D2.3

Report on certification requirements: certification instruments to facilitate the acceptance by safety and permitting authorities

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D 2.3	Report on certification requirements: certification instruments to facilitate the acceptance by safety and permitting authorities
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Partners short names

ENVI	Parco Scientifico Tecnologico Per L'ambiente Environment Park Torino Spa
IMI	Institute For Methods Innovation
IME	Fundacion IMDEA Energia
APRE	Agenzia per la Promozione della Ricerca Europea
CNH2	Centro Nacional Del Hidrogeno
RIGP	Regionalna Izba Gospodarcza Pomorza
CLUSTER TWEED	Cluster Tweed
BH2C	Balkanski Vodoroden Klaster

Abbreviations

BOP	Balance of Plant
CEI	Comitato Elettrotecnico Italiano
EEA	European Economic Area
FCEV	Fuel Cell Electric Vehicles
JTC	Joint Technical Committee
SAE	Society of Automotive Engineers
PED	Pressure Equipment Directive
P2G	Power-to-Gas
P2P	Power-to-Power
TC	Technical Committee
TPED	Transportable Pressure Directive
WI	Working Item

Executive Summary

This deliverable serves as an exploration of certification requirements for hydrogen technologies throughout Europe. It is structured to provide information to stakeholders—from policymakers to technology manufacturers and early adopters—in understanding and navigating the current landscape of certification for safety and permitting to promote hydrogen technology adoption. This will serve as a basis for discussion in the next phase of the project, which will culminate in the drafting of Guidelines on the subject.

Key points of the deliverable are:

- **Hydrogen Technology Certification**: the deliverable details the crucial EU directives for hydrogen technology certification, emphasizing the **CE Marking process** and the associated compliance requirements with European safety, health, and environmental standards;
- **Sector-Specific Applications**: The document elaborates on certification requirements specific to different sectors such as mobility (particularly railway and road sectors), industrial and residential/stationary applications through examples of innovative technologies.
- **Standardization Activities**: It reviews ongoing standardization efforts by various technical committees, focusing on establishing a supportive framework for hydrogen technologies. The activities of standardization bodies like CEN, CENELEC, ISO, and SAE are highlighted;

The deliverable synthesizes data from consortium experiences and stakeholder engagement activities, providing an overview of current standards and anticipated changes. It emphasizes the dynamic nature of standardization in hydrogen technologies, noting particular progress in safety and technology certification standards which are evolving to accommodate new market demands and innovations.

For certification issues, the overarching European requirements ensure a common base throughout Europe. European Directives, which support introduction of products in the common market, are used as reference, with very little need for country specific implementation. For this report, therefore, the distinction amongst countries adapted within D2.1, for instance, has not been required.

This deliverable provides a first depiction of the certification approach status around Europe, while information will be collected throughout the project supporting the drafting of the final guidelines to be issued by project HYPOP.

1 Introduction

HYPOP project aims to raise public awareness and trust towards hydrogen technologies and their systemic benefits. To do this, stakeholders' engagement is a pivotal aspect that has been taken into account for this project. Work package 2 (WP2) methodology involves tools to gather information from stakeholders through surveys, interviews and participation to events (engagement activity useful also for WP1). WP2 activities are crucial to provide the basis for the final guidelines that will support decision makers in introducing hydrogen in the local communities and economies. Specifically, technical data gathered about safety, permitting and certification requirements will be used for the workshops that will involve HYPOP's stakeholders and thus providing decision makers with valuable information coming from sharing real experiences and technical know-how. The research activity for D2.3 has covered the HYPOP countries of the partners involved in WP2 (Italy, Spain, Poland, Belgium and Bulgaria).

To compile D2.3 "Certification requirements", HYPOP's partners have cooperated to provide the best overview of the certification requirements needed for hydrogen technologies throughout Europe according to consortium experiences and data gathered through stakeholder engagement activities (see D5.4). HYPOP partners gathered information about demonstrative and real projects (D2.1, D.2.2 and D5.4), while references to certification protocols, directives followed and technical standards applied have been reported in this deliverable.

The deliverable introduces the three main directives for certification of hydrogen technologies - ATEX, Machinery and Pressure Equipment. Other EU Directives may apply and be relevant to the CE marking of the hydrogen technologies put on the market (a not comprehensive list is provided in Section 2.1 together with the details of the aforementioned ones). Real examples have been provided to support early adopters of H2 technologies that want to understand how to pursue certification of innovative hydrogen technologies as well as for the decision maker on safety and permitting aspects to increase their awareness.

Subsequently, some examples of the application of standards in different hydrogen sectors has been given.

Finally, the advance in hydrogen-related standards development is provided. The deliverable lists the main topics on which technical committees of the standardization bodies are working currently, to provide an overview of the framework of the next standards that will support hydrogen technologies deployment. As an added value, new standard proposals and revisions of existing ones from technical committees for hydrogen technologies are reviewed. A specific focus on the activities of one of the two main standardization bodies in Italy, UNI, has been made (Appendix A).

2 CE Marking for Hydrogen Technologies

2.1 Introduction: the CE Marking mechanism

The commercialization of products within the European single market is governed by a set of regulations and Directives aimed at ensuring consumers that **products** meet minimum requirements in terms of **safety, health, and environmental protection**. Products, regardless of their place of production, must comply with EU requirements and can be marketed within the European Economic Area only if they bear the **CE marking**. The CE Marking signify that products sold in the EEA have been assessed to meet high safety, health, and environmental protection requirements, i.e., it conforms to EU regulatory framework on those areas.

Even though each type of product has its own special characteristics that must be reflected in the applicable directive, the European Commission has tried to give each a common structure based on the conformity assessment procedures and fixing of the CE Marking, detailed in the Council Decision 93/465/CEE. Manufacturers have the responsibility to carry out the conformity assessment which generally requires the preparation of a technical file demonstrating the product's compliance with all relevant requirements at the European level and the drafting and signing of a Declaration of conformity. In some cases, where the risks to public health, safety and environment are higher, the product's conformity assessment may need to be conducted by a nationally recognized Notified Body that will follow the evaluation procedure provided for by the specific legislation for the product subject to the certification process.

There are two phases for the conformity assessment:

- Design assessment (of a prototype or a sample of the product) through relevant tests and studies;
- Production assessment (all product units must continue to comply in the same way as the sample studied in the design assessment phase), through control of production quality, preferably based on ISO 9001.2000 standards.

In addition, the procedure is further broken down into modules relating to the design and production phase, as shown in the diagram below.

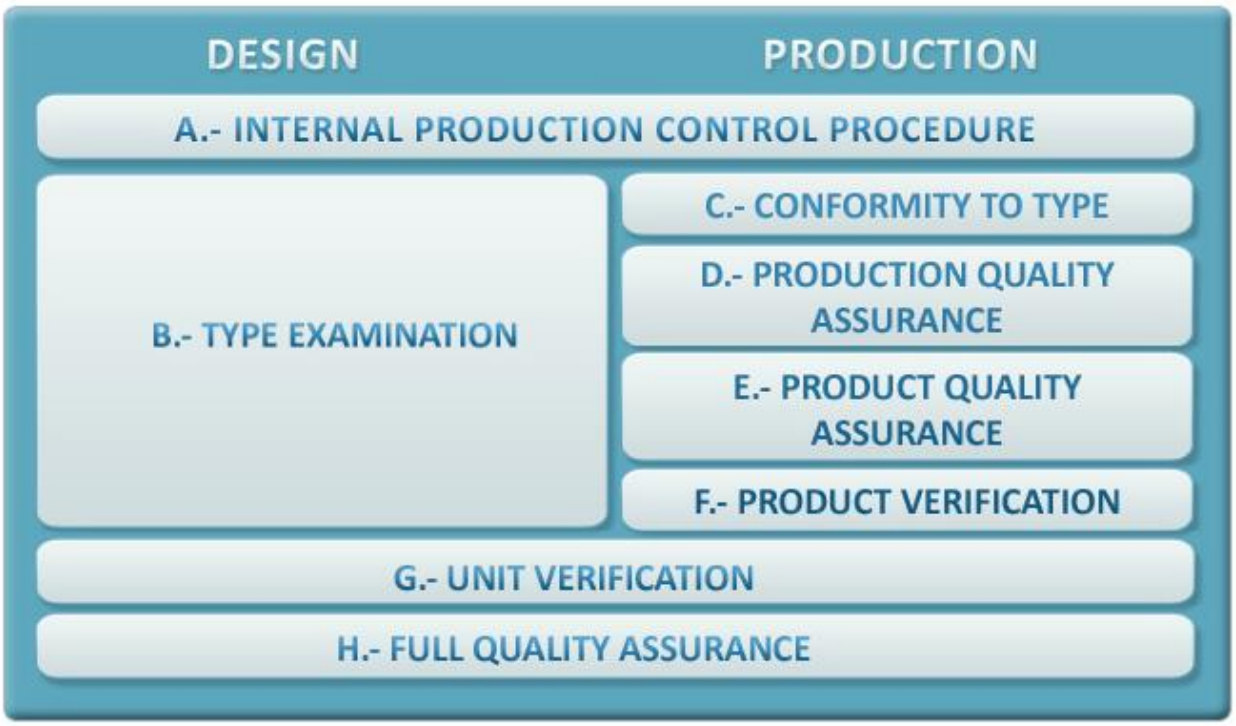

Figure 1 Mapping of modules vs phases of the conformity assessment (courtesy of DEKRA)

A description of the different modules is presented in the table below.

Table 1 Modules required under EU Directives for CE marking

Modules	Description
Module A: Internal production control (design and production phase)	The manufacturer provides the competent authorities with technical documentation containing information for the evaluation of the product's conformity to the Directives it must comply with. Some examples of the information required in the technical documentation are: • a general description of the product; • conceptual design and manufacturing drawings and schemes of components, sub-assemblies, circuits, etc.; • descriptions and explanations necessary for the understanding of those drawings and schemes and the operation of the product; • a list of the harmonised standards applied in full or in part; • results of design calculations made, examinations carried out and test reports etc.
Module B: EU type examination (design phase)	The Notified Body (see text) examines the technical design of a product, and it verifies and certifies that the technical design of such product complies with the applicable requirements. **This type of evaluation must be conducted with a sample of the complete product ("type of product") representative of the considered production flow.**

Modules	Description
	Generally, the Module B is followed by the other Modules, according to the specific requirements of the Directive considered.
Module C: Conformity to type (production phase)	Part of the conformity assessment based on internal production control. In this case the manufacturer should **provide information about the tests performed** to comply with the corresponding requirements of the Directive.
Module D: Production quality assurance (production phase)	Part of the conformity assessment directed at system level adopted by the manufacturer for **quality control of the production process.** In this case, the manufacturer should provide and describe the following elements (there is not an exhaustive list as it serves as example) together with the technical documentation of the approved type and a copy of the EU-type examination (Module B): **manufacturing, quality control and quality assurance techniques, process examinations and tests** that will be carried out before, during and after manufacture, and the frequency with which they will be carried out; the quality records, such as inspection reports and test data, calibration data, etc., and the means of monitoring the achievement of the required product quality and the effective operation of the quality system actions etc
Module E: Product quality assurance (production phase)	Part of the conformity assessment related to the application of adequate **quality systems for product inspection** adopted by the manufacturer. In this case, among the information to be produced, the manufacturer should provide to the Notified Body a **description of the tests and examinations that are carried out after the manufacture of the product as well as the quality records, such as inspection reports and test data**, calibration data etc. In addition to experience in quality management systems, the Notified Body will assess, through an audit at the manufacturer's premises, the competences that at least one member of the manufacturer's team should have about the relevant product field and product technology concerned, and knowledge of the applicable requirements of this Directive.
Module F: Product verification (production phase)	Part of the conformity assessment directed at the manufacturing process and its control. In this case, the Notified Body conducts **tests and examinations for each product individually** following harmonised standards or appropriate tests set by itself.
Module G: Unit verification (design and production phase)	In this case, the manufacturer prepares the general technical documentation that will be checked by the Notified Body. The **documentation could contain an analysis and assessment of the risks associated to the product** together with information about the conceptual design, manufacturing drawings, schemes of components, report of tests etc.

Modules	Description
	Moreover, to obtain the CE marking under this module, manufacturers will be subject to examinations and tests by the **Notified Body** as set out in the relevant harmonised standard/technical specification chosen.
Module H: Full quality assurance (design and production phase)	Module of the conformity assessment based on **full quality assurance** referring to the system of quality for design, production, final product inspection, and testing.

The modules to be followed by the manufacturer are established in the directives which apply to the product, although some directives may introduce their own modifications (generating variants of the above Modules). For some sectors/products, those for which use/application has a certain degree of risk, there is an obligatory certification to be obtained from the so-called Notified Bodies.

Notified Bodies, as defined by European law, are entities who are granted authority by national authorities to certify a product according to a specific European standard for CE Marking. They may be supported by accreditation bodies. Notified bodies may also be involved in the surveillance phase of products at the national and European level, and can remove a product from the market, even if **certified with the CE mark, if deemed risky for common health.**

Notified bodies are authorized to issue the "EU Type Examination" certificate and to carry out all or some of the phases of the conformity assessment. Manufacturers can prove compliance to the certification requirements according to the associated regulations/directives and the voluntary technical standards through documentation to be provided to the Notified Body and contained in the specific modules described above.

2.2 Application to hydrogen technologies

Hydrogen technologies must comply with various directives and regulations which, depending on the type, may require the involvement of a notified body.

Manufacturers of hydrogen technologies should present as a minimum mainly the same level and type of information within technical documentation described for Module A. The difference with other Modules concerns:

- **the type of assessment a technology will be subject to** (can concern the single unit, the product, its production process, the quality system…)**;**
- **the harmonized standards associated with the Directive;**
- **assessment procedures that may be** set by Notified Bodies involved (Notified Bodies can be freely chosen by Manufacturers provided that they are accredited by National Authorities).

Further modules may be indicated subsequently according to the applicable technology.

3 EU Directives applicable to hydrogen technologies

Member States are required to implement **EU Directives** and to directly transpose **regulations** through their own legislative tools. Unlike regulations that are immediately valid, European Directives must be transposed by each Member State, maintaining the basic characteristics, but in some cases, additional requirements may be introduced. Such differences can sometimes result in barriers. For this reason, an analysis was carried out to identify the main characteristics for the **certification of hydrogen technologies such as electrolysers, fuel cells, and storage systems but also the connected devices and most innovative H2 technologies**.

As mentioned in the Introduction, different health and safety legislation are relevant to the CE marking of hydrogen technologies. The following Table 2 lists some of the main EU Directives that can be applicable:

Table 2 EU Directives for CE marking of Hydrogen technologies

EU Directives	
Atex Equipment Directive (Atex 114)	Directive 2014/34/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to **equipment and protective systems intended for use in potentially explosive atmospheres**
Machinery Directive	Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on **machinery**, and amending Directive 95/16/EC
Pressure Equipment Directive	Directive 2014/68/EU of the European Parliament and of the Council of 15 May 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of **pressure equipment**
Atex Workplace Directive (Atex 137)	Directive 1999/92/EC of the European Parliament and of the Council of 16 December 1999 on minimum requirements for improving the **safety and health protection of workers potentially at risk from explosive atmospheres**
Low Voltage Directive	Directive 2014/35/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of **electrical equipment** designed for use within certain voltage limits

3.1 ATEX 114 « equipment » Directive

Directive 2014/34/EU on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres, also called ATEX 114 "equipment" Directive, applies to hydrogen technologies. Potentially explosive atmospheres are those where gases, vapours, or flammable dusts can mix with air and therefore explode under certain conditions. The **ATEX "equipment" Directive sets requirements for equipment and protection systems intended for use in potentially explosive atmospheres, including electrical equipment used on the surface, underground, and in fixed offshore installations.** Additionally, the ATEX Directive is extended to all safety, control, and regulation devices not used within an explosive atmosphere but necessary for the operation of the systems.

To achieve compliancy under this Directive, there are several Harmonised standards that can be applied[1].

3.1.1 APPLICATION TO HYDROGEN TECHNOLOGIES

Hydrogen, being a flammable gas, requires careful risk management, and compliance with the ATEX Directive is essential to ensure safety in environments where this fuel is used. **The ATEX directive applies, but it is not limited to, electrolysers, fuel cells, and storage systems**. Thus, **it is a fundamental reference for the certification of hydrogen technologies to be employed in industrial fields and, where necessary, also for mobility sector**. Exceptions must be considered as in some cases products are excluded from the scope of this directive, for example, if intended for:

- Use in a domestic and non-commercial environment, where a potentially explosive atmosphere can rarely be caused and only by an accidental gas leak;
- Maritime ships and mobile offshore units, as well as the equipment used on board such ships or units;
- Means of transport, such as vehicles and their trailers, intended solely for the transportation of people by air, on road networks, railways, or via waterways, and means of transporting goods by air, on road networks or railways, or via waterways; however, vehicles intended to be used in potentially explosive atmospheres are not excluded from the scope of the ATEX regulations.

In the case of the ATEX Directive, it is not the type of hydrogen device but where it is used that determines the classification.

3.1.2 CLASSIFICATION APPLICABLE TO HYDROGEN TECHNOLOGIES

Hydrogen technologies fall within the classification "Group II devices" as devices intended to be used in "other sites" liable to be endangered by explosive atmospheres.

In this ATEX classification, within Group II, categories 1, 2, and 3 are distinguished. These categories are associated with the level of safety a product can guarantee and the related risk on the environment. Group II devices are further distinguished based on the type of substances present in the explosive atmosphere. **If there is not a risk of a potentially explosive atmosphere outside, the ATEX Directive applies in any case to components that should be used inside the technology.**

The category depends on the required safety level and the environment in which hydrogen technology operates. To define such categories, zoning is necessary and the technical standard EN 60079 -10-1 is used for this scope. For example, in Italy the classification of dangerous zones is reported in the CEI EN 60079-10-1 Standard. According to this technical standard, dangerous areas can be classified based on the frequency and duration of occurrence of explosive atmospheres into the defined zones:

- **Zone 0**: An area where an explosive atmosphere consisting of a mixture of air and flammable substances in the form of gas, vapor, or mist is present continuously/ for long periods/ frequently;
- **Zone 1**: An area where, during normal activities, the formation of an explosive atmosphere consisting of a mixture of air and flammable substances in the form of gas, vapours, or mist is likely;

[1] Harmonised standards for ATEX Directive: https://ec.europa.eu/docsroom/documents/55578

- **Zone 2**: An area where, during normal activities, the formation of an explosive atmosphere consisting of a mixture of air and flammable substances in the form of gas, vapor, or mist is not likely and, if it does occur, it is only of short duration.

3.1.2.1 CATEGORY 1

If a hydrogen technology device is intended for environments where an explosive atmosphere due to mixtures of air and gas, vapours, mists, or air and dust mixtures is always, often, or for long periods present, then the classification requires the highest safety requirements (category 1). Devices in this category must meet additional requirements. In particular, in the case of gas, vapour, or mist atmospheres, the following information may be of interest to authorities involved in safety aspects. The device:

- must be equipped with independent protection features;
- the temperature of surfaces that can heat up must be kept below the maximum prescribed;
- must be designed so that the parts that can constitute a source of ignition can only be opened in the absence of energy or in conditions of intrinsic safety. If it is not possible to deactivate the devices, the manufacturer must affix a warning label on the accessible parts of the devices. If necessary, the devices must be equipped with suitable additional opening mechanisms.

3.1.2.2 CATEGORY 2

Devices classified as category 2 are intended for environments where explosive atmospheres due to gas, vapours, mists, or mixtures of air and dust are likely to occur. Devices in this category must also meet additional requirements. For example, requirements concern the temperature of heating surfaces and access to parts of the plant that can constitute an ignition source.

3.1.2.3 CATEGORY 3

Devices classified as category 3 are intended for environments where there is a low probability of explosive atmospheres due to gas, vapours, mists, or mixtures of air and dust occurring, and if it does occur, it is only for a short duration. Devices in this category must meet additional requirements. In particular, surface temperatures must not exceed the maximum temperatures indicated by the manufacturer. Exceeding is tolerable, in exceptional cases, if the manufacturer adopts additional special protection measures.

3.1.3 CONFORMITY ASSESSMENT PROCEDURE

The conformity assessment procedures for Group II devices and the different categories 1,2,3 vary according to the component of risk. Regarding the modules to be submitted, ATEX directive requires the Module C1: conformity to the type based on Internal production control plus supervised product testing. In this case, together with the technical documentation, the manufacturer should test for each individual product under all those aspects considered relevant. The Notified Body is present to supervise and control such tests.

Furthermore, for Group II and category 1 devices, the conformity assessment procedure requires the involvement of a notified body and consists of the EU type examination procedure (Module B) plus one of the following procedures:

- conformity to type procedure based on the quality assurance of the production process (Module D); or
- conformity to type procedure based on product verification (Module F).

For hydrogen technologies configured as category 2 devices, the conformity assessment procedure is structured as follows:

- for internal combustion engines and electrical devices belonging to Group II and category 2, the EU type examination procedure (Module B) must be followed, combined with one of the following procedures:
    - conformity to type based on internal production control combined with product testing under official control (Module C1), or
    - conformity to type based on product quality assurance (Module E);
- for other devices belonging to Group II and category 2, the internal production control (Module A) and submission to a notified body of the technical documentation must be done.

For Group II devices, category 3, the conformity assessment procedure consists of the internal production control (Module A). For Group II devices, in addition to the previously described procedures, it is possible to follow the conformity assessment procedure based on unit verification (Module G).

3.1.4 APPLICABLE STANDARDS

The table below shows some of the standards that apply to hydrogen technologies.

Table 3 Examples of Harmonised standards under ATEX Directive for electrolysers, storage systems and fuel cells

Harmonised standards for ATEX Directive	
EN 1127-1:2019	Explosive atmospheres – Explosion prevention and protection - Part 1: Basic concepts and methodology
EN 60079-29-1:2016	Explosive atmospheres - Part 29-1: Gas detectors - Performance requirements of detectors for flammable gases
EN 60079-30-1:2017	Explosive atmospheres - Part 30-1: Electrical resistance trace heating - General and testing requirements
EN ISO/IEC 80079-34:2011	Explosive atmospheres - Part 34: Application of quality systems for equipment manufacture

3.2 The Machinery Directive

The second relevant Directive for a manufacturer of hydrogen technologies is the **Directive 2006/42/EC on machinery**. This Directive has been recently replaced by EU Regulation 2023/1230, as the experience gained in applying Directive 2006/42/EC highlighted deficiencies and inconsistencies in product coverage and conformity assessment procedures. The Machinery Directive is considered repealed from January 14, 2027; thus, until that date, it remains a regulatory reference for all aspects of certification, including those for hydrogen technologies. Machinery Directive sets relevant certification requirements for various application fields, including industrial, mobility, and residential sectors. However, there are cases where this Directive does not apply. Machineries excluded are:

- machinery specially designed or put into service for nuclear purposes;
- machinery specially designed and constructed for military or police purposes;
- means of transport by air, waterway, or railway, excluding machines installed on such vehicles;
- motor vehicles of categories M and N and their trailers of category O, that are intended to be used on public roads,
- two- or three-wheel vehicles and quadricycles (L-category vehicle);
- motor vehicles exclusively intended for competition;

- maritime ships and offshore mobile units, as well as machinery installed on board such ships and/or units;
- machinery specially designed and built for research purposes to be temporarily used in laboratories.

Harmonized standards should be used as a reference to comply with minimum requirements under Machinery Directive[2].

3.2.1 APPLICATION TO HYDROGEN TECHNOLOGIES

Hydrogen systems fall within the framework of Machinery Directive because they can be defined as machinery assemblies, and this apply to most of the hydrogen technologies. It is however necessary to understand if innovative hydrogen technology falls under the exceptions indicated in the Directive (list of products included and excluded under Article 1 of Machinery Directive).

3.2.2 CLASSIFICATION APPLICABLE TO HYDROGEN TECHNOLOGIES

N/A

3.2.3 CONFORMITY ASSESSMENT PROCEDURE

Generally, the Machinery Directive allows for internal testing even if the product falls within the Directive's list, provided that the tests conform to a harmonized European standard that includes all relevant health and safety requirements. Moreover, the manufacturer of hydrogen technologies like compressors and pumps should provide technical documentation including a general description of the machine, documentation related to risk assessment, references to applied standards and technical specifications, and technical reports with results of internal tests conducted (analogy to Module A conformity assessment).

3.2.4 APPLICABLE STANDARDS

Some examples of harmonised standards that might apply to hydrogen technologies are reported below.

Table 4 Examples of Harmonised standards under Machinery Directive

Harmonised standards for Machinery Directive	
EN ISO 12100:2010	Safety of machinery - General principles for design - Risk assessment and risk reduction
EN 1127-1:2019	Explosive atmospheres – Explosion prevention and protection - Part 1: Basic concepts and methodology
EN ISO 13849-1:2023	Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design
EN ISO 13849-2:2012	Safety of machinery - Safety-related parts of control systems - Part 2: Validation
EN ISO 19353:2019	Safety of machinery - Fire prevention and fire protection

3.3 The Pressure Equipment Directive

A third Directive applicable for the certification of hydrogen technologies identified from the analysis of projects and stakeholders' engagement is the **Pressure Equipment Directive 2014/68/EU (PED Directive). This Directive falls within a broader framework that also includes the Simple Pressure Vessels Directive 2014/29/EU and the Transportable Pressure Equipment Directive 2010/35/EC.** Harmonised standards set the minimum requirements that need to be

[2] Harmonised standards for Machinery Directive: https://ec.europa.eu/docsroom/documents/55576)

fulfilled by the manufacturers as they will be the base of the conformity assessment carried out by Notified Bodies [3].

3.3.1 APPLICATION TO HYDROGEN TECHNOLOGIES

This legislation is primarily considered for the certification of hydrogen storage systems but generally also addresses other hydrogen technologies such as electrolysers and fuel cells, as they are technologies for which there is a risk related to maximum pressures allowed exceeding 0.5 bar above atmospheric pressure.

3.3.2 CLASSIFICATION APPLICABLE TO HYDROGEN TECHNOLOGIES

The classification of product into increasingly hazardous categories going from category I to IV is based on the criteria outlined in the related Annexes of the Directive. Specifically, for classification into the four categories mentioned, the following factors are considered:

- The maximum allowable pressure of the container holding the fluid (PS);
- The container's own volume (V) or nominal size (DN) in case of pipes;
- The fluid's group classification. Generally, gaseous hydrogen falls into group 1 as it is a flammable gas of category 1 and 2 (Gases that, at a temperature of 20 °C and a normal pressure of 101.3 kPa):
    - a) are flammable when mixed at 13% or less (by volume) with air; or
    - b) have a flammability range with air of at least 12 percentage points, regardless of their lower flammability limit as defined by Table 2.2.1 of EC Regulation n.1272/2008.

It is important to consider the technical requirements that apply to containers intended to hold gases whose vapour pressure at the container's maximum allowable temperature is at least 0.5 bar above the normal atmospheric pressure. In this case, for fluid groups of type 1 when the container's volume is more than 1 litre and the PS-V product exceeds 25 bar-L, and when the PS pressure is over 200 bar, the provisions of Annex II apply (Figure 2).

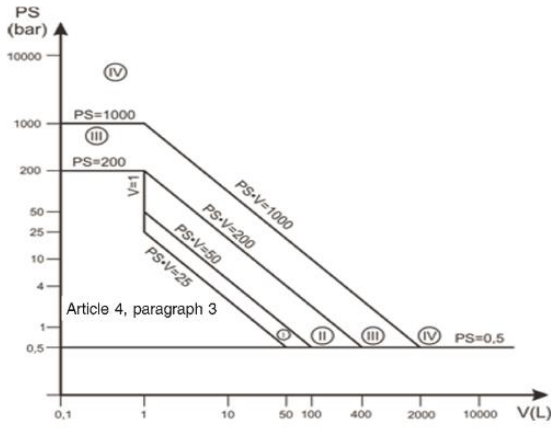

Table 1

Vessels referred to in Article 4(1)(a)(i), first indent

Figure 2 PS-V diagram for categorization of Pressure Equipment

[3] Harmonised standards for Pressure Equipment Directive: https://ec.europa.eu/docsroom/documents/51457

The **following references are made specifically to hydrogen storage systems**:

- **Solid storage in metal hydrides where the operating pressure is about 30 bar**. Depending on the storage's own volume, these systems can fall into categories ranging from category I upwards;
- **For hydrogen gas storage systems at 200 bar**, regardless of the storage's own volume, the reference category can be III or IV. **Other hydrogen technologies such as electrolysers and fuel cells must also meet the requirements of the PED regulation and can be connected to the storage system and to each other through piping, which is also defined by the regulation as pressure equipment where the maximum allowable pressure can be above 0.5 bar**. In the case of pipes intended to contain gas whose vapour pressure at the maximum allowable temperature is above 0.5 bar of normal atmospheric pressure (1013 mbar), for group 1 fluids, when the **Nominal Size (DN)** is greater than 25, the provisions reported in Annex II apply (Figure 3).

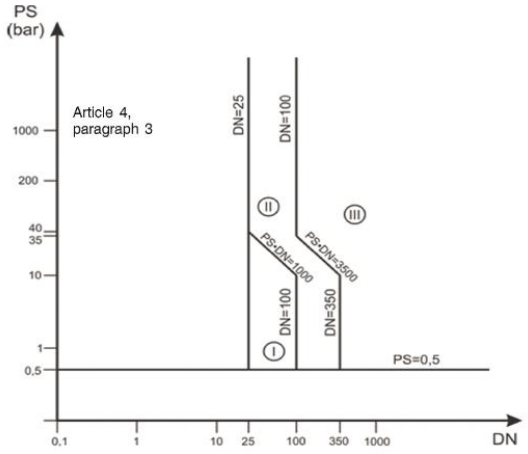

Table 6

Piping referred to in Article 4(1)(c)(i), first indent

Figure 3 PS- DN diagram for categorization of Pressure Equipment

3.3.3 CONFORMITY ASSESSMENT PROCEDURE

As with the Machinery Directive, in this case, the conformity assessment procedure leading to the Declaration of Conformity and CE Marking can be performed directly by the manufacturer if the hydrogen technology is category I according to internal production control protocols (Module A). This is also valid for hydrogen equipment.

For pressure equipment, including hydrogen technologies, falling within category II, III, and IV, the involvement of a notified body is required to certify it according to the PED Directive and within the national territory of interest. .

Involving a Notified Body increases the complexity of the assessment procedure and the safety conditions ensured as well. Specifically, the number of modules with the information to be provided and the assessment procedures grows with the associated risk of the pressure equipment. Except for Category I, all other cases, where a hydrogen technology falls within Categories II, III, IV, must involve a Notified Body

The conformity assessment procedures to be applied for the different categories are as follows:

Table 5 Correlation between modules needed for the conformity assessment and hazard category of the Pressure Equipment

Category	Modules
I	Module A
II	Modules A2 (analogous in terms of content to Module A with the addition of official checks on pressure equipment conducted at random and unannounced intervals by the notified body), D1 (quality assurance of the production process), E1 (Quality assurance of final product inspection and testing)
III	Modules B (EU type-examination of design) + D, Modules B (EU type-examination of design) + F, Modules B (type of production) + E, Modules B (EU type-examination of production) + C2 (conformity to type based on internal production control combined with testing of pressure equipment under official control at random intervals), Module H (conformity based on full quality assurance);
IV	Modules B (type of production) + D, Modules B (type of production) + F, Module G, Module H1 (conformity based on full quality assurance with design control).

Compared to Module B EU type-examination of design, EU type-examination of production adds the examination of a specimen, representative of the production envisaged, of the complete pressure equipment.

3.3.4 APPLICABLE STANDARDS

Some examples of the harmonised standards applicable to hydrogen technologies are reported below.

Table 6 Examples of Harmonised standards under Pressure Equipment Directive for hydrogen technologies above 0,5 bar

Harmonised standards for Pressure Equipment Directive	
EN 1349:2009	Industrial process control valves
EN 13445 1- to -5 :2021	Unfired pressure vessels (General; Design; Materials; Fabrication; Inspection and Testing)
EN 13480-2:2017	Metallic industrial piping

3.4 The Low Voltage Directive

The last Directive associated to hydrogen technologies is the Directive 2014/35/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits. It applies to electrical equipment designed for use with a **voltage rating of between 50 and 1 000 V for alternating current and between 75 and 1 500 V for direct current**.

3.4.1 APPLICATION TO HYDROGEN TECHNOLOGIES

The Directive is **applicable to most of the hydrogen systems and technologies. In fuel cells**, for example, voltage for alternating current is around 200 to 450 V according to the size of the technology. These products shall comply to the requirements described in the Directive to ensure public safety from physical injury, temperatures and radiation.

3.4.2 CLASSIFICATION APPLICABLE TO HYDROGEN TECHNOLOGIES

N/A

3.4.3 CONFORMITY ASSESSMENT PROCEDURE

Manufacturers do not need to involve a Notified Body in the conformity assessment. It is only required to comply with the information required in the **Module A for the Internal production control**. Specifically, technical documentation should contain (as an example): a general description of the electrical equipment; conceptual design and manufacturing drawings and schemes of components, sub-assemblies, circuits, etc.; a list of the harmonised standards[4] applied in full or in part; results of design calculations made, examinations carried out, etc.; and test reports.

3.4.4 APPLICABLE STANDARDS

See footnote.

[4] Harmonised standards for Low Voltage Directive: https://ec.europa.eu/docsroom/documents/59094

4 Certification Requirements application for H2 innovative technologies: some experiences

This section reports some experiences shared by stakeholders engaged during WP2 activities as well as the results of the data research pursued for the purposes of the project. Emphasis has been put on topics that appeared to have more resonance in this transition phase towards innovative hydrogen technologies in industrial, mobility and residential sectors. The applications reported include:

- Stationary/residential application: FC-based genset and hydrogen production and use for micro-grid/off grid remote areas;
- Industrial application: electrolyser;
- Mobility applications: homologation of railway vehicles; HRS and FCEV.

4.1 Stationary/residential application: FC-based genset

The EVERYWH2ERE project (H2020, G.A. nr 779606) aimed to **demonstrate an innovative integration of fuel cell (FC) technologies in portable power generators**, which are set to replace the predominantly diesel engine-based solutions currently in use, thus carving out a significant but specific market niche for FC technologies. Throughout the project, four PEMFC (Proton Exchange Membrane Fuel Cell) equipped, containerized "plug and play" generators—two rated at 25 kW and two at 100 kW—were constructed and evaluated through a pan-European demonstration campaign that adopted a "demonstration to market" approach (Figure 4). The project field-tested these prototypes at construction sites, music festivals, and urban public events across Europe, showcasing their versatility. The following Figure 5 shows the **innovative integration of different components in a containerized system**: FC (with its power electronics and control), battery system, storage system and BoP elements like compressors and pumps.

Figure 4 Example of test on site for EVERYWH2ERE Genset with bundles

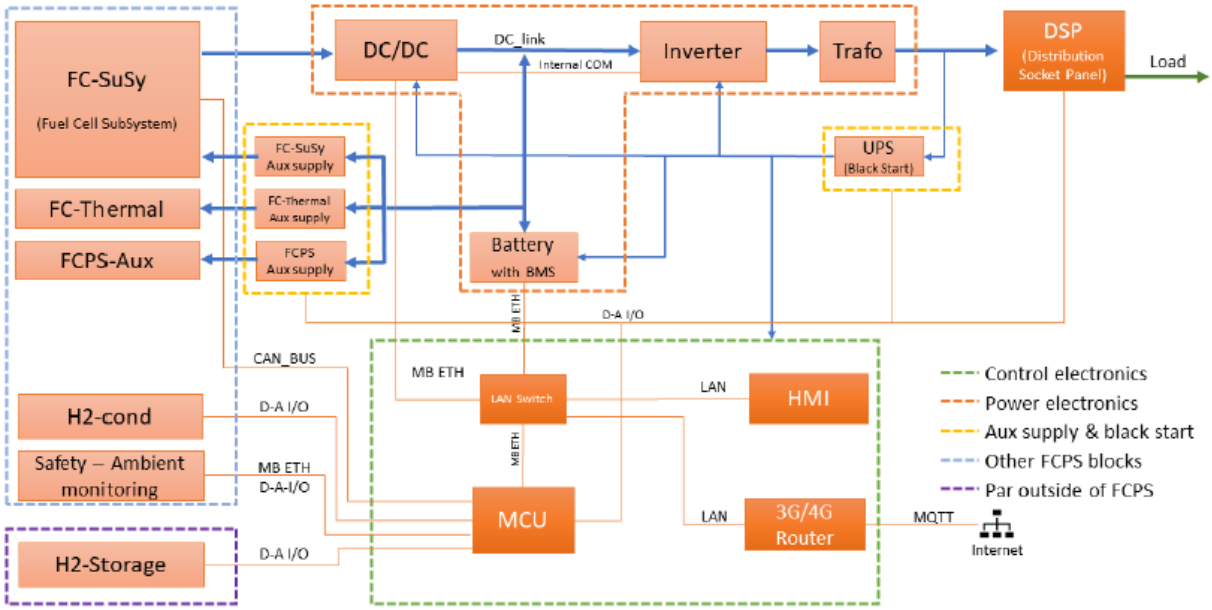

Figure 5 Genset block diagram from Deliverable 3.8 of EVERYWH2ERE project

Regarding the **Fuel Cells** the standards (Table 7) and regulations considered are:

- Directive 2014/34/EU - Explosive Atmosphere Directive.
- Directive 2014/35/EU - Low Voltage Directive;
- Directive 2014/68/EU – Pressure Equipment Directive.

Table 7 Standards for Fuel cell design and installation considered in EVERYWH2ERE project

Standard	Description
IEC 62282-2-100:2020	Fuel cell technologies - Part 2-100: Fuel cell modules – Safety
IEC/EN 62282-3-100:2012	Fuel cell technologies – Part 3-100: Stationary fuel cell power systems – Safety
IEC/EN 62282-5-100:2018	Fuel cell technologies – Part 5-100: Portable fuel cell power systems – Safety
IEC/EN 60950-1:2013	Information technology equipment -Safety – Part 1: General requirement
IEC 60079-29-1:2016	Explosive atmospheres – Part 29-1: Gas detectors – Performance requirements of detectors for flammable gases

For the safety requirements of the general **Hydrogen System**, it has been applied:

- The Machinery Directive 2006/42/EC;
- Gas Appliances Directive Regulation (EU) 2016/426;
- Technical standard: EN 60079-14:2014 "Explosive atmospheres - Part 14: Electrical installations design, selection and erection";
- Technical standard: EN 60079-17:2014 "Explosive atmospheres – Part 17: Verification and maintenance of electrical installations.

For the **storage system**, the configuration of **bundles of cylinders (350 bar)** has been chosen. These hydrogen technologies are subject to the following EU Directives: **Transportable Pressure**

Equipment Directive (European Directive 2010/35/EU (TPED)) and the **ADR** (European Agreement concerning the International Carriage of Dangerous Goods by Road). The bundles have been designed, manufactured, tested and inspected in compliance according to the **standards** (Table 8):

Table 8 Standards for storage system (bundles) considered in EVERYWH2ERE project

Standard	Description
EN ISO 11114-1:1997 (withdrawn, new version: ISO 11114-1:2020)	Transportable gas cylinders – Compatibility of cylinder and cylinder valve with gas contents – Part 1: Metallic materials
EN ISO 11114-4:2017	Transportable gas cylinders – Compatibility of cylinder and cylinder valve with gas contents – Part 4: Test methods for selecting metallic materials resistant to hydrogen
EN ISO 10961:2012	Gas cylinders - Cylinder bundles - Design, manufacture, testing and inspection

4.2 Stationary/residential application: hydrogen production and use for micro-grid/off grid remote areas

The EU funded project REMOTE (H2020, G.A. nr 779541), aimed to demonstrate the technical and economic feasibility of two **innovative energy storage solutions based on fuel cells** (an integrated P2P system and a non-integrated P2G+G2P system) for stationary/residential applications. Three real case studies in isolated micro-grids or off-grid remote areas implemented energy management solutions powered by renewable electricity and hydrogen. The following technical standards were considered for the different technologies operating in the project.

Standards applied to the Gas to Power system (fuel cell):

- IEC 60204-1:2016 "Safety of machinery – Electrical equipment of machines. Part 1: General requirements". A new version of this publication exists, IEC 60204-1:2016+A1:2021;
- IEC 61000-6-22016 Electromagnetic Compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments;
- IEC 61000-6-3:2020 Electromagnetic Compatibility (EMC) - Part 6-3: Generic standards - Emission standard for residential, commercial, and light-industrial environments;
- IEC TS 62282 Fuel cell technologies;
- ISO/TR 15916:2015 Basic Consideration for the safety of hydrogen systems.

Standards applied to the Power to Gas system (electrolyser):

- IEC 60204-1:2016 "Safety of machinery – Electrical equipment of machines. Part 1: General requirements". It has been recently reviewed with IEC 60204-1:2016+AMD1:2021
- IEC 61000-6-2:2016 Electromagnetic Compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments;
- IEC 61000-6-3:2020 Electromagnetic Compatibility (EMC) - Part 6-3: Generic standards - Emission standard for residential, commercial, and light-industrial environments;
- ISO 22734-1:2019 Hydrogen generators using the water electrolysis process – Part 1: Industrial and commercial applications;
- UNI EN ISO 13445-3 Unfired pressure vessels - Part 3: Design;
- EN ISO 4126-1 Safety Devices for protection against excessive pressure – Part 1: Safety valves;
- ISO/TR 15916 Basic Consideration for the safety of hydrogen systems.

Standards applied to the storage system:

- UNI EN ISO 13445-3 Unfired pressure vessels - Part 3: Design;
- EN ISO 4126-1 Safety Devices for protection against excessive pressure – Part 1: Safety valves;
- ISO/TR 15916 Basic Consideration for the safety of hydrogen systems.

4.3 Industrial application: protocol for electrolysers conformity - a general approach from Notified bodies

Regarding the certification of electrolysers, a protocol, i.e., a guideline for the voluntary certification of this technology, is described. Here, the main phases for the certification of an electrolyser according to the ISO 22734:2019 standard is showed. In general, the device must comply with certain requirements concerning:

- Operational conditions;
- HAZOP/Risk assessment according EN12100;
- Test and quality of materials of mechanical and electrical parts;
- Control and safety systems;
- Ionic medium.

The different requirements of a certification protocol can be summarized as follows:

- Generally, there is an obligation to comply with European directives to obtain the minimum requirements for CE Marking. It can be obtained following the applicable Directives that have already been described in detail in section 2.1. For electrolysers: Machinery Directive 2006/42/EC, PED Directive 2014/68/EU, and ATEX Directive 2014/34/EU;
- Next to the EU Directives, it is recommended but not mandatory to apply the standard ISO 22734 to meet the minimum safety requirements;
- Risk assessment through HAZOP methodology, SIL allocation (safety approach to safety circuits according to the international standard IEC 61508/61511), and risk assessment according to EN 12100 standard;
- It is then necessary to demonstrate compliance with the ATEX Directive as well (Directive 2014/34/EU). Working with potentially explosive atmospheres requires a classification of the potentially risk zones and verification of the equipment. This is also linked to the previous risk assessment activity and the standard EN-IEC 60079-10-1 (as mentioned in section 2.2) can provide a guideline for identifying and characterising potential leakage sources, assessing available ventilation and defining hazardous zones in the installation area;
- The conformity assessment also concerns the mechanical parts of the hydrogen production process through electrolysis. For this reason, the PED Directive on pressure equipment applies. The Notified Body is necessary for the risk assessment connected to high pressures during the operation. Therefore, these devices are associated with Risk Category IV: Highly complex pressure equipment with very high risks. Also, related to the mechanical parts, it is crucial to perform material qualifications according to EN 10204 (type 3.2), procedure qualifications (welding), welder and welding operator qualifications, material tests. German certifications that are part of the technical rules of the PED Directive like AD 2000 W0 –AD 2000 HP0 (these are certifications known for the construction of industrial plants and pressure equipment) are also considered for compliancy;
- To obtain experimental evidences of the conformity of the product design, the standard ISO/IEC 1705 can be followed. The final certification of the electrolyser can be achieved

once laboratory tests and supervised tests and inspections at the manufacturer and/or installation site are done and the results are reported in an appropriate technical document.

This protocol is aimed at various areas of use such as industrial, commercial, and residential, and different types of electrolysers such as Alkaline water electrolyser (AWE), Proton exchange membrane (PEM WE), and Anion exchange membrane (AEM WE). The certification system is in accordance with ISO 17065.

Overall, different certification bodies can provide different procedures and technical standards to achieve the declaration of conformity for hydrogen technologies according to the directives aforementioned so far and the technical standards reported.

Another evidence of the requirements for the certification of electrolysers has been provided by a manufacturer of electrolysers in Bulgaria (one of the stakeholders close to the partner BH2C) (Table 9Table 9). He shared the following technical standards necessary from Bulgarian authorities involved both in the certification and safety and permitting processes like Fire Safety and Civil Protection service, the National Security Agency, and the State Agency for Metrology and Technical Supervision:

Table 9 Technical standards for Electrolysers (evidence from Bulgaria)

Standard	Description
ISO 22734:2019	Hydrogen generators using water electrolysis for industrial, commercial and residential applications:
ISO/TR 15916:2015	Basic considerations for safety of hydrogen systems
EN 61511-1:2017	Functional safety - Safety systems for the manufacturing industry sector- Part 1: Framework, definitions, system, hardware and application
ISO 12100:2010	Safety of machinery — General design principles — Risk assessment and risk mitigation. It is important to add that this deliverable is under revision and it will be replaced by ISO/CD 12100
ISO 13850:2015	Safety of Machinery – Emergency stop function – Principles for design
IEC 61326-1:2012	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements
EN 55011:2016+A1:2017+A11:2020+A2:2021	Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement
EN 1593:2004	Non-Destructive testing- Leak testing – Bubble emission techniques
EN 61000-3-3:20136+A1:2019+A2:2022	Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current 16 A per phase and not subject to conditional connection

4.4 Mobility application: hydrogen technologies and vehicles homologation in railway sector

In Italy, within the framework of the recent development of the first Hydrogen Valley (H2iseo), the homologation of hydrogen-powered vehicles for the railway sector is a relevant hotspot to be considered. The activities involving the construction and also conceptual and regulatory aspects of the hydrogen valley have involved stakeholders, such as railway infrastructure managers, railway

companies, maintenance entities, and institutional players at multiple levels. **The National Agency for Railway and Road Infrastructure Safety (ANSFISA), on behalf of the Italian Ministry of Infrastructure and Transport, has developed Guidelines for the authorization of hydrogen-powered railway vehicles**. These guidelines can represent a step forward for hydrogen uptake as an alternative fuel for rail mobility sector complementing and exploiting the experiences that are still ongoing in H2iseo Valley. Below are listed both the technical standards and the guidelines considered fully applicable for the certification of hydrogen-powered vehicles for the railway sector, as well as standards proposals and drafts. Some of the technical standards reported indirectly refer also to hydrogen technologies complementing the ones mentioned (Table 10).

Table 10 Standards and standards proposals for H2-fuelled trains (Italian official guidelines)

Standard proposals (NP) and drafts waiting for consultation and voting (CDV) by the involved committees	
IEC/CDV 63341-1	Railway applications Fuel Cell Part 1: Fuel Cell Power System
IEC/CDV 63341-2	Railway applications Fuel Cell System Part 2: Hydrogen Storage System
IEC/CDV 63341-3	Railway applications Fuel Cell System Part 3: Performance requirements and tests methods
ISO/NP 17268-4	Refuelling connection devices for rail & road heavy duty
ISO/NP 19881-2	Fuel Container for rail
ISO/NP 19887-2	Fuel System Components for Rail
Standards considered for the certification of hydrogen-powered systems (also applicable to other sectors involving the use of electric fuel cell vehicles and with the potential presence of explosive atmospheres in fixed installations)	
ISO 14687	Hydrogen fuel quality — Product specification
IEC 62619	Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications
ISO/TR 15916	Basic considerations for the safety of hydrogen systems
SAE J2601-2	Fuelling Protocols for Gaseous Hydrogen Powered Heavy Duty Vehicles
SAE J2799	Hydrogen Surface Vehicle to Station Communications Hardware and Software
IEC 60079-10-1	Explosive atmospheres - Part 10-1: Classification of areas - Explosive gas atmospheres – Edition 3.0
CEI EN IEC 60079-0	Explosive atmospheres Part 0: Equipment - General requirements
ISO 17268	Gaseous hydrogen land vehicle refuelling connection devices
ISO 19881	Gaseous hydrogen Land vehicle fuel containers
ISO 19882	Gaseous hydrogen Thermally activated pressure relief devices for compressed hydrogen vehicle fuel containers
ISO 19887	Gaseous Hydrogen Fuel system components for hydrogen fuelled vehicles

ANSFISA also covers other types of mobility and the guidelines published for hydrogen-fuelled trains homologation do not exclude the possibility to transfer some of these certification requirements to other areas such as road mobility. Indeed, regulatory texts related to the approval of motor vehicles and their components are also mentioned, paving the way for similar works:

- Regulation (EU) 2019/2144 of 27 November 2019 on the approval requirements for motor vehicles and their trailers, as well as systems, components, and separate technical units intended for such vehicles;
- Implementing Regulation (EU) 2021/535 of 31 March 2021 laying down detailed rules for the application of Regulation (EU) 2019/2144.

4.5 Mobility applications: technical standards for Hydrogen Refuelling Stations (HRS) and FCEVs

Hydrogen refuelling stations are a combination of various hydrogen technologies, each of which must meet minimum requirements to be marketed within the European single market. As described in D2.1, safety requirements can be met by stakeholders following risk based or prescriptive approaches. **In the Italian case, prescriptions exist and guide the construction and operation of a facility like an HRS.** Nevertheless, even for this type of approaches, standardization plays a significant role for certification and compliancy to the legislation requirements.

To gain a deeper insight into the applicable standards for hydrogen technologies associated to HRS it is possible to consult the appendix A of the following scientific reference[5] (GENOVESE, Matteo, et al. Current standards and configurations for the permitting and operation of hydrogen refuelling stations. *International Journal of Hydrogen Energy*, 2023).

Indeed, for some of the elements of the distribution plant defined as dangerous, the Italian technical rule for hydrogen refuelling stations (DM 23 October 2018) mentions the following technical standards. These are also considered suitable guidelines for the construction and installation of a HRS according to the Italian authority responsible for evaluating safety aspects, i.e. the Fire Brigade:

- **For on-site production units at the HRS facility**:
  - ISO 16110-1 for steam reformers: "Hydrogen generators using fuel treatment technologies - Part 1: Safety";
  - **ISO 22734-1 for electrolysers: "Hydrogen generators using water electrolysis — Industrial, commercial, and residential applications**";
- **For compressors: standard EN 1012-3 "Compressors and vacuum pumps - Safety requirements - Part 3: Process compressors";**
- **For storage systems: standard ISO 19884 "Gaseous hydrogen — Cylinders and tubes for stationary storage".**

Thus, Italian authorities are fully aligned to the best technical standards available for these types of facility and their main components and this proves the usefulness of such standards.

Regarding mobility sector and HRS, stakeholder's engagement activity brought to the identification of a list of the technical standards necessary to achieve certification compliance of all the hydrogen technologies involved in the facility. It is the case of one of the RIGP's stakeholders which is planning to build **two publicly accessible hydrogen refuelling stations** in Poznań and **one innovative mobile station** in Włocławek in the framework of one of the largest national projects in terms of hydrogen production volumes ("Clean Cities – Hydrogen mobility in Poland (Phase I)").

[5] GENOVESE, Matteo, et al. Current standards and configurations for the permitting and operation of hydrogen refuelling stations. *International Journal of Hydrogen Energy*, 2023

Technical standards mentioned for HRS by this stakeholder are represented below (Table 11):

Table 11 Technical standards and technical reports for HRS (evidence from Poland)

Standard	Description
EN ISO 17268:2020	Connection equipment for refuelling of land vehicles fuelled by gaseous hydrogen
EN ISO 80079	Explosive atmospheres
EN 60079-10-1:2016-02	Explosive atmospheres - Part 10-1: Space classification - Gaseous atmospheres
EN 62305	Lightning protection for buildings - (all parts)
ISO 16111:2018	Transportable gas storage devices - Hydrogen absorbed in reversible metal hydride
ISO 19880-1:2020	Gaseous hydrogen - Fuelling stations - Part 1: General requirements
ISO 22734:2019	Hydrogen generators using water electrolysis - Industrial, commercial, and residential applications
ISO 14687:2019	Hydrogen fuel quality - Product specification
ISO 16110-1:2007	Hydrogen generators using fuel processing technologies - Part 1: Safety
ISO 16110-2:2010	Hydrogen generators using fuel processing technologies - Part 2: Test methods for performance
ISO/TR 15916:2015	Basic considerations for the safety of hydrogen systems
ISO 13984:1999	Liquid hydrogen - Land vehicle fuelling system interface
ISO/TS 20100:2008	Gaseous hydrogen - Fuelling stations
NFPA 2	Hydrogen Technologies Code
NFPA 15	Standard for Water Spray Fixed Systems for Fire Protection

HYPOP consortium decided to focus not only on hydrogen technologies for HRS because, thanks to the engagement activity, stakeholders pointed out the need to work also on hydrogen purity as an aspect considered relevant. **Hydrogen purity is indeed a hotspot and this is mainly due to the needs of FCEV, especially for those adopting PEMFC. It is possible to meet the minimum certification requirements following the ISO 14687:2019.** This document specifies the minimum quality characteristics of hydrogen fuel as distributed for use in vehicular and stationary applications. **According to the review program of ISO, after 5 years this technical standard is going to be replaced by another one that will be published soon, ISO/DIS 14687.**

5 Standardization activities of Technical Committees

5.1 Main standardisation activities

Standardization bodies are involved in the development of international standards and thus play a crucial role in the market uptake of innovative technologies or commercial technologies approaching new sectors. In the previous sections, standards have been often referred to, as they support the certification process and contribute to ensuring public safety, health and environmental protection.
The aim of this section is to show current and foreseen standards around hydrogen technologies supporting the compliance with the certification requirements of the regulatory framework analysed in D2.1 and D.2.2. This analysis starts with the review of the work of the technical committee of the main standardization bodies at the European level, CEN and CENELEC, and at the international level, ISO and IEC. They are actively working to provide standards that can be used by hydrogen supply chain players for demonstrating compliance with the competent authorities involved in the evaluation procedures for the safety and permitting of hydrogen technologies. Within this framework, also the Society of Automotive Engineers (SAE) is working to provide hydrogen technologies of standards capable to boost innovation in the market. Indeed, SAE standards are also considered for EU hydrogen market.

Given the importance of having standards supporting hydrogen technologies that increase trust and improve perception among stakeholders such as Fire Brigades, Ministries, public bodies for environmental protection and for territorial planning and safety, a **general analysis of the main active technical committees for industrial, mobility, and residential applications has been conducted**. Moreover, some of the main technical standards available today are reported even if the overall purpose of the present research was not to provide a comprehensive collection of both the standards and technical committees, which instead is available in the "Roadmap on hydrogen standardization"[6] document published by the European Clean Hydrogen Alliance. In the Conclusion section, a figure from the aforementioned Roadmap illustrating the status of the TCs involved in hydrogen standardization is presented. Through this deliverable, the aim is to show the main path of standardization framework for innovative technologies. In the case of one of the Italian standardization bodies, a specific focus on its activities is provided in Appendix A.

Together with the technical committees' activities, an overview of the development of standards for electrolysers, fuel cells, and storage systems, and the related connected devices has been provided.

The first two standardization bodies analysed at European level are CEN and CENELEC, which, through their technical committees and working groups, are contributing to hydrogen technologies development[7]:

- **CEN-CLC/JTC 6 "Hydrogen in energy system"** is responsible for standardization in the field of systems, devices, and connections for the production, storage, transport, and distribution, measurement, and use of hydrogen. In particular, the effort is focusing **on the ISO 22734-1 standard concerning hydrogen production via electrolysers**. There are 3 specific working

[6] Roadmap on hydrogen standardization" document published by the European Clean Hydrogen Alliance https://ec.europa.eu/docsroom/documents/53721/attachments/1/translations/en/renditions/native

[7] CEN-CENELEC Work programme 2024 https://wp2024.cencenelec.eu/sectors-list/energy-and-utilities/

groups within this technical committee working on other aspects related to hydrogen vocabulary and the guarantee of origin:
    - CEN/CLC/JTC 6/WG 1: Terms and Definitions;
    - CEN/CLC/JTC 6/WG 2: Guarantees of Origin;
    - CEN/CLC/JTC 6/WG 3: Hydrogen safety.
- **CEN/TC 23 "Transportable gas cylinders"** is working on technical standards for the storage and transport of compressed hydrogen. In particular, one of **their technical standard EN 17339 "Transportable gas cylinders - Fully wrapped carbon composite cylinders and tubes for hydrogen"** aims to define specific minimum requirements for the design, construction, prototype testing, and inspections during the production phase of Type II, III, and IV cylinders to be mounted on a frame (e.g., cylinder packs and tube trailers) and also composite material tubes for the storage of compressed gas. The legal reference is Directive 2008/68/EC on the transport of dangerous goods. **CEN/TC 23 published the technical standard EN 17533 "Gaseous hydrogen - Cylinders and tubes for stationary storage,"** which specifies the requirements for the design, manufacture, and testing of steel, stainless steel, aluminium alloy, or non-metallic construction material pressure vessels. These vessels can be of Type II, III, and IV or metallic seamless (Type I) with a maximum operating pressure for the storage of compressed hydrogen of 1,100 bar.
- **CEN/TC 58 "Safety and control devices for burners and appliances burning gaseous or liquid fuels"** is working to provide requirements for the Safety and control devices for equipment burning gaseous or liquid fuels, ranging from small domestic appliances to large industrial burners. They published **CEN/TR 17924:2023 "Safety and control devices for burners and appliances burning gaseous and/or liquid fuels - Guidance on hydrogen specific aspects".** This useful document for the application of hydrogen in the residential sector is under revision to integrate the results of technical tests into theorical considerations on hydrogen leakages;
- **CEN/TC 69 "Industrial valves"** which is working on (WI=00069246): Additional requirements for metallic valves for hydrogen application;
- **CEN/TC 234 "Gas infrastructure"** which is focusing on the functional requirements from the input of gas into the on-shore transmission to the determination and coordination of all gas infrastructure. At the moment, this technical committee is considering aspects regarding standards like:
    - EN 16726, describing the composition of high calorific gas to integrate parameters like the Wobbe Index parameter and the admissible hydrogen concentration. Its publication is expected by 2025;
    - EN 17928 series on the injection stations for hydrogen (and biomethane), to be finalized in 2024;
    - A new Work item on 'Gas infrastructure - Conversion of pipelines with maximum operating pressure over 16 bar for the use of hydrogen - Functional requirements' intended to be published as EN 1594-2.
- **CEN/TC 235 "Gas pressure regulators and associated safety devices for use in gas transmission and distribution**" which is working on (WI=00235019): Hydrogen Readiness of Gas Infrastructures - Requirements and Lab Test Procedure for Material Qualification of equipment;
- **CEN/TC 268 "Cryogenic vessels and specific hydrogen technologies applications**" is working on technical standards for the storage and transport of liquid hydrogen. This work will also be relevant for the refuelling protocols of hydrogen refuelling stations, for the

refuelling phases of FCEV vehicles, and for the quality that hydrogen must have to power FCs.

Information has been collected through the analysis of the CEN/CENELEC Work programme which still remains the recommended source to check for the most recent news and advance regarding hydrogen standardization.

The work of the technical committees of the international standardization body ISO was then analysed. Below are the **current technical committees working on hydrogen technologies**. In particular, the focus of ISO activity is on production, storage and dispensing of hydrogen and related equipment:

- **ISO/TC 22 "Road vehicles"** is working on all aspects for all types of road vehicles and their interfaces approved for operation on public roads for the whole life cycle concerning safety, security, sustainability, compatibility, interchangeability, maintenance, evaluation of performance and quality;
- **ISO/TC 58 "Gas cylinders"** is working for the standardization of gas cylinders and other pressure systems, their fittings and requirements relating to their manufacture and use. They published useful standards for certification of storage systems like:
    - **ISO 11114-1:2020/Amd 1:2023 "**Gas Cylinders - Compatibility of cylinder and valve materials with gas contents. Part 1: Metallic materials" (in collaboration with the previously mentioned CEN/TC 23 "Transportable Gas Cylinders"). This standard provides an update regarding the requirements for the safety combination of different metallic cylinders and valves materials according to gas content and mixtures;
    - **ISO 11515:2022 "Gas cylinders- Refillable composite reinforced tubes of water capacity between 450 l and 3,000 l - Design, construction and testing"**. This standard specifies the minimum requirements for the materials, design, construction and performance testing of:
        - Type 2 hoop-wrapped composite tubes;
        - Type 3 fully-wrapped composite tubes, and;
        - Type 4 fully-wrapped composite tubes

      with water capacities between 450 l and 3,000 l for storage and conveyance of compressed or liquefied gases with test pressures up to and including 1,600 bar and a design life of at least 15 years.
- **ISO/TC 197 "Hydrogen technologies"** is responsible for standardization in the field of systems and devices for the production, storage, transport, measurement, and use of hydrogen. **This technical committee is very active in this sector and has published the following technical standards:**
    - **ISO 16110-1:2007 "Hydrogen generators using fuel processing technologies - Part 1: Safety, Part 2: Test methods for performance."** This standard applies to hydrogen generation systems with a capacity less than 400 m^3/h at 0 °C and 101.325 kPa, which convert an incoming fuel into a hydrogen-rich stream with composition and conditions suitable for the type of device using the hydrogen (e.g. a fuel cell power system or a hydrogen compression, storage, and dispensing system). The scopes of application range from industrial, light industrial, commercial, and residential both indoor and outdoor;
    - **ISO 22734:2019 "Hydrogen generators using water electrolysis - Industrial, commercial, and residential applications,"** which defines the construction, safety,

and performance requirements of modular or factory-adapted equipment for the generation of gaseous hydrogen. **This standard concerns those gaseous hydrogen generators intended for industrial and commercial uses, and for indoor and outdoor residential use in protected areas, such as car ports, garages, storage areas, and similar areas of a dwelling but does not include those systems that can work in reverse mode like fuel cells to generate electricity**. This standard is under revision and will be replaced by ISO/DIS 22734-1 "Hydrogen generators using water electrolysis" Part 1: General requirements, test protocols, and safety requirements;

- **ISO 19881:2018 "Gaseous hydrogen - Land vehicle fuel containers**." This standard contains requirements related to the material, design, manufacture, marking, and testing of mass-produced refillable tanks exclusively intended for the storage of compressed gaseous hydrogen for operation of land vehicles. These tanks must have minimum characteristics: be permanently affixed to the vehicle, have a maximum water capacity of 1,000 l, and have a maximum working pressure not exceeding 70 MPa. The scope of this document is limited to hydrogen quality tanks for fuel cell vehicles according to ISO 14687 standard for land fuel cell vehicles and grade A or higher hydrogen according to ISO 14687 standard for internal combustion engine land vehicles. This document also contains requirements for hydrogen tanks acceptable for use on board light vehicles, heavy vehicles, and industrial trucks such as forklifts and other material handling vehicles. This standard will be replaced by ISO/DIS 19881 "Gaseous hydrogen Land vehicle fuel containers";
- **ISO 16111:2018 "Transportable gas storage devices - Hydrogen absorbed in reversible metal hydride."** This standard is relevant for transportable metal hydride storage systems. It defines the requirements applicable to the material, design, construction, and testing of transportable storage systems using enclosures with an internal volume not exceeding 150 l and with a maximum developed pressure (MDP) not exceeding 25 MPa. **It is not applicable to metal hydride storage systems intended to be used as fixed fuel tanks on board hydrogen-powered vehicles;**

- **ISO/TC 197/SC 1 "Hydrogen at scale and horizontal energy systems**" is a sub-committee instituted under ISO/TC 197 and that deals with the standardization of large-scale hydrogen systems and energy applications, including aspects related to testing, certification, sustainability and positioning, and coordination with other standardization bodies and stakeholders. This TC should support the implementation of large-scale projects where blending with other fuels is considered. The technical committee is also actively working on publishing standards for calculating pollutant gas emissions from the different possible processes for hydrogen production. **Among the various areas of work of ISO/TC 197/ SC1, there is a standard aimed at liquid hydrogen storage systems for a specific application, ISO/AWI 19888-1 "Hydrogen Technologies — Aerial Vehicles — Part 1: Liquid Hydrogen Fuel Storage System."** This technical standard intends to specify the procedures and testing requirements that a manufacturer must follow to verify the performance of a safe fuel storage system mounted on hydrogen-powered aerial vehicles.

Another standardization body analysed is the **IEC. Most of the IEC activity is related to FC technology and its use in stationary applications**. The most active IEC technical committee is **TC 105 "Fuel cell technologies"**. It has a lot of ongoing projects like for Micro CHP, Reverse operating FC power systems and portable FC power systems. Here are reported some of the standards considered (according to projects analysed and stakeholders' engagement activity in HYPOP):

- IEC 63341-3: Railway applications - Fuel cell systems for rolling stock - Part 3: Performance test methods for fuel cell power system;
- IEC 62282-8-201: Fuel cell technologies - Part 8-201: Energy storage systems using fuel cell modules in reverse mode - Test procedures for the performance of power-to-power systems;
- IEC 62282-3-300: Fuel cell technologies - Part 3-300: Stationary fuel cell power systems – Installation;
- IEC 62282-8-101: Fuel cell technologies - Part 8-101: Energy storage systems using fuel cell modules in reverse mode - Test procedures for the performance of solid oxide single cells and stacks, including reversible operation;
- IEC 62282-7-2: Fuel cell technologies - Part 7-2: Test methods - Single cell and stack performance tests for solid oxide fuel cells (SOFCs);
- IEC 62282-4-600:2022: Fuel cell technologies - Part 4-600: Fuel cell power systems for propulsion other than road vehicles and auxiliary power units (APU) - Fuel cell/battery hybrid systems performance test methods for excavators.

Another standardization body considered as a reference for some of the technologies in the hydrogen value chain is the **SAE Standards for Mobility Knowledge and Solutions (SAE).** This standardization body is mainly focused on hydrogen refuelling stations that, as a facility composed by different hydrogen technologies, also provides significant specific requirements for the connection devices between the dispenser and the vehicle that could contribute to the development of the hydrogen value chain, mainly for mobility.

Moreover, the technical committees and the analysis of the current standardization activity provided examples of the standards available for hydrogen technologies represented as follows:

- SAE J2601/2_202307 Fuelling Protocol for Gaseous Hydrogen Powered Heavy Duty Vehicles;
- SAE J3089_201810 Characterization of On-Board Vehicular Hydrogen Sensors;
- SAE J2579_202301 Standard for Fuel Systems in Fuel Cell and Other Hydrogen Vehicles;
- SAE J2600_201510 Compressed Hydrogen Surface Vehicle Fuelling Connection Devices;
- SAE J2601_202005 Fuelling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles;
- SAE J2578_202301 Recommended Practice for General Fuel Cell Vehicle Safety.

The main technical committee working on these standards is the Fuel Cell standard committee.

5.2 Summary of main standards under development of interest for innovative hydrogen technologies

The actual situation of the standards development sees technical committees working in parallel to provide standards that in some cases can also have a cross sectorial impact among industrial, residential and mobility fields. Innovative hydrogen technologies can indeed take advantage of this to comply with the certification requirements needed.

The projects analysed by HYPOP consortium allowed to identify some of the main TC's developments of standards which regard:

- Transversal fields of activity covering technologies for the production, storage, transport, and distribution, measurement, and use of hydrogen. **Main actions are concerning renewable hydrogen production** with CEN-CLC/JTC 6 "Hydrogen in energy system" (efforts on the ISO 22734-1 standard concerning hydrogen production via electrolysers) and ISO/TC

197 “Hydrogen technologies” (efforts on ISO 22734:2019 "Hydrogen generators using water electrolysis - Industrial, commercial, and residential applications").

- **Hydrogen storage** with the activity of CEN/TC 23 “Transportable gas cylinders” which is focusing on designing of composite materials cylinders and stationary applications for compressed hydrogen. Moreover, standards supporting **manufacturing and use of hydrogen cylinders** is carried out by ISO/TC 58 “Gas cylinders”. In the case of cryogenic hydrogen, CEN/TC 268 "Cryogenic vessels and specific hydrogen technologies applications" is working on technical standards for the **storage and transport of liquid hydrogen**, that will be relevant also for protocol for refuelling of HRS (main topic of SAE standards for HRS refuelling protocols) and refuelling of FCEV vehicles;
- For the residential sector is relevant the activity of CEN/TC 58 “**Safety and control devices for burners and appliances burning gaseous or liquid fuels**” as it ranges from small domestic appliances to large industrial burners;
- For **fuel cells** in reverse mode for power-to-power configurations (relevant also for residential sector) and among others in railway applications, there is the IEC/TC 105 “Fuel cell technologies”.

However, the framework is wider than this as it can be seen in the following figure, taken from the “Roadmap on hydrogen standardization” published by the European Clean Hydrogen Alliance. Hydrogen sector and its technologies are expected to be completely covered in the following years to provide stakeholders of instruments to comply the safety and permitting requirements.

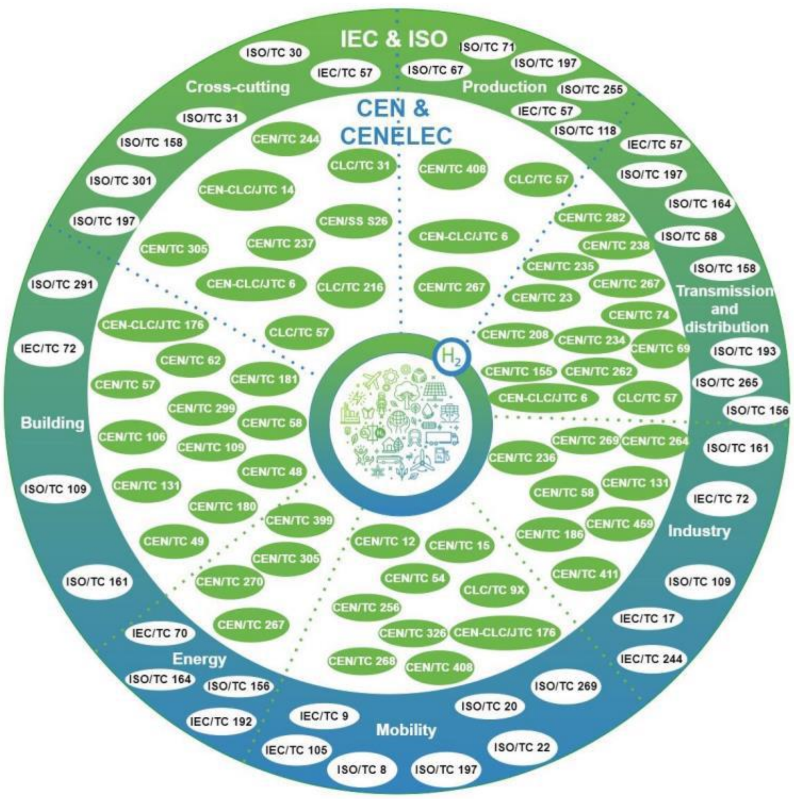

Figure 6 “Roadmap on hydrogen standardization” document published by the European Clean Hydrogen Alliance

6 Conclusions

Project HYPOP interacted with stakeholders, more specifically manufacturers and developers of innovative technologies, to understand how they achieved or worked to achieve CE marking.

The most relevant Directives for hydrogen technologies have been identified, on the basis of the experience shared. Such Directives are widely applied in Europe as they support the single market: CE marking is indeed a prerequisite for the commercialisation of any product within Europe.

The ATEX Directive primarily applies to electrolysers, fuel cells, and storage systems and it is also valid for other components of the BoP of a hydrogen facility due to the risk of explosive atmospheres, whichever the sector of application. Such technologies are classified in Group II, and assigned to a category depending on the risk of the specific use. Accordingly, the certification process entails a higher complexity of documentation and the involvement of a Notified Body to validate the product.

The **Machinery Directive** applies to products that compose hydrogen systems such as **pumps and compressors and other hydrogen technologies**. Generally, these do not necessarily have to be evaluated by a Notified Body, and therefore the information to report includes a general description of the product, conceptual design and manufacturing drawings and schemes of components, sub-assemblies, circuits.

Due to the generally high **working pressures above 0.5 bar**, a large portion of the **technologies aimed at the production, storage, distribution and use of hydrogen must comply with the requirements of the PED Directive**. Furthermore, the flammability characteristics of hydrogen mean that, for the certification, a storage system or electrolysers (categories III and IV) must undergo an evaluation by a Notified Body.

Most of the hydrogen technologies should also take into account the Low Voltage Directive as it is referred to electrical equipment that work under voltage rating between 50 and 1,000 V for alternating current and between 75 and 1,500 V for direct current (like **fuel cells**). In this case, the involvement of a Notified Body is not required, however, standards are available to support the self-declaration by the manufacturer.

Harmonised standards support the manufacturers/developers in achieving certification. Indeed, standardisation cover a very important role in supporting the introduction of innovation and in providing all stakeholders – from Notified Bodies to safety authorities – with a solid base for authorising the commercialisation and adoption of hydrogen technologies. Many Technical Committees (TCs) within the European and international standardisation bodies are working to provide updated standards in response to new applications and safety requirements, especially for new applications such as residential and mobility, where the perception of risk by the competent authorities is greater. Examples of innovative hydrogen technologies have been reported in this document. It is believed that the application of **hydrogen technologies in the industrial, mobility, and residential sectors will be further supported by the activity of technical committees** aimed at modifying and making the existing standards more efficient and possibly developing new ones based on the emerging technical needs and on the hydrogen new applications.

Significant ongoing effort among various standardization bodies to address sector-specific needs while ensuring that hydrogen technologies can be safely integrated into existing and new markets. The collaboration between these technical committees and stakeholders is crucial for the innovative and safe expansion of hydrogen technology applications across residential, mobility, and industrial

sectors. This cooperative approach not only addresses the current regulatory and safety challenges but also prepares the hydrogen economy for future growth and integration into diverse markets.

7 Appendix A

Within the deliverable, the work of the TC of international standardisation bodies have been mentioned. In some cases, the European/international committees have national "mirror" committees with the purpose of involving national experts in the study of international standards.

7.1 Italy

At Italian level, these national committees work within the framework of two standardization bodies, UNI and CEI, who also contribute to new technical standards for the hydrogen value chain.

Some examples of the UNI's standards development activity are reported here. In some cases, UNI delegates the standardization activity to independent organizations that are more vertical to specific sectors[8].

The main UNI's technical committees working on hydrogen are UNI/TC 056 and UNI/CT 286. UNI/TC 286 activity is linked to the one of the independent body, Comitato Termotecnico Italiano (CTI) (Table 12).

Table 12 Cross standardization activity between UNI and CTI

Technical committee	Scope
UNI/CT 286/GL 01	CTI - Tanks for hydrogen in land vehicles
UNI/CT 286/GL 02	CTI - Hydrogen from water electrolysis and fuels
UNI/CT 286/GL 03	CTI - Components for hydrogen gas transport - metal hydrides
UNI/CT 286/GL 04	CTI - Hydrogen gas and hydrogen mixtures refuelling stations
UNI/CT 286/GL 05	CTI - Specifications for hydrogen as a fuel

UNI/TC 056 (established in 2017 and mirror technical committee of CEN/CLC/JTC 6 "Hydrogen in energy systems" and ISO/TC 197 "Hydrogen technologies") works on Systems, devices and connections for the production, storage, transport, distribution, measurement and use of hydrogen, from renewable energy sources and other sources.

Excluded from the scope of activities are:

- the storage and transport of liquid hydrogen;
- the storage and transport of compressed hydrogen;
- the infrastructures covered by Mandate M/533 Alternative fuels infrastructures;
- the injection of hydrogen and mixtures of hydrogen with natural gas (H2NG) into gas infrastructures;
- the use of mixtures of natural gas with hydrogen.

In parallel, UNI cooperates with other international committees like IEC/TC 105 'Fuel cell technologies thanks to the CEI standardization body.

[8] https://www.uni.com/?s=idrogeno provides an overview about all the UNI standards for hydrogen.

All the references are from the UNI website[9] At the moment, there are 13 standards published by the UNI/TC 056 and no public inquiries are ongoing.

UNI/TC 056 has been recently working on projects for new standards like[10]:

1) project of standard UNI 1613708 (that should adopt ISO 22734:2019). This standard proposal deals with hydrogen generators and defines the construction, safety and performance requirements for modular or factory-fitted equipment for the generation of hydrogen gas, called hydrogen generators, which use the electrolytic splitting of water to produce hydrogen. It applies to hydrogen generators intended for industrial and commercial use, as well as for indoor and outdoor residential use in protected areas, such as car ports, garages, storage rooms and similar areas of a dwelling.
2) Project of standard UNI 1610884 (adopts ISO 16110-1:2007), applies to packaged, self-contained or factory-assembled hydrogen generation systems with a capacity of less than 400 m^3/h at 0°C and 101.325 kPa, referred to herein as hydrogen generators, that convert an input fuel into a hydrogen-rich stream of a composition and condition suitable for the type of device using the hydrogen (e.g. a fuel cell power system or a hydrogen compression, storage and delivery system).
3) Project of standard UNI 1610885 (adopts ISO 16110-2:2010). It provides test procedures for determining the performance of packaged, self-contained or factory-assembled hydrogen generation systems with the same features and under the same test conditions of the previous UNI 1610884 (ISO 16110-1:2007);
4) Project of standard UNI 1610887, contains requirements for the material, design, manufacture, marking and testing of refillable containers produced in series and intended exclusively for the storage of compressed hydrogen gas for the operation of land vehicles. These containers: are permanently attached to the vehicle, have a capacity of up to 1,000 l of water, and have a nominal working pressure not exceeding 70 MPa. The scope of the document is limited to hydrogen containers of suitable fuel cell grade according to ISO 14687 for fuel cell land vehicles and hydrogen of grade A or higher according to ISO 14687 for land vehicles with internal combustion engines. It also contains requirements for hydrogen containers acceptable for use on board light vehicles, heavy-duty vehicles and industrial motor trucks such as forklifts and other material handling vehicles. It adopts ISO 19881:2018.
5) Project of standard UNI 1610886, establishes minimum requirements for pressure relief devices intended for use on fuel containers for hydrogen-powered vehicles. The scope of this document is limited to thermally activated pressure relief devices installed on fuel containers used with fuel cell grade hydrogen according to SAE J2719 or ISO 14687 for fuel cell land vehicles, and Grade A or higher hydrogen for land vehicles with internal combustion engines. This document also contains requirements for thermally activated pressure relief devices acceptable for use on light vehicles, heavy vehicles and industrial trucks such as forklifts and other material

[9] *Dettaglio commissione - UNI - Ente Italiano di Normazione*

[10] *Publication of preliminary public enquiry March 2024 https://www.uni.com/undici-progetti-entrano-oggi-in-inchiesta-pubblica-preliminare-marzo-2024/*

handling vehicles. Safety devices designed to comply with this document are intended for use with high-quality hydrogen. It adopts ISO 19882:2018.

6) Project of standard UNI 1610890, specifies the requirements for wire or fabric reinforced hoses and hose assemblies suitable for hydrogen dispensing up to a nominal working pressure of 70 MPa, in the operating temperature range from -40°C to 65°C. The document contains safety requirements for the material, design, manufacture and testing of hydrogen gas hoses and hose assemblies for hydrogen filling stations. It adopts ISO 19880-5:2019[11].

Other technical committees of UNI are working in parallel for hydrogen standardization:

- UNI/CT 100 - CIG - Comitato Italiano Gas (Italian Gas Committee) is working on the UNI 1613560 project that establishes the criteria for verifying the existence of the safety requirements of domestic and similar systems for the use of combustible gases, regardless of the date of their construction, in order to establish whether the verified gas system can continue to be used in the state in which it is, without compromising safety, in accordance with current legislation. It deals exclusively with the verification aspects of installations. It also establishes the criteria for the verification of plants that are to be converted to the use of natural gas and hydrogen mixtures. It replaces UNI 10738:2012[12].
- UNI/CT 100 - CIG - Comitato Italiano Gas and is working on the project UNI 1612619. The document deals with safety and control devices for burners and gas and/or liquid fuel appliances. It is drawn up in anticipation of a forthcoming revision of standards concerning the safety, design, construction, performance and testing requirements for safety, control or regulation devices for burners and user appliances with variable mixtures. The aim of the document is to provide guidance on specific hydrogen-related aspects that need to be considered in the future standardisation work of CEN/TC 58. It also contains several indications and information that improve knowledge in relation to the potential use of hydrogen not only on specific products such as safety and control devices for gas burners and gas utilising appliances, but also on materials and seals, to the benefit of the whole gas chain. It implements CEN/TR 17924:2023.

The following is an example of the results of cooperation between UNI TCs and the independent body that represents specific sectors in Italy. Currently, there is only one Italian (and European) standard for testing heat generators that use 20% by volume of hydrogen mixed with natural gas for combustion. The first technical specification UNI/TS 11854 was published on February 24, 2022, developed within the Comitato Italiano Gas (CIG) with the contribution of Assotermica (the association of manufacturers of appliances and components for heating systems federated by Anima Confindustria) and dedicated to heat generators powered by natural gas and hydrogen mixtures up to 20% by volume[13].

[11] *Publication of preliminary public inquiry May 2022 https://www.uni.com/sono-quindici-i-progetti-entrati-oggi-in-inchiesta-pubblica-preliminare/*

[12] *Publication of preliminary public inquiry January 2024 https://www.uni.com/otto-progetti-entrano-oggi-in-inchiesta-pubblica-preliminare-2/*

[13] For more information about the UNI activities on hydrogen, there is a dedicated webpage with all the necessary information: https://www.uni.com/?s=idrogeno

The Italian electrotechnical committee (CEI) is working together with UNI by mean of the technical committee CT 052 – "Hydrogen" and it follows the activities of the Working group constituted under CEN/CLC/JTC 6 Hydrogen in energy systems and ISO/TC 197 Hydrogen technologies.

7.2 Spain

Spain has the following mirror committees:

- **CTN 181 – Hydrogen technologies committee:** Spanish mirror committee to ISO/TC 197 committee on Hydrogen technologies, responsible for adapting European normative such as UNE-ISO 14687:2006 about specifications, UNE-ISO/TR 15916:2007 IN about basic security considerations or UNE 181001:2010 about terminology. The secretariat is chaired by AeH2 (Spanish Hydrogen Association)
- **CTN 222 – Fuel cell technologies committee:** Spanish committee devoted to normalisation. It is a mirror for IEC/TC 105 about fuel cell technologies. The secretariat is chaired by CNH2 and is divided in 14 work groups which cover topics from terminology to security and environmental performance.
- **CTN 203/SC 69 - Electrical power/energy transfer systems for electrically propelled road vehicles and industrial trucks:** Spanish committee related to IEC/TC 69.

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