

HyApproval

Handbook for Hydrogen Refuelling Station Approval

EC FP6 Contract N° SES6 – 019813

Executive Summary



Introduction

Increasingly, national and local governments all over the world are confronted with challenges like security of supply, harmful emissions, climate change, and increasing costs arising from the use of oil based transport fuels. Besides the need to use hydrocarbon-based fossil fuels more effectively, hydrogen, preferably produced from renewable energy sources, has been recognized by many public and private organisations as an alternative for fossil fuels in future transport applications. All major car manufacturers, for instance, have developed hydrogen and fuel cell prototype vehicles that are currently being tested in everyday conditions. Most leading energy companies, normally with the support of industrial gas supply companies, have been operating hydrogen refuelling stations (HRS's) as a necessary learning step towards a future, which may include a widespread hydrogen distribution network. Some of these HRS's are integrated with the common liquid and gaseous fuels into Multi-fuel Refuelling Stations. In addition to economic motivators, this assists in supporting the public perception of hydrogen as a full-status motor fuel. Commercial hydrogen vehicles are expected to enter the market by 2015. The European Union (EU) has set a target for the use of hydrogen in the total transport fuel mix for 2020. The founding documents of the European Hydrogen and Fuel Cell Technology Platform (HFP - established in 2003 by the EC) provide a "Snapshot 2020" in which it is estimated that between 800,000 and 1.2 million cars fuelled by hydrogen will be on the European roads by 2020.

In agreement with the expectations of HFP, the HyWays project [www.hyways.de], finalised in summer of 2007, the conclusion is that by 2020 1 million hydrogen-fuelled road vehicles will be on the European roads through strong policy support and accelerated learning, and even 5 million in case of very strong policy support and accelerated learning. For 2030, HyWays estimated these numbers to be 15 and 50 million respectively.

In order to support these numbers of vehicles all over Europe, HyWays estimated that the following numbers of hydrogen refuelling stations across Europe would be required:

- for an introductory "lighthouse project" phase (2010-2015) some 400 stations in selected urban centres and some 500 stations on selected inter-connecting highways between these urban centres;
- for the phase of developing demand (2015-2025) between 13,000 and 20,000 stations;
- for the massive rollout phase after 2025 the same station patterns as today for conventional fuels will be reached.

In order to facilitate the introduction of hydrogen road vehicles into the market, in October 2007 the European Commission decided to support the formal approval of a regulation on motor vehicles using liquid or compressed gaseous hydrogen. This regulation will lay down common rules on the construction of these vehicles to ensure a smooth functioning of the internal market, high levels of public safety and the possibility of more sustainable forms of transport in the future.

The use of hydrogen as a transport fuel requires a regulatory framework to ensure that hydrogen transport applications are introduced in a coordinated fashion, complying with the highest safety standards. The HyApproval project, sponsored by the European Commission within the Sixth Framework Programme (FP6), was aimed at developing a universal Handbook (HB) to facilitate the approval process of hydrogen refuelling stations (HRS's) in Europe. The 24 month project started in October 2005 and was terminated in September 2007. It was performed by a balanced partnership of 25 partners from industry, SMEs and research institutes providing the critical mass and required knowledge. Many partners already have extensive expertise in developing HRS's all over the world. Key partners from China, Japan and USA have provided an additional liaison to international regulations, codes & standards activities.

HyApproval Project Goals

The goals of HyApproval were to provide a Handbook of technical and regulatory requirements to assist authorisation officials, companies and organisations with the implementation and operation of an HRS, to finalise the HRS technical guideline started under the EU project EIHP2 and to contribute to the international standards under development at ISO TC197, particularly to WG11 “Gaseous hydrogen – Fuelling stations” ISO/DTS 20012.

The HB should be based on *best practices* reflecting the existing technical knowledge and regulatory environment and should allow new technologies and design to be introduced at a later stage. In 5 EU countries (F/D/I/E/NL) and in China the HyApproval process included a review of an early version of the HB by country authorities to pursue “broad agreement” and to define “approval routes”. After finalising the HB process the developed requirements and procedures to get “Approval in Principle” were expected to be sufficiently advanced in order to seek HRS approval in any European country without major modifications. Approving authorities, HRS operators / owners, engineering firms, as well as the EU as a whole will benefit from the HB as it is expected to facilitate the safe implementation of a hydrogen infrastructure.

Safety Considerations

In the HyApproval project the following three stages (hierarchy) of safety assurance were identified:

- *Prevention of accidents* by application of state of the art technology, by following technical standards and by displaying simple handling procedures to users and operators, designing the user-machine-interfaces in a straight forward manner and emphasise training of personnel.
- *Mitigation*, e.g. creation of safety zones and safety distances.
- Structured and effective *emergency response*.

Prevention of accidents is by far the best way to assure safety. It is aimed at avoiding accidental hydrogen releases resulting from e.g. hardware failures, software failures, operational errors or external impact, which may be caused by factors such as incorrect system or equipment design, incorrect system specifications, inadequate maintenance, inadequate operating procedures, or insufficient training of personnel. Preventive measures cover the technical system (the hardware), maintenance, operations, good housekeeping, and fire prevention.

If, in spite of the preventive measures taken, a hydrogen leakage does occur, the formation of an explosive air-gas mixture is the major concern. Creating sufficient distance between the hazard source and vulnerable targets is an effective way to limit the consequences of an explosion. Zoning aims to create such safety distances, thereby taking both people on site (personnel and customers) and off-site (the general public) into account.

Finally, well prepared emergency response services may further reduce consequences if people were to be affected by an accident on an HRS.

To evaluate the effectiveness and to determine the requirements of the safety assurance system a risk assessment is often performed. A risk assessment process (e.g. for the approval of an HRS) may comprise of several components, as shown below. With increasing severity of hazards and consequences more and more rigorous and elaborate methods will be applied.

In the HyApproval project the use of such methods for the approval process of an HRS was demonstrated.

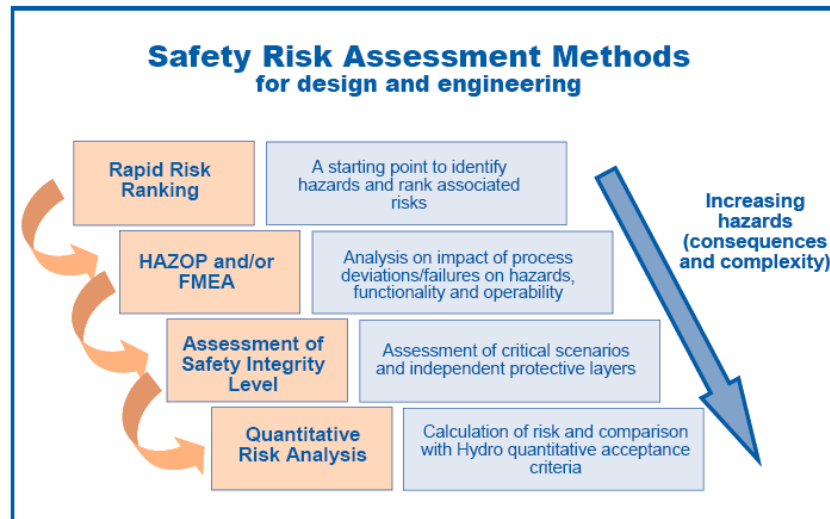


Figure 1: Safety Risk Assessment Methods

Introduction to the Handbook

The HyApproval project is aimed to develop a uniform approach to the installation and approval of Hydrogen Refuelling Stations (HRS's) throughout Europe, essentially by attempting to define a typical "European" (reference) refuelling station, which could be installed in most of the EU27 countries.

The CUTE project had clearly shown the need for harmonization of safety requirements and the permitting process as the various national authorities that were involved with the approval process for the HRS's had many different demands. This has made it difficult for the companies tasked with designing and building the HRS to propose one cost effective standard for hydrogen refuelling station sites. The HyApproval HRS Handbook is expected to address this issue.

In order to move towards the goal of enabling the development of cost effective hydrogen refuelling stations, subject to harmonized requirements, an "EU wide" approach needs to be implemented. As a first step, an EU draft guideline was initiated during the EIHP2 project. The HyApproval Handbook builds on this project by compiling recommendations, best practices (from this guideline and if necessary augmented with others), and applying these to a reference station, also designed during the HyApproval project.

The main goals of the Handbook are:

- to serve as a working document assisting and supporting authorities to issue permits to install and operate HRS's in Europe;
- to finalize the technical guideline started under EIHP2 and contribute to the international standard under development;
- to contribute to the safe implementation of a hydrogen infrastructure by addressing key safety issues like best available (safest) technology, definition of safety distances and best practices for operation and maintenance;
- to assist companies and organisations in the implementation and operation of hydrogen refuelling stations.

Therefore the target audience of the HB are mainly the authorities, regulators and the hydrogen refuelling station owners.

This document should also avoid that companies tasked with the design and construction of HRS's need to develop specific standards and site designs in the future. Instead it should be possible to use and promote EU uniform HRS layouts.

The present Handbook has been written as a standalone document. It is based on best practices reflecting the existing technical knowledge and regulatory environment, but it also includes flexibility to allow new technologies and designs to be introduced at a later stage. Along the 2-year development phase an early version of the HB was reviewed by authorities in 5 EU countries (France, Germany, Italy, Spain and The Netherlands) and in China to achieve "broad agreement" and to define "approval routes".

The Handbook provides recommendations for a EU27 uniform approval process for HRS. The Handbook is divided into two main parts:

- Part I: "Guidelines for design, operation & maintenance of a Hydrogen Refuelling Station" provides technical guidelines and best practices related to construction and operation of a hydrogen refuelling station. It includes the properties of hydrogen, and the list of regulations, codes and standards related to HRS. It also presents the methodologies for a risk assessment in the framework of a HRS approval.
- Part II: "Permitting process" proposes an approval route, which could be applicable all over Europe. It also highlights the HRS approval process differences between France, Germany, Italy, Spain, The Netherlands and China. It identifies the gaps between the various national processes. A feedback from the authorities is also included.

As hydrogen refuelling stations are still largely built as demonstration facilities, making allowance for further technological development and future innovations, is necessary. The safety of these HRS's can be addressed by the application of relevant risk assessment methodologies as described and demonstrated in the Handbook. As HRS's develop towards a commercial market further harmonisation can be achieved as technology becomes more mature and procedures more widely implemented and accepted.

Disclaimer

The Handbook is based on best knowledge and experiences of 2007 available in the HyApproval consortium. The design and system solutions presented in the Handbook document are selected on the basis of practice prior to 2007 and should not be understood as mandatory.

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Recommendations

The key recommendation is to develop an EC regulatory framework for hydrogen refuelling stations based on the proven combination of Essential requirements, Harmonized standards, and Notified bodies. This could be most efficiently achieved through the development of an EC Regulation (as opposed to an EC Directive).

Such a framework, which allows to address the key safety issues without impeding continued technological development, would establish a very streamlined EU 27 uniform permitting process (see Figure 2).

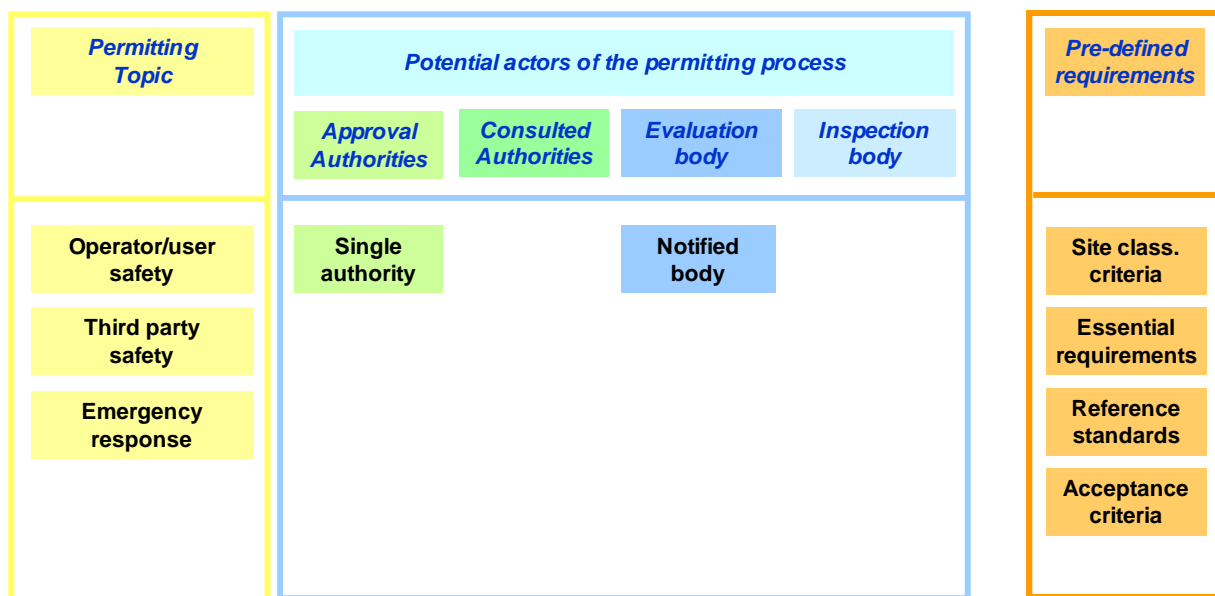


Figure 1: EU27 uniform permitting process

Going a step further, such a framework would allow for a mechanism of **fuelling station “type approval”** (similar to that of road vehicles), allowing a given station design to be approved for deployment in number in all EU 27 countries.

Until such a framework is fully established at EC level, national authorities are encouraged to adopt a permitting process structured similarly: one single authority, relying on the evaluation of one expert body, and referring to pre-established set of requirements and approval criteria.

International standards (ISO, IEC), developed considering the essential requirements set out in regulation, are the framework of choice for developing and providing fueling station design rules and criteria allowing to meet regulatory and permitting requirements.

Whereas as regulation is developed at the initiative of the concerned EC regulatory bodies, standards are developed mostly through the contribution of industry. **However, due to the link between regulation and standards that needs to be established**, a key feature of the proposed regulatory framework, **close cooperation between actors of both worlds is necessary**.

Finally, in parallel to the development of the adequate regulatory framework, **guidance and support needs to be provided to the stakeholders** regarding the applicable standards and regulation, explaining how to apply these as well as providing the underlying knowledge base.

Providing this type of guidance is a key objective of the HyApproval handbook, the content of which needs to be continuously updated. Also the fast growing environment of evolution of knowledge and experience requires a mandatory and frequent update of the Handbook. Thus the Handbook for some time will constitute a Living Document.

HyApproval Project Partners [between 01OCT2005 and 30SEP2007]

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