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"EDELWEISS-001" STANDARDIZED UNIT FOR TESTING HYDROGEN TRANSPORT SENSORS

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1. INTRODUCTION

The safety of hydrogen transport strongly depends on the prompt and precise detection of hydrogen leaks. Thus, the development and certification of hydrogen sensors is critical. To accomplish this, it is necessary to develop safe, accurate, and sensitive units for testing hydrogen sensors.

The aim of the work is to create a test facility to analyze sensors of every kind in a wide range of operating temperatures, and pressures at pre-blast hydrogen concentrations.

2. FIELDS OF APPLICATION

Hydrogen energy (hydrogen transport; hydrogen storage and transport systems, in particular, cryogenic vessels, cryogenic pipelines); atomic hydrogen energy, solar-hydrogen energy.

When hydrogen is produced onboard a vehicle, hydrogen is to be accumulated, as a rule, in hydride accumulators. Figure 1 shows a cryogenic tank of the hydrogen automobile.

Figure 2 depicts its structural design. It can be seen that such tank is provided by super-insulation. As a rule, for cryogenic small-sized tanks the number of shield-vacuum heat insulation (super-insulation) is very large and normally is not less than 100 layers (for big cryogenic reservoirs, the number of layers is not more than 32–40).

Figure1. A cryogenic hydrogen tank in the hydrogen car trunk (D. Orlov. Heat will save the world // Around the world, 2003, p. 67–73)

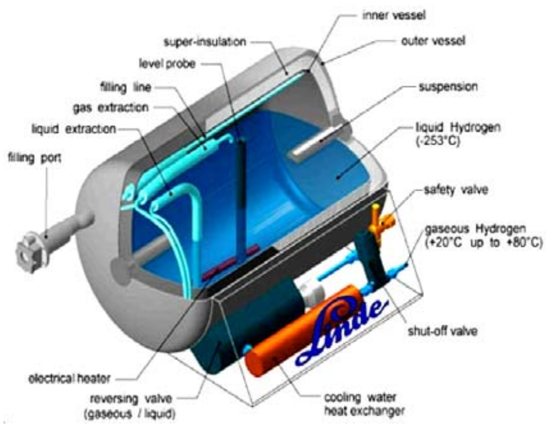

Figure 2. A cryogenic hydrogen tank (sectional view)

In case of a leak from the cryogenic reservoir into the vacuum cavity with super-insulation arising, a strong differentiation of the pressure value over the layers is observed. So a pressure ratio equal to 100 was sometimes observed between the peripheral (cold) layer (cold) and the peripheral (warm) layer. It means that it is extremely important to monitor leaks as far as close to the clod wall. At the present time, there are no detectors being capable to operate reliably in the cold super-insulation layers. Besides low temperatures, some physical and chemical effects occur in the cold super-insulation layers, which must be taken into account at the detector development. On Figure 3 is submitted fragment of the cryogenic pipeline with a hydrogen sensor and a control system located in the heat insulation cavity.

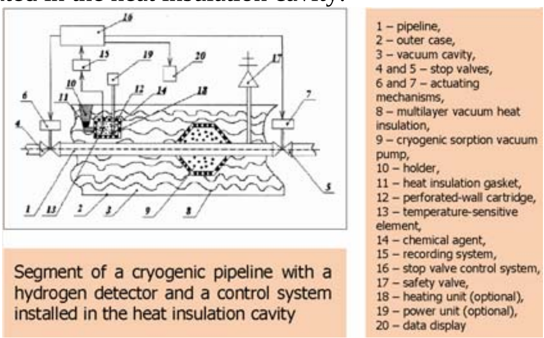

Figure 3. A fragment of the cryogenic pipeline with a hydrogen sensor and a control system located in the heat insulation cavity (A.L. Gusev et al. RF Patent No. 2113871)

3. METHODS

The facility makes possible testing of sensors in both static (pressure in the test chamber is constant) and dynamic **(**pumping and purification**)** conditions. The facility enables one to perform both qualitative and quantitative analysis on a control gaseous medium.

Sensors of every kind are tested by methods as follows: method of comparison with standard detectors in the range of T, P, c; mass-spectrometry; volumetric technique; chromatographic analysis.

3. APPROACHES

The basic principles of the development of the facility were to ensure maximum precision, capacity, safety, and automated testing.

4. CONSTRUCTION AND INNOVATIONS.

To ensure the greatest possible accuracy of testing, a system of precise supply of a standard (reference) gaseous mixture and high-pure hydrogen from hydrogen hydride accumulator (99.999%) is employed (*Figure* 4).

The gas channel of the test unit is equipped with a TI-15m helium leak detector designed to control the hermetic nature of the facility gas systems through the use of mass-spectrometry (vacuum chamber technique) [1] (*Figure* 5).

The vacuum system for pumping out the measuring chamber consists of a Pfeifer vacuum port, a series of vacuum pipelines, electrically controlled valves, and a measuring system (*Figure* 6).

The system for precise extra-pure hydrogen injection is comprised of a hydrogen hydride accumulator, digital scales-based precision system to measure the quantity of chemically combined hydrogen, and a precise gas leak detector [2-4].

The thermostatic control system is a Mini Tabai Subzero MK-71.

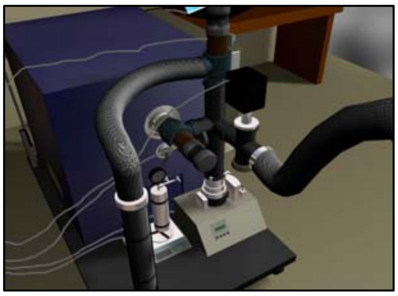

Figure 4 System of submission of especially pure hydrogen on base hydrides the accumulator

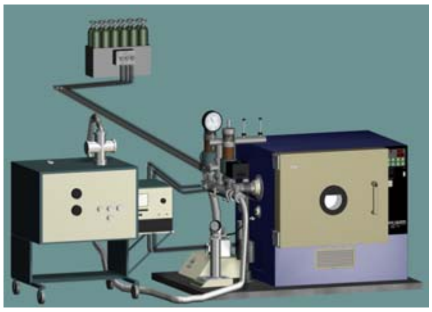

Figure 5.The general view of “Edelweiss-001” facility

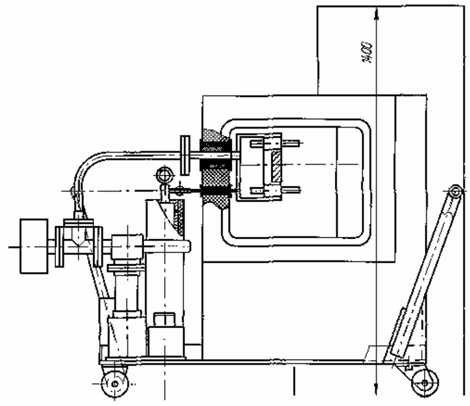

Figure 6. Diagram of the Edelweiss-001 plant

The measuring chamber includes 8 pickup sections to allow for simultaneous testing of eight sensors based on various principles of operation (*Figure* 7.).

Figure 7. Measuring chamber

The approach as such enables the comparison of sensor performance in various ranges of operating parameters.

The system is equipped with a unit for automated sample preparation via controls for concentration, gas composition, temperature, and flow (*Figure* 8).

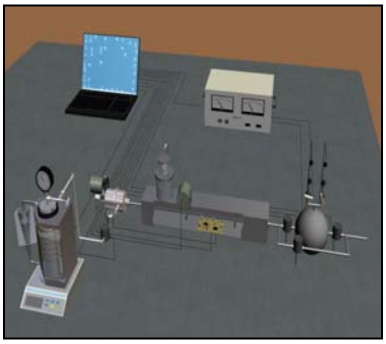

Figure8. Automatic system for generation of precision microflow of high purity hydrogen

Facility operation and control are performed through the computers utilizing the program, GeniDAQ Development Edition, which is used to create systems for data acquisition, assay, and visualization (*Figure* 9).

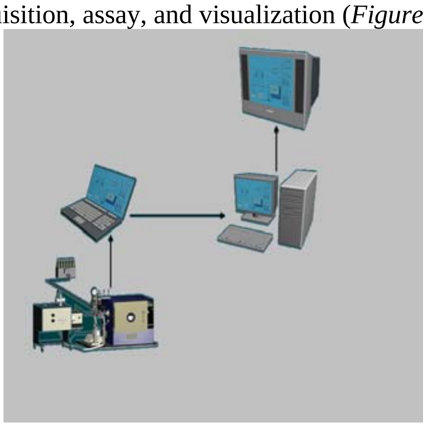

Figure 9. Control system of the stand and the control of parameters

Interfaces to connect the facility components with a personal computer are built on the basis of ADAM-4000 modules (analogue and digital input-output modules, interface transducers).

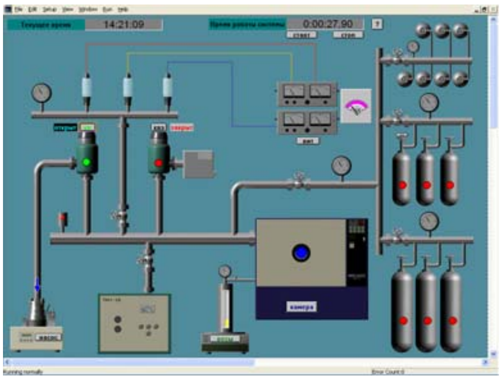

Figure10. The mnemonic circuit of the stand

5. RESULTS

The testing unit ensures testing of hydrogen sensors in the range of prior-blast concentrations (0.01 ÷ 3.5 vol.%), pressures (10^{-5} Pa ÷0,3 × 10^{5} Pa), and temperatures (183K ÷ 453 K).

Figure 11. Edelweiss-001” standardized unit for testing hydrogen sensors

CONCLUSION

When compared to the well-known analogues, the facility has a wider range of operating temperatures (to lower temperatures, in particular), concentrations, and pressures, and tests to be performed with higher accuracy, capacity, and reliability.

ACKNOWLEDGEMENTS

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[2]. spectrometric and manometric control of pressurization. OST 26-04-2569-80. Official Edition. 1986.

[3]. RU Patent No. 2051349. Apparatus for adjusting control gas flow. A.L. Gusev, I.I. Kudryavtsev. Int. Cl. G01M3/02.

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[5]. RU Patent No.1647319. Apparatus for adjusting control gas flow. A.L. Gusev, I.I. Kudryavtsev. Int. Cl.G01M3/04.