The Hydrogen Fuelling Station

ECTOS – Deliverable 4

Ecological City Transport System. Demonstration, Evaluation And Research Project Of Hydrogen Fuel Cell Bus Transportation System Of The Future.

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Delivery of the Hydrogen filling station for ECTOS (Reykjavík, Iceland)

According to the ECTOS project work packages the partner Norsk Hydro delivered the readymade modules needed to combine a full fledged hydrogen fuelling station in March 2003. The station has now been tested and formally inaugurated 24th of April 2003. The following report is a description of this milestone within ECTOS and a delivery in itself; delivery no 4.

1. Assumptions for the ECTOS hydrogen fuelling station -

According to the prerequisites of the project description, the hydrogen fuel station is tailor made to meet the settings in Reykjavík. Therefore the following assumptions apply:

- ✓ The hydrogen fuelling station is designed for designed to serve 3 fuel cell buses all of the same type
- ✓ Each bus will be filled with fuel once a day; two of them in the morning with 30 minutes interval and one in the afternoon at least 8 hours after the first two
- ✓ Fuelling time for the bus is maximum 15 min, estimated time 10 - 12 min.
- ✓ The storage pressure of gas onboard the bus is 350bar at 15°C
- ✓ Maximum pressure onboard the bus is 440bar at 85° C
- ✓ The purity of the hydrogen fuel is:

Oxygen in Hydrogen:	< 2	ppm (vol)
Moisture in Hydrogen:	< 5	ppm (vol)

2. Description Of The Hydrogen Fuelling Station

Hydrogen is generated in an electrolyser by the splitting water with an electric current into hydrogen and oxygen. The gases are generated at a pressure of 15 bar and the capacity of 60 Nm3/h H_2. The Oxygen is vented into the atmosphere. A bird's eye view of the station is provided in fig 1.

Figure 1. The components at the hydrogen station are: 1) Intake for water and electricity, 2) Electrolyser, 3) Cooling tower 4) Compressor, 5) Storage cylinders 6) Dispensing unit, 7) information panels

The process is best described within a flow chart like the simplified one in fig 2. It shows the main components and their functions.

Figure 2: Simplified process chart of hydrogen fuelling station.

To operate the electrolyser DC voltage is required. A specially designed **transformer** is therefore required to step down the incoming AC voltage to accommodate the required input voltage for the **rectifier**, which is related to the actual electrolyser capacity. Downstream of the electrolyser there is installed a gas purification equipment to remove traces of oxygen and moisture in the hydrogen gas. A de-oxidiser, which is a catalytic reactor, removes traces of oxygen. A water vapour adsorbent dryer removes traces of water in the hydrogen gas. The adsorbent has limited capacity and consequently the equipment is shifted between twin tower dryers.

A **high-pressure compressor** is included and delivered as a self contained unit including an instrument package to ensure safe and reliable operation. For the fuelling station with a storage pressure of 440 bar, an oil free diaphragm compressor is selected.

To avoid pressure fluctuations in the system a suction **buffer tank** is included between the compressor and the electrolyser.

Downstream of the compressor there is **a gas storage system**. The storage system comprises three independent storage banks, each equipped with its own pressure relief devices and pressure monitoring instruments. These three storage banks are required to provide a three stage "de-cant" sequence to ensure that the on-board vehicle storage tanks reach the optimum fill pressure within the required time. The gas storage consists of 7 vessels each containing 1,4 m^3 and it has a maximum operational storage pressure of 440 bar.

A **fuel gas dispenser** transfers high-pressure hydrogen gas from the station's storage banks onto the storage cylinders on-board the vehicle. The fuel gas dispenser is similar to a conventional fuel dispenser and is the mechanical interface between the hydrogen fuelling station storage banks and the vehicle. Safety features and metering equipment are built into the technology to ensure safe and reliable operation. Included in the safety features is a "break-away" device that isolates and ventilates the supply of hydrogen gas to the dispenser in the event that the vehicle drives away with the dispenser unit still connected to its fuel tank. The mechanical dispenser-to-vehicle connection is designed with an integral safety feature in the form of a physical, of the correct dimensional design that allows only the correct size connection to be used for the relevant pressure class of the vehicle's fuel tanks. The dispenser unit also has its own PLC unit monitoring the hydrogen gas fuel supplied to the vehicle, the pressure and the communication with the computer monitored fuelling station control system.

Maximum utilisation of the storage volume and the three-stage decanting sequence system is provided through a hydrogen **fuel distribution panel**. The purpose of this panel is to transfer safely high-pressure gaseous hydrogen from the production equipment to the storage banks and from the there to the hydrogen gas dispenser. This module controls both the routing of hydrogen gas from the hydrogen production plant to correct fuelling station storage bank and the routing of hydrogen gas from the correct storage bank to the dispenser. The gas distribution valve panel consists of manual isolation valves, non-return valves and pilot-air operated shutoff valves.

The plant is delivered complete with an integrated PLC system for safe and unattended operation. Essential **gas quality analysers** and **gas detectors** are also included.

3. Design policies for safety and control

A glance at the hydrogen fuel station now erected in Reykjavík does not reveal but a small fraction of all its design criteria (see fig 3). The overall deliverance of fuel-hydrogen follows strict safety measures. The entire process of manufacturing the fuel station is subject to security protocol. The design, fabrication, assembly and tests are all in accordance with recognised national codes for pressure-vessels and piping procedures for all mechanical equipment. Electric systems are in accordance with newest regulations, standards and codes of practice and where appropriate in accordance with all statutory requirements. This is normal procedure for all Norsk Hydro equipment as well as other recognised deliverers and in line with similar practice, for modern gasoline and natural gas fuelling stations.

The complete hydrogen fuelling station is earthed and bonded to protect against the hazards of stray electrical currents and static electricity. When located outdoors it must have lightning conductors in accordance with national regulations. Electric resistance shall account for < 10 Ohm.

The design and containers of the fuelling station ensure sufficient low and high-level natural ventilation to air. Outlets are located at the highest point of the container.
All areas that contain any potential source of hydrogen leakage are defined as a Hazardous Area (Hazard Zone 2 according to European regulations). The total area within a circle with at least two meters' radius from the potential hydrogen leak point is classified as Hazardous Area. The hydrogen fuelling station equipment, component selection, design, installation and certification is in accordance with the appropriate national and international recognised codes and regulations.

In practice the container housing the hydrogen equipment is classified as a Hazardous Area. All such rooms are provided with hydrogen in air analysers to detect and prevent hydrogen leaks. Normally an alarm is given at 20 % of LFL (Lower Flammability Limit; LFL = 4 % hydrogen in air) and at 40 % of LFL the plant is automatically shuts down. Inside hazardous area all instruments, electric motors, analysers, junction boxes etc. are designed and certified as suitable for a hazardous area. All areas defined as hazardous areas must have restricted access. Only authorised personnel is allowed to enter these areas. All usage of heat and non ex-certified tools or equipment is strictly prohibited.

The safety monitoring is based on an automatic fail-safe mode. All critical process variables are monitored by at least two independent instruments. As all process information is available in the PLC unit, the complete fuelling station is prepared for unattended operation and optional remote control. As a minimum the plant has at least one remote shut down facility.

The quality of the hydrogen and oxygen gas is continuously monitored to ensure that the plant is operating safely and providing hydrogen gas of the specified quality.

For safe processing during start-up, stand by mode and shut down mode during maintenance, the plant is provided with all necessary insulation, ventilation and purge-valves. Purging with inert gas is feasible whether for the entire equipment or specific parts of the plant. Nitrogen gas is normally

used for this purpose. The electrolyser is equipped with a total automatic system for purging before start up or when it is depressurised before shut down.

The electrolyser is of an alkaline type that uses 30% KOH in water solution as electrolyte. Therefore there is a safety shower and an eyewash available within the fuel station grounds. Also common fire fighting equipment is at hand such as a fire extinguisher and a fire emergency alarm button with automatic stop for the electrolyser.

Fig 3. The impressive external design of the first hydrogen fuel station in Reykjavík does not reveal all its splendid safety features.