FRENCH GUIDE TO CONFORMITY ASSESSMENT AND CERTIFICATION OF HYDROGEN SYSTEMS

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ABSTRACT

Hydrogen as energy carrier is referenced in French and European political strategies to realize the transition to low-carbon energy. In 2020 in France the government was launching a major investment plan amounting to 7.2 billion euros until 2030, to support the deployment of large-scale hydrogen technologies [1]. The implementation of this strategy should lead to the arrival of several new hydrogen systems that will need to be evaluated and certified regarding their compliance with safety requirements before being commercialized.

Conformity assessment and certification play an important role to achieve a good safety level on the EU market for the protection of workers and consumers. It is a way for the manufacturer to prove that hazards have been identified and risks are managed and to demonstrate his commitment to safety that are key to access to the EU market.

To assist manufacturers in identifying the applicable regulations, standards and procedures for putting their product on the market, Ineris elaborated a guidebook [2], with financial and technical support by ADEME, the French Agency for Ecological Transition and France Hydrogen, the French Association for Hydrogen and Fuel Cells. The preparation of this document also led to identifying gaps in the Regulations, Codes and Standards (RCS) framework and necessary resources for the implementation of the conformity assessment procedures.

This paper first describes the main regulatory procedures applicable for various types of hydrogen systems. Then describes the role of the actors involved in this process, with a special focus on the French context. And finally focuses on some of the gaps that were identified and formulates suggestions to address them.

1.0 INTRODUCTION

1.1 French policy in favor of the development of hydrogen technologies

Hydrogen produced from low carbon energy is now widely identified as a key for the transition to a low carbon economy. Several countries have launched wide investment plans to develop the new hydrogen technologies. French government has planned to spend 7.2 billion euros until 2030 to speed-up the deployment of infrastructures and support the development of new technologies. This plan will be operated through several national agencies in charge of environment (ADEME), research (ANR) and industrial investment (BPI) depending on the objective of the projects. The first calls for projects issued by ADEME are targeting the development of new technology bricks and the development of local H_2 ecosystems.

1.2 New needs of industrial actors in relation with certification

One of the expected outcomes of these plans at national and EU level is that new hydrogen systems for industry and transport will be put on the market in the next future. All these new systems will need to comply with the applicable safety regulations and be approved following the suitable certification processes.

Considering the complexity of the existing regulation it is difficult for some of the industrial actors to identify the applicable rules, procedures and standards. This is all the truer for start-ups and SMEs that are not issued from industrial groups but from research institutes and are thus not acquainted with the regulatory framework applicable to industrial products. In many cases, applying the regulation also implies to seek conformity by applying standards. Finding one's way through the permanently evolving standard corpus is also a real difficulty.

The application of the regulatory requirements also implies that the systems be tested and certified by adequate test laboratories and certification bodies. Currently not many of them in France have developed a specific offer for hydrogen systems, which implies additional costs and delays for the manufacturers who have to find solutions in other countries such as Germany and the Netherlands.

1.3 Guide for conformity evaluation and certification

In the context described above, Ineris has proposed to national authorities, the French agency of environment and energy (ADEME) and the French association for hydrogen (France Hydrogène) to write a guidebook for conformity assessment and certification of hydrogen systems.

The purpose of this guidebook was to present the applicable regulation and standard framework necessary to commercialize hydrogen systems and to list test labs and certification bodies available in France for accompanying the manufacturers during this process. The aim was also, during the preparation of the guidebook, to identify gaps in the current framework and formulate recommendations for the development of new regulations or standards for the testing and certification of a variety of systems.

This work was bibliographic, complemented by interviews with members of the hydrogen community within the Regulation working-group of France Hydrogène.

This paper focuses first on stationary applications and mobile machines not intended to be used on road and secondly on the case of road vehicles. For each case the applicable European regulatory framework to placing the product on the market is presented. Finally, gaps and needs that emerged from the interviews with stakeholders are discussed.

2.0 DESCRIPTION OF THE CONTENT OF THE GUIDE

2.1 Typology of hydrogen systems

The guidebook is dedicated to all systems and components that are intended to be put on the market in the context of the development of the new applications of hydrogen for power to gas and gas to power applications and mobility. It does not address explicitly more conventional hydrogen production and use technologies for industry e.g. production by methane reforming gases or use of hydrogen in chemical processes although part of the applicable regulatory framework. It targets the systems and not the industrial installations in which they will be implemented, which are covered by other regulation such as the SEVESO directive.

The systems addressed in the guide are the following

- Systems used in stationary (or mobile) power to gas and gas to power applications:
    - Electrolysers
    - Compressors
    - Storage tanks
    - Fuel cells
    - Pipes, fittings and valves
- Hydrogen refuelling stations
- Fuel cell road vehicles and their components

- Vehicles and machineries not intended to be used on roads
- New hydrogen mobility applications: planes, trains inland navigation boats, maritime navigation ships.

For these later applications, the guide only introduces the general applicable framework and points out mainly gaps and needs for a future regulation to be developed.

2.2 European regulatory framework applicable to putting on the market stationary applications and mobile machines not intended to be used on road

The general framework applicable to stationary applications and mobile machines that are not intended to be used on road is composed of several directives pertaining to the new European regulatory framework set out by regulation (EC) 765/2008 [3] and decision 768/2008/EC [4]. These directives and their application criteria are listed in table 1.

Table 1: EU directives applicable to stationary applications and mobile machines not intended to be used on road

Directive	**Application criteria**	**Comments**
PED – Pressure equipment directive 2014/68/EU [4]	Maximum allowable pressure (PS) > 0.5 barg Conformity assessment procedures vary in function of the product of PS and Volume (V) for vessels or of PS and nominal size (DN) for piping	Most of hydrogen systems use hydrogen at pressure above 0.5 barg and are thus concerned by PED In many cases the product of PS by Volume is such that the intervention of a notified body for the conformity assessment is required
Machinery directive 2006/42/CE [5]	A machinery is an assembly, fitted with or intended to be fitted with a drive system other than directly applied human or animal effort, consisting of linked parts or components, at least one of which moves, and which are joined together for a specific application. Assemblies of machinery as defined above are also machinery.	Most hydrogen systems fall into the machinery directive as machinery assemblies because they integrate, as essential part of their operation, compressors, pumps, fans… In most cases the conformity assessment does not require the intervention of a notified body

Directive	Application criteria	Comments
ATEX 2014/34/UE [6]	The system is explicitly intended to be used in a potentially explosive atmosphere (including explosive atmosphere outside the system generated by the system itself) and it contains its own potential ignition sources (electrical or mechanical)	Hydrogen being a highly flammable gas, the explosion risk is always to be considered. Yet, the ATEX directive does not apply if the system is not intended to be used in a potentially explosive atmosphere and if the system itself does not generate such potentially explosive atmosphere outside. If the potentially explosive atmosphere remains enclosed in the system, they are addressed under the machinery directive. In such a case though, ATEX certified components should be used inside the machinery. The intervention of a notified body is required only when the system is intended to be used in zone 0 or 1 (for gases) or 20 or 21 (for dust).
EMC – Electromagnetic compatibility 2014/30/UE [7]	EMC directive applies to appliance or combination thereof made available on the market as a single functional unit, intended for the end-user and liable to generate electromagnetic disturbance, or the performance of which is liable to be affected by such disturbance;	Most hydrogen system incorporate electronic appliances playing a role in process regulation or safety. For this reason, they fall under the scope of the EMC directive. They also sometimes can be the source of electromagnetic disturbances due to high intensity the electric currents. It is generally agreed that when properly assembled EMC certified components constitute an assembly that answer the requirements of the EMC directive. The intervention of a notified body is not required but it can be requested by the manufacturer on its own choice.

Directive	Application criteria	Comments
Low voltage 2014/35/UE [8]	This Directive shall apply 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.	Most hydrogen systems are concerned by this directive, which is mainly intended to protect persons and domestic animals against the danger of physical injury and other harm which might be caused by direct or indirect contact and to ensure that temperatures, arcs or radiation which could cause a danger are not produced. The intervention of a notified body is not required.
ROHS 2011/65/UE [9]	The directive applies to 'electrical and electronic equipment' or 'EEE', i.e. equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields and designed for use with a voltage rating not exceeding 1 000 volts for alternating current and 1 500 volts for direct current	The directive targets the elimination of certain hazardous substances from electrical and electronic appliances. Hydrogen systems are concerned when they incorporate such electrical and electronic appliances. The intervention of a notified body is not required.

All these directives share a set of common principles. Their application leads to establishing the CE conformity and CE marking.

They all specify essential safety requirements and define a framework of procedures for the demonstration that these requirements are met. Some of them impose that the conformity be verified and certified by an independent certification body, notified by the national authorities of an EU member. In practice, for most hydrogen systems, intervention of a notified body will be required only the assessment of conformity to the pressure equipment directive. Some may also need the intervention of a notified body for the conformity to the ATEX directive. The list of notified bodies can be found on the EU NANDO website[1]

The voluntary application of harmonised standards is recognised by all these directives as a means of establishing compliance. Harmonised standards are developed by recognised European Standards organisations (CEN, CENELEC or ETSI) following a request from the European Commission. The references of harmonised standards must be published in the Official Journal of the European Union[2]. The application of harmonised standards provides presumption of conformity to the essential requirements set out by the directive. The difficulty is often to identify the relevant standards. The guidebook provides lists of standards that most likely apply to hydrogen systems. It also provides a list of specific standards applicable to electrolysers, fuel cells and hydrogen refuelling stations, which are not considered as harmonised standards, most of them being currently only available at ISO level, but nevertheless offer a good framework for answering the essential requirements of the abovementioned

[1] https://ec.europa.eu/growth/tools-databases/nando/

[2] The list of harmonised standards is available at https://ec.europa.eu/growth/single-market/european-standards/harmonised-standards_en

directives. Table 2 and Table 3 list some of these standards. The guidebook provides additional details on the structure and contents of the standards.

Table 2: examples of generic harmonised standards relevant for the application of EU directives to hydrogen systems

EU directive	**Applicable relevant harmonised standards**
PED	EN 13445-1 to 5 : Unfired pressure vessels EN 764-1 to7: Pressure equipment, in particular EN 764-7 : Part 7 : safety systems for unfired pressure equipment EN 13480-1 to 8 : Metallic industrial piping EN 1349 : Industrial process control valves
Machinery directive	EN ISO 12100 Safety of machinery - General principles for design - Risk assessment and risk reduction EN 614-2 and 2: Safety of machinery - Ergonomic design principles EN 1127-1 : Explosives atmospheres - Explosion prevention and protection - Part 1 : basic concepts and methodology EN ISO 13849-1 and 2: Safety of machinery - Safety-related parts of control systems EN ISO 19353 : Safety of machinery - Fire prevention and fire protection
ATEX directive	EN 60079-0 to -32: Explosive atmospheres, in particular Part 0 : equipment - General requirements EN ISO 80079-36: Explosive atmospheres - Part 36 : non-electrical equipment for use in explosive atmospheres - Basic methods and requirements
EMC directive	EN IEC 61000 series: Electromagnetic compatibility (EMC)
Low tension	EN 61349-1: Low-voltage switchgear and controlgear assemblies Part 1: general rules

Table 3: specific standards applicable to some hydrogen systems

Hydrogen systems	Relevant standards
Electrolysers	ISO 22734 :2019 Hydrogen generators using water electrolysis process - Industrial, commercial, and residential applications
Compressors	EN 1012-3 : 2014 Compressors and vaccum pumps - Safety requirements - Part 3 : process compressors (not specific to hydrogen compressors)
High pressure storage	EN 17533 : 2020 Gaseous hydrogen - Cylinders and tubes for stationary storage

Hydrogen systems	Relevant standards
Storage as metal hydrides	ISO 16111 : 2018 Transportable gas storage devices - Hydrogen absorbed in reversible metal hydride (only applicable to transportable storage systems)
Fuel cells	EN IEC 62282 series: Fuel cell technologies
Hydrogen refuelling stations	EN 17127: Outdoor hydrogen refuelling points dispensing gaseous hydrogen and incorporating filling protocols EN ISO 17268 : Gaseous hydrogen land vehicle refuelling connection devices EN 17124 Hydrogen fuel - Product specification and quality assurance - Proton exchange membrane (PEM) fuel cell applications for road vehicles: ISO 19880-1 to 8 series : Gaseous hydrogen - Fuelling stations (only part 1, 3, 5 and 8 have been published, the other are still work in progress at ISO TC 197) The following SAE standards are cited as reference in ISO 19880-1 and EN 17127 for interoperability and management of the fueling protocols SAE J2600-2015 Compressed Hydrogen Surface Vehicle Fueling Connection Devices SAE J2601 Series : SAE J2601-2020 Fueling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles SAE J2601-2-2014 Fueling Protocol for Gaseous Hydrogen Powered Heavy Duty Vehicles SAE J2601-3-2013 Fueling Protocol for Gaseous Hydrogen Powered Industrial Trucks SAE J2799-2019 Hydrogen Surface Vehicle to Station Communications Hardware and Software

Note : although SAE standards are referred to in EN and ISO standards for interoperability and the definition of the fueling protocols, they are not considered as references in Europe for the homologation of hydrogen fuel cell vehicles nor the certification hydrogen refueling stations. In particular EN ISO 17268 remains the reference in Europe for the refueling connection devices.

Assessment of conformity

The process for assessment of conformity is described in Figure 1. It requires that the manufacturer has specified and documented the characteristics of his system and has made a risk analysis to determine the applicable essential safety requirements and assess that the corresponding risks have been properly taken into consideration in the product design.

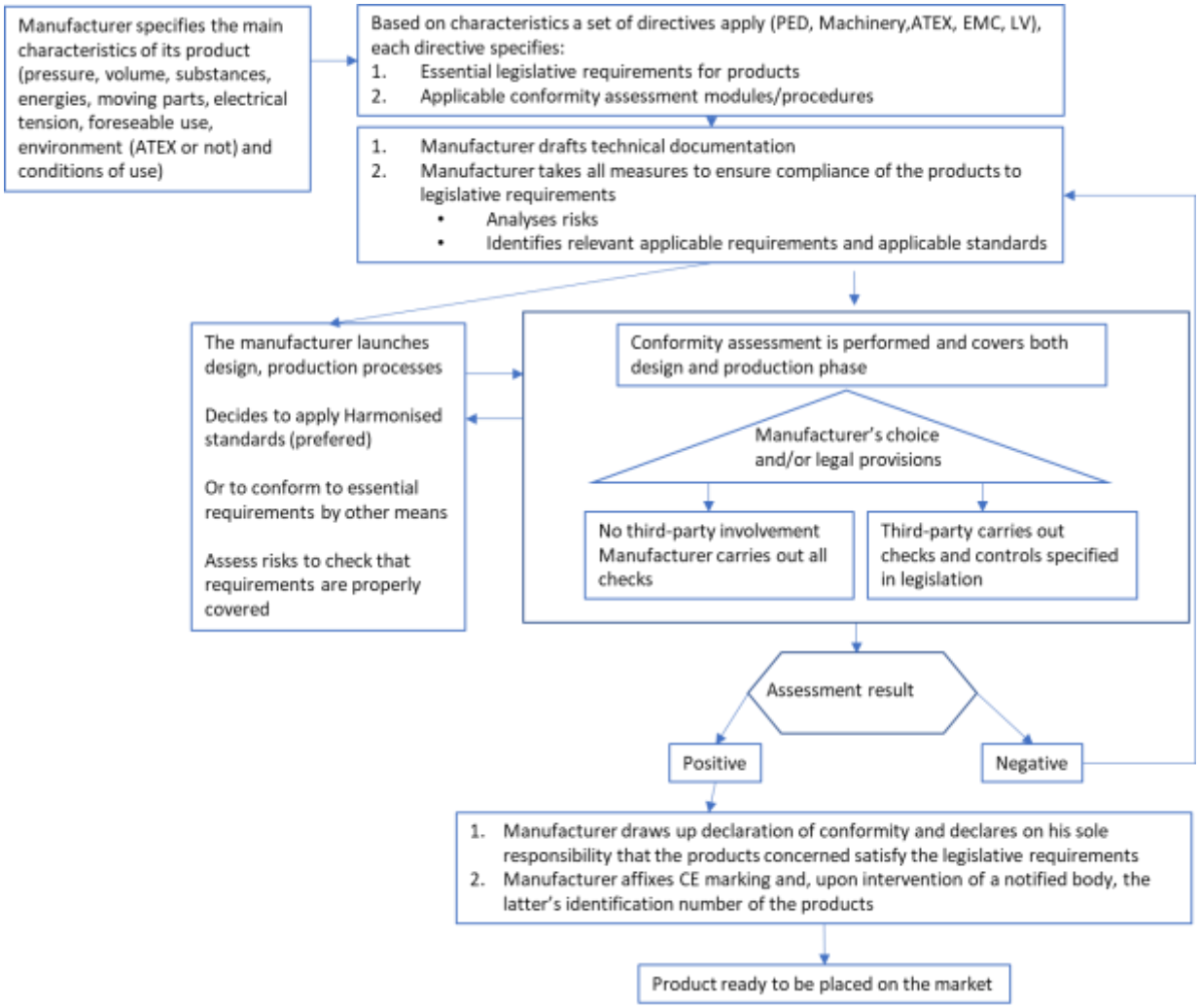

Figure 1: process for assessment of conformity adapted from the "Blue guide"[10]

2.4 Case of road vehicles

Regulatory framework

Road vehicles are currently covered in the EU framework by two complementary EU regulations: (EC) 79/2009 [11] and (EU) 406/2010 [12]. These regulation are in force until July 5th 2022 then, according to Regulation (EU) 2019/2144 [13] of the European parliament and of the council of 27 November 2019, they will be replaced by the application of UN regulation R134 [14] complemented the Commission implementing regulation (EU) 2021/535 just published on March 31st 2021 [15]. The type approval delivered until July 5th 2022 on the basis of regulation (EC) 79/2009 shall not be invalidated after entry into force of the new regulation.

This new regulatory framework based, for compressed hydrogen, on UN regulation R134 is focusing on the compressed hydrogen storage system comprising the storage vessel and its associated safety devices (TPRD, check valve and automatic shut-off valve), for which detailed testing procedures are defined. It also provides specifications of a vehicle fuel system incorporating the compressed hydrogen, which include crash tests and post-crash fuel-system integrity check. The new regulation (EU) 2021/535 includes requirements on material compatibility for both compressed and liquefied hydrogen, and specifications for storage systems and vehicles using liquefied hydrogen, which are not addressed in regulation R134.

Unlike the regulations (EC) 79/2009 and (EU) 406/2010, regulation R134 and (EU) 2021/535 do not specify characteristics and test protocols for other components of the compressed hydrogen fuel system, which are not part of the storage system itself, such as piping, pressure reducers, valves, filters… These components, which will not anymore be covered by the regulation remain covered by the ISO 12619 series, for which a revision was initiated. In its current version, the requirements of ISO 12619 are very close to those of (EC) 79/2009 regulation.

Regulation (EC) 79/2009 and now the new regulation 2019/2144 set out the framework and uniform procedures and technical specifications for the type-approval of vehicles, and of systems, components and separate technical units intended for such vehicles, as regards their general construction characteristics and safety.

Member states designate competent authorities for type approval. Tests are done by laboratories with adequate accreditations e.g. according to ISO 17025 standard.

Manufacturers shall submit files for the type-approval of vehicles and/or components. For the purposes of vehicle type-approval, manufacturers shall equip hydrogen-powered vehicles with hydrogen components and systems that comply with the requirements. Manufacturers shall provide the approval authorities with appropriate information concerning the vehicle specifications and test conditions.

Additional standards

In complement to the abovementioned regulations and details about their requirements, the guidebook also identifies a series of relevant international standards that apply to road vehicles. Unlike in the case of EU regulation applicable to stationary applications described in paragraph 2.2, the application of these standards does not provide a presumption of conformity. Among these standards, the ISO 12619 series is of particular interest considering the evolution of the EU regulation that no longer contains specifications for components that are not directly part of the hydrogen storage system. A revision of this standard series was recently decided at ISO TC 197.

Standard	**Scope**	**Comment**
ISO 12619 (Starting 2014) series Road vehicles — Compressed gaseous hydrogen (CGH2) and hydrogen/ natural gas blend fuel system components	Components of the H_2 fuel system Any type of vehicle (fuel cell or thermal motor)	Addresses the components not covered by R134/GTR 13
ISO 21266-1 : 2018 Road vehicles — Compressed gaseous hydrogen (CGH2) and hydrogen/ natural gas blends fuel systems —Safety requirements	Scope limited to internal combustion engine	General safety requirements: most of them consistent with R134/GTR 13 Some additional requirements (static test)
ISO 21266-2 : 2018 "Road vehicles — Compressed gaseous hydrogen (CGH2) and hydrogen/ natural gas blends fuel systems — Part 2: Test methods“	Scope limited to internal combustion engine	Details additional useful tests such as Receptacle mounting test (pull and torsion test) Static test for the mounting of the tank

Standard	Scope	Comment
ISO 19881:2018 Gaseous hydrogen — Land vehicle fuel containers	This standard specifies the requirements for hydrogen fuel containers manufactured in series Scope includes light duty vehicles covered by GTR13 but also heavy duty and other types of vehicles (off-road)	Consistent with R134/GTR13 for light duty vehicles +Introduces useful additional requirements on tank materials And tests that are required by EC 79/2009 but not by R134/GTR 13 such as high strain rate test (bullet) or boss torque test
ISO 19882:2018 "Gaseous hydrogen — Thermally activated pressure relief devices for compressed hydrogen vehicle fuel containers"	This document establishes minimum requirements for pressure relief devices intended for use on hydrogen fuelled vehicle fuel containers that comply with ISO 19881, IEC 62282-4-101, ANSI HGV 2, CSA B51 Part 2, EC79/EU406, SAE J2579, or the UN GTR No. 13.	Consistent with R134/GTR13
ISO 23273:2013 Fuel cell road vehicles — Safety specifications — Protection against hydrogen hazards for vehicles fuelled with compressed hydrogen	This International Standard specifies the essential requirements for fuel cell vehicles (FCV) with respect to the protection of persons and the environment inside and outside the vehicle against hydrogen-related hazards. It applies only to such FCV where compressed hydrogen is used as fuel for the fuel cell system.	Provides additional approaches for the qualification of hydrogen safety based on : - Hazard analysis - Demonstration of the safety concept

3.0 CHALLENGES AND NEEDS TO BE ADDRESSED

The preparation of the guidebook was the occasion to point-out a series of difficulties and challenges in the application of the regulatory framework in France. These challenges were reported by manufacturers or by laboratories and certification organizations involved in the conformity assessment process. Some of them are described in the next paragraphs.

3.1 Some issues and challenges related with the application of the EU framework

Quality of risk analysis and assessment

Risk analysis and risk assessment are key steps in the process to achieve conformity to the main EU directives, in particular PED, machinery and ATEX directives. Risk analysis is essential to identify those essential requirements that will need a detailed treatment in the machinery directive. It is also the basis for the decision to apply or not the ATEX directive as the identification of scenarios leading or not to the creation of an ATEX outside the system is often what will decide whether the system falls under ATEX directive or remains only concerned by the machinery directive. The safety measures and devices to be implemented in the context of these three directives result directly from the risk analysis and risk assessment especially in absence of detailed prescriptive standards. It is therefore important that the risk analysis and assessment be done by competent persons in a workgroup comprising people with a good knowledge of the process and following a structured method such as described in ISO 12100 of ISO 31010. It is also essential that the risk analysis be made on a design representative of the final product, a good practice being to revise the initial risk analysis when major modifications are made to the initial concept during the design process.

Quality of the technical documentation

The conformity assessment is based on the technical documentation, which constitutes an essential part of the certification file. The documents must be accurate, with a sufficient level of details and properly organized.

Management of explosion or fire risk

The risk of explosion or fire of a flammable mixture of hydrogen with air is always to be considered in hydrogen systems. The first step consists in analyzing the risk to identify under what circumstances and where such a flammable mixture could be formed and to relate this classification with the types of hazardous zones defined by the ATEX regulation (directives 2014/34/UE and 1999/92/CE [16]) and associated standards, especially the EN 60079-10-1 standards. The proper application of this methodology requires specific knowledge and competences, such as understanding of the gas explosion process and efficiency of specific mitigation strategies, that go beyond the generic capacity to apply risk analysis.

It is important to stress that in most cases the system will not be intended to be used in an ATEX zone and the ATEX risk analysis will conclude that at most a zone 2 will be generated outside due to potential leaks. This implies that the system will be covered solely by the machinery directive or the "self-certification" procedures of the ATEX directive, without the implication of a notified body. In this case, a lack of expertise during the explosion risk analysis done under the responsibility of the manufacturer, could have serious consequences on safety during the product lifetime.

The management of explosion risk within the system generally rely on a combination of safety devices such as ventilation and hydrogen detection combined with automated valve closure or other safety actions and the use of ATEX certified components if internal "zones" that have been defined. All these systems must to be properly designed and dimensioned considering the potential hydrogen release rates and they must have an appropriate combined reliability as defined for example in NF EN 50495 Safety devices required for the safe functioning of equipment with respect to explosion risks.

Compatibility of materials with hydrogen and long-term reliability

Due to the specific characteristics of hydrogen, the compatibility of hydrogen with materials remains an important issue. Although some standards, in particular the ISO 11114 series, provide guidance on the choice of materials or testing procedures, these standards do not really address the specific issue of medium to long-term reliability of components in a hydrogen rich environment. The feedback from manufacturer is that it happens frequently that components, such as valves, check valves, gaskets, fittings… that are sold as fit for hydrogen fail or present altered performances in a much shorter time than they would for other types of gases. The consequence of that is that such components should not be credited without further documented proofs of a high reliability in risk analysis. It should also incite

standardization groups to propose new work items on the development of standards addressing the medium to long term reliability of components for hydrogen systems.

Application of the "new approach" directives to vehicles not intended to be used on roads

Unless the manufacturer decides to voluntarily apply the regulation and approval process for road vehicles, vehicles not intended to be used on road are to be addressed through the EU directives described in paragraph 2.2. In particular they must comply with the PED directive although they most of the time are based on an architecture directly derived from the road vehicles. It is sometimes difficult to find on the market adequate components certified according the PED directive and not only the (EC) 79/2009 regulation. The global framework for assessing the specific hydrogen safety issues on such vehicles has still to be developed.

3.2 Conformity of hydrogen refueling stations

The case of hydrogen refueling stations is addressed in some details in the guidebook. Beside the application of the EU directives described in paragraph 2.2, which raises the difficulties already mentioned, refueling stations are faced with two other important conformity issues.

The first is related with the legal metrology of hydrogen. The measurement devices used for commercial transactions of hydrogen need to be certified under national legal metrology regulations or the EU MID directive. The national notified bodies are still defining the procedures and test benches to deliver and renew on a regular basis such certifications.

The second issue has to do with the fueling protocols. ISO 19880-1 and EN 17127 both require that the fueling station applies a fueling protocol that has been developed by a recognized standards development organization such as SAE J2601 or JPEC-S 0003 or that it applies a specific protocol developed approved by the manufacturer of the car destined to be filled at the station. Manufacturers may develop their own test benches to validate at factory that the station applies the right protocol, but car manufacturer might be willing to have that assurance from third party not only when the station is put in service but at regular intervals.

3.3 Test facilities for car and mobility components

With the development of mobility applications, the need for test facilities capable of testing systems with hydrogen gas in good safety and quality conditions increases. Many research institutes, testing labs and certification organizations are currently evolving to propose an offer to car and components manufacturers. The guidebook makes an inventory of the main available resources in France. This inventory is being progressively completed as more testing organizations are getting conscious of the importance to develop an offer for the ever-growing hydrogen community.

Table 4: list of hydrogen testing facilities in France

Name	**Description**
INERIS www.ineris.fr	Located in Verneuil en Halatte (60) in the North of France, INERIS, the French national institute for industrial environment and risks, has been developing activities on hydrogen safety for decades. INERIS is equipped with versatile underground test galleries in which tests involving fire and explosion and tank pneumatic burst can be undertaken. These test benches are used to study the hazardous phenomena in view of developing models and to test safety devices.

Name	Description
ISTHY www.isthy.fr	Located in Fontaine near Belfort, in the east of France, and currently under construction ISTHY will start operation in 2023. It will be specialized in testing tanks and components for the hydrogen technologies with a strong focus on mobility. It will propose all the tests required by regulation R134 but also standards applicable to stationary applications.
H2 Lab https://liten.cea.fr/cea-tech/liten/Pages/Collaborer/Collaborations-industrielles/H2LAB.aspx	H2 Lab is a network of French laboratories led by CEA Grenoble. It is mostly focused on testing fuel cells for mobility, high temperature electrolysers on performance and durability and high pressure storage vessels.
Plateforme reservoirs sous pression du ripault CEA le Ripault	Member of H2 Lab the test platform of Le Ripault offers facilities to develop, manufacture prototypes and test composite tanks
CETIM www.cetim.fr	The French Technology center for mechanical industry has developed facilities in Senlis and Nantes for testing composite tanks and materials including a 12 long burst pit it possesses a strong expertise on pressure vessels and composite materials
Ariane Group www.ariane.group	European leader in the development of space launchers, Ariane Group has developed a strong expertise in handling and testing liquid hydrogen systems under severe conditions. Ariane Group's test facilities are located in Vernon in the North west of France
LNE www.lne.fr	The French Laboratory of metrology and testing is currently developing the tests benches and protocols to assess the performance and conformity of measurement devices for the commercial transactions of hydrogen. It also possesses laboratories for testing a very large variety of aspects in relation with hydrogen safety
EVEER'HY'PÔLE eveerhypole.fr	Located near ALBI, EVEER'HY'POLE operates a test circuit equipped with hydrogen refueling stations for hydrogen vehicles.
EMITECH group www.emitech.fr	EMITECH group has several laboratories dedicated to the safety of vehicles and EMC certification, which are now evolving to propose tests in view of the type approval of hydrogen vehicles.

3.4 Knowledge and competence

In combination with the need for testing facilities, the development of the hydrogen technologies also generates a strong need of people who master at the same time the understanding of hydrogen technologies, the safety concepts and best practices and the regulatory framework. One of the objectives of the guidebook is to provide the initial basis for this transfer of knowledge on the regulatory framework.

3.5 Regulation and standards for new mobility applications

Regulation and standards for road cars, busses and trucks exist now for several years although recent changes in the EU framework led to adoption UN regulation R134 as the reference instead of former regulation (EC) 79/2009. The equivalent needs now to be developed for the new horizons of hydrogen mobility that are trains, ships for inland navigation and maritime transport, and airplanes and the related infrastructure.

For all these new applications, a general framework for approval exist (which allowed for the experimentation of prototypes) but the regulations and standards addressing the specificities of hydrogen systems need to be developed to facilitate the design and type approval on a regular basis.

Table 5: General framework regulations applicable to new hydrogen transport means

Sector	**Regulator**	**Framework regulations**
Air transport	European Union Aviation Safety Agency (EASA)	Regulation (EC) No 216/2008 of the European Parliament and of the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency Commission Regulation (EU) No 748/2012 of 03 Aug 2012 laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organizations
Maritime navigation	International maritime organisation (IMO)	International maritime conventions (SOLAS, Code IGF…)
Inland navigation	Commission centrale pour la navigation du Rhin (CCNR) Direction générale des infrastructures, des transports et de la mer (DGITM)	Directive (EU) 2016/1629 of the European parliament and of the council of 14 September 2016 laying down technical requirements for inland waterway vessels, amending Directive 2009/100/EC and repealing Directive 2006/87/EC
Rail transport	European Union Agency for railways (ERA)	Directive (EU) 2016/798 of the european parliament and of the council of 11 May 2016 on railway safety Directive (EU) 2016/797 of the european parliament and of the council of 11 May 2016 on the interoperability of the rail system within the European Union Commission implementing regulation (EU) 2018/545 of 4 April 2018 establishing practical arrangements for the railway vehicle authorisation and railway vehicle type authorisation process pursuant to Directive (EU) 2016/797 of the European Parliament and of the Council

4.0 CONCLUSIONS

As hydrogen technologies enter in a new era of mass development, the regulation and standard framework for conformity assessment is getting richer and more specific. Owing to the large variety of potential new applications of hydrogen, it is also complex to apprehend. For that reason, Ineris has written a guidebook intended to facilitate identification of applicable regulations and standards and test and certification organizations covering the situation in France. The guidebook also identifies some of the challenges that manufacturers face when applying the current EU framework to hydrogen systems such as the quality of risk analysis and assessment, the quality of technical documentation, the management of explosion risk, the compatibility of materials and equipment with hydrogen on the long run. Coping with these challenges imply to develop knowledge and competence among the actors of the hydrogen industry on the specific regulatory and standard issues. One of the objectives of the guidebook is to serve as a basis for developing training programs to answer this need.

The hydrogen technological landscape is currently in strong evolution. The development of new mobility applications such as boats, ships, trains and airplanes with their specific infrastructure imply that in a near future a complete set of specific regulations and standards has to be developed. These will be progressively added to future editions of the guidebook.

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   Source : https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008D0768
5. 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; Source: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014L0068
6. Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC; Source: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32006L0042
7. 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; Source: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014L0034
8. Directive 2014/30/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 electromagnetic compatibility; Source: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014L0030
9. 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; Source: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014L0035

10. Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment; Source: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32011L0065
11. The 'Blue Guide' on the implementation of EU products rules 2016; Source: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52016XC0726(02)&from=BG
12. Regulation (EC) No 79/2009 of the European Parliament and of the Council of 14 January 2009 on type-approval of hydrogen-powered motor vehicles, and amending Directive 2007/46/EC; Source: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32009R0079
13. Commission Regulation (EU) No 406/2010 of 26 April 2010 implementing Regulation (EC) No 79/2009 of the European Parliament and of the Council on type-approval of hydrogen-powered motor vehicles; Source: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32010R0406
14. Regulation (EU) 2019/2144 of the European Parliament and of the Council of 27 November 2019 on type-approval requirements for motor vehicles and their trailers, and systems, components and separate technical units intended for such vehicles, as regards their general safety and the protection of vehicle occupants and vulnerable road users, amending Regulation (EU) 2018/858 of the European Parliament and of the Council and repealing Regulations (EC) No 78/2009, (EC) No 79/2009 and (EC) No 661/2009 of the European Parliament and of the Council and Commission Regulations (EC) No 631/2009, (EU) No 406/2010, (EU) No 672/2010, (EU) No 1003/2010, (EU) No 1005/2010, (EU) No 1008/2010, (EU) No 1009/2010, (EU) No 19/2011, (EU) No 109/2011, (EU) No 458/2011, (EU) No 65/2012, (EU) No 130/2012, (EU) No 347/2012, (EU) No 351/2012, (EU) No 1230/2012 and (EU) 2015/166; Source: https://eur-lex.europa.eu/eli/reg/2019/2144/oj
15. Regulation No 134 of the Economic Commission for Europe of the United Nations (UN/ECE) — Uniform provisions concerning the approval of motor vehicles and their components with regard to the safety-related performance of hydrogen-fuelled vehicles (HFCV) [2019/795]; Source: https://op.europa.eu/en/publication-detail/-/publication/8aad3d19-7870-11e9-9f05-01aa75ed71a1/language-en
16. Commission Implementing Regulation (EU) 2021/535 of 31 March 2021 laying down rules for the application of Regulation (EU) 2019/2144 of the European Parliament and of the Council as regards uniform procedures and technical specifications for the type-approval of vehicles, and of systems, components and separate technical units intended for such vehicles, as regards their general construction characteristics and safety; Source: https://eur-lex.europa.eu/eli/reg_impl/2021/535/oj
17. Directive 1999/92/CE du Parlement européen et du Conseil, du 16 décembre 1999, concernant les prescriptions minimales visant à améliorer la protection en matière de sécurité et de santé des travailleurs susceptibles d'être exposés au risque d'atmosphères explosives ; Source : https://eur-lex.europa.eu/legal-content/FR/TXT/?uri=CELEX%3A31999L0092