LICENSING A FUEL CELL BUS AND A HYDROGEN FUELLING STATION IN BRAZIL

Neves Jr., N.P.[1] and Pinto, C.S.[2]
[1]Laboratório de Hidrogênio, Universidade Estadual de Campinas, P.O.Box 6039, 13083-970, Campinas, Brazil, nevesjr@ifi.unicamp.br
[2]Faculdade de Engenharia Mecânica, PSE, Universidade Estadual de Campinas, P.O.Box 6039, 13083-970, Campinas, Brazil, cspinto@ifi.unicamp.br

ABSTRACT

The Brazilian Fuel Cell Bus Project is being developed by a consortium comprising 14 national and international partners. The project was initially supported by the GEF/UNDP and MME/FINEP Brazil. The national coordination is under responsibility of MME and EMTU/SP, the São Paulo Metropolitan Urban Transport Company that also controls the bus operation and bus routes. This work reports the efforts done in order to obtain the necessary licenses to operate the first fuel cell buses for regular service in Brazil, as well as the first commercial hydrogen fuelling station to attend the vehicles.

1.0 INTRODUCTION

1.1 EMTU/SP Hydrogen Bus History and Basic Facts

The first Brazilian fuel cell bus was planned as an initiative of the Ministry of Mines and Energy (MME) and the Global Environment Facility (GEF) by means of the United Nations Development Program (UNDP) in 1999. In order to carry out the project an international consortium comprising several national and international partners has been established: MME, FINEP (Financing Agency of Studies and Projects), UNDP/GEF, EMTU/SP (São Paulo Metropolitan Urban Transport Company), the Government of São Paulo State by means of the Metropolitan Transport Secretary, Ballard Power Systems, Marcopolo, Nucellsys, Tuttotrasporti, AES Eletropaulo, Hydrogenics, Petrobras Distribuidora and EPRI International [1]. The program execution is under responsibility of EMTU/SP, which also controls the operation of the buses and bus routes.

This work aims to report some of the steps followed in order to obtain the necessary licenses, comprising safety and environmental aspects, to operate the first fuel cell buses for regular service in Brazil, as well as the first commercial hydrogen fuelling station to attend the vehicles. It is worth mentioning that the information contained in this paper is of exclusive responsibility of the authors and do not represent the view of the consortium, private companies and public organizations mentioned along the text. Moreover, the authors recommend the reading of the book “Brazilian Fuel Cell Bus: Renewable Technologies For The Urban Transport In Brazil” [1] where the history and all the credit to the personnel involved in the project is appropriately assigned.

2.0 MAIN CHARACTERISTICS OF THE PROJECT

The hybrid hydrogen fuel cell bus is a low-floor, 12.6 m vehicle for 90 passengers. It is powered by two 68 kW fuel cells, batteries and a 210 kW motor. Nine composite cylinders (aluminum reinforced with carbon fiber) store up to 45 kg of hydrogen in the bus at a pressure of 350 bar. This amount of fuel provides autonomy for 300 km, more than sufficient for a full day operation. After a series of tests in 2010, the bus was put into full service in an exclusive bus route to attend the public. Three new buses will be built incorporating the lessons learned so far, completing the fleet of four hydrogen buses that will operate in a specific route along with conventional diesel vehicles.

Besides the hydrogen bus, a refueling station was planned and built. Hydrogen is produced in a commercial water electrolysis plant. The gas is compressed up to 430 bar and stored in six stainless steel cylinders totaling 72 kg of hydrogen.

3.0 LICENSING COMPANIES WITH COMBUSTIBLE PRODUCTS

3.1 Information and comments about risk perception

In order to operate in Brazil companies need a variety of operating licenses and permits issued by organs of the municipal, state and federal governments. The licenses provided by the Fire Department of the Military Police of São Paulo (FD/SP) and the São Paulo Environmental Protection Agency (CETESB/SP) belong to the state jurisdiction, and are especially important in the case of companies that use combustible materials. The level of complexity for obtaining such permits depends on the amounts of combustible materials stored and their energy densities.

This paper will present some of the most relevant aspects in the procedures for obtaining operating licenses under responsibility of the 8th Fire Department of Santo André and CETESB/SP, to license BR Distribuidora's hydrogen fueling station, installed at EMTU/SP, city of São Bernardo do Campo, São Paulo metropolitan area, Brazil. These permits are required for the fuel stations and distributors of liquid and gaseous fuels, compressed natural gas (CNG) and liquefied petroleum gas (LPG). Applications using hydrogen in ICE vehicles [2] and fuel cells (VEGA project, only internal reports are available) had been conducted in the country before, but since the projects were developed on the campus of the State University of Campinas and other universities, the licenses were not mandatory.

It is worth mentioning that many chemical, petrochemical and gas companies in Brazil have operational licenses to handle tons of hydrogen and other combustible products daily. Currently there are also in the country about 1,800 CNG fuel stations and 1.65 million vehicles using this fuel, including most of the taxis in large cities. The use of natural gas in private vehicles is allowed in the country since 1997 and the few accidents reported were mostly caused by users who have tried to increase the autonomy installing LPG cylinders in the vehicles illegally.

In the authors' opinion, despite the similarity between natural gas and hydrogen, both compressed gaseous fuels lighter than air, the first commercial project involving a fleet of buses and a hydrogen fueling station apparently caused great concern in the licensing authorities and the Brazilian participants of consortium because of the risk perception associated with the use of hydrogen. Maybe a contribution for that concern was based on the fact that many Brazilian experts share the opinion that accidents with hydrogen should be avoided at all costs, otherwise the barriers to the use of this fuel in the country would become almost insuperable.

Further information about regulations, codes and standards and safety activities in Brazil may be found in the paper Hydrogen Safety Activities in Brazil also submitted to ICHS 2011 [3].

3.2 Main objectives of the FD/SP and CETESB/SP licenses

The operating license awarded by the FD/SP aims to demonstrate the good safety conditions of commercial and industrial facilities against fire and preservation of property, environment and people's lives, mainly within the boundaries of the company. The FD jurisdiction is the state of Sao Paulo and FD from other states may present diverse requests in order to issue permits and licenses. In general, the work of the FD/SP relies on its own 38 Technical Instructions (TI), which refer to the norms of the Brazilian Association for Technical Standards (ABNT) [1], called ABNT NBR[2], and

[1] ABNT is the exclusive representative in Brazil of the following international and regional organizations: ISO (International Organization for Standardization), IEC (International Electrotechnical Commission), COPANT (Panamerican Commission of Technical Standards) and AMN (MERCOSUR Standardization Association).

[2] ABNT NBR is the acronym for Brazilian Standard approved by ABNT. These standards are developed based on the demand of society (public and private entities), established by consensus and their adoption is voluntary. They become mandatory when this condition is established by the government by decrees, laws or administrative acts, as in the case of the FD/SP and CETESB/SP.

Regulation Norms (NR)[3]. In cases not covered by Brazilian standards, international publications and standards may be used.

Since the number of requests involving hydrogen is low, the FD/SP considers that there is no need to develop a Technical Instruction specific to that gas yet. Thus, the requirements of facilities, such as minimum distances, building characteristics and number of fire extinguishers, in many cases are defined by similarity to LPG. In the case of the hydrogen fueling station, however, the high technical quality of the team involved in the licensing process made possible the use of international standards specific to the use of hydrogen, such as the NPFA 497 and NFPA 55, for classification of areas and determination of minimum distances.

Licenses awarded by CETESB/SP are focused on protecting the environment and the lives of people outside the boundaries of the company. The procedures aim to quantitatively assess the risks related to emissions of gaseous and liquid effluents which may be harmful to the environment and health of the population, including cases of improper release of fuels and the explosion risks associated. CETESB has a state jurisdiction and, then, states other than Sao Paulo may present different approaches to licensing such projects. A good description of the licensing process adopted by CETESB/SP for projects involving hydrogen storage can be seen in the paper Hydrogen Risk Assessment in Sao Paulo State - Brazil also submitted to ICHS 2011 [4].

The location of the fueling station is mainly determined by the municipal zone plan. Many fueling stations in Brazil also supply compressed natural gas and, then, hydrogen fueling stations may follow the same permitting process.

3.3 Fuel cell bus licenses

The operating licenses for the fuel cell bus were obtained from three different organizations: IBAMA (The Brazilian Institute of Environment and Natural Resources), DENATRAN (National Road Transportation Department) and DETRAN/SP (São Paulo State Transportation Department).

IBAMA was responsible for the environmental license and it consisted of a permit for an electric vehicle powered by fuel cells. DENATRAN is in charge of the registration of all vehicles in Brazil and it was responsible for the transit permit for the bus. In order to receive the transit permit all relevant characteristics of the fuel cell bus had to be informed. DENATRAN also issued a permit exempting the bus from the Certificate of Conformity to the Transit Code (CAT) since it is considered a prototype vehicle. DETRAN/SP is in charge of the local registration of the vehicle, its license plates and documentation. The fact that EMTU also operates approximately one hundred electric buses in São Paulo City may have facilitated the obtaining of the permits for this new type of electric bus.

4.0 WORK DEVELOPED TO IMPROVE THE SAFETY OF THE HYDROGEN FUELING STATION

4.1 Visits to hydrogen fueling stations in Hamburg and Amsterdam

In order to improve the knowledge about operational procedures and safety measures to be applied in the project, the consortium organized a visit to inspect the hydrogen fueling stations in Hamburg and Amsterdam, as well as Nucellsys fuel cell system manufacture in Stuttgart/Nabern in May, 2007. The delegation was composed by key technical personnel of the consortium and authorities involved in the licensing process.

The knowledge acquired during the technical visits and the accomplishment of a HAZOP (Hazard and Operability Analysis) were used to enhance the Preliminary Hazard Analysis (PHA) which had been

[3] NR stands for Regulation or Norm set by the Ministry of Labor and Employment, with a mandatory character.

previously performed by the personnel of CENPES/Petrobras, BR Distribuidora and Hydrogenics. Finally, the PHA resulted in 16 recommendations to mitigate risks related to the operation of the hydrogen station and the actions were properly distributed between the BR Distribuidora, Hydrogenics and EMTU/SP. This document was incorporated into the licensing process of CETESB/SP and the FD/SP, and some of the recommendations are reported in the next item.

4.2 Some characteristics of the hydrogen fueling station to improve safety

The hydrogen pipelines connecting all equipment are installed in channels on the ground covered by gratings in order to avoid gas accumulation and facilitate inspection, similar to Hamburg's hydrogen fueling station. The same approach was employed with the wiring, but using separate channels.

Alkaline water electrolyzers present small leakages of the electrolyte that can cause environmental concern. The remedy adopted in this case was similar to Amsterdam's hydrogen fueling station, and a tray was installed under the electrolyzer module to collect the liquid.

Differently from Hamburg and Amsterdam stations, there are fireproof walls to isolate the hydrogen production area (water electrolysis system, compressor and storage vessels) from the rest of the facility (dispenser and administrative building). The classification of areas was accomplished according to NFPA 497-2008: gaseous hydrogen storage, Fig. 5.10.8 (b); compressor and electrolyzer, Fig. 5.10.9. The minimum distances were determined according to NPFA 55-2010, Table 10.3.2.2.1 (b).

Special care was taken to assure that the hydrogen storage cylinders would be permanently connected to two pressure safety valves (PSV), and that the valves could not be closed simultaneously. The flow through the PSV must be sufficient to attend all the cylinders connected to it.

Fig. 1 to Fig. 3 show the Hydrogen Fueling Station operated by BR Distribuidora and located at EMTU/SP, São Bernardo do Campo. Fig. 4 shows the first Brazilian Fuel Cell Bus.

Figure 1. View of the front of the Hydrogen Fueling Station, operated by BR Distribuidora and located at EMTU/SP, São Bernardo do Campo.

Figure 2: View of the back of the Hydrogen Fueling Station: a) compressor; b) hydrogen storage cylinders; c) fireproof walls; d) container with the alkaline water electrolysis system.

Figure 3: View of the back of the Hydrogen Fueling Station: a) compressor; b) hydrogen storage cylinders; d) fireproof walls.

Figure 4: View of the first Brazilian hybrid fuel cell bus.

An important contribution regarding safety made to the bus project was the development of a preliminary standard operating procedure for the FD/SP to attend emergencies involving the hydrogen bus fuel cell [5]. The document describes the most important characteristics of the vehicle and the procedures to isolate the area, to approach the vehicle and other arrangements. The document provides information about hydrogen and electricity installations, and points out all locations to drive the valves that cut the supply of hydrogen, located adjacent to the cylinders.

5.0 DISCUSSION

The authors understand that after the technical visits to similar projects in the world and after an objective evaluation of the amount of fuel involved in the operation of the fuel station and hydrogen bus the authorities involved in the licensing process noticed that the initial perception of risk of the venture had been overestimated. In fact, the procedures adopted by CETESB/SP made it clear that the licensing process was simplified, since the amount of hydrogen stored in the fuel station (72 kg) and bus (45 kg) represent a Reference Distance (RD)[4] of 34 m and 29 m, respectively, which makes the venture safe for the external population. Concerning the environmental issues, the relatively small amount of caustic solution used in the water electrolyzer does not represent high risk to the environment and can be neutralized with simple procedures. Thus, although the final operating license has not been issued by CETESB/SP yet, it is likely to occur without any additional difficulty after the commissioning of the water electrolysis system.

Regarding the license of the FD/SP one could conclude that the lack of specific standards for hydrogen in Brazil introduced some difficulties, but it did not obstruct the work. In fact the authors understand that the experience of the members of the consortium with electric vehicles and CNG vehicles may have been conveniently explored to accelerate the process. Additionally, the technical team responsible for obtaining the license did a competent work with respect to the analysis and mitigation of risks of the fuel station and fuel cell bus. As a result of the good degree of interaction the FD/SP already counts with a preliminary procedure to deal with emergencies involving the fuel cell bus [5].

During the elaboration of this work it was observed that the many different standard conditions used for gases [6] may lead to difficulties in determining the amount of hydrogen contained in pressurized cylinders. The use of mass (kg) instead of volume (m^3) can help avoid mistakes in calculating the

[4] Reference Distance (RD) is a circumference with a radius determined by the distance corresponding to 0.1 bar overpressure isocurve originated from a vapor cloud explosion plus the distance from the leak source to the cloud center. A comprehensive explanation of RD is given in the paper Hydrogen Risk Assessment in Sao Paulo State - Brazil [4] submitted to ICHS 2011.

amount of stored energy and therefore in the risk assessment. The use of LPG standards for hydrogen is not appropriate in many situations and it would be very interesting to cooperate with the FD/SP to verify and correct the distortions, if any, based on available knowledge.

During the visits to the hydrogen fuel station the authors could verify that the infrastructure and equipment used there are of high quality and contain all the necessary items to ensure safety during operation of the fuel station and fuel cell buses.

6.0 CONCLUSION

The Brazilian Fuel Cell Bus Project is the largest project using hydrogen for energy purposes in the transportation sector in Brazil. It is contributing decisively to a better understanding of the advantages of the hydrogen use and that the risks associated with that fuel can be adequately managed. Despite the important gaps in legislation about hydrogen in the country, it was demonstrated that it is possible to develop large projects with adequate safety using this fuel.

The cooperation between companies and governmental agencies has produced very positive results and the experience may be used to further accelerate the activities on hydrogen energy in the country.

Besides the cooperation between different national groups, the experience of the consortium makes clear that international cooperation is essential to accelerate the development of hydrogen technologies aiming for energy security, environmental improvement and sustainability.

ACKNOWLEDGEMENTS

The information contained in this paper is of exclusive responsibility of the authors and do not represent the view of the consortium, companies and public agencies mentioned along the text. With this in mind, the authors would like to acknowledge EMTU/SP and its personnel, especially Eng. Ivan Carlos Regina and Eng. Marcos Correia Lopes, and Eng. Eduardo Jorge Amorim de Almeida from BR Distribuidora that provided access to the installations and important operational information about whole project. A special thanks to Dr. Paulo Fernando Isabel dos Reis, CENPES/PETROBRAS, who played a key role in the project since its beginning and contributed to clarify important aspects of the work conducted by the technical team in search of the operating licenses. Many thanks to Mr. Sandro Roberto Tomaz and Mr. Giuseppe Giulio Michelino that provided valuable information about the licensing process conduct by CETESB/SP. Finally, our thanks to Lt. Col. Hamilton Coelho da Silva Filho, commander of the 8th Fire Department of Santo André, for the warm reception and important information about the procedures adopted by the corporation in the licensing process.

REFERENCES

1. MME. Brazilian Fuel Cell Bus: Renewable Technologies for the Urban Transport in Brazil, 2009, MME, Brasília, DF.
2. Lobkov, D.D; Sordi, A.; Neves Jr., N. P.; Silva, E.P.; Guimarães, C.A.B. Uso de combustíveis gasosos em transporte urbano. Revista dos Transportes Públicos, v. 29, p. 111-122, 2006.
3. Pinto, C.S., Neves Jr., N.P. and Silva, E.P., Hydrogen Safety Activities In Brazil. *Proceedings of ICHS 4*, San Francisco, USA, 2011 (in print).
4. Tomaz, S.R., Michelino, G.G. and Neves Jr., N.P., Hydrogen Risk Assessment in Sao Paulo State - Brazil. *Proceedings of ICHS 4*, San Francisco, USA, 2011 (in print).
5. Toller, C.C., Atendimento às emergências envolvendo ônibus com célula a combustível de hidrogênio: proposta de procedimento operacional padrão para o Corpo de Bombeiros da PMESP, Polícia Militar do Estado de São Paulo, Monografia para o Curso de Aperfeiçoamento de Oficiais, 2009.
6. L'Air Liquide, Gas Encyclopaedia, 1976, Elsevier, Amsterdam.