BiennalReportOnHydrogenSafety

Chapter VI:

LEGAL REQUIREMENTS, STANDARDS, AND OTHER CODES

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6. LEGAL REQUIREMENTS, STANDARDS, AND OTHER CODES

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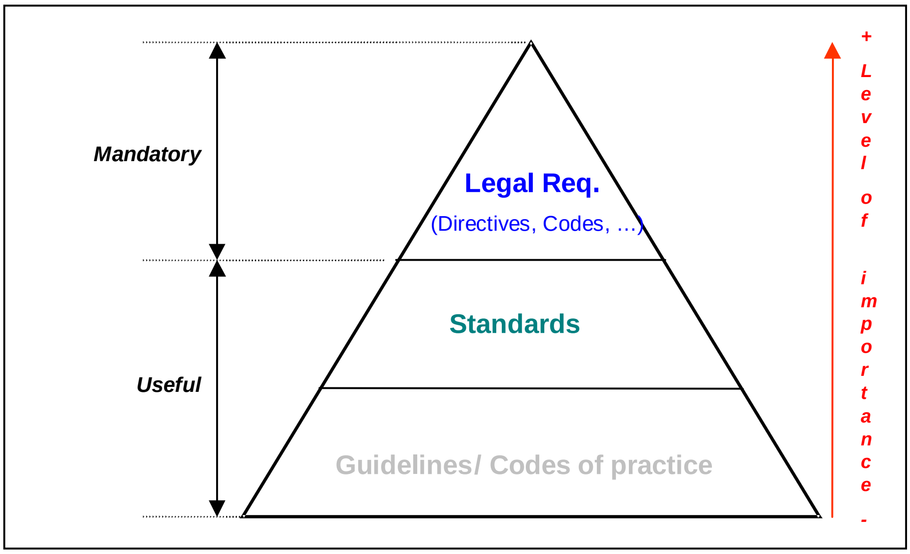
6.1. Definitions

6.1.1. General



As shown in the figure above, the main difference between legal requirements (regulations and codes) and standards is their legal status. Regulations are made by political bodies (parliaments, governments), they are legally binding, and prescribe an acceptable level of, for example, safety or emissions for the technology in question. In contrast following standards is voluntary, but they are a useful instrument for the industrial organisations or interest groups dealing with the technology in question.

6.1.2. Standards

A standard as discussed in this report is a document, established by consensus and approved by a recognised body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context. An international standard is a standard developed and adopted by an international standardisation organisation and made available to the public (as defined in IEC/ISO Guide 2).

The application of a standard is not obligatory, unless a regulation refers to that standard. Even then the legal power comes from the regulation, not from the standard.

6.1.3. Legal Requirements

A legal requirement (directive, regulation or code, etc.) is a national or European statutory text which is imposed by authority. It states requirements that are written and adopted by legislative bodies, so as to regulate a particular kind of activity.

Legal requirements are intended to guarantee that a product or system or activity will not impact on the human safety / health or on the environment.

6.1.3.1. European regulation

European laws, such as Directives, Regulations, European rules prevail over national laws. In order to carry out their task and in accordance with the provisions of the Treaty establishing the European Community (the EC Treaty), the Parliament acting jointly with the Council, the Council and the Commission make regulations and issue directives.

European Directive (art. 189 of the EC Treaty)

A directive shall be binding, as to the result to be achieved, upon each Member State to which it is addressed, but shall leave to the national authorities the choice of form and methods (national transcription).

Regulation (art. 189 of the EC Treaty)

A regulation shall have general application. It shall be binding in its entirety and directly applicable in all Member States. The EU has for example submitted a first draft of a regulation for the type approval of hydrogen cars for discussion.

6.2.3.2.International Road Vehicle Regulations

To facilitate global commerce in road vehicles it has long been recognised that there is a necessity to harmonise regulatory requirements across the major markets. These activities were initially undertaken on a European level by WP.29 a subsidiary body of the United Nations, Economic Commission for Europe, Inland Transport Committee, but that role has now expanded to a global one. WP.29 was originally titled Working Party On The Construction Vehicles but latterly has been renamed World Forum For Harmonisation Of Vehicle Regulations.

UNECE Regulation (1958 Agreement)[1]

[1] Reference : http://www.unece.org

In the framework of the United Nations' Economic Commission for Europe (UNECE) in Geneva, and for mobile applications, WP.29[2] and its subsidiary bodies are developing Regulations under the 1958 Agreement in cooperation with all Contracting Parties to the Agreement and non-governmental organizations (NGOs).
The 1958 Agreement is entitled “Agreement concerning the adoption of uniform technical prescriptions for wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles and the conditions for reciprocal recognition of approvals granted on the basis of these prescriptions.” UNECE Regulations are not applicable on a mandatory basis to all Contracting Parties to the 1958 Agreement, but if a Contracting Party decides to apply a UNECE Regulation, the adoption becomes a binding act. A contracting party that has adopted a Regulation under the 1958 Agreement is allowed to grant type approvals pursuant to that Regulation and is required to accept the type approval of any other contracting party that has adopted the same Regulation. European and some non-European countries, require an authority together with a technical service undertaking approval testing, to assess compliance of components and the vehicle with the legal requirements. The process is known as type approval. In contrast North America uses the self-certification process.
The 1958 Agreement was revised in 1995 (Revision 2) to promote the participation of non-european countries and became a global agreement. The United States did not adhere to this Agreement. Members of the 1958 agreement are: GERMANY, FRANCE, ITALY, NETHERLANDS, SWEDEN, BELGIUM, HUNGARY, CZECH REPUBLIC, SPAIN, YUGOSLAVIA, UNITED KINGDOM, AUSTRIA, LUXEMBOURG, SWITZERLAND, NORWAY, FINLAND, DENMARK, ROMANIA, POLAND, PORTUGAL, RUSSIAN FEDERATION, GREECE, IRELAND, CROATIA, SLOVENIA, SLOVAKIA, BELARUS, ESTONIA, BOSNIA AND HERZEGOVINA, LATVIA, BULGARIA, TURKEY , THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA, EUROPEAN COMMUNITY, JAPAN, AUSTRALIA, UKRAINE, and the REPUBLIC OF SOUTH AFRICA.

For instance, under the 1958 agreement, the Regulation 110 is related to the “uniform provisions concerning the approval of:

I. specific components of motor vehicles using compressed natural gas (NG) in their propulsion system ;
II. vehicles with regard to the installation of specific components of an approved type for the use of compressed natural gas (CNG) in their propulsion system.” is an example of UNECE Regulation.”

UN ECE 1998 Agreement (Global Technical Regulation)

Global Technical Regulations (GTR) apply to road vehicles. GTR contain technical requirements and are established under the 1998 Agreement ("Agreement concerning the establishing of global technical regulations for wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles", done at Geneva on 25 June 1998). GTR are different from the EU Directives and UN ECE regulations because they do not call for mutual recognition of type approvals or certifications; they permit exsiting approval procedures to be utilized by harmonizing only the technical requirements. The 1998 Agreement allows all regions of the world to participate in the development of GTRs for vehicles and their components. Canada, China, EC, France, Germany, Italy, Japan, Korea, the Russian Federation, South Africa, Spain, the UK and the USA are included in the contracting parties to this Agreement.

[2] Working Party 29 : New Vehicles Construction

6.2.3.3. Code

In legally terms, a code is a collection of rules, requirements or standards that have been made binding and mandatory by a local or national government (as defined in the ISO / TR 15916). In practical use of language the term code often refers to a North American document.
In this report, we distinguish “code” (with compelling power) and “code of practice” (which is a voluntary instrument – see paragraph 6.1.5.1. Code of practice).

6.1.4. New Approach Directives and Harmonised Standards[3]

The European Union introduced a series of measures to ensure the free movement of goods throughout the European Union (EU) and the European Free Trade Area (EFTA). New Approach Directives are one of these measures. These Directives aim at controlling product design and above all, at ensuring technical harmonisation of product safety requirements across Europe, so as to guarantee a high level of protection to the public.

New Approach has been laid down by the Council Resolution of 1985.
European harmonised standard provides the detailed technical information enabling manufacturers to meet the essential requirements. "Harmonised Standard" has a specific meaning in the context of the ECs “New Approach” to regulation [4]:

- that is in support of one or more Directives,
- that has been produced by CEN or CENELEC,
- when the reference has been published in the Official Journal of the EC (OJ),
- and that has been published by at least one national standards body.

A harmonised standard provides a presumption of conformity with the essential requirements covered by the standard. These standards - produced under a mandate from Member States through the Commission - give the technical measures to meet the essential.

The *Guide to the implementation of directives based on the New Approach and the Global Approach* defines essential requirements as follows:

- Essential requirements lay down the necessary elements for protecting the public interest.
- Essential requirements are mandatory. Only products complying with essential requirements may be placed in the market and put into service.
- Essential requirements must be applied as a function of the hazards inherent to a given product.

The New Approach Directives also explain to the manufacturers how to demonstrate conformity with the essential requirements. Products which meet the essential requirements are to display the CE marking, as described in the particular directive. CE marking means that the product can be sold anywhere in the Community/EEA[5].

When a product bears a CE marking , it means that:

- It complies with all applicable Directives,
- It can move freely in any member state.

Application of harmonised standards or other technical specifications remains voluntary, and manufacturers are free to choose any technical solution that provides compliance with the

[3] References : www.dti.gov.uk ; http://europa.eu.int ; http://asia.bsi-global.com
[4] Source : www.dti.gov.uk
[5] European Economic Area

essential requirements. (source Guide to the Implementation of Directives Based on New Approach and Global Approach – European Commission).

The following Council Directives are based on the New Approach principles:
- 73/23/EEC of 19 February 1973 on the harmonization of the laws of Member States relating to electrical equipment designed for use within certain voltage limits
- 89/336/EEC of 3 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility
- 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the approximation of the laws of the Member States concerning pressure equipment
- 98/37/EC of the European Parliament and of the Council of 22 June 1998 on the approximation of the laws of the Member States relating to machinery

6.1.5. Others

6.1.5.1. Code of practice

Codes of practice are usually a set of best practices for a specific product or system so as to ensure safe handling, maintenance and operation.

6.1.5.2. Guideline

A guideline or a guide is a document generally written for a given organisation, whether for its own needs, or for its customers' needs. Guidelines provide guidance to appropriate behaviour so as to ensure safety of people (workers, users and general public). It may also give information about codes, standards and regulations to comply with and about the recommended way to meet those requirements. For example, it gives information related to material properties, adequate installation, use of equipment and safety procedures. Guidelines may be intended:
- to authorities, who have to verify the conformity with applicable regulations and standards of a system and to approve it,
- to end-users of a given system, so that they can run the system in accordance with safety and performance requirements,
- to maintenance employers, so as to give them principles to observe during maintenance and cleaning up.

6.1.5.3. State of the art

State of the art is the most advance technique or method used at a given time.

6.1.5.4. Best engineering practices

Best engineering practices means the best practices performed in the design, construction, or operation of structures, machines, or other devices of industry and everyday life. Best engineering practices are defined from the industrial organisations and key implementors of a given technology.

6.2. REGULATIONS

Handling flammable, compressed, or cryogenic substances may be dangerous not only for the person doing it but also for others or the society as a whole. Industrialisation brought about not only much larger amounts of such substances used for processes of all kinds but also a more complex structure of the society which is more vulnerable from technical problems. This is why for the last two hundred centuries more or less all countries (or their provinces or communities) issued regulations in order to guarantee a minimum level of safety for human life and health as well as for material values. The increasing safety demands of the modern citizen towards the society, new technologies (nuclear, genetic) as well as new threats (terrorism) cause an ever increasing refinement of those rules. This paragraph deals in particular with regulations applicable to hydrogen and the safety issues associated with it.

The purpose of the regulations discussed here is at first to prevent damage to persons working with dangerous substances. This does not primarily mean somebody who handles them privately for his own purposes; it is not the role of the state to protect everybody from the effects of his own carelessness. It is quite different, however, in the case of somebody who handles something by order of his employer. Here the rules for dangerous substances in a commercial environment place the responsibility on the employer or the direct superior of the worker by demanding a certain level of technical equipment, education and information providing a reasonably safe process. Nonetheless any damage which might occur must not become so major that it affects the general public outside the working place or company.

Another important field for regulations is the transport of dangerous substances. Persons involved not in the handling of the substance, but only in their transport (like railway workers) shall be protected from unwanted effects, and the same holds for the general public.

What is true in each individual country applies also to a body like the European Union. Neither the European Commission nor the European Council or the European Parliament, however, can simply sidestep the sovereignty of the member states in replacing their national regulations by others. The instrument for achieving a common ground in all countries is directives. They define a certain level which is compelling, but not immediately for the individual citizen. Directives are rather directed to the member countries which are obliged to adopt them in their national legislation within a reasonable time. In doing so the national legislation has a certain manoeuvring space, but only to one side; the minimum level given by the directive must be maintained.

There is, of course, no such thing as a European Hydrogen Directive. Apart from a few exceptions for very important substances regulations are usually not substance specific, but application specific. So the correct question is not: “Which regulations apply to hydrogen?”, but rather: “Which regulations apply to what I want to do with hydrogen, and to the environment where I intend to do it?”.

Among the most important European directives applicable to hydrogen are those on pressure equipment. There are the Pressure Equipment Directive (PED) and separately the Transportable Pressure Equipment Directive (TPED). The latter is closely connected to international agreements on the transport of dangerous goods (ADR, RID, …).

Another important field of regulation when flammable gases are involved is the prevention of damage by explosions in case the gases are released unintentionally. This is mainly covered by the directives 94/9/EG (formerly ATEX 100) and 99/92/EG (formerly ATEX 118).

Prevention of major accidents and associated releases of harmful substances in the environment or the mitigation of the effects, respectively, is the subject of the Seveso II directive.

While these are the most important and specific ones there are numerous directives which might be applicable in a certain context or situation. The Machinery directive is an example for a document of very general character which applies to almost anything, including hydrogen technology.

The more important directives will be discussed below in detail.

Apart from the directives of the EU there are also other regulations from other sources. International transport of dangerous goods is dealt with in a number of international agreements which comprise ADR (road), RID (rail), IMO (sea) and ADNR (inland waterways). Air traffic is cared for by IATA and ICAO. For making sure that motor vehicles can be used internationally there are different provisions; one of them involves the UN ECE.

6.2.1. Health And Safety at Work and Major Hazards

6.2.1.1 Major Hazard Directive

6.2.1.2. ATEX directive EC/1999/92

Introduction

ATEX directive 1999/92/CE is relative to minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (ATEX).
Hydrogen is a flammable gas which can form an ATEX where mixed with air (such an ATEX is defined by the directive as a mixture in which, after ignition occurred, combustion spreads to the entire unburned mixture).
So, any employer who runs facilities where hydrogen is processed in shall comply with the requirements of the directive, because his workers are potentially at risk from the effects of explosions which may be produced by ignition of an ATEX which can be formed.
In the following chapters, are presented first the obligations of the employer and second the implementation of the directive to hydrogen.

Obligations of the Employer

The employer has a general obligation to provide protection to his workers potentially at risk from ATEX.
In order to provide this protection, the employer shall take technical and/or organisational measures appropriate to the nature of the operation, in order of priority and in accordance with the following basic principles :

- the prevention of the formation of ATEX or, where the nature of the activity does not allow that,
- the avoidance of the ignition of ATEX, and
- the mitigation of the detrimental effects of an explosion so as to ensure the health and safety of workers.

The directive indicates the different obligations which the employer shall carry out, the main of them being detailed underneath.

Risk assessment

In carrying out its obligations, the employer shall assess the specific risks arising from ATEX, taking into account at least of :

- the likelihood that ATEX's will occur and their persistence,
- the likelihood that ignition sources, including electrostatic discharges, will be present and become active and effective,
- the installations, substances used, processes, and their possible interactions, the scale of the anticipated effects.

Zone classification

A place in which an ATEX may occur in such quantities as to require special precautions to protect the health and safety of the workers concerned is deemed to be hazardous within the meaning of this directive.
The employer shall classify hazardous places where ATEX's may occur into zones on the basis of the frequency and duration of the occurrence of an ATEX and in accordance with the following definition :

- *Zone 0 :* a place in which an ATEX is present continuously or for long periods or frequently.
- *Zone 1:* a place in which an ATEX is likely to occur in normal operation occasionally.
- *Zone 2:* a place in which an ATEX is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

Where necessary, places where ATEX's may occur in such quantities as to endanger the health and safety of workers shall be marked with the underneath sign at their points of entry.

Explosion protection document

The employer shall ensure that a document, hereinafter referred to as the "explosion protection document", is drawn up and kept up to date. The explosion protection document shall demonstrate in particular:

- that the explosion risks have been determined and assessed,
- that adequate measures will be taken to attain the aims of this directive,
- those places which have been classified into zones as defined above,

Implementation of ATEX directive to hydrogen

As it has been written in § 2, the implementation of ATEX directive to facilities where hydrogen is processed in needs to define technical and/or organisational measures in accordance with the following basic principles:

- the prevention of the formation of ATEX, or
- the avoidance of the ignition of ATEX, and
- the mitigation of the detrimental effects of an explosion so as to ensure the health and safety of workers.

Prevention of the formation of ATEX

An ATEX is formed wherever hydrogen is mixed with air in such proportion as the hydrogen content in the mixture belongs to the explosivity range.

Hydrogen characteristics

The formation of an hydrogen-air ATEX is governed by the following characteristics :

- the high ability of hydrogen to combustion (a quite large explosivity range and a rather low LEL (see §) can be seen as corresponding to this characteristic),
- the very small size of the molecule, which explains :
  - a very low density (hydrogen is about 14,5 times lighter than air),
  - a high diffusion coefficient (see §).

Where can an ATEX be formed ?

There are different situations where ATEX's can be formed :

- inside a facility or in a workplace, in the vicinity of a facility,
- during normal or abnormal operation of the facility.

The following examples are given as illustrations of the possible situations :

- ATEX formed inside a facility where hydrogen is processed (e.g. a chemical reactor where a substance is hydrogenated), in case of an abnormal air ingress,
- ATEX formed inside a vessel containing air and a wet metallic powder, in case of the production of hydrogen due to the chemical reaction between powder and moisture,
- ATEX normally formed in the vicinity of lead batteries being refuelled,
- ATEX formed in the vicinity of a pressurised facility (vessel, pipework), in case of a hydrogen release through a leak orifice (seal of a flange, gasket of a valve…).

Prevention of ATEX formation

Prevention of ATEX formation inside a facility where air ingress is likely can be achieved by one of both methods :

- air dilution (see §),
- inerting (see §).

The most important means to prevent the formation of an ATEX outside a pressurised facility as a consequence of a leak is the maintenance of the facility for all the relevant aspects (mechanical, corrosion…).
Inside a workplace, a sufficient ventilation can also be a relevant means to strongly reduce the volume of ATEX.

Evaluation of ATEX volumes, shapes and places

When an ATEX can be formed inside a confinement, it should generally be considered as able to be present in the whole volume of the confinement.
For an ATEX formed by mixing with air of a hydrogen flow, the characteristics of the ATEX (volume, shape, place) strongly depends on the turbulence of the flow.
For a flow having a low momentum or no momentum at all (e.g. hydrogen evolving from batteries being refuelled), the mixing is not governed by turbulence but is only due to diffusion and buoyancy forces ; so, in a room, hydrogen will go up and an ATEX can accumulate under the ceiling of the room,
On the contrary, a flow having a high momentum can be considered as a high speed jet and the mixing with air mainly occurs inside the jet. The turbulence of a supersonic jet is surely high, but it can also be sufficiently high for a subsonic jet coming out from a small leak orifice, when the pressure inside the confinement is higher than tens of millibars. The ATEX zone has a very elongated shape and keeps close to the leak orifice. Then, two situations can be distinguished :

- for a release into a free space, pure air is entrained into the jet and the maximum extension of the ATEX does only depend on the hydrogen pressure and the cross section of the leak orifice : it does not depend on the duration of the leak because no accumulation of ATEX occurs. As an example, for a pressure of 3 bar abs. and an equivalent diameter of the leak orifice of 1 mm, the ATEX volume and maximum extension of ATEX on the jet axis are relatively weak (respectively 2 dm^3 and 60 cm),
- for a release into a confined, or semi-confined or obstructed space, re-circulation may occur more or less rapidly and the jet entrains an air having a higher and higher hydrogen content : the ATEX volume continuously increases with time and can reach a high value.

Physical accurate models are necessary to evaluate precisely the maximum volume of an ATEX generated by a leak, in order to evaluate the effects which would be produced in case of ignition and to decide whether or not the place of the ATEX must be classified as a zone.
EN 60079-10 standard gives a method to evaluate the ATEX volume, but it does not take into account the turbulent dilution of the released gas by air and consecutively, it strongly overestimates the ATEX volume.

Prevention of the ignition of ATEX

Ignition characteristics of hydrogen

Hydrogen is characterised by a very low value of MIE (see §), so the ignition likelihood of an hydrogen ATEX is high, particularly by the different types of electrostatics discharges.
When an hydrogen release occurs as a consequence of a mechanical rupture (rupture disc, mechanical impact…) the jet coming out from the containment generally ignites immediately, preventing the formation of an ATEX, but the ignition is not certain when there is no mechanical rupture (opening of a valve…).

Suppression of ignition sources in ATEX's

EN 1127-1 standard gives a list of all the possible ignition sources of ATEX and it is very difficult to be sure that each of them has been suppressed, particularly for hydrogen ATEX's, due to their very low MIE.
Nevertheless, the suppression of ignition sources shall be tentatively achieved.

Suppression of ignition sources by equipment

Ignition by equipment (electrical as non-electrical) will be prevented by :

- designing relevant ATEX zones (according to the likelihood of the ATEX)
- installing inside these zones adequate equipment, i.e. complying with the requirements of 94/9/EC directive which imposes the corresponding categories :
- in zone 0, category 1 equipment,
- in zone 1, category 2 equipment,
- in zone 2, category 3 equipment.

Moreover, the temperature class of the equipment can be T1 (surface temperature < 450°C).

Suppression of electrostatic sources

The ignition of an ATEX by an electrostatic source is probably the most difficult phenomenon to suppress.
Nevertheless, the suppression of electrostatic ignition sources shall be tentatively achieved, by the suppression of both phenomena:

- electrostatic charges accumulation,
- electrostatic discharges.

Mitigation of the detrimental effects of an ATEX explosion

Explosivity characteristics of hydrogen

Hydrogen has explosivity characteristics which show a high reactivity :

- its fundamental burning velocity is high (see §),
- inside elongated facilities, a flame acceleration will rapidly occur and a DDT is very likely,
- its combustion releases a high energy : its TNT equivalent is high (about 30g TNT for 1g of H_2).

Evaluation of effects

The detrimental effects which an ATEX explosion can cause to workers are mechanical and thermal.
The severity of the mechanical effects will depend on the distance between the ATEX and the workers.
The severity of the thermal effects depends on the volume of the ATEX (see § 3.1.4) and on the position of the burned gases after their expansion at the end of the explosion, relatively to the workers position.

Mitigation of explosion effects

Facilities inside which an ATEX explosion propagates shall be protected, one of the following devices being *a priori* possible:

- explosion venting,
- explosion suppression,
- isolating systems as flame arrester.

6.2.2. Pressure vessels regulation (static and transportable)

The PED (Pressure Equipment Directive – 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the approximation of the laws of the member States concerning pressure equipment) is applicable in Europe since December 1999 and mandatory since end of May 2002.
It applies to all stationary vessels with service pressure of more than 0,5 bar and a PV (Pressure water capacity) of more than 50 bar l.
In the case of the hydrogen energy applications, it is particularly relevant for all pressure vessels (cylinders) and safety accessories (valves, flexible hoses, connectors) used for hydrogen refuelling station.
This pressure equipment Directive allows to use everywhere in the EU the same design for the pressure vessels and associated accessories.
Since this Directive is mandatory in Europe, a number of "Notified Bodies" have been notified to Brussels by the authorities of each EU members states. These notified bodies can make the "evaluation of conformity" of the pressure equipment ; this evaluation is confirmed by the "CE" mark applied onto the equipment. Any notified body (from every country) can approve a CE marked equipment to be used in every country of the EU.
This Directive only defines the "essential requirements" which are given in its Annex 1. Detailed requirements are given in the harmonized standards (e.g. prepared by CEN). These EN-Standards are not mandatory, other procedures or "state of the Art" can be used by the manufacture in order to demonstrate to the notified body that the essential requirements are fulfilled.
Contrary to the TPED, this European Directive doesn't cover the use of the equipment (operational requirement, periodic inspection, …) which are still under national regulations. This may create difficulties if such equipment are to be moved from one country to another.

6.2.3. Transport of Hazardous goods regulations

The TPED (The Council Directive 1999/36/EC on transportable pressure equipment) applies to transportable pressure equipment and is mandatory since July 1st, 2003 for gas cylinders. It will also be applicable soon to bundles, drums and trailers (July 1st, 2005 optional and July 1st, 2007 mandatory).
In the case of the hydrogen energy applications, it is particularly relevant for the transport of hydrogen to the filling stations. It is also applicable to H2 pressure tanks used on vehicle when these tanks are removable, refilled independently from the vehicle and transported to H2 depots.
Like for the PED, a number of "Notified Bodies" have been notified to Brussels by the authorities of each EU member status. These Notified Bodies can make the evaluation of conformity of the pressure equipment. This evaluation is confirmed by the "Π" mark applied onto the equipment. Any Notified Body (for every country) can approved a CE marked equipment to be used in every country of the EU.
This Directive defines the main requirements and refers to the ADR/RID for the specific requirements.
ADR/RID is the transport regulation by road (ADR) and rail (RID) for Europe and many other countries around. TPED refers to "Class 2" (gases), ADR/RID covering also others dangerous substances.
EN (and ISO) standards are referred into the ADR/RID and give presumption of conformity to ADR/RID but normally other routes complying with the technical requirements of ADR/RID can be followed.

Contrary to the PED, TPED also covers the use of the equipment including periodic inspection and any other operational requirement. Consequently, it provides full harmonization in Europe. It also allows to "reassess" old national equipment to transform them into "Π" equipment.
In addition to "Notified Bodies", "Approved Bodies" can be nominated with a restricted scope.

6.2.3. Rule for hydrogen equipments: CE marking and most relevant directives

6.2.3.1. CE Marking

CE marking symbolises that the product marked fulfills all applicable provisions (or requirements) of applicable directive(s) that provide for CE marking (essential requirements, harmonised standards and specific dispositions), and that the product has been subject to the appropriate conformity assessment procedure(s) contained in the directive(s).
The scope of the CE marking regime is laid down in the relevant harmonisation directive(s), and can only be apllied by the legal entity responsible for the conformity of the product.
The CE marking is neither a mark of origin nor a quality mark.

The hydrogen system shall comply with the following directives in order to gain CE marking :
- Machinery directive ; 98/37/EC,
- Equipment and protective systems intended for use in Potentially Explosive Atmosphere ; 94/9/EC,
- Pressure equipment directive ; 97/23/EC,
- Low voltage diretive ; 73/23/EEC,
- Electromagnetic compatibility directive ; 89/336/EEC,
- Simple pressure vessels directives ; 87/404/EEC , 90/448/EC.

The most relevant EC requirements have been quoted in the next paragraphs.

6.2.3.4. Machinery Directive : 98/37/EC

This directive applies to machinery. It shall also apply to safety components placed on the market separately.
Essential safety and health requirements given in the Annex 1 of the Directive are summarised below.

General requirements

- The manufacturer has to assess the risks of its system in normal and abnormal uses, and during running and maintenance operations.
- Materials and products shall not endanger exposed persons' health and safety.
- Suitable lightning shall be provided.
- Machinery shall be designed so as to facilitate its safe handling, packaging and storage.

Controls

- Control systems shall be safe and reliable.
- Safety shall be taken into account :
  - for the design, localisation, signals of the control devices,
  - for the starting, the "re-starting", and the modification of the running,
  - for the stopping procedures (normal stopping and emergency stop),
  - for the mode selection,
- Prescriptions are given to ensure the safety of the equipment in case of failure of the power supply or of the control circuit.

Protection against mechanical hazards

- Machinery, components and fittings thereof must be so designed and constructed that they are stable enough, under the foreseen operating conditions for use without risk of overturning, falling or unexpected movement.

- Precautions shall be taken to prevent risks from falling or ejected objects.
- Vibrations produced by the equipment shall be reduced to the lowest level
- The various parts of the equipment and their linkages shall be so constructed that, when used normally, no instability, distortion, breakage or wear likely to impair their safety can occur.
- In so far as their purpose allows, accessible parts of the equipment shall have no sharp edges, no sharp angles, and no rough surfaces likely to cause injury.
- The moving parts of the equipment shall be designed to avoid hazards. Where hazards persist, adequate fixed guards or protective devices shall be installed.
- Persons slipping, tripping or falling shall be prevented.

Required characteristics of guards and protection devices

- General requirements are given for guards and protection devices and special requirements are given for movable, adjustable and fixed guards.

Protection against other hazards

Machinery must be designed and constructed by observing the following requirements.

- All hazards of an electrical nature must be prevented and specific rules in force relating to electrical equipment designed for use within certain voltage limits must apply.
- The build-up of potentially dangerous electrostatic charges must be prevented or /and the system must be fitted with a discharging system.
- All potential hazards associated with other types of energy than electricity must be avoided.
- Errors, likely to be made when fitting or refitting certain parts which could be a source of risk must be made impossible ; and where a faulty connection can be the source of risk, incorrect fluid connections, including electrical conductors, must be made impossible too.
- Any risk of injury caused by contact with or proximity to equipment parts or materials at high or very low temperatures must be eliminated and the risk of hot or very cold material being ejected should be assessed.
- All risk of fire or overheating and of explosion must be avoided. Precautions must be taken if the machine is intended to be used in a potentially explosive atmosphere. Dedicated Directives in force must be complied with for the electrical equipment.
- Risks resulting from the emission of airborne noise and from vibrations are reduced to the lowest level.
- Any emission of radiation is limited to the extent necessary for its operation and the effects on exposed persons are non-existent or reduced to non-dangerous proportions.
- External radiation must not interfere with the equipment running.
- Risks due to gases, liquids, dust, vapours and other waste materials which it produces must be avoided.

Maintenance

- Maintenance areas shall be located outside hazardous zones.
- The equipment shall be at a standstill during maintenance.
- Access to operating position and servicing points must be facilitated.
- All machinery must be fitted with means to isolate it from all energy sources.
- The need for operator intervention shall be limited, if not it must be possible to carry it out easily and in safety.

6.2.3.5. Equipment and Protective Systems intended for Use in Potentially Explosive Atmosphere: 94/9/ EC

This Directive applies to equipment and protective systems intended for use in potentially explosive atmospheres. It also applies to controlling devices and regulating devices intended for use outside potentially explosive atmospheres but required for or contributing to the safe

functioning of equipment and protective systems with respect to the risks of explosion are also covered by the scope of this Directive.
Essential safety and health requirements given in the Annex 2 of the Directive are summarised below.

General requirements

- Equipment and protective systems intended for use in potentially explosive atmospheres must be designed from the point of view of integrated explosion safety. In this connection, the manufacturer must take measures :
    - to prevent the formation of ATEX which may be produced or released by equipment and by protective systems themselves,
    - to prevent the ignition of ATEX (electrical and non-electrical source of ignition),
    - to halt the explosion immediately and/or to limit the range of explosion flames and explosion pressures to a sufficient level of safety.
- Equipment and protective systems must be designed by taking ito account :
    - the potential operating faults,
    - special checking and maintenance,
    - and the surrounding area conditions.
- All equipment and protective systems must be CE marked and be accompanied by appropriate instructions (particular with regard to safety).

Selection of materials

- Used materials must not neither trigger off an explosion, nor impair explosion prevention and protection.

Design and construction

Equipment and protective systems must be designed and constructed:
- with due regard to explosion protection even for the components to be incorporated into or used as replacements in equipment ;
- so as to limit escapes of hydrogen or other flammable gases (enclosed structures, prevention of non-tight joints, flameproof enclosure systems, …) ;
- so as to withstand relevant external stresses ;
- so that , if the equipment and protective systems are in a housing or a locked container forming part of the explosion protection itself, it must be possible to safely open it ;
- so as to avoid injuries and high surface temperatures and to eliminate non-electrical hazards ;
- so to avoid dangerous overloading.

Potential ignition sources

- Hazards arising from different ignition sources such as sparks, flames, electric arcs, mechanical sparks, , high surface temperatures, acoustic energy, optical radiation, electromagnetic waves, and other ignition sources must not occur.
- Static electricity, stray electricity and leakage currents, overheatings, pressure compensation operations must not result in dangerous situations capable of ignite an ATEX.

Hazards arising from external effects

- Equipment and protective systems must be capable of performing their intended function in full safety even when subjected to external stresses (environmental conditions, vibrations, thermal stresses, chemical stresses caused by aggressive substances, …).

Safety-related devices

Essential requirements are given for the safety devices, such as :

- The running of safety devices independently of any measurement or control devices required for the operation,
- The rapid detection of any failure of a safety device,
- The fail-safe principle for electrical circuits,
- The direct connection between the safety-relate switching and the relevant control devices,
- The security of the equipment and/or protective systems in case of safety device failure
- The incorporation of a safety factor on the alarm thresholds of devices with a measuring function.

Integration of safety requirements relating to the system

Essential requirements are given related to :

- Automatic processes which deviate from the intended operating conditions,
- Activation of the emergency shutdown system,
- Power failure,
- Connections,
- Placing of warning devices as parts of equipment.

Supplementary requirements in respect of equipment

General requirements for equipment categories are given in the table below.

Category 1	Category 2	Category 3
High probability of ATEX due to gases, vapours, mists or dust **Very high level of protection** for electrical and non electrical equipment	**Medium probability of ATEX** due to gases, vapours, mists or dust **High level of protection** for electrical and non electrical equipment	**Low probability of ATEX** due to gases, vapours, mists or dust **Normal level of protection** for electrical and non electrical equipment

Detailed requirements for each category are given in the Annex 2 of the 94/9/EC Directive.

Supplementary requirements in respect of protective systems

- Protective systems must reduce the effects of an explosion to a sufficient level of safety.
- They must be designed so that explosions are prevented from spreading through dangerous chain reactions or flashover and incipient explosions do not become detonations.
- In the event of a power failure, protective systems must retain their capacity to function for a period sufficient to avoid a dangerous situation.
- Maximal pressure and temperature to be taken for the design of protective systems must be the one which can be expected during an explosion occurring under extreme operating conditions.
- Protective systems such as pressure relief systems, explosion suppression systems, explosion decoupling systems must be designed so as to ensure their function whatever the size of the explosion.
- Protective systems must be capable of being integrated into a circuit with a suitable alarm threshold so that, if necessary, there is cessation of product feed and output and shutdown of equipment parts which can no longer function safely.

6.2.3.6. Pressure vessel directive : 97/23/EC

This directive applies to the design, manufacturing and evaluation of CE conformity of pressurised equipment or set of equipment that work under a pressure above 0,5 bar.
Essential safety and health requirements given in the Annex 1 of the Directive are summarised below.

General requirements

The manufacturer has to apply the general safety principles given in the Directive. It concerns especially the risks assessment of its system.

Design

- The manufacturer must ensure the safety of its equipment throughout its intended life ;
- Pressure vessel must be designed for adequate strength (internal/external pressure, traffic, wind, corrosion, fatigue, …). It shall be properly designed using comprehensive calculation methods and experimental design method ;
- Provisions are given to ensure safe handling and operation (especially related to closures and openings, dangerous discharge of pressure relief blow-off, …) ;
- Pressure equipment shall be designed and constructed so that all necessary examinations to ensure safety can be carried out ;
- Adequate means must be provided for the draining and venting of pressure equipment where necessary (during operation ad during cleaning, inspection and maintenance) ;
- Where necessary, adequate allowance or protection against corrosion or other chemical attack must be provided ;
- Where severe conditions of erosion or abrasion may arise, adequate measures must be taken to minimise effects and/or to replace the parts which are most affected.
- Assemblies must be so designed so as to not create a hazard ;
- Where appropriate, the pressure equipment must be so designed and provided with accessories, or provision made for their fitting, as to ensure safe filling and discharge in particular with respect to hazards from filling (overfilling, overpressure) and discharge (uncontrolled release of the pressurised fluid) and unsafe connections or disconnections ;
- Protection against exceeding the allowable limits of pressure equipment must be provided (adequate protective devices) ;
- Safety accessories must be reliable and suitable for their intended duty, be independent of other functions, comply with appropriate design principles (in particular fail-safe modes, redundancy, diversity and self-diagnosis) ;

Manufacturing

- Preparation of the component parts must not be detrimental to the safety of the pressure equipment (due to defects, cracks, changes) ;
- Permanent joints and adjacent zones must be free of any surface or internal defects detrimental to the safety of the equipment. Non-destructive tests of permanent joints must be carried out by suitable qualified personnel. ;
- Heat treatment must be applied when there is a risk that the manufacturing process will modify the material properties impacting on the safety ;
- The material making up the components of the equipment must be identified through suitable procedures ;
- Pressure equipment must be subjected to final assessment : final inspection, proof test, inspection of safety devices ;
- The CE marking and the required information (as listed in the Annex 1 of the Directive) must be given on the pressure equipment ;

- When pressure equipment is placed on the market, it must be accompanied, as far as relevant, with instructions for the user, containing all the necessary safety information (for mounting and assembling, putting into service, use, maintenance). If appropriate, these instructions must also refer to hazards arising from misuse.

Materials

- Materials used for the manufacture of pressure equipment must be suitable for such application during the scheduled lifetime unless replacement is foreseen.

Specific pressure equipment requirements

- Fired or otherwise heated pressure equipment with a risk of overheating (steam and hot-water generators and process-heating equipment for other than steam and hot water generation) must be calculated, designed and manufactured so as to avoid or to minimise risks of a significant loss of containment from overheating.
- Piping must be designed and manufactured so that to ensure safety of the system (e.g. pay attention to the potential damage from turbulence and formation of vortices and to the risk of fatigue due to vibrations in pipes).

Specific quantitative requirements for certain pressure equipment

- Provisions given in this section apply as a general rule for : allowable stresses, joint coefficients, pressure limiting devices particularly for pressure vessels, hydrostatic test pressure and material characteristics.

6.2.3.7. Low voltage directive : 73/23/EEC

For the purposes of this Directive "electrical equipment" means any 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.
The Annex 1 of the Directive gives principal elements of the safety objectives for electrical equipment designed for use within certain voltage limits. These requirements are described hereafter.

Safety requirements

- The electrical equipment shall be resistant to non-mechanical influences in expected environmental conditions, in such a way that persons, domestic animals and property are not endangered,
- The electrical equipment shall not endanger persons, domestic animals and property in foreseeable conditions of overload,
- The electrical equipment, together with its component parts, shall be made in such a way as to ensure that it can be safely and properly assembled and connected,
- Electrical components and the electricity supply connections are so designed and manufactured as to ensure that protection against all hazards of electrical nature is assured providing that the equipment is used in applications for which it was made and is adequately maintained,
- Persons and domestic animals must be adequately protected against danger of physical injury or other harm which might be caused by electrical contact direct or indirect,
- Temperatures, arcs or radiation which would cause a danger, must not be produced,
- Persons, domestic animals and property are adequately protected against non-electrical dangers caused by the electrical equipment which are revealed by experience,
- The insulation shall be suitable for foreseeable conditions

6.2.3.8. Electromagnetic compatibility directive : 89/336/EEC

This Directive applies to apparatus liable to cause electromagnetic disturbance or the performance of which is liable to be affected by such disturbance.
It defines the protection requirements and inspection procedures relating thereto.
The Annex 3 of the Directive gives an illustrative list of the principal protection requirements as follows:

- The maximum electromagnetic disturbance generated by the hydrogen system shall be such as not to hinder the operation of apparatus referred in the list hereafter,
- The hydrogen system shall be so constructed that it has an adequate level of intrinsic immunity to electromagnetic disturbance generated by apparatus referred to in (c) to enable it to operate unhindered where it is intended to work,
- Both statements above refer to radio and telecommunications equipment and other apparatus complying with the standards, in particular to the following apparatus :
  - domestic radio and television receivers
  - industrial manufacturing equipment
  - mobile radio equipment
  - mobile radio and commercial radiotelephone equipment
  - medical and scientific apparatus
  - information technology equipment
  - domestic power plants and household electronic equipment
  - aeronautical and marine radio apparatus
  - educational electronic equipment
  - telecommunications networks and apparatus
  - radio and television broadcast transmitters
  - lights and fluorescent lamps.

6.2.4. UN WP29 GRPE Draft ECE Regulations

Work on proposals for harmonised hydrogen vehicle regulations for Europe was initiated in 1998 by the European Integrated Hydrogen Project (EIHP). After a survey of existing regulations identified none applicable directly to the use of hydrogen in vehicles, EIHP initiated the process of developing initial proposals for new, flexible harmonised regulations. The draft proposals were based as far as possible on performance requirements rather than historical technical solutions with the aim of encouraging rather than restricting the development and introduction of safe, new technologies. Various analyses were undertaken by the EIHP partners to provide a base from which to develop draft harmonised regulations.
For the basis of the draft harmonised regulations, EIHP chose United Nations' Economic Commission for Europe (ECE) at the time GTR were not possible. Additionally the ECE was the drafting body for related alternative fuel regulations for CNG and LPG.
Due to differences in the technologies between compressed gaseous (CGH_2) and liquid hydrogen (LH_2) storage, two drafts were developed. The drafts cover vehicle storage, on-board refilling and fuel supply components and installation of the components/systems within vehicles.
A primary objective of the regulations was to avoid defining technical solutions by developing performance requirements. In a similar manner efforts were made to avoid limiting the development of future hydrogen technologies, e.g. by avoiding specifying upper limits for CGH_2 storage pressures. The aim of the draft regulations was to enhance the safe and economic manufacture and use of hydrogen fuelled vehicles.
Validation of the draft hydrogen regulations was an ongoing process. A workshop was held in 1999 to discuss the basis of the draft regulations, to which representatives were invited from national authorities, industry and research institutions. Later comments on the proposals were obtained from national authorities and external experts which were integrated into the proposals.
The continuous development process was continued into EIHP2 and resulted in a number of

iterations until wide consensus was achieved. In particular the gaseous hydrogen draft was heavily revised to avoid difficulties experienced during the certification of CNG components/vehicles to ECE R110. Additionally the draft resulting from the first phase of EIHP was further validated within EIHP2 by following the test and approval procedures for storage vessels and the installation of the associated hydrogen system onboard vehicles by BMW and DaimlerChrysler.

The proposals were presented to UN ECE WP29 (http://www.unece.org/trans/main/welcwp29.htm) in 2001 and were subsequently forwarded to the subsidiary group, Working Party on Pollution and Energy (GRPE) which established an ad-hoc or informal group to coordinate the further technical development of the drafts and to achieve wide international consensus. The informal group is now known as Informal Group "Hydrogen/Fuel Cell Vehicles" (IG-HFCV) and was integrated in the H2FCV sub-working group environment. Work included harmonisation meetings with ISO experts developing standards with similar scopes. The scope of the draft ECE regulations includes the hydrogen storage, refilling and fuel supply components and systems, and their installation within a road vehicle as OEM equipment but excludes, for example, the fuel cell system.

The draft ECE LH_2 regulation was introduced as a formal working document at the GRPE in 2003 (http://www.unece.org/trans/doc/2003/wp29grpe/TRANS-WP29-GRPE-2003-14e.pdf) together with latest amendments (http://www.unece.org/trans/doc/2003/wp29grpe/TRANS-WP29-GRPE-2003-14a1e.pdf).

The draft ECE CGH_2 regulation was introduced as a formal working document at the GRPE in 2004 (http://www.unece.org/trans/doc/2004/wp29grpe/TRANS-WP29-GRPE-2004-03e.pdf) together with latest amendments (http://www.unece.org/trans/doc/2004/wp29grpe/TRANS-WP29-GRPE-2004-03a1e.pdf).

During 2005 UN ECE WP29 took the decision not to proceed with ECE Regulations for hydrogen vehicles and instead develop a completely new GTR.

6.2.5. UN ECE WP29 GTR

During 2005 UN ECE WP29 took the decision to proceed directly to a completely new GTR and initiated development work following support from the major markets of Europe, Japan and USA amongst others. Authorities and manufacturers in all major countries or regions including Europe, North America and Japan have agreed that long term legal requirements for the use of hydrogen in motor vehicles should be based on Global Technical Regulations (GTR) under the UN ECE WP29 "1998 Agreement". A GTR contains technical requirements allowing compliance to be "approved" in accordance with the normal system of each country, i.e. type approval or self-certification. The work is being undertaken by the Informal Group "Hydrogen/Fuel Cell Vehicles" (IG-HFCV) co-sponsored by Germany, Japan and the USA and lead by Germany providing the project manager for the HFCV GTR. Despite universal agreement on the ultimate aim of GTR for hydrogen vehicles, there are still significant open discussions regarding the scope, timescale and route to the introduction of such a document. Hydrogen GTR(s) are not likely to be in place until early in the next decade at the very earliest. The current roadmap to the introduction of a GTR can be seen at:
http://www.unece.org/trans/doc/2005/wp29/WP29-136-24e.pdf.

6.2.6. European Regulation

Following the WP.29 decision to abandon the development of ECE regulations, as well as the slow progress in the GTR development, the EC has now initiated the development of a European Regulation based on the draft ECE hydrogen regulations. The first draft was out for public consultation via internet by 15 Septembber 2006.. The European Regulation will adopt a split level approach meaning that there will be:

i) A political document presented for discussion and adoption by the European Parliament and the Council, including scope, reason, etc. (the document which was out for public consultation)

ii) A technical document presented for discussion and adoption at Commission level, through CATP (Committee for the Adaptation to Technical Progress), including technical requirements and testing procedures.

The approach means that the two documents will be discussed in parallel, so some technical discussions can take place with the aim of improving the current drafts. Target date for approval of the regulation is end of 2008.

6.3. STANDARDISATION

Though standards and regulations are frequently mentioned together it should be remembered that they are two fundamentally different things. While regulations are mandatory for everybody in its domain, standards are not. Standards facilitate the trade and use of goods or services. Their main role is to make components or services fit together: pressure cylinders with valves, valves with regulators and further equipment leading the gas to the place of use. This, however, also involves safety issues, and so there is of course an interface with regulations.
The following table highlights the most important characteristics of legal requirements and standards:

	Legal requirements	**Standards**
	Protection of the public, the environment, employees, material values etc. from damage or danger	Facilitation of the free exchange of gods and services
Source	Legislative bodies, governments or other political bodies; sometimes technical expert committees under supervision of the former	Free agreement by those parties which are interested in such a standard
Legal character	Law, ordinance or otherwise mandatory instruments	In principle not mandatory, but may be referenced in a regulation or considered as acceptable practice in court

It is difficult to make standards for a technical field which is new and in constant development. Frequently a standard reflects a state of the art which has found to be useful by longer experience. They are of little use during the development phase of a product or technology; they may even choke the technical progress if they set too narrow margins, or they will remain ineffective. Standard makers in such a field (hydrogen and fuel cells certainly are one of them) shall restrict themselves to such provisions as will be necessary to ensure that the new product or technology can be introduced in the market easily and generally.
Neither is it necessary that standardization bodies produce a lot of special standards for their field when there are already perfectly satisfactory general papers. Here an annex which deals with particular features for this application will perfectly do in many cases.
The basically clear distinction between regulations and standards stated above is somewhat softened by the fact that directives and other regulations may refer to standards. If this happens the user is obliged to follow this standard, giving it a power similar to that of a regulation. But regulations usually contain some provision for the case that technical progress produces new products or applications not explicitly covered by the existing standards. These are required to meet the same safety objectives. Just the process to prove that they do is more tedious. While in

the case of a conventional product the reference to the standards is enough, extensive test reports may be necessary for new ones. Certification may be done initially on an individual basis only. As soon as the new product proves that there is a market for it its manufacturers often develop appropriate standards and introduce them in the regulations. This may take time, but it is a general experience with new technologies.
These general remarks should make clear that it is useless to ordain standardisation work or to expect a certain number of papers at a given deadline. These activities are not and can not be directed by some superior body but they depend on the free agreement of those people who make the products or activities the standards apply to. Their simple desire to create a friendly market environment is usually driving force enough for the necessary standards to appear in due time.

6.3.3. Standardisation panorama

A common marketplace with common regulations needs also common or at least harmonised standards. While ISO is doing this on a world wide scale, there is also CEN for the domain of the EU and associated countries. A similar situation prevails with IEC and CENELEC for the field of electrotechnical standards.
The following table clarifies the standardisation situation:

	general	**electrical**	**other**
World	ISO	IEC	…
Interface	Vienna agreement		
EU	CEN	CENELEC	…

The Vienna agreement between ISO and CEN and between IEC and CENELEC, respectively, is to prevent duplicate work and contradictory results. It contains basically two things:

- A topic which is dealt with in ISO or IEC (or CEN or CENELEC, depending who starts first) must not be dealt with by CEN or CENELEC (or ISO or IEC) at the same time.
- Papers produced by one body can (and preferably should) be adopted by the corresponding partner body in a simplified and accelerated procedure.

Since there is a Technical Committee on “Hydrogen Technologies” in ISO (TC 197) there is no such committee in CEN. The European experts rather participate in the ISO working groups. A similar situation prevails for fuel cells with IEC TC 105 “Fuel Cell Technology”. Given the global character of the technical development this is certainly appropriate. De facto CEN and CENELC will not start the drafting of hydrogen or fuel cell relevant standards anymore and leave this for international activity on ISO and IEC levels.

6.3.4. International activity (ISO and IEC) and related applications

6.3.4.2.ISO Technical Committee “Hydrogen Technologies”

The most important committee on standards for hydrogen technology is ISO TC 197 “Hydrogen Technologies”. The secretariat is held by the Québec standardisation organisation Bureau de Normalisation du Québec (BNQ) in Canada.
Every TC has P (participant) and O (observer) members from among the national standard bodies which are members of ISO. While the O members receive all the papers and can attend the TC plenary meetings, only P members have the right to nominate experts for the working groups and to vote on the results. The membership of ISO TC 197 at this time is this:

P members	**O members**
Argentina	Australia
Austria	China
Belgium	Czech Republic
Canada	Hungary

P members	O members
Denmark	India
Egypt	Jamaica
France	Libya
Germany	Serbia / Montenegro
Italy	Thailand
Japan	Turkey
Korea (Republic of)	United Kingdom
Netherlands	
Norway	
Russia	
Spain	
Sweden	
Switzerland	
USA	

The work of ISO TC 197 is organized in (at this time) twelve working groups, but not all of them are active. Some of them have finished their task a while ago and exist only formally. Only the active ones are given in the table.

No.	Topic	Secretariat
1	Liquid hydrogen - Land vehicles fuel tanks	Canada
5	Gaseous hydrogen - Land vehicle filling connectors	Canada
6	Gaseous hydrogen and hydrogen blends - Land vehicle fuel tanks	Canada
8	Hydrogen generators using water electrolysis process	Canada
9	Hydrogen generators using fuel processing technologies	Netherlands
10	Transportable gas storage devices - Hydrogen absorbed in reversible metal hydride	USA
11	Gaseous hydrogen - Service stations	Canada
12	Hydrogen fuel - Product specification	Japan
13	Hydrogen detectors	Japan

The following official documents have been published by ISO TC 197:

- ISO 13984:1999 Liquid hydrogen -- Land vehicle fuelling system interface
- ISO 14687:1999 Hydrogen fuel -- Product specification
- ISO 14687:1999/Cor 1:2001 (Update of the above)
- ISO/PAS 15594:2004 Airport hydrogen fuelling facility operations
- ISO/TR 15916:2004 Basic considerations for the safety of hydrogen systems
- ISO 17268:2006 Compressed hydrogen surface vehicle refuelling connection devices

  ▪

  ▪ ISO TC22 “Road Vehicles”is also a key hydrogen standard developer through its sub-committees SC 21 “Electrically propelled Road Vehicles” and SC 25 “Vehicles using gaseous fuels”. The following official hydrogen related document is to be published by SC21 during 2006:

- ISO 23273-2 Fuel cell road vehicles -- Safety specifications -- Part 2: Protection against hydrogen hazards for vehicles fuelled with compressed hydrogen

6.3.4.3. IEC Technical Committee “Fuel Cells”

The secretariat of IEC TC 105 “Fuel Cells” is held by Germany. The current situation in terms of members is like this:

P members	O members
Canada	Australia
China	Austria
Denmark	Belgium
Finland	Egypt
France	Norway
Germany	Poland
Israel	Portugal
Italy	Serbia / Montenegro
Japan	Thailand
Korea (Republic of)	
Netherlands	
Spain	
Sweden	
Switzerland	
United Kingdom	
USA	

The working groups are:

No.	Topic	Secretariat
1	Terminology	USA
2	Fuel Cell Modules	Germany
3	Stationary Fuel Cell Power Plants - Safety	USA
4	Performance of Fuel Cell Power Plants	Japan
5	Stationary Fuel Cell Power Plants - Installation	Germany
6	Fuel Cell System for Propulsion and auxiliary power systems (APU)	Germany
7	Portable Fuel Cell Appliances – Safety and Performance requirements	Canada
8	Micro Fuel Cell Power Systems - Safety	USA
9	Micro Fuel Cell Power Systems - Performance	Japan
10	Micro Fuel Cell Power Systems - Interchangeability	Japan

No papers have yet been published by this TC, but quite a few can be expected in the foreseeable future.

6.3.4.4.Interactions

There are numerous interfaces between hydrogen standards and those from other fields, like pressure vessels, vehicles, etc. Work on hydrogen standards can not be done in an isolated way, but only in cooperation with the other committees. ISO TC 197 and IEC TC 105 have a liaison with each other. ISO TC 197 has other liaisons with ten ISO TCs and a few sub-committees, plus other liaisons with external bodies as the European Hydrogen Association and the National Hydrogen Association (USA). The situation is similar for IEC TC 105.

6.4. LIST OF SOME USEFUL GUIDELINES AND OTHER DOCUMENTS

❖ NASA “Guidelines for Hydrogen System Design, Materials Selection, Operations, Storage, and Transportation” (1997), US DoE “Guidelines for Safety Aspects of Proposed Hydrogen Properties”, etc.

- Commission des Communautés Européennes ; « Eléments pour un guide de sécurité hydrogène, Expérimentations spécifiques, choix d'appareils et matériels adaptés - Volume 1» ; Rapport EUR 9689 FR ; Luxembourg 1985
- Commission des Communautés Européennes ; « Eléments pour un guide de sécurité hydrogène, Aperçu d'ensemble - Volume 2» ; Rapport EUR 9689 FR ; Luxembourg 1985
- FM Global ; « Hydrogen » ; Property Loss Prevention Data Sheets 7-91 ; September 2000
- IGC 15/96/E, Gaseous Hydrogen Stations. Industrial Gases Council, Brussels, Belgium
- IGC 06/93/E, Safety in Storage, Handling and Distribution of Liquid Hydrogen. Industrial Gases Council, Brussels, Belgium
- ISO/TR 15916 ; « Basic considerations for the safety of hydrogen systems / Considérations fondamentales pour la sécurité des systèmes à l'hydrogène », First edition : 2004-02-15
- NASA standard NSS 1740.16 ; « SAFETY STANDARD FOR HYDROGEN AND HYDROGEN SYSTEMS, Guidelines for Hydrogen System Design, Materials Selection, Operations, Storage, and Transportation » ; Office of Safety and Mission Assurance ; Washington, DC 20546
- NASA/TM—2003–212059 ; « Guide for Hydrogen Hazards Analysis on Components and Systems » ; Harold Beeson (Lyndon B. Johnson Space Center White Sands Test Facility), Stephen Woods (Honeywell Technology Solutions Inc. White Sands Test Facility) ; Published as TP-WSTF-937, October 2003
- NASA ; NASA Glenn Safety Manual, CHAPTER 6 – « HYDROGEN » ; Revision Date: 9/03 - Biannual Review

This document can be found at
http://www.hq.nasa.gov/office/codeq/doctree/safeheal.htm

- NFPA 50A ; "Standard for gaseous Hydrogen Systems at consumer sites" ; National Fire Protection Association, Quincy, MA, USA, 1999
- NFPA 50B ; "Standard for liquefied hydrogen systems at consumer sites" ; National Fire Protection Association, Quincy, MA, USA, 1999
- NFPA 853 ; « Standard for the Installation of Stationary Fuel Cell Power Plants » ; National Fire Protection Association, Quincy, MA, USA, 2003
- NRCC 27406 ; "Safety guide for hydrogen" ; Hydrogen safety committee, National Research Council of Canada, Ottawa 1987

6.5. RECENT PROGRESS

At the time of writing this report we find that hydrogen energy and fuel cells become increasingly important in economical and also politcal terms. Those who make regulations and standards see this and increase their activity. IEC TC 105 is now in a stage where a number of the work items have matured to committee drafts at the same time. They are under consideration both in IEC TC 105 and ISO TC 197 in parallel. ISO TC 197 has created a new working group on sensors recently which is to cooperate closely with IEC which has already produced standards on similar items years ago.
In terms of legal requirements the sector which needs the greatest attention is hydrogen as fuel for road vehicles and the associated infrastructure. For the reasons explained above in detail a global regulation is not available and will not be for a while. So the European Commission has submitted a preliminary draft for an European Regulation for the type approval of hydrogen cars to the community for comments. HySafe as well has sent a position to Brussels. The EC funded project HyApproval works on the establishment of a Handbook for the approval of hydrogen refuelling stations for road vehicles, first in Europe but due to its international partners also coordinated with the leading world markets (China, Japan, USA). The important and difficult thing with a document on a field developing as rapidly as this is to make it specific enough to meet its purpose while at the same time not to make it so specific that it brakes technical progress. Since national regulations in some countries make it practically impossible to

put a hydrogen car on public roads the intended regulation is in principle highly desirable. Some common guide on approving filling stations would also be of help, though here the national regulations have a greater weight.