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Italy before bringing them on road – Final Report**

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## **1 INTRODUCTION**

### **1.1 General considerations**

The scope of this report is to analyse the Italian regulation frame for acceptance and utilization of fuel cell vehicles (FCVs). This, in particular, is the update of the previous version, after the first experience of homologation: one vehicle is now running with a standard plate and the related considerations are reported in the following.

The technology, because its importance and novelty, requires to be urgently integrated into a frame of standards and laws, continuously updated to the actual state of the art, that should constitute the summary of the guarantees for the various components of the society (customers, public) towards the technology itself, in order to not compromise the chances of its acceptance.

In the case of FCVs we can assume that a first reference should be the regulations already existent for the electric vehicles, but unfortunately also even this field is not yet well covered and, in addition, we have to manage also the issues related to the hydrogen fuel. These last, furthermore, shall be also related to the regulations for the fuel supply infrastructures.

The actual general framework, then, provides only some partial references, to be also updated, as background for the new technology, and a large part of items that are supported by the European and International technical regulations on the specific matters.

It should be also remembered that a first degree of FCVs acceptance will be related to the emissions regulations of Italian law, but this element is not expressly dedicated to the new technology and cover all the transportation means and industrial activities; therefore it will not constitute an argument for this report.

The report, then, will consider a path for outlining an Italian regulations frame considering the existent references, where suitable, related both to the internal combustion and electric vehicles frame of standards and to the work in progress for the new technology definition.

### **1.2 Acronyms**

ANFIA: “Associazione Nazionale Fra Industrie Automobilistiche” (National association between automotive industries)

CEI: “Comitato Elettrotecnico Italiano” (Italian electrotechnical committee)

CPA: “Centro Prove Autoveicoli” (Center for vehicles testing)

CUNA: “Commissione tecnica di UNificazione dell’Autoveicolo” (Technical commission for vehicle unification)

DIS: Draft International Standard

D.P.R.: “Decreto del Presidente della Repubblica” (President of Italian Republic decree)

FCVs: Fuel Cell Vehicles

FMEA: Failure Mode Effect Analysis

FTA: Fault Tree Analysis

ISO: International Standard Organization

IVA: “Imposta sul Valore Aggiunto” (Value added tax)

UN-ECE: United Nation Economic Commission for Europe

### 1.3 References

- ISO DIS 23273-1 – Fuel cell road vehicles – Safety Specifications – Vehicle functional safety
- ISO DIS 23273-2 – Fuel cell road vehicles – Safety specifications – Protection against hydrogen hazard for vehicles fuelled with compressed hydrogen
- ISO DIS 23273-3 – Fuel cell road vehicles – Safety Specifications – Protection of persons against electric shock
- ISO 6469-1 – Electric road vehicles – Safety Specifications – On-board electrical energy storage
- ISO 6469-2 – Electric road vehicles – Safety Specifications – Vehicle functional safety
- ISO 6469-3 – Electric road vehicles – Safety Specifications – Protection of persons against electric hazards
- CEI 69-1 – Electrical installation of battery powered road vehicles
- D.P.R. 5 February 1953 n.39 (article n.20) “Testo unico delle leggi sulle tasse automobilistiche” (unique text on automotive taxes)
- Preliminary draft proposal for a Regulation of the European Parliament and of the Council relating to the type-approval of hydrogen powered motor vehicles - version 2 - updated on 13 July 2006
- E/ECE/324, Rev. 2/Add.99, Regulation N°. 100, 11/04/1997

## **2 STATE OF THE ART**

### **2.1 The way to approach**

It is necessary to distinguish between two areas of interest: the first is related to the acceptance requirements and the second is related to the market regulations, as mainly fiscal and administrative issues.

The first area is that, we say, of homologation, where we do not find, actually, any specific rule or code, but where the law itself cannot contribute directly and only can supply a general frame, constituted by articles and decrees, around a content that should be described by specific technological commissions.

The second one, instead, will concern the group of rules and decrees that should be defined in order to allow the FCVs to be acceptable, in particular, at their first stage of market proposal in comparison with the traditional internal combustion vehicles.

Also in this case the references are lacking. Only some preliminary initiatives for electric vehicles are in progress or have been established in Italy and can be considered as background.

Nevertheless, now, we are also waiting for the work in progress of a group of specialists, appointed by the Italian Ministry of Interiors that will elaborate some proposals for future Italian laws related to the FCVs. In the meantime, some few standards and rules for electric vehicles are available and the other references will be found among the European and International standards.

The two different types of consideration are following in this paper.

### **2.2 The homologation path**

The vehicle authorisation for circulating on public roads in Italy follows the verification that a department dependent from Ministry of Transportation, the “Motorizzazione Civile”, organized by provincial offices, does according to the requirements of specific homologation standards. These standards are Italian laws that, as in the other European country, derive from technical rules defined by the specific commission of European Community.

The vehicle technical standards in Italy, moreover, are also a competence of Ministry of Transportation that appoints the activities of rules definition to national associations on the matter (ANFIA, CUNA).

The regulations so defined in Italy encompass various items, as safety, fiscal constraints, number of passengers, maximum payload, emissions, and foresee two main types of procedure:

- homologation as unique specimen: for single vehicles; extendable to other identical vehicles, in a few quantity;
- homologation of type: for series production.

For Zero Regio Italian prototypes the first procedure will apply. Furthermore, if the vehicle is derived from a normal production series, already approved by legislation, the homologation as unique specimen can be simplified, provided that the vehicle constructor gives its authorisation to the modifications executed on the prototype.

The kind of propulsion is not specified into the regulations and the rules contain a certain number of requirements that are specific for internal combustion engine and do not apply to electric vehicles with batteries and/or fuel cells.

This situation produces in certain cases some limitations to the vehicles propelled by electric motors, as for the weight that is related to the administrative issues, and in general even for some more risks to the users, due to the characteristics of the new technologies, not yet covered by technical standards transformed in regulations.

In general, the rules for homologation from the point of view of the new technologies can be divided into three classes:

- A class: referred to the vehicle characteristics not related to the type of propulsion;
- B class: considering in some way the type of vehicle propulsion and acceptable only after suitable amendment;
- C class: explicitly referred to vehicles with internal combustion engines and, then, to be substituted by new regulations and not to be applied to the electric vehicles.

The first class put all the constraints necessary for users and pedestrians safety (active and passive), identification and handling of vehicles: also the FCVs, obviously, must be compatible with them.

Into the second class, instead, we can identify some rules that should be adapted as:

- internal accessories: information to driver on dashboard layout, providing the necessary amendments due to the differences between the propulsion systems;
- braking system: covering the lacking of the engine brake during parking, considering the possible different masses and the presence of an electric motor brake during running;
- fuel tank: different characteristics of fuel and no fuel for batteries;
- weight;

or revised, at the actual early stage of the new technology, as;

- defrosting and defogging of glass surfaces: the actual range limitation of FCVs (and in general of the electric vehicles) should suggest some minor constraints respect to the energy required by this functionality that, anyway, is critical also for safety; a compromise could involve the rules related to the performances and consumption evaluation;
- heating and conditioning systems: for the same reason above;
- performance and consumption: in relation to the energetic considerations of a limited range.

Into the C class are reported rules specific for internal combustion engines and not applicable, then, to any type of electric vehicle (pollutions, emissions, acoustic noise level).

On the other side, instead, in FCVs there are some issues that should be well considered that are not covered by the actual legislation, as the electrical safety and the hydrogen line and tank layout. Additionally it should be considered also the EMC care, in particular for the point for view of the susceptibility, and the shock and vibration constraints, in particular for the more heavy components as the fuel cell stack and/or the power battery buffer.

Regarding the electrical safety, usually, the reference is the Italian CEI standard 69-1, that rules the insulation resistance values and related measurement. Corresponding contents are in the UN-ECE 100 and ISO 6469-1 and ISO 6469-3 for electric vehicles and in ISO DIS 23273-3 that is still in progress specifically for FCVs.

As an additional standard support: functionality safety is covered by ISO 6469-2 for electric vehicles, while for FCVs the corresponding standard is the ISO DIS 23273-1 and specific considerations on hydrogen safety are in the ISO DIS 23273-2.

The homologation procedure, in case of unique specimen, will require a technical documentation of the single prototype, with reference to the main modifications occurred with respect to the base vehicle. A summary of this documentation should be also produced with a main reference to safety aspects. The technical relation, in particular, has to contain also a FMEA analysis or equivalent (ISO DIS 23273-1). Certificates of approval for each main component, according to the available reference standards (GRPE, ISO), will be finally annexed to the technical relation.

These two relations will be submitted to the provincial office of “Motorizzazione civile”, department of Transportation Ministry, in charge as “Centro Prove Autoveicoli” (CPA) (Center for vehicles testing), that will analyse the technical documentation and will require a set of tests related to the previously mentioned reference standards.

The main tests will concern: speed and consumption measurements, insulation measurement, weighing, braking, verification of dashboard layout.

The documentation will be submitted also to the car manufacturer, where necessary, for approval.

The tests will be performed according to CPA directives. Then, after a positive result of the tests, after the approval from the car manufacturer, after the demonstration of the European Certificate of Conformity related to the base vehicle, the certificate of homologation for the prototype will be produced and a number plate will be delivered.

The homologation procedure in case of series production, instead, is not yet established, waiting for the new regulations in progress, because the tests and verifications should be more severe.

### **2.3 The Italian laws and incentives for the market**

The only Italian laws available about zero emissions vehicle are those for promoting the market of electric vehicles with batteries.

The first one lasts since 1953 (D.P.R. 5 February 1953 n.39 - article n.20) and provides an exemption from the annual tax of possession for five years after the homologation. This exemption will apply also to Zero Regio FCVs vehicles, that are electrical at all.

Other laws provided financial support to Italian public administrations for the purchasing of electric vehicles. This could be a basis for new initiatives on this way.

The rest of the regulations frame in Italy does not concern directly the electric vehicles – and FCVs in particular – even if this is very wide: road regulations, vehicle revision matter, homologation matter as we stated in the previous paragraph.

Additionally there is not yet any support for the value added tax (IVA) that is applied to the electric vehicles as to the others.

Anyway, as stated in the first paragraph of this chapter, a work is in progress from the group appointed by the Ministry of Interiors. This activity is organised in three main arguments and contains issues related directly or indirectly to the FCVs and are conceived in order to promote their technical development. This is the content of next chapter.

### **3 WORK IN PROGRESS**

#### **3.1 Legislation proposals for technical and safety acceptance**

The working group delegated from the Ministry of Interiors has been constituted and coordinated by members of Italian Fire Brigade and collects representatives from university and consultancy bodies, all experts on safety matters.

The activity of this group has been addressed to development and definition of the technical content for future Italian laws on the matter of hydrogen infrastructures and transportation means and FCVs.

The final results of this activity will produce a framework of laws addressing the technical acceptability of the new vehicles and their related infrastructure, encompassing the homologation issues and the necessary requirements for a better exploitation of the technology.

Three main projects have been established:

- the first one concerns the multifuel refilling station, with hydrogen, and has been approved from European Commission and, now, is an Italian law decree since 31<sup>st</sup> of August 2006, in force since 13<sup>th</sup> September 2006; it allows the vehicles refilling at 350 bar and is open to possible improvements of the technologies, in order to increase the working pressure according to future needs;
- the second is related to the vehicles and is in progress waiting for the assessment from the Ministry; it is foreseen a final elaboration of it to law format for the end of 2006; actually, nevertheless, the procedure is still in stand by, without a defined deadline.
- the third is still a draft in progress about the hydrogen transportation and the vehicle parking; the working group foresees some final stage of approval procedure for the first part of 2007; but, actually, the procedure is still in stand by, without a defined deadline.

This frame of work would constitute a law structure for the hydrogen technology and, in particular, would establish the regulations for FCVs, also related to the homologations issues; but the not defined deadline of the procedure announces a long time waiting period.

In particular the second law project is strongly expected, that would define the technical characteristics suitable for FCVs approval, from the point of view of safety and functionality. By other side also the first project will influence this aspect allowing the technology for 350 bar and, possibly, more.

#### **3.2 The legislation needs for juridical and market acceptance**

Regarding new procedures and laws related to taxation and also to insurance of FCVs all the work has to be still started.

It is possible only to outline some indications that should help the general acceptance of the vehicles from the market and should constitute a criterion of acceptability also for the public authorities, from the economical point of view and in relation to the necessary guarantee for the circulation. In this case the cost is the main factor and should be related to the other traditional fulfilment of law, as insurance and taxes.

A further framework of laws, in effect, is required for aligning FVCs to the traditional vehicle, overcoming the initial disadvantages due to the major cost and the minor range, provided that the technology can assure equivalent performances.

For this path of legislation it will be necessary also to distinguish between the various possible type of customers: public authorities, private users, business fleet, goods transportation and delivery, taxis (private persons transport service). Probably, the public authorities and business fleet or goods transportation services will have the more easy way to get a customer role into the new technology development, while all kind of private utilizations will wait for long term reduction of costs, actually not affordable by any possible incentives.

## 4 THE FIRST HOMOLOGATION AND THE PROSPECTIVE

### 4.1 The requirements and the tests

The first vehicle of Mantova fleet was registered successfully following the indicated procedure as unique specimen.

In more details, other than the formal steps, the delivery of documentation and the standard tests as previously described, several specific tests prepared the final acceptance of the prototype.

Additionally, the new EC draft regulation for hydrogen vehicles and related components has been assumed as further reference for prototype acceptance. This draft is based on GRPE proposal and documentation that was already considered as a main reference for prototype design and components installation.

The first aim was to reach an overall running on a test track over 2000 km, as endurance test, after the completion of all the standard tests related to braking and weighting of the vehicle.

Then EMC verifications followed, together with the test for the hydrogen sensor on board, the measurement of the insulation resistance (as electric vehicle) and the execution of a hydrogen tank refilling at 350 bar; finally a test for consumption verification has been also performed on dynamometric bench on a standard cycle (NEDC).

More in details:

- The endurance test has been performed with the execution of several driving cycles on the testing track until reaching a total distance more than 2'000 km. The different cycles provided various driving conditions, as speed rings, irregular surfaces, hills. During the tests the main parameters of fuel cell systems were monitored, as voltage and current of stack, temperature and pressure of hydrogen tank. The scope was to demonstrate that, during the driving cycles and after the total amount of distance covered, the vehicle had always good functionality and driveability.
- The test for hydrogen detection has been performed to verify the behaviour of the hydrogen sensor installed inside the vehicle: the sensor must operate regularly according to the specification claimed by the manufacturer in the presence of well defined amount of hydrogen set as reference. The experience has to be repeated at least two times with good result with the direct supervision of the official authorities in charge for the homologation.
- The insulation resistance test is required by the international regulations for the electric vehicles, in particular: E/ECE/324, Rev. 2/Add.99,

Regulation N°. 100, 11/04/1997. The test has the aim of verifying that the insulation resistance of the protective shields around the vehicle active parts, potentially electrically conductive or supplied by high voltage, be greater than the threshold values set by the regulations

- The maximum pressure level for refilling has been reached in several refuelling experiences, for which it has been also verified that the refilling time is not greater than a minimum time and the tank temperature remains within the normal values. Through the vehicle parameters monitoring, moreover, it has been verified that the driving on road, after the refilling at high pressure, is completely regular.
- The consumption measurement has been executed on dynamometric bench according to the international standard based on NEDC (New European Driving Cycle).

#### 4.2 The first registration and the perspectives for the future

The first vehicle, finally, has been approved as unique specimen. The approval, actually, still contains some restrictions, as the limitation to 200 bar refilling and the requirement of asking permission to the local authorities for circulating into the public roads.

In the following figures the official documents of the first Panda Hydrogen homologated are reported. They are the registration to the Public Register of Automobiles (Fig.1) and the authorisation to the circulation (Fig. 2); into the two rectangular frames at the lower half of the second document the limitations are reported.



Fig. 1 – Registration



Fig. 2 – Permission

The other two vehicles are following with a shortened procedure, where the administrative issues are already fulfilled with reference to the first prototype and the tests have been reduced only to the endurance running (testing track for 2'000 km) and the hydrogen sensor verification.

Additionally it was also required that the vehicles would be driven only by trained personnel. For this aim a training activity has also been performed, as it has been foreseen, anyway, within the project framework.

Finally it is also requested that the vehicle, at the end of the project testing activity, should be controlled by the Italian authorities of Provincial Department appointed by the Ministry of Transportation for the technical verifications. Moreover, the vehicle, cannot be given to other parties without Ministry of Transportation authorisation.

These limitations, nevertheless, are only provisional and temporary and could be overcome when it will be reached a sufficient amount of experience with the first car, based on a total running over 10'000 km or a period of one year of testing.

Now the 10'000 km have been completed and the next step of approval history will be the proposal to the Italian authorities for a revision of these initial requirements limiting the acceptance of the vehicle.

The main cause of this transient condition is related to the need of performing several kilometres in real conditions and with trained driver. After this period, once a reasonable distance has been fulfilled or the time elapsed, during testing, has overcome some threshold, as set by the authorities, the vehicles will be accepted within the frame of the actual infrastructure services at 350 bar and allowing a more friendly use regarding the public environment, avoiding the need of special permission from local authorities.

It is certain, anyway, that the vehicles, along the continuation of the project, will be driven only by trained personnel.

## 5 CONCLUSIONS

The homologation process for FCVs of Italian Zero Regio fleet has been completed as a traditional vehicle, with a subset of additional specific tests supported by International technical standards, related to electric vehicles and in progress by EC expressly for FCVs.

At the moment, anyway, some provisional and transitory restrictions are applied to the use of the vehicle in public environment.

Next steps of procedure, for future vehicles better use and implementation, will be the overcoming of the initial restrictions, in order to facilitate and harmonize the use of the cars to the new frame of laws that is in progress.

The vehicles, for the all duration of the project will be driven only by trained personnel, except for publicity and dissemination activities, where other people, accompanied by the trained drivers, could use and test the cars.

Nothing, finally, has been yet established, at the moment, for the taxation and assurance issues, that could produce an additional cost effect: this will constitute a possible problem that would be analysed during the activity of the project itself.