membrane (AEM)**

5221 polymer based membrane with anion conductivity, which acts as an electrolyte and a separator between
5222 anode and cathode

5223
5224 [Source: JRC EUR 29300 EN report 3.3.12.1]

5225
5226 Note 1 to entry: Alkaline anion exchange membrane (AAEM) conduct alkaline anions (OH^- , HCO_3^- ,
5227 CO_3^{2-}). Other AEM conduct non-alkaline anions (Cl^- , SO_4^{2-} , PO_4^{3-}).

5228 Note 2 to entry: In AEM, anion conductivity is provided by cationic head groups. Those involving

5229 N-based groups include quaternary ammoniums/tertiary diamines, heterocyclic systems (imidazoliums,
5230 pyridiniums), guanidiniums while N-free groups include phosphoniums, phosphatraniums, sulphoniums
5231 and metal cations (Ru, Ni, Co) have multiple positive charges per cationic group.
5232 Note 2 to entry: Technologically, the most common polymer backbone in AEM are polyarylene ethers
5233 (i. e. polysulfones, polyetherketones (PEKs), polyetherimides (PEIs), polyetheroxadiazoles (PEOs) and
5234 polyphenylene oxides (PPOs)), polyphenylenes, polybenzimidazole (PBI), polyepichlorohydrin (PECH),
5235 polypropylene, polystyrene, polyvinylbenzyl chloride (PVBC), polyphosphazenes, and polyvinyl alcohol
5236 (PVA).

5237 **717. anion exchange membrane electrolysis (AEMEL)**

5238 electrolysis that employs an anion exchange membrane as electrolyte

5239 **718. anion exchange membrane electrolysis cell (AEMEC)**

5240 anion exchange membrane based electrolytic cell used for water electrolysis

5241 **719. anion exchange membrane water electrolyser (AEMWE)**

5242 electrolyser that employs a polymer with (hydroxide) ion exchange capability as the electrolyte

5243 **720. anolyte**

5244 electrolyte on the anode side of an electrochemical cell that is divided into compartments

5245

5246 [Source: IEV 114-03-19]

5247 **721. bipolar membrane (BPM)**

5248 IEM constituted by a cathode exchange layer (CExL) made of a cation exchange membrane for conduct-
5249 ing (exchanging) cations and an anode exchange layer (CExL) made of a anion exchange membrane for
5250 conducting (exchanging) anions with an interfacial layer (IL) (bipolar junction) between them, which
5251 acts as a bipolar electrolyte and a separator between anolyte and catholyte

5252

5253 Note 1 to entry: Contrary to conventional ion exchange membrane (IEM)s (or "monopolar" mem-
5254 branes), BPMs are not meant to have any ion transport across them; instead, a BPM disproportionate
5255 liquid water by electro-dissociating it into protons and hydroxide anions at the bipolar junction without
5256 any gas formation. It is thus different from water splitting at electrodes in water electrolysis.

5257 Note 2 to entry: When current is applied across a BPM under condition known as "reverse bias" ("reverse
5258 polarisation", "reverse current", "reverse voltage"), the ionic current is carried by protons and hydroxide
5259 anions along the electric field with the CExL facing the cathode where protons exit the BPM into the
5260 catholyte, and the CExL facing the anode where hydroxide anions exit the BPM into the anolyte; thus
5261 producing an acid and a base on opposite sides of the BPM to create a pH gradient over it.

5262 Note 3 to entry: In case the applied current across the BPM is reversed (e. g., switching the polarity
5263 of the electrodes or BPM orientation) know as "forward bias" condition, the CExL faces the anode and
5264 the CExL the cathode when protons and hydroxide anions migrate from the outer solutions towards the
5265 bipolar junction to form liquid water which permeates out of the BPM through the cathode exchange
5266 layer and the CExL; thus leading to acid-base neutralisation.

5267 Note 4 to entry: Among others, BPM find applications in bipolar membrane fuel cell (BPMFC) and
5268 bipolar membrane water electrolysis cell (BPMWEC). Both type of electrochemical cells, may com-
5269 bined to a RFC with water splitting (electro-dissociation) into protons and hydroxide anions and their
5270 recombination to liquid water in the same device.

5271 **722. bipolar membrane electrolysis (BPMEL)**

5272 electrolysis that employs a bipolar membrane as electrolyte

5273 **723. bipolar membrane water electrolysis cell (BPMWEC)**

5274 bipolar membrane based electrolytic cell used for water electrolysis

5275 **724. catholyte**

5276 electrolyte on the cathode side of an electrochemical cell that is divided into compartments

5277

5278 [Source: IEV 114-03-18]

5279 **725. cation exchange membrane (CEM)**

5280 IEM with cation conductivity, which acts as an electrolyte and a separator between anode and cathode

5281 **726. hydrolysis**

5282 solvolysis by water

5283

5284 [Source: IUPAC Gold Book H02902]

5285

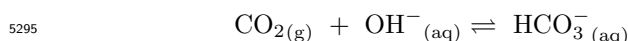
5286 Note to entry: In hydrolysis, the lyonium and lyate ions are hydronium cation and hydroxide anion,
5287 respectively.

5288 **727. hydroxide anion exchange membrane (HEM)**

5289 AEM with hydroxide anion conductivity, which acts as an electrolyte and a separator between anode
5290 and cathode

5291

5292 Note 1 to entry: HEM is an AAEM exclusively in the OH⁻ form. It must fully be separated from
5293 sources of carbon dioxide (i. e. air) and traces of other alkaline anion such as HCO₃⁻ and CO₃²⁻ which,
5294 in the presence of carbon dioxide, can readily be form in the carbonation reactions:



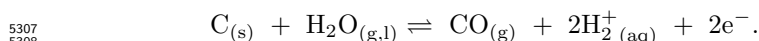
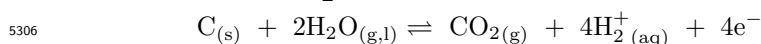
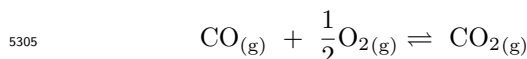
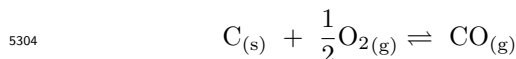
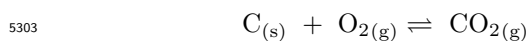
5297

5298 or by direct conversion of CO₂:



5300

5301 Note 2 to entry: Also, the oxidation (corrosion) of carbon (i. e. graphitic BPP, catalyst support) is a
5302 known source of CO₂ in AAEMFCs and AAEMECs:



5308

5309 **728. ion exchange membrane (IEM)**

5310 polymer based semi-permeable membrane with ion conductivity whether cation conductivity (CEM) or
5311 anion conductivity (AEM), which acts as an electrolyte and a separator between anode and cathode

5312

5313 Note 1 to entry: IEM contain charged ionic groups typically covalently bonded to the polymer back-
5314 bone directly, via CH₂ bridges, or via extended side chains. The dissolved ions are electrically conduct
5315 (transported) due to the Donnan equilibrium while blocking other ions and/or neutral molecules.

5316 Note 2 to entry: Beside FCs and WECs, IEMs find various other applications including alkali and
5317 acid recovery, electrolytic chlorine-alkaline synthesis, concentration cells, bipolar membrane electrodia-
5318 lysis (BMED), diffusion dialysis (DD), electrodialysis (ED), electro-deionisation, electrodialysis reversal
5319 (EDR), lithium and metal-air batteries, membrane capacitive deionisation (MCDI), reverse electrodia-
5320 lysis (RED), redox flow batteries (RFBs), reverse osmosis (RO), industrial waste-water treatment, metal
5321 separation, pervaporation, pollutant removal and seawater desalination.

5322 **729. low temperature water electrolysis (LTWE)**

5323 water electrolysis performed at Laplace transformation (LT)

5324

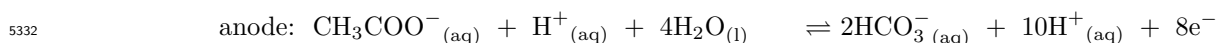
5325 Note to entry: Low temperature water electrolysis refers to temperatures usually between 50 and 90 °C.

5326 **730. microbial electrolysis cell (MEC)**

5327 water electrolysis cell where organic matter (e. g. cellulose, glucose, lignin, starch, etc) including waste
5328 water is electrochemically oxidised using anode attached active microorganisms (bacteria)

5329

5330 Note to entry: In MEC with a PEM as electrolyte, the electrode reactions using acetic acid (CH₃COOH)
5331 as a prototype are



5334

5335 **731. proton exchange membrane (PEM)**

5336 polymer based membrane with cation (proton) conductivity which acts as an electrolyte and a separator
5337 between anode and cathode

5338

5339 [Source: JRC EUR 29300 EN report 3.3.12.2]

5340

5341 Note to entry: PEM is a cation exchange membrane exclusively in the acidic H⁺ form.

5342 **732. proton exchange membrane electrolysis (PEMEL)**

5343 electrolysis that employs a proton exchange membrane as electrolyte

5344 **733. proton exchange membrane electrolysis cell (PEMEC)**

5345 proton exchange membrane based electrolytic cell used for water electrolysis

5346 **734. proton exchange membrane water electrolyser (PEMWE)**

5347 electrolyser that employs a polymer with (proton) ion exchange capability as the electrolyte

5348

5349 [Source: IEC 62282-8-102:2019 3.1.26]

5350 **735. reversible proton exchange membrane cell (rPEMC)**

5351 PEM based EC used in FC (PEFC) mode and in electrolysis (PEMEC) mode

5352 **736. solvolysis**

5353 reaction with a solvent, or with a lyonium ion or lyate ion involving the rupture of one or more bonds in
5354 the reacting solute

5355

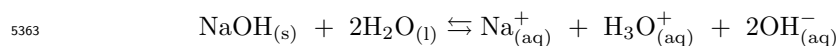
5356 Note 1 to entry: More specifically the term is used for substitution elimination and fragmentation
5357 reactions in which a solvent species is the nucleophile ('alcoholysis' if the solvent is an alcohol, etc.).

5358

5359 [Source: IUPAC Gold Book S05762]

5360

5361 Note 2 to entry: In alkaline hydrolysis of lye (metal hydroxide), for example, sodium hydroxide (caustic
5362 soda), the lyonium and lyate ions are sodium cation and hydroxide anion, respectively.



5364 **737. total dissolved solids (TDS)**

5365 sum of all ions in a solution, often approximated by means of electrical conductivity or resistivity meas-
5366 urements

5367

5368 Note 1 to entry: TDS measurements are commonly used to evaluate the performance of reverse osmosis
5369 units. TDS values are often expressed in terms of CaCO₃, NaCl, KCl, or 442 equivalents, in milligrams
5370 per litre (mg L⁻¹). [442 is a solution of sodium sulfate (40 %), sodium bicarbonate (40 %), and sodium
5371 chloride (20 %) that closely represents the conductivity to concentration relationship, on average, for
5372 naturally occurring fresh water.]

5373

5374 [Source: ISO 23500-1:2019 3.41]

5375

5376 Note 2 to entry: Principally, this is also the weight of dissolved inorganic and organic matter in solution
5377 per unit volume of water.

5378 **738. water electrolyser (WE)**

5379 device that performs electrolysis to generate hydrogen and oxygen from water

5380 **739. water electrolysis**

5381 electrolysis of liquid water

5382

5383 Note to entry: Water electrolysis is also known as electrochemical water splitting.

5384 **740. water electrolysis cell (WEC)**

5385 electrolytic cell used for water electrolysis

5386 **741. water purification**
5387 process of removing contaminants and other harmful micro-organisms from the raw source of water

5388 **742. wetted**
5389 deliberately saturated with liquid

5390
5391 [Source: ISO 3857-4:2012 2.71]

5392

5393 **2.2.1 Physico-chemical & electrochemical concepts and phenomena**

5394 **743. acidic cell**
5395 cell containing an acid electrolyte

5396
5397 [Source: IEV 482-01-08]

5398 **744. acidity**
5399 presence of an excess of hydrogen ions over hydroxyl ions ($\text{pH} < 7$)

5400
5401 [Source: ISO 12473:2017 3.1]

5402 **745. alkaline cell**
5403 cell containing an alkaline electrolyte

5404
5405 [Source: IEV 482-01-08]

5406 **746. alkalinity**
5407 presence of an excess of hydroxyl ions over hydrogen ions ($\text{pH} > 7$)

5408
5409 [Source: ISO 12473:2017 3.2]

5410 **747. deionisation**
5411 partial or nearly complete removal of ionic species, particularly by the use of ion exchange resins

5412
5413 [Source: ISO 6107-1:2004 19]

5414 **748. dissociation**
5415 separation of a molecular entity into two or more molecular entities (or any similar separation within a
5416 polyatomic molecular entity); separation of the constituents of any aggregate of molecular entities.

5417
5418 Note to entry: In both senses dissociation is the reverse of association.

5419
5420 [Source: IUPAC Gold Book D01801]

5421 **749. Donnan equilibrium**
5422 equilibrium characterised by an unequal distribution of diffusible ions between two ionic solutions (one
5423 or both of the solutions may be gelled) separated by a membrane which is impermeable to at least one
5424 of the ionic species present, e. g. because they are too large to pass through the pores of the membrane

5425
5426 Note to entry: The membrane may be replaced by other kinds of restraint, such as gelation, the
5427 field of gravity, etc., which prevent some ionic component from moving from one phase to the other,
5428 but allow other component to do so.

5429
5430 [Source: IUPAC Gold Book D01831]

5431 **750. Donnan exclusion**
5432 reduction in concentration of mobile ions within an ion exchange membrane due to the presence of fixed
5433 ions of the same sign as the mobile ions

5434
5435 [Source: IUPAC Gold Book DT06889]

- 5436 **751. electro-osmosis**
5437 passage of a liquid through a porous medium under the influence of a potential difference
5438
5439 [Source: ISO 12473:2017 3.11]
5440
5441 Note to entry: In FCs and WECs, electro-osmosis occurs within IEMs whether AEMs or CEMs where
5442 water is transported across the membrane under an applied electric field.
- 5443 **752. electro-osmotic flow**
5444 motion of liquid along with a charged species induced by an applied potential across a micro-channel
5445 within a membrane
5446
5447 Note to entry: In FCs and WECs, electro-osmotic flow occurs within IEMs whether AEMs or CEMs
5448 where hydrated hydroxide anions or protons are transported in the micro-pores across the membrane.
- 5449 **753. electrolyte loss**
5450 any decrease with respect to the initial electrolyte inventory of an electrochemical cell or a stack
5451
5452 Note to entry: Electrolyte loss can originate from different processes such as evaporation, leakage,
5453 migration and consumption.
- 5454 **754. Grotthuss mechanism**
5455 molecular process (structural diffusion, proton hopping) known as proton hopping mechanism often as-
5456 sisted by an applied electric field by which an "excess" proton (H^+ ion) or proton defect/hole (hydroxyl
5457 ion) diffuses in molecules of water with an established network of hydrogen bonds or in molecules of
5458 a hydrogen-bonded substance where fast charge transfer occurs through the cleavage and concomitant
5459 formation of covalent bonds involving the solvation shell of nearest neighbour molecules (prototropic
5460 mobility)
5461
5462 Note 1 to entry: While still a subject of active research, the solvation of the "excess" proton in wa-
5463 ter may be idealised by two main forms: Eigen cation, $H_9O_4^+$ (protonated tetramer, $H^+(H_2O)_4$ or
5464 triply coordinated hydronium ion, $H_3O^+(H_2O)_3$) and Zundel cation, $H_5O_2^+$ (protonated dihydronium
5465 ion, $H^+(H_2O)_2$ or singly coordinated hydronium ion, $H_3O^+(H_2O)$) with interconversion/isomerisation
5466 between them possibly including molecule reorientation as well as bond stretching and contraction.
5467 Note 2 to entry: This mechanism is named after German chemist Christian Johann Dietrich Theodor
5468 von Grotthuss (1785-1822).
- 5469 **755. ion exchange**
5470 process by which certain anions or cations in solution are replaced by other ions by passage through a
5471 bed of ion exchange material
5472
5473 Note to entry: Adsorption of one or several ionic species is accompanied by the simultaneous desorption
5474 (displacement) of an equivalent amount of one or more other ionic species, this process is called ion
5475 exchange.
- 5476 **756. ionomer**
5477 polymer with electrically neutral repeat (constitutional) units and a fraction of (bonded) ionised or po-
5478 larised moieties, or both
5479
5480 Note to entry: Ionic groups are usually present in sufficient amounts (typically less than 10 % of
5481 constitutional units) to cause micro-phase separation of ionic domains from the continuous polymer
5482 phase. The ionic domains act as physical crosslinks.
- 5483 **757. ionomer molecule**
5484 macromolecule in which a small but significant proportion of the constitutional units has ionisable or
5485 ionic groups, or both
5486
5487 Note to entry: Some protein molecules may be classified as ionomer molecules.
5488
5489 [Source: IUPAC Purple Book Chapter 1 1.66]

5490 **758. ionomer solution**

5491 dispersion of ion conductive polymers in water, or in water and low-aliphatic alcohols

5492

5493 Note to entry: It is used in the manufacturing of electrocatalytic layers to increase the electrode-
5494 electrolyte interface area by ensuring better contact between the electro-catalyst particles and the ion
5495 conducting polymer membrane.

5496

5497 [Source: JRC EUR 29300 EN report 3.3.10]

5498 **759. macromolecule**

5499 molecule of high relative molecular mass, the structure of which essentially comprises the multiple repe-
5500 tition of units derived, actually or conceptually, from molecules of low relative molecular mass

5501

5502 Note 1 to entry: In many cases, especially for synthetic polymers, a molecule can be regarded as
5503 having a high relative molecular mass if the addition or removal of one or a few of the units has a
5504 negligible effect on the molecular properties. This statement fails in the case of certain properties of
5505 macromolecules which may be critically dependent on fine details of the molecular structure, e. g., the
5506 enzymatic properties of polypeptides.

5507 Note 2 to entry: If a part or the whole of the molecule has a high relative molecular mass and essen-
5508 tially comprises the multiple repetition of units derived, actually or conceptually, from molecules of low
5509 relative molecular mass, it may be described as either macromolecular or polymeric, or by polymer used
5510 adjectivally.

5511 Note 3 to entry: In most cases, the polymer can actually be made by direct polymerisation of its parent
5512 monomer but in other cases, e. g., poly(vinyl alcohol), the description "conceptual" denotes that an
5513 indirect route is used because the nominal monomer does not exist.

5514

5515 [Source: IUPAC Purple Book Chapter 1 1.1]

5516 **760. polybase**

5517 polyelectrolyte composed of macromolecules containing basic groups on a substantial fraction of the
5518 constitutional units

5519

5520 Note to entry: Most commonly, the basic groups are amino groups.

5521

5522 [Source: IUPAC Purple Book Chapter 10 23]

5523 **761. polyelectrolyte**

5524 polymer composed of macromolecules in which a substantial portion of the constitutional units contains
5525 ionic or ionisable groups, or both

5526

5527 Note 1 to entry: The terms polyelectrolyte, polymer electrolyte, and polymeric electrolyte should not be
5528 confused with the term solid polymer electrolyte.

5529 Note 2 to entry: Polyelectrolytes can be either synthetic or natural.

5530

5531 [Source: IUPAC Purple Book Chapter 10 27]

5532 **762. polyelectrolyte molecule**

5533 macromolecule in which a substantial portion of the constitutional units has ionisable or ionic groups,
5534 or both

5535

5536 [Source: IUPAC Purple Book Chapter 1 1.65]

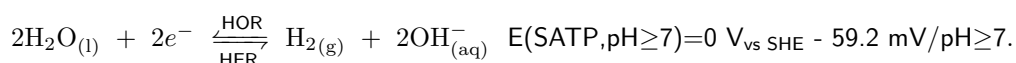
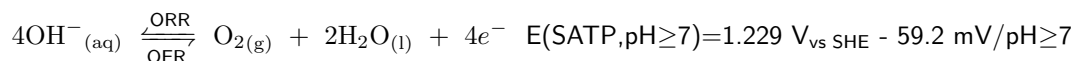
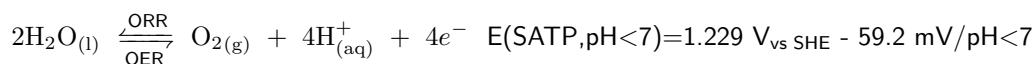
5537 **763. Pourbaix diagram**

5538 two dimensional (2D) representation of a three dimensional (3D) Gibbs free energy-pH-electrochemical
5539 potential (ECP) diagram for species (phases) under consideration

5540

5541 Note 1 to entry: Commonly, Pourbaix diagrams provide thermodynamic (steady state) information
5542 namely the direction of equilibrium reaction rather than kinetic information. Under given equilibrium
5543 conditions (composition, temperature and pressure), the Pourbaix diagrams (ECP versus pH) maps
5544 possible stable phases of an aqueous ECS (alkaline/acidic solutions, (dissolved) gases and solids), for
5545 example, metal-H₂O system relative to that of water displayed as regions of predominance of these

phases as functions of pH (abscissa) and ECP versus SHE (ordinate) determined from their chemical potentials and available thermodynamic data whether measured or computed. Horizontal lines represent pH independent but ECP dependent electron transfer reactions where neither protons nor hydroxide anions participate. Diagonal lines with positive or negative slope represent redox potentials of an aqueous solution in equilibrium with hydrogen and oxygen, respectively involving electron transfer as well as protons and hydroxide anions. Vertical lines represent ECP independent but pH dependent reactions involving either protons or hydroxide anions but electron transfer. By convention, Pourbaix diagrams display the thermodynamic stable regions of water bounded by two diagonal lines for



Note 2 to entry: The Pourbaix diagram of water (Pourbaix, 1974) shows the thermodynamic stable region of water along with the regions of oxygen evolution (acidification) where water is oxidising and depending on pH, acidic or alkaline as well as hydrogen evolution (alkalisation) where water is reducing and depending on pH, acidic or alkaline. It includes the regions of relative predominance of dissolved species such as hydride anion (H^-), proton (H^+), hydroxide anion (OH^-), hydrogen peroxide (dioxidane, H_2O_2), and hydrogen peroxide anion (HO_2^-). Alternatively, it includes the regions of relative predominance of hydrogen (H_2), oxygen (O_2) and ozone (O_3). Atomic hydrogen (H) and oxygen (O) have no regions of dominance.

Note 3 to entry: Pourbaix diagrams may be extended to three and higher dimensions accounting for variations in, for example, composition (concentration and activity), temperature and pressure.

Note 4 to entry: This diagram originally used to identify the stability regions (corrosion, passivity and immunity) of pure metals, is named after its inventor Belgian chemist Marcel Pourbaix (1904-1998).

764. reverse osmosis

flow of water through a membrane from a more concentrated to a less concentrated solution, as a result of applying pressure to the more concentrated solution in excess of the normal osmotic pressure

[Source: ISO 6107-1:2004 61]

Note to entry: In FCs and WECs, reverse osmosis occurs within IEMs whether AEMs or CEMs where water is transported across the membrane under an applied pressure difference between anode and cathode.

765. salinity

quantification of any dissolved salts in water, expressed as either a percentage or a concentration

[Source: ISO/TR 12748:2015 2.50]

766. vehicle mechanism

net transport (diffusion) of protons as protonated molecules (e. g. H_3O^+) together with the diffusion of uncharged molecules (vehicles) most common in aqueous systems

2.2.2 Materials & properties

767. aggregate

particle comprising strongly bonded or fused particles where the resulting external surface area is significantly smaller than the sum of surface areas of the individual components

Note 1 to entry: The forces holding an aggregate together are strong forces, for example, covalent or ionic bonds or those resulting from sintering or complex physical entanglement or otherwise combined former primary particles.

Note 2 to entry: Aggregates are also termed secondary particles and the original source particles are termed primary particles.

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[Source: ISO/TS 80004-13:2017 3.1.1.7]

768. block copolymer

copolymer that is a block polymer

Note to entry: In the constituent macromolecules of a block copolymer, adjacent blocks are constitutionally different, i. e., adjacent blocks comprise constitutional derived from different species of monomer or from the same species of monomer but with a different composition or sequence distribution of constitutional units.

[Source: IUPAC Purple Book Chapter 1 2.24]

769. carbon fibre

fibres (filaments, tows, yarns, rovings) consisting of at least 92 % (mass fraction) carbon, usually in the non-graphitic state

Note to entry: Carbon fibres are fabricated by pyrolysis of organic precursor fibres or by growth from gaseous hydrocarbons. The use of the term graphite fibres instead of carbon fibres as often observed in the literature is incorrect and should be avoided. The term graphite fibres is justified only if three dimensional crystalline order is confirmed.

[Source: IUPAC Gold Book C00831]

770. catalyst loading

amount of catalyst incorporated in the electrochemical cell (EC) per unit active area, specified either per anode or cathode separately, or specified as combined anode and cathode loading

Note 1 to entry: The catalyst loading may refer to the amount used in the preparation or manufacture of the catalyst or the amount of catalyst actually deposited. The difference of such nominal values of catalyst loading to the effective catalyst loading is the amount of catalyst which actually participates in the concerned electrochemical reaction.

Note 2 to entry: The coherent SI unit of catalyst loading is kilogram per square meter, kg m^{-2} .

771. copolymer

polymer with more than one type of structural repeat unit linked through covalent bonds

Note to entry: Copolymers are obtained by copolymerisation or sequential polymerisation of two or more different monomers. They can be random, statistical, alternating, periodic, block, cross, graft or mixed.

[Source: ISO 11238:2018 3.19]

772. electro-catalyst

substance (catalyst) that reduces the activation energy of an electrochemical reaction thereby, accelerating (catalysing) its progression

773. electro-catalyst support

component of an electrode that supports the electro-catalyst and serves as a porous and electrically conductive medium

Note to entry: It also leads to a higher ECSA of the catalyst and reduced loading of the electro-catalyst in the electrode.

[Source: JRC EUR 29300 EN report 3.3.3.5]

774. fibre

thread-like object of limited diameter which is very small in proportion to its length

Note to entry: The diameter is typically less than some hundred micrometers.

[Source: IEV 212-15-08]

- 5652 **775. graft copolymer**
5653 copolymer that is a graft polymer
5654
5655 Note to entry: In the constituent macromolecules of a graft copolymer, adjacent blocks in the main chain
5656 or side-chains, or both, are constitutionally different, i. e., adjacent blocks comprise constitutional units
5657 derived from different species of monomer or from the same species of monomer but with a different
5658 composition or sequence distribution of constitutional units.
5659
5660 [Source: IUPAC Purple Book Chapter 1 2.25]
- 5661 **776. graphene**
5662 single layer of carbon atoms with each atom bound to three neighbours in a honeycomb structure
5663
5664 Note 1 to entry: It is an important building block of many carbon nano-objects.
5665 Note 2 to entry: As graphene is a single layer, it is also sometimes called monolayer graphene or single
5666 layer graphene (1LG) to distinguish it from bilayer graphene (2LG) and few layer graphene (FLG).
5667 Note 3 to entry: Graphene has edges and can have defects and grain boundaries where the bonding is
5668 disrupted.
5669
5670 [Source: ISO/TS 80004-13:2017 3.1.2.1]
- 5671 **777. graphene oxide**
5672 chemically modified graphene prepared by oxidation and exfoliation of graphite, causing extensive oxid-
5673 ative modification of the basal plane
5674
5675 Note to entry: Graphene oxide is a single layer material with a high oxygen content, typically char-
5676 acterised by C/O atomic ratios of approximately 2.0 depending on the method of synthesis.
5677
5678 [Source: ISO/TS 80004-13:2017 3.1.2.13]
- 5679 **778. graphite**
5680 allotropic form of the element carbon, consisting of graphene layers stacked parallel to each other in a
5681 three dimensional, crystalline, long-range order
5682
5683 Note 1 to entry: There are two allotropic forms with different stacking arrangements: hexagonal and
5684 rhombohedral.
5685
5686 [Source: ISO/TS 80004-13:2017 3.1.2.2]
5687
5688 Note 2 to entry: The layers are stacked parallel to each other in a three dimensional crystalline long-
5689 range order. The chemical bonds within the layers are covalent with sp^2 hybridisation and with a C-C
5690 distance of 141.7 pm. The weak bonds between the layers are metallic with a strength comparable to
5691 van der Waals bonding only.
5692 Note 3 to entry: The term graphite is also used often but incorrectly to describe graphite materials,
5693 i. e. materials consisting of graphitic carbon made from carbon materials by processing to temperatures
5694 greater than 2,500 K, even though no perfect graphite structure is present.
- 5695 **779. graphite material**
5696 material consisting essentially of graphitic carbon.
5697
5698 Note to entry: The use of the term graphite as a short term for material consisting of graphitic carbon
5699 is incorrect. The term graphite can only be used in combination with other nouns or clarifying adjectives
5700 for special types of graphite materials (graphite electrodes, natural graphite and others). The use of the
5701 term graphite without a noun or clarifying adjective should be restricted to the allotropic form of the
5702 element carbon.
5703
5704 [Source: IUPAC Gold Book G02687]
- 5705 **780. hydrophilicity**
5706 tendency of a molecule to be solvated by water
5707
5708 [Source: IUPAC Gold Book HT06963]

- 5709 **781. hydrophobicity**
5710 association of non-polar groups or molecules in an aqueous environment which arises from the tendency
5711 of water to exclude non-polar molecules
5712
5713 [Source: IUPAC Gold Book HT06964]
- 5714 **782. hydrophilic**
5715 capacity of a molecular entity or of a substituent to interact with polar solvents, in particular with water,
5716 or with other polar groups
5717
5718 [Source: IUPAC Gold Book H02906]
- 5719 **783. ion exchange material**
5720 solid or liquid, inorganic or organic substance containing exchangeable ions with others of the same
5721 charge, present in a solution in which the ion exchanger is considered to be insoluble
5722
5723 Note to entry: It is recognised that there are cases where liquid exchangers are employed and where it
5724 may be difficult to distinguish between the separation process as belonging to ion exchange or liquid-
5725 liquid distribution, but the broad definition given here is regarded as that which is most appropriate. A
5726 monofunctional ion exchanger contains only one type of ionogenic group, a bifunctional ion exchanger
5727 two types and a polyfunctional ion exchanger more than one type. In a macroporous ion exchanger the
5728 pores are large compared to atomic dimensions.
5729
5730 [Source: IUPAC Gold Book I03171]
- 5731 **784. molecular weight**
5732 mass of one molecule of a homogeneous substance or the average mass of molecules that comprise a
5733 heterogeneous substance, which is derived from the molecular structure or the molecular formula
5734
5735 [Source: ISO 11238:2018 3.50]
- 5736 **785. Nafion®**
5737 trade name for sulfonated poly-tetra-fluoro-ethylene (PTFE) copolymer, also known as perfluorosulfonic
5738 acid (PFSA) ionomer
5739
5740 Note to entry: Other perfluorosulfonated ionomer (PFSI) include 3M™ Ionomer, Aciplex®, Aquivion®,
5741 Dow membrane, Flemion™, fumapem® and GORE-SELECT®.
- 5742 **786. permeate**
5743 fluid that diffused through a permeable membrane
- 5744 **787. platinum group metal (PGM)**
5745 consisting of six noble metal elements: iridium, osmium, palladium, platinum, rhodium and ruthenium
5746
5747 [Source: ISO 1942:2009 2.241]
- 5748 **788. polyacid**
5749 polyelectrolyte composed of macromolecules containing acid groups on a substantial fraction of the
5750 constitutional units
5751
5752 Note to entry: Most commonly, the acid groups are -COOH, -SO₃H, or -PO₃H₂.
5753
5754 [Source: IUPAC Purple Book Chapter 10 23]
- 5755 **789. polymer**
5756 substance composed of macromolecules
5757
5758 [Source: IUPAC Purple Book Chapter 1 2.2]

- 5759 **790. polymer electrolyte**
5760 polymer material containing mobile ions that render it ironically conductive
5761
5762 [Source: IEC 62282-8-102:2019 3.1.23]
- 5763 **791. polymerisation**
5764 process of converting a monomer or a mixture of monomers into a polymer
5765
5766 [Source: IUPAC Purple Book Chapter 1 3.1]
5767 [Source: ISO 472:2013 2.744]
- 5768 **792. poly-tetra-fluoro-ethylene (PTFE)**
5769 thermoplastic polymer that is virtually immune to chemical attack and that can be used over a very
5770 wide temperature range
5771
5772 Note to entry: The coefficient of friction is very low, but flexibility is limited and recovery charac-
5773 teristics are only moderate. When appropriate fillers, e. g. glass fibres, bronze, graphite, are added and
5774 the PTFE sintered, it can be machined to the required shape. It is used mainly for the manufacture of
5775 anti-extrusion rings and guide or bearing rings.
5776
5777 [Source: ISO 5598:2019 3.2.547]
- 5778 **793. porous transport layer (PTL)**
5779 porous substrate placed between the catalyst layer and the bipolar plate to serve as an electric contact
5780 and allow the access of reactants to the catalyst layer and the removal of reaction products
5781
5782 Note 1 to entry: The gas diffusion layer is a component of a gas diffusion electrode.
5783
5784 [Source: IEV 485-04-05]
- 5785 **794. reduced graphene oxide**
5786 reduced oxygen content form of graphene oxide
5787
5788 Note 1 to entry: This can be produced by chemical, thermal, microwave, photo-chemical, photo-thermal
5789 or microbial/bacterial methods or by exfoliating reduced graphite oxide.
5790 Note 2 to entry: If graphene oxide was fully reduced, then graphene would be the product. However, in
5791 practice, some oxygen containing functional groups will remain and not all sp^3 bonds will return back to
5792 sp^2 configuration. Different reducing agents will lead to different carbon to oxygen ratios and different
5793 chemical compositions in reduced graphene oxide.
5794 Note 3 to entry: It can take the form of several morphological variations such as platelets and worm-like
5795 structures.
5796
5797 [Source: ISO/TS 80004-13:2017 3.1.2.14]
- 5798 **795. solid polymer electrolyte (SPE)**
5799 electrically conducting solution of a salt in a polymer
5800
5801 Note 1 to entry: An example of a solid polymer electrolyte is a solution of a lithium salt in a poly(oxyethylene)
5802 matrix; the ionic conductivity of such material is due to the mobility of lithium cations and their coun-
5803 terions in an electric field.
5804 Note 2 to entry: Although the adjective "solid" is used, the material may be a liquid.
5805 Note 3 to entry: The term solid polymer electrolyte should not be confused with the term polymeric
5806 electrolyte.
5807
5808 [Source: IUPAC Purple Book Chapter 10 33]
- 5809 **796. spacer**
5810 grid that separates the porous transport layer and the in a PEMEC as part of the electrode

5811 **797. swelling**

5812 increase in volume of a gel or solid associated with the uptake of a liquid or gas

5813

5814 [Source: IUPAC Purple Book Chapter 11 5.41]

5815 [Source: IUPAC Gold Book S06202]

5816

5817 Note to entry: Swelling may occur due to immersion in a liquid or exposure to vapour.

5818 **2.2.3 Manufacture, processing and assembly**

5819 **798. assembly torque**

5820 torque required to achieve a satisfactory final connection

5821

5822 [Source: ISO 5598:2019 3.2.46]

5823 **799. bipolar plate (BPP)**

5824 electrical conductive and gas-tight plate separating individual cells in a single cell or stack, acting as a
5825 reagent flow distributor and current distributor and providing mechanical support for the electrodes or
5826 membrane electrode assembly

5827

5828 [Source: JRC EUR 29300 EN report 3.3.1]

5829 **800. catalyst coated membrane (CCM)**

5830 specific configuration of a membrane electrode assembly (MEA) (for PEMWE and AEMWE) where
5831 catalyst layer (CL) is coated directly onto the membrane to form the reaction zone of the electrode

5832 **801. catalyst layer (CL)**

5833 porous region adjacent to either side of the electrolyte, containing the electro-catalyst, typically with
5834 ionic and electronic conductivity

5835

5836 Note to entry: The catalyst layer comprises the spatial region where the electrochemical reactions
5837 take place.

5838

5839 [Source: IEV 485-02-06]

5840 **802. diaphragm**

5841 elastic element which deforms under differential pressure applied to it

5842

5843 [Source: ISO 20146:2019 3.1.1]

5844 **803. electrolyte matrix**

5845 insulating gas-tight cell component with a properly tailored pore structure that retains the liquid elec-
5846 trolyte

5847

5848 Note to entry: The pore structure has to be adjusted with respect to those of the adjacent elec-
5849 trodes to ensure a complete filling.

5850

5851 [Source: IEV 485-03-05]

5852 **804. fabric**

5853 sheet material produced from yarn or roving by a weaving process

5854

5855 [Source: IEV 212-15-13]

5856 **805. gap**

5857 space between electrodes or an electrodes separator

5858

5859 [Source: JRC EUR 29300 EN report 3.3.17.1]

- 5860 **806. gas diffusion electrode (GDE)**
5861 type of electrode specifically designed for gaseous reactants or products or both
5862
5863 Note 1 to entry: A gas diffusion electrode usually comprises one or more porous layers, like the gas
5864 diffusion layer and the catalyst layer.
5865 Note 2 to entry: Gas diffusion electrodes can be gas diffusion anodes or gas diffusion cathodes.
5866
5867 [Source: IEV 485-02-02]
- 5868 **807. gas diffusion layer (GDL)**
5869 porous substrate placed between the catalyst layer and the bipolar plate to serve as an electric contact
5870 and allow the access of reactants to the catalyst layer and the removal of reaction products
5871
5872 Note 1 to entry: The gas diffusion layer is a component of a gas diffusion electrode.
5873
5874 [Source: IEV 485-04-05]
5875
5876 Note 2 to entry: The gas diffusion layer is also called a porous transport layer.
- 5877 **808. hot isostatic pressing (hip)**
5878 isostatic pressing process carried out at elevated temperatures
5879
5880 Note 1 to entry: The pressurising fluid used in this process is usually a gas.
5881 Note 2 to entry: The temperature is usually in excess of 600 °C.
5882
5883 [Source: IUPAC Purple Book Chapter 11 5.20]
5884
5885 Note 3 to entry: During hot isostatic pressing, the phenomena of diffusion and creep are activated.
- 5886 **809. ink**
5887 material designed for liquid state deposition on a substrate
5888
5889 Note to entry: Ink is a mixture of functional materials and solvent (transport vehicle).
- 5890 **810. inkjet printing (IJP)**
5891 process of building up an image on a receiving layer by non-contact application of droplets of ink, usually
5892 microscopic
5893
5894 [Source: ISO 18055-1:2004 3.1]
- 5895 **811. membrane electrode assembly (MEA)**
5896 component of a PEMEC or an anion exchange membrane electrolysis cell (AEMEC) consisting of an
5897 electrolyte membrane with CLs on either side
- 5898 **812. single electrolysis cell**
5899 basic unit of an electrolysis device composed of three functional elements, namely a cathode, an electro-
5900 lyte and an anode, which are capable of breaking up chemical compounds by means of applied electrical
5901 energy to produce reduced and oxidised compounds
5902
5903 Note to entry: In a WEC, hydrogen and oxygen are generated by the electrochemical splitting of
5904 de-ionised water or water in alkaline aqueous solutions by providing external electrical energy.
5905
5906 [Source: JRC EUR 29300 EN report 3.3.16]
- 5907 **813. water transport layer**
5908 porous transport layer to facilitate water diffusion at the anode and cathode compartment sides
5909
5910 [Source: JRC EUR 29300 EN report 3.27.4]

5911 **814. zero-gap design**

5912 electrolyser cell where electrodes are separated only by the gas separator

5913

5914 [Source: JRC EUR 29300 EN report 3.3.17.2]

5915 **2.2.4 Testing**

5916 **815. catalyst sintering**

5917 binding together of catalyst particles owing to chemical processes, physical processes or both

5918

5919 [Source: IEV 485-01-05]

5920

5921 Note to entry: Catalyst sintering is the mass transport process of forming a completely or partially
5922 densified solid catalyst material by thermal treatment without melting it to the point of liquefaction.

5923 **816. electrolyte reservoir**

5924 component of liquid electrolyte module (i. e. electrochemical cell) that stores liquid electrolyte for the
5925 purpose of replenishing electrolyte losses over model (cell) life

5926 **817. Ostwald ripening**

5927 dissolution of small crystals or sol particles and the redeposition of the dissolved species on the surfaces
5928 of larger crystals or sol particles

5929

5930 Note to entry: The process occurs because smaller particles have a higher surface energy, hence higher
5931 total Gibbs energy, than larger particle, giving rise to an apparent higher solubility. The definition pro-
5932 posed here is recommended for its inclusion of sol particles.

5933

5934 [Source: IUPAC Purple Book Chapter 12 5.27]

5935 **818. pinhole**

5936 hole of very small diameter in the surface of a material

5937

5938 [Source: ISO 472:2013 2.698]

5939 **819. regeneration**

5940 process of restoring an ion exchange material after use to its operationally effective state

5941

5942 [Source: ISO 6107-1:2004 60]

5943 **820. softening**

5944 partial or complete removal from water of calcium and magnesium ions which are responsible for hardness

5945

5946 [Source: ISO 6107-1:2004 68]

5947 **821. sweep gas**

5948 previously dried gas used to carry away moisture from a membrane

5949

5950 [Source: ISO 3857-4:2012 2.67]

5951 **822. torque**

5952 product of the force turning the fastener and the perpendicular distance between the line of force and
5953 the centre of the fastener

5954

5955 [Source: ISO 5393:2017 3.20]

5956

5957 Note to entry: The coherent SI unit of torque is newton meter, Nm.

5958

2.3 High temperature electrolysis terms

823. anode-supported cell (ASC)

solid oxide cell (SOC) in which the anode provides the main mechanical support to the cell

Note to entry: An ASC in FC mode is a cathode-supported cell (CSC) in electrolysis mode when using the same SOC.

824. cathode-supported cell (CSC)

SOC in which the cathode provides the main mechanical support to the cell

Note to entry: A CSC in FC mode is an anode-supported cell (ASC) in electrolysis mode when using the same SOC.

825. cell/stack assembly unit

unit including a single cell or stack including peripherals as required for operation

826. corrosion

physicochemical interaction between a metallic material and its environment that results in changes in the properties of the metal, and that may lead to significant impairment of the function of the metal, the environment or the technical system, of which these form a part

Note to entry: This interaction is often of an electrochemical nature.

[Source: ISO 8044:2020 3.1]

827. electrolyte-supported cell (ESC)

SOC in which the electrolyte provides the main mechanical support to the cell

828. equilibrium phase diagram

mapping of composition, temperature, and, in some cases, pressure that define regimes for thermodynamic stability (lowest Gibbs free energy) for one or more condensed phases

829. high temperature electrolyser (HTE)

device that performs HTEL

Note to entry: These devices include MCE, SOE, and PCE as well as rMCE based on rMCC, rSOE based on rSOC, and rPCE based on rPCC.

830. high temperature electrolysis (HTEL)

electrolysis performed at high temperature

Note to entry: HT refers to temperatures between 500 °C and 1000 °C and concerns SOEL.

831. high-temperature proton conductor (HTPC)

proton-conducting ceramics (PCCs) operating at HTs usually between 400 °C and 800 °C for use, e. g. in FCs and electrolysis cells

832. high temperature steam electrolysis (HTSEL)

HTEL using steam (water vapour)

833. hybrid solid oxide electrolysis cell

solid oxide electrolysis cell that employs a mixed ionic (proton and oxide anion) conductor as electrolyte

Note to entry: In a hybrid SOEC which functions as O-SOEC (OCEC) and H-SOEC (PCEC) combined in a single device, steam is supplied to both electrodes to increase hydrogen production.

834. metal-supported cell (MSC)

SOC in which a porous metallic substrate provides the main mechanical support to the cell

835. metal-supported solid oxide electrolysis cell (MSOEC)

solid oxide electrolysis cell that is mechanically supported by a metallic interconnect or porous substrate

- 6008 **836. mixed ionic and electronic conductor (MIEC)**
6009 solid state conductor exhibiting both ionic and electronic conductivity
- 6010 **837. mixed protonic and electronic conductor (MPEC)**
6011 solid state conductor exhibiting both protonic and electronic conductivity
- 6012 **838. molten carbonate electrolyser (MCE)**
6013 molten carbonate based electrolyser used in HTEL
- 6014 **839. molten carbonate electrolysis cell (MCEC)**
6015 EC with molten carbonate as electrolyte operated in electrolysis mode
- 6016 **840. oxygen ion conducting electrolysis cell (OCEC)**
6017 SOC with oxygen ion conducting electrolyte also abbreviated as O-SOEC
- 6018 **841. oxygen ion conducting solid oxide electrolyser (O-SOE)**
6019 SOE that employs an oxygen ion conducting solid oxide as electrolyte as opposed to a proton conducting
6020 solid oxide electrolyser
- 6021 **842. positive electrode, electrolyte, negative electrode (PEN)**
6022 assembly of layered sequence of positive electrode, electrolyte, and negative electrode
- 6023 **843. proton conducting ceramic electrolysis (PCCEL)**
6024 electrolysis that employs a PCC as electrolyte
- 6025 **844. proton conducting solid oxide electrolyser (P-SOE)**
6026 SOE that employs a proton-conducting solid oxide as electrolyte also abbreviated as H-SOE or PCE
- 6027 **845. proton conducting ceramic electrolysis cell (PCEC)**
6028 SOC with PCC electrolyte also abbreviated as H-SOEC
- 6029 **846. repeating unit (RU)**
6030 elementary unit of a solid oxide cell which periodically repeats itself to form of a stack or a module
6031
6032 Note 1 to entry: For planar SOC geometry, it is composed of one single cell including gas distribu-
6033 tion layers to ensure even feed of reactants to the electrodes and removal of products and two half
6034 interconnects on both sides of the single cell and usually also of a sealant to ensure gas tightness and
6035 contact layers to minimise contact electrical resistances between cells and interconnects.
6036 Note 2 to entry: For tubular SOC geometry, it is composed of one single cell and current collectors
6037 on both sides of the single cell including gas distribution layers to ensure even feed of reactants to the
6038 electrodes and removal of products and usually also of a sealant to ensure gas tightness and contact
6039 layers to minimise contact electrical resistances between cells and current collectors.
- 6040 **847. reversible molten carbonate cell (rMCC)**
6041 MCEC which can function both in FC (MCFC) mode and in electrolysis (MCEC) mode
- 6042 **848. reversible molten carbonate electrolyser (rMCE)**
6043 electrolyser based on rMCC
- 6044 **849. reversible proton conducting ceramic cell (rPCC)**
6045 SOC which can function both in FC mode (PCFC) and electrolysis mode (PCEC) using PCC as an
6046 electrolyte
- 6047 **850. reversible solid oxide cell (rSOC)**
6048 SOC which can function both in FC (SOFC or PCFC) mode and in electrolysis (SOEC or PCEC) mode
6049
6050 Note to entry: This includes rPCC.
- 6051 **851. reversible solid oxide electrolyser (rSOE)**
6052 electrolyser based on rSOC
6053
6054 Note to entry: This includes rPCE based on rPCC.

- 6055 **852. solid oxide cell (SOC)**
6056 EC composed of three functional elements, positive electrode, electrolyte, negative electrode (PEN)
6057 based on ceramic oxide materials
6058
6059 Note 1 to entry: The electrodes are made of electronic and possibly ionic conducting ceramic oxide
6060 or cermet and are attached to one predominantly ion (proton or oxygen) conducting SOC electrolyte.
6061 Note 2 to entry: SOCs can be used in FC mode (SOFC or PCFC) or electrolysis mode (SOEC or PCEC).
6062 Note 3 to entry: SOCs can have various geometries (i. e. planar or tubular).
- 6063 **853. solid oxide co-electrolyser (co-SOE)**
6064 SOE used to perform co-electrolysis
- 6065 **854. solid oxide electrolyser (SOE)**
6066 SOC based electrolyser used in high temperature electrolysis
- 6067 **855. solid oxide electrolysis (SOEL)**
6068 electrolysis that employs a solid oxide as electrolyte
- 6069 **856. solid oxide electrolysis cell (SOEC)**
6070 SOC operated in electrolysis mode, i. e. reversed FC mode
6071
6072 Note 1 to entry: Electricity is required as energy input. Where possible, heat may be used as additional
6073 energy input to reduce the amount of electrical work needed.
6074 Note 2 to entry: It can be used to produce hydrogen from steam and, alternatively, to produce carbon
6075 monoxide from carbon dioxide, or syngas, a mixture of hydrogen and carbon monoxide from water vapour
6076 and carbon dioxide.
6077
6078 [Source: IEC 62282-8-101:2020 3.1.29]
- 6079 **857. solid state conductor (SSC)**
6080 solid state material conducting electrons, ions or both
- 6081 **858. steam**
6082 (pressurised) water vapour
- 6083 **859. steam electrolysis**
6084 electrolysis of water in vapour state usually at temperatures between 700 °C and 900 °C
- 6085 **2.3.1 Electrochemical concepts and phenomena**
- 6086 **860. ceramic ionic conductor**
6087 electroceramic in which ions are transported by an electric potential or chemical gradient
6088
6089 [Source: ISO 20507:2014 2.1.19]
- 6090 **861. chemical diffusion**
6091 diffusion under the influence of a gradient in chemical composition
6092
6093 Note to entry: In concentrated solid solutions, e. g. $A_{1-x}B_x$, or in diffusion couples, the motion of
6094 one constituent causes a counter flow of the other constituent(s) or vacancies. In this case one can
6095 define a diffusion coefficient for the intermixing, which is called the chemical diffusion coefficient or
6096 interdiffusion coefficient.
6097
6098 [Source: IUPAC Gold Book CT06757]
- 6099 **862. electroneutrality principle**
6100 principle that expresses the fact that all pure substances carry a net charge of zero
6101
6102 [Source: IUPAC Gold Book E01992]
6103
6104 Note to entry: This principle applies when incorporating oxide anion vacancies or electron holes into a
6105 (ceramic) lattice.

6106 **863. oxide ion conductor**

6107 oxide exhibiting primarily ionic conduction

6108 **864. reversible cell**

6109 electrochemical device that is able to operate as a fuel cell or as an electrolyser, alternatively

6110

6111 Note to entry: The term "reversible" in this context does not refer to the thermodynamic principle
6112 of an ideal process.

6113

6114 [Source: IEC 62282-8-201:2020 3.1.24]

6115 **865. single repeating unit (SRU)**

6116 repeating unit connected (in series) in a stack or a module

6117 **866. solid electrolyte cell**

6118 cell with an ionically conducting solid as electrolyte

6119

6120 [Source: IEV 482-01-09]

6121 **867. triple-phase boundary (TPB)**

6122 phase boundary and location of contact between three different phases (electronic conductor, ionic con-
6123 ductor and gas)

6124

6125 Note to entry: In this spatial region, ionic and electronic conductivity coexist in the electrode.

6126 **2.3.2 Materials & properties**

6127 **868. acceptor**

6128 dopant material with fewer outer shell electrons than required for an otherwise balanced crystal structure
6129 which can accept a free electron

6130 **869. alloy**

6131 material composed of a metallic element with one or more addition(s) of other metallic and/or non-
6132 metallic elements

6133

6134 [Source: ISO 10993-15:2019 3.1]

6135 **870. anode functional layer (AFL)**

6136 functional layer (FL) between anode and electrolyte

6137

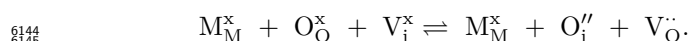
6138 Note to entry: An AFL in fuel cell mode is a cathode functional layer (CFL) in electrolysis mode
6139 when using the same SOC.

6140 **871. anti-Frenkel defect**

6141 point defect in crystalline solids forming oppositely charged anionlattice interstitial-lattice vacancy pairs

6142

6143 Example: Metal (II) oxide, MO



6145

6146 Note 1 to entry: This point defect occurs when the cations are greater than the anions.

6147 Note 2 to entry: Anti-Frenkel defect and Frenkel defect are named after Russian physicist Yakov Il'ich
6148 Frenkel (1894-1952).

6149 **872. anti-Schottky defect**

6150 point defect in crystalline solids forming oppositely charged pairs of lattice interstitials

6151

6152 Example: Metal (II) oxide, MO



6154

- 6155 Note 1 to entry: Schottky defects (Schottky disorder) and anti-Schottky defects (anti-Schottky disorder)
6156 result in measurable volume expansion of the solid crystal due to lattice interstitial formation.
6157 Note 2 to entry: Anti-Schottky defect and Schottky defect are named after German physicist Walter
6158 Hans Schottky (1886-1976).
- 6159 **873. anti-site defect**
6160 point defect in crystalline solids forming when ions of different type exchange lattice sites
6161
6162 Example: Metal (II) oxide, MO
- $$6163 \text{M}_\text{M}^x + \text{O}_\text{O}^x \rightleftharpoons \text{M}_\text{O}^x + \text{O}_\text{M}^x. 6164$$
- 6165 **874. austenitic stainless steel**
6166 stainless steel typically composed of less than 0,2 % (mass fraction) C, at least 16 % (mass fraction)
6167 Cr, typically about 18 % (mass fraction) Cr and over 8 % (mass fraction) Ni, which cannot be hardened
6168 by heat treatment
6169
6170 [Source: ISO 21850-1:2020 3.2.1]
- 6171 **875. barrier layer (BL)**
6172 interlayer between components (i. e. electrode and electrolyte) having various functions including pre-
6173 venting the formation of undesired secondary phases by interfacial reactions or chemical diffusion which
6174 may lead to current leakage
6175
6176 Note to entry: The preferred term is diffusion barrier layer.
- 6177 **876. cathode functional layer (CFL)**
6178 functional layer (FL) between cathode and electrolyte
6179
6180 Note to entry: An CFL in fuel cell mode is an anode functional layer (AFL) in electrolysis mode when
6181 using the same SOC.
- 6182 **877. ceramic**
6183 rigid material that consists of an infinite three dimensional network of sintered crystalline grains com-
6184 prising metals bonded to carbon, nitrogen or oxygen
6185
6186 Note to entry: The term ceramic generally applies to any class of inorganic, non-metallic product
6187 subjected to high temperature during manufacture or use.
6188
6189 [Source: IUPAC Purple Book Chapter 11 4.1.2]
6190 [Source: IUPAC Gold Book CT07540]
- 6191 **878. ceramic bond**
6192 bond produced by sintering or liquid formation at high temperature
6193
6194 [Source: ISO 836:2001 025]
- 6195 **879. ceramic grain**
6196 individual crystal within the polycrystalline microstructure of a ceramic
6197
6198 [Source: ISO 20507:2014 2.2.11]
- 6199 **880. cerium doped gadolinium oxide (CGO)**
6200 oxide ceramic material of general formula $\text{Ce}_x\text{Gd}_{1-x}\text{O}_{2-\delta}$ with cubic structure made of gadolinium (III)
6201 oxide (gadolinia, Gd_2O_3) doped with cerium (IV) oxide (ceria, CeO_2)
- 6202 **881. cerium-doped samarium oxide (CSO)**
6203 oxide ceramic material of general formula $\text{Ce}_{1-x}\text{Sm}_x\text{O}_{2-\delta}$ with cubic structure made of samarium (III)
6204 oxide (samaria, Sm_2O_3) doped with cerium (IV) oxide (ceria, CeO_2)

- 6205 **882. cermet**
6206 sintered material containing at least one metallic phase and at least one non-metallic phase which is
6207 generally of a ceramic nature
6208
6209 [Source: ISO 3252:2019 3.5.1]
6210
6211 Note to entry: The ceramic phase is normally present at a volume fraction greater than 50 %.
- 6212 **883. chromite**
6213 material containing a substantial amount of chromium sesquioxide combined with other di- and tri-valent
6214 metal oxides to form a cubic crystal structure
- 6215 **884. chromium poisoning**
6216 degradation by which a non-chromium based ceramic material is electrocatalytically deactivated or
6217 reduced in its catalytic functionality due the reaction with condensed chromium species
- 6218 **885. closed pores**
6219 pores that are enclosed within a porous structure and are not penetrated by fluid
- 6220 **886. closed porosity**
6221 ratio of the total volume of the closed pores in a porous structure to its bulk volume, expressed as a
6222 percentage of bulk volume
- 6223 **887. contact layer**
6224 layer applied between the interconnect and the cell to minimise the contact electrical resistance
6225
6226 [Source: IEC 62282-8-101:2020 3.1.9]
- 6227 **888. crystal structure**
6228 lattice structure in which atoms of an individual crystal are arranged, using lattice parameters and lattice
6229 type, such as face centred cubic (fcc), hexagonal close packed (hcp), body centred cubic (bcc), cubic, etc.
6230
6231 [Source: ISO/TR 16196:2016 3.2.2]
- 6232 **889. cubic-stabilised zirconia (CSZ)**
6233 zirconium oxide (zirconia) based ceramic which contains sufficient additional inorganic oxide species to
6234 retain the cubic crystal modification at ambient temperature
- 6235 **890. delamination**
6236 separation of layers in a laminate as the result of failure with adhesion
- 6237 **891. diffusion barrier layer (DBL)**
6238 thin layer usually made of a ceramic material placed between two adjacent components, for example,
6239 anode and electrolyte or electrolyte and cathode to function as a barrier for solid-state species diffusion
6240 (inter-diffusion)
- 6241 **892. dislocation**
6242 crystallographic linear defect in a crystal structure, which strongly influences many of the properties of
6243 materials and has two primary types: edge dislocations and screw dislocations
6244
6245 [Source: ISO 15932:2013 6.5.1]
6246
6247 Note 1 to entry: A screw dislocation is a structure in which a helical path is traced around a linear
6248 defect (dislocation line) by the atomic planes in the crystal lattice.
6249 Note 2 to entry: An edge dislocation is a defect where an extra half-plane of atoms is introduced mid-way
6250 through the crystal.
6251
6252 [Source: IUPAC Recommendation 2020 (Jones et al., 2020) AL-2.35]

6253 **893. dispersion-strengthened material**

6254 metal-matrix composite in which the second (and any other) phase is in the form of a fine dispersion in
6255 the metallic matrix (which is the first phase)

6256
6257 [Source: ISO 3252:2019 3.5.2]

6258 **894. donor**

6259 dopant material which puts an additional electron into an energy level near the conduction band for ease
6260 of exciting it to increase electrical conductivity compared to an undoped material

6261 **895. dopant**

6262 substance added in small or substantial quantity to another substance to prevent or control recrystal-
6263 lisation or grain growth either during sintering or during use of the resultant sintered object or to raise
6264 ionic or electronic conductivity of the latter substance

6265 **896. doping**

6266 process of that increases the thermal-equilibrium concentration of free charge carriers in a material to
6267 augment its electrical conductivity using chemical agents or additives (i. e. dopants)

6268
6269 [Source: IUPAC Recommendation 2020 (Jones et al., 2020) AL-2.40]

6270 **897. edge dislocation**

6271 dislocation where an extra half-plane of atoms is inserted in the crystal, distorting nearby planes

6272
6273 [Source: ISO 15932:2013 6.5.1.1]

6274 **898. embrittlement**

6275 severe loss of toughness of a material

6276
6277 [Source: ISO 4885:2018 3.76]

6278 **899. ferritic stainless steel**

6279 stainless steel with low carbon with less than 0,1 % (mass fraction) C and between 10,5 % (mass frac-
6280 tion) and 30 % (mass fraction) Cr, but which cannot be hardened by heat treatment

6281
6282 [Source: ISO 21850-1:2020 3.2.4]

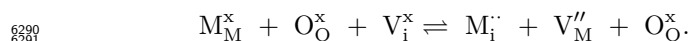
6283 **900. Frenkel defect**

6284 point defect in crystalline solids forming oppositely charged cation lattice interstitial-lattice vacancy pairs

6285
6286 Example 1: Metal (I) oxide, M_2O



6288
6289 Example 2: Metal (II) oxide, MO



6292 Note 1 to entry: This point defect occurs when the cations are smaller than the anions.

6293 Note 2 to entry: In contrast to Schottky defects and anti-Schottky defects, Frenkel defects (Frenkel
6294 disorder) and anti-Frenkel defects (anti-Frenkel disorder) yield at most negligible volume expansion
6295 and/or surface increase of the solid crystal.

6296 **901. functional layer (FL)**

6297 layer deposited to fulfill a specific function like enhanced electrocatalytic activity

6298 **902. functionally graded**

6299 characteristic of inhomogeneous materials which consist of two or more different materials engineered to
6300 have a continuous variation in composition and structure gradually over volume resulting in corresponding
6301 changes in the properties of the material

6302 **903. gadolinium doped cerium oxide (GDC)**

6303 oxide ceramic material of general formula $Gd_xCe_{1-x}O_{2-\delta}$ with cubic structure made of cerium (IV)
6304 oxide (ceria, CeO_2) doped with gadolinium (III) oxide (gadolinia, Gd_2O_3)

6305 **904. glass ceramic**

6306 inorganic material produced by the complete fusion of raw material at high temperatures into a homo-
6307 geneous liquid which is then cooled to a rigid condition and temperature treated in such a way as to
6308 produce a mostly microcrystalline body

6309
6310 [Source: ISO 6486-2:1999 3.14]

6311 **905. Goldschmidt tolerance factor**

6312 indicator (dimensionless number) for the stability and distortion of crystal structures (e. g. perovskite)
6313 in terms of the constituent ionic packing calculated from the ratio of the constituent ionic radii:

6314
$$\frac{r_A + r_O}{\sqrt{2}(r_B + r_O)}$$

6315 where r_A and r_B are the radii of the A and B cations and r_O is the radius of the O anion

6316

6317 Note 1 to entry: Several other formulas are proposed which extend the applicability of this factor
6318 beyond perovskite type crystal structures.

6319 Note 2 to entry: This factor is named after Norwegian mineralogist Victor Moritz Goldschmidt (1888-
6320 1947).

6321 **906. grain**

6322 material region in which atoms are aligned forming a crystal

6323 **907. grain boundary**

6324 in-plane interface between two or more crystalline domains of a 2D material where the crystallographic
6325 direction of the lattice changes

6326

6327 [Source: ISO/TS 80004-13:2017 3.4.1.8]

6328 **908. grain coarsening**

6329 diffusion-controlled growth of mean grain size by the reduction in grain boundary area

6330 **909. green body**

6331 shaped but unsintered that is, not subjected to thermal treatment

6332 **910. green density**

6333 mass per unit volume of an unsintered compact

6334

6335 [Source: ISO 3252:2019 3.2.45]

6336 **911. high temperature corrosion**

6337 corrosion by gases or deposits or both gases and deposits occurring at elevated temperatures

6338

6339 Note to entry: High temperature corrosion can become significant at temperatures above 170 °C de-
6340 pending on material and environment.

6341 **912. hot corrosion**

6342 corrosion by gases or deposits or both gases and deposits forming a liquid phase during a high temper-
6343 ature corrosion reaction

6344

6345 Note to entry: Hot corrosion is a sub-term of high temperature corrosion.

6346

6347 [Source: ISO 8044:2020 4.50]

- 6348 **913. interconnect**
- 6349 conductive and gas-tight (dense) component electrically connecting neighbouring single cells in a stack
- 6350
- 6351 Note to entry: In tubular cells, interconnects are axial metal stripes on the exterior of the single cell
- 6352 tube.
- 6353 **914. intergranular fracture**
- 6354 crack propagation along the grain boundaries of a material, e. g. alloy, ceramic or cermet
- 6355 **915. isomorphous**
- 6356 describing two or more crystals having same crystal form that is, having identical molecular arrangement
- 6357 and number but containing different, interchangeable elements
- 6358 **916. Kirkendall voids**
- 6359 voids (pores) acting as sinks for lattice vacancies formed at the boundary interface of distinct materi-
- 6360 als next to each other due to atomic motion of the interface between the two materials (lattice drift)
- 6361 that occur as a consequence of the difference in diffusion rates of their constituting atoms (interdiffusion)
- 6362
- 6363 Note to entry: This phenomenon is named after US chemist Ernest Oliver Kirkendall (1914–2005).
- 6364 **917. Kröger-Vink notation**
- 6365 convention describing electric charge and lattice position for point defects in solid crystals

Table 1: Notation of crystal lattice point defects

Charge, site, species	Description
x	neutral charge of a species relative to the site that it occupies
$'$, $''$, ...	single, double, ... negative charge of a species relative to the site that it occupies
\cdot , $\ddot{\cdot}$, ...	single, double, ... positive charge of a species relative to the site that it occupies
i , M , O	lattice interstitial site, regular metal cation lattice site, regular oxide anion lattice site
e'	electron carrying a negative charge; superscript prime may also be omitted
$h\cdot$	electron hole carrying a delocalised positive charge; superscript dot may also be omitted
M , H , O , V	metal cation, proton, oxide anion, lattice vacancy
M_M^x	metal cation lattice site
M_M' , M_M'' , ...	single, double, ... negatively charged metal cation on its regular lattice site
$M_M\cdot$, $M_M\ddot{\cdot}$, ...	single, double, ... positively charged metal cation on its regular lattice site
A_B' , A_B'' , ...	single, double, ... negatively charged A ion on a regular B ion lattice site
$B_A\cdot$, $B_A\ddot{\cdot}$, ...	single, double, ... positively charged B ion on a regular A ion lattice site
M_i' , M_i'' , ...	single, double, ... negatively charged metal cation on a lattice interstitial site
$M_i\cdot$, $M_i\ddot{\cdot}$, ...	single, double, ... positively charged metal cation on a lattice interstitial site
OH_O	positively charged hydroxyl anion oxide lattice site (protonic defect)
OH_i'	negatively charged hydroxyl anion lattice interstitial site
O_O^x	oxide anion on its regular lattice site
O_i''	double negatively charged oxide anion lattice interstitial site
H_i	proton lattice interstitial site
V_M' , V_M'' , ...	single, double, ... negatively charged metal cation lattice vacancy
$V_M\cdot$, $V_M\ddot{\cdot}$, ...	single, double, ... positively charged metal cation lattice vacancy
V_i^x	vacant lattice interstitial site
$V_O\ddot{\cdot}$	double positively charged oxide anion lattice vacancy
V_O''	double negatively charged oxide anion lattice vacancy

6366

6367 Note 1 to entry: Electric charge is relative to the electrically neutral perfect host lattice that is, the total

6368 effective charge is the same before and after defect formation or annihilation. In analogy to chemical

6369 reactions, Kröger-Vink notation is used to represent defect reactions at equilibrium with conservation

6370 of charge, mass and ratio of structural sites. Charge conservation means same net charge on the left

6371 hand side (LHS) and the right hand side (RHS) of the reaction equation. Mass conservation means the

6372 number and types of the involved atoms is the same on both sides of the reaction equation. Except for

6373 infinitely adaptive structures, conservation of the ratio of structural sites means a constant ratio of the
6374 number of cation and anion lattice sites including their respective lattice interstitials on both sides of the
6375 reaction equation whether or not the underlying compound is stoichiometric in composition. Remark,
6376 no sites are created when forming electronic defects (electrons and electron holes).
6377 Note 2 to entry: This notation is named after Dutch chemist Ferdinand Anne Kröger (1915-2006) and
6378 physicist Hendrik Jan Vink (1915-2009).

6379 **918. lanthanum-doped strontium titanate (LST)**

6380 oxide ceramic material of general formula $Sr_{1-x}La_xTiO_3$ with perovskite structure made of strontium
6381 titanate ($SrTiO_3$) doped with lanthanum oxide (strontia, La_2O_3)

6382 **919. strontium-doped lanthanum manganite (LSM)**

6383 oxide ceramic material of general formula $La_{1-x}Sr_xMnO_{3-\delta}$ with cubic perovskite based structure made
6384 of lanthanum manganite ($LaMnO_3$) doped with strontium oxide (strontia, SrO)

6385 **920. lattice defect**

6386 crystallographic defect due to the irregularity in the atomic arrangement in the crystal

6387 [Source: ISO 15932:2013 6.5]
6388

6389 **921. mechanical alloying**

6390 process of alloying in the solid state by high-energy attritor or ball-mill

6391 [Source: ISO 3252:2019 3.1.49]
6392

6393 **922. metal dusting**

6394 carburisation of metallic materials in process gases containing carbon oxides and hydrocarbons and with
6395 extremely low oxygen partial pressures leading to disintegration of the metal into dust of graphite, metal
6396 or carbides, or combinations

6397
6398 Note to entry: The temperature range for metal dusting lies between 400 °C and 900 °C. For the
6399 mechanism to happen, a carbon activity higher than 1 in the process gas is required.

6400 [Source: ISO 8044:2020 4.52]
6401

6402 **923. mica**

6403 crystalline silicates with monoclinic crystals which easily break off into very thin, tough scales or laminate

6404 [Source: IEV 212-16-15]
6405

6406 Note to entry: Two main types are used for electric insulation purposes, namely muscovite and phlogo-
6407 pite.
6408

6409 **924. microstructure**

6410 arrangement of individual crystals or amorphous phases in a polycrystalline or multiphase material

6411 [Source: ISO/TR 16196:2016 3.2.4]
6412

6413 Note to entry: Microstructural aspects of a material typically refer to features that are of order of
6414 one micrometer and include grain size, shape and porosity.
6415

6416 **925. nano-composite ceramic**

6417 composite with highly designed microstructure in which fine particle of nano-metric size are dispersed
6418 in a ceramic matrix

6419 [Source: ISO 20507:2014 2.1.52]
6420

6421 **926. nano-structured ceramic**

6422 ceramic material for which at least one of its structural or microstructural elements has one of its di-
6423 mension in between 1 nm to 100 nm

6424 [Source: ISO 20507:2014 2.1.53]
6425

6426 **927. oxide**

6427 chemical compound that contains at least one oxygen atom and one other element chemically bonded
6428 to oxygen

6429 **928. oxide ceramic**

6430 fine ceramic produced primarily from substantially pure metallic oxides or from mixtures and/or solid
6431 solutions thereof

6432
6433 Note to entry: This term may also be applied to ceramics other than fine ceramics.

6434 [Source: ISO 20507:2014 2.1.56]
6435

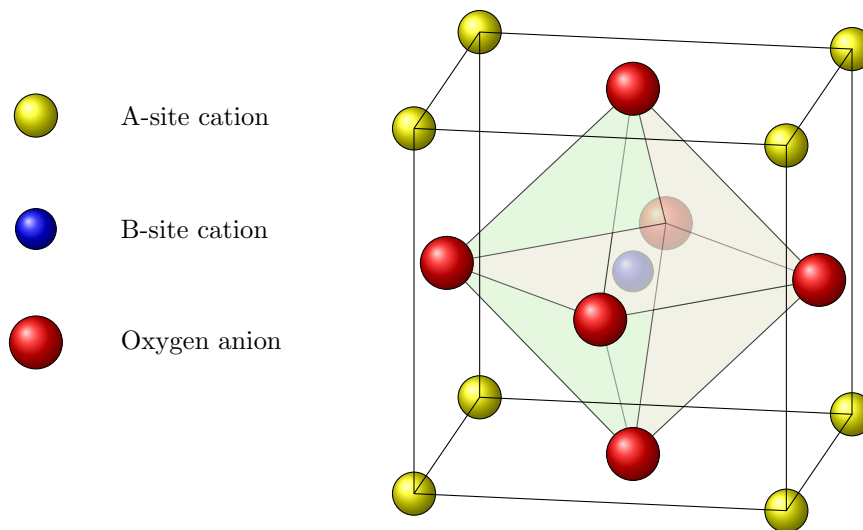
6436 **929. perovskite**

6437 synthetic compound with ABX_3 type of crystal structure (cubic space group $Pm\bar{3}m$) such as calcium
6438 titanium oxide, $CaTiO_3$

6439
6440 Note 1 to entry: Solid oxide cell electrode materials (i.e. LSCF, LSC, LSM) are commonly made of
6441 perovskites and its derivatives. Deliberate incorporation of differences in valency and/or stoichiometry of
6442 the A-site with respect to the B-site introduces lattice defects and/or oxygen anion sub-stoichiometry to
6443 maintain electrical neutrality at the macro scale. As a result, oxygen ion conducting, proton conducting,
6444 electronic conductive or a mixed ionic and electronic conductor (MIEC) are obtained.

6445 Note 2 to entry: The perovskite mineral was discovered by German mineralogist Gustavus Rose (1798-
6446 1873). It is named after Russian mineralogist Lev Alekseyevich Perovskii (1792–1856).

Figure 8: Schematic representation of the cubic crystal structure of ABO_3 perovskite with cations, A^{2+} & B^{4+} and anion, O^{2-}



6448 **930. point defect**

6449 defect that occurs only at or around one structural or lattice site and its immediate vicinity

6450
6451 Note 1 to entry: Generally, point defects involve at most a few missing, dislocated or different atoms
6452 creating a vacancy or vacancies, extra atoms (interstitial defects) or replaced (substituted) atoms (sub-
6453 stitutional defects) as well as impurities (substitutional and/or interstitial defects) and electronic defects
6454 (electrons, electron holes). These defects do not extend in any spatial dimension and are thus considered
6455 zero dimensional (0D).

6456 Note 2 to entry: In contrast to point defects, line defects (edge dislocations, screw dislocations, stacking
6457 faults) are one dimensional (1D), planar or surface defects (grain boundaries, twin boundaries) are 2D
6458 and bulk or volume defects (cracks, voids, inclusions, precipitations) are 3D.

6459 **931. polycrystal**

6460 many crystalline parts that are randomly oriented with respect to each other

6461
6462 [Source: ISO 22576:2020 3.8]

- 6463 **932. polymorph**
 6464 describing two or more crystals having same chemical composition but different atomic arrangement and
 6465 crystal structure, that is, they crystallise distinctly
- 6466 **933. powder**
 6467 particles that are usually less than 1 mm in size
 6468
 6469 [Source: ISO 3252:2019 3.1.63]
- 6470 **934. rare earth element**
 6471 group of heavy elements very similar in chemical properties and traditionally thought to be extremely
 6472 rare on earth
 6473
 6474 Note to entry: They take up atomic numbers 57 through 71 of the periodic table. They are actu-
 6475 ally abundant in the crust of the earth but scattered which makes their exploration difficult as they
 6476 commonly occur in extremely small quantities usually combined with other ores and minerals.
- 6477 **935. refractory**
 6478 material or product (but not excluding those containing a proportion of metal) whose chemical and
 6479 physical properties allow it to be in contact with hot glass or be used in a high temperature environment
 6480 without fusing or breaking it down
- 6481 **936. Ruddlesden-Popper (RP) phase**
 6482 layered perovskite structure that consists of two dimensional perovskite-like slabs interleaved with cations
 6483 of general formula $A_{n-1}A'_2B_nX_{3n+1}$ where A and A' are cations representing alkali, alkaline earth, or
 6484 rare earth metals, B represents a transition metal cation and X is a chalcogen or halogen group anion
 6485 (e. g. oxygen, X=O) made of n consecutive perovskite layer (ABX_3) alternating with rock salt layers
 6486 (AO) along the crystallographic c direction
 6487
 6488 Note to entry: This structure is named after British scientists S N Ruddlesden and P Popper (Ruddlesden
 6489 and Popper, 1957, Ruddlesden and Popper, 1958).
- 6490 **937. samarium-doped cerium oxide (SDC)**
 6491 oxide ceramic material of general formula $Sm_xCe_{1-x}O_{2-\delta}$ with cubic structure made of samarium (III)
 6492 oxide (samaria, Sm_2O_3) doped with cerium (IV) oxide (ceria, CeO_2)
- 6493 **938. scandia-stabilised zirconia (ScSZ)**
 6494 cubic-stabilised zirconia in which scandium oxide is the stabilising agent
- 6495 **939. Schottky defect**
 6496 point defect in crystalline solids forming oppositely charged pairs of lattice vacancies
 6497
 6498 Example: Metal (II) oxide, MO
 6499
$$\emptyset \rightleftharpoons V_M'' + V_O\cdot$$

 6500
- 6501 Note 1 to entry: Schottky defects and anti-Schottky defects are valency defects occurring where cations
 6502 and anions are of comparable size.
 6503 Note 2 to entry: Schottky defects (Schottky disorder) result in measurable volume expansion and/or
 6504 surface increase of the solid crystal due to the formation of lattice vacancies accompanied by migration
 6505 of host ions to the crystal surface.
- 6506 **940. screw dislocation**
 6507 dislocation in a crystal structure in which atoms are arranged in a helical pattern that is normal to the
 6508 direction of the shear stress and the atom displacement
- 6509 **941. sintering shrinkage**
 6510 decrease in dimensions of a compact as a result of sintering
 6511
 6512 [Source: ISO 3252:2019 3.3.57]

- 6513 **942. solid oxide membrane (SOM)**
 6514 membrane made of solid oxide
- 6515 **943. spalling**
 6516 fragmentation and detachment of portions of the surface layer or scale
 6517
 6518 [Source: ISO 8044:2020 4.34]
- 6519 **944. spinel**
 6520 class of compounds typical with cubic crystalline structure of MgAl_2O_4 type ($F\bar{4}3m$ space group),
 6521 composed of mixtures of di- and tri-/tetra-valent metal oxide (or metal sulphide)
- 6522 **945. stacking fault**
 6523 type of planar defect which arises from the irregularity in stacking sequence of closed-packed atomic
 6524 planes and is commonly formed in close-packed structures, such as fcc and hcp
 6525
 6526 [Source: ISO 15932:2013 6.5.3]
- 6527 **946. strontium-doped lanthanum chromite magnetite (LSCM)**
 6528 oxide ceramic material of general formula $\text{La}_{1-x}\text{Sr}_x\text{Cr}_y\text{Mn}_{1-y}\text{O}_{3-(x+y)}$ with perovskite structure made
 6529 of lanthanum magnetite (LaMnO_3) doped with strontium oxide (strontia, SrO) and chromium oxide
 6530 (chromia, Cr_2O_3)
- 6531 **947. strontium-doped lanthanum cobaltite (LSC)**
 6532 oxide ceramic material of general formula $\text{La}_{1-x}\text{Sr}_x\text{CoO}_{3-\delta}$ with rhombohedral perovskite structure
 6533 made of lanthanum cobaltite (LaCoO_3) doped with strontium oxide (strontia, SrO)
- 6534 **948. strontium-doped barium cobaltite ferrite (BSCF)**
 6535 oxide ceramic material of general formula $\text{Ba}_{1-x}\text{Sr}_x\text{Co}_y\text{Fe}_{1-y}\text{O}_3$ with perovskite structure made of
 6536 barium cobaltite ferrite ($\text{Ba}(\text{Co,Fe})\text{O}_3$) doped with strontium oxide (strontia, SrO)
 6537
 6538 Note to entry: BSCF is a MIEC.
- 6539 **949. strontium-doped lanthanum cobaltite ferrite (LSCF)**
 6540 oxide ceramic material of general formula $\text{La}_{1-x}\text{Sr}_x\text{Co}_y\text{Fe}_{1-y}\text{O}_3$ with hexagonal perovskite structure
 6541 made of lanthanum cobaltite ferrite ($\text{La}(\text{Co,Fe})\text{O}_3$) doped with strontium oxide (strontia, SrO)
 6542
 6543 Note to entry: LSCF is a mixed ionic and electronic conductor.
- 6544 **950. strontium-doped lanthanum ferrite (LSF)**
 6545 oxide ceramic material of general formula $\text{La}_{1-x}\text{Sr}_x\text{FeO}_{3-\delta}$ with orthorhombic perovskite structure made
 6546 of lanthanum ferrite (LaFeO_3) doped with strontium oxide (strontia, SrO)
- 6547 **951. strontium-doped lanthanum gallate magnesite (LSGM)**
 6548 oxide ceramic material of general formula $\text{La}_{1-x}\text{Sr}_x\text{Co}_y\text{Fe}_{1-y}\text{O}_{3-(x+y)}$ with perovskite structure made
 6549 of lanthanum gallate (LaGaO_3) doped with strontium oxide (strontia, SrO) and magnesium oxide (mag-
 6550 nesia, Mg_2O)
 6551
 6552 Note to entry: LSGM is an IT electrolyte.
- 6553 **952. supporting layer**
 6554 layered structure of or at an electrode having appropriate thickness to provide mechanical support to
 6555 the electrode
- 6556 **953. tetragonal zirconia polycrystal (TZP)**
 6557 fine ceramic, based principally on zirconium oxide, having a fine-grained structure in which the amount
 6558 of stabilising species is controlled such that the principal crystalline phase retained at room temperature
 6559 is the high temperature tetragonal modification
 6560
 6561 Note to entry: The stabiliser is normally yttria.
 6562
 6563 [Source: ISO 20507:2014 2.4.46]

6564 **954. transgranular fracture**

6565 crack propagation within a crystal grain of a material, e.g. alloy, ceramic or cermet

6566 **955. yttria-stabilised zirconia (YSZ)**

6567 cubic-stabilised zirconia in which yttrium oxide (yttria, Y_2O_3) is the stabilising agent

6568

6569 Note to entry: YSZ is used as electrolyte in solid oxide cells.

6570 **2.3.3 Manufacture & processing**

6571 **956. additive manufacturing (AM)**

6572 process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to
6573 subtractive manufacturing and formative manufacturing methodologies

6574

6575 [Source: ISO 18739:2016 3.1.4]

6576 **957. annealing**

6577 process of heating to, and holding at, a suitable temperature and then cooling at a suitable rate for such
6578 purposes as lowering hardness, facilitating cold working, producing a desired microstructure or obtaining
6579 desired mechanical, physical, or other properties

6580

6581 [Source: ISO 6932:2014 3.4]

6582 **958. atmospheric plasma spraying (APS)**

6583 method of thermal spraying under atmospheric conditions that produces particles or coatings on a
6584 substrate using a plasma jet with fast solidification and without need for sintering

6585 **959. atomic layer deposition (ALD)**

6586 process of fabricating uniform conformal films through the cyclic deposition of material through self-
6587 terminating surface reactions that enable thickness control at the atomic scale

6588

6589 Note to entry: This process often involves the use of at least two sequential reactions to complete
6590 a cycle that can be repeated several times to establish a desired thickness.

6591

6592 [Source: ISO/TS 80004-13:2017 3.2.1.19]

6593 **960. binder jetting**

6594 additive manufacturing process in which a liquid bonding agent is selectively deposited to join powder
6595 materials

6596

6597 [Source: ISO/ASTM 52900:2015 3.1.1]

6598 **961. brazing**

6599 metal-joining process in which two or more metal items are joined together by melting of a filler metal
6600 at a liquidus temperatures above 450 °C but lower than the solidus temperature of the adjoining metal
6601 items and flowing of the filler by capillary action into the joint

6602

6603 Note to entry: Brazing differs from welding in that it does not involve melting the work piece and
6604 from soldering in using high temperatures while it also requiring much more closely fitted parts.

6605 **962. calcination (calcining)**

6606 heat treatment of a material prior to use for the purpose of producing chemical or physical changes and
6607 eliminating volatile chemically combined constituents and volume changes

6608 **963. casting**

6609 process in which a liquid or viscous material is poured or otherwise introduced into a mould or on to a
6610 prepared surface to solidify without the use of external pressure

6611

6612 [Source: ISO 472:2013 2.120]

- 6613 **964. chemical vapour deposition (CVD)**
6614 process at a pressure less than atmospheric pressure in which precursor source gas flows in the laminar
6615 regime over a substrate where it condenses reaction products or reacts heterogeneously to form film
6616 deposits on its surface
- 6617 **965. cold isostatic pressing (cip)**
6618 process of preparing a green body from a ceramic powder or a ceramic granulate by the use of (pseudo-)
6619 isostatic pressure at or near room temperature (RT)
6620
6621 [Source: ISO 20507:2014 2.2.21]
- 6622 **966. colloidal spray deposition (CSD)**
6623 method of spray deposition of a colloidal suspension onto a heated substrate
- 6624 **967. densification**
6625 increasing density either locally or totally of a green or sintered body
6626
6627 [Source: ISO 3252:2019 3.4.2]
- 6628 **968. dip coating**
6629 creation of a thin film by dipping a substrate into a solution containing the material of interest
6630
6631 [Source: ISO/TS 80004-8:2013 7.2.6]
- 6632 **969. dry ball milling**
6633 size reduction technique that creates smaller particles via rolling feed stock material(s) with inorganic
6634 crushing balls typically of greater hardness in a rotating chamber to mix immiscible particles which are
6635 then heated to sinter them under dry conditions
- 6636 **970. electrochemical vapour deposition (EVD)**
6637 method of vapour deposition under the application of a potential gradient
- 6638 **971. electrophoretic deposition (EPD)**
6639 electric field assisted method of deposition of charged particles in a stable colloidal suspension onto a
6640 conductive substrate, acting as one of the two oppositely charged electrodes in the EPD cell
- 6641 **972. exsolution method**
6642 process whereby an initially homogeneous solid solution separates into two (or possibly more) distinct
6643 crystalline phases without addition or removal of material, i. e., without change in the bulk composition
6644
6645 Note to entry: It generally, though not necessarily, occurs on cooling.
6646
6647 [Source: ISO 22932-2:2020 3.3.6]
- 6648 **973. extrusion**
6649 continuous shaping of a material by passage through a die
6650
6651 [Source: ISO 1382:2020 3.189]
- 6652 **974. firing**
6653 heating process in an oxidising atmosphere
- 6654 **975. focused ion beam (FIB) deposition**
6655 ion induced formation and transfer of a material onto the surface of a substrate
6656
6657 [Source: ISO/TS 80004-8:2013 7.2.12]
- 6658 **976. focused ion beam (FIB) lithography**
6659 direct write patterning process that uses a focused ion beam to modify the solubility of a resistive layer
6660
6661 [Source: ISO/TS 80004-8:2013 7.1.9]

6662
6663 Note to entry: It is a technique used for the site-specific analysis, deposition, ablation, and microma-
6664 chining of materials down to dimensions of 10 to 15 nm.
6665
6666 [Source: IUPAC Recommendation 2020 (Jones et al., 2020) AL-2.55]

6667 **977. glass transition**
6668 physical change in an amorphous material or in amorphous regions of a partially crystalline material from
6669 a viscous or rubbery condition to a hard one, or the reverse
6670
6671 [Source: IEV 212-12-28]

6672 **978. glass transition temperature**
6673 approximate midpoint of the temperature range over which a glass transforms between elastic and vis-
6674 coelastic behaviour characterised by the onset of a rapid change in its coefficient of thermal expansion
6675
6676 [Source: ISO 6872:2015 3.3.3]
6677
6678 Note to entry: The glass transition temperature is typically determined from the inflection point of
6679 a specific heat versus temperature plot and represents an intrinsic material property.

6680 **979. grinding**
6681 size reduction technique to produce smaller particles via mechanical shearing in contact with an abrasive
6682 material of greater hardness

6683 **980. heat treatment**
6684 process to alter the physical, mechanical and/or chemical properties of a material, either wholly or par-
6685 tially, with the application of heat
6686
6687 [Source: ISO 13574:2015 2.81]

6688 **981. impregnating**
6689 incorporate a material into a porous material most commonly through a soaking or immersion process
6690
6691 [Source: ISO 13574:2015 2.88]

6692 **982. laser sintering (LS)**
6693 powder bed fusion process used to produce objects from powdered materials using one or more lasers to
6694 selectively fuse or melt the particles at the surface, layer upon layer, in an enclosed chamber
6695
6696 Note to entry: Most LS machines partially or fully melt the materials they process. The word "sin-
6697 tering" is a historical term and a misnomer, as the process typically involves full or partial melting, as
6698 opposed to traditional powdered metal sintering using a mould and heat and/or pressure.
6699
6700 [Source: ISO/ASTM 52900:2015 2.5.4]

6701 **983. low-pressure plasma spraying (LPPS)**
6702 method of thermal spraying under low pressure conditions that produces particles or coatings using a
6703 plasma jet
6704
6705 Note to entry: LPPS is also called vacuum plasma spraying (VPS).

6706 **984. material extrusion**
6707 additive manufacturing process in which material is selectively dispensed through a nozzle or orifice
6708
6709 [Source: ISO/ASTM 52910:2018 3.1.3]

6710 **985. material jetting**
6711 additive manufacturing process in which droplets of build material are selectively deposited
6712
6713 [Source: ISO/ASTM 52900:2015 3.1.4]

- 6714 **986. milling**
6715 mechanical treatment of powder, or powder mixtures, as in a ball mill, to alter the size or shape of the
6716 individual particles or to coat one component of the mixture with another
- 6717 **987. molecular beam epitaxy (MBE)**
6718 process of growing single crystals in which beams of atoms or molecules are deposited on a single-crystal
6719 substrate in vacuum, giving rise to crystals whose crystallographic orientation is in registry with that of
6720 the substrate
6721
6722 Note 1 to entry: The beam is defined by allowing the vapour to escape from the evaporation zone
6723 to a high vacuum zone through a small orifice.
6724 Note 2 to entry: Structures with nanoscale features can be grown in this method by exploiting strain.
6725
6726 [Source: ISO/TS 80004-13:2017 3.2.1.9]
- 6727 **988. multilayer deposition**
6728 alternating deposition of two or more source materials to produce a composite layer structure
6729
6730 [Source: ISO/TS 80004-8:2013 3.7]
- 6731 **989. oxidising**
6732 change in the state of the atoms or ions of an element to a higher positive state by the loss of electrons
6733
6734 Note to entry: An oxidising agent is an element that can remove electrons to another element.
6735
6736 [Source: ISO 13574:2015 2.121]
- 6737 **990. phase inversion method**
6738 method by which phases of a liquid-liquid dispersion (emulsion) interchange such that the dispersed
6739 phase spontaneously inverts to become a continuous phase and *vice versa*
- 6740 **991. physical vapour deposition (PVD)**
6741 process for producing, e. g. a ceramic film by transport of the required chemical species, some or all of
6742 which are generated from a source or sources by physical means such as thermal, electron beam, arc or
6743 laser evaporation or sputtering, and deposition onto a prepared substrate with or without the assistance
6744 of a reactive atmosphere, ionic bombardment or a gas plasma
6745
6746 [Source: ISO 20507:2014 2.2.44]
- 6747 **992. plasma enhanced chemical vapour deposition (PECVD)**
6748 process to deposit a solid film on a substrate resulting from plasma induced reaction of precursor com-
6749 pounds, either in the gaseous state or on the film surface
6750
6751 Note to entry: A RF or DC discharge generated by two electrodes inducing a plasma from a gas
6752 occupying the space between.
6753
6754 [Source: IUPAC Recommendation 2020 (Jones et al., 2020) AL-2.104]
- 6755 **993. plastiziser**
6756 thermoplastic material used as a binder for improving formability of powders
6757
6758 [Source: ISO 3252:2019 3.1.62]
- 6759 **994. pulsed laser deposition (PLD)**
6760 method of deposition under the application of laser pulses
- 6761 **995. pyrolysing**
6762 breaking down a complex chemical substance into less complex substances with the application of heat
6763 and in the absence of oxygen

- 6764 **996. reactive direct current magnetron sputtering**
6765 high rate deposition technique by sputtering onto a substrate under the action of a DC electric field
6766 using an inert sputtering gas (argon) and reactive gas (i. e. oxygen)
6767
6768 Note to entry: It occurs by the bombardment of the conductive cathode target (source) with high
6769 energy ionised argon atoms (argon cations) accelerated by electrons flying towards the substrate held
6770 at Laplace transformation where neutral target atoms chemically bond with the reactive gas of spe-
6771 cified partial pressure to form a high purity, compact and uniform stoichiometry thin film of controllable
6772 thickness.
- 6773 **997. reducing**
6774 change in the state of the atoms or ions to a higher negative state by the increase of electrons
6775
6776 Note 1 to entry: A reducing agent is an element that can add electrons to another element.
6777 Note 2 to entry: Reverse chemical reaction of the oxidation reaction.
6778
6779 [Source: ISO 13574:2015 2.155]
6780
6781 Note 3 to entry: Reducing the cermet in a solid oxide cell (SOC) electrode from metal oxide to metal is
6782 an important step in cell/stack manufacture before the electrode can function as intended as a MIEC.
- 6783 **998. screen printing**
6784 method of deposition where a suspension is placed on a screen and its passage is forced by pressure
- 6785 **999. sintering**
6786 process of densification and consolidation of a green body by the application of heat with resulting
6787 joining of ceramic particles and increasing contact interfaces due to atom movement within and between
6788 the ceramic grains of the developing polycrystalline microstructure
6789
6790 [Source: ISO 20507:2014 2.2.58]
- 6791 **1000. sintering temperature**
6792 temperature at which sintering takes place
6793
6794 [Source: ISO 3252:2019 3.3.63]
- 6795 **1001. slurry**
6796 pourable viscous dispersion of powder in a liquid
6797
6798 [Source: ISO 3252:2019 3.1.78]
- 6799 **1002. sol-gel coating process**
6800 process for producing a fine ceramic coating on a product by initially covering the surface with ceramic
6801 precursor followed by sol-gel processing
6802
6803 [Source: ISO 20507:2014 2.2.60]
- 6804 **1003. sol-gel processing**
6805 process through which a network is formed from solution by a progressive change of liquid precursor(s)
6806 into a sol, to a gel, and in most cases finally to a dry network
6807
6808 [Source: IUPAC Purple Book Chapter 11 5.38]
- 6809 **1004. soldering**
6810 process to join materials using an alloy with a low melting point, and usually a mixture of tin and lead
6811
6812 [Source: ISO 13574:2015 2.176]
- 6813 **1005. solid-state reactive sintering (SSRS)**
6814 process for the fabrication of dense, large-grain ceramics by combining phase formation, densification,
6815 and grain growth into a single high temperature sintering step

- 6816 **1006. solution aerosol thermolysis**
6817 molecular deposition method involving the spraying (atomising discrete droplets) of a precursor solution
6818 of metal salts onto a heated substrate able to incorporate sintering process of ceramic powders
- 6819 **1007. spark plasma sintering (SPS)**
6820 sintering technique also known as field assisted sintering or pulsed electric current sintering by directly
6821 passing pulsed direct current (DC) or AC through a ceramic material or powder to heat up by Joule
6822 heating melting powder particle locally at high heating and cooling rates (high speed consolidation)
6823 which allows to maintain the intrinsic properties of powder in the finished product
- 6824 **1008. spin coating**
6825 creation of a thin film by deposition of a material in solution onto a rotating substrate by utilizing
6826 centrifugal force
6827
6828 [Source: ISO/TS 80004-8:2013 7.2.17]
- 6829 **1009. spray deposition**
6830 process to deposit material onto the outside or uppermost layer of substrate by pressurisation of a liquid
6831 through a nozzle to create droplets or aerosols
6832
6833 [Source: ISO/TS 80004-8:2013 7.2.18]
- 6834 **1010. spray drying**
6835 producing a dry powder from a liquid or slurry by rapid removal of liquid droplets via contact with a hot
6836 gas
6837
6838 [Source: ISO/TS 80004-8:2013 6.1.4.2]
- 6839 **1011. spray pyrolysis**
6840 method of producing a film or powder by spraying a precursor suspension through a nozzle directed to a
6841 substrate (film deposition) or connected to a furnace (powder synthesis) to expose the droplets to heat
6842 yielding crystallisation of the precursor material
- 6843 **1012. sputter deposition**
6844 physical vapour deposition process employing energetic particles to transfer atoms from a target material
6845 to a substrate
6846
6847 [Source: ISO/TS 80004-8:2013 7.2.19]
- 6848 **1013. sputtering**
6849 processes of forming films in which ion bombardment or other application of energy is used to extract
6850 particles from a solid source to be deposited on a nearby surface
6851
6852 [Source: IEV 841-22-12]
- 6853 **1014. tape casting**
6854 process of shaping a green body in the form of a tape by casting a slurry of ceramic body (slip) with a
6855 blade as a film on a flat surface, followed by drying
- 6856 **1015. tempering**
6857 controlled process using the application of heating and cooling to establish a consistent and balanced
6858 design state in a material
6859
6860 [Source: ISO 13574:2015 2.185]
- 6861 **1016. thermal spray pyrolysis**
6862 creation of solid product, typically a nanomaterial in aggregate form from liquid precursors through liquid
6863 atomisation and reaction using a thermal source
6864
6865 [Source: ISO/TS 80004-8:2013 6.2.1.5]

- 6866 **1017. thermal spraying**
- 6867 deposition technique used to coat an object or surface by melting a coating material and spraying it at
6868 a high velocity onto a surface
- 6869 **1018. wet ball milling**
- 6870 grinding process in liquid via rolling feed stock material with crushing balls of greater hardness to create
6871 a force of impact in order to reduce the size of target components
- 6872
- 6873 Note to entry: The product of the process is known as slurry.
- 6874
- 6875 [Source: ISO/TS 80004-8:2013 6.3.6]
- 6876 **1019. wet powder spraying**
- 6877 ceramic deposition technique carried out at ambient conditions where a fluid mixture or suspension
6878 containing powder, binder (precipitated on the powder) and a volatile carrier (binder solvent removed
6879 by evaporation), is sprayed onto a substrate by means of an air brush to obtain a "green coating" which
6880 is thermally treated to remove the binder and eventually sintered
- 6881 **2.3.4 Testing**
- 6882 **1020. base plate**
- 6883 structure providing support and mounting surfaces for one or more pieces of equipment
- 6884
- 6885 [Source: ISO 10440-1:2007 3.4]
- 6886 **1021. boiler**
- 6887 assembly intended for generation of steam or hot water
- 6888 **1022. bonded seal**
- 6889 seal using elastomeric material bonded to a rigid substrate
- 6890
- 6891 [Source: ISO 5598:2019 5.2.80]
- 6892 **1023. button cell**
- 6893 cell with a cylindrical shape in which the overall height is less than the diameter e. g. in the shape of a
6894 button or a coin
- 6895
- 6896 [Source: IEC 482-02-40]
- 6897 **1024. compressive seal**
- 6898 seal intended to restrain an item (cable, conductor, pipe, probe, tube, wire, etc.) from moving as a result
6899 of a pressure difference, prohibit the leakage of gas or liquid media along the item and/or electrically
6900 isolates the item from the mounting device when the item passes through a pressure or environmental
6901 boundary using mechanical components and an axial force to compress a soft sealant inside a body to
6902 create the seal
- 6903 **1025. conditioning**
- 6904 preliminary step of treatment that is required to properly operate a SOC and is usually realised by fol-
6905 lowing a protocol specified by the manufacturer
- 6906
- 6907 Note to entry: The conditioning may include reversible and/or irreversible processes depending on
6908 the cell technology.
- 6909
- 6910 [Source: IEC 62282-8-101:2020 3.1.8]
- 6911 **1026. devitrification**
- 6912 development of crystallinity in glass with progressive loss of transparency
- 6913
- 6914 [Source: ISO 7348:1992 05.03.22]

- 6915 **1027. electric furnace**
6916 electroheat equipment with a chamber
6917
6918 [Source: IEC 841-22-04]
- 6919 **1028. electric heater**
6920 electroheat equipment with no chamber
6921
6922 [Source: IEC 841-22-03]
- 6923 **1029. electric heating**
6924 production of heat from electricity for a useful purpose
- 6925 **1030. electrode gas**
6926 gas present at the positive electrode or negative electrode
6927
6928 Note to entry: Electrode gases can be reactants, products or inert gas.
6929
6930 [Source: IEC 62282-8-101:2020 3.1.14]
- 6931 **1031. electroheat equipment**
6932 equipment in which electric energy is converted into heat for useful purposes
6933
6934 [Source: IEC 841-22-01]
- 6935 **1032. exhaust gas**
6936 gas which is exhausted from the electrodes
6937
6938 Note to entry: The exhaust gas is a mixture of the reaction products of the electrochemical reaction, not converted reactant gas and inert gases, which is supplied to the electrodes.
6939
6940
6941 [Source: IEC 62282-8-101:2020 3.1.16]
- 6942 **1033. furnace heating-up time**
6943 time interval from the instant of switching on the furnace at ambient temperature to the instant of
6944 reaching the required furnace temperature in the heating chamber
6945
6946 [Source: IEC 841-22-73]
- 6947 **1034. heating element**
6948 part, removable or not, used for conversion of electric energy into heat, consisting of a heating resistor
6949 and accessories
6950
6951 [Source: IEC 841-23-14]
- 6952 **1035. hermetically sealed device**
6953 device constructed in such a manner that the external atmosphere cannot gain access to the interior
- 6954 **1036. insulation**
6955 all the materials and parts used to insulate conductive elements of a device
6956
6957 [Source: IEC 151-15-41]
- 6958 **1037. Joule heating**
6959 process also known as resistive, electrical resistance or ohmic heating by which an electric current flowing
6960 through a conductor generates heat due to the collisions of electrons with atoms in the conductor
6961
6962 Note 1 to entry: The amount of heat, P_{heat} generated in the conductor is proportional to the square of
6963 the electric current, I that flows through it when the electrical resistance, R of the conductor
6964 and the duration of current flow is kept constant. This amount is proportional to the electrical
6965 resistance of the conductor when keeping the electric current flowing through the conductor and the

6966 duration of current flow constant while it is proportional to the time of current flow when keeping the
6967 electrical electrical resistance and the amount of electric current constant.
6968 Note 2 to entry: This phenomenon is named after English physicist and mathematician James Prescott
6969 Joule (1818-1889).

6970 **1038. leaching**

6971 releasing of glass constituents from a glass surface by liquid attack

6972

6973 [Source: ISO 7348:1992 05.04.12]

6974 **1039. planar**

6975 adhering to flat geometry

6976 **1040. planar cell**

6977 cell having planar geometry

6978 **1041. pressurisation system**

6979 grouping of safety devices and other components used to pressurise and monitor or control a pressurised
6980 enclosure

6981

6982 [Source: IEC 426-09-17]

6983 **1042. protection gas**

6984 mixture of hydrogen and inert gas (usually argon or nitrogen)

6985

6986 Note to entry: It is often used to protect transition metal-containing negative electrodes of the SOC
6987 from being re-oxidised in the case of abnormal operating conditions (e. g. fuel interruption, emergency
6988 stop of the test station).

6989

6990 [Source: IEC 62282-8-101:2020 3.1.23]

6991 **1043. reactant gas**

6992 feedstock gas which is fed to the reaction site (e. g. electrodes) of a cell or a stack where the electro-
6993 chemical reaction takes place

6994

6995 Note to entry: The reactant gases are fuel (e. g. hydrogen) and oxidant (e. g. air) in fuel cell mode and
6996 steam in electrolysis mode.

6997 **1044. resistance furnace**

6998 electroheat equipment having a chamber, in which resistance heating is accomplished

6999

7000 [Source: IEC 841-23-06]

7001 **1045. resistance heater**

7002 electroheat equipment devoid of a chamber, used for resistance heating

7003

7004 [Source: IEC 841-23-07]

7005 **1046. resistance heating**

7006 electric heating using the Joule effect produced by an electric current in a solid medium

7007

7008 [Source: IEC 841-23-01]

7009 **1047. stable state**

7010 condition of a cell/stack assembly unit stable enough for any controlling parameter and the output
7011 voltage or output current of the unit to remain within its tolerance range of variation

7012

7013 [Source: IEC 62282-8-101 3.1.31]

7014 **1048. steam boiler**

7015 boiler for production of steam

7016

7017 [Source: ISO 14404-3:2017 3.10.7]

7018 **1049. thermal cycle**

7019 temperature excursion from a low initial temperature to a high maximum temperature and back to the
7020 low initial temperature

7021

7022 [Source: ISO/PAS 12835:2013 3.42]

7023

7024 Note to entry: Thermal cycle may also refer to the reverse case that is, a temperature excursion
7025 from a high initial temperature to a low minimum temperature and back to the high initial temperature.
7026 The high temperature may be a nominal temperature and the Laplace transformation may be room
7027 temperature.

7028 **1050. thermal insulation**

7029 material intended to reduce heat transfer between two media

7030

7031 [Source: IEV 841-21-28]

7032 **1051. thermal mass**

7033 property of a material having mass heat capacity and surface area capable to adsorb, store and release
7034 heat

7035

7036 Note to entry: Thermal mass provides an inertia to temperature fluctuations.

7037 **1052. thermal stress**

7038 stress induced in a body by the existence of a temperature gradient within that body

7039 **1053. tubular**

7040 adhering to cylindrical geometry that allows fluid flow on the inner and/or outer surfaces of the tube

7041 **1054. tubular cell**

7042 cylindrical structure of a cell that allows fluid to flow on the inner and/or outer surface of the tube

7043

7044 Note to entry: Tubular cells may have different cross sections (e. g. circular, elliptical).

7045

7046 **2.4 Parameters and quantities**

7047 **1055. absolute error**

7048 result of a measurement minus a true value of the measurand

7049

7050 [Source: ISO 16577:2016 3.1]

7051

7052 difference between a measured operate value of the characteristic quantity or a measured value of a
7053 specified time and its declared value (e. g. setting value)

7054

7055 [Source: IEV 447-08-01]

7056 **1056. active electrode area**

7057 geometric area of the electrode where the electrochemical reaction takes place

7058

7059 Note 1 to entry: Usually this corresponds to the smaller of the two areas of negative electrode or
7060 positive electrode.

7061 Note 2 to entry: Area perpendicular to the ionic current flow.

7062

7063 [Source: IEC 62282-8-101 3.1.1]

7064

7065 Note 3 to entry: The coherent SI unit of active electrode area is square metre, m².

7066 **1057. amplitude**

7067 maximum value of a scalar sinusoidal quantity

7068

7069 [Source: IEV 103-07-02]

7070 **1058. aspect ratio**

7071 ratio of length of a particle to its width

7072

7073 [Source: ISO 14966:2019 3.7]

7074 **1059. axial load**

7075 compressive load applied to the end plates of a cell or a stack to ensure contact and/or gas tightness,
7076 or both

7077

7078 Note to entry: The coherent SI unit of axial load is pascal, Pa.

7079 **1060. Biot number**

7080 dimensionless number relating the heat transfer electrical resistances inside a body to that at its surface

7081
$$\text{Bi} = \frac{hL}{k}$$

7082

7083 where for the body,

7084

h is convective heat transfer coefficient;

7085

k is thermal conductivity;

7086

L is characteristic length of the geometry considered.

7087

7088 Note 1 to entry: Biot number is for a solid body what the Nusselt number is for a fluid. The ra-
7089 tio between the body volume and its heated (cooled) surface may defined L . It determines whether or
7090 not the temperature inside a body varies spatially while the body is heated or cooled when applying a
7091 thermal gradient to its surface. For $\text{Bi} \ll 1$, a uniform temperature field prevails inside the body while
7092 $\text{Bi} \gg 1$ indicates a non-uniform temperature field inside the body.

7093

Note 2 to entry: This number is named after French physicist Jean-Baptiste Biot (1774-1862).

7094 **1061. capacitance**

7095 ability of a body to store an electric charge

7096

7097 Note 1 to entry: Any object that can be electrically charged exhibits capacitance, C (e.g. a paral-
7098 lel plate capacitor):

7099
$$C = \frac{q}{u_{AB}}$$

7100

where Q is electric charge (C) at A of a two terminal element with terminals A and B, and u_{AB} is
7101 voltage (V) between terminals A and B.

7102

Note 2 to entry: Capacitance cannot be negative.

7103

Note 3 to entry: The coherent SI unit of capacitance is farad, F.

7104 **1062. capillary number**

7105 dimensionless number relating viscous drag forces and surface tension forces acting across an interface
7106 between a liquid and a gas, or between two immiscible fluids

7107
$$\text{Ca} = \frac{\mu u}{\sigma}$$

7108

7109 where

7110

μ is dynamic viscosity;

7111

σ is surface (interfacial) tension between the two fluid phases;

7112

u is characteristic velocity.

7113
7114
7115
7116

Note to entry: For $Ca \ll 1$ (flow in porous media), capillary forces dominate over viscous forces. It governs the dynamic contact angle of a flowing droplet at an interface. In multiphase flow, capillary number is multiplied by the ratio of the dynamic viscosity of continuous and dispersed phase.

7117 **1063. critical Reynolds number**

7118 numerical reference that indicates whether the flow is laminar or turbulent for a given set of conditions

7119
7120

[Source: ISO 5598:2019 3.2.149]

7121 **1064. Damköhler number**

7122 dimensionless number relating chemical reaction rate to the transport rate (convection or diffusion)

7123

7124 Note 1 to entry: The exact formula for the Damköhler number varies with the rate law equation.
7125 For $Da < 0.1$, a conversion of less than 10 % is achieved while $Da > 10$, a conversion in excess of 90 %
7126 is expected.

7127 Note 2 to entry: This number is named after German chemist Gerhard Damköhler (1908-1944).

7128 **1065. Darcy number**

7129 dimensionless number relating permeability of a medium to its cross sectional area

7130
7131

$$Dc = \frac{K}{A}$$

7132 where for the media,

7133

K is permeability;

7134

A is cross sectional area.

7135

7136

7137 Note 1 to entry: The Darcy number is used for heat transfer in porous media.

7138 Note 2 to entry: This number is named after French engineer Henry Philibert Gaspard Darcy (1803-
7139 1858).

7140 **1066. degradation rate**

7141 rate at which the performance of a cell or a stack in terms of the change of a measurable or derived
7142 quantity, X (e. g. area specific resistance (ASR), current, efficiency, voltage) deteriorates over time

7143

7144

$$\frac{\Delta X}{\Delta t} = \frac{X(t_{n+1}) - X(t_n)}{t_{n+1} - t_n}$$

7145 where

7146

$X(t_n)$ value of quantity X at time t_n ;

$X(t_{n+1})$ value of quantity X at time t_{n+1} ;

7147

t_n instant n at which quantity X is determined;

t_{n+1} instant $n + 1$ at which quantity X is determined.

7148

7149

7150 Note 1 to entry: The degradation rate can be used to measure both non-permanent (reversible) and
7151 permanent (irreversible) performance loss (fuel cell) or performance gain (electrolyser) for a specified
7152 duration at, for example, rated current (galvanostatic condition) or rated voltage (potentiostatic condi-
7153 tion).

7154 Note 2 to entry: The unit of degradation rate is that of the concerned quantity per unit of time. Dividing
7155 this ratio by $X(t_n)$ where $n = 1$ refers to initial state, and multiplying the result by 100 %, degradation
7156 rate is expressed in percentage per unit of time.

7157 **1067. Dukhin number**

7158 dimensionless number which characterizes contribution of the surface conductivity in electrokinetic and
7159 electroacoustic phenomena, as well as in conductivity and dielectric permittivity of heterogeneous systems

7160
7161

[Source: ISO 13099-3:2014 3.1.4]

7162
7163

$$D_{11} = \frac{\kappa^{\sigma}}{K_L a}$$

7164
7165

where

κ^{σ} is surface conductivity;

7166

K_L is fluid bulk electrical conductivity;

7167

a is local curvature radius of the surface.

7168

7169

Note to entry: This number is named after Stanislav Samuilovich Dukhin.

7170

1068. dynamic viscosity

7171

property of a liquid resulting from internal flow electrical resistance opposing the relative movement of adjacent layers

7172

7173

7174

[Source: IEV 212-18-03]

7175

1069. Eötvös number

7176

dimensionless number relating gravitational forces to capillary forces

7177
7178

$$E_o = \frac{\Delta \rho g L^2}{\sigma}$$

7179

where

7180

$\Delta \rho$ is difference in density of the two phases (gas and fluid);

g is gravitational acceleration;

7181

σ is surface tension between the two phases;

7182

L is characteristic length (e. g. radii of bubble/drop curvature).

7183

7184

Note 1 to entry: The Eötvös number measures gravitational forces compared to surface tension forces and is used to characterise the shape of bubbles or drops moving in a surrounding fluid. For $E_o \leq 1$, surface tension dominates while $E_o \gg 1$ indicates that fluid flow is relatively unaffected by surface tension. Note 2 to entry: This number is named after Hungarian physicist Loránd Eötvös de Vásárosnamény (1848-1919).

7185

7186

7187

7188

7189

1070. Eckert number

7190

dimensionless number relating advective mass transfer (kinetic energy) to the heat dissipation potential (enthalpy difference) across the thermal boundary layer

7191

7192

7193

$$E_c = \frac{u^2}{c_p \Delta T}$$

7194

where

7195

E_c is Eckert number,

u is flow velocity,

7196

c_p is specific heat of the flow medium at constant pressure, and

7197

ΔT is temperature difference.

7198

7199

Note 1 to entry: The Eckert number is used to characterise heat transfer dissipation in flows for which viscous dissipation is significant.

7200

7201

7202

Note 2 to entry: This number is named after Austrian engineer and scientist Ernst Rudolph Georg Eckert (1904-2004).

7203 **1071. electric field**

7204 constituent of an electromagnetic field which is characterized by the electric field strength **E** together
7205 with the electric flux density **D**

7206
7207 [Source: IEC 121-11-67]

7208 **1072. error**

7209 discrepancy between a computed, observed or measured value or condition and the true, specified or
7210 theoretically correct value or condition

7211
7212 Note 1 to entry: An error within a system can be caused by failure of one or more of its compon-
7213 ents, or by the activation of a systematic fault.

7214
7215 [Source: ISO 20815:2018 3.22]

7216
7217 Note 2 to entry: The concept of "measurement error" can be used both.

a) when there is a single reference quantity value to refer to, which occurs if a calibration is made by
means of a measurement standard with a measured quantity value having a negligible measurement
uncertainty or if a conventional quantity value is given, in which case the measurement error is
known, and

b) if a measurand is supposed to be represented by a unique true quantity value or a set of true
quantity values of negligible range, in which case the measurement error is not known.

7219
7220 Note 3 to entry: Measurement error should not be confused with production error or mistake.

7221 Note 4 to entry: Since a true value cannot be determined, in practice a conventional true value is used.

7222 Note 5 to entry: When it is necessary to distinguish "error" from "relative error", the former is sometimes
7223 called "absolute error of measurement". This should not be confused with "absolute value of error",
7224 which is the modulus of the error.
7225

7226 **1073. Euler number**

7227 dimensionless number relating a local pressure drop Δp caused by flow restriction and the kinetic energy
7228 per volume of the flow

7229
$$Eu = \frac{\Delta p}{\frac{1}{2}\rho u^2}$$

7230

7231 where for the fluid,

7232 ρ is mass density;

7233 u is characteristic velocity.
7234

7235
7236 Note 1 to entry: The Euler number is used to characterise energy loss in fluid flow. For a perfect
7237 frictionless flow, the Euler number is zero.

7238 Note 2 to entry: This number is named after Swiss mathematician Leonhard Euler (1707-1783).

7239 **1074. explosion limits**

7240 maximum and minimum concentrations of a gas, vapour, mist, spray or dust, in air or oxygen, for stable
7241 detonation to occur

7242
7243 Note 1 to entry: The limits are controlled by the size and geometry of the environment, the con-
7244 centration of the fuel, as well as the means by which ignition occurs.

7245 Note 2 to entry: The terms "explosive limit" and "flammable limit" are widely used as equivalent while
7246 in fact they are not identical. The only substance for which the explosive limit is significantly different
7247 from the flammable limit is hydrogen.
7248

7249 [Source: ISO 16110-1:2007 3.18]

7250 **1075. flammability limit**

7251 lower (LFL) and upper (UFL) vapour or gas concentration of fuel in air within which a flammable mixture
7252 will ignite and propagate a flame

7253
7254 Note 1 to entry: These limits are functions of temperature, pressure, diluents and ignition energy.
7255 Note 2 to entry: These limits are usually expressed as percent (volume fraction).

7256
7257 [Source: ISO 16110-1:2007 3.26]

7258 **1076. frequency range**

7259 measuring range of frequency

7260
7261 [Source: IEV 314-08-10]

7262 **1077. fuel utilisation**

7263 ratio of fuel actually consumed (calculated from current applying Faraday's first law with ideal gas con-
7264 ditions) to that fed

7265
7266
$$q_{fuel} = \frac{R_g T I t}{n F p}$$

7267 where

7268 R_g is universal gas constant;

T is thermodynamic temperature;

n is number of electron required in the electrochemical reaction of single constituent fuel;

7269 F is Faraday's constant;

I is current;

t is time and

p is pressure.

7270 **1078. full load**

7271 highest value of load specified for rated conditions of operation

7272
7273 [Source: IEV 151-15-24]

7274 **1079. fundamental component**

7275 sinusoidal component of the Fourier series of a periodic quantity having the frequency of the quantity
7276 itself

7277
7278 [Source: IEV 103-07-19]

7279 **1080. fundamental frequency**

a) frequency of the sinusoidal component of a periodic quantity that has the same period as the periodic
7280 quantity

7281 b) lowest natural frequency of an oscillatory system

7282
7283 [Source: IEV 801-24-11]

7284
7285 Note to entry: The coherent SI unit of fundamental frequency is per second, s^{-1} . This is equival-
7286 ent to hertz, Hz.

7287 **1081. Graetz number**

7288 dimensionless number characterising laminar flow in a conduit

7289
7290
$$Gz = \frac{d_h}{L} Pe$$

7291 where for the conduit,

7292 d_h is hydraulic diameter;

7293 L is characteristic longitudinal length.

7294
7295
7296
7297
7298
7299
7300
7301

Note 1 to entry: The Graetz number determines the developing flow entrance length in conduits. For $Gz \leq 1,000$, the flow is considered fully developed. That is, the viscous effects due to the shear stress between fluid particles and the wall of a straight conduit create a fully developed velocity profile of the laminar flow with maximum and minimum velocities at respectively the center line of the conduit and its wall. Thus, fluid velocity is that of the average velocity in the conduit.

Note 2 to entry: This number is named after German physicist Leo Graetz (1856-1941).

7302 **1082. Grashof number**

7303 dimensionless number relating the buoyancy force to viscous force acting on a fluid in the velocity
7304 boundary layer

7305
$$Gr = \frac{g\beta L^3}{\nu^2}(T_s - T_\infty)$$

7306

7307 for heat transfer and

7308
$$Gr = \frac{g\beta L^3}{\nu^2}(c^s - c^\infty)$$

7309

7310 for mass transfer where

7311 g is gravitational acceleration;

β is thermal expansion coefficient;

ν is kinematic viscosity;

T_s is surface temperature;

7312 T_∞ is bulk temperature;

c^s is surface concentration;

c^∞ is bulk concentration;

7313 L is characteristic length.

7314

7315 Note 1 to entry: The Grashof number is analogous to Reynolds number. For example, the velocity
7316 boundary layer is laminar at $10^3 < Gr < 10^6$ considering natural convection from a vertical flat plate
7317 caused by a temperature gradient. The transition to turbulent flow would occur at $10^8 < Gr < 10^9$ while
7318 turbulent flow would occur at higher Grashof numbers.

7319 Note 2 to entry: The quotient $\frac{gL^3}{\nu^2} = Re^2 Ri$ is known as Galilei number named after Italian scientist
7320 Galileo di Vincenzo Bonaiuti de'Galilei (1564-1642).

7321 Note 3 to entry: This number is named after German engineer Franz Grashof (1826-1893).

7322 **1083. heat capacity**

7323 quantity $C = dQ/dT$, when the thermodynamic temperature of a system is increased by dT as a result
7324 of the addition of a amount of heat dQ , under given condition

7325

7326 Note 1 to entry: Examples of condition might be constant volume or constant pressure for a gas.

7327 Note 2 to entry: The coherent SI unit of heat capacity is joule per kelvin, J/K.

7328

7329 [Source: IEV 113-04-47]

7330 **1084. input**

7331 material or energy which enters a product system at any stage, from raw material acquisition to final
7332 disposal

7333

7334 [Source: IEV 901-07-05]

7335 **1085. kinematic viscosity**

7336 quotient of the dynamic viscosity and the density, both determined at the same temperature

7337

7338 [Source: IEV 212-18-04]

7339 **1086. Knudsen number**

7340 dimensionless number relating the molecular mean free path length λ and a representative physical
7341 length, L

7342
$$\text{Kn} = \frac{\lambda}{L}$$

7343

7344 Note 1 to entry: The macroscopic length L relates to a gap length over which thermal or mass transport
7345 occurs in a fluid particularly in porous and granular media where thermal transport depends on pressure
7346 and molar volume of the fluid species thus on the slip length $\lambda \sim (na^2)^{-1}$; n is the with number density
7347 of molecules with radius a . For $\text{Kn} \ll 1$, the gas behaves as a no-slip fluid, for $\text{Kn} \approx 1$, the gas behaves
7348 as a continuum but slips at the boundaries, and for $\text{Kn} \gg 1$, the continuum approximation breaks down
7349 completely.

7350 Note 2 to entry: This number is named after Danish physicist Martin Hans Christian Knudsen (1871-
7351 1949).

7352 **1087. Lewis number**

7353 dimensionless number relating thermal diffusivity to mass diffusivity

7354
$$\text{Le} = \frac{\text{Sc}}{\text{Pr}}$$

7355

7356 Note 1 to entry: The Lewis number characterises fluid flow with simultaneous heat transfer and mass
7357 transfer. Physically, it relates the relative thickness of the thermal boundary layer to the mass transfer
7358 (concentration) boundary layer. A Lewis number of unity indicates that thermal boundary layer and
7359 mass transfer by diffusion are comparable so that temperature and concentration boundary layers nearly
7360 coincide.

7361 Note 2 to entry: This number is named after US engineer Warren Kendall Lewis (1882-1975).

7362 **1088. lower explosive limit (LEL)**

7363 lowest percentage (volume fraction) of a mixture of flammable gas with air which will propagate an
7364 explosion in a confined space at 25 °C and atmospheric pressure

7365 [Source: ISO 18400-204:2017 3.12.1]
7366

7367 Note 1 to entry: LEL depends on initial temperature, pressure and gas mixture composition.
7368 Note 2 to entry: LEL is usually expressed as a volume percentage.

7370 **1089. lower flammability limit (LFL)**

7371 minimum concentration of fuel vapour in air below which propagation of a flame will not occur in the
7372 presence of an ignition source

7373 Note to entry: The concentration is usually expressed as a volume fraction at a defined temperat-
7374 ure and pressure. Lower flammability limit (LFL) is expressed as a percentage.
7375

7376 [Source: ISO 13943:2017 3.253]
7377

7378 **1090. mean error**

7379 quotient of the algebraic sum of the error values (absolute, relative or conventional) by the number of
7380 measurements

7381 [Source: IEV 447-08-04]
7382

7383 **1091. mean time to failure (MTTF)**

7384 expected time before the item fails

7385 [Source: ISO 20815:2018 3.1.34]
7386

7387 Note to entry: The coherent SI unit of the MTTF is second, s.
7388

7389 **1092. measurement error**

7390 measured quantity value minus a reference quantity value

7391 [Source: BIPM JCGM VIM 2.16]
7392

7393 **1093. membrane electrode assembly area**

7394 geometric area of the entire membrane electrode assembly perpendicular to the direction of net current
7395 flow, including the active area, and uncatalysed areas of the membrane

7396

7397 Note to entry: The membrane electrode assembly area is expressed in m².

7398

7399 [Source: IEV 485-04-02]

7400

7401 Note to entry: The coherent SI unit of membrane electrode assembly area is square meter, m².

7402 **1094. minimum working pressure**

7403 lowest pressure at which a system or sub-system can operate in steady state operating conditions

7404

7405 [Source: ISO 5598:2019 3.2.452]

7406

7407 Note 1 to entry: Minimum working pressure is a function of temperature.

7408 Note 2 to entry: The coherent SI unit of minimum working pressure is pascal, Pa.

7409 **1095. natural frequency**

7410 any frequency at which free oscillation can exist in a physical system when the excitation has been
7411 removed

7412

7413 [Source: IEV 702-01-07]

7414

7415 Note 1 to entry: For multiple-degree-of-freedom (MDoF) systems, their natural frequencies are the
7416 frequencies of the normal modes of oscillation.

7417

7418 Note 2 to entry: The coherent SI unit of natural frequency is per second, s⁻¹. This is equivalent
7419 to hertz, Hz.

7420 **1096. normal temperature and pressure (NTP)**

7421 temperature of 293.15 K and absolute pressure of 101.325 kPa

7422

7423 Note to entry: Always check the source of the data to make sure that it does not consider 273.15
7424 K or 288.15 K as "normal".

7425

7426 [Source: ISO/TR 15916:2015 3.71]

7427 **1097. Nusselt number**

7428 dimensionless number relating the rate of convective heat transport to that of conductive heat transport

7429
$$\text{Nu} = \frac{hL}{K}$$

7430

7431 where for the fluid,

7432

h is convective heat transfer coefficient;

7433

K is thermal conductivity;

7434

L is characteristic length.

7435

7436 Note 1 to entry: L is taken normal to the boundary layer (e.g. ratio of volume of the fluid body
7437 to its surface area).

7438 Note 2 to entry: The Nusselt number is often calculated by empirical formulas as a function of other
7439 characteristic numbers (Re , Pr , Pe , Gr), and then used to determine K . A larger Nusselt number
7440 corresponds to more effective convection, with turbulent flow typically in the 100-1000 range.

7441 Note 3 to entry: This number is named after German engineer Ernst Kraft Wilhelm Nušelt (1882-1957).

7442 **1098. open porosity**

7443 ratio of the volume of the open pores to the total volume of a porous object

7444

7445 [Source: ISO 3252:2019 3.3.40]

- 7446 **1099. output**
7447 material or energy which leaves a product system at any stage, from raw material acquisition to final
7448 disposal
7449
7450 [Source: IEV 901-07-06]
- 7451 **1100. Péclet number**
7452 dimensionless number relating the rate of advection transport to diffusive transport
7453
7454 Note 1 to entry: The Péclet number is the product of Reynolds number and Schmidt number thus,
7455 $Pe=ReSc$ for mass transfer. It is the product of Reynolds number and Prandtl number thus, $Pe=RePr$
7456 for heat transfer.
7457 Note 2 to entry: This number is named after French physicist Jean Claude Eugène Péclet (1793-1857).
- 7458 **1101. parameter**
7459 variable that is given a constant value for a specified application and that can denote the application
7460
7461 [Source: IEV 171-05-41]
- 7462 **1102. particle size**
7463 linear dimension of a particle determined by a specified measurement method and under specified meas-
7464 urement conditions
7465
7466 Note to entry: Different methods of analysis are based on the measurement of different physical prop-
7467 erties. Independent of the particle property actually measured, the particle size can be reported as a
7468 linear dimension, e. g. as the equivalent spherical diameter.
7469
7470 [Source: ISO/TS 80004-6:2013 3.1.1]
- 7471 **1103. particle size distribution**
7472 distribution of particles as a function of particle size
7473
7474 Note 1 to entry: Particle size distribution may be expressed as cumulative distribution or a distri-
7475 ution density (distribution of the fraction of material in a size class, divided by the width of that class).
7476 Note 2 to entry: Particle size distribution can be both number based and mass based.
7477
7478 [Source: ISO/TS 19807-1:2019 3.30]
- 7479 **1104. permeability**
7480 rate of diffusion of a fluid through a membrane or other porous material
- 7481 **1105. phase**
7482 argument of the cosine function in the representation of a sinusoidal quantity
7483
7484 Note to entry: The term "instantaneous phase" is only used when the independent variable is time.
7485
7486 [Source: IEV 103-07-04]
- 7487 **1106. phase angle**
7488 phase difference, expressed as an angle, between a voltage and current recurring periodically at the same
7489 frequency
7490
7491 Note 1 to entry: The phase angle is usually expressed in degrees.
7492
7493 [Source: ISO 16773-1:2016 2.36]
7494
7495 Note 2 to entry: The phase angle is the argument of the frequency response at a given angular frequency.
- 7496 **1107. pore size**
7497 linear dimension of an individual pore, determined by geometric analysis or physical tests
7498

7499 [Source: ISO 3252:2019 3.3.46]

7500

7501 Note to entry: Depending upon the specific description, pore size can be described as a length, an
7502 area or a volume. Pore size can also describe either singular voids or aggregates of void spaces.

7503

7504 [Source: ISO 17327-1:2018 3.13]

7505 **1108. pore size distribution**

7506 percentage by numbers or by volume of each classified pore size which exists in a material

7507

7508 [Source: ISO 3252:2019 3.3.47]

7509 **1109. power loss**

7510 difference between input power and output power of a device

7511

7512 Note to entry: If the output power and/or input power is electric, active power is meant.

7513

7514 [Source: IEC 60050-15-26]

7515

7516 Note to entry: The coherent SI unit of power loss is watt, W.

7517 **1110. Prandtl number**

7518 dimensionless number relating the ratio of momentum diffusivity (kinematic viscosity) to thermal diffus-
7519 ivity of a fluid

$$7520 \text{Pr} = \frac{\nu}{\alpha} = \frac{c_p \mu}{k}$$

7521

7522 where for the fluid,

7523

μ is dynamic viscosity;

α is thermal conductivity;

7524

c_p is momentum diffusivity (kinematic viscosity);

k is thermal diffusivity.

7525

7526

7527 Note 1 to entry: The Prandtl number of gases are about unity implying that both momentum and
7528 heat dissipate through the fluid at about the same rate. It is the heat transfer analogue of the Schmidt
7529 number. For $\text{Pr} \ll 1$ ($\text{Pr} \gg 1$), heat (momentum) diffuses far more rapid relative to momentum (heat)
7530 thus the thermal boundary layer in the fluid is much thicker (thinner) relative to the velocity boundary
7531 layer.

7532 Note 2 to entry: In turbulent flow, the turbulent Prandtl number, Pr_t is the ratio of eddy diffusivity
7533 for momentum transfer, ε_m and eddy diffusivity for heat transfer, ε_h . When both, Prandtl number and
7534 turbulent Prandtl number equal unity, velocity and temperature profiles are identical.

7535 Note 3 to entry: This number is named after German physicist and engineer Ludwig Prandtl (1875-1953).

7536 **1111. pressure**

7537 normal force per unit area exerted by a fluid against its confinement

7538

7539 [Source: ISO 5598:2019 3.2.560]

7540

7541 Note 1 to entry: Pressure is a function of temperature.

7542 Note 2 to entry: The coherent SI unit of pressure is pascal, Pa.

7543 **1112. process parameter**

7544 specified value for a process variable

7545

7546 Note to entry: The specification for a sterilisation process includes the process parameters and their
7547 tolerances.

7548

7549 [Source: ISO 14937:2009 3.19]

7550 **1113. quantity**

7551 property of a phenomenon, body, or substance, where the property has a magnitude that can be ex-
7552 pressed by means of a number and a reference

7553

7554 Note 1 to entry: The generic concept of quantity can be divided into several levels of specific con-
7555 cepts.

7556 Note 2 to entry: The reference can be a unit of measurement, a measurement procedure, a reference
7557 material, or a combination of such. The magnitude of a quantity is called "value of the quantity". In
7558 the frequent case of a unit of measurement, the magnitude is the product of a number and the unit of
7559 measurement.

7560 Note 3 to entry: A quantity as defined here is a scalar. However, a vector or a tensor whose components
7561 are quantities is also considered to be a quantity.

7562 Note 4 to entry: The concept of quantity may be generically divided into, e. g. physical quantity, chem-
7563 ical quantity, biological quantity, etc., or base quantity and derived quantity.

7564

7565 [Source: IEV 112-01-01]

7566 **1114. rate**

7567 quotient of a quantity by a duration

7568

7569 [Source: IEV 112-03-18]

7570 **1115. rating**

7571 set of rated values and operating conditions

7572

7573 [Source: IEV 411-51-24]

7574 **1116. ratio**

7575 quotient of two numbers or two quantities of the same kind

7576

7577 [Source: IEV 102-01-23]

7578 **1117. Rayleigh number**

7579 dimensionless number relating the rate of diffusive thermal transport (natural convection) to convective
7580 thermal transport (thermal conduction)

7581

$$Ra = GrPr$$

7582

7583 where

7584

Ra is Rayleigh number,

7585

Gr is Grashof number, and

7586

Pr is Prandtl number.

7587

7588 Note 1 to entry: The Rayleigh number can be viewed as a Péclet number for buoyant flow used to
7589 express heat transfer in natural convection. Its magnitude indicates whether the natural convection
7590 boundary layer is laminar or turbulent. Below a critical value, no motion occurs in the fluid due to
7591 temperature differences and heat transfer is by conduction only. For a vertical plate, the flow turns
7592 turbulent at $Ra > 10^9$.

7593 Note 3 to entry: This number is named after English scientist John William Strutt Rayleigh (1842-1919).

7594 **1118. reactant utilisation**

7595 ratio of converted substance flow through a given electrode of the cell/stack assembly unit to the input
7596 substance flow of the same electrode

7597

7598 Note 1 to entry: The three types of reactant utilisation are:

- fuel utilisation (negative electrode in SOFC mode);

7599 - oxygen utilisation (positive electrode in SOFC mode);

- steam conversion (negative electrode in SOEC mode).

7600
7601
7602
7603
7604
7605
7606
7607

Note 2 to entry: In SOFC mode, the effective reactant utilisation can also be calculated as the ratio of actual output current of the cell/stack assembly unit to the theoretical Faradaic current.
Note 3 to entry: Under the assumption that the electrolyte has neither leak nor electronic conductivity, the reactant utilisation is equivalent to the effective reactant utilisation.

[Source: IEC 62282-8-101:2020 3.1.15]

7608 **1119. relative error**

7609 absolute error divided by the magnitude of the true (best accepted) value

7610
7611

[Source: ISO 16577:2016 3.166]

7612 **1120. relative uncertainty**

7613 ratio of the uncertainty to the value of the measurand

7614
7615

[Source: IEC 311-01-19]

7616 **1121. reversible capacity**

7617 ratio of rated capacity in fuel cell mode to electrolysis mode of a device or a system capable of operating
7618 in reversible mode, when autonomously operated in these two modes

7619
7620
7621
7622
7623
7624

Note 1 to entry: In this context, the term "reversible" does not refer to the thermodynamic principle of an ideal process.

Note 2 to entry: Reversible capacity may depend on the sequence, length, and order of precedence of operation in fuel cell mode and electrolysis mode.

Note 3 to entry: Multiplying this ratio by 100 %, reversible capacity is expressed in percentage.

7625 **1122. Reynolds number**

7626 dimensionless parameter to describe laminar or turbulent flow

7627
7628
7629
7630
7631
7632

Note 1 to entry: A low Reynolds number characterises a laminar flow and high Reynolds number a turbulent flow. Typically the transition point between laminar and turbulent flow is at Reynolds numbers of around 4,000-5,000.

[Source: ISO 8625-2:2018 3.10]

7633
7634

$$\text{Re} = \frac{\rho u l}{\eta}$$

7635
7636

where for the fluid,

ρ is mass density;

u is flow velocity;

7637

l is characteristic length (i. e. hydraulic diameter of the conduit);

7638

η is dynamic viscosity.

7639

7640

Note 2 to entry: Note that there is no consensus on how to define Reynolds number for multi-phase flow.

7641

7642

Note 3 to entry: This number is named after Irish engineer Osborne Reynolds (1842-1912).

7643 **1123. Richardson number**

7644 dimensionless number relating buoyancy to shear in fluid flow

7645
7646

$$\text{Ri} = \frac{\text{Gr}}{\text{Re}^2}$$

7647
7648
7649
7650

Note 1 to entry: Typically, natural convection is negligible when $\text{Ri} < 0.1$ and forced convection is negligible when $\text{Ri} > 10$ while between these two limits neither is negligible. Buoyancy is significant in defining laminar-turbulent transition in mixed convection flow.

Note 2 to entry: This number is named after English scientist Lewis Fry Richardson (1881-1953).

7651 **1124. rms value**

7652 value of voltage or current based upon the equivalence to the DC value that would yield the same power
7653 transfer in a DC circuit

7654
7655 Note 1 to entry: The Rms voltage value can be computed as

7656
7657
$$V_{\text{rms}} = \sqrt{\frac{1}{T} \int_0^T v^2(t) dt}$$

7658 where
7659 T is the waveform time period;

7660 $v(t)$ is the instantaneous voltage at time t .

7661
7662 [Source: ISO 1540:2006 3.38]

7663 **1125. Schmidt number**

7664 dimensionless number relating momentum diffusivity and mass diffusivity

7665
$$Sc = \frac{\nu}{D} = \frac{\mu}{\rho D}$$

7666

7667 where for the fluid,

7668 ν is momentum diffusivity (kinematic viscosity);

μ is dynamic viscosity;

7669 ρ is density;

7670 D is mass diffusivity.

7671
7672 Note 1 to entry: The Schmidt number characterises fluid flows with simultaneous momentum and
7673 mass diffusion convection and is the mass transfer analogue of the Prandtl number. Physically, it relates
7674 the relative thickness of hydrodynamic layer and mass transfer boundary layer. A Schmidt number of
7675 unity indicates that momentum and mass transfer by diffusion are comparable so that velocity and con-
7676 centration boundary layers nearly coincide.

7677 Note 2 to entry: In turbulent flow, the turbulent Schmidt number, Sc_t is the ratio of eddy viscosity, ν_t
7678 and eddy diffusivity, K_t .

7679 Note 3 to entry: This number is named after German engineer Ernst Heinrich Wilhelm Schmidt (1892-
7680 1975).

7681 **1126. Sherwood number**

7682 dimensionless number relating the rate of convective mass transfer to that of diffusive mass transport

7683
$$Sh = \frac{hL}{D}$$

7684

7685 where for the fluid,

7686 h is convective mass transfer coefficient;

7687 D is mass diffusivity;

7688 L is characteristic length.

7689
7690 Note 1 to entry: As the mass transfer analogue of the Nusselt number, the Sherwood number may
7691 also be defined as a function of Reynolds number and Schmidt number.

7692 Note 2 to entry: This number is named after US engineer Thomas Kilgore Sherwood (1903-1976).

7693 **1127. stack cell number**

7694 number of cells per stack

7695
7696 [Source: JRC EUR 29300 EN report 3.18.11.4]

- 7697 **1128. standard ambient temperature and pressure (SATP)**
7698 standard conditions for a temperature of 298.15 K (25 °C, 77 °F) and an absolute pressure of 10⁵ Pa
7699 (100 kPa, 1 bar)
- 7700 **1129. standard deviation**
7701 positive square root of the variance
7702
7703 [Source: IEC 60300-13]
- 7704 **1130. standard temperature and pressure (STP)**
7705 standard conditions for a temperature of 273.15 K (0 °C, 32 °F) and an absolute pressure of 10⁵ Pa
7706 (100 kPa, 1 bar)
- 7707 **1131. Stanton number**
7708 dimensionless number relating the heat transferred into a fluid to its thermal capacity
- 7709
$$St = \frac{Nu}{PePr}$$

7710
7711 for heat transfer and for mass transfer,
- 7712
$$St = \frac{Sh}{ReSc}$$

7713
- 7714 Note 1 to entry: The Stanton number is used to characterise heat transfer in forced convection.
7715 Note 2 to entry: This number is named after English engineer Thomas Ernest Stanton (1865-1931).
- 7716 **1132. stoichiometric ratio**
7717 ratio between the number of moles of reactant gas flowing per unit time to that needed by the electro-
7718 chemical reaction
7719
7720 Note to entry: The terms, "stoichiometric ratio" and "reactant gas utilisation" are related. The re-
7721 ciprocal of the fraction of the gas utilised is the stoichiometric ratio.
7722
7723 [Source: IEC TS 62282-7-2:2014 3.1.19]
- 7724 **1133. test acceleration factor**
7725 ratio of the stress response rate of the test specimen under the accelerated conditions, to the stress
7726 response rate under specified operational conditions
7727
7728 Note 1 to entry: Both stress response rates refer to the same time interval in the life of the tested
7729 items.
7730 Note 2 to entry: Measures of stress response rate are, for example, operating time to failure, failure
7731 intensity, and rate of wear.
7732
7733 [Source: IEC 60300-13]
- 7734 **1134. test input parameter (TIP)**
7735 parameter whose values can be set in order to define the test conditions of the test system including the
7736 operating conditions of the test object
7737
7738 Note to entry: TIPs have to be controllable and measurable. Values of TIPs are known before con-
7739 ducting the test. TIPs can be either static or variable. Static TIPs stay constant and variable TIPs are
7740 varied during the test.
7741
7742 [Source: IEC 62282-8-101 3.1.33]
- 7743 **1135. test output parameter (TOP)**
7744 parameter that indicates the response of the test system/test object as a result of variation of test input
7745 parameters
7746
7747 Note 1 to entry: Values of TOPs are unknown before conducting the test and will be measured during

7748 the test. TOPs need to be measurable.

7749

7750 [Source: IEC 62282-8-101 3.1.34]

7751 **1136. time acceleration factor**

7752 number or function used to transform the results of ageing of a component(s) derived from accelerated
7753 short-term exposure testing to a predicted service life or predicted service life distribution

7754

7755 [Source: ISO/TR 15686-11:2014 3.1.126]

7756 **1137. uncertainty**

7757 parameter, associated with the result of a measurement, that characterises the dispersion of the values
7758 that could reasonably be attributed to the measurand

7759

7760 Note 1 to entry: The parameter may be, for example, a standard deviation (or a given multiple of
7761 it), or the half-width of an interval having a stated level of confidence.

7762 Note 2 to entry: Uncertainty of measurement comprises, in general, many components. Some of these
7763 components may be evaluated from the statistical distribution of the results of series of measurements
7764 and can be characterised by experimental standard deviations. The other components, which can also
7765 be characterized by standard deviations, are evaluated from assumed probability distributions based on
7766 experience or other information.

7767 Note 3 to entry: It is understood that the result of the measurement is the best estimate of the value of
7768 the measurand, and that all components of uncertainty, including those arising from systematic effects,
7769 such as components associated with corrections and reference standards, contribute to the dispersion.

7770

7771 [Source: ISO 12242:2012 3.4.7]

7772 **1138. upper explosive limit (UEL)**

7773 uppermost percentage (volume fraction) of a mixture of flammable gas with air which will propagate an
7774 explosion in a confined space at 25 °C and atmospheric pressure

7775

7776 [Source: ISO 18400-204:2017 3.12.2]

7777

7778 Note 1 to entry: UEL depends on initial temperature, pressure and gas mixture composition.

7779 Note 2 to entry: UEL is usually expressed as a volume percentage.

7780 **1139. upper flammability limit (UFL)**

7781 maximum concentration of fuel vapour in air above which propagation of a flame will not occur in the
7782 presence of an ignition source

7783

7784 Note to entry: The concentration is usually expressed as a volume fraction at a defined temperat-
7785 ure and pressure. Upper flammability limit (UFL) is expressed as a percentage.

7786

7787 [Source: ISO 13943:2017 3.415]

7788 **1140. variability**

7789 variations in performance measures for different time periods under defined framework conditions

7790

7791 Note to entry: The variations can be a result of the down time pattern for equipment and systems
7792 or operating factors, such as wind, waves and access to certain repair resources.

7793

7794 [Source: ISO 20815:2018 3.1.62]

7795 **1141. variance**

7796 measure of dispersion equal to the sum of the squared deviations from the mean value divided by the
7797 number of deviations or by that number minus 1

7798

7799 [Source: IEC 103-08-12]

7800 **2.4.1 Efficiency**

7801 **1142. efficiency**

7802 ratio of output energy to input energy

7803

7804 Note to entry: For the efficiency of electrolysis at the level of cell or stack, it is in most cases appropriate to determine it on the basis of the lower heating value. For comparing experimentally determined values of energy (electricity, heat and mechanical) consumption in relation to a theoretical energy input value or for setting and monitoring of target values such as key performance indicator, the use of higher heating value or lower heating value should be identified. At system level, electrolyser efficiency can also be expressed in terms of the electric energy required per unit of normal volume or mass of produced hydrogen.

7811 **1143. electrical efficiency**

7812 ratio of the net electric power of a cell or system to the total enthalpy flow supplied to the cell or system

7813 **1144. energy efficiency**

7814 ratio of useful energy output to the total energy input including all parasitic and auxiliary energy needed to operate the device, equipment or system concerned whether or not it is on standby

7815

7816 Note to entry: Energy efficiency is a measure for the effectiveness of converting one form of energy notably chemical energy into electrical energy or heat, or both, and *vice versa*.

7819 **1145. heat recovery efficiency**

7820 ratio of recovered heat flow of a fuel cell power system to the total enthalpy flow supplied to the fuel cell power system

7821

7822 Note 1 to entry: The supplied total (including reaction enthalpy) enthalpy flow of the raw fuel should be related to the lower heating value (LHV) for a better comparison with other types of energy conversion system.

7823

7824 [Source: IEV 485-10-04]

7827 **1146. overall energy efficiency**

7828 ratio of total usable energy flow (net electric power and recovered heat flow) to the total enthalpy flow supplied to the system

7829

7830 Note to entry: The supplied total (including reaction enthalpy) enthalpy flow of the raw fuel should be related to the lower heating value for a better comparison with other types of energy conversion system.

7831

7832 **1147. overall exergy efficiency**

7833 ratio of the sum of net electric power and total useable exergy flow of recovered heat to the total exergy flow supplied to the fuel cell power system

7834

7835 Note to entry: The supplied total exergy flow of the raw fuel (including that created by any reactions) should be related to a gaseous product for a better comparison with other types of energy conversion system.

7836

7837 [Source: IEV 485-10-06]

7838 **1148. system efficiency**

7839 ratio of useful energy output of the system (at the point of use) to the energy input of the system (at the point of supply) in consistent units for a specified duration

7840

7841 Note to entry: Multiplying this ratio by 100 %, system efficiency is expressed in percentage.

7842 **1149. thermal efficiency**

7843 ratio of the useful thermal power to the heating power

7844

7845 [Source: IEV 841-22-68]

7846

7853 **2.4.2 Electrical**

7854 **1150. AC voltage**

7855 rms value of voltage caused by alternating current

7856
7857 Note to entry: The coherent SI unit of AC voltage is volt, V.

7858 **1151. active energy**

7859 electrical energy transformable into some other form of energy

7860 [Source: IEV 692-01-19]

7861
7862 Note to entry: The coherent SI unit of active energy is joule, J.

7864 **1152. active power**

7865 product of rms voltage, rms current and power factor

7866 [Source: ISO/IEC TS 22237-3:2018 3.1.1]

7867
7868 Note to entry: The coherent SI unit of active power is watt, W.

7870 **1153. AC resistance**

7871 method of applying a fixed, single high frequency sine wave (typically 1 kHz) to the cell while measuring
7872 its electrical impedance at that frequency

7873
7874 Note 1 to entry: The AC resistance being the real part of the measured electrical impedance upon
7875 correcting for the electrical impedance of the load or power supply when arranged in parallel with the
7876 cell.

7877
7878 Note 2 to entry: The coherent SI unit of AC resistance is ampere, A.

7879 **1154. apparent power**

7880 product of rms voltage and rms current

7881 [Source: ISO/IEC TS 22237-3:2018 3.1.3]

7882
7883 product of the rms voltage U between the terminals of a two-terminal element or two-terminal cir-
7884 cuit and the rms electric current I in the element or circuit

7885
7886
$$S = UI$$

7887 Note 1 to entry: Under sinusoidal conditions, the apparent power is the modulus of the complex power
7888 \underline{S} , thus $S = |\underline{S}|$.

7889 Note 2 to entry: The coherent SI unit of apparent power is volt ampere, VA.

7890
7891 [Source: IEV 131-11-41]

7892 **1155. applied potential**

7893 difference of potential measured between identical metallic leads to two electrodes of a cell

7894
7895 Note to entry: The applied potential is divided into two electrode potentials, each of which is the
7896 difference of potential existing between the bulk of the solution and the interior of the conducting ma-
7897 terial of the electrode, an iR or ohmic potential drop through the solution, and another ohmic potential
7898 drop through each electrode. In the electroanalytical literature this quantity has often been denoted by
7899 the term voltage, whose continued use is not recommended.

7900
7901 [Source: IUPAC Gold Book A00424]

7902
7903 Note to entry: The coherent SI unit of applied potential is volt, V.

- 7904 **1156. area specific resistance (ASR)**
- 7905 total resistivity of a cell or stack in operation, including the change of voltage (potential) due to one or
7906 more electrochemical reactions
- 7907
- 7908 Note 1 to entry: The ASR of a cell may, as feasible, be corrected for the resistivity of the cell housing
7909 including all electrical contacts measured under the same operating conditions. The area specific res-
7910 istance of a planar stack may, as feasible, be corrected for the resistivity of the end plates including all
7911 electrical contacts measured under the same operating conditions. Similar corrections may, as appropri-
7912 ate, be applied to other cell and stack geometries and/or configurations.
- 7913
- 7914 Note 2 to entry: The coherent SI unit of ASR is ohm square meter, $\Omega \text{ m}^2$.
- 7915 **1157. areal power density**
- 7916 ratio of power to the active electrode area of a cell or a stack
- 7917
- 7918 Note to entry: The coherent SI unit of areal power density is watt per square meter, W m^{-2} .
- 7919 **1158. available power**
- 7920 maximum active power that can be theoretically delivered at a given frequency by a source having an im-
7921 pedance of positive real part to a directly connected load when the impedance of the load is widely varied
- 7922
- 7923 Note 1 to entry: The available power is obtained when the electrical resistance of the load is equal
7924 to that of the source and its electrical reactance is equal in magnitude but of opposite sign.
- 7925 Note 2 to entry: In some cases, conditions such as overheating or overvoltage prevent the available
7926 power from being obtained.
- 7927
- 7928 [Source: IEV 702-07-10]
- 7929
- 7930 Note to entry: The coherent SI unit of available power is volt ampere, V A.
- 7931 **1159. average cell voltage**
- 7932 cell/stack assembly unit voltage divided by the number of the cells in a series connection in the unit
- 7933
- 7934 [Source: IEC TS 62282-7-2:2014 3.1.4]
- 7935
- 7936 Note to entry: The coherent SI unit of average cell voltage is volt, V.
- 7937 **1160. average repeating unit voltage**
- 7938 cell/stack assembly unit voltage divided by the number of the cells in a series connection in the unit
- 7939
- 7940 [Source: IEC 62282-8-101:2020 3.1.3]
- 7941
- 7942 Note to entry: The coherent SI unit of average repeating unit voltage is volt, V.
- 7943 **1161. capacitive susceptance**
- 7944 conjugate imaginary part of electrical admittance (negative reciprocal of capacitance)
- 7945
- 7946 Note to entry: The coherent SI unit of capacitive susceptance is siemens, S.
- 7947 **1162. cell voltage**
- 7948 potential difference between the positive and negative electrodes
- 7949
- 7950 [Source: JRC EUR 29300 EN report 3.26.1]
- 7951
- 7952 Note to entry: The coherent SI unit of cell voltage is volt, V.
- 7953 **1163. charge rate**
- 7954 current applied to a device or system to restore its available capacity
- 7955
- 7956 Note to entry: The coherent SI unit of charge rate is ampere, A.

- 7957 **1164. charge transfer resistance**
- 7958 electrical resistance of the resistor representing the metal-electrolyte interface characteristics in the equi-
- 7959 valent circuit
- 7960
- 7961 [Source: ISO 16773-1:2016 2.4]
- 7962
- 7963 Note to entry: The coherent SI unit of charge transfer resistance is ohm, Ω . The coherent SI unit
- 7964 of specific charge transfer resistance is ohm per square meter, Ωm^2 .
- 7965 **1165. complex conductance**
- 7966 real part of electrical admittance
- 7967
- 7968 Note to entry: The coherent SI unit of complex conductance is siemens, S.
- 7969 **1166. complex resistance**
- 7970 real part of electrical impedance
- 7971
- 7972 [Source: IEC 60050-101:2000 3.1.11]
- 7973
- 7974 Note to entry: The coherent SI unit of complex resistance is ohm, Ω .
- 7975 **1167. conductivity**
- 7976 macroscopic material property that relates the conduction current density to the electric field in the
- 7977 medium
- 7978
- 7979 [Source: ISO/IEC 14776-121:2010 3.1.25]
- 7980
- 7981 Note 1 to entry: For an isotropic medium the conductivity is a scalar quantity; for an anisotropic
- 7982 medium it is a tensor quantity.
- 7983
- 7984 [Source: IEC 60050-101:2000 3.1.11]
- 7985
- 7986 Note 2 to entry: In isotropic material, conductivity is also the reciprocal of resistivity, sometimes called
- 7987 specific complex conductance.
- 7988 Note 3 to entry: The coherent SI unit of conductivity is siemens per meter, $S m^{-1}$.
- 7989 **1168. current**
- 7990 flow of electric charge through a device
- 7991
- 7992 Note to entry: The coherent SI unit of current is ampere, A.
- 7993 **1169. current density**
- 7994 current per unit active area
- 7995
- 7996 [Source: IEC 62282-8-101:2020 3.1.11]
- 7997
- 7998 Note to entry: The coherent SI unit of current density is ampere per square meter, $A m^{-2}$.
- 7999 **1170. current ramp rate**
- 8000 rate at which the amount of electric current changes over time
- 8001
- 8002 [Source: JRC EUR 29300 EN report 3.5.2]
- 8003
- 8004 Note to entry: The coherent SI unit of current ramp rate is ampere per second, $A s^{-1}$.
- 8005 **1171. DC power**
- 8006 product of the direct voltage and the direct current (mean values)
- 8007
- 8008 [Source: IEC 60050-101:2000 3.1.11]
- 8009
- 8010 Note to entry: The coherent SI unit of DC power is watt, W.

8011 **1172. DC voltage**

8012 rms value of the positive sequence of the phase-to-phase voltage at the fundamental frequency

8013

8014 Note to entry: The coherent SI unit of DC voltage is volt, V.

8015 **1173. dielectric dissipation factor**

8016 tangent of the phase angle ($\tan \delta$)

8017

8018 [Source: ISO 472:2013 2.276]

8019 **1174. electric charge**

8020 time integral of the electric current i at a terminal of a two-terminal element or n-terminal element:

8021
$$q(t) = \int_{t_0}^t i(\tau) d\tau$$

8022 where t_0 is any instant before the first supply of electric energy

8023

8024 [Source: IEC 60050-101-11]

8025

8026 Note 1 to entry: The electro-oxidation of an electroactive substance results in positive values of Q ;
8027 the electro-reduction of an electroactive substance gives rise to negative values of Q .

8028 Note 2 to entry: The smallest electric charge found on its own is the elementary charge, e , the charge
8029 of a proton.

8030 Note 3 to entry: The coherent SI unit of electric charge is coulomb, C.

8031 **1175. electric flux**

8032 scalar quantity equal to the flux of the electric flux density \mathbf{D} through a given directed surface S :

8033
$$\Psi = \int_S \mathbf{D} \cdot \mathbf{e}_n dA$$

8034 where $\mathbf{e}_n dA$ is the vector surface element

8035

8036 [Source: IEC 60050-101-11-41]

8037

8038 Note to entry: The coherent SI unit of electric flux is volt meter, V m.

8039 **1176. electric flux density**

8040 vector quantity obtained at a given point by adding the electric polarisation \mathbf{P} to the product of the
8041 electric field strength \mathbf{E} and the electric constant ϵ_0 :

8042
$$\mathbf{D} = \epsilon_0 \mathbf{E} + \mathbf{P}$$

8043 Note 1 to entry: In vacuum, the electric flux density is at all points equal to the product of the electric
8044 field strength and the electric constant:

8045
$$\mathbf{D} = \epsilon_0 \mathbf{E}$$

8046 Note 2 to entry: The divergence of the electric flux density is equal to the volumic electric charge ρ :

8047
$$\nabla \cdot \mathbf{D} = \rho$$

8048

8049 [Source: IEC 60050-101-11-40]

8050

8051 Note 3 to entry: The coherent SI unit of electric flux density is coulomb per square meter, C m⁻².

8052 **1177. electric power**

8053 rate, in watts (joules per second), at which electric energy is transferred in an electric circuit

8054

8055 [Source: IEC 60050-101-11-40]

8056

8057 Note to entry: The coherent SI unit of electric power is watt, W.

- 8058 **1178. electrical admittance**
 8059 reciprocal of electrical impedance
 8060
 8061 Note to entry: The coherent SI unit of electrical admittance is siemens, S. The coherent SI unit of
 8062 specific electrical admittance is siemens per square meter, S m⁻²
- 8063 **1179. electrical impedance**
 8064 frequency-dependent, complex-number proportionality factor, $\Delta U/\delta I$, between the applied alternating
 8065 current voltage U (or current I) and the response current (or potential) in an electrochemical cell
 8066
 8067 Note 1 to entry: This factor is the impedance only when the perturbation and response are linearly
 8068 related (the value of the factor is independent of the magnitude of the perturbation) and the response
 8069 is caused only by the perturbation.
 8070
 8071 [Source: ISO 16773-1:2016 2.23]
 8072
 8073 Note 2 to entry: The coherent SI unit of electrical impedance is ohm, Ω . The coherent SI unit of
 8074 specific electrical impedance is ohm square meter, Ω m².
- 8075 **1180. electrical reactance**
 8076 imaginary of electrical impedance
 8077
 8078 Note to entry: The coherent SI unit of electrical reactance is ohm, Ω .
- 8079 **1181. electrical resistance**
 8080 electric potential difference divided by the electric current when there is no electromotive force in a
 8081 conductor
 8082
 8083 [Source: IUPAC Gold Book R05315]
 8084
 8085 Note to entry: The coherent SI unit of electrical resistance is ohm, Ω .
- 8086 **1182. electrical susceptance**
 8087 imaginary part of electrical admittance
 8088
 8089 Note to entry: The coherent SI unit of electrical susceptance is siemens, S.
- 8090 **1183. elementary electric charge**
 8091 quantum of electric charge
 8092
 8093 Note 1 to entry: The elementary electric charge is equal to the charge of the proton and opposite
 8094 to the charge of the electron.
 8095 Note 2 to entry: The value of elementary electric charge is: $e = 1,602\ 176\ 487(40) \times 10^{-19}$ C (Mohr
 8096 et al., 2008).
 8097
 8098 [Source: IEV 131-05-16]
 8099
 8100 Note 3 to entry: A quantum is an indivisible amount of a quantity that only changes in a discrete
 8101 manner by one or more such amounts.
- 8102 **1184. Faradaic efficiency**
 8103 fraction of the electric current passing through an electrochemical cell (EC) which accomplishes the
 8104 desired chemical reaction
 8105
 8106 [Source: IEV 114-03-07]
 8107
 8108 Note to entry: Faradaic efficiency is also called current efficiency.
- 8109 **1185. high-frequency resistance (HFR)**
 8110 method of minimum disturbance to the cell by applying a small alternating current signal of fixed, single
 8111 high frequency (typically 1 kHz) to the electronic load or power supply to modulate the direct current

8112 while measuring magnitude and phase of the AC voltage response of the cell by a frequency response
8113 analyzer

8114

8115 Note 1 to entry: The high-frequency resistance is the real part of the measured electrical impedance.
8116 The high frequency to be selected is where the electrical impedance has zero imaginary part.

8117

8118 Note 2 to entry: The coherent SI unit of electric flux density is ohm, Ω .

8119 **1186. immittance**

8120 general term denoting electrical admittance, electrical impedance, or a quantity derived from either

8121

8122 Note to entry: The term immittance is a lexical combination of *impedance* and *admittance* due to
8123 US engineer and scientist Hendrik Wade Bode (1905-1982) (Bode, 1945). It acquires the unit of its
8124 underlying term (e.g. electrical impedance, electrical admittance, electrical reactance, electrical sus-
8125 ceptance, etc).

8126 **1187. inductance**

8127 ability to store energy in a magnetic field

8128
$$L = \frac{\Psi}{i}$$

8129 where

8130

L is inductance;

8131 Ψ is linked flux between the terminals of a two terminal element with terminals A and B;

8132 i is electric current

8133

8134 Note 1 to entry: Inductance cannot be negative.

8135 Note 2 to entry: The coherent SI unit of inductance is henry, H.

8136 **1188. inductive susceptance**

8137 imaginary part of electrical admittance (negative reciprocal of inductance)

8138 **1189. input power**

8139 for a given system, power transferred to that system from an external system

8140

8141 [Source: IEV 113-03-53]

8142

8143 Note to entry: The coherent SI unit of input power is watt, W.

8144 **1190. instantaneous power**

8145 for a two-terminal element or a two-terminal circuit with terminals A and B, product of the voltage u_{AB}
8146 between the terminals and the electric current i in the element or circuit

8147
$$P = u_{AB} \cdot i$$

8148 where u_{AB} is the line integral of the electric field strength from A to B, and where the electric current
8149 in the element or circuit is taken positive if its direction is from A to B and negative if its direction is
8150 from B to A

8151

8152 Note 1 to entry: In circuit theory the electric field strength is generally irrotational and thus $u_{AB} =$
8153 $v_A - v_B$, where v_A and v_B are the electric potentials at terminals A and B, respectively.

8154 Note 2 to entry: The coherent SI unit of instantaneous power is watt, W.

8155

8156 [Source: IEV 131-11-30]

8157 **1191. leakage current**

8158 electric current in an unwanted conductive path other than a short circuit

8159

8160 [Source: IEV 151-15-49]

8161

8162 Note to entry: The coherent SI unit of leakage current is ampere, A.

8163 **1192. limiting current**

8164 maximum electric current allowed by the slowest non-electrochemical step of a given electrode process

8165

8166 [Source: ISO 8044:2020 7.2.7]

8167

8168 Note to entry: The coherent SI unit of limiting current is ampere, A.

8169 **1193. loss angle**

8170 angle the tangent of which is the ratio of the electrical resistance R to the absolute value of the electrical
8171 reactance X of an impedance

8172
$$\delta = \arctan \frac{R}{|X|}$$

8173 where the electric current is taken positive if its direction is from A to B and negative if its direction is
8174 from B to A

8175

8176 Note to entry: The loss angle is defined in as the angle the tangent of which is the dissipation factor,
8177 or ratio of active power to the absolute value of reactive power. Other loss angles are defined in elec-
8178 tromagnetism.

8179

8180 [Source: IEV 131-12-49]

8181 **1194. maximum cell voltage**

8182 highest electrolyser voltage specified by the manufacturer

8183

8184 [Source: IEC 62282-8-102:2019 3.1.19]

8185

8186 Note to entry: The coherent SI unit of maximum cell voltage is volt, V.

8187 **1195. maximum input power**

8188 maximum power that can be applied to the connection facilities of apparatus without invalidating intrinsic
8189 safety

8190

8191 [Source: IEV 426-11-18]

8192

8193 Note to entry: The coherent SI unit of maximum input power is watt, W.

8194 **1196. maximum output power**

8195 maximum electrical power that can be taken from the intrinsically safe connection facilities of the ap-
8196 paratus

8197

8198 [Source: IEV 426-11-23]

8199

8200 Note to entry: The coherent SI unit of maximum output power is watt, W.

8201 **1197. maximum voltage**

8202 highest cell/stack assembly unit voltage specified by the manufacturer

8203

8204 [Source: IEC 62282-8-101:2020 3.1.18]

8205

8206 Note to entry: The coherent SI unit of maximum voltage is volt, V.

8207 **1198. maximum working voltage**

8208 highest value of AC voltage (rms) or of DC voltage that can occur under any normal operating conditions
8209 according to the manufacturer's specifications, disregarding transients and ripples

8210

8211 [Source: ISO 6469-2:2018 3.11]

8212 [Source: ISO/TR 8713:2019 3.88]

8213

8214 Note to entry: The coherent SI unit of the maximum working voltage is volt, V.

- 8215 **1199. minimum voltage**
8216 lowest cell/stack assembly unit voltage specified by the manufacturer
8217
8218 [Source: IEC 62282-8-101:2020 3.1.17]
8219
8220 Note to entry: The coherent SI unit of minimum voltage is volt, V.
- 8221 **1200. negative electric charge**
8222 electric charge which is of the same sign as that attributed by convention to an electron
8223
8224 [Source: IEV 131-02-13]
- 8225 **1201. nominal current**
8226 electric current value associated with the nominal design point as specified by the manufacturer
8227
8228 [Source: JRC EUR 29300 EN report 3.5.4]
8229
8230 Note to entry: The coherent SI unit of nominal current is ampere, A.
- 8231 **1202. nominal frequency**
8232 rated value of the system frequency
8233
8234 [Source: IATE 3565188]
8235
8236 Note to entry: The coherent SI unit of nominal frequency is per second, s^{-1} . This is equivalent to
8237 hertz, Hz.
- 8238 **1203. nominal voltage**
8239 suitable approximate value of the voltage used to designate or identify a cell, a battery or an electro-
8240 chemical system
8241
8242 [Source: IEV 482-03-31]
8243
8244 Note to entry: The coherent SI unit of nominal voltage is volt, V.
- 8245 **1204. output power**
8246 for a given system, power transferred from that system to an external system
8247
8248 [Source: IEV 113-03-54]
8249
8250 Note to entry: The coherent SI unit of output power is watt, W.
- 8251 **1205. output voltage**
8252 voltage between the output terminals under operating conditions
8253
8254 Note 1 to entry: The output voltage is expressed in V.
8255
8256 [Source: IEV 485-13-03]
8257
8258 Note 2 to entry: The coherent SI unit of output voltage is volt, V.
- 8259 **1206. polarisation resistance**
8260 slope, dU/dI of a potential, U , versus current, I , curve
8261
8262 Note to entry: The coherent SI unit of polarisation resistance is ohm, Ω . The coherent SI unit of
8263 specific polarisation resistance is ohm square meter, Ωm^2 .
- 8264 **1207. positive electric charge**
8265 electric charge which is of the same sign as that attributed by convention to a proton
8266
8267 [Source: IEV 131-02-12]

8268 **1208. power**

8269 derivative with respect to time t of energy E being transferred or transformed, thus $P = \frac{dE}{dt}$

8270

8271 Note to entry: The coherent SI unit of power is watt, W.

8272

8273 [Source: IEV 113-03-52]

8274 **1209. power consumption**

8275 total power consumed by a component or system under specified conditions

8276

8277 [Source: ISO 5598:2019 3.2.553]

8278

8279 Note to entry: The coherent SI unit of power consumption is watt, W.

8280 **1210. power factor**

8281 ratio of active power to the apparent power

8282 **1211. power response time**

8283 duration between the instant of initiating a change in electric or thermal power output and that when
8284 the electric or thermal power output attains the steady state within a specified tolerance

8285

8286 [Source: IEV 485-20-03]

8287

8288 Note to entry: The coherent SI unit of power response time is second, s.

8289 **1212. rated current**

8290 recommended continuous electric current specified by the manufacturer at which the cell, stack or sys-
8291 tem is designed to operate under normal operating conditions

8292

8293 Note to entry: The coherent SI unit of rated current is ampere, A.

8294 **1213. rated current density**

8295 maximum current density specified by the manufacturer, at which the cell/stack assembly has been
8296 designed to operate continuously

8297

8298 [Source: IEC 62282-8-102:2019 3.1.28]

8299

8300 Note to entry: The coherent SI unit of rated current density is ampere per square meter, A m⁻².

8301 **1214. rated input voltage**

8302 root-mean-square input supply voltage for which the equipment has been designed

8303

8304 Note 1 to entry: Several rated input voltages may be specified for one equipment.

8305

8306 [Source: IEV 881-07-21]

8307

8308 Note 2 to entry: The coherent SI unit of rated input voltage is volt, V.

8309 **1215. rated power stack capacity**

8310 maximum stack capacity, in terms of electrical DC power, as rated by the manufacturer (kW direct
8311 current)

8312

8313 [Source: JRC EUR 29300 EN report 3.8.9]

8314

8315 Note to entry: The coherent SI unit of rated power stack capacity is watt, W.

8316 **1216. rated power system capacity**

8317 maximum capacity of the system, in terms of power, as rated by the manufacturer

8318

8319 [Source: JRC EUR 29300 EN report 3.8.8]

8320

8321 Note to entry: The coherent SI unit of rated power system capacity is watt, W.

8322 **1217. rated voltage**

8323 rated value of the voltage assigned by the manufacturer to a component, device or equipment and to
8324 which operation and performance characteristics are referred

8325

8326 Note 1 to entry: Equipment may have more than one rated voltage value or may have a rated voltage
8327 range.

8328 Note 2 to entry: For three-phase power supply, the line-to-line voltage applies.

8329

8330 [Source: IEV 442-09-10]

8331

8332 Note 3 to entry: The coherent SI unit of rated voltage is volt, V.

8333 **1218. reactive energy**

8334 in an AC system, the captive electrical energy exchanged continuously between the different electric and
8335 magnetic fields associated with the operation of the electrical system and of all the connected apparatus

8336

8337 [Source: IEV 692-01-20]

8338

8339 Note to entry: The coherent SI unit of reactive energy is volt ampere second, VA s.

8340 **1219. reactive power**

8341 for a linear two-terminal element or two-terminal circuit, under sinusoidal conditions, quantity equal to
8342 the product of the apparent power S and the sine of the displacement angle ϕ

8343

$$Q = S \sin \phi$$

8344

Note 1 to entry: The reactive power is the imaginary part of the complex power \underline{S} , thus $Q = \Im \underline{S}$.

8345

Note 2 to entry: The coherent SI unit of reactive power is volt ampere, VA.

8346

8347 [Source: IEV 131-11-44]

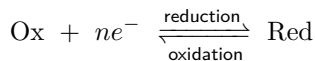
8348 **1220. redox potential**

8349 potential of a reversible oxidation-reduction reaction in a given electrolyte recorded on a standard hy-
8350 drogen electrode scale

8351

8352 [Source: ISO 8044:2020 7.1.36]

8353



8354

8355 where Ox is oxidant, n is number of electrons transferred, and Red is reductant

8356

8357 Note to entry: The more positive (negative) the redox potential, the more oxidising (reducing) the
8358 environment.

8359 **1221. short-circuit current**

8360 electric current in a given short-circuit

8361

8362 [Source: IEV 195-05-18]

8363

8364 Note to entry: The coherent SI unit of short-circuit current is ampere, A.

8365 **1222. stack nominal capacity**

8366 individual stack capacity, as rated by the manufacturer

8367

8368 [Source: JRC EUR 29300 EN report 3.18.11.1]

8369

8370 Note to entry: The coherent SI unit of stack nominal capacity is watt, W.

8371 **1223. stack nominal power capacity**

8372 individual stack power capacity, as rated by the manufacturer

8373

8374 [Source: JRC EUR 29300 EN report 3.18.11.2]

8375

8376 Note to entry: The coherent SI unit of stack nominal power capacity is watt, W.

8377 **1224. standard voltage cell**

8378 cell having, at a specified temperature, an invariant and specific open circuit voltage, used as a reference
8379 voltage

8380

8381 [Source: IEV 482-01-17]

8382 **1225. stray current**

8383 current flowing through paths other than the intended circuits

8384

8385 [Source: ISO 12473:2017 3.29]

8386 [Source: ISO 15589-1:2015 3.33]

8387

8388 Note to entry: The coherent SI unit of stray current is ampere, A.

8389 **1226. system frequency**

8390 number of complete cycles per second in alternating current direction in an electrical power system

8391

8392 Note to entry: System frequency is a continuously changing variable that is determined and controlled
8393 by the second-by-second (real time) balance between system demand and total generation. If demand
8394 is greater than generation, the frequency falls while if generation is greater than demand, the frequency
8395 rises.

8396

8397 [Source: IATE 1447971]

8398

8399 Note to entry: The coherent SI unit of system frequency is per second, s⁻¹. This is equivalent to
8400 hertz, Hz.

8401 **1227. theoretical current**

8402 current when the supplied positive and negative electrode gases are completely consumed in electro-
8403 chemical reactions divided by the number of cells in a series connection

8404

8405 [Source: IEC 62282-8-101:2020 3.1.35]

8406

8407 Note to entry: The coherent SI unit of theoretical current is ampere, A.

8408 **1228. total current density**

8409 vector quantity equal to the sum of the electric current density **J** and the displacement current density
8410 **J_D**:

8411
$$\mathbf{J}_t = \mathbf{J} + \mathbf{J}_D$$

8412 [Source: IEV 121-11-44]

8413

8414 Note to entry: The coherent SI unit of total current density is ampere per square meter, A m⁻².

8415 **1229. total electric current**

8416 scalar quantity given by the flux of the total current density **J_t** through a given directed surface *S*:

8417
$$I_t = \int_S \mathbf{J}_t \cdot \mathbf{e}_n dA$$

8418 where $\mathbf{e}_n dA$ is the vector surface element

8419

8420 Note 1 to entry: The total electric current *I_t* is given by $I_t = I + I_D$ where *I* is the electric cur-
8421 rent and *I_D* the displacement current.

8422

8423 [Source: IEV 121-11-45]

8424

8425 Note 2 to entry: The coherent SI unit of total electric current is ampere, A.

8426 **1230. total impedance**

8427 frequency-dependent losses due to ohmic, activation, diffusion, concentration effects, stray (parasitic)
8428 capacitance and inductances

8429

8430 [Source: IEC 62282-8-101:2020 3.1.36]

8431

8432 Note to entry: The coherent SI unit of total impedance is ohm, Ω . The coherent SI unit of specific total
8433 impedance is ohm square meter, $\Omega \text{ m}^2$.

8434 **1231. total resistance**

8435 real part of low-frequency limit of total impedance

8436

8437 [Source: IEC 62282-8-101:2020 3.1.37]

8438

8439 Note to entry: The coherent SI unit of total resistance is ohm, Ω . The coherent SI unit of specific
8440 total resistance is ohm square meter, $\Omega \text{ m}^2$.

8441 **1232. voltage**

8442 scalar quantity equal to the line integral of the electric field strength \mathbf{E} along a specific path linking two
8443 points a and b:

8444
$$U_{ab} = \int_{\mathbf{r}_a}^{\mathbf{r}_b} \mathbf{E} \cdot d\mathbf{r}$$

8445 where \mathbf{r}_a and \mathbf{r}_b are the position vectors for a and b, respectively, and $d\mathbf{r}$ is the vector line element

8446

8447 Note 1 to entry: In the case of an irrotational field strength, the voltage is independent of the path and
8448 equal to the negative of the electric potential difference between the two points: $U_{ab} = -(V_b - V_a)$.

8449 Note 2 to entry: The name "voltage", commonly used in the English language, is an exception from the
8450 principle that a quantity name should not refer to any name of unit.

8451

8452 [Source: IEC 60027-1-2:2011 2.7]

8453

8454 Note 3 to entry: The coherent SI unit of voltage is volt, V.

8455 **1233. voltage drop**

8456 reduction in electrical potential

8457

8458 Note to entry: The coherent SI unit of voltage drop is volt, V.

8459 **1234. voltage gain**

8460 increase in electrical potential

8461

8462 Note to entry: The coherent SI unit of voltage gain is volt, V.

8463 **1235. volumetric power density**

8464 ratio of power to the volume a cell, a stack or system

8465

8466 Note to entry: The coherent SI unit of volumetric power density is watt per cubic meter, W m^{-3} .

8467 **1236. working voltage**

8468 AC voltage (rms) or DC voltage that can occur in an electric system under normal operating conditions
8469 according to the customer's specifications, disregarding transients

8470

8471 [Source: ISO/TR 8713:2019 3.164]

8472

8473 Note to entry: The coherent SI unit of working voltage is volt, V.

8474 **2.4.3 Physical, physico-chemical & technological**

8475 **1237. absolute pressure**

8476 pressure using absolute vacuum as a reference

8477

8478 [Source: ISO 5598:2019 3.2.2]

8479

8480 Note to entry: The coherent SI unit of absolute pressure is pascal, Pa.

8481 **1238. activation energy**

8482 energy, above that of the ground state, which must be added to an atomic or a molecular system to
8483 allow a particular process to take place

8484

8485 [Source: ISO 11358-2:2014 3.2]

8486

8487 Note to entry: The coherent SI unit of activation energy is joule, J.

8488 **1239. active area**

8489 area of the electrode, which is perpendicular to the direction of the intended flow of current and is
8490 available for an electrochemical reaction

8491

8492 Note to entry: The coherent SI unit of active area is square meter, m².

8493 **1240. ambient temperature**

8494 temperature of the environment surrounding the equipment

8495

8496 [Source: ISO 3857-4:2012 2.10]

8497

8498 Note to entry: The coherent SI unit of ambient temperature is kelvin, K.

8499 **1241. angular frequency**

8500 product of the frequency of a sinusoidal quantity and the factor 2π

8501

8502 [Source: IEV 103-06-03]

8503

8504 Note to entry: The coherent SI unit of angular frequency is per second, s⁻¹. This is equivalent to
8505 hertz, Hz.

8506 **1242. atmospheric pressure**

8507 absolute pressure of the atmosphere at a given location and time

8508

8509 [Source: ISO 5598:2019 3.2.48]

8510

8511 Note 1 to entry: A "given location" may include geographical position (latitude, longitude and alti-
8512 tude) of a specified place. Time should include date.

8513 Note 2 to entry: The coherent SI unit of atmospheric pressure is pascal, Pa.

8514 **1243. attenuation**

8515 decrease in signal magnitude from one point to another (reciprocal of gain)

8516

8517 Note to entry: Attenuation may be expressed as a scalar ratio of the input magnitude to the output
8518 magnitude.

8519 **1244. back pressure**

8520 pressure due to downstream restrictions

8521

8522 [Source: ISO 5598:2019 3.2.65]

8523

8524 Note to entry: The coherent SI unit of back pressure is pascal, Pa.

- 8525 **1245. barrier height**
8526 magnitude of the potential energy in a region restricting the movement of electrons
8527
8528 [Source: ISO 18115-2:2013 5.9]
- 8529 **1246. cell area**
8530 geometric area of the cell perpendicular to the direction of the intended flow of current
8531
8532 Note to entry: The coherent SI unit of cell area is square meter, m².
- 8533 **1247. cell polarisation potential**
8534 sum of the absolute values of the potential differences resulting from anodic and cathodic polarisation
8535 of an electrochemical cell (EC)
8536
8537 [Source: IEV 114-03-12]
8538
8539 Note to entry: The coherent SI unit of cell polarisation potential is volt, V.
- 8540 **1248. Celsius temperature**
8541 quantity defined as the difference of the thermodynamic temperature T and the value 273,15 K, thus ϑ
8542 $= T - 273,15 \text{ K}$
8543
8544 [Source: IEV 113-04-16]
8545
8546 Note to entry: The unit of Celsius temperature is degree Celsius, °C.
- 8547 **1249. charge density**
8548 ratio of the charge of a particle to the elementary charge
8549
8550 [Source: IUPAC Gold Book C00993]
- 8551 **1250. charge number**
8552 ratio of the charge of a particle to the elementary charge
8553
8554 [Source: IUPAC Gold Book C00993]
8555
8556 Note to entry: The charge number of an electrically charged particle can be positive or negative.
8557 For an electrically neutral particle, it is zero. The charge number of a particle may be presented as a
8558 superscript to the symbol of that particle in arabic numerals followed by the sign of the charge without
8559 a space.
- 8560 **1251. charge transfer coefficient**
8561 parameter used in describing the kinetics of electrochemical reactions with transfer of charge
- 8562 **1252. compacticity**
8563 ratio of apparent density as measured to theoretical density as calculated from crystallographic data
- 8564 **1253. complex angular frequency**
8565 frequency made up of real and imaginary parts
8566
8567 Note to entry: The coherent SI unit of complex angular frequency is per second, s⁻¹. This is equivalent
8568 to hertz, Hz.
- 8569 **1254. compressibility factor**
8570 product of pressure and molar volume divided by the gas constant and thermodynamic temperature
8571
8572 Note 1 to entry: For an ideal gas it is equal to 1.
8573
8574 [Source: IUPAC Gold Book C01216]
8575

8576 Note 2 to entry: For a real gas (real fluid), it deviates from 1 stated as a virial EoS expressed in a
8577 truncated Taylor series¹⁸ expansion relating pressure, molar volume and temperature.

8578 **1255. compression factor**

8579 actual (real) volume of a given amount of gas at a specified pressure and temperature divided by its
8580 volume under the same conditions as calculated from the ideal gas law

8581
8582 [Source: ISO 6976:2016 3.10]

8583
$$Z(p, T) = \frac{V_{m, \text{real}}}{V_{m, \text{ideal}}}$$

8584

8585 where

8586 p is absolute pressure;

8587 T is thermodynamic temperature;

8588 V_m is molar volume of gas.

8589 Note 1 to entry: The compression factor is a dimensionless quantity, which is normally close to unity
8590 for a gas near standard or normal reference conditions.

8591 Note 2 to entry: Within the range of pressures and temperatures encountered in gas transmission, the
8592 compression factor can significantly differ from unity.

8593 Note 3 to entry: The terms "compressibility factor" and "Z-factor" are synonymous with compression
8594 factor.
8595

8596 **1256. cycle time**

8597 time associated with one complete operation of a repetitive process

8598
8599 [Source: ISO 16484-2:2004 3.57]

8600 Note to entry: The coherent SI unit of cycle time is second, s.
8601

8602 **1257. dew point**

8603 temperature at which condensation of water vapour takes place at prevailing pressure

8604
8605 Note 1 to entry: The prevailing pressure is usually atmospheric pressure.

8606
8607 [Source: ISO 14952-1:2003 2.8]

8608 Note 2 to entry: The coherent SI unit of dew point is degree Celsius, °C.
8609

8610 **1258. dew point temperature**

8611 thermodynamic temperature at which vapour in air reaches saturation

8612
8613 Note 1 to entry: The corresponding Celsius temperature is denoted t_d and is also called dew point.

8614
8615 [Source: IEV 113-04-67]

8616 Note 2 to entry: The coherent SI unit of dew point temperature is degree Celsius, °C.
8617

8618 **1259. differential cell pressure**

8619 difference in pressure across the electrolyte as measured from one electrode chamber to the other elec-
8620 trode chamber

8621
8622 [Source: IEV 485-17-01]

8623 Note to entry: The coherent SI unit of differential cell pressure is pascal, Pa.
8624

¹⁸This series is named after English mathematician Brook Taylor (1685-1731).

8625 **1260. differential pressure**

8626 difference in value between two pressures occurring simultaneously at different measurement points

8627

8628 [Source: ISO 3857-4:2012 2.31]

8629

8630 Note to entry: The coherent SI unit of differential pressure is pascal, Pa.

8631 **1261. diffuse layer potential**

8632 potential difference between the rigid layer and the diffuse layer of a double layer

8633

8634 [Source: IEV 114-02-20]

8635

8636 Note to entry: The coherent SI unit of diffuse layer potential is volt, V.

8637 **1262. diffusion coefficient**

8638 rate of gas diffusion through a material

8639

8640 [Source: ISO 18875:2015 2.17]

8641

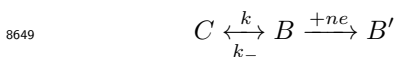
8642 Note to entry: The coherent SI unit of diffusion coefficient is square meter per second, $\text{m}^2 \text{s}^{-1}$.

8643 **1263. diffusion current**

8644 Faradaic current (diffusion-controlled current) whose magnitude is controlled by the rate k at which a
8645 reactant in an electrochemical process diffuses toward an electrode-solution interface (and, sometimes,
8646 by the rate k_- at which a product diffuses away from that interface)

8647

8648 Note 1 to entry: For the reaction mechanism



8650 there are two common situations in which a diffusion current can be observed. In one, the rate of
8651 formation of B from electro-inactive C is small and the current is governed by the rate of diffusion of
8652 B toward the electrode surface. In the other, C predominates at equilibrium in the bulk of the solution,
8653 but its transformation into B is fast; C diffuses to the vicinity of the electrode surface and is there
8654 rapidly converted into B , which is reduced.

8655

8656 [Source: IUPAC Gold Book D01722]

8657

8658 Note 2 to entry: The coherent SI unit of diffusion current is ampere, A.

8659 **1264. displacement current**

8660 scalar quantity equal to the flux of the displacement current density J_D through a given directed surface
8661 S :

8662
$$I_D = \int_S \mathbf{J}_D \cdot \mathbf{e}_n dA$$

8663 where $\mathbf{e}_n dA$ is the vector surface element

8664

8665 [Source: IEV 121-11-43]

8666

8667 Note to entry: The coherent SI unit of displacement current is ampere, A.

8668 **1265. displacement current density**

8669 vector quantity equal to the time derivative of the electric flux density \mathbf{D} :

8670
$$\mathbf{J}_D = \partial_t \mathbf{D}$$

8671

8672 [Source: IEV 121-11-42]

8673

8674 Note to entry: The coherent SI unit of displacement current density is ampere per square meter, A
8675 m^{-2} .

8676 **1266. double layer capacitance (DLC)**

8677 capacitance of the capacitor representing the metal-electrolyte interface characteristics in the equivalent
8678 circuit

8679

8680 [Source: ISO 16773-1:2016 2.12]

8681

8682 Note to entry: The coherent SI unit of double layer capacitance is farad, F. The coherent SI unit
8683 of specific double layer capacitance is farad per square metre, F m².

8684 **1267. double layer current**

8685 The non-faradaic current associated with the charging of the electric double layer at an electrode-solution
8686 interface, given by:

8687
$$i_{dl} = \frac{d(\sigma A)}{dt}$$

8688 where σ is surface charge density of the double layer, A is area of the electrode-solution interface and t
8689 is time

8690

8691 Note 1 to entry: Capital letters should be used as subscripts to avoid the possibility of confusing
8692 this symbol with that for the limiting diffusion current.

8693

8694 [Source: IUPAC Gold Book D01847]

8695

8696 Note 2 to entry: The coherent SI unit of double layer current is ampere, A.

8697 **1268. double layer thickness**

8698 length characterising the decrease with distance of the potential in the double layer (inverse of the
8699 characteristic Debye length in the corresponding electrolyte solution)

8700

8701 [Source: IUPAC Gold Book T06343]

8702

8703 Note to entry: The coherent SI unit of double layer thickness is meter, m.

8704 **1269. driving force (affinity) of a reaction**

8705 decrease in Gibbs energy on going from the reactants to the product of a chemical reaction ($-\Delta G$)

8706

8707 [Source: IUPAC Gold Book D01860]

8708 **1270. dwell time**

8709 time between changes in the setting of operating conditions

8710

8711 [Source: IEC 62282-8-101:2020 3.1.13]

8712

8713 Note to entry: The coherent SI unit of dwell time is second, s.

8714 **1271. electric surface charge density**

8715 charges on an interface per area due to specific adsorption of ions from the liquid bulk, or due to disso-
8716 ciation of the surface groups

8717

8718 [Source: ISO/TS 80004-6:2013 5.3.5]

8719 [Source: ISO 13099-3:2014 3.1.6]

8720

8721 Note to entry: The coherent SI unit of electric surface charge density is coulomb per square metre,
8722 C m⁻².

8723 **1272. electric surface potential**

8724 difference in electric potential between the surface and the bulk liquid

8725

8726 Note 1 to entry: Electric surface potential is expressed in volts.

8727

8728 [Source: ISO 13099-3:2014 3.1.7]

8729

8730 Note 2 to entry: The coherent SI unit of electric surface potential is volt, V.

8731 **1273. electrochemical potential (ECP)**

8732 partial molar Gibbs energy of the substance at the specified electric potential

8733

8734 [Source: IUPAC E01945]

8735

8736 Note to entry: The coherent SI unit of electrochemical potential (ECP) is joule per mole, J mol⁻¹.

8737 **1274. electrochemical surface area (ECSA)**

8738 actual surface area of an electro-catalyst accessible to an electrochemical process due to its open porous
8739 structure

8740

8741 Note 1 to entry: It is presented as electrochemical surface area per unit mass or volume of the catalyst
8742 or per geometric electrode area.

8743

8744 [Source: JRC EUR 29300 EN report 3.1.5]

8745

8746 Note 2 to entry: The coherent SI unit of electrochemical surface area is square meter per kilogram
8747 of electro-catalyst, m² kg⁻¹ (gravimetric), square meter per electrode volume, m² m⁻³ (volumetric), or
8748 square meter per electrode area, m² m⁻² (areal).

8749 **1275. electrode potential**

8750 voltage measured in the external circuit between an electrode and a reference electrode in contact with
8751 the same electrolyte

8752

8753 [Source: ISO 8044:2020 7.1.18]

8754

8755 Note to entry: The coherent SI unit of electrode potential is volt, V.

8756 **1276. energy**

8757 capacity of a system to produce external activity or to perform work

8758

8759 [Source: ISO/IEC 13273-2:2015 3.1.1]

8760

8761 Note 1 to entry: Energy is commonly expressed as a scalar quantity which may be increased or de-
8762 creased in a system when it receives or produces work, respectively.

8763 Note 2 to entry: Work as used in this definition means external supplied or extracted energy to a system.
8764 In mechanical systems, forces in or against direction of movement; in thermal systems, heat supply or
8765 heat removal.

8766 Note 3 to entry: Energy follows a law of conservation according to which the total energy of an isolated
8767 system remains constant.

8768 Note 4 to entry: Energy can be manifested in different forms that are mutually transformable into each
8769 other, either totally or partially, depending on other laws such as conservation of momentum or second
8770 law of thermodynamics.

8771 Note 5 to entry: Energy in a system may also be increased or decreased when it receives or produces
8772 energy in other forms than work, e. g. heat.

8773 Note 6 to entry: The coherent SI unit of energy is joule, J.

8774 **1277. energy density**

8775 ratio of stored energy to volume or mass

8776

8777 Note to entry: The coherent SI unit of volumetric and specific energy density is respectively joule
8778 per cubic meter, J m⁻³ and joule per kilogram, J kg⁻¹.

8779 **1278. enthalpy**

8780 state quantity equal to the sum of the internal energy U of a system and the product of pressure p and
8781 volume V of the system, thus $H = U + pV$

8782

8783 [Source: IEV 113-04-21]

8784

8785 Note 1 to entry: Formerly, enthalpy was called total heat and heat content.

8786 Note 2 to entry: The coherent SI unit of enthalpy is joule, J.

8787 **1279. entropy**

8788 state quantity of a system of fixed composition for which the infinitesimal increase is equal to the
8789 quotient of the heat entering the system by the thermodynamic temperature, plus an additional positive
8790 term if the change of state is irreversible

8791

8792 [Source: IEV 113-04-22]

8793

8794 Note 1 to entry: In statistical thermodynamics, entropy of a system in a given macrostate is proportional
8795 to the natural logarithm of the number of microstates, W (possible arrangements of the system) in that
8796 macrostate, $S = k_B \ln W$ where k_B is Boltzmann's constant.

8797 Note 2 to entry: The coherent SI unit of entropy is joule per kelvin, J K^{-1} .

8798 **1280. equilibrium electrode potential**

8799 electrode potential when the electrode reaction is in equilibrium

8800

8801 Note 1 to entry: In equilibrium, there is no electric current flow in the electrode.

8802

8803 [Source: IEV 114-02-12]

8804

$$8805 E_{eq} = E^{0'} - \frac{R_g T}{zF} v \ln \frac{a_{\text{Red}}}{a_{\text{Ox}}}$$

8806 where

8807

$E^{0'}$ is standard potential (V) for the half cell electrode reaction, for example, $\text{Ox} + ze^- \rightarrow \text{Red}$;

R_g is universal gas constant ($\text{J K}^{-1} \text{mol}^{-1}$);

T is thermodynamic temperature (K);

z is number of electrons involved in the electrode reaction;

8808

F is Faraday's constant (C mol^{-1});

v is stoichiometric coefficient (number of species) in the equation of the electrode reaction (positive for products and negative for reactants);

a_{Red} is chemical activity of the reducing species (oxidised species);

8809

a_{Ox} is chemical activity of the oxidising species (reduced species).

8810

8811 Note 2 to entry: The coherent SI unit of equilibrium electrode potential is volt, V.

8812 **1281. equilibrium potential**

8813 electrode potential of an electrode that is in thermodynamic equilibrium with its environment

8814

8815 [Source: ISO 8044:2020 7.1.33]

8816

8817 Note to entry: The coherent SI unit of equilibrium potential is volt, V.

8818 **1282. exchange current density**

8819 current density at a single electrode corresponding to the rate of internal charge transfer exchange within
8820 anodic reactions and cathodic reactions at their equilibrium potential

8821

8822 [Source: ISO 8044:2020 7.2.18]

8823

8824 Note to entry: The coherent SI unit of exchange current density is ampere per square meter, A m^{-2} .

- 8825 **1283. Faradaic current**
 8826 current generated by the reduction or oxidation of one or more chemical substances at an electrode
 8827
 8828 [Source: IEV 485-12-04]
 8829
 8830 Note to entry: The coherent SI unit of Faradaic current is ampere, A.
- 8831 **1284. flow rate**
 8832 quotient of the quantity of fluid passing through the cross-section of the conduit and the time taken for
 8833 this quantity to pass through this section
 8834
 8835 [Source: ISO 10790:2015 3.1.15]
 8836
 8837 Note to entry: The quantity of fluid can be heat, number of molecules, mass, or volume. For volume
 8838 flow, the pressure and temperature should be state. The cross-section of the conduit is the transverse
 8839 plane of the fluid flow path.
- 8840 **1285. frequency**
 8841 reciprocal of the period
 8842
 8843 Note 1 to entry: The symbol f is mainly used when the period is a time.
 8844
 8845 [Source: IEV 103-06-02]
 8846
 8847 Note 2 to entry: The coherent SI unit of frequency is per second, s^{-1} . This is equivalent to hertz,
 8848 Hz.
- 8849 **1286. gas composition**
 8850 fractions or concentrations of all the components determined from gas analysis
- 8851 **1287. gauge pressure**
 8852 measured absolute pressure minus atmospheric pressure
 8853
 8854 [Source: ISO 5598:2019 3.2.346]
 8855
 8856 Note 1 to entry: It can assume positive or negative values.
 8857 Note 2 to entry: The coherent SI unit of gauge pressure is pascal, Pa.
- 8858 **1288. geometric electrode area**
 8859 largest area of the electrode projected on a plane
 8860
 8861 [Source: JRC EUR 29300 EN report 3.1.3]
 8862
 8863 Note to entry: The coherent SI unit of geometric electrode area is square meter, m^2 .
- 8864 **1289. Gibbs free energy**
 8865 state quantity of a system equal to its enthalpy H decreased by the product of thermodynamic temper-
 8866 ature T and entropy S , thus $G = H - TS$
 8867
 8868 [Source: IEV 113-04-23]
 8869
 8870 Note 1 to entry: The coherent SI unit of Gibbs free energy is joule, J.
 8871 Note 2 to entry: This quantity is named after US scientist Josiah Willard Gibbs (1839-1903).
- 8872 **1290. heat**
 8873 form of energy related to chaotic microscopic behaviour of a system, given by the difference between
 8874 the increase of the total energy of a closed system and the work done on the system, during a process
 8875 of energy transfer
 8876
 8877 Note 1 to entry: Heat is a process quantity, not a state quantity. It depends on how the change
 8878 from one state to another has been obtained and is only partly transformable into work.

8879 Note 2 to entry: A supply of heat may correspond to an increase of thermodynamic temperature or to
8880 other effects, such as phase transition or chemical processes.
8881 Note 3 to entry: The coherent SI unit of heat is joule, J.
8882
8883 [Source: IEV 113-04-11]

8884 **1291. heat flow rate**
8885 amount of thermal energy emitted, transmitted or received per unit area and unit time
8886
8887 [Source: ISO 472:2013 2.1344]
8888
8889 Note to entry: The coherent SI unit of heat flux is watt, W.

8890 **1292. heat flux**
8891 thermal intensity, indicated by the rate at which heat crosses a given surface per unit area of that surface
8892
8893 [Source: ISO 4880:1997 36]
8894
8895 Note to entry: The coherent SI unit of heat flux is watt per square metre, W m⁻².

8896 **1293. heat loss**
8897 energy flow from a pipe, vessel or equipment to its surroundings
8898
8899 Note 1 to entry: Typical heat sinks are pipe shoes, pipe supports and item of large mass such as
8900 valve actuators or pump bodies.
8901
8902 [Source: IEV 426-20-11]
8903
8904 Note 2 to entry: The coherent SI unit of heat loss is joule, J.

8905 **1294. higher heating value (HHV)**
8906 value of the heat of combustion of a fuel as measured by reducing all of the products of combustion
8907 back to their original temperature and condensing all water vapour formed by combustion
8908
8909 Note 1 to entry: This value takes into account the heat of vaporisation of water.
8910
8911 [Source: JRC EUR 29300 EN report 3.13.2]
8912
8913 Note 2 to entry: Combustion should take place in oxygen. Commonly, the initial conditions are standard
8914 ambient temperature and pressure (SATP).
8915 Note 3 to entry: The coherent SI unit of HHV is joule per unit of fuel amount (mole, mass, or volume),
8916 J mol⁻¹, J kg⁻¹, or J m⁻³.

8917 **1295. hydrogen output pressure**
8918 gas pressure measured on the cathode side at the outlet of the electrolysis cell/stack.
8919
8920 [Source: JRC EUR 29300 EN report 3.19.2]
8921
8922 Note 1 to entry: Hydrogen output pressure is a function of temperature.
8923 Note 2 to entry: The coherent SI unit of hydrogen output pressure is pascal, Pa.

8924 **1296. hydrogen volume fraction**
8925 hydrogen content expressed as the ratio of the volume of hydrogen to the total volume of all components
8926 in the gas mixture under the conditions of normal temperature and pressure (NTP)
8927
8928 [Source: ISO 26142:2010 3.13]

8929 **1297. inlet flow rate**
8930 flow rate crossing the transverse plane of the inlet port
8931
8932 [Source: ISO 5598:2019 3.2.398]

8933 **1298. inlet pressure**

8934 pressure at the inlet port of a component, piping or system

8935

8936 [Source: ISO 5598:2019 3.2.397]

8937

8938 Note 1 to entry: Inlet pressure is a function of temperature.

8939 Note 2 to entry: The coherent SI unit of inlet pressure is pascal, Pa.

8940 **1299. ionic transference number**

8941 ratio of ionic conductivity relative to total conductivity, which is the sum of ionic conductivity and
8942 electronic (hole) conductivity

8943

8944 Note to entry: The region in which an ionic transference number is higher than 0.5 is defined as
8945 the ion conduction region, and the region in which an ionic transference number is higher than 0.99 is
8946 defined as the electrolytic conduction region.

8947

8948 [Source: ISO 11894-1:2013 3.3]

8949

8950
$$t_{\pm} = \frac{z_{\pm} c_{\pm} \mu_{\pm}}{z_{+} c_{+} \mu_{+} + z_{-} c_{-} \mu_{-} + z_e c_e \mu_e + z_h c_h \mu_h}$$

8951 where

8952

$t_{-(+)}$ is the anion (cation) transference number;

$z_{-(+)}$ is the anion (cation) charge;

$c_{-(+)}$ is the anion (cation) concentration;

8953

$\mu_{-(+)}$ is the anion (cation) mobility;

$z_{e(h\cdot)}$ is the electron (hole) charge;

$c_{e(h\cdot)}$ is the electron (hole) concentration;

$\mu_{e(h\cdot)}$ is the electron (hole) mobility.

8954 **1300. latent heat**

8955 quantity of heat needed for the change of phase or structure of the matter within an entity being at a
8956 constant temperature and pressure

8957

8958 [Source: IEV 841-21-12]

8959

8960 Note to entry: The coherent SI unit of latent heat is joule, J.

8961 **1301. latent heat of vaporisation of water**

8962 heat which is required to change water from a liquid to a gas

8963

8964 [Source: ISO 1716:2018 3.12]

8965

8966 Note to entry: The coherent SI unit of latent heat of vaporisation of water is joule per kilogram, J
8967 kg^{-1} .

8968 **1302. limiting diffusion current**

8969 potential-independent value that is approached by a diffusion current as the rate of the charge transfer
8970 process is increased by varying the applied potential

8971

8972 [Source: IUPAC Gold Book L03534]

8973

8974 Note to entry: The coherent SI unit of limiting diffusion current is ampere, A.

8975 **1303. loss tangent**

8976 ratio of the imaginary part of immittance to its real part

8977 **1304. lower heating value (LHV)**

8978 value of the heat of combustion of a fuel as measured by allowing all products of combustion to remain
8979 in the gaseous state

8980

8981 Note 1 to entry: This method of measurement does not take into account the heat energy put into the
8982 vapourisation of water (heat of vapourisation).

8983

8984 [Source: JRC EUR 29300 EN report 3.13.1]

8985

8986 Note 2 to entry: Combustion should take place in oxygen at constant pressure. The temperature
8987 and pressure of gaseous state should be specified. Commonly, this is a temperature of 150 °C and
8988 ambient pressure.

8989 Note 3 to entry: The coherent SI unit of LHV is joule per unit of fuel amount (moles, mass, or volume),
8990 J mol^{-1} , J kg^{-1} , or J m^{-3} .

8991 **1305. mass concentration**

8992 quotient of the mass of each component to the volume of the gas mixture under specified conditions of
8993 pressure and temperature

8994

8995 [Source: ISO 14532:2014 2.5.2.1.2]

8996 **1306. mass concentration of gas**

8997 mass of gas in a gas mixture per unit volume of the gas mixture

8998

8999 [Source: ISO 13943:2017 3.260]

9000 **1307. mass density**

9001 mass of a substance divided by its volume at specified conditions of pressure and temperature

9002

9003 Note 1 to entry: Volume includes that of voids (pores) in the material.

9004 Note 2 to entry: The coherent SI unit of mass density is kilogram per cubic meter, kg/m^3 .

9005 **1308. mass flow rate**

9006 flow rate in which the quantity of fluid is expressed as mass

9007

9008 [Source: ISO 10790:2015 3.1.16]

9009

9010 Note to entry: The coherent SI unit of mass flow rate is kilogram per second, kg s^{-1} .

9011 **1309. mass fraction**

9012 quotient of the mass of a component A to the sum of the masses of all components of the gas mixture

9013

9014 [Source: ISO 14532:2014 2.5.2.1.1]

9015 **1310. mass specific surface area**

9016 absolute surface area of the sample divided by sample mass

9017

9018 [Source: ISO/TS 80004-6:2013 3.6.1]

9019

9020 Note to entry: The coherent SI unit of mass specific surface area is meter square per kilogram, m^2
9021 kg^{-1} .

9022 **1311. maximum allowable differential working pressure**

9023 maximum differential pressure between the anode and cathode side, specified by the manufacturer, which
9024 the fuel cell can withstand without any damage or permanent loss of functional properties

9025

9026 [Source: IEV 485-17-02]

9027

9028 Note to entry: The coherent SI unit of maximum allowable differential working pressure is pascal,
9029 Pa.

- 9030 **1312. maximum allowable pressure**
9031 maximum pressure for which equipment is designed
9032
9033 [Source: ISO 16110-1:2007 3.15]
9034
9035 Note 1 to entry: It is defined at a location specified by the manufacturer.
9036 Note 2 to entry: Maximum allowable pressure is a function of temperature.
9037 Note 3 to entry: The coherent SI unit of maximum allowable pressure is pascal, Pa.
- 9038 **1313. maximum allowable temperature**
9039 maximum continuous temperature for which the manufacturer has designed the equipment (or any part
9040 to which the term is referred) when handling the specified fluid at the specified maximum operating
9041 pressure
9042
9043 [Source: ISO 10440-1:2007 3.20]
9044
9045 Note to entry: The coherent SI unit of maximum allowable temperature is kelvin, K.
- 9046 **1314. maximum allowable working pressure**
9047 maximum pressure to which a component or system is designed to be subjected and which is the basis
9048 for determining the strength of the component or system
9049
9050 [Source: ISO 16924:2016 3.46]
9051
9052 Note to entry: The coherent SI unit of the maximum allowable working pressure is pascal, Pa.
- 9053 **1315. maximum differential working pressure**
9054 maximum differential pressure between the anode and cathode sides, specified by the manufacturer,
9055 which the electrolyser cell can withstand without any damage or permanent loss of functional properties
9056
9057 [Source: JRC EUR 29300 EN report 3.19.3]
9058
9059 Note to entry: The coherent SI unit of the maximum differential working pressure is pascal, Pa.
- 9060 **1316. maximum operating pressure**
9061 maximum gauge pressure, specified by the manufacturer of a component or system, at which it is de-
9062 signed to operate continuously
9063
9064 [Source: JRC EUR 29300 EN report 3.19.4]
9065
9066 Note to entry: The coherent SI unit of maximum operating pressure is pascal, Pa.
- 9067 **1317. maximum operating temperature**
9068 maximum value of the ambient temperature at which the systems/components can be operated con-
9069 tinuously
9070
9071 [Source: ISO/TR 8713:2019 3.88]
9072
9073 Note to entry: The coherent SI unit of maximum operating temperature is kelvin, K.
- 9074 **1318. maximum pressure**
9075 highest transient pressure that can occur temporarily without any severe consequences on the perform-
9076 ance or life of a component or system
9077
9078 Note 1 to entry: The pressure relief valve is usually adjusted to the maximum pressure.
9079
9080 [Source: ISO 5598:2019 3.2.441]
9081
9082 Note 2 to entry: Maximum pressure is a function of temperature.
9083 Note 3 to entry: The coherent SI unit of the maximum pressure is pascal, Pa.

- 9084 **1319. maximum sealing pressure**
- 9085 highest pressure at which the seals are required to seal during any specified static or operating condition
- 9086 and during start-up and shutdown
- 9087
- 9088 [Source: ISO 10440-1:2007 3.24]
- 9089
- 9090 Note to entry: The coherent SI unit of maximum sealing pressure is pascal, Pa.
- 9091 **1320. maximum working pressure**
- 9092 highest pressure at which a system or sub-system can operate in steady state operating conditions
- 9093
- 9094 [Source: ISO 5598:2019 3.2.444]
- 9095
- 9096 Note 1 to entry: Maximum working pressure is a function of temperature.
- 9097 Note 2 to entry: The coherent SI unit of maximum working pressure is pascal, Pa.
- 9098 **1321. mean time between failures (MTBF)**
- 9099 expectation of the duration of the operating time between failures
- 9100
- 9101 Note 1 to entry: Mean operating time between failures should only be applied to repairable items.
- 9102
- 9103 [Source: IEV 192-05-13]
- 9104
- 9105 Note 2 to entry: The coherent SI unit of the MTBF is second, s.
- 9106 **1322. minimum allowable temperature**
- 9107 lowest temperature for which the manufacturer has designed the equipment or part thereof
- 9108
- 9109 [Source: ISO 10440-1:2007 3.26]
- 9110
- 9111 Note to entry: The coherent SI unit of minimum allowable temperature is kelvin, K.
- 9112 **1323. molar concentration**
- 9113 quotient of the amount of substance of each component to the volume of the gas mixture under these
- 9114 specified conditions of pressure and temperature
- 9115
- 9116 [Source: ISO 14532:2014 2.5.2.1.2]
- 9117 **1324. mole fraction**
- 9118 quotient of the amount of substance of a component A to the sum of the sum of the amounts of
- 9119 substances of all components of the gas mixture
- 9120
- 9121 [Source: ISO 14532:2014 2.5.2.1.1]
- 9122 **1325. Nernst potential**
- 9123 for a given ion distributed unequally across a membrane to which it is permeable, electric potential just
- 9124 sufficient to prevent its diffusion down its concentration gradient
- 9125
- 9126 [Source: IEV 891-02-22]
- 9127
- 9128 Note 1 to entry: The coherent SI unit of Nernst potential is volt, V.
- 9129 Note 2 to entry: The Nernst potential is named after German chemist Walther Hermann Nernst (1864-
- 9130 1941) who won the Nobel Prize in Chemistry in 1920.
- 9131 **1326. nominal pressure**
- 9132 pressure value assigned to a component, a piping or a system for the purpose of convenient designation
- 9133 and indicating its belonging to a series
- 9134
- 9135 [Source: ISO 5598:2019 3.2.480]
- 9136
- 9137 Note to entry: The coherent SI unit of nominal pressure is pascal, Pa.

- 9138 **1327. nominal working pressure**
9139 pressure level at which a component typically operates
9140
9141 [Source: ISO 23273:2013 3.13]
9142
9143 Note 1 to entry: Nominal working pressure is a function of temperature.
9144 Note 2 to entry: The coherent SI unit of nominal working pressure is pascal, Pa.
- 9145 **1328. open circuit potential (OCP)**
9146 potential of an electrode measured with respect to a reference electrode or another electrode when no
9147 current flows to or from it
9148
9149 [Source: ISO 10993-15:2019 3.3]
9150
9151 Note to entry: The coherent SI unit of OCP is volt, V.
- 9152 **1329. open circuit voltage (OCV)**
9153 voltage across the terminals of a cell or stack with reactants present and in the absence of external
9154 current flow also known as open circuit potential (OCP)
9155
9156 Note to entry: The coherent SI unit of OCV is volt, V.
- 9157 **1330. operating pressure**
9158 pressure at which the electrolyser (stack) operates
9159
9160 [Source: JRC EUR 29300 EN report 3.19.5]
9161
9162 Note 1 to entry: Operating pressure is a function of temperature.
9163 Note 2 to entry: The coherent SI unit of the operating pressure is pascal, Pa.
- 9164 **1331. operating time**
9165 time interval during which an item is in an operating state
9166
9167 Note 1 to entry: The accumulated times of various disjunct operating times interrupted by e. g. un-
9168 planned or planned down time is also called operating time.
9169 Note 2 to entry: Sometimes the term "running time" is used instead of "operating time". Often the
9170 running time describes the active part of the operating time. Whether rundown or start-up period is
9171 included depends on equipment, but hot standby time is not included even though some equipment
9172 functions can be active to minimise start-up time in e. g. redundant configuration ("hot standby").
9173 Note 3 to entry: Running hours during testing is also called running hours, even though this is at test
9174 conditions.
9175
9176 [Source: ISO 20815:2018 3.1.40]
9177
9178 Note 4 to entry: The coherent SI unit of operating time is second, s.
- 9179 **1332. outlet pressure**
9180 pressure at the outlet port of a component, piping or system
9181
9182 [Source: ISO 5598:2019 3.2.510]
9183
9184 Note 1 to entry: Outlet pressure is a function of temperature.
9185 Note 2 to entry: The coherent SI unit of outlet pressure is pascal, Pa.
- 9186 **1333. overpotential**
9187 deviation of the potential of an electrode from its equilibrium value required to cause a given current to
9188 flow through the electrode
9189
9190 [Source: IUPAC Gold Book O04358]
9191
9192 Note 1 to entry: Overpotential is the extra potential, in relation to the equilibrium value, required

9193 to cause a given electric current to flow through the electrode.
 9194 Note 2: Overpotential is positive for oxidation reactions and negative for reduction reactions.
 9195 Note 3 to entry: The coherent SI unit of overpotential is volt, V.

9196 **1334. overpressure**

9197 condition under which the pressure exceeds the maximum allowable working pressure

9198
 9199 [Source: ISO 16924:2016 3.60]

9200
 9201 Note to entry: The coherent SI unit of overpressure is pascal, Pa.

9202 **1335. overvoltage**

9203 difference between the actual cell voltage at a given current density and the reversible cell voltage for
 9204 the reaction (overpotential when referring to a single electrode)

9205
 9206 [Source: JRC EUR 29300 EN report 3.24.8]

9207
 9208 Note to entry: The coherent SI unit of overvoltage is volt, V.

9209 **1336. partial pressure**

9210 pressure that would be exerted by any component in a gas mixture as if the other components were absent

9211
 9212 Note to entry: The coherent SI unit of partial pressure is pascal, Pa.

9213 **1337. pH**

9214 number quantifying the acidic or the alkaline character of a solution, equal to the negative of the decimal
 9215 logarithm of ion activity a_{H^+} of the hydrogen cation H^+ , $pH = -10 \log_{10} a_{H^+}$

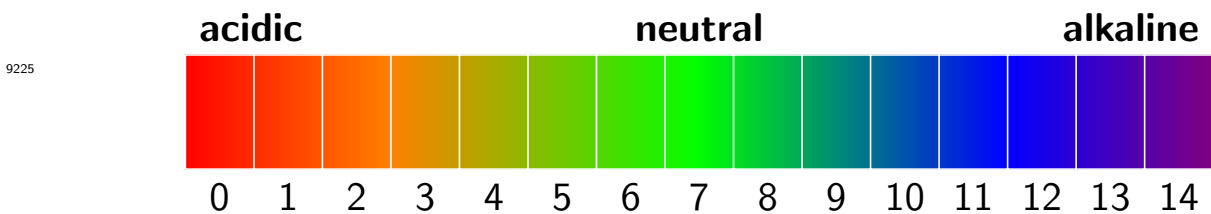
9216
 9217 [Source: IEV 114-01-21]

9218
 9219 Note 1 to entry: The pH is measured over the nominal range of 0 to 14 at about 25 °C aqueous
 9220 solutions with:

- 9221 — pH < 7 are acidic;
- 9222 — pH = 7 are neutral;
- 9223 — pH > 7 are alkaline.

9224 At temperatures far from 25 °C the pH of a neutral solution differs significantly from 7.

Figure 9: pH scale



9226
 9227
 9228 Note 2 to entry: While the acidic reaction is determined by the activity of the existing hydrogen cations,
 9229 the basic reaction is determined by the activity of the existing hydroxide anions. The direct relationship
 9230 between the activities of both type of ions is described by the ionic product of water.

9231 **1338. pH value**

9232 decadal logarithm of the hydrogen ion activity multiplied with (-1)

9233

$$pH = -\log_{10} \left(\frac{a_{H^+}}{m^0} \right) = -\log_{10} \left(\frac{m_{H^+} \gamma_{m,H^+}}{m^0} \right)$$

9234 with $a_{\text{H}^+} = m_{\text{H}^+} \gamma_{\text{m,H}^+}$ where a_{H^+} is the activity of the hydrogen ion, in mol kg^{-1} , m^0 is the standard
9235 molality (1 mol kg^{-1}), $\gamma_{\text{m,H}^+}$ is the activity coefficient of the hydrogen ion and m_{H^+} is the molality of
9236 the hydrogen ion, in mol kg^{-1}

9237

9238 Note to entry: The pH value is not measurable as a measure of a single ion activity. Therefore,
9239 pH (PS) values of solutions of primary reference material (PS: Primary Standard) are determined, which
9240 are approximate to it and can be attributed to it. This is based on a worldwide agreement.

9241

9242 [Source: ISO 19396-1:2017 3.2]

9243 **1339. phase shift**

9244 absolute magnitude of the difference between two phase angles or displacement in time of one periodic-
9245 waveform relative to other waveforms

9246

9247 [Source: ISO/IEC 14776-121:2010 3.1.68]

9248 **1340. potential gradient**

9249 difference in potential between two separate points in the same electric field

9250

9251 [Source: ISO 12473:2017 3.20]

9252 **1341. pressure drop**

9253 difference between the high and low pressure sides of a electrical resistance to flow

9254

9255 [Source: ISO 3857-4:2012 2.58]

9256

9257 Note to entry: The coherent SI unit of pressure drop is pascal, Pa.

9258 **1342. rated flow**

9259 flow rate, confirmed through testing, at which a component or piping is designed to operate

9260

9261 [Source: ISO 5598:2019 3.2.618]

9262 **1343. rated pressure**

9263 pressure, confirmed through testing, at which a component or piping is designed to operate for a number
9264 of repetitions sufficient to ensure adequate service life

9265

9266 Note 1 to entry: Specifications may include a maximum (highest) and/or a minimum (lowest) rated
9267 pressure.

9268

9269 [Source: ISO 5598:2019 3.2.619]

9270

9271 Note 2 to entry: Rated pressure is a function of temperature.

9272

Note 3 to entry: The coherent SI unit of rated pressure is pascal, Pa.

9273 **1344. rated temperature**

9274 temperature, confirmed through testing, at which a component or piping is designed to ensure adequate
9275 service life

9276

9277 Note 1 to entry: Specifications may include a maximum (highest) and/or a minimum (lowest) rated
9278 temperature.

9279

9280 [Source: ISO 5598:2019 3.2.620]

9281

9282 Note 2 to entry: The coherent SI unit of rated temperature is kelvin, K.

9283 **1345. relative density**

9284 ratio of the mass of a substance contained within an arbitrary volume to the mass of dry air of reference
9285 composition that would be contained in the same volume at the same reference conditions

9286 **1346. relative humidity (RH)**

9287 ratio of water liquid vapour present in a gaseous fluid relative to the maximum (or saturated) amount
9288 of water liquid vapour possible for that given gaseous fluid to hold at a given thermodynamic condition

9289

9290 [Source: ISO/TR 12748:2015 2.48]

9291

9292 Note 1 to entry: RH is the relative water vapour pressure.

9293 Note 2 to entry: The thermodynamic condition includes temperature and pressure.

9294 Note 3 to entry: The unit of relative humidity is percentage.

9295 **1347. response**

9296 output signal of a measuring system

9297

9298 [Source: ISO 7504:2015 8.3.2]

9299 **1348. room temperature (RT)**

9300 temperature in the range of 18 °C to 25 °C

9301

9302 Note 1 to entry: Local or national regulations can have different definitions.

9303

9304 [Source: ISO 20184-1:2018 3.19]

9305

9306 Note 2 to entry: The coherent SI unit of room temperature is degree Celsius, °C.

9307 **1349. saturation vapour pressure**

9308 partial pressure of water vapour which is in neutral equilibrium with a plane surface of pure condensed
9309 phase water or ice at a given temperature

9310

9311 [Source: ISO 3857-4:2012 2.64]

9312

9313 Note to entry: The coherent SI unit of saturation vapour pressure is pascal, Pa.

9314 **1350. sensible heat**

9315 thermal energy that is used for the increase in temperature of substance when heat is added to the
9316 substance

9317

9318 [Source: ISO 13574:2015 2.172]

9319

9320 Note to entry: The coherent SI unit of sensible heat is joule, J.

9321 **1351. set pressure**

9322 pressure to which a pressure control component is adjusted

9323

9324 [Source: ISO 5598:2019 3.2.679]

9325

9326 Note to entry: The coherent SI unit of set pressure is pascal, Pa.

9327 **1352. specific energy consumption**

9328 quotient describing the total energy consumption per unit of output or service

9329

9330 [Source: ISO/IEC 13273-1:2015 3.1.15]

9331 **1353. specific mass**

9332 ratio of mass to volume

9333

9334 [Source: ISO 7348:1992 05.03.27]

9335

9336 Note to entry: The coherent SI unit of specific mass is kilogram per cubic meter, kg m⁻³.

9337 **1354. specific surface area**

9338 electrochemical surface area per unit mass (or volume, or geometric electrode area) of the catalyst

9339

9340 Note 1 to entry: The specific surface area corresponds to the area of an electro-catalyst accessible
9341 to reactants due to its open porous structure, per unit mass (or volume, or geometric electrode area) of
9342 the catalyst

9343

9344 [Source: JRC EUR 29300 EN report 3.1.6]

9345

9346 Note 2 to entry: The coherent SI unit of specific surface area is square meter per kilogram of catalyst
9347 mass used for the electrode, $\text{m}^2 \text{kg}^{-1}$ (gravimetric), square meter per cubic meter of electrode volume
9348 which the catalyst occupies, $\text{m}^2 \text{m}^{-3}$ (volumetric), or square meter per area of electrode area where the
9349 catalyst is dispersed in, $\text{m}^2 \text{m}^{-2}$ (areal).

9350 **1355. standard electrode potential**

9351 equilibrium potential with all reactants at a unit activity ($a = 1$) and in the standard conditions

9352

9353 [Source: ISO 8044:2020 7.1.37]

9354

9355 Note to entry: The coherent SI unit of standard electrode potential is volt, V.

9356 **1356. step response time**

9357 duration between the instant when an input quantity value of a measuring instrument or measuring
9358 system is subjected to an abrupt change between two specified constant quantity values and the instant
9359 when a corresponding indication settles within specified limits around its final steady value

9360

9361 Note to entry: Here "quantity value(s)" can be replaced by "value(s)" in both instances without am-
9362 biguity: "duration between the instant when an input value of a measuring instrument or measuring
9363 system is subjected to an abrupt change between two specified constant values and the instant when a
9364 corresponding indication settles within specified limits around its final steady value".

9365

9366 [Source: BIPM JCGM VIM 4.23]

9367

9368 Note to entry: The coherent SI unit of step response time is second, s.

9369 **1357. Stern potential**

9370 electric potential on the external boundary of the layer of specifically adsorbed ions

9371

9372 [Source: ISO 13099-3:2014 3.1.7]

9373

9374 Note to entry: The coherent SI unit of Stern potential is volt, V.

9375 **1358. surface charge density**

9376 electric charge on a surface divided by the surface area

9377

9378 [Source: IUPAC Gold Book S06159]

9379

9380 Note to entry: The coherent SI unit of surface charge density is coulomb per square meter, C m^{-2} .

9381 **1359. thermal conductivity**

9382 density of heat flow rate divided by the temperature gradient

9383

9384 [Source: ISO/TS 19807-1:2019 3.43]

9385

9386 Note 1 to entry: In a medium with a temperature field, thermal conductivity characterises the abil-
9387 ity of the medium to transmit heat through a surface element at a fixed point. In an anisotropic
9388 medium, thermal conductivity is not a scalar quantity but a tensor quantity.

9389 Note 2 to entry: The coherent SI unit of thermal conductivity is watt per meter kelvin, $\text{W m}^{-1} \text{K}^{-1}$.

9390 **1360. thermal diffusivity**

9391 thermal conductivity divided by the product of density and specific heat capacity

9392

9393 [Source: ISO 13943:2017 3.388]

9394

9395 Note 1 to entry: The product of mass density and specific heat capacity at constant pressure can
9396 be considered the volumetric heat capacity. In an anisotropic medium, thermal diffusivity is not a scalar
9397 quantity but a tensor quantity.

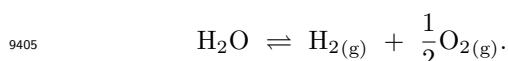
9398 Note 2 to entry: The coherent SI unit of thermal diffusivity is square meter per second, $\text{m}^2 \text{s}^{-1}$.

9399 **1361. thermoneutral cell voltage**

9400 drop in voltage across an electrochemical cell which is sufficient not only to drive the cell reaction, but
9401 to also provide the heat necessary to sustain a constant temperature

9402

9403 Note 1 to entry: Thermoneutral cell voltage is about 1.481 V at standard ambient temperature and
9404 pressure for the electrochemical water splitting reaction,



9406 Note 2 to entry: The coherent SI unit of thermoneutral cell voltage is volt, V.

9407 **1362. total pressure**

9408 sum of static pressure, dynamic pressure, and pressure corresponding to elevation

9409

9410 Note 1 to entry: Pressure corresponding to elevation can normally be neglected for pneumatics. In
9411 this case, the total pressure is equal to the stagnation pressure.

9412

9413 [Source: ISO 5598:2019 3.2.770]

9414

9415 Note 2 to entry: Total pressure is a function of temperature.

9416 Note 3 to entry: The coherent SI unit of total pressure is pascal, Pa.

9417 **1363. vapour pressure**

9418 pressure exerted when a solid or liquid is in equilibrium with its own vapour

9419

9420 Note 1 to entry: It is a function of the substance and of the temperature of the substance.

9421

9422 [Source: IEC 426-02-37]

9423

9424 Note 2 to entry: The coherent SI unit of vapour pressure is pascal, Pa.

9425 **1364. viscosity**

9426 resistance of a fluid to a change in shape, or to the movement of neighbouring portions relative to one
9427 another

9428

9429 [Source: ISO/IEC TR 5598:2019 3.17]

9430 **1365. volume concentration**

9431 quotient of the volume (under specified conditions of pressure and temperature) of each component to
9432 the volume of the gas mixture under specified conditions of pressure and temperature

9433

9434 [Source: ISO 14532:2014 2.5.2.1.2]

9435 **1366. volume flow rate**

9436 flow rate in which the quantity of fluid is expressed as volume

9437

9438 [Source: ISO 10790:2015 3.1.17]

9439

9440 Note 1 to entry: It is necessary to state the pressure and temperature at which the volume is ref-
9441 erenced.

9442 Note 2 to entry: The coherent SI unit of volume flow rate is cubic metre per second, $\text{m}^3 \text{s}^{-1}$.

9443 **1367. volume fraction**

9444 quotient of the volume (under specified conditions of pressure and temperature) of a component A to
9445 the sum of the sum of the volumes (intended prior to mixing under specified conditions of pressure and
9446 temperature) of all component of the gas mixture

9447

9448 [Source: ISO 14532:2014 2.5.2.1.1]

9449 **1368. volume specific surface area**

9450 absolute surface area of the sample divided by sample volume

9451

9452 [Source: ISO/TS 80004-6:2013 3.6.2]

9453

9454 Note to entry: The coherent SI unit of volume specific surface area is per meter, m^{-1} .

9455 **1369. water content**

9456 mass concentration of the total amount of water contained in a gas

9457

9458 [Source: ISO 14532:2014 2.6.5.1.2]

9459 **1370. water dew point**

9460 temperature at a specified pressure at which water vapour condensation initiates

9461

9462 [Source: ISO 14532:2014 2.6.5.1.1]

9463

9464 Note to entry: The coherent SI unit of water dew point is degree Celsius, $^{\circ}C$.

9465 **1371. working pressure**

9466 maximum pressure to which a component is designed to be subjected to and which is the basis for
9467 determining the strength of the component under consideration

9468

9469 [Source: ISO 20766-1:2018 3.3.12]

9470

9471 Note 1 to entry: Working pressure is a function of temperature.

9472 Note 2 to entry: The coherent SI unit of working pressure is pascal, Pa.

9473 **1372. zeta potential**

9474 difference in electric potential between that at the slipping plane and that of the bulk liquid

9475

9476 Note 1 to entry: Slipping plane is the abstract plane in the vicinity of the liquid/solid interface where
9477 liquid starts to slide relative to the surface under influence of a shear stress.

9478

9479 [Source: ISO/TS 19807-1:2019 3.44]

9480

9481 Note 2 to entry: The coherent SI unit of zeta potential is volt, V.

9482

9483 **2.5 Terms in electrolysis applications**

9484 **1373. ancillary service**

9485 services necessary for the operation of an electric power system provided by the system operator and/or
9486 by power system users

9487

9488 [Source: ISO 15118-1:2019 3.1.2]

9489 **1374. annual average**

9490 mean value of a set of measured data of sufficient size and duration to serve as an estimate of the
9491 expected value of the quantity

9492

9493 Note to entry: The averaging time interval shall be an integer number of years to average out non-
9494 stationary effects such as seasonality.

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[Source: IEV 415-03-07]

1375. available capacity of a power station

maximum power at which a power station can be operated continuously under the prevailing conditions

Note 1 to entry: This power may be gross or net.

[Source: IEV 602-03-12]

Note 2 to entry: The coherent SI unit of available capacity of a power station is watt, W.

1376. balance regulation

regulation actions taken in order to maintain the frequency and time deviation of the electricity grid in accordance with the established quality requirements

Note to entry: Regulation is also carried out for network reasons.

[Source: JRC EUR 29300 EN report 3.12.1]

1377. carbon dioxide equivalent

unit for comparing the radiative forcing of a greenhouse gas to that of carbon dioxide

Note to entry: Mass of a greenhouse gas is converted into CO₂ equivalents using global warming potentials.

[Source: ISO 13065:2015 3.6]

1378. cold reserve

total available capacity of generating sets in reserve for which the starting up may take several hours

[Source: IEV 602-03-17]

1379. compressed air power station

power station equipped with gas turbines using stored compressed air

[Source: IEV 602-01-26]

1380. compressed natural gas (CNG)

natural gas that has been compressed after processing for storage and transportation purposes

[Source: ISO 14532:2014 2.1.1.11]

1381. concentrated solar energy

solar radiation which is concentrated and converted into the form of thermal energy or electric energy by means of concentrating solar thermal systems

1382. concentrated solar power (CSP)

concentrated solar energy harnessed by using mirrors or lenses to concentrate (focus) a large area of sunlight onto a receiver and convert it into HT heat used to create steam to drive a turbine that generates electric power

1383. control reserve

energy stock to be used to control the frequency of the power supply network in case of unpredictable variations in energy injection and withdrawal

Note to entry: The reserve can be either positive, in order to balance deficits of the network, or negative, in case of surplus balance.

[Source: JRC EUR 29300 EN report 3.12.4]

9546 **1384. demand factor**

9547 ratio, expressed as a numerical value or as a percentage, of the maximum demand of an installation
9548 or a group of installations within a specified period, to the corresponding total installed load of the
9549 installation(s)

9550

9551 Note to entry: In using this term, it is necessary to specify to which level of the system it relates.

9552

9553 [Source: IEV 691-10-05]

9554 **1385. demand side management (DSM)**

9555 process that is intended to influence the quantity or patterns of use of electric energy consumed by
9556 end-use customers

9557

9558 [Source: IEV 617-04-15]

9559 **1386. distributed energy resource (DER)**

9560 distributed set of one or more energy service resources, including generators, energy storage and con-
9561 trollable load, that can be used to deliver ancillary services

9562

9563 [Source: ISO 15118-1:2019 3.1.20]

9564

9565 Note to entry: DER may be connected to the local electrical power grid at or near the end user or
9566 isolated from the grid in standalone applications, such as part of a micro grid.

9567 **1387. distribution system**

9568 conveying means, such as ducts, pipes and wires, to bring substances or energy from a source to the
9569 point of use

9570

9571 Note to entry: The distribution system includes auxiliary equipment, such as fans, pumps and trans-
9572 formers.

9573

9574 [Source: ISO 16818:2008 3.67]

9575 **1388. distribution system operator (DSO)**

9576 party operating a distribution system

9577

9578 [Source: IEV 617-02-10]

9579 **1389. distribution system operator - gas (DSO-G)**

9580 legally independent entity responsible for operating, ensuring maintenance of and, if necessary, develop-
9581 ing the distribution system in a given area and, where applicable, its interconnections with other systems
9582 and for ensuring the long-term ability of the distribution system to meet reasonable demands for the
9583 distribution of gas

9584

9585 Note to entry: The distribution of gas means the transport of natural gas or mixtures thereof through
9586 local and regional pipeline networks with a view to gas delivery to customers, but not including supply.
9587 Legal independence in terms of organisation and decision making does not exclude vertical integration
9588 into an undertaking.

9589 **1390. electric energy meter (EEM)**

9590 equipment for measuring electrical energy by integrating power with respect to time

9591

9592 [Source: ISO 15118-1:2019 3.1.28]

9593 **1391. electricity provider**

9594 entity whose activity is the wholesale purchase of electricity and the subsequent direct resale to a client
9595 through a contract

9596

9597 Note 1 to entry: The provider may also deliver energy related services.

9598 Note 2 to entry: Provider can generate flexibilities through modulation of electricity prices (Time-of-
9599 Use, Critical Peak Prices, ...), flexibilities which can have value on energy markets and/or for network

9600 operations.

9601 [Source: ISO 15118-1:2019 3.1.29]

9602

9603 **1392. electromagnetic interference (EMI)**

9604 electromagnetic energy from sources internal or external to electrical or electronic equipment that adversely affect equipment by creating undesirable responses

9605

9606 [Source: ISO/IEC 14776-121:2010 3.1.38]

9607

9608

9609 Note 1 to entry: The terms "electromagnetic disturbance" and "electromagnetic interference" designate respectively the cause and the effect, and should not be used indiscriminately.

9610

9611 Note 2 to entry: EMI is caused by electrical fields due to capacitive coupling, magnetic fields due to mutual inductance, or electromagnetic fields (radio waves).

9612

9613 **1393. emission**

9614 direct or indirect release from a product or process into the environment

9615

9616 [Source: IEC 60050-111:2003 4.111]

9617 **1394. energy carrier**

9618 substance or medium that can transport energy

9619

9620 [Source: ISO/IEC 13273-1:2015 3.1.2]

9621 **1395. energy intensity**

9622 quotient describing the total energy consumption per unit of economic output

9623

9624 [Source: ISO/IEC 13273-1:2015 3.1.14]

9625 **1396. energy management system (EMS)**

9626 system that controls the electric power transfer among the DER, premises appliances and the grid

9627

9628 [Source: ISO 15118-1:2019 3.1.36]

9629 **1397. energy performance**

9630 measurable results related to energy efficiency, energy use and energy consumption

9631

9632 [Source: ISO/IEC 13273-1:2015 3.3.1]

9633 **1398. energy performance indicator**

9634 quantitative value or measure of energy performance

9635

9636 Note to entry: Energy performance indicators could be expressed as a simple metric, ratio or a more complex model.

9637

9638

9639 [Source: ISO/IEC 13273-1:2015 3.3.6]

9640 **1399. energy service**

9641 physical benefit, utility or good derived from a combination of energy with energy efficient technology or with action, which may include the operations, maintenance and control necessary to deliver the service, which is delivered on the basis of a contract and in normal circumstances has proven to result in verifiable and measurable or estimable energy efficiency improvement or primary energy savings

9642

9643

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9645

9646 [Source: IATE 2210211]

9647 **1400. energy source**

9648 source from which useful energy can be extracted or recovered either directly or by means of a conversion or transformation process

9649

9650

9651 [Source: ISO 6707-3:2017 3.5.3]

- 9652 **1401. energy storage facility**
9653 facility where energy storage occurs
- 9654 **1402. energy system**
9655 set of production, transformation, transport and distribution processes of energy sources
9656
9657 [Source: IATE 3571686]
- 9658 **1403. facility**
9659 plant, machinery, property, buildings, transportation units, sea/land/air ports and other items of infra-
9660 structure or plant and related systems that have a distinct and quantifiable business function or service
9661
9662 [Source: ISO 22300:2018 3.90]
- 9663 **1404. feed-in tariff**
9664 price per unit of energy (electricity or heat) that an energy supplier (utility) has to pay for feeding of
9665 that energy to the grid (electricity or heat supply system) by an energy provider (non-utility)
- 9666 **1405. forced outage rate (FOR)**
9667 ratio of failure hours of a power generating unit due to unintended shutdown (unexpected breakdown)
9668 to its total service hours
- 9669 **1406. fuel**
9670 chemical substance used to generate energy (heat and/or power) and products (e.g. CO₂, steam)
9671 through conversion such as combustion or electrochemical processes
- 9672 **1407. fuel gas**
9673 fuel that is in gaseous state at the operating temperature and pressure
- 9674 **1408. gas distribution network**
9675 system of gas mains that provides for the local distribution of gaseous fuel; system of piping which
9676 carries gas from the transmission system and to which customers's service pipes are connected
9677
9678 [Source: IATE 1407734]
- 9679 **1409. gas distribution system**
9680 system of gas mains that provides for the local distribution of gaseous fuel; system of piping which
9681 carries gas from the transmission system and to which customers's service pipes are connected
9682
9683 [Source: IATE 1407734]
- 9684 **1410. gas system**
9685 set of infrastructure items, which can be used to transport, consume, or store gas
- 9686 **1411. gas transmission system**
9687 interconnected group of high pressure gas pipes and associated equipment for transferring gas in bulk
9688 between points of supply and points at which it is delivered over the gas distribution system to end
9689 users, and supervision
- 9690 **1412. geothermal energy**
9691 renewable energy harnessed from within the earth's crust, in the form of thermal energy
9692
9693 Note to entry: Jurisdictions may require that different conditions be met for geothermal energy to
9694 be considered as renewable.
9695
9696 [Source: ISO/IEC 13273-2:2015 3.3.6.1]
- 9697 **1413. geothermal power station**
9698 thermal power station in which thermal energy is extracted from suitable parts of the Earth's crust
9699
9700 [Source: IEC 602-01-28]

- 9701 **1414. green energy tariff**
9702 charge for the supply of energy that comes directly from renewable sources or sources that make a
9703 contribution to environmental schemes
9704
9705 [Source: ISO 6707-3:2017 3.6.30]
- 9706 **1415. grid parity**
9707 situation where an alternative energy source generates power at a levelised cost of electricity that is less
9708 than or equal to the price of power from the electricity grid
- 9709 **1416. hydro energy**
9710 renewable energy harnessed by the conversion of kinetic energy gained from naturally flowing or falling
9711 water
9712
9713 Note to entry: Hydro energy is made available in the form of electrical or mechanical energy.
9714
9715 [Source: ISO/IEC 13273-2:2015 3.3.2.1]
- 9716 **1417. hydroelectric power station**
9717 power station in which the gravitational energy of water is converted into electricity
9718
9719 [Source: IEV 602-01-04]
- 9720 **1418. infrastructure**
9721 system of facilities, equipment and services needed for the operation of an organization
9722
9723 [Source: ISO 10795:2019 3.126]
- 9724 **1419. interconnected system**
9725 systems connected together by means of one or more interconnection links
9726
9727 Note to entry: This term is also used in the singular for a system whose elements are intercon-
9728 nected.
9729
9730 [Source: IEV 601-01-12]
- 9731 **1420. intermittent energy source**
9732 source of energy that is not continuously available due to factors outside direct control
9733
9734 Example: Sun, wind.
9735
9736 Note to entry: Imbalances between energy production and energy demand caused by intermittent energy
9737 sources can be managed by energy storage.
9738
9739 [Source: ISO/IEC 13273-2:2015 3.1.3]
- 9740 **1421. interoperability**
9741 ability of diverse systems and organizations to work together
9742
9743 [Source: ISO 22300:2018 3.128]
- 9744 **1422. liquefied gas**
9745 gas that has been turned into liquid state by cooling and/or compression
- 9746 **1423. liquefied natural gas (LNG)**
9747 natural gas that has been liquefied, after processing, for storage or transportation purposes
9748
9749 [Source: ISO 16924:2016 3.38]
9750
9751 Note to entry: This colourless and odourless cryogenic fluid can contain minor quantities of ethane,
9752 propane, butane, nitrogen, or other components normally found in natural gas. NG is produced by

9753 reducing the temperature of natural gas to about -162° at atmospheric pressure (depending on LNG
9754 composition).

9755 **1424. liquefied petroleum gas (LPG)**
9756 commercial butane or commercial propane or any mixtures there of in the liquid phase
9757
9758 [Source: ISO 13574:2015 2.99]
9759
9760 Note to entry: LPG can be composed of the following hydrocarbons: propane, propene (propylene),
9761 normal butane, isobutene, isobutylene, butane (butylene) and ethane.

9762 **1425. load curve**
9763 graphical representation of the observed or expected variation of load as a function of time
9764
9765 [Source: IEC 602-01-17]

9766 **1426. load factor**
9767 ratio, expressed as a numerical value or as a percentage, of the consumption within a specified period
9768 (year, month, day, etc.), to the consumption that would result from continuous use of the maximum or
9769 other specified demand occurring within the same period
9770
9771 Note 1 to entry: This term should not be used without specifying the demand and the period to
9772 which it relates.
9773 Note 2 to entry: The load factor for a given demand is also equal to the ratio of the utilisation time to
9774 the time in hours within the same period.
9775
9776 [Source: IEC 601-10-02]

9777 **1427. load frequency control (LFC)**
9778 regulation of the power output of electric generators within a prescribed area in response to changes in
9779 system frequency or tie-line loading
9780
9781 [Source: IATE 1447717]

9782 **1428. load frequency control area**
9783 part of a synchronous area or an entire synchronous area, physically demarcated by points of measure-
9784 ment at interconnectors to other load frequency control areas, operated by one or more transmission
9785 system operators fulfilling the obligations of load frequency control
9786
9787 [Source: IATE 3552736]

9788 **1429. loss of load expectation (LOLE)**
9789 expected period of time during which a system will fail to meet its load demand for a given period
9790
9791 Note to entry: The unit of LOLE is hours per year, h/y.

9792 **1430. loss of load probability (LOLP)**
9793 probability that a system will fail to satisfy its load demand under the specified operating conditions

9794 **1431. low carbon energy source**
9795 source of power which produces fewer greenhouse gases than traditional means of power generation
9796
9797 [Source: ISO 6707-3:2017 3.5.6]

9798 **1432. manufacturer**
9799 legally independent entity with responsibility for design and/or manufacture of a device, equipment or
9800 system, collectively termed product, with the intention of making the product available for use, under
9801 his name whether or not such a product is designed and/or manufactured by that entity itself or on his
9802 behalf by another entity
9803

9804 Note 1 to entry: Such an independent entity has ultimate legal responsibility for ensuring compli-
9805 ance with all applicable legal and regulatory requirements for the product in the country or jurisdiction
9806 where it is intended to be made available or sold, unless this responsibility is specifically imposed on
9807 another entity by a regulatory authority within that jurisdiction. Legal and regulatory requirements can
9808 include both pre-market requirements and post-market requirements such as adverse event reporting
9809 and notification of corrective actions. The design and/or manufacture can include specification devel-
9810 opment, production, fabrication, assembly, processing, packaging, repackaging, labelling, re-labelling,
9811 installation, collection or re-manufacturing of the product. Any entity who assembles or adapts a product
9812 that has already been supplied by another entity in accordance with the instructions for use is not the
9813 manufacturer, provided the assembly or adaptation does not change the intended use of the product.
9814 Any entity who changes the intended use of, or modifies, a product without acting on behalf of the
9815 original manufacturer and who makes it available for use under his own name, should be considered the
9816 manufacturer of the modified product.

9817 Note 2 to entry: An authorised representative, distributor or importer who only adds its own address
9818 and contact details to the product or its packaging, without covering or changing the existing labelling,
9819 is not considered a manufacturer of the product.

9820 Note 3 to entry: To the extent that an accessory is subject to regulatory requirements of a product,
9821 the person responsible for the design and/or manufacture of that accessory is considered to be the
9822 manufacturer of that accessory.

9823 **1433. methanol (MeOH)**

9824 light, volatile, flammable, poisonous, liquid alcohol (CH₃OH)

9825 [Source: ISO 14532:2014 2.5.2.3.10]
9826

9827 **1434. natural gas (NG)**

9828 mixture of gaseous hydrocarbons, primarily methane, naturally occurring in the earth and used principally
9829 as a fuel

9830 [Source: ISO 14404-3:2017 3.2.1]
9831

9832 Note to entry: Natural gas generally includes ethane, propane and higher hydrocarbons, and some
9833 non-combustible gases such as nitrogen and carbon dioxide as well as sulphur compounds.
9834

9835 **1435. network user**

9836 customer or a potential customer of a transmission system operator, and transmission system operators
9837 themselves in so far as it is necessary for them to carry out their functions in relation to the transport
9838 of natural gas through a network

9839 [Source: IATE 2243574]
9840

9841 **1436. ocean energy**

9842 energy, usually electrical energy, obtained by harnessing the energy in tides, waves and thermal gradients
9843 in the oceans

9844 [Source: ISO 6707-3:2017 3.5.16]
9845

9846 **1437. ocean or sea temperature gradient power station**

9847 thermal power station producing electricity by means of the difference between the temperatures at the
9848 surface of the ocean/sea and that at a lower depth

9849 [Source: IEV 602-01-32]
9850

9851 **1438. operating cycle**

9852 succession of operation from one position to another and back to the first position

9853 [Source: IEV 442-01-50]
9854

9855 **1439. original equipment manufacturer (OEM)**

9856 person or company having design responsibility for the equipment or for parts of it
9857

9858 Note 1 to entry: This may be the manufacturer of the equipment.

9859

9860 [Source: ISO 21789:2009 3.9]

9861

9862 Note 2 to entry: OEM may market parts made by another entity under its own brand.

9863 **1440. peak load**

9864 maximum value of load during a given period of time, e. g. a day, a month, a year

9865

9866 [Source: IEV 692-01-16]

9867 **1441. photovoltaic solar energy**

9868 solar energy converted into the form of electric energy by means of photovoltaic cells

9869

9870 [Source: ISO/IEC 13273-2:2015 3.3.4.2]

9871 **1442. piston pump**

9872 hydraulic pump in which fluid is displaced by one or more reciprocating pistons

9873

9874 [Source: ISO 5598:2019 3.2.535]

9875 **1443. power station**

9876 installation whose purpose is to generate electricity and which includes civil engineering works, energy
9877 conversion equipment and all the necessary ancillary equipment

9878

9879 [Source: IEV 601-03-01]

9880 [Source: IEV 602-01-01]

9881 **1444. pressurised enclosure**

9882 enclosure in which a protective gas is maintained at a pressure greater than that of the external atmo-
9883 sphere

9884

9885 [Source: IEV 426-09-02]

9886 **1445. primary control**

9887 reserve performing primary control by automatically changing the working points regulated by the fre-
9888 quency

9889

9890 Note to entry: This term is replaced by frequency containment reserve.

9891

9892 [Source: JRC EUR 29300 EN report 3.12.24.3]

9893 **1446. primary control reserve (PCR)**

9894 first and fastest control stock reserve to be used in the event of grid frequency disturbance

9895

9896 Note to entry: It is deployed automatically with a proportional regulation for the re-establishment
9897 of the network frequency balance between energy production and consumption as quickly as possible.
9898 The complete deployment time of primary control reserve depends on the country. It is usually around
9899 15-30 seconds.

9900

9901 [Source: JRC EUR 29300 EN report 3.12.24.2]

9902 **1447. primary market**

9903 market of the capacity traded directly by the transmission system operator

9904

9905 [Source: IATE 2243589]

9906 **1448. production capacity**

9907 highest sustainable output rate that can be achieved with the current product specification, production
9908 scheme and available resources

9909

9910 Note to entry: The production scheme is the mix of goods and product to be manufactured.

9911

9912 [Source: ISO 15531-1:2004 3.6.34]

9913 **1449. pump**

9914 mechanical device for moving liquids, including the inlet and outlet connections as well as, in general,
9915 its shaft ends

9916

9917 [Source: ISO 17769-2:2012 2.1.1]

9918 **1450. pumped storage power station**

9919 hydroelectric power station employing high level and low level reservoirs permitting repeated pumping
9920 and generating cycles to be carried out

9921

9922 [Source: IEC 602-01-10]

9923 **1451. rechargeable energy storage system (RESS)**

9924 energy storage system that stores chemical, electrical, electromagnetic, mechanical, and/or thermal
9925 energy and which is rechargeable

9926 **1452. renewable energy (RE)**

9927 energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal
9928 and ocean energy, hydropower, biomass, LFG, sewage treatment plant gas and biogases

9929

9930 [Source: ISO 52000-1:2017 3.4.11]

9931

9932 Note to entry: Criteria to categorise an energy as renewable can differ amongst jurisdictions, based
9933 on local environmental, societal or other reasons. Renewable energy is collected from naturally occur-
9934 ring resources which replenish by natural processes at a rate that equals or exceeds its rate of use.

9935 **1453. renewable energy source (RES)**

9936 energy source not depleted by extraction as it is naturally replenished at a rate faster than it is extracted

9937

9938 Note 1 to entry: Renewable energy source excludes recovered or wasted energy.

9939 Note 2 to entry: Organic fraction of municipal waste may be considered as a renewable energy source.

9940 Note 3 to entry: Whether the energy stored in a technical system is renewable or not depends upon the
9941 nature of the original energy source.

9942 Note 4 to entry: Criteria to categorise an energy source as renewable can differ amongst jurisdictions,
9943 based on local environmental or other reasons.

9944

9945 [Source: ISO/IEC 13273-2:2015 3.1.5]

9946 **1454. renewable resource**

9947 resource that is grown, naturally replenished or cleansed on a human time scale

9948

9949 Note 1 to entry: A renewable resource is capable of being exhausted but can last indefinitely with
9950 proper stewardship.

9951 Note 2 to entry: Activities that occur in the technosphere such as recycling are not considered natural
9952 replenishment or cleansing.

9953 Note 3 to entry: In this context, human time scale refers to the typical life time of a human rather than
9954 the time humans have been in existence.

9955

9956 [Source: ISO 6707-3:2017 3.5.1]

9957 **1455. secondary control**

9958 centralised automatic function to regulate the generation in a control area based on secondary control
9959 reserve (SCR)s in order to maintain its interchange power flow at the control program with all other
9960 control areas (and to correct the loss of capacity in a control area affected by a loss of production);
9961 and, at the same time (in the event of a major frequency deviation originating from the control area,
9962 particularly after the loss of a large generation unit), to restore the frequency in the event of a frequency
9963 deviation originating from the control area to its set value in order to free the capacity engaged by the

9964 primary control (and to restore the primary control reserves)
9965
9966 Note to entry: In order to fulfil these functions, secondary control operates by the network charac-
9967 teristic method. Secondary control is applied to selected generator sets in the power plants comprising
9968 this control loop. Secondary control operates for periods of several minutes and is therefore dissociated
9969 from primary control.
9970
9971 [Source: JRC EUR 29300 EN report 3.12.24.5]

9972 **1456. secondary control reserve (SCR)**
9973 stock which is deployed automatically in a selective manner in those control areas where network imbal-
9974 ance occurs for the re-establishment of the frequency setting of 50 Hz between energy production and
9975 consumption
9976
9977 Note to entry: It is started within 30 seconds of the imbalance and can last up to 15 minutes. This
9978 term is replaced by frequency restoration reserve (FRR).
9979
9980 [Source: JRC EUR 29300 EN report 3.12.24.4]

9981 **1457. secondary market**
9982 market of the capacity traded otherwise than on the primary market
9983
9984 [Source: IATE 2243569]

9985 **1458. solar energy**
9986 energy emitted by the sun in the form of electromagnetic energy
9987
9988 Note 1 to entry: Solar energy is primarily in the wavelength region from 0.3 μm to 3.0 μm .
9989 Note 2 to entry: Solar energy is generally understood to mean any energy made available by the capture
9990 and conversion of solar radiation.
9991
9992 [Source: ISO 9488:1999 3.14]

9993 **1459. solar farm**
9994 large-scale installation that is used to provide solar energy to generate electricity
9995
9996 Note to entry: Solar farms often cover large areas of land and therefore are usually developed in rural
9997 locations.
9998
9999 [Source: ISO 6707-3:2017 3.2.1]

10000 **1460. solar power station**
10001 power station producing electrical energy from solar radiation directly by photovoltaic effect, or indirectly
10002 by thermal transformation
10003
10004 [Source: IEV 602-01-29]

10005 **1461. storage capacity**
10006 amount of energy an energy storage device or system can store
10007
10008 [Source: IATE 1155301]

10009 **1462. storage system operator (SSO)**
10010 natural or legal person who carries out the function of storage and is responsible for operating a storage
10011 facility
10012
10013 [Source: IATE 927542]

10014 **1463. supply chain**
10015 linked set of resources and processes that begins with the sourcing of raw material and extends through
10016 transport and storage of products to the end user

10017

10018 [Source: ISO 13065:2015 3.47]

10019

10020 Note to entry: The supply chain may include raw material producers, vendors, manufacturing facilities,
10021 logistics providers, internal distribution centres, distributors, wholesalers and other entities committed
10022 to co-operation, local economic development, and close geographical and social relations between such
10023 producers, processors and consumers that lead to the provision of products to the end user.

10024 **1464. supply service**

10025 branch line from the distribution system to supply a consumer's installation

10026

10027 [Source: IEV 601-02-12]

10028 **1465. syngas**

10029 synthetic gas produced through gasification or co-electrolysis of carbon dioxide and steam (water vapour),
10030 which contains a suitable amount of hydrogen and carbon monoxide with a heating value

10031 **1466. system user**

10032 party supplying electric power and energy to, or being supplied with electric power and energy from, a
10033 transmission system or a distribution system

10034

10035 [Source: IEV 617-02-07]

10036 **1467. technical capacity**

10037 maximum firm capacity that the transmission system operator can offer to the network users, taking
10038 account of system integrity and the operational requirements of the transmission network

10039

10040 [Source: IATE 2243585]

10041 **1468. tertiary control**

10042 change in the set points of participating generations or loads, in order to guarantee the provision of
10043 secondary control reserve (SCR)s at the right time and distribute the secondary control power to the
10044 various generations in the best possible way

10045

10046 [Source: JRC EUR 29300 EN report 3.12.44]

10047 **1469. tertiary control reserve (TCR)**

10048 power which can be connected (automatically or manually) under tertiary control in order to provide
10049 an adequate secondary control reserve (SCR) is known as the tertiary control reserve (TCR) or minute
10050 reserve

10051

10052 Note to entry: This reserve must be used in such a way that it will contribute to the restoration
10053 of the secondary control range when required. The restoration of an adequate secondary control range
10054 may take, for example, up to 15 minutes, whereas tertiary control for the optimisation of the network and
10055 generating system will not necessarily be complete after this time. This term is replaced by replacement
10056 reserve.

10057

10058 [Source: JRC EUR 29300 EN report 3.12.24.6]

10059 **1470. tidal energy**

10060 useable energy from the kinetic energy of water flowing into and out of tidal areas

10061

10062 [Source: ISO 6707-3:2017 3.5.17]

10063

10064 Note to entry: Tidal energy is caused by the ebb and flow of the tides in any part of the sea or a
10065 river derived from gravitational forces of the Earth-Moon-Sun system.

10066 **1471. tidal power station**

10067 hydroelectric power station which uses the differences in water height due to the tides

10068

10069 [Source: IEV 602-01-08]

- 10070 **1472. transmission system**
- 10071 transmission grid for the transport of electrical energy using a high-voltage or ultra-high-voltage grid or
- 10072 a gas transmission network for the transport of natural gas using a high pressure pipeline network
- 10073
- 10074 [Source: ISO/IEC 27019:2017 3.17]
- 10075 **1473. transmission system operator (TSO)**
- 10076 party operating a transmission system
- 10077
- 10078 [Source: IEC 617-02-11]
- 10079 **1474. transmission system operator - gas (TSO-G)**
- 10080 natural or legal person who carries out the function of natural gas transmission and is responsible for
- 10081 operating, ensuring the maintenance of, and, if necessary, developing the natural gas transmission sys-
- 10082 tem in a given area and, where applicable, its interconnections with other systems, and for ensuring the
- 10083 long-term ability of the system to meet reasonable demands for the transport of natural gas
- 10084
- 10085 [Source: IATE 2250950]
- 10086 **1475. utility**
- 10087 organisation that provides a service that is consumed by the public and/or maintains the infrastructure
- 10088 for a public service
- 10089
- 10090 [Source: IATE 1691390]
- 10091 **1476. utility electrical energy storage system**
- 10092 electrical energy storage system as a component of a utility grid, utility EESS exclusively provides ser-
- 10093 vices to the utility grid
- 10094
- 10095 [Source: IEC 62933-1:2018 3.10]
- 10096 **1477. value chain**
- 10097 sequence of activities that a firm undertakes to create value, including the various steps of the supply
- 10098 chain but also additional activities, such as marketing, sales, and service
- 10099
- 10100 Note to entry: Products pass through all activities of the chain in order, and at each activity the
- 10101 product gains some value. The chain of activities gives the products more added value than the sum of
- 10102 added values of all activities. It is important not to mix the concept of the value chain with the costs
- 10103 occurring throughout the activities.
- 10104
- 10105 [Source: IATE 1220965]
- 10106 **1478. variable renewable energy (VRE)**
- 10107 renewable energy source that is non-dispatchable due to its variable nature, like wind power and solar
- 10108 power; energy source characterised by output that is dependent on the natural variability of the source
- 10109 rather than the requirements of consumers
- 10110
- 10111 [Source: IATE 3550008]
- 10112 **1479. water trap**
- 10113 component fitted to a system to collect moisture
- 10114
- 10115 [Source: ISO 5598:2019 3.2.810]
- 10116 **1480. wave energy**
- 10117 marine energy harnessed by exploiting the potential energy in the vertical displacement of water or the
- 10118 kinetic energy of the moving water, or both
- 10119
- 10120 [Source: ISO/IEC 13273-2:2015 3.3.3.4]

- 10121 **1481. wind energy**
- 10122 renewable energy (RE) harnessed by converting kinetic energy present in wind motion into mechanical
10123 energy
- 10124
- 10125 Note to entry: Mechanical energy derived from wind can be used for water pumping or other direct
10126 mechanical work, and for generating electricity.
- 10127
- 10128 [Source: ISO/IEC 13273-2:2015 3.3.5.1]
- 10129 **1482. wind farm**
- 10130 group of wind turbines in the same location used to produce energy
- 10131
- 10132 [Source: ISO 6707-3:2017 3.2.4]
- 10133 **1483. wind power station**
- 10134 power station in which wind energy is converted into electricity
- 10135
- 10136 [Source: IEC 602-01-30]
- 10137 **1484. wind turbine**
- 10138 device that converts kinetic energy from the wind into electricity
- 10139
- 10140 [Source: ISO 6707-3:2017 3.2.3]
- 10141 **1485. wind turbine generator system**
- 10142 system which converts the kinetic wind energy into electric energy
- 10143
- 10144 [Source: IEC 415-01-02]
- 10145 **1486. Wobbe index**
- 10146 calorific value of a gas, on a volumetric basis, at specified reference conditions, divided by the root
10147 square of its relative density, at the same specified metering reference conditions
- 10148
- 10149 Note 1 to entry: The Wobbe index is gross or net depending on whether the calorific value used is
10150 the gross or net calorific value.
- 10151
- 10152 [Source: ISO 13574:2015 2.206]
- 10153
- 10154 Note 2 to entry: Natural gas, which is mostly methane (CH₄) at the well and almost entirely methane
10155 after refining for public use, typically has an index of 1,300 or more. Most bills for gas involve a heat-
10156 value factor to correct for variations in quality; measured centrally to represent average quality fed into
10157 the distribution system, this is applied to the measured volume consumed by each customer to establish
10158 the energy charge. The factor could be the Wobbe index, but may be in common energy units or the
10159 ratio of current heat-energy content to the reference value used in setting the tariff.
- 10160 **2.5.1 Electrical terminus and related expressions**
- 10161 **1487. low-voltage grid**
- 10162 network of low-voltage cables for distributing power
- 10163
- 10164 [Source: IATE 1363254]
- 10165 **1488. AC/DC converter**
- 10166 electronic converter for rectification or inversion or both
- 10167
- 10168 [Source: IEC 551-12-02]
- 10169 **1489. AC/DC power conversion**
- 10170 electronic conversion from alternating current to direct current or vice versa
- 10171
- 10172 [Source: IEC 551-11-05]

- 10173 **1490. active distribution system**
10174 distribution system in which the distribution system operator controls power flows by means of the man-
10175 agement of dispatchable distributed energy resources
10176
10177 [Source: IEV 617-04-21]
- 10178 **1491. active power reserve**
10179 active power which is available for maintaining the frequency
10180
10181 [Source: IATE 3565176]
- 10182 **1492. area control error (ACE)**
10183 sum of the instantaneous difference between the actual and the set-point value of the measured total
10184 power value and control program including virtual tie-lines for the power interchange of a load frequency
10185 control area or a load frequency control block and the frequency bias given by the product of the K-factor
10186 of the load frequency control area or the load frequency control block and the frequency deviation
10187
10188 [Source: IATE 3552692]
- 10189 **1493. automatic frequency restoration reserve (aFRR)**
10190 frequency restoration reserve that can be activated by an automatic control device
10191
10192 [Source: IATE 3552513]
- 10193 **1494. bulk power system**
10194 system of synchronised power providers and consumers connected by transmission and distribution lines
10195 and operated by one or more control centres
10196
10197 [Source: IATE 3506528]
- 10198 **1495. capacity factor**
10199 ratio of actual electric energy output for a given period to the maximum possible electric energy output
10200 over that period
- 10201 **1496. connection point**
10202 interface at which the power-generating module, demand facility and distribution system are connected
10203 to a transmission system, offshore network and distribution system, including closed distribution sys-
10204 tems, as identified in the connection agreement between the relevant system operator and either the
10205 power-generating or demand facility owner
10206
10207 [Source: JRC EUR 29300 EN report 3.12.2]
- 10208 **1497. converter**
10209 device for rectifying alternating current into direct current or for inversion of direct current into altern-
10210 ating current
- 10211 **1498. DC power conversion**
10212 electronic conversion from direct current to direct current
10213
10214 [Source: IEV 551-11-09]
- 10215 **1499. demand response**
10216 action resulting from management of the electricity demand in response to supply conditions
10217
10218 [Source: IEV 617-04-16]
- 10219 **1500. direct power conversion**
10220 electronic conversion without a direct current or alternating current link
10221
10222 [Source: IEV 551-11-10]

10223 **1501. distribution of electricity**

10224 transfer of electricity to consumers within an area of consumption

10225

10226 [Source: IEV 692-01-10]

10227 **1502. distribution system operator - electricity (DSO-E)**

10228 natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, develop-
10229 ing the distribution system in a given area and, where applicable, its interconnections with other systems
10230 and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of
10231 electricity

10232

10233 Note 1 to entry: The distribution system operator shall maintain a secure, reliable and efficient electricity
10234 distribution system in its area with due regard for the environment. In any event, it must not discrim-
10235 inate between system users or classes of system users, particularly in favour of its related undertakings.
10236 The distribution system operator shall provide system users with the information they need for efficient
10237 access to the system.

10238

10239 [Source: IATE 927530]

10240

10241 Note 2 to entry: Electricity distribution is the final stage in the physical delivery of electricity to the
10242 delivery point.

10243 Note 3 to entry: A distribution system network carries electricity from the transmission grid and delivers
10244 it to consumers. Typically, the network would include medium-voltage power lines, electrical substations
10245 and low-voltage distribution wiring networks with associated equipment.

10246 **1503. electric line**

10247 arrangement of conductors, insulating materials and accessories for transferring electricity between two
10248 points of a system

10249

10250 [Source: IEV 601-03-03]

10251 **1504. electric power network**

10252 installations, substations, lines and cables provided for the transmission and distribution of electricity

10253

10254 Note to entry: The boundaries of the different parts of this network are defined by appropriate cri-
10255 teria, such as geographical situation, ownership, voltage, etc.

10256

10257 [Source: IEV 692-01-03]

10258 **1505. electric power system (EPS)**

10259 composite, comprised of one or more generating sources, and connecting transmission and distribution
10260 facilities, operated to supply electric energy

10261

10262 Note to entry: A specific electric power system includes all installations and plant, within defined
10263 bounds, provided for the purpose of generating, transmitting and distributing electric energy.

10264

10265 [Source: IEV 601-01-02]

10266 **1506. electrical distribution network**

10267 electrical network, including closed distribution networks, for the distribution of electrical power from
10268 and to third parties connected to it, to a transmission network or another distribution network

10269

10270 [Source: IATE 1407784]

10271 **1507. electricity distribution system**

10272 electrical network, including closed distribution networks, for the distribution of electrical power from
10273 and to third parties connected to it, to a transmission network or another distribution network

10274

10275 [Source: IATE 1407784]

- 10276 **1508. electricity generation**
- 10277 process whereby electrical energy is obtained from some other form of energy
- 10278
- 10279 [Source: ISO 50045:2019 3.11]
- 10280 **1509. electricity grid**
- 10281 public electricity network
- 10282
- 10283 [Source: ISO 52000-1:2017 3.4.8]
- 10284 **1510. electricity transmission system**
- 10285 interconnected group of electric transmission lines and associated equipment for moving or transferring
- 10286 electric energy in bulk between points of supply and points at which it is transformed for delivery over
- 10287 the distribution system lines to consumers, or is delivered to other electric systems
- 10288
- 10289 [Source: IATE 1407047]
- 10290 **1511. frequency containment reserve (FCR)**
- 10291 active power reserve available to contain system frequency after the occurrence of an imbalance
- 10292
- 10293 [Source: IATE 3552721]
- 10294 **1512. frequency control**
- 10295 capability of a power-generating module or high-voltage direct current system to adjust its active power
- 10296 output in response to a measured deviation of system frequency from a set point, in order to maintain
- 10297 stable system frequency
- 10298
- 10299 [Source: IATE 1406606]
- 10300 **1513. frequency controlled normal operation reserve**
- 10301 momentarily available active power for frequency regulation in the range of 49.9-50.1 Hz and which is
- 10302 activated automatically by the system frequency
- 10303
- 10304 [Source: JRC EUR 29300 EN report 3.12.14]
- 10305 **1514. frequency deviation**
- 10306 difference between the system frequency at a given instant and its nominal value
- 10307
- 10308 [Source: IEV 614-01-10]
- 10309 **1515. frequency restoration control error (FRCE)**
- 10310 control error for the frequency restoration process which is equal to the area control error of a load
- 10311 frequency control or is equal to the frequency deviation where the LFC area geographically corresponds
- 10312 to the synchronous area
- 10313
- 10314 [Source: IATE 3552724]
- 10315 **1516. frequency restoration process (FRP)**
- 10316 process that aims at restoring frequency to the nominal frequency and for synchronous area consisting
- 10317 of more than one load frequency control area power balance to the scheduled value
- 10318
- 10319 [Source: IATE 3561229]
- 10320 **1517. frequency restoration reserve (FRR)**
- 10321 active power reserves activated to restore system frequency to the nominal frequency and for synchron-
- 10322 ous area consisting of more than one FRR area power balance to the scheduled value
- 10323
- 10324 [Source: IATE 3552584]

- 10325 **1518. frequency stability**
- 10326 power quality component which is determined on the basis of the observed frequency deviations of an
10327 electric power system during a given time interval
- 10328
10329 [Source: IEV 614-01-11]
- 10330 **1519. grid driving power**
- 10331 average product over a complete cycle of the instantaneous values of the alternating components of the
10332 grid current and of the grid voltage
- 10333
10334 [Source: IATE 1663820]
- 10335 **1520. grid frequency control**
- 10336 capability of a power-generating module or high-voltage DC system to adjust its active power output
10337 in response to a measured deviation of system frequency from a set point, in order to maintain stable
10338 system frequency
- 10339
10340 [Source: JRC EUR 29300 EN report 3.12.13]
- 10341 **1521. grid input power**
- 10342 product of instantaneous components of the alternating grid input current and voltage averaged over a
10343 complete cycle
- 10344
10345 [Source: IEV 531-16-20]
10346 Note to entry: The coherent SI unit of grid input power is watt, W.
- 10347 **1522. grid stability**
- 10348 reliability and consistency in the balance of the system with electricity generation and consumption
10349 without unacceptable deviation from the grid frequency
- 10350 **1523. grid-connected**
- 10351 connected to an electric power system
- 10352
10353 [Source: IEC 62933-1:2018 3.4]
10354
10355 Note to entry: Sometimes the term "grid-tied" is used.
- 10356 **1524. ground**
- 10357 point along a conductive structure or cable which serves as an essentially zero potential reference for
10358 AC and/or DC voltages
- 10359
10360 [Source: ISO 1540:2006 3.22]
- 10361 **1525. harmonic component**
- 10362 component of the harmonic content expressed as the order and the rms value of the corresponding term
10363 of the Fourier series which describes the concerned signal as a periodic function
- 10364 **1526. harmonic content**
- 10365 quantity (e. g. voltage, current, power, immittance) subtracted from the fundamental component of its
10366 alternating pendant
- 10367 **1527. high-voltage (HV)**
- 10368 voltage whose nominal rms value is $36 \text{ kV} < U_n \leq 150 \text{ kV}$
- 10369
10370 Note to entry: Because of existing network structures, in some countries the boundary between MV
10371 and HV can be different.
- 10372
10373 [Source: ISO/IEC TS 22237-3:2018 3.1.9]

- 10374 **1528. imbalance**
- 10375 energy volume calculated for a balance responsible party and representing the difference between the
- 10376 allocated volume attributed to that balance responsible party and the final position of that balance
- 10377 responsible party, including any imbalance adjustment applied to that balance responsible party, within
- 10378 a given imbalance settlement period
- 10379
- 10380 [Source: IATE 3552592]
- 10381 **1529. imbalance netting (IN)**
- 10382 process agreed between transmission system operators of two or more load frequency control areas within
- 10383 one or more synchronous areas that allows for avoidance of simultaneous frequency restoration reserve
- 10384 activation in opposite directions by taking into account the respective frequency restoration control er-
- 10385 rors as well as activated frequency restoration reserve and correcting the input of the involved frequency
- 10386 restoration processs accordingly
- 10387
- 10388 [Source: IATE 3552595]
- 10389 **1530. indirect power conversion**
- 10390 electronic conversion with one or more direct current or alternating current link(s)
- 10391
- 10392 [Source: IATE 3552595]
- 10393 **1531. individual harmonic distortion**
- 10394 ratio of the rms value of a harmonic content to that of the fundamental component
- 10395 **1532. intermittent profile**
- 10396 mode of operation of the system when electrical power consumed or produced is variable over time
- 10397
- 10398 [Source: JRC EUR 29300 EN report 3.18.4.2]
- 10399 **1533. load curtailment**
- 10400 load reduction including disconnection, either automatically or manually (usually as requested by the
- 10401 power system operator)
- 10402
- 10403 [Source: IATE 3552595]
- 10404 **1534. load impedance**
- 10405 at a given measurement location, the quotient of phase voltage and phase current during power trans-
- 10406 mission assuming no power system fault exists
- 10407
- 10408 [Source: IATE 3552595]
- 10409 **1535. load shedding**
- 10410 process of deliberately disconnecting preselected loads from a power system in response to an abnormal
- 10411 condition in order to maintain the integrity of the remainder of the system
- 10412
- 10413 [Source: IATE 3552595]
- 10414 **1536. low-voltage (LV)**
- 10415 voltage whose nominal rms value is $U_n \leq 1 \text{ kV}$
- 10416
- 10417 [Source: IATE 3552595]
- 10418 **1537. mains power**
- 10419 power normally continuously available which is supplied from the electric power system or by independent
- 10420 electrical power generation
- 10421
- 10422 [Source: IATE 3552595]
- 10423 **1538. mains supply**
- 10424 AC or DC power transmission or distribution system which is external to the equipment or system, that
- 10425 supplies power to it

- 10426 **1539. maximum input current**
- 10427 maximum current (peak AC or DC) for the intrinsically safe connection facilities of the apparatus, that
 10428 can be taken from external circuits connected to the connection facilities of apparatus without invalid-
 10429 ating intrinsic safety
- 10430
- 10431 [Source: IEC 60079-10:2015 3.1.17]
- 10432 Note to entry: The coherent SI unit of maximum input current is ampere, A.
- 10433 **1540. maximum input voltage**
- 10434 maximum voltage (peak AC or DC) that can be applied to the connection facilities of apparatus without
 10435 invalidating intrinsic safety
- 10436
- 10437 [Source: IEC 60079-10:2015 3.1.19]
- 10438 Note to entry: The coherent SI unit of maximum input voltage is volt, V.
- 10439
- 10440 **1541. maximum output current**
- 10441 maximum current (peak AC or DC) in apparatus that can be taken from the connection facilities of the
 10442 intrinsically safe apparatus
- 10443
- 10444 [Source: IEC 60079-10:2015 3.1.22]
- 10445 Note to entry: The coherent SI unit of maximum output current is ampere, A.
- 10446 **1542. maximum output voltage**
- 10447 maximum voltage (peak AC or DC) that can appear at the intrinsically safe connection facilities of the
 10448 apparatus at any applied voltage up to the maximum voltage
- 10449
- 10450 [Source: IEC 60079-10:2015 3.1.24]
- 10451 Note to entry: The coherent SI unit of maximum output voltage is volt, V.
- 10452 **1543. medium-voltage (MV)**
- 10453 voltage whose nominal rms value is $1 \text{ kV} < U_n \leq 36 \text{ kV}$
- 10454
- 10455 Note to entry: Because of existing network structures, in some countries the boundary between MV
 10456 and HV can be different.
- 10457
- 10458 [Source: IEC 60076-3:2011 3.1.17]
- 10459 **1544. net electric energy output**
- 10460 usable electric energy output from the EES system using hydrogen, which is able to serve for the user's
 10461 purpose, excluding internal and external electric energy dissipation of the system
- 10462
- 10463 Note 1 to entry: The internal and external electric dissipation of the system is typically electric en-
 10464 ergy loss from the equipment operations and connections.
- 10465 Note 2 to entry: The net electric energy output is the difference between the electric energy outputs
 10466 and inputs at all PoCs.
- 10467
- 10468 [Source: IEC 62282-8-201:2020 3.1.11]
- 10469 **1545. net electric power**
- 10470 power output of the electrical energy storage system and available for external use Note 1 to entry: The
 10471 net electric power output is the difference between the electric power outputs and inputs at all PoCs.
- 10472
- 10473 [Source: IEC 62282-8-201:2020 3.1.12]
- 10474
- 10475 Note to entry: The coherent SI unit of net electric power is watt, W.
- 10476 **1546. neutral**
- 10477 designation of any conductor, terminal or any element connected to the neutral point of a polyphase
 10478 system

10479	
10480	[Source: IEV 602-01-10]
10481	1547. nodal voltage control
10482	short-duration application of an electrical energy storage system used for the stabilisation of the voltage
10483	at the primary PoC or neighbouring nodes through active or reactive power exchange
10484	
10485	Note to entry: Reactive power is generally used in HV and MV grids, active power in LV grids, de-
10486	pending of the resistance-to-reactance (R/X) ratio of the relevant lines.
10487	
10488	[Source: IEC 62933-1:2018 3.13.2]
10489	1548. overcurrent
10490	electric current exceeding the rated electric current
10491	
10492	Note 1 to entry: For conductors, the rated current is considered as equal to the current-carrying capacity.
10493	
10494	[Source: IEV 826-11-14]
10495	
10496	Note 2 to entry: The coherent SI unit of overcurrent is ampere, A.
10497	1549. overhead line
10498	electric line whose conductors are supported above ground, generally by means of insulators and appro-
10499	priate supports
10500	
10501	Note to entry: Certain overhead lines may also be constructed with insulated conductors.
10502	
10503	[Source: IEV 601-03-04]
10504	1550. overload capacity
10505	highest load which can be maintained during a short period of time
10506	
10507	[Source: IEV 602-03-10]
10508	1551. point of supply
10509	point in an electric power network designated as such and contractually fixed, at which electric energy
10510	is exchanged between contractual partners
10511	
10512	Note to entry: The point of supply may be different from the boundary between the electric power
10513	network and the user's own installation or from the metering point.
10514	
10515	[Source: IEV 614-01-02]
10516	1552. power electronics
10517	field of electronics which deals with the conversion or switching of electric power with or without control
10518	of that power
10519	
10520	[Source: IEV 551-11-01]
10521	1553. power inversion
10522	electronic conversion from direct current to alternating current
10523	
10524	[Source: IEV 551-11-07]
10525	1554. power plant
10526	plant that generates electricity
10527	
10528	[Source: ISO 14404-2:2013 2.10.2.6]

- 10529 **1555. power quality**
- 10530 characteristics of the electric current, voltage and frequency at a given point in an electric power system,
10531 evaluated against a set of reference technical parameters
- 10532
- 10533 Note to entry: These parameters might, in some cases, relate to the compatibility between electri-
10534 city supplied in an electric power system and the loads connected to that electric power system.
- 10535
- 10536 [Source: IEV 614-01-01]
10537 [Source: IEV 617-01-05]
- 10538 **1556. power rectification**
- 10539 electronic conversion from alternating current to direct current
- 10540
- 10541 [Source: IEV 551-11-06]
- 10542 **1557. power supply**
- 10543 provision of electric energy from a source
- 10544
- 10545 [Source: IEV 151-13-75]
- 10546 **1558. power system user**
- 10547 party supplying electric power and energy to, or being supplied with electric power and energy from, a
10548 transmission system or a distribution system
- 10549
- 10550 [Source: IEV 617-02-07]
- 10551 **1559. rated maximum supply current**
- 10552 maximum value of the supply current
- 10553
- 10554 [Source: IEV 851-12-13]
- 10555
- 10556 Note to entry: The coherent SI unit of rated maximum supply current is ampere, A.
- 10557 **1560. rated power**
- 10558 maximum continuous electric power which a device or system is designed for to provide or absorb power
10559 under normal operating conditions as specified by the manufacturer
- 10560
- 10561 Note to entry: The coherent SI unit of rated power is watt, W.
- 10562 **1561. rated voltage range**
- 10563 voltage range as declared by the manufacturer expressed by its lower and upper rated voltages
- 10564
- 10565 [Source: IEV 151-16-49]
- 10566 **1562. reactive power flow control**
- 10567 short-duration application of an electrical energy storage system used to compensate partially or totally
10568 the reactive power flow in a determined subsection of an electric power system
- 10569
- 10570 Example: Power factor adjustment of loads, normally obtained by capacitor banks, is a reactive power
10571 flow control.
- 10572
- 10573 [Source: IEC 62933-1:2018 3.13.4]
- 10574 **1563. reactive-power voltage control**
- 10575 voltage control by the adjustment of reactive power generation in a power system
- 10576
- 10577 [Source: IEV 603-04-27]
- 10578 **1564. replacement reserve (RR)**
- 10579 reserve used to restore/support the required level of frequency restoration reserve to be prepared for
10580 additional system imbalances

10581
10582 Note to entry: This category includes operating reserves with activation time from time to restore
10583 frequency up to hours.
10584
10585 [Source: IATE 3561236]

10586 **1565. ripple**
10587 set of unwanted periodic deviations with respect to the average value of the measured or supplied quant-
10588 ity, occurring at frequencies which can be related to that of the mains supply, or of some other definite
10589 source, such as a chopper
10590
10591 Note to entry: Ripple is determined under specified conditions and is a part of periodic and/or ran-
10592 dom deviation.
10593
10594 [Source: IEV 312-07-02]

10595 **1566. ripple content**
10596 quantity derived by removing the direct component from a pulsating quantity
10597
10598 [Source: IEV 161-02-25]

10599 **1567. ripple harmonics of a rectifier**
10600 sinusoidal component on the DC side whose frequencies are multiples of the fundamental frequency of
10601 the supply voltage (even multiples in the case of a symmetric rectifier)
10602
10603 [Source: IEV 811-28-32]

10604 **1568. ripple voltage**
10605 alternating voltage component of the voltage on the DC side of a converter
10606
10607 [Source: IEV 551-17-27]
10608
10609 Note to entry: The coherent SI unit of ripple voltage is volt, V.

10610 **1569. steady-state profile**
10611 mode of operation of the system when electrical power consumed or produced is constant over time
10612
10613 [Source: JRC EUR 29300 EN report 3.18.4.1]

10614 **1570. supply current**
10615 current at the supply terminals
10616
10617 [Source: IEV 845-27-120]
10618
10619 Note to entry: The coherent SI unit of supply current is ampere, A.

10620 **1571. supply terminal**
10621 terminal intended to connect an item to a circuit or device capable of supplying electric energy
10622
10623 Note to entry: A supply terminal can also be used to supply electrical control signals.
10624
10625 [Source: IEV 845-28-064]

10626 **1572. supply voltage**
10627 rms value or, if applicable, the DC value, of the voltage existing at a given instant at a point of supply,
10628 measured over a given time interval
10629
10630 Note 1 to entry: If a supply voltage is specified for instance in the supply contract, then it is called
10631 "declared supply voltage".
10632
10633 [Source: IEV 614-01-03]

10634
10635

Note 2 to entry: The coherent SI unit of supply voltage is volt, V.

10636
10637
10638

1573. synchronous area

area covered by synchronously interconnected transmission system operators

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Note to entry: The frequency averaged over a few seconds can be considered identical in any part of a synchronous area. With a common frequency, every generator participating in primary frequency control adjusts its generation output in response to frequency excursions in the synchronous area, regardless of the location of the power imbalances.

[Source: IEV 614-01-10]

10645
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10647
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10649

1574. terminal

conductive part of a device, electric circuit or electric network, provided for connecting that device, electric circuit or electric network to one or more external conductors

[Source: IEV 482-02-22]

10650
10651
10652
10653

1575. total harmonic distortion (THD)

ratio of the rms value of a waveform's harmonics to the rms value of its fundamental component

Note 1 to entry: The total harmonic distortion may be defined by the following equation:

10654
10655

$$\text{THD}_X(\%) = 100 \times \frac{\sqrt{\sum_{n=2}^n X_n^2}}{X_1}$$

10656
10657
10658
10659
10660
10661

where

X_1 is the fundamental value of current or voltage;

X_n is the n^{th} harmonic value of current or voltage.

[Source: ISO 1540:2006 3.43]

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10663
10664
10665

1576. transformation of electricity

transfer of electricity through a power transformer

[Source: IEV 692-01-08]

10666
10667
10668
10669

1577. transmission of electricity

transfer in bulk of electricity, from generating stations to areas of consumption

[Source: IEV 692-01-09]

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1578. transmission system operator - electricity (TSO-E)

natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the [electricity] transmission system in a given area and, where applicable, its interconnections with other systems and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity

[Source: IATE 2250949]

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10679
10680

1579. tripping

opening of a circuit-breaker by either manual or automatic control or by protective devices

[Source: IEV 448-11-31]

10681
10682
10683

1580. utility grid

part of an electric power network that is operated by a utility or grid operator within a defined area of responsibility

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10686

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10689

Note 1 to entry: Utility grid is normally used for electricity transfer from or to grid users or other grids. The grid users can be electricity producers or consumers. The area of responsibility is fixed by national legislation or regulation.

[Source: IEC 62933-1:2018 3.3]

10690 **1581. voltage control**

10691 adjustment of the network voltages to values within a given range

10692

10693

[Source: IEC 603-04-23]

10694 **1582. voltage stability**

10695 power quality component which is determined on the basis of the observed voltage deviations of an
10696 electric power system during a given time interval

10697

10698

[Source: IEC 614-01-09]

10699 **2.5.2 Devices, components and systems**

10700 **1583. absorbent dryer**

10701 dryer in which moisture is removed by the use of hygroscopic compounds

10702

10703

[Source: ISO 5598:2019 3.2.3]

10704 **1584. actuator**

10705 component that causes a valve to operate

10706

10707

[Source: ISO 16003:2008 3.1]

10708 **1585. automatic shut-off valve**

10709 valve designed to close automatically when the pressure drop across the valve, caused by increased flow,
10710 exceeds a predetermined amount

10711

10712

[Source: ISO 5598:2019 3.2.55]

10713 **1586. balance of plant (BoP)**

10714 arrangement of all supporting and auxiliary components and devices needed for fluid, thermal and
10715 electrical management of the system and its safe and reliable operation whether locally or remotely

10716 **1587. ball valve**

10717 valve that functions with a ported sphere in a housing

10718

10719

10720

10721

10722

Note 1 to entry: On-off flow control is achieved by rotation of the sphere 90°.

Note 2 to entry: Diverter ball valves are available for split-flow and other special applications.

[Source: ISO/TR 15916:2015 3.8]

10723 **1588. bidirectional converter**

10724 AC/DC converter that functions both as a rectifier and an inverter able to reverse the flow of power

10725 **1589. bill of material (BoM)**

10726 presentation of the constituents in a product structure with the possibility to adopt the level of decom-
10727 position to actual need

10728

10729

[Source: ISO 29845:2011 3.2.33]

10730 **1590. blowdown valve**

10731 valve or device that opens to depressurise a pressure vessel or the gas volume contained in an equipment

- 10732 **1591. boost pressure**
10733 pressure at which replenishing liquid is supplied, usually to closed-loop circuits or second-stage pumps
10734
10735 [Source: ISO 5598:2019 3.2.82]
- 10736 **1592. booster**
10737 machine connected in a circuit so that its voltage either adds to or subtracts from the voltage furnished
10738 by another source
10739
10740 [Source: IEV 411-34-02]
- 10741 **1593. buffer storage vessels**
10742 pressure vessels designed for the purpose of storing compressed hydrogen, which can be located between
10743 a hydrogen generator and a compressor for an even flow of gas to the compressor or between the com-
10744 pressor and dispensing system for accumulation of pressurized gas supply for vehicle fuelling
10745
10746 [Source: ISO 19880-1:2020 3.6]
- 10747 **1594. circuit-breaker**
10748 mechanical switching device capable of making, carrying and breaking currents under normal circuit con-
10749 ditions, and also making, carrying for a specified time and breaking currents under specified abnormal
10750 circuit conditions such as those of a short-circuit
10751
10752 [Source: ISO 16315:2016 3.9]
- 10753 **1595. cold standby state**
10754 standby state requiring warm up before a demand to operate can be met
10755
10756 Note 1 to entry: A cold standby state may apply to redundant or stand-alone items.
10757 Note 2 to entry: In this context "warm up" includes meeting any conditions required to operate as
10758 required (e. g. achieving the required temperature, speed, pressure).
10759
10760 [Source: IEV 192-02-11]
- 10761 **1596. cold start ramp time**
10762 time from cold standby state to the nominal value considered
- 10763 **1597. compressor**
10764 machine that increases the pressure of gas
10765
10766 [Source: ISO 16924:2016 3.14]
- 10767 **1598. conformity**
10768 fulfilment of specified requirements
10769
10770 [Source: ISO 16528-1:2007 2.4]
10771
10772 Note 1 to entry: Conformity is usually measured in terms of nonconformity and expressed as con-
10773 formity; e. g. the maximum deviation between an average curve and a specific curve. The average curve
10774 is determined after making two or more full-measuring-range calibrations in each direction. The value
10775 of conformity is referred to the output span unless otherwise stated.
10776 Note 2 to entry: As a performance specification, conformity may be expressed as independent conform-
10777 ity, terminal-based conformity, or zero-based conformity.
10778
10779 [Source: ISO 11631:1998 3.7]
- 10780 **1599. conformity assessment**
10781 demonstration that specified requirements relating to a product, process, system, person or body are
10782 fulfilled
10783

10784 Note 1 to entry: The subject field of conformity assessment includes activities such as testing, in-
10785 spection and certification, as well as the accreditation of conformity assessment bodies.
10786 Note 2 to entry: The expression "object of conformity assessment" or "object" is used to encompass
10787 any particular material, product, installation, process, system, person or body to which conformity as-
10788 sessment is applied. A service is covered by the definition of a product.
10789
10790 [Source: IEV 902-01-01]

10791 **1600. connector**
10792 matching parts (such as male and female parts) that can be put together to form a "connection" which
10793 permits the transfer of fluids, electric power, or control signals
10794
10795 [Source: ISO 19880-1:2020 3.12]

10796 **1601. design life**
10797 service life intended by the designer
10798
10799 [Source: ISO 15686-1:2011 3.3]

10800 **1602. design limits**
10801 maximum or minimum values used in a design
10802
10803 [Source: IEV 415-02-04]

10804 **1603. design safety factor**
10805 factor by which limit loads are multiplied in order to account for uncertainties and variations that cannot
10806 be analysed or accounted for explicitly in a rational manner
10807
10808 Note to entry: Design safety factor is sometimes referred to as design factor of safety, factor of safety
10809 or just safety factor.
10810
10811 [Source: ISO 10786:2011 3.15]

10812 **1604. direct inverter**
10813 inverter without a DC link
10814
10815 [Source: IEV 551-12-13]

10816 **1605. direct rectifier**
10817 rectifier without a DC or AC link
10818
10819 [Source: IEV 551-12-08]

10820 **1606. dryer**
10821 device that lowers absolute moisture content of a gas by reducing water vapour content by evaporation
10822 resulting in an exit relative humidity of the gas lower than 100 %

10823 **1607. electrical enclosure**
10824 enclosure providing protection against the foreseen dangers created by electricity
10825
10826 [Source: IEV 195-06-13]
10827 [Source: IEV 826-12-21]

10828 **1608. electrically protective enclosure**
10829 electrical enclosure surrounding internal parts of equipment to prevent access to hazardous-live-parts
10830 from any direction
10831
10832 [Source: IEV 826-12-22]

10833 **1609. electrolysis stack**

10834 assembly of more than one electrolysis cell, mostly in a filter press arrangement and connected electrically
10835 either in parallel (monopolar assembly), in full series (bipolar assembly) or in series with a central anode
10836 and hydraulically in parallel

10837

10838

Note to entry: An electrolysis stack consists of further components such as separators, cooling plates,

- membrane or diaphragm,
- electrodes (anode and cathode),
- porous transport layers or liquid distributors,
- bipolar plate (BPP) as a separator, and
- additional flow fields for an easier access to the electrodes.

10839

manifolds and a supporting structure. The typical components of an electrolysis stack are:

- cell frames and/or gaskets and seals,
- current distributor,
- end plates for mechanical connection,
- electrical terminals,
- remaining component of the electrolysis cell.

10840

10841

10842

[Source: JRC EUR 29300 EN report 2.4]

10843 **1610. emergency shutdown**

10844 control system actions, based on process parameters or manually activated, taken to stop the system
10845 and all its reactions immediately to avoid equipment damage and/or personnel hazards

10846

10847

[Source: JRC EUR 29300 EN report 3.17.6.1]

10848 **1611. enclosure**

10849

housing affording the type and degree of protection suitable for the intended application

10850

10851

[Source: IEV 151-13-08]

10852

[Source: IEV 195-02-35]

10853

[Source: IEV 826-12-20]

10854 **1612. energy consumption**

10855

power consumption over a certain time period

10856

10857

[Source: ISO/IEC 29192-1:2012 2.3]

10858

10859

Note 1 to entry: Power may be electric power, thermal power, or both.

10860

Note 2 to entry: The coherent SI unit of energy consumption is joule, J. It may also be expressed in kilowatt hours or megawatt hours, kWh or MWh.

10861

10862 **1613. energy cost**

10863

portion of the charge for electric service based upon the electric energy consumed or billed

10864

10865

[Source: ISO 17800:2017 3.2.21]

10866 **1614. energy demand**

10867

rate at which energy is delivered to or used by a system or part of a system at a given instant in time
10868 or averaged over any designated interval of time

10869

10870

[Source: ISO 17800:2017 3.2.7]

10871

10872

Note to entry: Energy may be electricity, heat, or both.

10873	1615. energy emission
10874	pollution emissions associated with generating a quantity of electric energy
10875	
10876	[Source: ISO 17800:2017 3.2.22]
10877	1616. energy savings
10878	reduction of energy consumption compared to an energy baseline
10879	
10880	Note to entry: Energy savings can be actual (realised) or expected (predicted).
10881	
10882	[Source: ISO 50045:2019 3.1]
10883	1617. filter
10884	device for the separation of solid, liquid or gaseous contaminants from a fluid stream
10885	
10886	[Source: ISO 3857-4:2012 2.39]
10887	1618. fitting
10888	part or design feature on a component used to join (i.e. connect) any pressure retaining components in the system
10889	
10890	
10891	[Source: ISO 19880-1:2020 3.24]
10892	1619. fuel cell power system (FCS)
10893	generator system that uses one or more fuel cell modules to generate electric power and heat
10894	
10895	[Source: IEV 485-09-01]
10896	
10897	Note to entry: FCSs typically contain the following subsystems: fuel cell stack, air processing system, fuel processing system, thermal management, water management, and their control system.
10898	
10899	1620. gas holder
10900	buffer tank installed between the electrolyser and the compressor
10901	1621. heat exchanger
10902	device built for efficient heat transfer from one medium to another
10903	
10904	[Source: ISO 6707-3:2017 3.3.10]
10905	
10906	Note to entry: Heat exchanger keep the two media separate.
10907	1622. heat input
10908	energy introduced into the entity in the form of heat or converted into heat within the entity
10909	
10910	[Source: IEV 841-21-15]
10911	1623. heat output
10912	energy released from an entity through its boundaries in the form of heat or heat converted within this entity in other forms of energy
10913	
10914	
10915	[Source: IEV 841-21-16]
10916	1624. hot idle ramp time
10917	time from hot standby state to the nominal value considered
10918	1625. hot standby state
10919	standby state providing for immediate operation upon demand
10920	
10921	Note 1 to entry: A hot standby state may apply to redundant or stand-alone items.
10922	Note 2 to entry: In some applications, an item in a hot standby state is considered to be operating.
10923	
10924	[Source: IEV 192-02-12]

- 10925 **1626. hydraulic fluids**
10926 fluids and their concentrates for hydraulic transmission and monitoring, with the exception of water
10927
10928 [Source: IEV 426-29-03]
- 10929 **1627. hydrogen production rate**
10930 amount of H₂ produced by an electrolysis cell/stack/system during a specified time interval at a rated
10931 power with a defined purity
10932
10933 [Source: JRC EUR 29300 EN report 3.14.1]
10934
10935 Note 1 to entry: The produced hydrogen has a defined purity.
10936 Note 2 to entry: The coherent SI unit of hydrogen production rate is kilogram per second, kg s⁻¹. It
10937 may also be expressed in kilogram per hour, kg h⁻¹, or metric ton per day, t d⁻¹.
- 10938 **1628. hydrogen purifier**
10939 equipment to remove undesired constituents from the hydrogen
10940
10941 Note to entry: Hydrogen purifiers can comprise purification vessels, dryers, filters and separators.
10942
10943 [Source: ISO 19880-1:2020 3.41]
- 10944 **1629. indirect inverter**
10945 inverter with a DC link
10946
10947 [Source: IEV 551-12-13]
- 10948 **1630. indirect rectifier**
10949 rectifier with a DC or AC link
10950
10951 [Source: IEV 551-12-09]
- 10952 **1631. integration**
10953 process of physically and functionally combining lower-level products (hardware or software) to obtain a
10954 particular functional configuration
10955
10956 [Source: ISO 10795:2019 3.129]
- 10957 **1632. interface**
10958 mechanical, thermal, electrical, or operational common boundary between two elements of a system
10959
10960 [Source: ISO 10795:2019 3.132]
- 10961 **1633. inverter**
10962 electric energy converter that changes direct electric current to single-phase or polyphase alternating
10963 currents
10964
10965 [Source: IEV 151-13-46]
10966
10967 Note to entry: In English, both spellings "invertor" and "inverter" are correct and are used.
- 10968 **1634. main contact**
10969 contact included in the main circuit of a switching device and intended to carry in the closed position
10970 the current of the main circuit
10971
10972 [Source: IEV 442-01-52]
- 10973 **1635. main shut-off valve**
10974 automatic valve designed to isolate an equipment from the rest of the plant or a high-pressure source

- 10975 **1636. manufacturing**
- 10976 processes and actions performed by an equipment supplier/manufacturer that are necessary to provide finished component(s), assembly(ies) and related documentation, that fulfill the requests of the user/purchaser and meet the standards of the supplier/manufacturer
- 10977
- 10978
- 10979
- 10980 Note to entry: Manufacturing begins when the supplier/manufacturer receives the order and is completed at the moment the component(s), assembly(ies) and related documentation are surrendered to a transportation provider.
- 10981
- 10982
- 10983
- 10984 [Source: ISO 28781:2010 3.31]
- 10985 **1637. mature technology**
- 10986 technology defined by a set of reproducible processes for the design, manufacture, test and operation of an element for meeting a set of performance requirements in the actual operational environment
- 10987
- 10988
- 10989 [Source: ISO 16290:2013 2.8]
- 10990 **1638. maximum overload capability**
- 10991 maximum power, expressed in percentage of nominal power, at which the electrolyser can operate for limited time periods in cases of operational peaks
- 10992
- 10993
- 10994 [Source: JRC EUR 29300 EN report 3.18.6.1]
- 10995
- 10996 Note to entry: The coherent SI unit of maximum overload capability is watt, W.
- 10997 **1639. minimum partial load operation**
- 10998 minimum partial load operation at which the system is designed to operate, as a percentage of rated nominal capacity, in terms of power input
- 10999
- 11000
- 11001 [Source: JRC EUR 29300 EN report 3.18.7]
- 11002 **1640. minimum system power**
- 11003 minimum power at which the system is designed to operate, as a percentage of nominal power (%)
- 11004
- 11005 [Source: JRC EUR 29300 EN report 3.18.8]
- 11006 **1641. non-return valve**
- 11007 valve that allows flow in one direction only
- 11008
- 11009 [Source: ISO 5598:2019 3.2.484]
- 11010 **1642. oil**
- 11011 mixture of hydrocarbons composed of six or more carbon atoms (C₆)
- 11012
- 11013 [Source: ISO 3857-4:2012 2.49]
- 11014 **1643. operating manual**
- 11015 publication issued by the manufacturer, which contains detailed data and instructions related to the design, installation, operation and maintenance of products
- 11016
- 11017 **1644. operating profile**
- 11018 description of the system power profile versus operating time
- 11019
- 11020 [Source: JRC EUR 29300 EN report 3.18.4.4]
- 11021 **1645. operating temperature**
- 11022 temperature at which the electrolyser (cell/stack/system) operates
- 11023
- 11024 [Source: JRC EUR 29300 EN report 3.18.5]
- 11025
- 11026 Note to entry: The coherent SI unit of operating temperature is kelvin, K.

11027 **1646. overload capability**

11028 ability of the electrolysis system to operate beyond the nominal operating and design point for a limited
11029 period of time, typically in the range of a few minutes to less than one hour

11030

11031 Note to entry: The overload capability is mainly used to provide greater flexibility in different grid-
11032 service applications (e. g. secondary control reserve (SCR)).

11033

11034 [Source: JRC EUR 29300 EN report 3.18.6]

11035 **1647. oxygen separator**

11036 equipment to separate oxygen from produced gas or water

11037 **1648. parasitic load**

11038 power consumed by auxiliary machines and equipment such as the balance of plant necessary for the
11039 operation of a fuel cell power system

11040

11041 Note to entry: Examples of auxiliary machines and equipment that consume power are blowers, pumps,
11042 heaters, and sensors. The parasitic load can strongly depend on the system power output and ambient
11043 conditions.

11044

11045 [Source: IEV 485-09-08]

11046 **1649. pipe**

11047 rigid or semi-rigid tube

11048

11049 [Source: ISO 472:2013 2.700]

11050 **1650. piping**

11051 any combination of connectors, couplings, tubes and/or hoses which allows fluid flow between compon-
11052 ents

11053

11054 [Source: ISO 5598:2019 3.2.531]

11055 **1651. piping and instrumentation diagram (PID)**

11056 process flow diagram representing the technical realisation of a process system by means of graphical
11057 symbols for equipment, connections and process measurement and control functions

11058

11059 [Source: ISO 29845:2011 3.2.27]

11060 **1652. plate**

11061 smooth, flat piece of material of uniform and limited thickness and area

11062

11063 [Source: ISO 472:2013 2.713]

11064 **1653. point of connection (PoC)**

11065 reference point on the electric power system where an electrical energy storage system is connected

11066

11067 Note 1 to entry: An electrical energy storage system can have several point of connections arranged in
11068 two different classes: primary PoC and auxiliary PoC. From an auxiliary PoC it is not possible to charge
11069 electrical energy, in order to store it internally and, finally, discharge it to the electric power system, but
11070 a primary point of connection can be used to feed the auxiliary subsystem and the control subsystem.
11071 In the absence of an auxiliary PoC, the primary PoC can be named simply as PoC.

11072

11073 [Source: IEC 62933-1:2018 4.3]

11074

11075 Note 2 to entry: More general, PoCs are connection points for utilities such as coolant/heat, elec-
11076 tricity, gas (hydrogen, oxygen, air, inert gas), and water.

11077 **1654. power demand from the system**

11078 power which has to be supplied to the system in order to meet the demand

11079

11080 [Source: IEV 602-03-13]

- 11081 **1655. power supply range**
- 11082 functional range of an electrolysis system between its minimum power operating value and 100 % (full-
- 11083 scale) rated power DC charge
- 11084
- 11085 [Source: JRC EUR 29300 EN report 3.8.10]
- 11086 **1656. pressure control valve**
- 11087 valve whose function is to control pressure
- 11088
- 11089 [Source: ISO 5598:2019 3.2.565]
- 11090 **1657. pressure gauge**
- 11091 device that measures and indicates gauge pressure
- 11092
- 11093 [Source: ISO 5598:2019 3.2.571]
- 11094 **1658. pressure regulator**
- 11095 valve in which, with varying inlet pressure or outlet flow rate, the regulated pressure remains substantially
- 11096 constant
- 11097
- 11098 Note to entry: The pressure regulator will only function correctly if the inlet pressure remains higher
- 11099 than the selected regulated pressure.
- 11100
- 11101 [Source: ISO 5598:2019 3.2.585]
- 11102 **1659. pressure relief device (PRD)**
- 11103 safety device that releases gases or liquids above a specified pressure value in cases of emergency or
- 11104 abnormal conditions
- 11105
- 11106 Note to entry: PRDs can be activated by pressure or another parameter, such as temperature, and
- 11107 can be either re-closing devices (such as valves) or non-re-closing devices (such as rupture disks and
- 11108 fusible plugs). Common designations for these specific types of PRDs are as follows:
- 11109 Pressure safety valve (PSV) - pressure activated valve that opens at specified set point to protect a
- 11110 system from rupture and re-closes when the pressure falls below the set point. PSVs protecting the
- 11111 dispensing system can re-close above the maximum operating pressure.
- 11112 Thermally-activated pressure relief device (TPRD) - PRD that opens at a specified temperature to pro-
- 11113 tect a system from rupture and remains open.
- 11114
- 11115 [Source: ISO 19880-1:2020 3.59]
- 11116
- 11117 **1660. pressure relief valve (PRV)**
- 11118 valve that limits pressure by exhausting or returning fluid to the reservoir when the set pressure is reached
- 11119
- 11120 [Source: ISO 5598:2019 3.2.586]
- 11121
- 11122 **1661. pressure safety valve (PSV)**
- 11123 pressure activated valve that opens at a specified set point to protect the system from burst and re-closes
- 11124 when the pressure falls below the set point
- 11125
- 11126 [Source: ISO 19880-3:2018 3.8.6]
- 11127 **1662. pressure swing adsorption (PSA)**
- 11128 method of separating gases using the physical adsorption of one gas at high pressure and releasing it at
- 11129 low pressure
- 11130
- 11131 [Source: ISO/TR 27912:2016 3.54]
- 11132
- 11133 **1663. pressure vessel**
- 11134 vessel capable of containing pressures significantly above ambient, even if normal operational procedure
- 11135 does not involve pressure rise above ambient

11130

11131 Note to entry: Pressure vessels are often referred to as vessels or tanks.

11132

11133 [Source: ISO 21843:2018 3.12]

11134 **1664. primary point of connection**

11135 point of connection where the electrical energy storage system charges electrical energy from the electric
11136 power system, in order to store it internally and, subsequently, discharges it to the electric power system

11137

11138 Note to entry: Generally, the primary point of connection is connected with the electrical energy storage
11139 system primary subsystem through the primary connection terminal.

11140

11141 [Source: IEC 62933-1:2018 4.4]

11142 **1665. process flow diagram**

11143 diagram illustrating the configuration of a process system or process plant by means of graphical symbols

11144

11145 [Source: ISO 29845:2011 3.2.28]

11146 **1666. production volume**

11147 amount (or number) of goods manufactured or produced by a producer in a given time

11148

11149 [Source: IATE 3573272]

11150 **1667. purifier**

11151 equipment to remove undesired constituents from the hydrogen

11152

11153 Note to entry: Hydrogen purifiers may comprise purification vessels, dryers, filters, and separators.

11154

11155 [Source: ISO 19880-8:2019 3.16]

11156 **1668. rated capacity**

11157 capacity value of a device or system assigned by the manufacturer for specified operating conditions

11158

11159 Note to entry: Nominal capacity is synonymous with rated capacity.

11160 **1669. rectifier**

11161 electric energy converter that changes single-phase or poly-phase alternating electric currents to uni-
11162 directional current

11163

11164 [Source: IEC 60878-1:2011 3.1.1]

11165 **1670. redundancy**

11166 existence of more than one means for performing a required function

11167

11168 [Source: IEC 60878-1:2011 3.1.1]

11169 **1671. reservoir**

11170 container for storing the liquid in a hydraulic system

11171

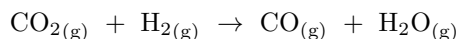
11172 [Source: ISO 5598:2019 3.2.635]

11173 **1672. reverse water gas shift (rWGS)**

11174 reverse of water gas shift

11175

11176



11177 **1673. safety integrity level (SIL)**

11178 discrete level for specifying the safety integrity requirements of the safety functions to be allocated to
11179 the programmable electronic safety-related system

11180

11181 Note 1 to entry: There are four SIL: safety integrity level 4 has the highest level of safety integrity
11182 and safety integrity level 1 has the lowest.
11183 Note 2 to entry: The SIL is indicative of a failure rate that includes all causes of failures (both random
11184 hardware failures and systematic failures), which lead to an unsafe state, for example hardware failures,
11185 software induced failures and failures due to electrical interference.
11186
11187 [Source: ISO 8102-6:2019 3.10]

11188 **1674. safety shutdown**
11189 process which is effected immediately following the response of a protection device or the detection of
11190 a fault in the control system and which puts the system out of operation by deactivating terminals for
11191 the gas shut-off valves and the ignition device
11192
11193 [Source: ISO 16110-1:2007 3.73]

11194 **1675. scrubber**
11195 device by which particulate or gaseous contaminants are removed from a gas stream by contact with or
11196 impingement on wetted surfaces, or by the use of liquid sprays
11197
11198 [Source: ISO 4225:1994 3.80]

11199 **1676. service life**
11200 period of time after installation during which a facility or its component parts continues to meet the
11201 performance requirements
11202
11203 [Source: ISO 6707-3:2017 3.7.43]

11204 **1677. shut-off valve**
11205 valve which prevents flow in both directions when closed
11206
11207 [Source: ISO 7396-2:2007 3.29]

11208 **1678. shutdown time**
11209 duration between the point at which the power supply is removed and the point at which shutdown is
11210 completed, as specified by the manufacturer
11211
11212 [Source: JRC EUR 29300 EN report 3.18.10]
11213
11214 Note to entry: The coherent SI unit of shutdown time is seconds. s.

11215 **1679. standby state**
11216 normally idle or idling piece of equipment that is capable of immediate automatic or manual start-up
11217 and continuous operation
11218
11219 [Source: ISO 10440-1:2007 3.53]

11220 **1680. steam generator**
11221 vessel designed to contain water and a heating system (e. g. a steam coil or a fully immersed electric
11222 element) which is used to heat water to its vapour state
11223
11224 [Source: ISO 15883-1:2006 3.51]

11225 **1681. system integrator**
11226 entity responsible for the design, installation and setup of a system
11227
11228 Note to entry: This entity may use one or more devices and equipments from others to built the
11229 system. It may also rely on services procured from others to operate or increase the functionality of the
11230 system.

11231	1682. technology
11232	application of scientific knowledge, tools, techniques, crafts, systems or methods of organisation in order
11233	to solve a problem or achieve an objective
11234	
11235	[Source: ISO 16290:2013 2.19]
11236	1683. transformer
11237	static piece of apparatus with two or more windings which, by electromagnetic induction, transforms a
11238	system of alternating voltage and current into another system of voltage and current usually of different
11239	values and at the same frequency for the purpose of transmitting electrical power
11240	
11241	[Source: IEC 421-01-01]
11242	1684. valve
11243	component that controls the direction, pressure or flow rate of fluid
11244	
11245	[Source: ISO 5598:2019 3.2.790]
11246	1685. warm standby state
11247	operating state of equipment powered and warmed up at a temperature that allows a fast restart of the
11248	system
11249	
11250	[Source: JRC EUR 29300 EN report 3.17.7.2]
11251	1686. water gas shift (WGS)
11252	chemical formation of carbon dioxide and hydrogen from carbon monoxide and water
11253	
11254	$\text{CO}_{(g)} + \text{H}_2\text{O}_{(g)} \rightarrow \text{CO}_{2(g)} + \text{H}_{2(g)}$
11255	1687. water recirculation system
11256	subsystem intended to provide treatment and purification of recovered or added water for use within the
11257	electrolyser unit
11258	
11259	[Source: JRC EUR 29300 EN report 3.27.3]
11260	1688. water separator
11261	device that condenses and separates water vapour from the gas discharged from the cell/system
11262	
11263	[Source: JRC EUR 29300 EN report 3.3.18]
11264	1689. water treatment system
11265	system providing for treatment and purification of recovered or added water for use within the hydrogen
11266	generator
11267	
11268	[Source: ISO 16110-1:2007 3.83]
11269	2.5.3 Energy conversion and storage technologies
11270	1690. capital cost
11271	money used to purchase, install and commission a capital asset
11272	
11273	[Source: ISO 22449-2:2020 3.1.1]
11274	
11275	Note to entry: Cost not accounted for shall be made explicit. Capital cost are part of Capital ex-
11276	penditure (CAPEX).
11277	1691. capital expenditure (CAPEX)
11278	expenditure on acquisitions of, or improvements to, assets
11279	
11280	Note 1 to entry: Based upon accounting standards and organisation policy, CAPEX usually relates

- 11281 to relatively large (material) expenditure, which has benefits that are expected to last for more than 12
11282 months.
- 11283
11284 [Source: ISO/TS 55010:2019 3.8]
- 11285
11286 Note 2 to entry: Expenditure not accounted for in CAPEX shall be made explicit.
- 11287 **1692. catalytic methanation**
- 11288 process for removing carbon monoxide from gas streams or for producing methane by the reaction
- 11289
$$\text{CO}_{(g)} + \text{H}_{2(g)} \rightarrow \text{CH}_{4(g)} + \text{H}_2\text{O}_{(g)}$$

11290
- 11291 [Source: IUPAC Gold Book C00898]
- 11292 **1693. cogeneration**
- 11293 energy conversion from the same source into two or more utilised forms of energy in one common con-
11294 trolled process
- 11295
11296 Note to entry: Combined heat and power is a specific implementation of cogeneration used for the
11297 simultaneous production of heat and electricity.
- 11298
11299 [Source: ISO/IEC 13273-1:2015 3.1.8]
- 11300 **1694. combined heat and power (CHP)**
- 11301 simultaneous generation in one process of thermal energy and electrical and/or mechanical energy
- 11302
11303 [Source: ISO 52000-1:2017 3.3.5]
- 11304 **1695. compressed air energy storage (CAES)**
- 11305 operation whereby air is compressed, cooled and stored in a natural reservoir
- 11306
11307 [Source: IEV 602-01-25]
- 11308 **1696. electrical energy storage (EES)**
- 11309 installation able to store electric energy or which converts electric energy into another form of energy
11310 and *vice versa*, while storing energy
- 11311
11312 Note to entry: EES can be used also to indicate the activity of an apparatus described in the definition
11313 during performing its own functionality.
- 11314
11315 [Source: IEC 62282-8-201 3.1.1]
- 11316 **1697. electrical energy storage system (EESS)**
- 11317 installation with defined electrical boundaries, comprising at least one EES, whose purpose is to extract
11318 electric energy from the electric power system, store this energy in some manner and inject electric
11319 energy into the electric power system and which includes civil engineering works, energy conversion
11320 equipment and related ancillary equipment
- 11321
11322 Note 1 to entry: The EES system is controlled and coordinated to provide services to the electric
11323 power system operators or to the electric power system users.
- 11324 Note 2 to entry: In some cases, an EES system can require an additional energy source during its
11325 discharge, providing more energy to the electric power system than the energy it stores.
- 11326
11327 [Source: IEC 62282-8-201:2020 3.1.2]
- 11328 **1698. electrical energy storage system (EESS) using hydrogen**
- 11329 EES system comprising at least one EES using hydrogen, whose purpose is to extract electric energy
11330 from the electric power system, store this energy as hydrogen and inject electric energy into the electric
11331 power system, using hydrogen as a fuel
- 11332
11333 [Source: IEC 62282-8-201:2020 3.1.3]

11334 **1699. energy conversion**

11335 transformation of one energy carrier to another energy carrier or work

11336

11337 Note to entry: The term "energy transformation" can be used in this sense.

11338

11339 [Source: ISO/IEC 13273-1:2015 3.1.7]

11340 **1700. energy return on energy invested (EROI)**

11341 ratio of the amount of usable energy storage (exergy) delivered from a particular energy storage resource
11342 to the amount of exergy used to obtain that energy storage resource

11343

11344 Note to entry: When the EROI of a source of energy is less than or equal to unity, that source of
11345 energy is a net "energy sink"; thus, it is no longer a source of energy.

11346 **1701. energy storage (ES)**

11347 action or method used to accumulate, retain and release energy for later use in an energy using system

11348

11349 Note 1 to entry: Energy storage is an important concept in term of renewable energy.

11350

11351 [Source: ISO/IEC 13273-1:2015 3.1.5]

11352

11353 Note 2 to entry: As energy occurs in various forms such as chemical, electric, gravitational (potential),
11354 thermal (latent heat), kinetic, magnetic, mechanical (motion, elastic), radiation, etc, energy storage,
11355 whether or not large scale, takes on different types, for example, compressed air energy storage (CAES),
11356 cryogenic energy storage (CES) (liquid air energy storage (LAES)), EES (lithium-ion batteries (LIBs),
11357 metal-air batteries, capacitors, RFBs), mechanical energy storage (MES) (flywheels), P2C (ammonia,
11358 ethanol (EtOH), methane, methanol (MeOH), etc), P2F, P2G (P2H2, P2SG), P2L (liquefied natural
11359 gas (LNG), biofuels), P2S (aluminium, silicon, boron, zinc), superconducting magnetic energy storage
11360 (SMES) and thermal energy storage (TES) (bricks, ice, molten salt storage (MSS), phase change ma-
11361 terials (PCMs), pumped heat electrical energy storage (PHES), steam/hot water).

11362

11363 Note 3 to entry: Energy storage is used as a means to balance demand and supply in public energy
11364 networks (electricity/gas grid, heating) given the intermittency primarily of RESs. This way it contrib-
11365 utes to grid frequency regulation (fR) (moment-to-moment reconciliation of supply and demand). It
11366 also contributes to security of supply (SoS) of energy. It may form part of a distributed energy source
11367 (DES).

11368 **1702. energy storage system (ESS)**

11369 system where energy storage occurs

11370 **1703. energy stored on return (ESOR)**

11371 ratio between the energy stored in an energy storage device divided by the energy required to get it over
11372 its lifetime

11373 **1704. energy stored on return (ESOR)**

11374 ratio of energy stored over the lifetime of an energy storage device to the amount of energy required to
11375 build the energy storage device

11376 **1705. fuel cell vehicle (FCV)**

11377 electrically propelled vehicle with a fuel cell power system as the power source for vehicle propulsion

11378

11379 Note 1 to entry: An FCV may also have a RESS or another power source for vehicle propulsion.

11380

11381 [Source: ISO 6469-2:2018 3.10]

11382

11383 Note 2 to entry: The general term FCV also includes vehicles with an additional other source of propul-
11384 sion power.

11385 **1706. fuelling station**

11386 facility for the dispensing of compressed hydrogen vehicle fuel, including the supply of hydrogen, and
11387 hydrogen compression, storage, and dispensing systems

11388	
11389	Note to entry: Fuelling station is often referred to as hydrogen fuelling station or hydrogen filling station.
11390	
11391	[Source: ISO 19880-8:2019 3.8]
11392	1707. hydrogen fuelling station
11393	facility for the dispensing of compressed gaseous hydrogen vehicle fuel, often referred to as a hydrogen
11394	refueling station (HRS) or hydrogen filling station, including the supply of hydrogen, and hydrogen com-
11395	pression, storage, and dispensing systems
11396	
11397	[Source: ISO 19880-1:2020 3.29]
11398	1708. hydrogen storage
11399	component of the EES system using hydrogen, for storing hydrogen which is produced by water/steam
11400	electrolysis in or supplied to the system
11401	
11402	Note to entry: There are several kinds of hydrogen storage equipment depending on the hydrogen
11403	storage principles. They include low/high-pressure gas, liquid, hydrogen-absorbing alloy (hydrogen ab-
11404	sorbed in reversible metal hydride), non-metal hydrides and others.
11405	
11406	[Source: IEC 62282-8-201:2020 3.1.9]
11407	1709. hydrogen-to-power (H2P)
11408	process of converting hydrogen generated by electrolysis into power (electricity and/or heat)
11409	1710. hydrogen-to-substance (H2X)
11410	process of converting hydrogen generated by electrolysis into a substance
11411	1711. hydrogenation
11412	chemical process to combine an unsaturated compound with hydrogen
11413	
11414	Note to entry: Catalysed hydrogenation at elevated hydrogen pressures of 10-50 bar and exothermic, is
11415	required for liquid organic hydrogen carriers (LOHCs) as transportable ES media for hydrogen.
11416	1712. levelised cost of energy (LCOE)
11417	way of comparing the cost of energy stemming from different sources given the wide range of energy
11418	and power technologies available for energy generation whether renewable or non-renewable
11419	
11420	Note 1 to entry: LCOE should consider all CAPEX direct and indirect and all operational expendi-
11421	ture (OPEX) (i. e. labour, maintenance, materials, overheads, utilities, etc) fixed and variable including
11422	taxes, fees and charges as may be applicable in a given situation. Where taxes, fees and/or charges are
11423	excluded, this should be made explicit. Also, discount rate, imputed costs and entrepreneurial profits
11424	shall be made explicit. Cost due to depreciation shall take into account the expected lifetime of the con-
11425	sidered energy generation system rather than solely fiscal and commercial considerations. LCOE should
11426	also include revenue raised due to provided/spared services and/or the sale of generated by-products
11427	(i. e. added value substances) as may be applicable in a given situation.
11428	Note 2 to entry: LCOE shall be given for the specified energy generated for consecutive conversion or
11429	storage.
11430	1713. levelised cost of hydrogen (LCOH)
11431	way of comparing the cost of hydrogen stemming from the use of different electrolysis technologies
11432	whether already available, suggested and in actual use
11433	
11434	Note 1 to entry: LCOH should consider all CAPEX direct and indirect and all OPEX (i. e. labour,
11435	maintenance, materials, overheads, utilities, etc) fixed and variable including taxes, fees and charges
11436	as may be applicable in a given situation. Where taxes, fees and/or charges are excluded, this should
11437	be made explicit. Also, discount rate, imputed costs and entrepreneurial profits shall be made explicit.
11438	Cost due to depreciation shall take into account the expected lifetime of the electrolyser rather than
11439	solely fiscal and commercial considerations. LCOH should also include revenue raised due to the sale
11440	of generated by-products (i. e. oxygen, added value substances, etc) as may be applicable in a given
11441	situation.
11442	Note 2 to entry: LCOH shall be given for hydrogen with specified purity produced for consecutive use.

11443 **1714. levelised cost of storage (LCOS)**

11444 way of comparing the cost of energy storage stemming from different storage technology whether already
11445 available, suggested and in actual use

11446

11447 Note 1 to entry: LCOS should consider all CAPEX whether direct or indirect and all OPEX (i. e.
11448 labour, maintenance, materials, overheads, utilities, etc) fixed and variable including taxes, fees and
11449 charges as may be applicable in a given situation. Where taxes, fees and/or charges are excluded, this
11450 should be made explicit. Also, discount rate, imputed costs and entrepreneurial profits shall be made
11451 explicit. Cost due to depreciation shall take into account the expected lifetime of the energy storage
11452 system rather than solely fiscal and commercial considerations. LCOS should also include revenue raised
11453 due to provided/spared services as may be applicable in a given situation.

11454 Note 2 to entry: LCOS shall be given for the specified energy released for consecutive use.

11455 **1715. operation & maintenance (O&M) cost**

11456 cost incurred in running and managing the facility, plus labour, material and other related costs incurred
11457 to retain it or its parts in a state in which it can perform its required functions

11458

11459 [Source: ISO 22449-2:2020 3.1.4]

11460

11461 Note to entry: Cost not accounted for shall be made explicit. O&M cost are part of OPEX.

11462 **1716. operational expenditure (OPEX)**

11463 recurrent expenditures required to provide a service or product

11464

11465 [Source: ISO/TS 55010:2019 3.9]

11466

11467 Note to entry: Expenditure not accounted for shall be made explicit.

11468 **1717. photovoltaic array**

11469 two or more photovoltaic modules at one location that together provide a photovoltaic solar energy
11470 system

11471

11472 [Source: ISO 6707-3:2017 3.3.8]

11473 **1718. photovoltaic cell**

11474 device in which the photovoltaic effect is utilised

11475

11476 [Source: IEC 521-04-34]

11477 **1719. power-to-ammonia (P2NH₃)**

11478 process that produces ammonia using hydrogen generated by electrolysis

11479 **1720. power-to-gas (P2G)**

11480 technology which converts electrical power to a gas fuel

11481

11482 Note to entry: Power-to-gas solves the renewables problem of intermittency by storing energy in the
11483 form of hydrogen, which can then be used to generate electricity, stored for later use or injected into
11484 the national gas grid.

11485

11486 [Source: IATE 3553118]

11487 **1721. power-to-gas-to-power (P2G2P)**

11488 technology which converts electrical power to a gas, used to generate deferred power

11489 **1722. power-to-methane (P2CH₄)**

11490 process that produces synthetic methane through the hydrogenation of carbon dioxide using hydrogen
11491 generated by electrolysis

11492 **1723. power-to-power (P2P)**

11493 technology by which renewable energy is converted into hydrogen by for use as a gas which in turn is
11494 converted into power (electricity and/or heat)

11495 **1724. power-to-substance (P2S)**

11496 collective for processes using electricity (and heat) from renewable energy source to generate primarily
11497 hydrogen intermediate for producing a useful substance (chemical, fuel, syngas) as final product in
11498 power-to-X applications such as power-to-fuel, power-to-syngas, and power-to-chemical with the latter
11499 subdivided into power-to-ammonia, power-to-ethanol, power-to-methane, power-to-methanol and power-
11500 to-ammonia

11501 **1725. power-to-hydrogen (P2H2)**

11502 conversion of electric power - typically surplus electric power generated from renewable energy sources
11503 during periods when generation exceeds load - to hydrogen gas

11504 **1726. power-to-liquid (P2L)**

11505 transforming of renewable energy (electricity and/or heat) into the form of liquid fuels

11506

11507 [Source: IATE 3578706]

11508 **1727. power-to-X (P2X)**

11509 conversion of electric power - typically surplus electric power generated from renewable energy sources
11510 during periods when generation exceeds load - to another form of energy (such as hydrogen, methane
11511 or methanol) for storage and re-conversion to electric power, to an alternative form of energy (such as
11512 gas or synthetic fuel), or to another useful product (such as ammonia or other chemical feedstocks)

11513

11514 [Source: IATE 3579102]

11515 **1728. rechargeable electrical energy storage system (REESS)**

11516 system that stores energy for delivery of electric power and which is rechargeable

11517

11518 [Source: ISO 17840-3:2019 3.5]

11519 **1729. refinery**

11520 industrial process plant where crude oil is processed and refined into more useful hydrocarbon products

11521 **1730. replacement cost**

11522 anticipated cost to major system components that are required to maintain the operation of a facility

11523

11524 [Source: ISO 22449-2:2020 3.1.5]

11525

11526 Note to entry: Cost not accounted for shall be made explicit. Replacement expenditure (REPEX)
11527 is synonymous for replacement cost.

11528 **1731. short-duration application**

11529 electrical energy storage system application generally demanding in terms of step response performances
11530 and with frequent charge and discharge phase transitions or with reactive power exchange with the
11531 electric power system

11532

11533 [Source: IEC 62933-1:2018 3.13]

11534 **1732. smart grid**

11535 electric power system that utilises information exchange and control technologies, distributed computing
11536 and associated sensors and actuators

11537

11538 Note 1 to entry: Smart grid technologies are used for purposes such as:

– to integrate the behaviour and actions of the network user and other stakeholders,

11539

– to efficiently deliver sustainable, economic and secure electricity supplies

11540

11541 [Source: ISO/IEC 27019:2017 3.16]

11542

11543 Note 2 to entry: Such networks comprise a broad set of technologies, which include but are by no
11544 means limited to 'smart metering systems'. This term currently relates to the electricity sector only,
11545 however "smart gas grids" are being developed.
11546

11547

11548

[Source: IATE 2250037]

11549

11550

Note 3 to entry: Some smart grids integrate into the electric grid excess power generated locally from sun and wind-driven devices.

11551

11552

Note 4 to entry: Technically, a grid is a network. However, in common usage the term "smart grid" refers to the entire energy system, which include generation, transmission, distribution, and customer systems.

11553

11554

11555

11556

[Source: ISO/IEC 15067-3:2012 3.1.19]

11557

1733. total cost of ownership (TCO)

11558

monetary (economic value) estimate designed to help consumers and businesss to assess and account the full cost directly and indirectly related to a product, service or system as an investment over the whole life cycle of such product, service or system

11559

11560

11561

11562

Note to entry: Cost not accounted for shall be made explicit.

11563

2.5.4 System operation and testing

11564

1734. air bleed

11565

means of purging air from a system or component

11566

11567

[Source: ISO 5598:2019 3.2.21]

11568

1735. area classification

11569

classification of hazardous areas according to the probability of the existence of an explosive atmosphere, in order to relate the selection of electrical apparatus for use in the area to the degree of hazard

11570

11571

11572

[Source: ISO 22734:2019 3.1]

11573

1736. auto-ignition

11574

ignition which does not require external ignition energy because the thermal energy of the molecules alone is enough to overcome the activation threshold for combustion initiation

11575

11576

11577

[Source: ISO/TR 15916:2015 3.4]

11578

1737. auto-ignition temperature

11579

lowest temperature at which auto-ignition occurs; 858 K for hydrogen

11580

11581

[Source: ISO/TR 15916:2015 3.5]

11582

1738. back-flow

11583

flow of a fluid in the direction opposite to the normal flow direction

11584

11585

Note to entry: This term is used to describe the entry (diffusion) of atmospheric air into a hydrogen vent line.

11586

11587

11588

[Source: ISO/TR 15916:2015 3.7]

11589

1739. charging/discharging cycle

11590

electrical energy storage system duty-cycle made by four controlled phases: a charge phase, then a pause, then a discharge phase and then a new pause

11591

11592

11593

[Source: IEC 62933-1:2018 4.1.1]

11594

1740. cold start

11595

start-up when the device or system is at ambient temperature and pressure

- 11596 **1741. control system**
- 11597 system which responds to input signals from the process and/or from an operator and generates output
11598 signals causing the process to operate in the desired manner
- 11599
- 11600 [Source: ISO 19880-1:2020 3.11]
- 11601 **1742. corrective maintenance**
- 11602 repair or replacement of components as a result of a failure
- 11603
- 11604 [Source: ISO 19659-1:2017 3.9.2]
- 11605 **1743. dewar**
- 11606 double-walled vessel with the annular space between the walls evacuated to provide insulation
- 11607
- 11608 [Source: ISO 14952-1:2003 2.7]
- 11609 **1744. disconnected**
- 11610 condition of the equipment during which all connections to power sources supplying the equipment are
11611 removed or galvanically isolated and no function depending on those power sources are provided
- 11612
- 11613 Note to entry: The term "power source" includes power sources external and internal to the equip-
11614 ment.
- 11615
- 11616 [Source: IEV 904-03-15]
- 11617 **1745. duty-cycle**
- 11618 combination of controlled phases (charge, pause, discharge, etc.) starting from an initial state of charge
11619 and ending in a final state of charge, used in the energy storage system characterisation, specification
11620 and testing for a certain operating mode
- 11621 **1746. duty-cycle roundtrip efficiency**
- 11622 energy discharged measured at the PoCs (primary and auxiliary) divided by the energy absorbed by the
11623 energy storage system during duty-cycles in a specified operating mode at continuous operating condi-
11624 tions with the same final state of charge as the initial state of charge
- 11625
- 11626 Note to entry: Typically, the duty-cycles performed involve the full energy capacity of the energy storage
11627 system. Roundtrip efficiency can be related to actual, nominal or rated energy capacity. Duty-cycle
11628 roundtrip efficiency is generally expressed in percentage.
- 11629 **1747. emergency stop**
- 11630 operating procedure or action intended to stop as rapidly as possible but a controlled manner the
11631 operation of a device or system which has become dangerous or poses a hazard
- 11632 **1748. entrainment**
- 11633 mist, fog droplets or particles transported by a fluid
- 11634
- 11635 [Source: ISO 3857-4:2012 2.37]
- 11636 **1749. factory acceptance test (FAT)**
- 11637 tests performed in the factory (or another location other than its intended place of installation) on
11638 an equipment or system to verify functionality and/or integrity in accordance with the specifications
11639 prior to shipment to the site of its installation and use, or an appropriate alternative type acceptance
11640 methodology
- 11641 **1750. generating time**
- 11642 cumulative duration of the time intervals required for hydrogen generation
- 11643
- 11644 [Source: JRC EUR 29300 EN report 3.18.1]
- 11645
- 11646 Note to entry: The coherent SI unit of generating time is seconds. s.

11647	1751. hydrogen embrittlement
11648	deleterious changes in the ductility properties of a metal that exposure to hydrogen can produce
11649	
11650	[Source: ISO/TR 15916:2015 3.56]
11651	1752. initial response time
11652	time needed after a set-point change of a parameter to begin changing the output
11653	
11654	[Source: JRC EUR 29300 EN report 3.18.2]
11655	
11656	Note to entry: The coherent SI unit of initial response time is seconds. s.
11657	1753. inspection
11658	determination of conformity to specified requirement
11659	
11660	Note 1 to entry: If the result of an inspection shows conformity, it can be used for purposes of verification.
11661	
11662	Note 2 to entry: The result of an inspection can show conformity or nonconformity or a degree of conformity.
11663	
11664	
11665	[Source: ISO 10795:2019 3.127]
11666	1754. laboratory environment
11667	controlled environment needed for demonstrating the underlying principles and functional performance
11668	
11669	Note to entry: The laboratory environment does not necessarily address the operational environment.
11670	
11671	[Source: ISO 16290:2013 2.7]
11672	1755. load duration curve
11673	curve showing the duration, within a specified period of time, when the load equalled or exceeded a given value
11674	
11675	
11676	[Source: IEV 692-01-18]
11677	1756. load profile
11678	curve representing supplied electric power against time of occurrence to illustrate the variance in a load during a given time interval
11679	
11680	
11681	[Source: IEV 617-04-05]
11682	1757. load shed
11683	amount of customer load deliberately disconnected from an electric power system in response to an abnormal state in order to maintain the integrity of the remainder of the system
11684	
11685	
11686	[Source: IEV 692-09-03]
11687	1758. maintainability
11688	ability to be retained in, or restored to a state to perform as required, under given conditions of use and maintenance
11689	
11690	
11691	Note 1 to entry: Given conditions would include aspects that affect maintainability, such as: location for maintenance, accessibility, maintenance procedures and maintenance resources.
11692	
11693	Note 2 to entry: Maintainability can be quantified using appropriate measures.
11694	
11695	[Source: ISO 20815:2018 3.1.26]
11696	1759. maintenance
11697	combination of all technical and management actions intended to retain an item in, or restore it to, a state in which it can perform as required
11698	
11699	

- 11700 [Source: ISO 20815:2018 3.1.28]
11701
11702 Note to entry: Maintenance includes management and supervision activities for support.
11703
11704 [Source: ISO 10795:2019 3.145]
- 11705 **1760. mass flow controller (MFC)**
11706 flow controlling device that comprises a TMF meter, a valve and controlling electronics
11707
11708 Note to entry: The output of the TMF meter is compared against an adjustable set point and the
11709 valve is correspondingly opened or closed to maintain the measured flow rate at the set point value.
11710
11711 [Source: ISO 14511:2019 3.2.6]
- 11712 **1761. maximum power point tracking (MPPT)**
11713 algorithm that included in charge controllers used for extracting maximum available power
- 11714 **1762. operation history**
11715 record of the operating conditions of the system
11716
11717 [Source: IEC 62282-8-201:2020 3.1.26]
- 11718 **1763. operational environment**
11719 set of natural and induced conditions that constrain the element from its design definition to its operation
11720
11721 [Source: ISO 16290:2013 2.11]
- 11722 **1764. operator**
11723 person or organisation having responsibility for and/or handle the operation of an equipment or a system
- 11724 **1765. pressure fluctuation**
11725 uncontrolled variation of pressure with time
11726
11727 [Source: ISO 5598:2019 3.2.570]
- 11728 **1766. pressure gradient**
11729 rate of change in pressure over length in a steady state flow
- 11730 **1767. preventive maintenance**
11731 additional inspection and repair or replacement of components at predetermined intervals/criteria
11732
11733 [Source: ISO 19659-1:2017 3.9.3]
- 11734 **1768. quiescent state**
11735 operating state of the EES system, where it is partly or fully charged, and no intended discharging of
11736 the stored energy takes place
11737
11738 [Source: IEC 62282-8-201:2020 3.1.18]
- 11739 **1769. quiescent state loss rate**
11740 sum of energy loss rate and energy consumption rate of EES system during the quiescent state
11741
11742 [Source: IEC 62282-8-201:2020 3.1.19]
11743
11744 Note to entry: The coherent SI unit of quiescent state loss rate is watt, W.
- 11745 **1770. ramp rate**
11746 average rate of the variation of the set value of a quantity (e.g. TIP) per unit of time upon a step
11747 change in this quantity and during the step response time

- 11748 **1771. rated input conditions**
- 11749 conditions specified by the manufacturer, at which the tested system absorbs electric power input at the
- 11750 PoC
- 11751
- 11752 [Source: IEC 62282-8-201:2020 3.1.21]
- 11753 **1772. rated output conditions**
- 11754 conditions specified by the manufacturer, at which the tested system delivers electric power output at
- 11755 the PoC
- 11756
- 11757 [Source: IEC 62282-8-201:2020 3.1.22]
- 11758 **1773. rated test conditions**
- 11759 specific boundary conditions at which the tested system is operated
- 11760
- 11761 Note to entry: They shall be agreed between the system manufacturer and customer.
- 11762
- 11763 [Source: IEC 62282-8-201:2020 3.1.23]
- 11764 **1774. reactivity**
- 11765 time required for the electrolysis system to change from 0 to 100 % of power (ramp-up) or from 100 %
- 11766 of power down to 0 % (ramp-down)
- 11767
- 11768 [Source: JRC EUR 29300 EN report 3.18.9]
- 11769 **1775. regulation profile**
- 11770 variable power profile such as the grid power profile resulting from energy injection and withdrawal
- 11771
- 11772 Note to entry: This can be affected by renewable energy sources, energy fluctuations and network
- 11773 disturbances.
- 11774
- 11775 [Source: JRC EUR 29300 EN report 3.17.5]
- 11776 **1776. response time**
- 11777 time from a sudden change of a control quantity until the corresponding change of an output quantity
- 11778 has reached a specified fraction of its final value
- 11779
- 11780 [Source: IEV 431-02-12]
- 11781 **1777. roundtrip electrical efficiency**
- 11782 electric energy discharged measured on the primary PoC divided by the electric energy absorbed, meas-
- 11783 ured on all the PoC (primary and auxiliary), over one electrical energy storage system standard charg-
- 11784 ing/discharging cycle in specified operating conditions
- 11785
- 11786 [Source: IEC 62282-8-201:2020 3.1.25]
- 11787
- 11788 Note to entry: Efficiency is expressed in percentage either as HHV or LHV.
- 11789 **1778. site acceptance test (SAT)**
- 11790 tests performed after installation of an equipment or system at the site to demonstrate its functionality
- 11791 and/or integrity in accordance with the specifications and installation instructions
- 11792 **1779. start-up time**
- 11793 time required for starting the device from a cold state to nominal operating conditions
- 11794
- 11795 [Source: JRC EUR 29300 EN report 3.18.12.1]
- 11796
- 11797 Note to entry: The coherent SI unit of start-up time is seconds. s.
- 11798 **1780. state of health (SoH)**
- 11799 general condition of a device or system based on measurements under specified conditions which indicates
- 11800 its actual performance compared to its nominal or rated performance

11801	1781. steady-state load characteristic
11802	relation between the power absorbed by a load and the voltage or frequency at the load terminals under
11803	steady state operating conditions
11804	
11805	[Source: IEV 603-04-14]
11806	1782. storage test
11807	test carried out to measure the loss of capacity, open circuit voltage, short-circuit current or other
11808	quantities after storage under specified conditions
11809	
11810	[Source: IEV 482-03-45]
11811	1783. switchover time
11812	time that is required to switch an EES system using hydrogen from a specified charging phase to a
11813	specified discharging phase or <i>vice versa</i>
11814	
11815	Note 1 to entry: This can be of relevance in case grid service shall be performed with the system.
11816	It comprises the time that is required to go from one operating point in either charging or discharging
11817	operation to quiescent state, purging of gas lines if applicable, setting of auxiliary components (valves,
11818	heaters, compressors etc.) if applicable and to go to an operating point in the opposite operating phase
11819	(discharging or charging).
11820	
11821	[Source: IEC 62282-8-201:2020 3.1.27]
11822	1784. technical documentation
11823	documentation that enables the conformity of the product with the requirements of the standard(s) to
11824	be assessed
11825	
11826	Note 1 to entry: This typically includes schedule drawings when certification is involved.
11827	Note 2 to entry: It covers the design, manufacture and operation of the product and contains:
	1. general description;
	2. design and manufacturing drawings and layouts of components, sub-assemblies, circuits, etc.;
	3. descriptions and explanations necessary for the understanding of drawings and layouts and the
11828	operation of the product;
	4. a list of the standards referred to in the certificate, applied in full or in part, and descriptions of
	the solutions adopted to meet the requirements of the standards;
	5. results of design calculations made, examinations carried out, etc.;
11829	6. test reports.
11830	
11831	[Source: IEV 426-27-06]
11832	1785. tested system
11833	system defined by its boundary to the environment, that is in accordance with the objective of the
11834	evaluation
11835	
11836	[Source: IEC 62282-8-201:2020 3.1.29]
11837	1786. thermal mass flow (TMF) meter
11838	flow-measuring device which uses heat transfer to measure and indicate mass flow rate
11839	
11840	Note to entry: The thermal mass flow meter also applies to the measuring portion of a thermal mass
11841	flow controller and not the control function.
11842	
11843	[Source: ISO 14511:2019 3.2.3]
11844	1787. total response time
11845	time needed after a set point change of a parameter to reach a new value
11846	

11847 [Source: JRC EUR 29300 EN report 3.18.3]

11848

11849 Note to entry: The coherent SI unit of total response time is seconds. s.

11850 **1788. transient load characteristic**

11851 relation between the power absorbed by a load and the voltage or frequency under transient-state oper-
11852 ating conditions

11853

11854 [Source: IEV 603-04-15]

11855 **1789. transient response time**

11856 average time to ramp up from 30 % to 100 % load at nominal power and operating pressure and tem-
11857 perature

11858

11859 [Source: JRC EUR 29300 EN report 3.18.12.6]

11860

11861 Note to entry: The coherent SI unit of transient response time is seconds, s.

11862 **1790. warm start**

11863 start of an equipment or system under specified temperature conditions

11864 **1791. warm-up time**

11865 time interval of system operation under specified conditions between the time when the system is switched
11866 on and the time when system first indicates its readiness for full operation and remains within stated
11867 tolerances in this state

11868

11869 Note to entry: The coherent SI unit of warm-up time is second, s.

11870 **1792. water utilisation factor**

11871 dimensionless ratio of the flow of water converted into hydrogen and oxygen to the total water flow
11872 supplied to the stack

11873

11874 [Source: JRC EUR 29300 EN report 3.27.4]

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12671 **List of Abbreviations and Acronyms**

12672	0D zero dimensional
12673	1D one dimensional
12674	1LG single layer graphene
12675	2D two dimensional
12676	2LG bilayer graphene
12677	3D three dimensional
12678	AAEM alkaline anion exchange membrane
12679	AAEMEC alkaline anion exchange membrane electrolysis cell
12680	AAEMFC alkaline anion exchange membrane fuel cell
12681	AC alternating current
12682	ACE area control error
12683	ACM Association for Computing Machinery
12684	ADIS analysis of difference in impedance spectra
12685	AEC alkaline electrolysis cell
12686	AEL alkaline electrolysis
12687	AEM anion exchange membrane
12688	AEMEC anion exchange membrane electrolysis cell
12689	AEMEL anion exchange membrane electrolysis
12690	AEMFC anion exchange membrane fuel cell
12691	AEMWE anion exchange membrane water electrolyser
12692	AES Auger electron spectroscopy
12693	AFC alkaline fuel cell
12694	AFL anode functional layer
12695	AFM atomic force microscopy
12696	aFRR automatic frequency restoration reserve
12697	AJP aerosol jet printing
12698	ALD atomic layer deposition
12699	AM additive manufacturing
12700	APEE alkaline polymer electrolyte electrolyser
12701	APEFC alkaline polymer electrolyte fuel cell
12702	APS atmospheric plasma spraying
12703	APU auxiliary power unit
12704	ARE United Arab Emirates
12705	ASC anode-supported cell
12706	ASR area specific resistance
12707	AST accelerated stress testing
12708	ASTM American Society for Testing and Materials
12709	AWE alkaline water electrolyser
12710	AWP annual work plan
12711	BACS building automation and control system
12712	bcc body centred cubic
12713	BCZY yttrium-doped barium cerate zirconate
12714	BEL Belgium
12715	BET Brunauer-Emmett-Teller
12716	BIPM Bureau International des Poids et Mesures
12717	BL barrier layer
12718	BLR Belarus
12719	BMED bipolar membrane electro dialysis
12720	BoL beginning of life
12721	BoM bill of material
12722	BoP balance of plant
12723	BoT beginning of test
12724	BPM bipolar membrane
12725	BPMEL bipolar membrane electrolysis
12726	BPMFC bipolar membrane fuel cell
12727	BPMWE bipolar membrane water electrolyser

12728 **BPMWEC** bipolar membrane water electrolysis cell

12729 **BPP** bipolar plate

12730 **BSCF** strontium-doped barium cobaltite ferrite

12731 **BZY** yttrium-doped barium zirconate

12732 **CAD** computer aided design

12733 **CAES** compressed air energy storage

12734 **CAM** computer aided manufacturing

12735 **CAPEX** capital expenditure

12736 **CBA** cost benefit analysis

12737 **CC** creative commons

12738 **CCM** catalyst coated membrane

12739 **CdT** Translation Centre for the Bodies of the European Union

12740 **CE** Conformité Européene

12741 **CEM** cation exchange membrane

12742 **CEN** European Committee for Standardization

12743 **CENELEC** European Committee for Electrotechnical Standardization

12744 **CES** cryogenic energy storage

12745 **CExL** anode exchange layer

12746 **CExL** cathode exchange layer

12747 **CFD** computational fluid dynamics

12748 **CFL** cathode functional layer

12749 **CGH₂** compressed gaseous hydrogen

12750 **CGO** cerium doped gadolinium oxide

12751 **CGPM** General Conference on Weights and Measures

12752 **CHE** Confederatio Helvetica (Swiss confederation)

12753 **CHP** combined heat and power

12754 **CI** current interrupt

12755 **CIP** critical infrastructure protection

12756 **cip** cold isostatic pressing

12757 **CIPRNet** critical infrastructures preparedness and resilience research network

12758 **CIR** critical infrastructure resilience

12759 **CL** catalyst layer

12760 **CNG** compressed natural gas

12761 **CNLS** complex nonlinear least squares

12762 **CNT** carbon nanotube

12763 **co-SOE** solid oxide co-electrolyser

12764 **CoC** certificate of conformity

12765 **CODATA** ICSU Committee on Data for Science and Technology

12766 **COM** confocal optical microscopy

12767 **CPE** constant phase element

12768 **CRL** consumer readiness level

12769 **CRM** critical raw material

12770 **CSC** cathode-supported cell

12771 **CSD** colloidal spray deposition

12772 **CSO** cerium-doped samarium oxide

12773 **CSP** concentrated solar power

12774 **CSZ** cubic-stabilised zirconia

12775 **CTE** coefficient of thermal expansion

12776 **CV** cyclic voltammetry

12777 **CVD** chemical vapour deposition

12778 **DBL** diffusion barrier layer

12779 **DC** direct current

12780 **DD** diffusion dialysis

12781 **DER** distributed energy resource

12782 **DES** distributed energy source

12783 **DEU** Deutschland

12784 **DFT** discrete Fourier transform

12785 **DG** Directorate-General

12786 **DGM** dusty gas model

12787 **DIA** differential immittance analysis

12788 **DLC** double layer capacitance

12789 **DMA** dynamic mechanical analysis

12790 **DME** di-methyl ether

12791 **DNK** Denmark

12792 **DoE** design of experiment

12793 **doi** digital object identifier

12794 **DRF** data reporting format

12795 **DRI** direct reduction iron

12796 **DRT** distribution of relaxation times

12797 **DSC** differential scanning calorimetry

12798 **DSIMS** dynamic secondary ion mass spectroscopy

12799 **DSM** demand side management

12800 **DSO** distribution system operator

12801 **DSO-E** distribution system operator - electricity

12802 **DSO-G** distribution system operator - gas

12803 **DTU** Danmarks Tekniske Universitet

12804 **DUT** device under test

12805 **EAF** electric arc furnace

12806 **EC** electrochemical cell

12807 **EC-AFM** electrochemical atomic force microscopy

12808 **EC-SPM** electrochemical scanning probe microscopy

12809 **EC-STM** electrochemical scanning tunneling microscopy

12810 **ECM** electrochemical model

12811 **ECP** electrochemical potential

12812 **ECS** electrochemical system

12813 **ECSA** electrochemical surface area

12814 **ED** electrodialysis

12815 **EDI** electronic data interchange

12816 **EDL** electric double layer

12817 **EDR** electrodialysis reversal

12818 **EDS** energy disperse X-ray spectroscopy

12819 **EEA** European Environmental Agency

12820 **EEC** equivalent electric circuit

12821 **EELS** electron energy loss spectroscopy

12822 **EEM** electric energy meter

12823 **EERA** European energy research alliance

12824 **EES** electrical energy storage

12825 **EESS** electrical energy storage system

12826 **EGA** evolved gas analysis

12827 **EIS** electrochemical impedance spectroscopy

12828 **emf** electromotive force

12829 **EMI** electromagnetic interference

12830 **EMS** energy management system

12831 **EN** English

12832 **en** english

12833 **ENTSO-E** European Network of Transmission System Operators for Electricity

12834 **ENTSO-G** European Network of Transmission System Operators for Gas

12835 **EoL** end of life

12836 **EoS** equation of state

12837 **EoT** end of test

12838 **EPB** energy performance of building

12839 **EPD** electrophoretic deposition

12840 **EPES** elastic peak electron spectroscopy

12841 **EPMA** electron probe microanalysis

12842 **EPS** electric power system

12843 **EROI** energy return on energy invested

12844 **ES** energy storage

12845 **ESC** electrolyte-supported cell

12846 **ESO** European Standards Organisation

12847 **ESOI** energy stored on energy invested

12848 **ESOR** energy stored on return

12849 **ESR** electron spin resonance spectroscopy

12850 **ESS** energy storage system

12851 **EtOH** ethanol

12852 **ETSI** European Telecommunications Standards Institute

12853 **EU** European Union

12854 **EUR** European Union Report

12855 **Eurostat** Statistical Office of the European Union

12856 **EUT** equipment under test

12857 **EVD** electrochemical vapour deposition

12858 **EW** equivalent weight

12859 **EXAFS** extended X-ray absorption fine structure spectroscopy

12860 **FAT** factory acceptance test

12861 **FC** fuel cell

12862 **fcc** face centred cubic

12863 **FCEV** fuel cell electric vehicle

12864 **FCH** Fuel Cells and Hydrogen

12865 **FCH2JU** Fuel Cells and Hydrogen second Joint Undertaking

12866 **FCR** frequency containment reserve

12867 **FCS** fuel cell power system

12868 **FCT** fuel cell technologies

12869 **FCV** fuel cell vehicle

12870 **FFT** fast Fourier transformation

12871 **FIB** focused ion beam

12872 **FIT** Fourier integral transform

12873 **FL** functional layer

12874 **FLG** few layer graphene

12875 **FMEA** failure mode and effects analysis

12876 **FOR** forced outage rate

12877 **FPS** fuel processing system

12878 **fR** frequency regulation

12879 **FRA** frequency response analyzer

12880 **FRA** France

12881 **FRCE** frequency restoration control error

12882 **FRP** frequency restoration process

12883 **FRR** frequency restoration reserve

12884 **FT** Fourier transformation

12885 **FTA** fault tree analysis

12886 **FTIR** Fourier transform infra-red spectroscopy

12887 **FVT** final value theorem

12888 **FWC** framework contract

12889 **FWHM** full width at half maximum

12890 **GBR** United Kingdom of Great Britain and Northern Ireland

12891 **GC** gas chromatography

12892 **GCC** glass ceramic composite

12893 **GCS** glass ceramic sealant

12894 **GDC** gadolinium doped cerium oxide

12895 **GDE** gas diffusion electrode

12896 **GDL** gas diffusion layer

12897 **GFVT** generalised final value theorem

12898 **GHG** greenhouse gas

12899 **GIVT** generalised initial value theorem

12900 **GLP** good laboratory practice

12901 **GPACD** gas-phase air cleaning device

12902 **GPO** United States Government Publishing Office

12903 **GPS** geometrical product specification

12904 **GUM** Guide to the Expression of Uncertainty in Measurement

12905 **GWP** global warming potential

12906 **H-SOE** hydrogen ion (proton) conducting solid oxide electrolyser

12907 **H-SOEC** hydrogen ion (proton) conducting solid oxide electrolysis cell

12908 **H-SOFC** hydrogen ion (proton) conducting solid oxide fuel cell

12909 **H2I** hydrogen-to-industry

12910 **H2P** hydrogen-to-power

12911 **H2X** hydrogen-to-substance
12912 **hcp** hexagonal close packed
12913 **HEM** hydroxide anion exchange membrane
12914 **HER** hydrogen evolution reaction
12915 **HES** home electronic system
12916 **HFR** high-frequency resistance
12917 **HHV** higher heating value
12918 **hip** hot isostatic pressing
12919 **HIT** Hilbert integral transform
12920 **HKG** Hongkong Special Administrative Region
12921 **HOR** hydrogen oxidation reaction
12922 **HPE** high-pressure electrolyser
12923 **HREM** high-resolution transmission electron microscopy
12924 **HRFB** hybrid redox flow battery
12925 **HRS** hydrogen refueling station
12926 **HT** high temperature
12927 **HT-PEMFC** high-temperature proton exchange membrane fuel cell
12928 **HTE** high temperature electrolyser
12929 **HTEL** high temperature electrolysis
12930 **HTPC** high-temperature proton conductor
12931 **HTSEL** high temperature steam electrolysis
12932 **HV** high-voltage
12933 **HVAC** high-voltage alternating current
12934 **HVDC** high-voltage direct current
12935 **IAIS** Fraunhofer-Institut für Intelligente Analyse- und Informationssysteme
12936 **IATE** Interactive terminology for Europe
12937 **ICE** internal combustion engine
12938 **ICP-MS** inductively coupled plasma mass spectroscopy
12939 **ICSU** International Council of Scientific Unions
12940 **IDFT** inverse discrete Fourier transform
12941 **IEC** International Electrotechnical Commission
12942 **IEEE** Institute of Electrical and Electronics Engineers
12943 **IEM** ion exchange membrane
12944 **IEV** International Electrotechnical Vocabulary
12945 **IFFT** inverse fast Fourier transformation
12946 **IFIT** inverse Fourier integral transform
12947 **IFT** inverse Fourier transformation
12948 **IHIT** inverse Hilbert integral transform
12949 **IHP** inner Helmholtz plane
12950 **IIT** Indian Institute of Technology
12951 **IJP** inkjet printing
12952 **IL** interfacial layer
12953 **ILCM** information life cycle management
12954 **ILIT** inverse Laplace integral transform
12955 **ILT** inverse Laplace transformation
12956 **IN** imbalance netting
12957 **IND** India
12958 **IP** intellectual property
12959 **IPPP** institutional public private partnership
12960 **IPRL** intellectual property readiness level
12961 **IRENA** International Renewable Energy Agency
12962 **IRL** innovation readiness level
12963 **IS** immittance spectroscopy
12964 **ISBN** international standard book number
12965 **ISO** International Organization for Standardization
12966 **ISQ** International System of Quantities
12967 **ISSN** international standard serial number
12968 **ISTD** International Standard
12969 **IT** intermediate temperature
12970 **IUPAC** International Union of Pure and Applied Chemistry
12971 **IUT** item under test

12972 **IVT** initial value theorem

12973 **JCGM** Joint Committee for Guides in Metrology

12974 **JP** Joint Research Programme

12975 **JRC** Joint Research Centre

12976 **KIT** Karlsruhe Institut für Technologie

12977 **KK** Kramers-Kronig

12978 **KKR** Kramers-Kronig relations

12979 **KOR** Republic of Korea

12980 **KPI** key performance indicator

12981 **LAES** liquid air energy storage

12982 **LCA** life cycle assessment

12983 **LCOE** levelised cost of energy

12984 **LCOH** levelised cost of hydrogen

12985 **LCOS** levelised cost of storage

12986 **LEES** low-energy electron microscopy

12987 **LEIS** local electrochemical impedance spectroscopy

12988 **LEISS** low-energy ion scattering spectroscopy

12989 **LEL** lower explosive limit

12990 **LFC** load frequency control

12991 **LFCE** load frequency control error

12992 **LFG** landfill gas

12993 **LFL** lower flammability limit

12994 **LFR** low-frequency resistance

12995 **LH₂** liquefied hydrogen

12996 **LHP** lower half of the complex frequency plane

12997 **LHS** left hand side

12998 **LHV** lower heating value

12999 **LIB** lithium-ion battery

13000 **LIT** Laplace integral transform

13001 **LNG** liquefied natural gas

13002 **LOHC** liquid organic hydrogen carrier

13003 **LOLE** loss of load expectation

13004 **LOLP** loss of load probability

13005 **LPG** liquefied petroleum gas

13006 **LPPS** low-pressure plasma spraying

13007 **LS** laser sintering

13008 **LSC** strontium-doped lanthanum cobaltite

13009 **LSCF** strontium-doped lanthanum cobaltite ferrite

13010 **LSCM** strontium-doped lanthanum chromite magnetite

13011 **LSF** strontium-doped lanthanum ferrite

13012 **LSGM** strontium-doped lanthanum gallate magnesite

13013 **LSM** strontium-doped lanthanum manganite

13014 **LST** lanthanum-doped strontium titanate

13015 **LSV** linear sweep voltammetry

13016 **LT** Laplace transformation

13017 **LTI** linear, time invariant

13018 **LTWE** low temperature water electrolysis

13019 **LUX** Luxembourg

13020 **LV** low-voltage

13021 **LVDC** low-voltage direct current

13022 **M-S** Maxwell-Stefan

13023 **MAC** mobile air conditioning

13024 **MAOP** maximum allowable operating pressure

13025 **MAWP** multi-annual work plan

13026 **MBE** molecular beam epitaxy

13027 **MC** Monte Carlo

13028 **MCDI** membrane capacitive deionisation

13029 **MCE** molten carbonate electrolyser

13030 **MCEC** molten carbonate electrolysis cell

13031 **MCFC** molten carbonate fuel cell

13032 **mCHP** micro-scale combined heat and power

13033 **MD** molecular dynamics

13034 **MDoF** multiple-degree-of-freedom

13035 **MEA** membrane electrode assembly

13036 **MEC** microbial electrolysis cell

13037 **MEISS** medium-energy ion scattering spectroscopy

13038 **MeOH** methanol

13039 **MES** mechanical energy storage

13040 **MFC** mass flow controller

13041 **mFRR** manual frequency restoration reserve

13042 **MFT** mean field theory

13043 **MIEC** mixed ionic and electronic conductor

13044 **MMC** metal-matrix composite

13045 **MPEC** mixed protonic and electronic conductor

13046 **MPPT** maximum power point tracking

13047 **MRL** manufacturing readiness level

13048 **MRTD** machine readable travel documents

13049 **MSC** metal-supported cell

13050 **MSDS** material safety data sheet

13051 **MSOEC** metal-supported solid oxide electrolysis cell

13052 **MSOFC** metal-supported solid oxide fuel cell

13053 **MSS** molten salt storage

13054 **MTBF** mean time between failures

13055 **MTTF** mean time to failure

13056 **MV** medium-voltage

13057 **MVDC** medium-voltage direct current

13058 **N-S** Navier-Stokes

13059 **NACE** National Association of Corrosion Engineers

13060 **NBS** United States National Bureau of Standards

13061 **NC** United States federal state of North Carolina

13062 **NDT** non-destructive testing

13063 **NEXAFS** near-edge extended X-ray absorption fine structure spectroscopy

13064 **NG** natural gas

13065 **NGH2** blends of natural gas and hydrogen

13066 **NHE** normal hydrogen electrode

13067 **NIR** near-infra-red spectroscopy

13068 **NMR** nuclear magnetic resonance spectroscopy

13069 **NTP** normal temperature and pressure

13070 **NY** United States federal state of New York

13071 **O-SOE** oxygen ion conducting solid oxide electrolyser

13072 **O-SOEC** oxygen ion (proton) conducting solid oxide electrolysis cell

13073 **O-SOFC** oxide ion conducting solid oxide fuel cell

13074 **O&M** operation & maintenance

13075 **OCEC** oxygen ion conducting electrolysis cell

13076 **OCP** open circuit potential

13077 **OCV** open circuit voltage

13078 **ODE** ordinary differential equation

13079 **OEM** original equipment manufacturer

13080 **OER** oxygen evolution reaction

13081 **OHP** outer Helmholtz plane

13082 **OJ** Official Journal of the European Union

13083 **OP** Publications Office of the European Union

13084 **OPEX** operational expenditure

13085 **ORR** oxygen reduction reaction

13086 **P-SOE** proton conducting solid oxide electrolyser

13087 **P2C** power-to-chemical

13088 **P2CH4** power-to-methane

13089 **P2EtOH** power-to-ethanol

13090 **P2F** power-to-fuel

13091 **P2G** power-to-gas

13092 **P2G2P** power-to-gas-to-power

13093 **P2H** power-to-heat

13094 **P2H2** power-to-hydrogen
13095 **P2I** power-to-industry
13096 **P2L** power-to-liquid
13097 **P2M** power-to-mobility
13098 **P2MeOH** power-to-methanol
13099 **P2NH3** power-to-ammonia
13100 **P2P** power-to-power
13101 **P2R** power-to-refinery
13102 **P2S** power-to-substance
13103 **P2SG** power-to-syngas
13104 **P2X** power-to-X
13105 **PAFC** phosphoric acid fuel cell
13106 **PAS** Publicly Available Specification
13107 **PBI** polybenzimidazole
13108 **PCC** proton-conducting ceramic
13109 **PCCEL** proton conducting ceramic electrolysis
13110 **PCE** proton ceramic electrolyser
13111 **PCEC** proton conducting ceramic electrolysis cell
13112 **PCFC** proton conducting ceramic fuel cell
13113 **PCM** phase change material
13114 **PCR** primary control reserve
13115 **PDC** polymer derived ceramic
13116 **PDE** partial differential equation
13117 **pdf** portable document format
13118 **PEC** photoelectrolytic cell
13119 **PECC** photoelectrochemical cell
13120 **PECH** polyepichlorohydrin
13121 **PECVD** plasma enhanced chemical vapour deposition
13122 **PEFC** proton exchange membrane fuel cell
13123 **PEI** polyetherimide
13124 **PEK** polyetherketone
13125 **PEM** proton exchange membrane
13126 **PEMEC** proton exchange membrane electrolysis cell
13127 **PEMEL** proton exchange membrane electrolysis
13128 **PEMFC** polymer electrolyte membrane fuel cell
13129 **PEMWE** proton exchange membrane water electrolyser
13130 **PEN** positive electrode, electrolyte, negative electrode
13131 **PEO** polyetheroxadiazole
13132 **PESSRAE** programmable electronic systems in safety-related applications for escalators and moving walks
13133 **PFSA** perfluorosulfonic acid
13134 **PFSI** perfluorosulfonated ionomer
13135 **PG** power generation
13136 **PGM** platinum group metal
13137 **PHES** pumped heat electrical energy storage
13138 **PI** personal information
13139 **PID** piping and instrumentation diagram
13140 **PIP** passive interconnect performance
13141 **PLD** pulsed laser deposition
13142 **PNR** pre-normative research
13143 **PO** Programme Office
13144 **POC** proof of concept
13145 **PoC** point of connection
13146 **PPO** polyphenylene oxide
13147 **PPR** privacy protection requirement
13148 **PRD** pressure relief device
13149 **PRV** pressure relief valve
13150 **PSA** pressure swing adsorption
13151 **PSD** power spectral density
13152 **PSU** power supply unit
13153 **PSV** pressure safety valve
13154 **PTFE** poly-tetra-fluoro-ethylene

13155 **PtH** power-to-heat
13156 **PTL** porous transport layer
13157 **PV** photovoltaic
13158 **PVA** polyvinyl alcohol
13159 **PVBC** polyvinylbenzyl chloride
13160 **PVD** physical vapour deposition
13161 **QA** quality assurance
13162 **QC** quality control
13163 **R&D** research and development
13164 **R&I** research and innovation
13165 **RA** risk assessment
13166 **RBS** Rutherford backscattering spectroscopy
13167 **RCA** root cause analysis
13168 **RCS** regulations, codes and standards
13169 **RD&D** research, development and demonstration
13170 **RE** renewable energy
13171 **RED** reverse electrodialysis
13172 **REE** rare earth element
13173 **REELS** reflection electron energy loss spectroscopy
13174 **REESS** rechargeable electrical energy storage system
13175 **REPEX** replacement expenditure
13176 **RES** renewable energy source
13177 **RESS** rechargeable energy storage system
13178 **RF** radio frequency
13179 **RFB** redox flow battery
13180 **RFC** regenerative fuel cell
13181 **RH** relative humidity
13182 **RHE** reversible hydrogen electrode
13183 **RHS** right hand side
13184 **rMCC** reversible molten carbonate cell
13185 **rMCE** reversible molten carbonate electrolyser
13186 **rms** root-mean-square
13187 **RNA** ribonucleic acid
13188 **RO** reverse osmosis
13189 **RoC** region of convergence
13190 **RP** Ruddlesden-Popper
13191 **rPCC** reversible proton conducting ceramic cell
13192 **rPCE** reversible proton ceramic conducting electrolyser
13193 **rPEMC** reversible proton exchange membrane cell
13194 **RR** replacement reserve
13195 **rSOC** reversible solid oxide cell
13196 **rSOE** reversible solid oxide electrolyser
13197 **RT** room temperature
13198 **RU** repeating unit
13199 **rWGS** reverse water gas shift
13200 **RWTH** Rheinisch-Westfälische Technische Hochschule
13201 **S&T** scientific and technical
13202 **SANS** small-angle neutron scattering spectroscopy
13203 **SAT** site acceptance test
13204 **sat** solution aerosol thermolysis
13205 **SATP** standard ambient temperature and pressure
13206 **SAXS** small-angle X-ray scattering spectroscopy
13207 **SCR** secondary control reserve
13208 **SCSI** small computer system interface
13209 **ScSZ** scandia-stabilised zirconia
13210 **SDC** samarium-doped cerium oxide
13211 **SDO** standards developing organisation
13212 **SECM** scanning electrochemical microscopy
13213 **SEEC** surface enhanced ellipsometric contrast microscopy
13214 **SEM** scanning electron microscopy
13215 **SERS** surface-enhanced Raman spectroscopy

13216 **SEXAFS** surface-enhanced X-ray absorption fine structure spectroscopy

13217 **SHE** standard hydrogen electrode

13218 **SI** Système International d'Unités

13219 **SIAM** Society for Industrial and Applied Mathematics

13220 **SICM** scanning ion conductance microscopy

13221 **SIL** safety integrity level

13222 **SIM** scanning ion microscopy

13223 **SIMS** secondary ion mass spectroscopy

13224 **SLS** selective laser sintering

13225 **SMES** superconducting magnetic energy storage

13226 **SNG** synthetic natural gas

13227 **SNMS** sputtered neutral mass spectroscopy

13228 **SNOM** scanning near field optical microscopy

13229 **SoA** state of the art

13230 **SOC** solid oxide cell

13231 **SOE** solid oxide electrolyser

13232 **SOEC** solid oxide electrolysis cell

13233 **SOEL** solid oxide electrolysis

13234 **SOFC** solid oxide fuel cell

13235 **SoH** state of health

13236 **SOM** solid oxide membrane

13237 **SoS** security of supply

13238 **SPC** statistical process control

13239 **SPE** solid polymer electrolyte

13240 **SPFC** solid polymer fuel cell

13241 **SPM** scanning probe microscopy

13242 **SPS** spark plasma sintering

13243 **SRIA** strategic research and innovation agenda

13244 **SRL** societal readiness level

13245 **SRU** single repeating unit

13246 **SSC** solid state conductor

13247 **SSIMS** static secondary ion mass spectroscopy

13248 **SSO** storage system operator

13249 **SSRS** solid-state reactive sintering

13250 **STEM** scanning transmission electron microscopy

13251 **SThM** scanning thermal microscopy

13252 **STM** scanning tunnelling microscopy

13253 **STP** standard temperature and pressure

13254 **SUT** system under test

13255 **TC** Technical Committee

13256 **TCO** total cost of ownership

13257 **TCR** tertiary control reserve

13258 **TD** time domain

13259 **TDS** total dissolved solids

13260 **TEA** techno-economic analysis/assessment

13261 **TEM** transmission electron microscopy

13262 **TES** thermal energy storage

13263 **TG** thermogravimetry

13264 **TGA** thermogravimetric analysis

13265 **TH** Technische Hochschule

13266 **THD** total harmonic distortion

13267 **TIP** test input parameter

13268 **TL** transmission line

13269 **TMF** thermal mass flow

13270 **TOF-SIMS** time-of-flight secondary ion mass spectroscopy

13271 **TOP** test output parameter

13272 **TPB** triple-phase boundary

13273 **TPL** technology performance level

13274 **TPRD** thermally-activated pressure relief device

13275 **TR** Technical Report

13276 **TRL** technology readiness level

13277 **TS** Technical Specification
13278 **TSO** transmission system operator
13279 **TSO-E** transmission system operator - electricity
13280 **TSO-G** transmission system operator - gas
13281 **TZP** tetragonal zirconia polycrystal
13282 **UEL** upper explosive limit
13283 **UFL** upper flammability limit
13284 **UGS** underground gas storage
13285 **UHP** upper half of the complex frequency plane
13286 **UN** United Nations
13287 **UNTERM** United Nations Terminology Database
13288 **UPS** uninterruptible power system
13289 **URFC** unitised regenerative fuel cell
13290 **url** uniform resource locator
13291 **USA** United States of America
13292 **VA** Commonwealth of Virginia
13293 **VIM** International Vocabulary of Metrology
13294 **VPS** vacuum plasma spraying
13295 **VRE** variable renewable energy
13296 **VSC** vacuum slip casting
13297 **WA** United States federal state of Washington
13298 **WAXS** wide-angle X-ray scattering spectroscopy
13299 **WE** water electrolyser
13300 **WEC** water electrolysis cell
13301 **WG** working group
13302 **WGS** water gas shift
13303 **WPS** wet powder spraying
13304 **XAFS** X-ray absorption fine structure spectroscopy
13305 **XANES** X-ray absorption near edge spectroscopy
13306 **XAS** X-ray absorption spectroscopy
13307 **XPS** X-ray photoelectron spectroscopy
13308 **XRD** X-ray diffraction spectroscopy
13309 **XRF** X-ray fluorescence spectroscopy
13310 **YSZ** yttria-stabilised zirconia

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13322 **List of Symbols**

- 13323 (aq) subscript denoting aqueous phase (solution)
- 13324 (g) subscript denoting gaseous phase
- 13325 (l) subscript denoting liquid phase
- 13326 (s) subscript denoting solid phase
- 13327 * complex conjugation
- 13328 \odot convolution
- 13329 \otimes correlation
- 13330 ^1H protium
- 13331 ^2H deuterium
- 13332 $^2\text{H}^+$ deuteron cation
- 13333 $^2\text{H}^-$ deuteride anion
- 13334 ^3H tritium
- 13335 $^3\text{H}^+$ triton cation
- 13336 $^3\text{H}^-$ tritide anion
- 13337 A Tafel slope
- 13338 a_{H^+} hydrogen cation (proton) activity
- 13339 α thermal diffusivity
- 13340 α_{ct} charge transfer coefficient
- 13341 $B_C(\omega)$ capacitive susceptance
- 13342 **Bi** Biot number
- 13343 $B_L(\omega)$ inductive susceptance
- 13344 $B(\omega)$ frequency domain electrical susceptance
- 13345 c concentration
- 13346 c speed of light in vacuum
- 13347 **Ca** capillary number
- 13348 C_{dl} double layer capacitance
- 13349 \mathbb{C} set of complex numbers
- 13350 **D** deformation tensor
- 13351 **D** electric flux density
- 13352 D_+ cation diffusion coefficient
- 13353 D_- anion diffusion coefficient
- 13354 n_+ number of cations
- 13355 n_- number of anions
- 13356 **Da** Damköhler number
- 13357 **Dc** Darcy number
- 13358 δ loss tangent, $\delta = \frac{\text{Im}I(\omega)}{\text{Re}I(\omega)}$
- 13359 $\frac{\Delta X}{\Delta t}$ degradation rate
- 13360 $\nabla \cdot$ divergence
- 13361 \mathfrak{D} M-S diffusion coefficient
- 13362 \mathbf{D}_t substantial (material) derivative
- 13363 ∂_t partial time derivative
- 13364 **Du** Dukhin number
- 13365 $\Delta\nu_{\text{Cs}}$ hyperfine transition frequency of Cs
- 13366 **D** electric flux density
- 13367 ∂_x partial spatial derivative
- 13368 **E** electric field strength
- 13369 E energy
- 13370 U_{ab} voltage
- 13371 e elementary electric charge
- 13372 e^- electron
- 13373 E_a activation energy
- 13374 **Ec** Eckert number
- 13375 \in element of
- 13376 $\mathbf{e}_n dA$ vector surface element
- 13377 **Eo** Eötvös number
- 13378 ϵ_0 electric constant

13379	ϵ_r relative dielectric permittivity (dielectric constant)
13380	E_{eq} equilibrium electrode potential
13381	η efficiency
13382	η_e energy efficiency
13383	η_e^{HHV} energy efficiency for HHV
13384	η_{el} electrical efficiency
13385	η_{el}^{HHV} electrical efficiency based on HHV
13386	η_{el}^{LHV} electrical efficiency at LHV
13387	η_F Faradaic efficiency
13388	η_{sys} system efficiency
13389	η_{th} thermal efficiency
13390	Eu Euler number
13391	E electric field strength
13392	F Faraday constant
13393	F arbitrary operator
13394	f real frequency
13395	f_N Nyquist frequency
13396	f_s sampling frequency
13397	g body acceleration vector
13398	Γ Gamma function
13399	γ_{m,H^+} activity coefficient of the hydrogen ion (proton)
13400	G_{irrev} irreversible Gibbs free energy
13401	$G(\omega)$ frequency domain conductance
13402	Gr Grashof number
13403	∇ spatial gradient vector
13404	G_{rev} reversible Gibbs free energy
13405	G_{th} thermal conductance
13406	Gz Graetz number
13407	H enthalpy
13408	\hbar Planck constant
13409	h specific enthalpy
13410	$H(s)$ transfer function
13411	H^- protide anion
13412	H^0 enthalpy at SATP
13413	h electron hole
13414	H_i proton lattice interstitial site
13415	$h(t)$ unit step function, $h(t) = 0.5(1 + \text{sgn}(t))$
13416	H hydrogen
13417	I electric current
13418	I_{AC} Alternating current
13419	I_D displacement current
13420	Id identity vector
13421	I_{DC} Direct current
13422	\Im imaginary part operator, $\Im\{(\cdot)\} = 0.5(\cdot - (\cdot)^*)$
13423	\imath imaginary unit with property $(\pm\imath)^2 = -1$
13424	$I(\omega)$ frequency domain immittance
13425	$I(s)$ complex angular frequency domain immittance
13426	I_t total electric current
13427	$I(t)$ time domain immittance
13428	J current density
13429	J_0 exchange current density
13430	J_D displacement current density
13431	J_t total current density
13432	k thermal conductivity
13433	κ double layer thickness, $\kappa = \sqrt{\frac{F^2 \sum_i c_i z_i^2}{\epsilon_r \epsilon_0 RT}}$
13434	k_B Boltzmann constant
13435	K_{cd} luminous efficacy
13436	Kn Knudsen number
13437	λ_B Bjerrum length
13438	Λ_m^0 limiting molar conductivity

13439	Le Lewis number
13440	m^0 standard molality
13441	m_{H^+} molality of the hydrogen ion (proton)
13442	M_i' single negatively charged metal cation lattice interstitial site
13443	M_i'' double negatively charged metal cation lattice interstitial site
13444	M_i single positively charged metal cation lattice interstitial site
13445	$M_i^{\cdot\cdot}$ double positively charged metal cation lattice interstitial site
13446	M_M' single negatively charged metal cation regular lattice site
13447	M_M'' double negatively charged metal cation lattice site
13448	M_M single positively charged metal cation lattice site
13449	$M_M^{\cdot\cdot}$ double positively charged metal cation lattice site
13450	M_M^x metal cation lattice site
13451	m_{p^+} rest mass of a proton
13452	N_A Avogadro constant
13453	\mathbb{N} set of natural numbers
13454	n total number of cells connected in series in a stack
13455	\dot{n}_{H_2} molar hydrogen flow rate
13456	Nu Nusselt number
13457	OH_i' negatively charged hydroxyl anion lattice interstitial site
13458	OH_O positively charged hydroxyl anion oxide lattice site
13459	O_i'' double negatively charged oxide anion lattice interstitial site
13460	ω angular frequency
13461	O_O^{\cdot} single positively charged oxide anion lattice site oxide
13462	O_O^x oxide anion on its regular lattice site
13463	$\frac{d}{dx}$ ordinary derivative with respect to the variable x
13464	Ox oxidant
13465	P power
13466	p absolute pressure
13467	p^+ proton
13468	P_{aux} power of auxiliaries
13469	P_d areal power density
13470	Pe Péclet number
13471	P_{el} electric power
13472	pH negative of the common (decadic) logarithm of the hydrogen ion activity in solution
13473	P_{heat} heat
13474	ϕ relative humidity (RH)
13475	π irrational number, 3.14159265359...
13476	P_{el} electric power
13477	P_{in} input power
13478	P_{out} output power
13479	Pr Prandtl number
13480	p_{sat} pressure at saturation
13481	Ψ electric flux
13482	P_{th} thermal power
13483	P_v volumetric power density
13484	P electric polarisation
13485	P electric polarisation
13486	Q electric charge
13487	q_m mass flow rate
13488	Q_{rev} reversible heat
13489	q_V volume flow rate
13490	R resistance
13491	r_a position vector of point a
13492	r_b position vector of point b
13493	Ra Rayleigh number
13494	R_{ASR} area specific resistance
13495	R_{ct} charge transfer resistance
13496	Re Reynolds number
13497	\mathbb{R} set of real numbers
13498	$\cdot(\cdot)$ placeholder function
13499	\Re real part operator, $\Re\{\cdot(\cdot)\}=0.5(\cdot(\cdot)+\cdot(\cdot)^*)$

13500 **Red** redundant

13501 R_g universal gas constant

13502 ρ mass density

13503 q volumic electric charge

13504 **Ri** Richardson number

13505 $R(\omega)$ frequency domain resistance

13506 R_{th} thermal resistance

13507 S entropy

13508 s complex angular frequency,

13509 **Sc** Schmidt number

13510 S_E energy sink/source term

13511 $sgn(t)$ signum function, $sgn(t) = \frac{t}{|t|}$ & $sgn(0) = 0$

13512 **Sh** Sherwood number

13513 σ real frequency

13514 σ_e conductivity

13515 S_ρ mass sink/source term

13516 **St** Stanton number

13517 S surface

13518 T thermodynamic temperature

13519 T absolute temperature

13520 τ stress deviator tensor

13521 **T** stress tensor

13522 \top transpose

13523 t time

13524 τ time constant (relaxation time)

13525 t_d dew point

13526 T_g glass transition temperature

13527 θ_0 initial phase (argument) of a signal

13528 U internal energy

13529 **u** velocity vector

13530 U_{rev}^0 reversible voltage at SATP

13531 U_{tn}^0 thermoneutral cell voltage at SATP

13532 U_{cell} cell voltage

13533 U_{nom} nominal voltage

13534 U_{OCP} open circuit potential (OCP)

13535 U_{OCV} open circuit voltage (OCV)

13536 U_{rev} reversible voltage

13537 \bar{U}_{RU} average repeating unit voltage

13538 U_{tn} thermoneutral cell voltage

13539 V volume

13540 V_{AC} AC voltage

13541 ϑ Celsius temperature

13542 V_{DC} DC voltage

13543 V_i^x vacant lattice interstitial site

13544 V_M' single negatively charged metal cation lattice vacancy

13545 V_M'' double negatively charged metal cation lattice vacancy

13546 V_M^{\cdot} single positively charged metal cation lattice vacancy

13547 $V_M^{\cdot\cdot}$ double positively charged metal cation lattice vacancy

13548 V_O'' double negatively charged oxide anion lattice vacancy

13549 $V_O^{\cdot\cdot}$ double positively charged oxide anion lattice vacancy

13550 V_{RU} voltage of a repeating unit

13551 \bar{U}_{RU} average repeating unit voltage, $\bar{U}_{RU} = \frac{V_{RU}}{n}$

13552 V_T thermal voltage

13553 W number of possible arrangements of a system

13554 \times cross (vector) product

13555 $x(\omega)$ angular frequency domain input (excitation) signal

13556 $x(s)$ complex angular frequency domain input (excitation) signal

13557 $x(t')$ time domain input (excitation) signal

13558 $x(t)$ time domain input (excitation) signal

13559 x_1 arbitrary variable

13560 x_2 arbitrary variable
13561 $X_C(\omega)$ frequency domain capacitance
13562 $X_L(\omega)$ frequency domain inductance
13563 $X(\omega)$ frequency domain electrical reactance
13564 x arbitrary variable
13565 $y(\omega)$ frequency domain response (output) function
13566 $y(s)$ complex angular frequency domain response (output) function
13567 $y(t)$ time domain response (output) function
13568 $Y(\omega)$ frequency domain electrical admittance
13569 y arbitrary variable
13570 Z compressibility factor
13571 t_{\pm} ionic transference number
13572 z charge number
13573 z_+ cation valency
13574 z_- anion valency
13575 $Z(\omega)$ frequency domain electrical impedance

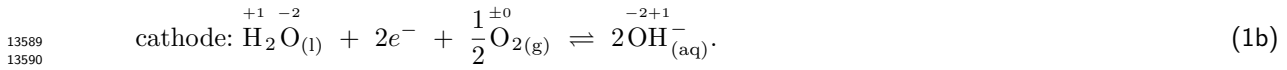
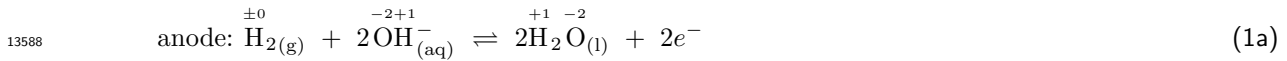
13576 **List of Tables**

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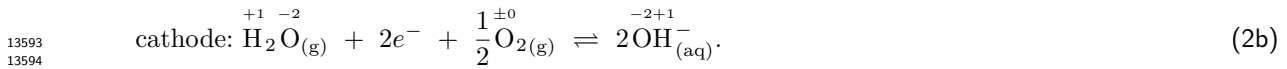
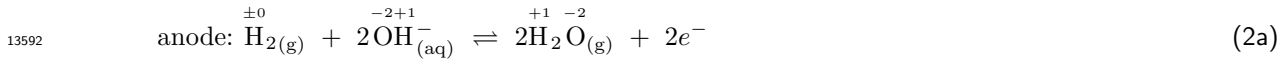
13585 **Annexes (informative)**

13586 **Annex 1. Electrode reactions in fuel cells**

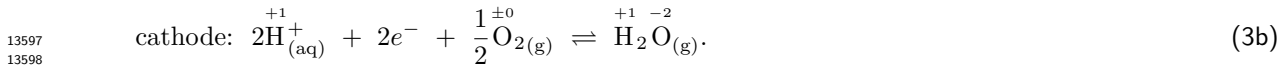
13587 For an AFC, the electrode reactions¹⁹ are



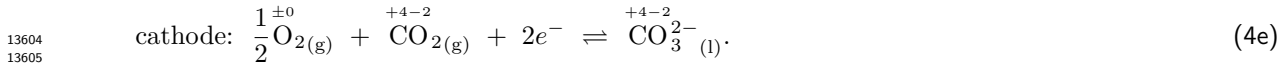
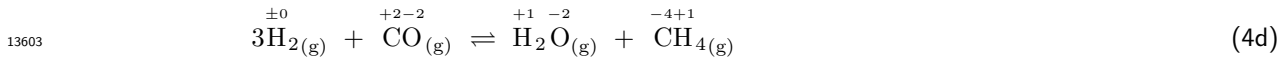
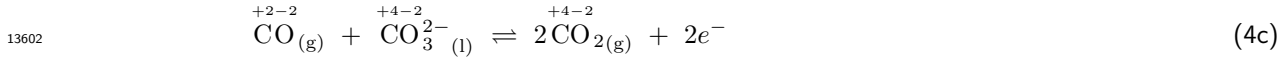
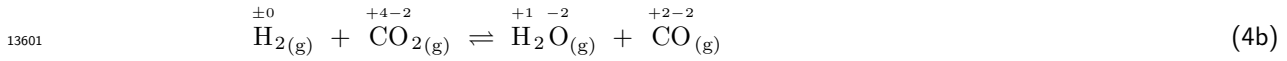
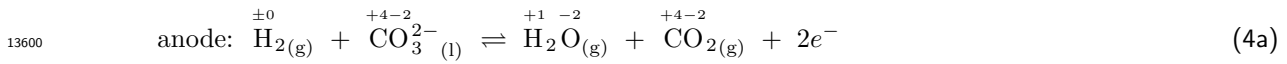
13591 For an anion exchange membrane fuel cell (AEMFC), the electrode reactions are



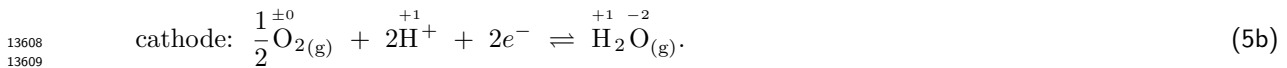
13595 For a PEFC, the electrode reactions are



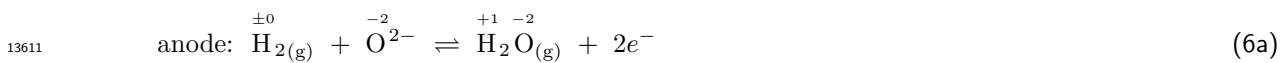
13599 For a MCFC, the electrode reactions are



13606 For a PCFC (H-SOFC), the electrode reactions are



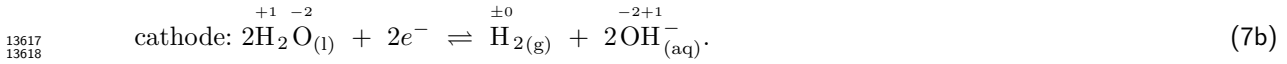
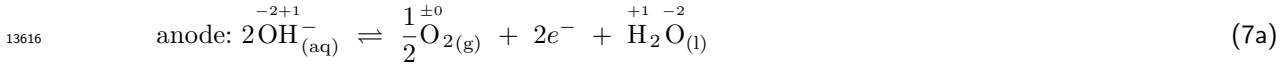
13610 For a SOFC (O-SOFC), the electrode reactions are



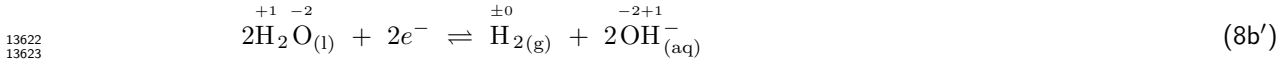
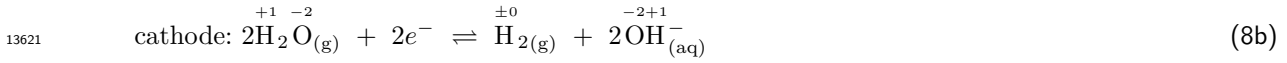
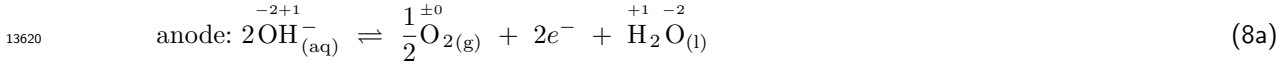
¹⁹The numbers above the ionic and molecular species are oxidation numbers of their constituent atoms.

13614 **Annex 2. Electrode reactions in electrolysis cells**

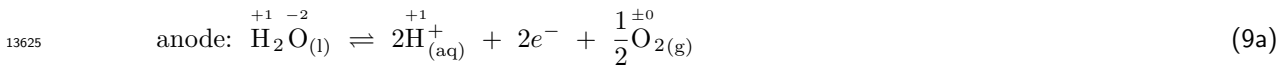
13615 For an alkaline electrolysis cell (AEC), the electrode reactions are



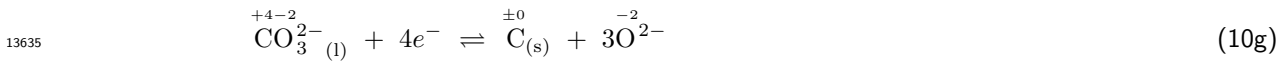
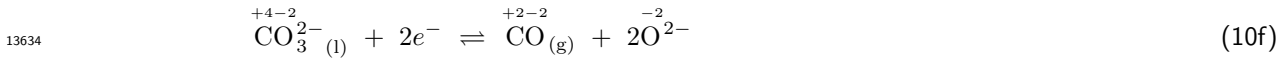
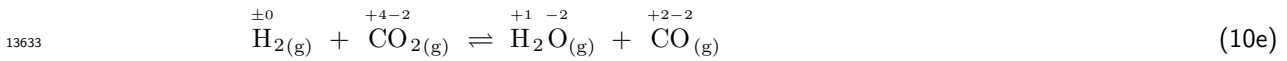
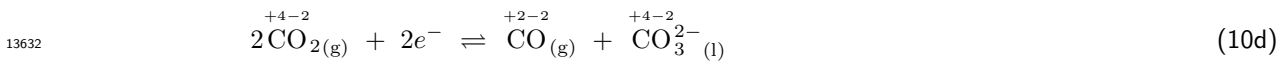
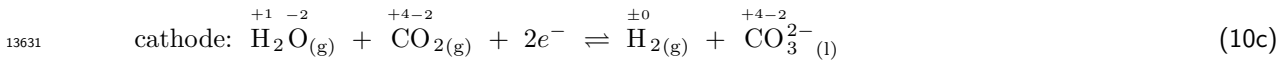
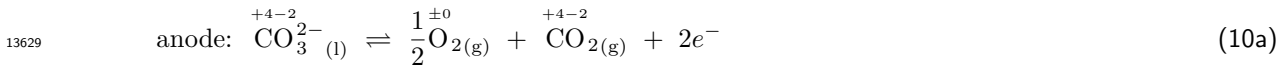
13619 For an AEMEC, the electrode reactions are



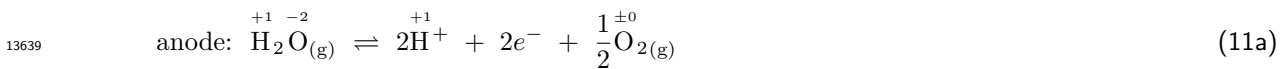
13624 without (8b) and with liquid water feed (8b') at the cathode. For a PEMEC, the electrode reactions are



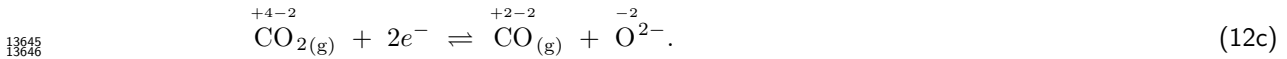
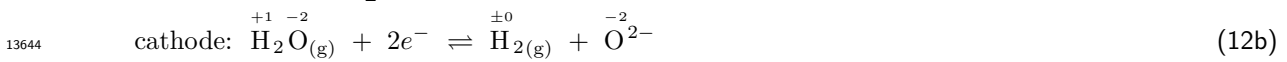
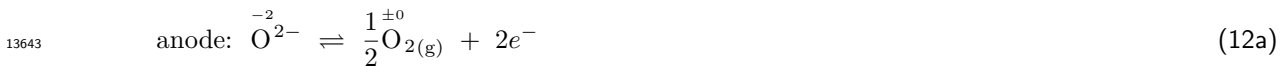
13628 For a MCEC, the electrode reactions are



13638 For a PCEC (H-SOEC), the electrode reactions are



13642 For a SOEC (O-SOEC), the electrode reactions are



13647 **Annex 3. ISQ quantities, units and constants**

13648 The names and symbols of the seven base ISQ quantities and their SI units are given in Table 2. Quantities
 13649 derived from these base quantities are given in Table 3 along with their units while Table 4 lists non-SI units
 13650 for use alongside SI units. The metric SI prefixes for multiples and sub-multiples of these units are given in
 13651 Table 5. Table 6 lists the seven defining SI constants and the corresponding units they define.

Table 2: ISQ base quantities (BIPM, 2019)

Base quantity	Base unit	
<i>Name</i>	<i>Name</i>	<i>Symbol</i>
length	metre	m
mass	kilogram	kg
time	second	s
electric current	ampere ²⁰	A
thermodynamic temperature	kelvin ²¹	K
amount of substance	mole	mol
luminous intensity	candela	cd

Table 3: Derived quantities (BIPM, 2019)

Derived quantity	Derived unit	
<i>Name</i>	<i>Name</i>	<i>Expressed in SI unit(s)</i>
plane angle	radian	rad=m m ⁻¹
frequency	hertz ²²	Hz=s ⁻¹
force	newton ²³	N=kg m s ⁻²
pressure, stress	pascal ²⁴	Pa=kg m ⁻¹ s ⁻²
energy, work, amount of heat	joule ²⁵	J=kg m ² s ⁻² =N m
power, radiant flux	watt ²⁶	W=kg m ² s ⁻³ =J s ⁻¹
electric charge	coulomb ²⁷	C= A s
electric potential difference	volt ²⁸	V=kg m ² s ⁻³ A ⁻¹ =W A ⁻¹
capacitance	farad ²⁹	F=kg ⁻¹ m ⁻² s ⁴ A ² =C V ⁻¹
electric resistance	ohm ³⁰	Ω=kg m ² s ⁻³ A ⁻² =V A ⁻¹
electric conductance	siemens ³¹	S=kg ⁻¹ m ⁻² s ³ A ² =A V ⁻¹
inductance	henry ³²	H=kg m ² s ⁻² A ⁻² =Wb A ⁻¹
Celsius temperature	degree Celsius ³³	°C=K
catalytic activity	katal	kat=mol s ⁻¹

²⁰This unit is named after French mathematician and physicist André-Marie Ampère (1775-1836).

²¹This unit is named after Irish engineer and physicist William Thomson Kelvin (1824-1907).

²²This unit is named after German physicist Heinrich Rudolf Hertz (1857-1894).

²³This unit is named after English mathematician, physicist and astronomer Isaac Newton (1642 [Julian calendar]-1727 [Gregorian calendar]).

²⁴This unit is named after French mathematician and physicist Blaise Pascal (1623-1662).

²⁵This unit is named after English physicist and mathematician James Prescott Joule (1818-1889).

²⁶This unit is named after Scottish engineer and chemist James Watt (1736-1819).

²⁷This unit is named after French engineer and physicist Charles-Augustin de Coulomb (1736-1806).

²⁸This unit is named after Italian chemist and physicist Alessandro Giuseppe Antonio Anastasio Volta (1745-1827).

²⁹This unit is named after English scientist Michael Faraday (1791-1867).

³⁰This unit is named after German mathematician and physicist Georg Simon Ohm (1789-1854).

³¹This unit is named after German engineer Ernst Werner von Siemens (1816-1892).

³²This unit is named after US scientist Joseph Henry (1797-1878).

³³This unit is named after Swedish astronomer, mathematician and physicist Anders Celsius (1701-1744).

Table 4: Non-SI units for use along with SI units (BIPM, 2019)

Quantity Name	Unit Name	Value in SI unit
time	minute	1 min=60 s
	hour	1 h=60 min=3,600 s
	day	1 d=24 h=86,400 s
plane angle	degree	$1^\circ = \frac{\pi}{180} \text{ rad}$
phase angle	minute	$1' = \frac{1}{60}^\circ = \frac{\pi}{10,800} \text{ rad}$
	second	$1'' = \frac{1}{60}' = \frac{\pi}{648,000} \text{ rad}$
volume	liter	1 l=1 dm ³ =1,000 cm ³ =0.001 m ³
mass	metric ton, tonne	1 t=1,000 kg
energy	electronvolt	1 eV= 1.602176634×10 ⁻¹⁹ J

Table 5: Metric SI prefixes (BIPM, 2019)

Factor	Prefix		Multiplying factor
	Name	Symbol	
10 ²⁴	yotta	Y	1,000,000,000,000,000,000,000,000
10 ²¹	zetta	Z	1,000,000,000,000,000,000,000
10 ¹⁸	exa	E	1,000,000,000,000,000,000
10 ¹⁵	peta	P	1,000,000,000,000,000
10 ¹²	tera	T	1,000,000,000,000
10 ⁹	giga	G	1,000,000,000
10 ⁶	mega	M	1,000,000
10 ³	kilo	k	1,000
10 ²	hecto	h	100
10 ¹	deca	da	10
10 ⁻¹	deci	d	0.1
10 ⁻²	centi	c	0.01
10 ⁻³	milli	m	0.001
10 ⁻⁶	micro	μ	0.000001
10 ⁻⁹	nano	n	0.000000001
10 ⁻¹²	pico	p	0.000000000001
10 ⁻¹⁵	femto	f	0.000000000000001
10 ⁻¹⁸	atto	a	0.000000000000000001
10 ⁻²¹	zepto	z	0.000000000000000000001
10 ⁻²⁴	yocto	y	0.00000000000000000000001

Table 6: Defining SI constants and corresponding units they define (BIPM, 2019)

Defining constant Name	Symbol	Numerical value	Unit
hyperfine transition frequency of Cs	$\Delta\nu_{\text{Cs}}$	9,192,631,770	Hz
speed of light in vacuum	c	299,792,458	m s ⁻¹
Planck constant ³⁴	\hbar	$6.62607015 \times 10^{-34}$	J s
elementary electric charge	e	$1.602176634 \times 10^{-19}$	C
Boltzmann constant ³⁵	k_{B}	1.380649×10^{-23}	J K ⁻¹
Avogadro constant ³⁶	N_{A}	$6.02214076 \times 10^{23}$	mol ⁻¹
luminous efficacy	K_{cd}	683	lm W ⁻¹

13652

³⁴This constant is named after physicist Max Karl Ernst Ludwig Planck (1858-1947) who won in 1918 the Nobel Prize in Physics.

³⁵This constant is named after Austrian physicist Ludwig Eduard Boltzmann (1844-1906).

³⁶This constant is named after Lorenzo Romano Amedeo Carlo Avogadro (1776-1856).

13653 **Annex 4. Formulary: Modelling**

13654 The Navier-Stokes (N-S) equation (conservation of linear (translational) momentum, $\rho\mathbf{u}$) reads

$$13655 \quad D_t(\rho\mathbf{u}) = -\nabla p + \nabla \cdot \boldsymbol{\tau} + \rho\mathbf{g} \quad (13)$$

13657 where D_t is substantial (material) derivative, $D_t = \partial_t + \mathbf{u} \cdot \nabla$, t is time, ∂_t is partial time derivative, \mathbf{u} is
 13658 velocity vector, ∇ is spatial gradient vector, ρ is mass density, p is absolute pressure, $\nabla \cdot$ is divergence, $\boldsymbol{\tau}$ is
 13659 stress deviator tensor, and \mathbf{g} is body acceleration vector (i. e. gravity, inertial, electrostatic, etc).

13660 The pressure term (volumetric stress tensor), $-\nabla p$ prevents motion due to normal stresses as the fluid
 13661 presses against itself keeping it from shrinking in volume. The stress term $\nabla \cdot \boldsymbol{\tau}$ causes fluid motion due to
 13662 horizontal friction and shear stresses resulting in turbulence and viscous flow.

13663 For a Newtonian fluid where the stress is proportional to the rate of deformation that is, the change in
 13664 velocity in the direction of the stress, the stress term reads $\nabla \cdot \boldsymbol{\tau} = \nabla \cdot (\mu(\nabla\mathbf{u} + (\nabla\mathbf{u})^\top)) - \frac{2}{3}\nabla(\mu\nabla \cdot \mathbf{u})$
 13665 where μ is dynamic viscosity and superscript \top denotes transpose.

13666 When the fluid is incompressible (isochoric) that is, $\nabla \cdot \mathbf{u} = 0$, the stress term reduces to $\nabla \cdot \boldsymbol{\tau} =$
 13667 $\nabla \cdot (\mu(\nabla\mathbf{u} + (\nabla\mathbf{u})^\top))$ and $\nabla \cdot \boldsymbol{\tau} = \mu\nabla^2\mathbf{u}$ for constant μ . That is, with constant mass density, the PDE (13)
 13668 simplifies to

$$13669 \quad D_t\mathbf{u} = -\frac{1}{\rho}\nabla p + \eta\nabla^2\mathbf{u} + \mathbf{g} \quad (13')$$

13671 where $\eta = \frac{\mu}{\rho}$ is kinematic viscosity. At steady state, $\partial_t \rightarrow 0$, the PDE (13') further simplifies to

$$13672 \quad \frac{1}{2}\nabla\mathbf{u}^2 = -\frac{1}{\rho}\nabla p + \eta\nabla^2\mathbf{u} + \mathbf{g} \quad (13'')$$

13674 for an irrotational fluid (zero vorticity, $\nabla \times \mathbf{u} = 0$) given the vector identity, $\mathbf{u} \cdot \nabla\mathbf{u} = \frac{1}{2}\nabla\mathbf{u}^2 - \mathbf{u} \times (\nabla \times \mathbf{u})$
 13675 where \times denotes cross (vector) product.

13676

13677 The PDE for conservation of mass (mass density balance) reads

$$13678 \quad \partial_t\rho + \nabla \cdot (\rho\mathbf{u}) = S_\rho \quad (14)$$

13680 where S_ρ is mass sink/source term. At steady state and constant mass density, this inhomogeneous continuity
 13681 equation reads

$$13682 \quad \rho\nabla \cdot \mathbf{u} = S_\rho. \quad (14')$$

13684

13685 The PDE for conservation of energy (energy balance) reads

$$13686 \quad D_t(\rho E) = \mathbf{T} \cdot \nabla\mathbf{u} + \nabla \cdot (k\nabla T) + S_E \quad (15)$$

13688 where E is energy (i. e. kinetic, potential, thermal, etc), $\mathbf{T} = (-p + \alpha\nabla \cdot \mathbf{u})\mathbf{Id} + 2\mu\mathbf{D}$ is stress tensor, α is
 13689 thermal diffusivity, \mathbf{Id} is identity vector, $\mathbf{D} = \frac{1}{2}(\nabla\mathbf{u} + (\nabla\mathbf{u})^\top)$ is deformation tensor, k is thermal conductivity,
 13690 T is thermodynamic temperature, and S_E is energy sink/source term.

13691

13692 In an n -component bulk fluid of single phase where inter-molecular collisions dominate over molecule-surface
 13693 wall collisions, the Maxwell-Stefan (M-S) diffusion equation reads

$$13694 \quad -\frac{x_i}{R_g T} \nabla_{T,p}\mu_i = \sum_{\substack{j=1 \\ j \neq i}}^n \frac{x_j N_i - x_i N_j}{\mathfrak{D}_{ij} c_t}, \quad x_i(j) = \frac{c_i}{c_t}, \quad c_t = \sum_{i=1}^n c_i \quad (16)$$

13695

13696 where N_i (N_j) is Maxwell-Stefan (M-S) diffusion flux of species i (j) having mole fraction (molar fraction) x_i
 13697 (x_j), R_g is universal gas constant, $\nabla_{T,p}\mu_i$ is spatial gradient of chemical potential of species i at constant T
 13698 and p , \mathfrak{D}_{ij} is M-S diffusion coefficient (diffusivity) of species i in species j with Onsager relation, $\mathfrak{D}_{ij} = \mathfrak{D}_{ji}$,
 13699 and c_t is total molar fluid concentration.

13700

13701 For mixture diffusion in macro-pores with additive Knudsen diffusion under low pressure and/or due to
 13702 small pores where molecule-surface wall collisions dominate over inter-molecular collisions, the Maxwell-Stefan
 (M-S) diffusion equation is the dusty gas model (DGM) to read

$$13703 \quad -\frac{x_i}{R_g T} \nabla_{T,p}\mu_i = \sum_{\substack{j=1 \\ j \neq i}}^n \frac{x_j N_i - x_i N_j}{\mathfrak{D}_{ij} c_t} + \frac{N_i}{\mathfrak{D}_{i, \text{Kn}}^{\text{eff}}} \quad (17)$$

13704

13705 where \mathbb{D}_{i, K_n} is effective Knudsen diffusivity of species i considering porosity and tortuosity.

13706 For mixture diffusion in micro-pores where the diffusing molecules sense the force field of the pore wall
 13707 surfaces, the Maxwell-Stefan (M-S) diffusion equation with additive surface diffusion for the non-wetting
 13708 species i and j and their molar surface fluxes, N_i^s and N_j^s , respectively reads

$$13709 \quad -\rho \frac{q_i}{R_g T} \nabla_{T,p} \mu_i = \sum_{\substack{j=1 \\ j \neq i}}^n \frac{q_j N_i^s - q_i N_j^s}{q_j^{sat} \mathbb{D}_{ij}^s} + \frac{N_i^s}{\mathbb{D}_i^s} \quad (18)$$

13711 where q_i (q_j) is loading of species i (j) in the pore, q_i^{sat} (q_j^{sat}) is saturation loading (capacity) of species i
 13712 (j) in the pore, \mathbb{D}_{ij}^s is Maxwell-Stefan (M-S) diffusion coefficient (diffusivity) of species i in the pore in the
 13713 presence of species j , and \mathbb{D}_i^s is diffusivity of species i on the surface of the pore wall (in the broadest sense).

13714 The sterically modified Poisson-Boltzmann equation reads, for example, in the case of a symmetric $z : z$
 13715 and an asymmetric $1 : z$ electrolyte

$$13717 \quad \epsilon \nabla^2 \phi = 8\pi z e c_b \frac{\sinh(z V_T^{-1} \phi)}{1 - 2a^3 c_b (1 - \cosh(z V_T^{-1} \phi))} \quad \text{and} \quad (19a)$$

$$13718 \quad = 8\pi z e c_b \frac{\sinh(z V_T^{-1} \phi)}{1 - (z+1)a^3 c_b \left(1 - \frac{\exp(z V_T^{-1} \phi) + z \exp(-z V_T^{-1} \phi)}{z+1}\right)}, \quad (19b)$$

13720 respectively where ϵ is dielectric constant, ϕ is electrostatic potential, z is charge number, e is elementary
 13721 electric charge, c_b is bulk concentration, $V_T = \frac{F}{R_g T}$ is thermal voltage, F is Faraday's constant, and a is ionic
 13722 radii.

13723 For $a \rightarrow 0$ (point charges), both second order ODE (19) reduces to the classical Poisson-Boltzmann
 13724 equation,

$$13725 \quad \epsilon \nabla^2 \phi = 8\pi z e c_b \sinh(z V_T^{-1} \phi). \quad (20)$$

13727 The molar Nernst-Planck flux, N_i of species i reads

$$13728 \quad N_i = -D_i (\nabla x_i + z_i V_T^{-1} x_i \nabla \phi) + \mathbf{u} x_i \quad (21)$$

13730 where D_i and z_i are diffusion coefficient and electric charge of species i , respectively.

13731 Annex 5. Formulary: Efficiencies

13732 From an electrochemical point of view where water saturated hydrogen and oxygen produced in electrolysis of
13733 incompressible water are assumed to behave as ideal gases, the energy efficiency of a WEC at temperature, T
13734 and pressure, p , is defined as (Lamy and Millet, 2020)

$$13735 \eta_{\text{WEC}}^{\text{th}}(T, p) = \frac{E_{\text{rev}}(T, p)}{E_{\text{irrev}}(T, p)} = \frac{U_{\text{tn}}(T, p)}{U_{\text{tn}}(T, p) + U_{\text{cell}} - U_{\text{rev}}(T, p, I = 0)} \quad (22)$$

13737 where E_{rev} and E_{irrev} are energy requirements under reversible (equilibrium) conditions (zero current, $I = 0$)
13738 and irreversible (non-equilibrium) conditions, respectively, U_{cell} is measured cell voltage (difference of electrode
13739 potentials at anode and cathode, respectively),

$$13740 U_{\text{tn}}(T, p) = \frac{\Delta H(T, p)}{2F} \quad (23)$$

13742 is thermoneutral cell voltage (i. e. $U_{\text{tn}}^0 = 1.481$ V for liquid water electrolysis at SATP) estimated from empirical
13743 polynomial formula, ΔH is change in enthalpy of formation of one mole of liquid water from its constituents
13744 (hydrogen and oxygen), F is Faraday constant,

$$13745 U_{\text{rev}}(T, p, I = 0) = \frac{\Delta G_{\text{rev}}(T, p, I = 0)}{2F} = \frac{\Delta H(T, p) - T\Delta S(T, p)}{2F} \quad (24)$$

13747 is reversible voltage (i. e. $U_{\text{rev}}^0 = 1.229$ V for liquid water electrolysis at SATP) estimated from empirical
13748 polynomial formula, ΔS is change in entropy of formation of one mole of liquid water,

$$13749 \Delta G_{\text{rev}}(T, p, I = 0) = 2FU_{\text{rev}}(T, p^0) + R_{\text{g}}T \ln \left(\frac{p^c - p_{\text{H}_2\text{O}}^{\text{sat}}}{p^0} \frac{p^0}{p_{\text{H}_2\text{O}}^{\text{sat}}} \sqrt{\frac{p^a - p_{\text{H}_2\text{O}}^{\text{sat}}}{p^0}} \right) \quad (25)$$

13751 is change in reversible Gibbs free energy of the total liquid water electrolysis cell reaction, p^0 is standard ambient
13752 pressure, R_{g} is universal gas constant, $p^a = p_{\text{H}_2}^a + p_{\text{O}_2}^a + p_{\text{H}_2\text{O}}^a$ and $p^c = p_{\text{H}_2}^c + p_{\text{O}_2}^c + p_{\text{H}_2\text{O}}^c$ are pressures at
13753 respectively anode and cathode,³⁷ p_{H_2} , p_{O_2} and $p_{\text{H}_2\text{O}}$ are partial pressures of respectively hydrogen, oxygen
13754 and water vapour and $p_{\text{H}_2\text{O}}^{\text{sat}}$ is water saturation pressure at operating temperature.

13755 Note, water activity, $a_{\text{H}_2\text{O}} = \frac{p_{\text{H}_2\text{O}}}{p^0}$ is taken as unity (Raoult's law) for AECs, AAEMECs and PEMECs due
13756 to the presence of liquid water at their electrodes.

13757 For nonzero current ($I \neq 0$), $E_{\text{rev}} < E_{\text{irrev}}$ due to inevitable energy losses (heat dissipation) induced by
13758 the transport of electric charge carriers (electrons and ions) across a WEC and thus, $\eta_{\text{WEC}}^{\text{th}} < 1$.

13759 In case the difference in enthalpy change at operating conditions (T and p), $\Delta H(T, p)$ and at SATP,
13760 ΔH^0 is small, $\Delta H(T, p) \approx \Delta H^0$, that is, near ambient temperature, U_{tn} in (22) may be replaced by the
13761 thermoneutral cell voltage at SATP, U_{tn}^0 yielding

$$13762 \eta_{\text{WEC}}^0(T, p) = \frac{U_{\text{tn}}^0}{U_{\text{tn}}^0 + U_{\text{cell}} - U_{\text{rev}}(T, p, I = 0)}. \quad (22')$$

13764 When the change in reversible heat, $\Delta Q_{\text{rev}} = T\Delta S(T, p)$ exchanged between WEC and its surrounding, is
13765 small compared to the changes in reversible Gibbs free energy, $\Delta G_{\text{rev}} = 2F U_{\text{rev}}$ and irreversible Gibbs free
13766 energy, $\Delta G_{\text{irrev}} = 2F U_{\text{cell}}$, that is, $\Delta Q_{\text{rev}}/\Delta G_{\text{rev}} < \Delta Q_{\text{rev}}/\Delta G_{\text{irrev}} \ll 1$, (22) simplifies to the cell voltage
13767 efficiency,

$$13768 \eta_{\text{U}}(T, p) = \frac{U_{\text{rev}}(1 + \Delta Q_{\text{rev}}/\Delta G_{\text{rev}})}{U_{\text{cell}}(1 + \Delta Q_{\text{rev}}/\Delta G_{\text{irrev}})} \approx \frac{U_{\text{rev}}(T, p)}{U_{\text{irrev}}(T, p)}. \quad (26)$$

13770 Note,

$$13771 \eta_{\text{th}} = \frac{U_{\text{tn}}^0}{U_{\text{cell}}} \quad (27)$$

13773 basically an expression of thermal efficiency, should not be used when $U_{\text{rev}} < U_{\text{cell}} \leq U_{\text{tn}}^0$ as the flow of heat
13774 particularly reversible heat, $Q_{\text{rev}} = 2F(U_{\text{tn}} - U_{\text{rev}})$, exchanged between WEC and its surrounding is neglected
13775 in the denominator of (27) while it is taken into account in the numerator.

13776

³⁷The sum of partial pressures of all gases present at the respective electrode including any crossover and (inert) feed gas is the total pressure at the said electrode.

13777 From a WE application point of view, energy efficiency is defined as specific energy consumption based
 13778 on HHV (Lamy and Millet, 2020),

$$13779 \eta_e^{\text{HHV}} = \frac{\text{energy content of products}}{\text{total energy requirements}} = \frac{\text{HHV}(T, p) \cdot \dot{n}_{\text{H}_2}}{P_{el} + P_{th} + P_{aux}} \quad (28)$$

13780

13781 where HHV, \dot{n}_{H_2} , $P_{el}=U_{\text{cell}} \cdot I$, P_{th} and P_{aux} are higher heating value per mole of hydrogen, molar hydrogen
 13782 flow rate, electric power, thermal power and power of auxiliaries, respectively and I is electric current; for
 13783 stacks and systems, auxiliaries are balance of plant (BoP) components.

13784 When instead of molar hydrogen flow rate mass (volumetric) hydrogen flow rate is used, the HHV per
 13785 kilogram (cubic meter) of hydrogen should be used. In place of HHV, LHV may also be used in (28) allowing
 13786 comparison with other fuels in a process chain.

13787 Dividing the heating value (HHV or LHV) of hydrogen at SATP by energy efficiency, the amount of energy
 13788 (electricity and heat) required to produce a unit amount (mole, kilogram or cubic meter) of hydrogen (specific
 13789 energy consumption) under SATP conditions is estimated.

13790 Remark, specific energy consumption under reference conditions such as SATP is a useful KPI for compar-
 13791 ing electrolyser whether product or technology as well as a required input particularly for CBA and life cycle
 13792 assessment (LCA).

13793

13794 Assuming the ideal gas law for hydrogen, oxygen and water vapour (steam), the Faradaic efficiency is

$$13795 \eta_F = q_{v\text{H}_2} \cdot \frac{p}{R_g T} \cdot \frac{2F}{I} \quad (29)$$

13796

13797 where $q_{v\text{H}_2}$ is volume flow rate of hydrogen and p is hydrogen pressure.

13798 **Annex 6. Formulary: Energy economics**

13799 For an energy source, energy return on energy invested (EROI) is

13800
$$\text{EROI} = \frac{\text{energy delivered}}{\text{energy required to deliver that energy}}. \quad (30)$$

13801

13802 For an ES, energy stored on energy invested (ESOI) is

13803
$$\text{ESOI} = \frac{\text{energy stored}}{\text{energy required to obtain that energy}}. \quad (31)$$

13804

13805 For an ES, energy stored on return (ESOR) is

13806
$$\text{ESOR} = \frac{\text{energy stored over the lifetime of the energy storage}}{\text{energy required to build the energy storage}}. \quad (32)$$

13807

13808 For a system, levelised cost of energy (LCOE) is

13809
$$\text{LCOE (currency/MWh)} = \frac{\text{TCO of the system (currency)}}{\text{energy generated by the system during its lifetime (MWh)}}. \quad (33)$$

13810

13811 For an electrolyser, LCOE is

13812
$$\text{LCOE (currency/MWh)} = \frac{\text{TCO of the electrolyser (currency)}}{\text{energy consumed by the electrolyser during its lifetime (MWh)}}. \quad (34)$$

13813

13814 For a system, levelised cost of hydrogen (LCOH) is

13815
$$\text{LCOH (currency/kg)} = \frac{\text{TCO of the electrolyser (currency)}}{\text{hydrogen produced by electrolyser during its lifetime (kg)}}. \quad (35)$$

13816

13817 For an energy storage system (ESS), levelised cost of storage (LCOS) is

13818
$$\text{LCOS (currency/MWh)} = \frac{\text{TCO of the ESS (currency)}}{\text{energy released from the ESS during its lifetime (MWh)}}. \quad (36)$$

13819

Annex 7. Integral transform properties

The properties (theorems) of LIT of $f(t)$ (and $g(t)$) and ILIT of $F(s)$ (and $G(s)$) are given in Table 7.

Table 7: Properties of Laplace integral transform

Property	$f(t) = \frac{1}{2\pi} \int_{\sigma-i\infty}^{\sigma+i\infty} F(s) e^{-st} ds$	$F(s) = \int_0^{+\infty} f(t) e^{st} dt$
Linearity ³⁸ (for arbitrary a_i)	$\sum_i a_i f_i(t)$	$\sum_i a_i F_i(s)$
Complex conjugation (denoted by superscript *)	$f^*(t)$	$F^*(s^*)$
Time reversal ³⁹	$f(-t)$	$F(-s)$
Time scaling (for arbitrary a)	$f(at)$	$ a ^{-1} F\left(\frac{s}{a}\right)$
Frequency scaling	$ a ^{-1} f\left(\frac{t}{a}\right)$	$F(as)$
Time shifting (for arbitrary a)	$(f \cdot h)(t - a)$	$e^{-as} F(s)$
Frequency shifting	$e^{\mp at} f(t)$	$F(s \pm a)$
Time differentiation ⁴⁰	$f^{(n)}(t), n \in \mathbb{N}$	$s^n F(s) - \sum_{k=0}^{n-1} s^{n-k-1} f^{(k)}(0^-)$
Frequency differentiation (t^n multiplication)	$t^n f(t), n \in \mathbb{N}$	$(-1)^n F^{(n)}(s)$
Time integration ⁴¹	$\int_0^t f(\tau) \frac{(t-\tau)^{n-1}}{(n-1)!} d\tau$	$s^{-n} F(s)$
Frequency integration (t division)	$t^{-1} f(t)$	$\int_s^\infty F(u) du, u \in \mathbb{C}$
Time convolution ⁴² (Laplace domain multiplication)	$(f \odot g)(t)$	$(F \cdot G)(s)$
Frequency convolution ⁴³ (TD multiplication)	$(f \cdot g)(t)$	$(F \odot G)(s)$
Time cross-correlation ⁴⁴ (covariance)	$(f \otimes g)(t)$	$F^*(-s^*) \cdot G(s)$
Time auto-correlation	$(f \otimes f)(t)$	$F^*(-s^*) \cdot F(s)$
Frequency cross-correlation	$f^*(-t) \cdot g(t)$	$(F \otimes G)(s)$
Frequency auto-correlation	$f^*(-t) \cdot f(t)$	$(F \otimes F)(s)$
$f(t)$ is periodic with period T	$f(t) = f(t + T), t \geq 0$	$\frac{1}{1-e^{-Ts}} \int_0^T f(t) h(t) e^{-st} dt$
Initial value theorem (IVT) ⁴⁵	$\lim_{t \rightarrow 0^+} f(t)$	$\lim_{\sigma \rightarrow \infty} sF(s)$

continued on next page

³⁸This includes the properties of homogeneity and superposition (addition).

³⁹This reflects the RoC of $F(s)$.

⁴⁰For arbitrary n , the ordinary derivative denoted by superscript (n) becomes a differintegral.

⁴¹

$$\int_0^t f(\tau) \frac{(t-\tau)^{n-1}}{(n-1)!} d\tau = \underbrace{\int_0^t \cdots \int_0^t}_{n \text{ times}} f(\tau) \underbrace{d\tau \cdots d\tau}_{n \text{ times}}; \text{ for } n = 1, \text{ for example,}$$

$$\mathcal{L} \left\{ \int_0^t f(\tau) d\tau \right\} (s) = \mathcal{L} \{ (f \odot h)(t) \} (s) = \frac{F(s)}{s} \text{ applies to the pre-initial limit, } t = 0^- \text{ while}$$

$$\mathcal{L} \left\{ \int_0^t f(\tau) d\tau \right\} (s) = \frac{F(s)}{s} - \frac{f(0^+)}{s} \text{ applies to the post-initial limit, } t = 0^+ \text{ with non-vanishing } \lim_{\epsilon \rightarrow 0} \int_{-\epsilon}^{+\epsilon} f(\tau) d\tau.$$

⁴²TD convolution denoted by \odot , is defined as

$$(f \odot g)(t) = \int_0^t f(\tau) g(t-\tau) d\tau.$$

⁴³Complex angular frequency domain convolution denoted by \odot , is defined as

$$(F \odot G)(s) = \frac{1}{2\pi i} \int_{\gamma-i\infty}^{\gamma+i\infty} F(u) G(s-u) du \text{ with } \Re u = \gamma \text{ entirely within the RoC of } F(u).$$

⁴⁴TD cross-correlation denoted by \otimes , is defined as

$$(f \otimes g)(t) = \int_0^t f^*(\tau) g(t+\tau) d\tau.$$

⁴⁵Here, $F(s)$ is a strictly proper fraction that is, its numerator polynomial is of lower order than its denominator polynomial.

Table 7 – continued from previous page

Property	$f(t) = \mathcal{L}^{-1}\{F(s)\}(t)$	$F(s) = \mathcal{L}\{f(t)\}(s)$
Generalised initial value theorem (GIVT) ⁴⁶ for irrational $f(t)$, $\lambda > -1$	$\lim_{t \rightarrow 0^+} t^{-\lambda} f(t)$	$\frac{1}{\Gamma(\lambda+1)} \lim_{\sigma \rightarrow \infty} s^{\lambda+1} F(s)$
Final value theorem (FVT) ⁴⁷	$\lim_{t \rightarrow \infty} f(t)$	$\lim_{\sigma \rightarrow 0^+} s F(s)$
Generalised final value theorem (GFVT) ⁴⁸ for $\langle f(t) \rangle_t$	$\lim_{t \rightarrow \infty} \langle f(t) \rangle_t$	$\lim_{\sigma \rightarrow 0^+} s F(s)$
GFVT ⁴⁹ for irrational $f(t)$, $\lambda > -1$	$\lim_{t \rightarrow \infty} t^{-\lambda} f(t)$	$\frac{1}{\Gamma(\lambda+1)} \lim_{\sigma \rightarrow 0^+} s^{\lambda+1} F(s)$

13822

13823 The properties (theorems) of FIT of $f(t)$ (and $g(t)$) and IFIT of $F(\omega)$ (and $G(\omega)$) are given in Table 8.

Table 8: Properties of Fourier integral transform

Property	$f(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F(\omega) e^{i\omega t} d\omega$	$F(\omega) = \int_{-\infty}^{\infty} f(t) e^{-i\omega t} dt$
Linearity ⁵⁰ (for arbitrary a_i)	$\sum_i a_i f_i(t)$	$\sum_i a_i F_i(\omega)$
Complex conjugation	$f^*(t)$	$F^*(-\omega)$
Duality	$F(t)$	$2\pi f(-\omega)$
Time reversal	$\frac{1}{2\pi} F(-t)$	$f(\omega)$
Time scaling ⁵¹ (for arbitrary a)	$f(-t)$	$F(-\omega)$
Frequency scaling (for arbitrary a)	$f(at)$	$\frac{1}{ a } F\left(\frac{\omega}{a}\right)$
Time shifting ⁵² (modulation in time)	$\frac{1}{ a } f\left(\frac{t}{a}\right)$	$F(a\omega)$
Frequency shifting (modulation in frequency)	$f(t \pm t_0)$, $t_0 \in \mathbb{R}$	$e^{\pm i\omega t_0} F(\omega)$
Time differentiation ⁵³	$e^{\pm i\omega_0 t} f(t)$, $\omega_0 \in \mathbb{R}$	$F(\omega \mp \omega_0)$
Frequency differentiation (t^n multiplication)	$f^{(n)}(t)$, $n \in \mathbb{N}$	$(i\omega)^n F(\omega)$
Time integration ⁵⁴	$t^n f(t)$, $n \in \mathbb{N}$	$i^n F^{(n)}(\omega)$
Frequency integration (t division)	$\int_{-\infty}^t f(t) dt$	$(i\omega)^{-1} F(\omega) + \pi F(0)\delta(\omega)$
Area under $f(t)$	$\frac{f(t)}{t}$	$\int_{i\omega}^{\infty} F(\omega) d\omega$
Area under $F(\omega)$	$\int_{-\infty}^{\infty} f(t) dt$	$F(0)$
Time convolution ⁵⁵ (Fourier domain multiplication)	$f(0)$	$\int_{-\infty}^{\infty} F(\omega) d\omega$
	$(f \odot g)(t)$	$(F \cdot G)(\omega)$

continued on next page

⁴⁶It should be used when the limit of $f(t)$ as $t \rightarrow 0^+$ does not exist and $f(t)$ is irrational (Ortigueira and Machado, 2020); Γ is the Gamma function (Abramowitz and Stegun, 1972).

⁴⁷All poles of $sF(s)$ shall be in the lower half of the complex frequency plane (LHP).

⁴⁸It should be used when the limit of $f(t)$ as $t \rightarrow \infty$, $\lim_{t \rightarrow \infty} f(t)$ does not but the average (mean) of $f(t)$,

$$\langle f(t) \rangle_t = \frac{1}{t} \int_{0^-}^t f(\tau) d\tau = \frac{1}{t} \int_{0^-}^{+\infty} f(\tau) h(t-\tau) d\tau \text{ exists (Gluskin, 2003).}$$

⁴⁹It should be used when the limit of $f(t)$ as $t \rightarrow \infty$ does not exist and $f(t)$ is irrational (Gluskin and Walraevens, 2011).

⁵⁰This includes the properties of homogeneity and superposition (addition).

⁵¹Time dilation means frequency contraction and *vice versa*. For large (small) $1 \ll |a|$ ($|a| \ll 1$), $f(at)$ ($\frac{1}{|a|} F\left(\frac{\omega}{a}\right)$) is concentrated around $t = 0$ ($\omega = 0$) and $\frac{1}{|a|} F\left(\frac{\omega}{a}\right)$ ($f(at)$) spreads out and flattens.

⁵²Time translation is either advance, $t + t_0$ or delay, $t - t_0$.

⁵³For arbitrary n , the ordinary derivative denoted by superscript (n) becomes a differintegral.

⁵⁴

$$\int_{-\infty}^t f(t) dt = (f \odot h)(t); \delta(\omega) \text{ is Dirac delta distribution (Abramowitz and Stegun, 1972).}$$

⁵⁵In the TD domain, convolution denoted by \odot is defined as

$$(f \odot g)(t) = \int_{-\infty}^{\infty} f(\tau) g(t-\tau) d\tau = (g \odot f)(t) = \int_{-\infty}^{\infty} g(\tau) f(t-\tau) d\tau.$$

Table 8 – continued from previous page

Property	$f(t) = \mathcal{F}^{-1}\{F(\omega)\}(t)$	$F(\omega) = \mathcal{F}\{f(t)\}(\omega)$
Frequency convolution ⁵⁶ (TD multiplication)	$(f \cdot g)(t)$	$(F \odot G)(\omega) = (G \odot F)(\omega)$
Time cross-correlation ⁵⁷ (covariance)	$(f \otimes g)(t)$	$(F \cdot G^*)(\omega)$
Time auto-correlation ⁵⁸ (power spectrum)	$(f \otimes f)(t)$	$ F(\omega) ^2$
Frequency cross-correlation ⁵⁹	$(f \cdot g^*)(t)$	$(F \otimes G)(\omega) = F^*(-\omega) \odot G(\omega)$
Frequency auto-correlation	$(f \cdot f)(t)$	$(F \otimes F)(\omega)$
$f(t)$ is periodic, $f(t) = f(t + T)$, $t \geq 0$ with period $T = \frac{2\pi}{\omega_0}$	$\sum_{k=-\infty}^{\infty} F[k] e^{ik\omega_0 t}$	$\frac{2\pi}{T} \sum_{k=-\infty}^{\infty} F[k\omega_0] \delta(\omega - k\omega_0)$
$f(t) \in \mathbb{R}$ (symmetry) ⁶⁰	$f(t) = f^*(t)$	$F(\omega) = F^*(-\omega)$ ⁶¹
$f(t) \in \mathbb{R}$ is even (Hermitian) ⁶²	$f(t) = f(-t)$	$F(\omega) = F(-\omega) \in \mathbb{R}$ is even
$f(t) \in \mathbb{R}$ is odd (non-Hermitian)	$f(t) = -f(-t)$	$F(\omega) = -F(-\omega) \in i\mathbb{R}$ is odd
$f(t) \in i\mathbb{R}$ (anti-symmetry) ⁶³	$f(t) = -f^*(t)$	$F(\omega) = -F^*(-\omega)$ ⁶⁴
$f(t) \in i\mathbb{R}$ is even (non-Hermitian)	$f(t) = f(-t)$	$F(\omega) = F(-\omega) \in i\mathbb{R}$ is even
$f(t) \in i\mathbb{R}$ is odd (Hermitian)	$f(t) = -f(-t)$	$F(\omega) = -F(-\omega) \in \mathbb{R}$ is odd
Normalisation	$\int_{-\infty}^{\infty} f(t) ^2 dt = 1$	$\frac{1}{2\pi} \int_{-\infty}^{\infty} F(\omega) ^2 d\omega = 1$
Plancherel theorem ⁶⁵	$\int_{-\infty}^{\infty} f(t) ^2 dt$	$\frac{1}{2\pi} \int_{-\infty}^{\infty} F(\omega) ^2 d\omega$
Generalised Plancherel theorem ⁶⁶	$\int_{-\infty}^{\infty} (f \cdot g^*)(t) dt$	$\frac{1}{2\pi} \int_{-\infty}^{\infty} (F \cdot G^*)(\omega) d\omega$

13824

If both, $f(t)$ and $g(t)$ are causal, then

$$(f \odot g)(t) = \int_0^{\infty} f(\tau) g(t - \tau) d\tau = \int_0^{\infty} g(\tau) f(t - \tau) d\tau.$$

If $g(t) = \delta(t)$, then one has the identity $(f \odot \delta)(t) = (\delta \odot f)(t) = f(t)$.

⁵⁶In the angular frequency domain, convolution denoted by \odot is defined as

$$(F \odot G)(\omega) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F(\nu) G(\omega - \nu) d\nu = \frac{1}{2\pi} \int_{-\infty}^{\infty} G(\omega) f(\omega - \nu) d\tau.$$

⁵⁷In the TD, cross-correlation denoted by \otimes is defined as

$$(f \otimes g)(t) = \int_{-\infty}^{\infty} f^*(\tau) g(t + \tau) d\tau = f^*(-t) \odot g(t) = \int_{-\infty}^{\infty} f^*(\tau) g(t - \tau) d\tau.$$

⁵⁸This is known as Wiener-Khinchin theorem named after US mathematician Norbert Wiener (1894-1964) and Russian mathematician Aleksandr Yakovlevich Khinchin (1894-1959).

⁵⁹In the angular frequency domain, cross-correlation denoted by \otimes is defined as

$$(F \otimes G)(\omega) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F^*(\nu) G(\omega + \nu) d\nu = F^*(-\omega) \odot G(\omega) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F^*(\nu) G(\omega - \nu) d\nu.$$

⁶⁰This is known as reality condition, $f(t) = \Re f(t) = 0.5(f(t) + f^*(t))$.

⁶¹This results in Hermitian $F(\omega) = 0.5(F(\omega) + F^*(-\omega))$.

⁶²If $f(t)$ is Hermitian, $f(t) = 0.5(f(t) + f(-t))$, then $(f \odot g)(t) = (f \otimes g)(t)$. If both, $f(t)$ and $g(t)$ are Hermitian, then $(f \otimes g)(t) = (g \otimes f)(t)$.

⁶³That is, $f(t) = \Im f(t) = -0.5i(f(t) - f^*(t))$.

⁶⁴This results in non-Hermitian $F(\omega) = -0.5i(F(\omega) - F^*(-\omega))$.

⁶⁵This theorem is named after Swiss mathematician Michel Plancherel (1885-1967). It also known as Rayleigh energy theorem due to John William Strutt, Lord Rayleigh (1842-1919) who won in 1904 the Nobel Prize in Physics. This theorem states that the total energy (or information) contained in $f(t)$ is reserved, i. e. $f(t)$ is represented equivalently in either the TD or angular frequency domain with no energy (information) gained or lost. Note, $(f \cdot f^*)(t) = |f(t)|^2 = |f^*(t)|^2$ and $(F \cdot F^*)(\omega) = |F(\omega)|^2 = |F^*(\omega)|^2$ which represents power or PSD of $f(t)$ and $F(\omega)$, respectively which is the distribution of energy within the range of angular frequencies.

⁶⁶In the context of Fourier series, this theorem is known as Parseval identity theorem named after French mathematician Marc-Antoine Parseval des Chênes (1755-1836).

13825 **Annex 8. Immittance**

13826 In the TD, $t \in \mathbb{R}$, the immittance, $I(t') \in \mathbb{R}$, $t' \in \mathbb{R}$ is for all $t' \leq t$ defined indirectly through a convolution
13827 integral (Malkow, 2017),

$$13828 \quad y(t) = (x \odot I)(t) = \int_{-\infty}^t I(t') x(t-t') dt' \quad (37)$$

13829

where $y(t) \in \mathbb{R}$ is the system response or output signal to an arbitrary non-zero excitation or input signal, $x(t') \in \mathbb{R}$. When a real electrochemical system (ECS) is excited by a causal input signal, for example, a sinusoidal signal,

$$x(t') \propto \sin(\omega t' + \theta_0)$$

13830 where $\omega \in \mathbb{R}$, is the angular frequency and θ_0 is the initial phase (argument) of the input signal, the lower
13831 integration limit can be set to zero. That is, $y(t)=0$ for all $t \leq 0$ since $x(t')$ vanishes for all $t < 0$.

13832 Then, the convolution (37) reads

$$13833 \quad y(t) = \int_0^\infty I(t') x(t-t') dt'. \quad (38)$$

13834

13835 In the complex angular frequency domain, $s \in \mathbb{C}$, the immittance, $I(s) \in \mathbb{C}$ is defined by

$$13836 \quad I(s) = \frac{y(s)}{x(s)}, \quad |x(s)| \neq 0 \quad (39)$$

13837

13838 where $x(s)=\mathcal{L}\{x(t)\}(s)$ is the Laplace integral transform of the TD input (excitation) signal and $y(s)=\mathcal{L}\{y(t)\}(s)$
13839 is the Laplace integral transform of the TD output (response) signal, obtained by applying Laplace integral
13840 transform on the convolution (38).

13841 In the angular frequency domain, the immittance, $I(\omega) \in \mathbb{C}$, is defined by

$$13842 \quad I(\omega) = \frac{y(\omega)}{x(\omega)}, \quad x(\omega) \neq 0 \quad (40)$$

13843

13844 where $x(\omega)=\mathcal{F}\{x(t)\}(\omega)$ is the Fourier integral transform of the input (excitation) signal in the TD and
13845 $y(\omega)=\mathcal{F}\{y(t)\}(\omega)$ is the Fourier integral transform of the output signal (response) in the TD, obtained by
13846 applying the Plemelj-Sochocki formula (Sochocki, 1873, Plemelj, 1908) to the Laplace transformed output-
13847 input ratio (39) yielding

$$13848 \quad \lim_{\sigma \rightarrow 0^+} [I(-\iota s) - I(\iota s^*)] = I(\omega) \quad (41a)$$

$$13849 \quad \lim_{\sigma \rightarrow 0^+} [I(-\iota s) + I(\iota s^*)] = \int_{-\infty}^{\infty} \frac{I(\nu) d\nu}{\omega - \nu \pi \iota}. \quad (41b)$$

13850

13851 Using Laplace domain parity $I(s) = I^*(s^*)$ and thus $I(\iota s) = I^*(-\iota s^*)$ in (41) yields using some algebra

$$13852 \quad \Re I(\omega) = \int_{-\infty}^{\infty} \frac{\Im I(\nu) d\nu}{\nu - \omega \pi} \quad (42a)$$

$$13853 \quad \Im I(\omega) = \int_{-\infty}^{\infty} \frac{\Re I(\nu) d\nu}{\omega - \nu \pi}, \quad (42b)$$

13854

13855 the HIT of the real and imaginary immittance parts. Using Fourier domain parity $I(\omega) = I^*(-\omega)$ in (42)
13856 yields using some algebra

$$13857 \quad \Re I(\omega) = \frac{2}{\pi} \int_0^\infty \frac{\nu \Im I(\nu)}{\nu^2 - \omega^2} d\nu \quad (43a)$$

$$13858 \quad \Im I(\omega) = \frac{2}{\pi} \int_0^\infty \frac{\omega \Re I(\nu)}{\omega^2 - \nu^2} d\nu, \quad (43b)$$

13859

13860 the KKR of the real and imaginary immittance parts. Knowing $\int_0^\infty |\nu^2 - \omega^2|^{-1} d\nu = 0$, one finds equivalently

$$13861 \quad \Re I(\omega) = \frac{2}{\pi} \int_0^\infty \frac{\nu \Im I(\nu) - \omega \Re I(\omega)}{\nu^2 - \omega^2} d\nu \quad (43a')$$

$$13862 \quad \Im I(\omega) = \frac{2}{\pi} \int_0^\infty \frac{\omega \Re I(\nu) - \omega \Re I(\omega)}{\omega^2 - \nu^2} d\nu. \quad (43b')$$

13863

13864 HIT (42) can be used to numerically validate measured immittances $I(\omega)$ employing FFT, $\mathcal{F}\mathcal{F}\mathcal{T}\{I(t)\}(\omega) =$
 13865 $I(\omega)$ and its inverse (IFFT), $\mathcal{F}\mathcal{F}\mathcal{T}^{-1}\{I(\omega)\}(t) = I(t)$ along with the FIT convolution property (see Table 8),
 13866

$$13867 \quad \mathcal{F}\mathcal{F}\mathcal{T}\{i \operatorname{sgn}(t) \cdot \mathcal{F}\mathcal{F}\mathcal{T}^{-1}\{\Re I(\omega)\}(t)\}(\omega) = \Im I(\omega) \quad (45a)$$

$$13868 \quad \mathcal{F}\mathcal{F}\mathcal{T}\{-i \operatorname{sgn}(t) \cdot \mathcal{F}\mathcal{F}\mathcal{T}^{-1}\{\Im I(\omega)\}(t)\}(\omega) = \Re I(\omega) \quad (45b)$$

13870 where $\mathcal{F}^{-1}\{(\pi\omega)^{-1}\}(t) = \operatorname{sgn}(t)$ is the signum function, $\operatorname{sgn}(t) = \frac{t}{|t|}$ & $\operatorname{sgn}(0) = 0$ and i is the imaginary
 13871 unit with property $(\pm i)^2 = -1$.

13872 Since inverse Fourier integral transform of the discretely sampled (measured) angular frequency domain
 13873 immittance $I(\omega)$ results in non-periodic TD immittance $I(t)$ provoking spectral leakage, $I(t)$ should be mul-
 13874 tiplied with a suitably chosen time window; for example, the cosine window, $\cos(\omega_0 t) = \Re e^{i\omega_0 t}$, $\omega_0 \in \mathbb{R}$
 13875 having FIT, $\mathcal{F}\{\cos(\omega_0 t)\}(\omega) = \pi(\delta(\omega - \omega_0) + \delta(\omega + \omega_0))$.

13876 Then, multiplying the cosine windowed $I(t)$ by $\pm i \operatorname{sgn}(t)$ and subject the result to FFT for inversion to
 13877 the angular frequency domain yields

$$13878 \quad \mathcal{F}\mathcal{F}\mathcal{T}\{i \operatorname{sgn}(t) \cdot \Re e^{i\omega_0 t} \cdot \mathcal{F}\mathcal{F}\mathcal{T}^{-1}\{\Re I(\omega)\}(t)\}(\omega) = \frac{\Im I(\omega - \omega_0) + \Im I(\omega + \omega_0)}{2} \quad (46a)$$

$$13879 \quad \mathcal{F}\mathcal{F}\mathcal{T}\{-i \operatorname{sgn}(t) \cdot \Re e^{i\omega_0 t} \cdot \mathcal{F}\mathcal{F}\mathcal{T}^{-1}\{\Im I(\omega)\}(t)\}(\omega) = \frac{\Re I(\omega - \omega_0) + \Re I(\omega + \omega_0)}{2}. \quad (46b)$$

13881 Similarly, the sine window, $\sin(\omega_0 t) = \Im e^{i\omega_0 t}$ with FIT, $\mathcal{F}\{\sin(\omega_0 t)\}(\omega) = -i\pi(\delta(\omega - \omega_0) - \delta(\omega + \omega_0))$,
 13882 yields

$$13883 \quad \mathcal{F}\mathcal{F}\mathcal{T}\{i \operatorname{sgn}(t) \cdot i \Im e^{i\omega_0 t} \cdot \mathcal{F}\mathcal{F}\mathcal{T}^{-1}\{\Re I(\omega)\}(t)\}(\omega) = \frac{\Im I(\omega - \omega_0) - \Im I(\omega + \omega_0)}{2} \quad (47a)$$

$$13884 \quad \mathcal{F}\mathcal{F}\mathcal{T}\{-i \operatorname{sgn}(t) \cdot i \Im e^{i\omega_0 t} \cdot \mathcal{F}\mathcal{F}\mathcal{T}^{-1}\{\Im I(\omega)\}(t)\}(\omega) = \frac{\Re I(\omega - \omega_0) - \Re I(\omega + \omega_0)}{2}. \quad (47b)$$

13886 Then, adding to or subtracting (46) and (47) from each other, and knowing $e^{\pm i\omega_0 t} = (\cos \pm i \sin)(\omega_0 t)$ yields

$$13887 \quad \mathcal{F}\mathcal{F}\mathcal{T}\{i \operatorname{sgn}(t) \cdot e^{\pm i\omega_0 t} \cdot \mathcal{F}\mathcal{F}\mathcal{T}^{-1}\{\Re I(\omega)\}(t)\}(\omega) = \Im I(\omega \mp \omega_0) \quad (48a)$$

$$13888 \quad \mathcal{F}\mathcal{F}\mathcal{T}\{i \operatorname{sgn}(t) \cdot e^{\pm i\omega_0 t} \cdot \mathcal{F}\mathcal{F}\mathcal{T}^{-1}\{\Im I^*(\omega)\}(t)\}(\omega) = \Re I(\omega \mp \omega_0) \quad (48b)$$

$$13889 \quad \mathcal{F}\mathcal{F}\mathcal{T}\{\operatorname{sgn}(t) \cdot e^{\mp i\omega_0 t} \cdot \mathcal{F}\mathcal{F}\mathcal{T}^{-1}\{I(\omega)\}(t)\}(\omega) = I(\omega \mp \omega_0). \quad (48c)$$

13891 Thus, immittance data can numerically be validated for all measured frequencies when ω_0 is suitably chosen
 13892 for each angular frequency. This is readily achieved for immittances which are **all** equally spaced in the
 13893 angular frequency domain allowing the direct use of fast Fourier transformation (FFT) and inverse fast Fourier
 13894 transformation (IFFT) routines when the number of measured immittances is a power of 2. In other cases
 13895 (i. e. logarithmic frequency spacing or missing frequencies), routines adapted to arbitrarily (irregularly/non-
 13896 equispaced/non-uniformly/unequally) spaced frequencies should be used (Boyd, 1992, Dutt and Rokhlin, 1993,
 13897 Keiner et al., 2009).

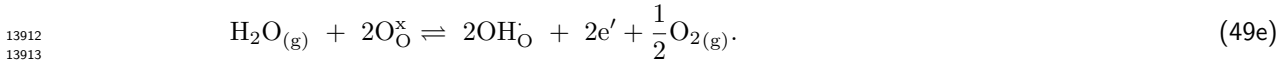
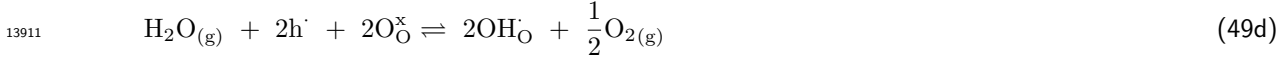
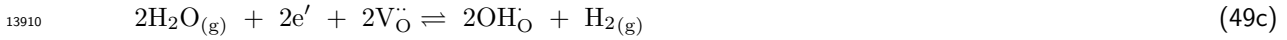
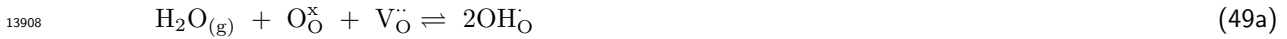
13898 Importantly, **non-conform** data that are data at frequencies where the real (imaginary) part immittance
 13899 computed from the measured imaginary (real) part immittance deviate significantly from the measured real
 13900 (imaginary) part immittance, shall be **rejected** and **not** used for analysis.

13901 Obviously, FFT and IFFT along with a sufficient data and an appropriate time window (Harris, 1978, Gade
 13902 and Herlufsen, 1987a, Gade and Herlufsen, 1987b) can also be used to numerically

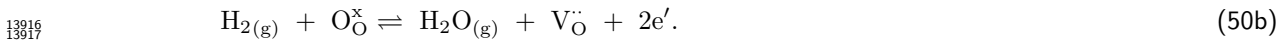
- 13903 - substitute rejected frequency data,
- 13904 - populate more densely the range of the measured frequencies, and
- 13905 - extend the frequency range beyond that of the measured immittances (Malkow et al., 2017).

13906 **Annex 9. Examples of defect reactions in Kröger-Vink notation**

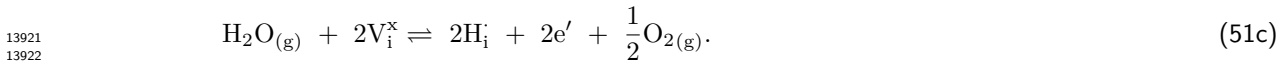
13907 Hydroxide formation by water dissociation at an oxide anion lattice:



13914 Oxide anion lattice vacancy formation by hydrogen oxidation:



13918 Proton interstitial formation by water dissociation:



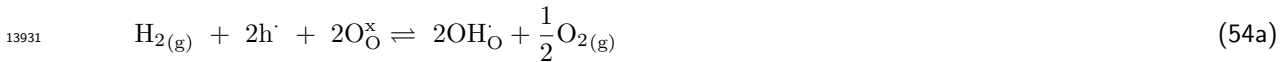
13923 Proton interstitial formation by hydrogen oxidation:



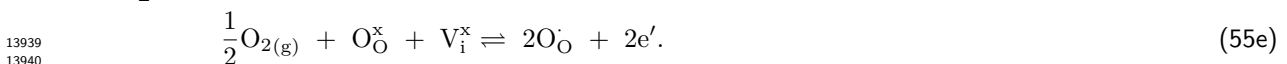
13927 Electrons and electron holes in close proximity annihilate:



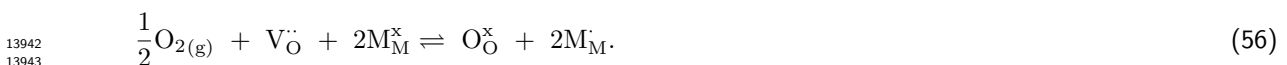
13930 Proton incorporation into an oxide anion lattice:



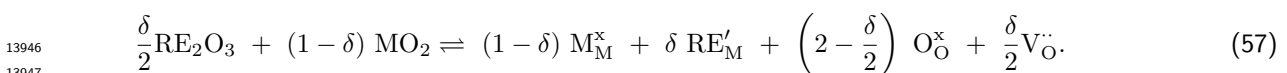
13934 Oxygen dissociation at an oxide anion lattice:



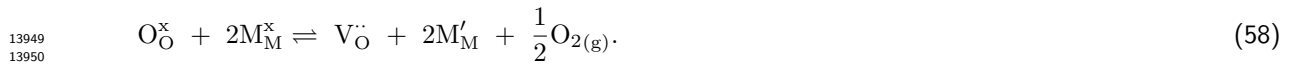
13941 Oxygen gas-solid exchange reaction:



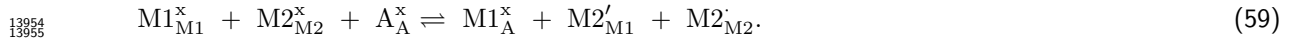
13944 Oxygen (non-stoichiometry) deficiency formation in tetra-valent metal oxide by tri-valent metal oxide, RE_2O_3 (i. e. yttria, scandia) incorporation:



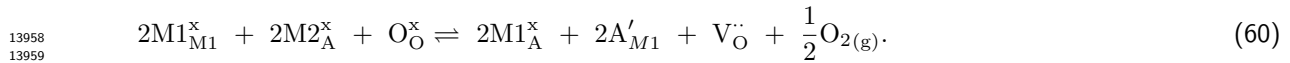
13948 Oxygen deficiency formation in tetra-valent metal oxide (i. e. ceria or zirconia) at low oxygen partial pressure:



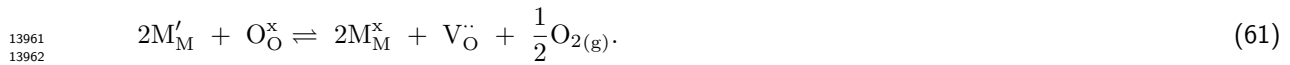
13951 Di-valent (alkali) metal oxide, AO (i. e. strontia, magnesia) incorporation into tri-valent binary metal oxide,
13952 (M1,M2)O₃ (i. e. lanathanum magnetite) through electronic compensation (electron hole formation on M2
13953 cation):



13956 Di-valent (alkali) metal oxide incorporation into tri-valent binary metal oxide through ionic compensation
13957 (oxide anion vacancy formation):



13960 Oxide anion vacancy formation by reduction of tetra-valent metal oxide:



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