I&E INDUSTRIES & ENVIRONMENT

The Use of Alternative Fuels in the Railway Sector

A White Paper written in collaboration by SGS, RENFE, ENAGAS, CNH2 and SEGULA

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Table of contents

Introduction

THE DECARBONIZATION PROCESS

As part of the global goal of zero emissions by 2050 and as part of the process of decarbonizing the economy, initiatives have been established, both at European and national level, to drastically reduce emissions through clean and sustainable energies, including hydrogen and gases from renewable sources.

At the national level and following the guidelines set by Europe, the 2050 Long-Term Strategy promotes the development and use of hydrogen, in addition to gases of renewable origin, in those applications where electrification or substitution by direct renewable uses is unfeasible. These applications include industry and heavy transport, especially the railway sector. The World Energy Outlook 2023 (WEO 2023) report published by the International Energy Agency (IEA) estimates, in the Net Zero Emissions 2050 scenario, that the contribution of neutral fuels in "Non Road" mobility will be 75%.

In Spain, through the National Integrated Energy and Climate Plan and the Hydrogen Roadmap, specific measures and objectives are established, both in the medium and long term, to increase the substitution of fossil fuels and gradually achieve the decarbonization of the sector. The general objective is to position Spain as a technological benchmark in the production and use of hydrogen and renewable gases, contributing to decarbonization and positioning Spanish industry and technology as a global benchmark in the sector. In this context and through initiatives such as the implementation of the Alternative Fuels Infrastructure Regulation (AFIR) and the REPowerEU agreement, it is promoted to increase the capacity of renewable energies, including hydrogen and biomethane, raising the binding target for 2030 to 42.5%, with the ambition to reach 45%, which would almost double the current share of renewable energies in the European Union. The development of the transport and storage infrastructures promoted by these initiatives and EU regulation will not only facilitate the improvement of hydrogen's competitiveness, but also its territorial structuring will allow the development and promotion of the distribution network through the installation of alternative fuel recharging and refueling stations throughout Europe. This will enable the transport sector to significantly reduce its carbon footprint.

INITIATIVES IN THE RAILWAY SECTOR

New railway propulsion technologies based on hydrogen and renewable gases are a sustainable and efficient alternative for those railway sections that are not electrified and currently require fossil fuels for their operation. In Spain, there are still more than 4,000 kilometers of unelectrified railway tracks, operated by more than 250 diesel trains and locomotives, and as a result, only 60% of the energy consumed by the railway sector is electric.

The practical and economic feasibility of electrification of railway lines is intrinsically determined by the intensity of the circulations and although formulas are currently being sought to divert part of the heavy traffic by road and medium-distance air transit, it is essential to develop alternatives to diesel fuel for those segments in which electrification is not feasible or, alternatively, It is more interesting because of the characteristics of the railway route in particular, especially in urban areas or short distances. Battery systems, hydrogen, renewable gases and even hybrid or dual systems are real alternatives called to occupy that space in the coming years.

Spanish railway operators and builders are in the midst of developing and validating the technology needed to undertake this energy transition, prioritizing the safety and operability of new propulsion systems. Currently, the first prototype units are already in the track testing phase that will confirm the viability of the new technologies and thus position the Spanish railway sector as one of the world benchmarks in achieving the green economy. Some of the most representative current railway projects are:

- S3600 Bimodo Electric – H2 Project, a European project promoted by RENFE and ENAGAS. It is a converted unit of the S3600 series that will allow dual propulsion, electric traction powered by catenary and additionally, with H2 fuel cell. Of note is the innovation in the storage and use of liquid hydrogen, considerably increasing its autonomy.
- The railway manufacturer CAF, together with RENFE, ADIF and the CNH2 National Hydrogen Centre, have formed a technological alliance to develop hydrogen fuel cell propulsion in the FCH2Rail project.
- The other major Spanish railway builder TALGO, with the collaboration of the CNH2 National Hydrogen Centre, has developed the Vittal-One renewable hydrogen dual train. This prototype is based on fuel cell technology with hydrogen gas storage and is currently in the testing phase.

IMPLEMENTATION OF THE RAILWAY SAFETY PROCESS

The main priority in the development of hydrogen and renewable gas technology in the railway sector is to ensure its safety, both in the rolling stock itself and in all the infrastructure and supply logistics necessary for its operation. New propulsion systems and their corresponding operation must be at least as safe as current railway systems. To this end, the correct and exhaustive application of the current regulatory and normative framework is essential. In Europe, the Interoperability and Safety Directives have been the two fundamental benchmarks on which the high safety indexes in the current railway system have been based. Both concepts are intimately related and are difficult to diverge when we talk about the comprehensive management of railway safety.

The management and implementation of the railway safety process is based on the assessment and control of risks. This concept takes on special relevance for those systems of an innovative nature, such as the use of hydrogen and gases of renewable origin, where the lack of previous references and return of experience make it difficult to truly assess the dangers, forcing in many cases to establish excessively restrictive operational limitations that condition and penalize the viability of new systems. When in doubt of any anomalous behavior in the system, with good judgment, the precautionary principle should always prevail and bring the system to a safe state. Therefore, the greater the knowledge of the behavior of hydrogen and gases of renewable origin in the railway field, the greater the ability to identify and discriminate the real risks, establishing effective mitigations without falling into over-protection that penalizes the operability and availability of the system in a way and unnecessarily. To address the risks of hydrogen and gases of renewable origin in the railway environment, threat analysis methodologies must be applied to identify and control all risks in the system, both those specific to the railway field (FMECA, FTA, CCF, etc.) and those specific to the gas world (HAZID, HAZOP, ATEX, QRA, etc.).

RENFE and ENAGAS have been committed to the decarbonization of the railway sector for a long time. During these years, RENFE and ENAGAS have developed and continue to develop emblematic projects based on the use of natural gas and hydrogen: S2600 LNG prototype (first prototype train powered by liquefied natural gas), CEF S1600 LNG Locomotive Project, S2600 BIOGAS and S3600 H2 Bimodo. These projects have been approached from a comprehensive perspective. In addition to the design and implementation of the new traction systems for rail vehicles, new infrastructures and equipment have been developed to ensure the logistics and supply chain with the new alternative fuels, as well as the corresponding operational processes and procedures for safe operation and maintenance.

Fig. 1.- View of the LNG train 2605-2606 at the Soto Ribera level crossing, author Álvaro Fernández Guerra

Fig. 2.- H2 Fuel Cell

Each of these projects is in a different phase of development within the life cycle. For practical purposes, the same degree of TRL (Technology Readiness Levels) innovation cannot be considered as a project that is approached with mature and proven technologies in real environments as when experimental products and equipment or prototypes are split. Thus, within the developments of RENFE and ENAGAS, we find already consolidated projects that are in operation and maintenance, others in the manufacturing and testing phase and, finally, others in the initial phase of specification and design.

For each of the projects and in each phase of the life cycle, it is important to highlight the complexity and technological challenges that RENFE and ENAGAS have had to face, each step and solution provided has been an opportunity to acquire new knowledge about these new technologies, enriching practices that allow us to extract great lessons learned and obtain a valuable return on experience. This approach, especially in terms of safety and the associated risks, is crucial for tackling new projects and consolidating the use of new fuels in the railway world.

Railway operations with alternative fuels to diesel, such as hydrogen and gases of renewable origin, require a change of mentality when it comes to operating and maintaining new traction systems, as well as their supply logistics. To traditional fire safety measures (EN 45545) Implemented in conventional railway systems, protection mechanisms must be introduced derived from the particularities and physicochemical characteristics of the new fuels. The high volatility and wide range of flammability, natural gas (4.7% - 13.7% concentration in air) and especially hydrogen (4% - 74% concentration in air), require new operational procedures (loading, emptying, inerting, etc.) to cover the new threats with all the guarantees. In addition, if to obtain greater energy density and autonomy, new fuels are stored in the liquid phase (-160°C LNG and -253°C LH2), appropriate measures will also have to be taken to counteract the unwanted effects of cryogenic technology such as cold burns, material embrittlement or sudden vaporization.

From the experience of these projects using hydrogen or gases of renewable origin, both in liquid and gaseous phases, some of the main threats identified have been extracted, as well as proposals for the approach to mitigate them:

RISK IDENTIFICATION	VALIDATION METHOD (NORMATIVE/TEST/ESTIMATION)	PROTECTION IMPLEMENTED
• Side Impact	• UNE-EN 12663-1:2011+A1	• Side Protective Fenders
• Structural failure	• Directive 2014/34/EU Potentially explosive atmospheres	• H2/GN Detectors
• Template	• Dielectric Strength Test	• Fire Detectors
• Geometric variation of masses	• Dispersion tests of NG/H2 in tunnels	• Safety Valves
• Electrical risk	• Structural analysis	• TPRD Valves
• NG/H2 or LNG/LH2 leaks	• Gauge Analysis	• Pressure Relief Valves
• Cryogenic and LNG/LH2 temperatures		• Cold Cut Interlock
• Overpressure & BOG		• Anti-flashback devices
• Heating stages regulation		• Specific design of the venting system
• Venting enclosed spaces (tunnel)		
• Catenary vents		

Studies and analysis of the alternative fuel's behavior

One of the great difficulties when facing alternative fuel projects, based on hydrogen and renewable gases, is to determine objectively and reliably the level of risks, frequency, and consequences of the identified threats. This is mainly due to the lack of knowledge and previous references of their behavior in the railway environment, where a wide diversity of systems with particular physicochemical characteristics coexists, a source of potential risks. Given the complexity of assessing the real risks of new fuels, RENFE and ENAGAS, in collaboration with different experts and technology centers such as the CNH2 National Hydrogen Centre, considered it necessary to deepen the study of the behavior of hydrogen and renewable gases in an environment as complex and specific as the railway one. The approach adopted to carry out a risk assessment and acceptance in this environment was twofold, both theoretical and empirical. On the one hand, studies, analyses, and theoretical simulations were carried out and on the other, tests were carried out in laboratories and similar environments or systems where behavior can be analyzed in real conditions.

For the tunnel testing phase, told with the invaluable collaboration of the Barredo Foundation, whose objective is the promotion and development of all applied research, technological development and training activities that are of interest to industries. The Barredo Foundation made available to the project the 'San Pedro de Anes' Experimental Centre, located in the old San Pedro station, part of the railway line that transported coal from the Langreo mining account to the port of Gijón and which currently has the facilities of the test tunnel, a laboratory warehouse for testing fans, extinguishing systems, waste collection, control and auxiliary systems.

Fig. 3.- Test Tunnel

Fig. 4.- San Pedro de Anes Experimental Center

To guarantee the technical feasibility and safety of liquefied natural gas and hydrogen as alternative fuels for commercial exploitation in rail transport and based on the determination of risks identified in the system as a whole, the behavior of different natural gas and hydrogen leaks is analyzed, both at the level of Computational Fluid Dynamic CFD simulation. Like tunnel test cases, the leaks that could occur from a railway vehicle are considered, analyzing the potential risks at a given concentration of hydrogen or natural gas, depending on the scenarios, exhaust rates and existing ventilation. These studies aim to obtain the data and information necessary to Define security measures to be implemented in the design that avoid incurring restrictions in the operation to guarantee its safety:

- Continuous leakage of natural gas and hydrogen, gas phase, in the vehicle circulating that stops inside a tunnel, the immediate consequence of which is the accumulation of gas inside, which at any source of ignition can trigger a deflagration or fire.
- Leakage of natural gas and hydrogen due to uncontrolled venting of the natural gas installation and the hydrogen installation, in the presence of electrical potential, with the risk of electric arc formation under catenary voltage and subsequent fire or deflagration.

For this reason, CFD simulation studies and subsequent empirical tests were carried out on the behavior of hydrogen leaks in tunnels, specifically in the San Pedro de Anes tunnel of the Barredo Foundation in Asturias (24 experimental scenarios and 65 models have been considered, for different exhaust rates and vents, which has reported more than 1.8 million data, This has led to the behavior of a natural gas and hydrogen leak in a confined environment.

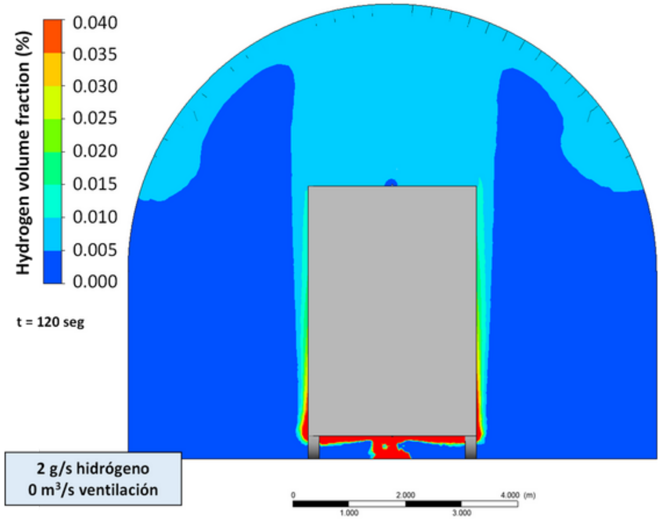

Fig. 5.- CFD simulation – Underframe leak

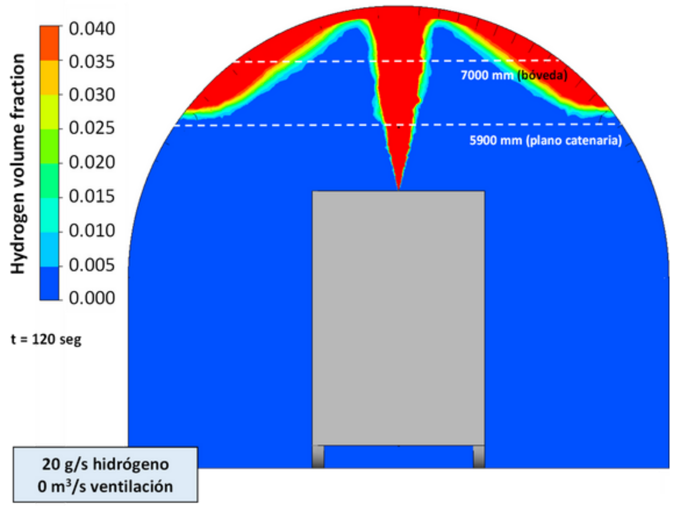

Fig. 6.- CFD simulation – Roof leak

In the same way, dielectric strength tests were carried out under different operating conditions and voltage levels, evaluating the impact of the concentration of hydrogen or natural gas on the insulation parameters in the medium. To assess the increase in electrical risk in the presence of natural gas and hydrogen, the study is completed with dielectric strength tests at different gas concentrations and high voltage ranges (specifically, 5 concentrations of natural gas and hydrogen in air, 4 distances between electrodes and wide scanning of voltages have been considered), specifically from 0 kV to 200 kV.

Likewise, the effect that the presence of a catalytic recombinant would have at the point where hydrogen leakage occurs in the gas phase was also analyzed, with the aim of eliminating or reducing this leakage.

The studies of the behavior of the use of alternative fuels, hydrogen, and natural gas, are structured under 4 blocks:

BLOCK 1: MODELLING OF HYDROGEN LEAKS USING CFD SIMULATION SOFTWARE, TO EVALUATE THE DISPERSION BEHAVIOR OF THE EFFLUENT MIXTURE UNDER DIFFERENT RISK SCENARIOS

The different mathematical models developed are analyzed, according to the rate of exhaust and ventilation in the tunnel. These models have been developed using ANSYS FLUENT simulation software. The purpose is to evaluate the hydrogen leaks generated from a train inside the tunnel, to simulate the behavior of the dispersion of the mixture (air/CH4 and air/H2) under different risk scenarios.

SCENARIOS FOR ESCAPE RATES FROM THE TRAIN		
Leakage PSV primary LNG tank and H2 cylinder	• Leakage of natural gas in the gas and hydrogen phase • caused by malfunction in the opening of the safety valve	• Vehicle top (on frame)
PSV secondary LNG tank leak	• Natural gas leak in the gas phase caused by malfunction in • the closing of the primary safety valve of a tank, generating • a secondary safety valve relief	• Underside of the vehicle (under frame)
PSV Leak Power Line	• Leakage of natural gas in the gas and hydrogen phase • caused by malfunction of a safety valve in the power system	• Underside of the vehicle (under frame)
Leakage corresponding to unburned gases	• Continuous leakage of unburned gases with flue gases	• Vehicle top (on frame)

SCENARIO	VALUE	CORRESPONDENCE
Zero ventilation	• 0 m3/s	• Zero speed in the tunnel or stationary train conditions inside the tunnel
Low ventilation	• 130 m3/s	• A single exhaust fan in operation (Barredo Foundation tunnel)
Medium ventilation	• 200 m3/s	• Two exhaust fans in operation (Barredo Foundation tunnel)
High ventilation	• 600 m3/s	• All exhaust fans in operation (Barredo Foundation tunnel)
Maximum ventilation	• 2000 m3/s	• Flow rate equivalent to the train running inside the tunnel (approx. 140 km/h)

The gas dispersion, the concentration reached as we move away from the leak point, the stratification produced and the behavior in the control domain are analyzed through mathematical models, according to different exhaust rates and different ventilation velocities in the tunnel. Especially relevant are the concentrations of natural gas and hydrogen obtained in the electrified lines present in the tunnel, especially in the catenary and signal line.

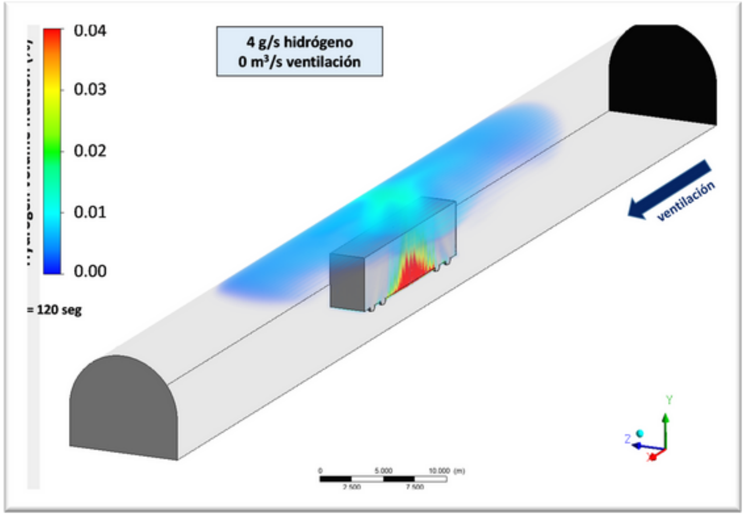

Fig. 7.- CFD simulation – Without forced ventilation

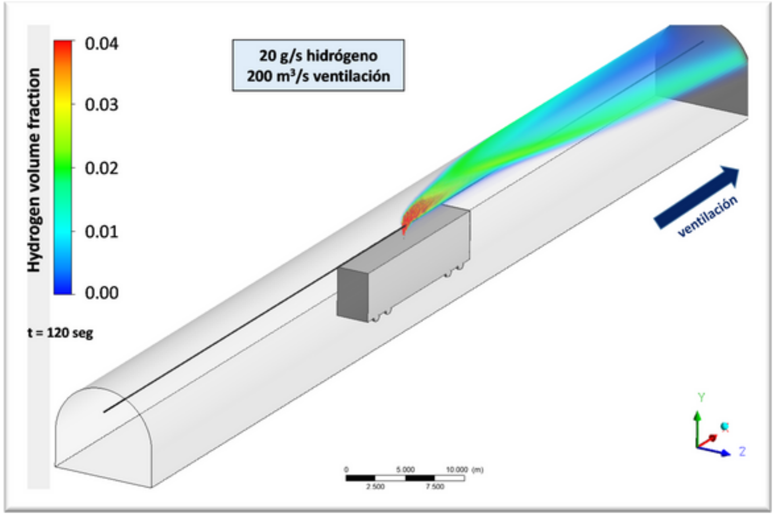

Fig. 8.- CFD simulation – With forced ventilation

BLOCK 2: EXPERIMENTAL ANALYSIS OF HYDROGEN DISPERSION IN A REAL OPERATING ENVIRONMENT, USING A NETWORK OF 100 SENSORS TO CHARACTERIZE THE CONCENTRATION OF A HYPOTHETICAL RAILWAY VEHICLE LEAK INSIDE A TUNNEL


Fig. 9.- GN and H2 fuels for the tests

Fig. 10.- Railway test model


Fig. 11.- Sensor network

This study includes the different tests carried out in the tunnel of the "San Pedro de Anes" Experimental Centre of the Barredo Foundation (council of Siero, Asturias), to analyze the behavior of different hydrogen and natural gas leaks from a railway vehicle.

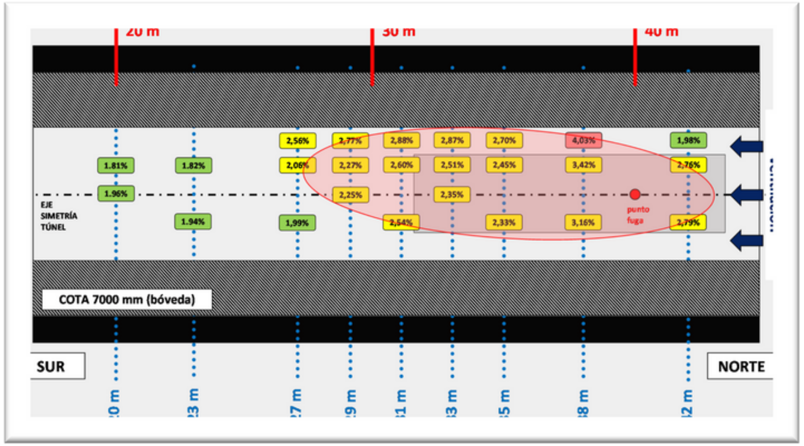

Fig. 12.- Sensor configuration

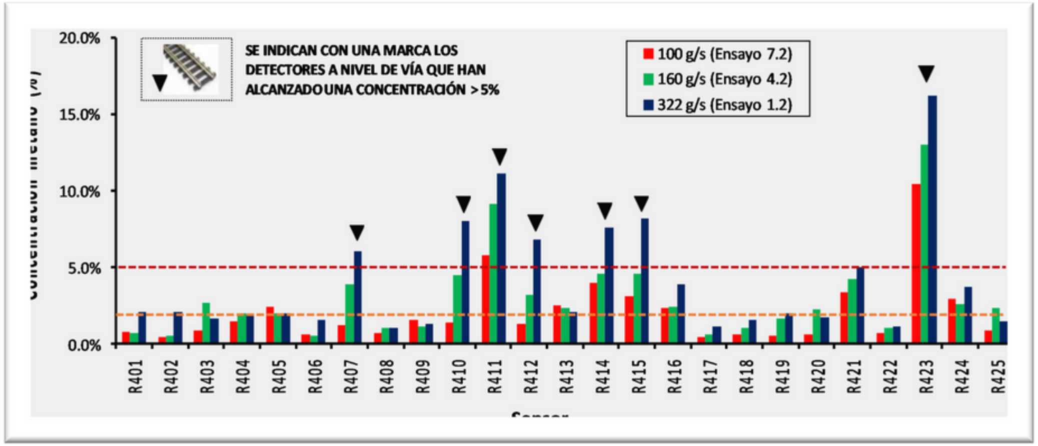

Fig. 13.- Test results

The results obtained allow us to know the fraction of natural gas and hydrogen (%) that exists in different areas of the tunnel by means of a monitoring matrix made up of 100 sensors, which allow the identification of the concentrations reached in the risk areas of the tunnel (catenary and other electrified lines present in the infrastructure).

More specifically, the experimental study carried out covers the following aspects:

- Installation in the tunnel of a network of 100 sensors, distributed around a potential methane leak, with the capacity to monitor data every 1s, to obtain very detailed values of the dispersion of the leaks considered.
- Installation of conducted methane outlets so that the estimated exhaust rates can be generated in a controlled manner. These exits are located where you would potentially be located on the train. In addition, the existing ventilation will be controlled and measured.
- Assembly and positioning of a frame whose volume reproduces the space that the railway traction system would occupy inside the tunnel.
- Generation of gas leaks, collection of sensor data and subsequent analysis of results.

See results on next page.

NUMBER	LEAK POSITION GN	TUNNEL VENTILATION		DURATION
	-	m3/s	m/s	s
1		0	0,00	10
2	INFERIOR	130	1,98	20
3		200	3,05	40
4		0	0,00	15
5	SUPERIOR	130	1,98	30
6		200	3,05	60
7		0	0,00	15
8	SUPERIOR	130	1,98	30
9		200	3,05	60
10		0	0,00	300
11	INFERIOR	130	1,98	600
12		200	3,05	1200
13		0	0,00	300
14	SUPERIOR	130	1,98	600
15		200	3,05	1200
16		0	0,00	300
17	INFERIOR	130	1,98	600
18		200	3,05	1200
19		0	0,00	15
20	SUPERIOR	130	1,98	30
21		200	3,05	60

NUMBER	BREAKAWAY POSITION H2	TUNNEL VENTILATION		DURATION
	-	m3/s	m/s	s
1		0	0,00	10
2	INFERIOR	130	1,98	20
3		200	3,05	40
4		0	0,00	15
5	SUPERIOR	130	1,98	30
6		200	3,05	60
7		0	0,00	15
8	SUPERIOR	130	1,98	30
9		200	3,05	60
10		0	0,00	300
11	INFERIOR	130	1,98	600
12		200	3,05	1200
13		0	0,00	300
14	SUPERIOR	130	1,98	600
15		200	3,05	1200
16		0	0,00	300
17	INFERIOR	130	1,98	600
18		200	3,05	1200
19		0	0,00	15
20	SUPERIOR	130	1,98	30
21		200	3,05	60
22		0	0,00	300
23	INFERIOR	130	1,98	600
24		200	3,05	600

BLOCK 3: DIELECTRIC STRENGTH TESTS ACCORDING TO DIFFERENT AIR/HYDROGEN MIXTURES, TO EVALUATE THE FORMATION OF ELECTRIC ARC IN THE PRESENCE OF POTENTIAL

Dielectric strength is the limit value of the electric field strength at which a material loses its insulating property and becomes conductive. The release of natural gas or hydrogen can vary the usual values of dielectric strength of air which, in the presence of voltage, can trigger the formation of an electric arc. To evaluate these changes in dielectric strength, different known mixtures of air/natural gas and air/hydrogen have been prepared. Using these mixtures and considering different distances between electrodes, the breakdown stresses under controlled conditions have been determined, to determine how the concentrations of natural gas and hydrogen in the air can modify the conditions of electric arc formation. The results contained in this annex correspond to the dielectric strength tests for different air/hydrogen mixtures, carried out by means of a voltage surge ramp until the electric field breaks, in accordance with the EN 60243-1 standard.

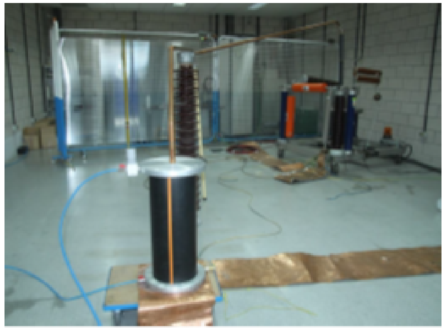

Fig. 14.- Electrical test specimen

Fig. 15.- High voltage testing laboratory

BLOCK 4: LABORATORY-SCALE CATALYTIC RECOMBINANT TESTS TO MITIGATE POTENTIAL GAS LEAKS, IN ORDER TO VERIFY WHETHER THESE SYSTEMS CAN BE IMPLEMENTED IN RAIL VEHICLES

This study presents laboratory-scale results using passive autocatalytic recombiners (PARs) to evaluate their potential to reduce the concentration of possible hydrogen leaks through the recombination of hydrogen and oxygen. These systems are currently used in other energy applications, such as nuclear power plants, and the aim is to determine whether they could be used in transport-related applications. All the tests carried out in this block of activities have been developed by HySA Infrastructure (South Africa), an entity that has extensive experience in the study and testing of PAR (Passive Autocatalytic Recombiner) systems for use with hydrogen in different applications.

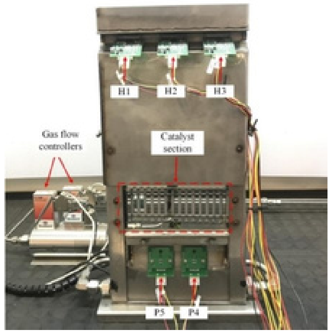

Fig. 16.- Passive Autocatalytic Recombiners (PAR)

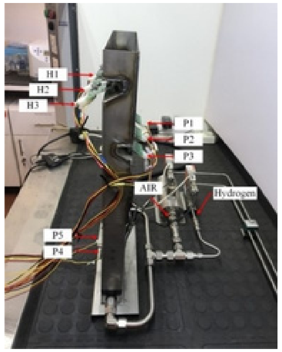

Fig. 17.- PAR behavior test

Main findings of studies and tests

The results extracted from the different studies allow relevant information to be obtained to assess the risks more accurately and establish effective mitigation measures. The studies carried out make it possible to identify scenarios whose level of risk may be considered unacceptable and to establish appropriate mitigation and protection measures to guarantee safety, prioritizing their implementation in the design and thus, minimizing possible restrictions or limitations during operation. Based on the results achieved, the following recommendations are presented:

DIELECTRIC STRENGTH STUDY AND TESTS

The presence of concentrations of natural gas or hydrogen in the air modifies the dielectric characteristics of the medium, reducing the level of insulation and favoring the formation of electric arcs on the points under stress. It is observed that the electrical risk due to indirect contact is not significantly increased in the case of natural gas, being significantly higher in the case of hydrogen. The level of insulation also depends on external agents such as humidity, air density that varies with altitude above sea level, rainfall, and the environment. The worst conditions for loss of dielectric strength occur in the face of high relative humidity, low atmospheric pressure, environmental pollution, and high temperatures. For this reason, the total effect of natural gas or hydrogen concentrations together with the particular boundary conditions should be analyzed in each area of use. In cases where such effects are hazardous, additional mitigation measures will be required. These measures may be aimed at increasing the distances or insulation materials or limiting the concentrations of natural gas or hydrogen in the presence of high voltage.

NATURAL GAS DISPERSION TEST IN TUNNEL

The leaks generated on the roof of the unit (upper part of the train) show a dispersion whose concentrations are below the flammability limit of natural gas (5%). Therefore, the potential risk of a leak in the upper parts does not have significant consequences. However, in leaks generated under the unit (under the frame or lower parts) there is a potential risk of accumulation and/or pocketing of natural gas in rack areas, generating an enclosed or partially confined space. From the results obtained and in a general way, the following recommendations can be implemented to mitigate and reduce the risks associated with the use of natural gas in the railway field:

- All atmospheric discharge points (reliefs) from existing safety valves in the gas installation must be conveyed to the upper part of the train, in order to avoid pockets in the lower part as a result of operational vents. It would not apply the safety valve for LNG tanks (Regulation R110) associated with operation after failure of the first valve (driven to the roof) whose discharge would be carried out locally and not conducted.
- The implementation of automated fuel detection and cut-off systems in the presence of natural gas, by means of sufficient detectors to cover the gas installation under the frame, reduces the level of risk. The level of security integrity associated with this system will be determined on a case-by-case basis, according to the established risk acceptability criteria.

HYDROGEN GAS DISPERSION TEST IN TUNNEL

In leaks generated under the unit (under the frame or lower parts) there is a potential risk of accumulation and/or pocketing of hydrogen in areas of the frame, generating an enclosed or partially confined space. The hydrogen that does not accumulate rises to the tunnel vault, registering concentrations below the lower explosive limit. To eliminate or minimize this risk, the following considerations are recommended:

- Whenever possible, it is recommended not to locate the high-pressure hydrogen storage system on the roof.
- If it is essential to locate the high-pressure storage system on the ceiling, the following considerations are recommended:
    - It is not advisable to use joints in process lines considered as potential sources of exhaust (threaded joints, fittings, etc.), which could generate a hydrogen leak.
    - The implementation of an automated hydrogen cutting system for each existing pressure storage tank in such a way as to become independent and limit the amount of hydrogen that can potentially leak. The level of security integrity associated with this system will be determined on a case-by-case basis, according to established risk acceptability criteria.

HYDROGEN GAS DISPERSION TEST IN TUNNEL CONT.

- All atmospheric discharge points (reliefs) from existing safety valves in the installation must be conveyed to the upper part of the train at the end of the train to avoid pockets in the lower part as a result of operational vents. However, it must be ensured that the pressure at the discharge point of this relief is low pressure (around 10 bar) in order to record concentrations below the explosive limit. In addition, atmospheric discharge points must be equipped with adequate flame arresters.
- In underframe installations, it is recommended to implement an automated hydrogen cutting system associated with a hydrogen detection system, consisting of a sufficient number of detectors covering the entire gas installation under the frame. The level of security integrity associated with this system will be determined in the relevant risk analyses.
- These measures can be combined with the use of passive catalytic recombiners (PARs) to reduce hydrogen concentrations in the event of leaks.

Conclusion

The next few years are key to achieving the global goals of zero emissions and decarbonization, in this process and particularly in the railway world, alternatives to diesel fuel must be found. Among these alternatives are hydrogen and renewable gases, like any innovative development and even more so taking into account the complexity of the railway system, a period of research, knowledge and maturity is required.

There is no such thing as 100% security. The concept of a "secure system" does not imply that there are no risks, but that they are identified and controlled. The level of risk can be reduced by adopting preventive measures, aimed at reducing the frequency or probability of occurrence, or through mitigation and protection measures, reducing the severity or severity in the event of an accident.

Rail transport is undoubtedly one of the safest means of transport and should remain so. The existing regulatory framework, Safety and Interoperability Directives and their transposition into Royal Decree 929/2020, makes it possible to ensure that new hydrogen and renewable gas technologies are incorporated into railway traction systems safely and reliably. Risk assessment and control is crucial in this process and with this objective in mind, RENFE and ENAGAS have opted to acquire greater knowledge of these technologies through specific studies, both theoretical and empirical, contributing to making decarbonization in rail transport a reality.

The use of hydrogen and renewable gas technologies in the railway sector is totally viable and safe, its characteristics and particularities require the adoption of certain measures, both in its design and operation, to control its risks and we have the necessary regulatory framework to guarantee its compliance.

About the authors

SGS

SGS is the world's leading testing, inspection and certification company, recognized as the global benchmark for sustainability, quality and integrity. SGS' 98,000 employees operate a network of 2,650 offices and laboratories, working together to enable a better, safer and more interconnected world.
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ENAGAS is an international benchmark in the development, maintenance, and operation of energy infrastructures. ENAGAS pursues the objective of contributing to guaranteeing the security of energy supply and promoting innovation that accelerates the decarbonization process and thus creates value for the different stakeholders.
www.enagas.es

RENFE

RENFE's mission is to provide passenger and freight services under the principle of safety and sustainability. It carries out its activity with a clear focus on the customer, with criteria of quality, efficiency, and innovation, working on the progressive replacement of diesel with cleaner energies (Liquefied Natural Gas), or free of local pollution and greenhouse effect (Hydrogen Fuel Cell).
www.renfe.com

CNH2

The National Center for Experimentation of Hydrogen and Fuel Cell Technologies (CNH2) is a national research center, aimed at promoting scientific and technological research in hydrogen and fuel cell technologies, at the service of the entire scientific, technological and industrial community.
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