Services along the hydrogen value chain

Storage:

Pressure vessels

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H_2 competence @ TÜV NORD

1. Energy generation

Wind energy

2. H_2 generation

Electrolysis

Seawater desalination plants

3. Distribution/transport

Electrical grid

Pipelines

District heating

Intelligent networks

Pipelines

Refuelling stations/ filling systems

Tankers (lorry, train, ship)

4. Storage

Battery storage

Gas tanks

Cavern storage (H_2 and CO_2)

Pressure vessels

H_2 hybrid storage

5. Consumption/use

Fuel cell systems

Methanol synthesis units

Refinery

Mobility

In every field of services, we support you in the following phases:

- Concept/planning
- Production
- Operation

Concept/planning

We support you in the concept phase with comprehensive services that will give your project the security it needs in technical and legal aspects from the very start. From product design through the assessment of requirements and technical specifications to plant development and process optimisation, our specialists have the details and the desired goal in view and are equipped and prepared for your tasks with ultra-modern IT and AI instruments as well as a broad spectrum of risk analysis, certification, test and evaluation services.

Production

With specific testing,auditing and approval services, we provide neutral and technically competent support as a notified and accredited body for manufacturers. This includes assessment and certification as a material manufacturer, obligatory for the production of certain products. Our range of services also includes the assessment of manufacturing processes, material assessments, stress tests, damage appraisal and product certifications. In addition, on top of monitoring production, we also support commissioning, assembly works and personnel instruction in production processes.

Operation

After setup and commissioning, we help you when operations are up and running to avoid shutdowns, eliminate technical sources of danger and reduce costs with the use of software-supported maintenance systems. We take on the task of carrying out all recurring inspections and specific tests of electrical and mechanical plants and systems. We can also create risk-based maintenance plans and provide you with tailor-made strategies to reduce operational risks and increase plant safety over the long term.

Hydrogen pressure vessels in mobile and stationary use

With the increase in hydrogen applications, the need for storage solutions for mobile application on land and sea has also risen, as has the demand for stationary solutions in the industrial environment, at refuelling stations or in research facilities. Pressure vessels are used for this, vessels which, according to the Operational Safety Directive, require monitoring and thus must be fitted with safety features to protect the container and the operator against potential excess temperatures or pressures.

The current solutions include pressure vessels in metal and composites that store gaseous hydrogen (CGH_2) at pressure levels from 20 to 1,000 bar and cryotanks that store cryogenic liquid hydrogen (LH_2) in vacuum-insulated containers at relatively low pressures of up to 4 bar. New concepts are assessing the high-pressure storage of cryogenic hydrogen (CcH_2). In addition, hydrogen can be stored in solid form – also currently in development are metal hydride storage facilities that can take large quantities of hydrogen at minimal volume and at optimal energy efficiency.

We are your experienced partner in the comprehensive monitoring of production and the evaluation of pressure containers, as well as in the development of prototypes for mobile and stationary applications. With competent experts and the most modern analysis and measurement methods, we supply reliable findings regarding the durability of the materials used, ensure conformity with national and international regulations and support you in benefiting from subsidies. Do get in touch.

Pressure vessels for gaseous hydrogen (CGH_2)

For the storage of gaseous hydrogen, cylindrical vessels of various sizes and materials are used. For stationary use, say, in industrial facilities, large steel tanks that store CGH_2 in the low-pressure range (20–200 bar) are deployed. Refuelling stations also have additionally sheathed vessels for higher pressure levels in the mid-range of 450–500 bar and the high-pressure range up to 1,000 bar.

The development of pressure containers to store gaseous hydrogen is constantly progressing. Reasons for this include the requirement to save weight and ensure stability, durability, environmental friendliness and recyclability in the materials used. On the market are four types of pressure vessels, where the pressure tanks of types I, II and III contain metallic components. Starting from type IV, pressure vessels made of fibre-reinforced plastics are asserting themselves as an alternative and are preferred in mobile applications because of their weight advantages. The next generation, type V, will bring yet further weight savings and be made almost completely out of carbon and hybrid fibres.

Pressure vessel types to store gaseous hydrogen (CGH_2)

Hydrogen vessel type I:
- walls in chromium molybdenum steel
- typical nominal pressure 200 bar
- use as transport container and for stationary storage

Hydrogen vessel type II:
- metallic walls and sheathing of the cylindrical component in glass or carbon fibre
- nominal pressures up to 1,000 bar
- use for stationary storage at hydrogen refuelling stations

Hydrogen vessel type III:
- liner of aluminium and complete sheathing in carbon fibre
- typical nominal pressure 350 and 700 bar
- use in fuel cell vehicles and stationary applications

Hydrogen vessel type IV:
- liner of plastic and complete sheathing in carbon fibre
- nominal pressure range 350 to 700 bar
- use in fuel cell vehicles and transport containers

Hydrogen vessel type V (various processes under development, incl.):
- carbon-fibre composites (CFC materials)
- thermoplastic fibre-reinforced composites (FRCs), carbon neutral
- additional weight saving as against type IV vessels

Pressure vessels for liquid hydrogen (LH_2)

In contrast to the high-pressure storage of gaseous hydrogen, liquid hydrogen is usually stored at low pressure, as a rule between 1.2 and 3.5 bar.

To transform hydrogen into its liquid, cryogenic phase at -253 °C, a lot of energy is required and special cooling technologies must be used. The advantage is the increase in the volumetric energy density and thus the option to transport and store larger quantities of hydrogen in less space. The volume of current cryotanks for stationary storage of LH_2 runs from approx. 3,000 to 80,000 litres (thus 2,500 to over 65,000 cubic metres of gas at a pressure of 1 bar).

Cryotanks have an inner and an outer tank made of stainless steel, between which is a high vacuum and multiple layers of insulation. Despite the best possible thermal insulation measures, boil-off losses occur which, depending on the size and fill level of the tank, can amount to 1 to 2 % per day. These arise because of the unavoidable ingress of heat into the interior of the tank, making the operational pressure there of, as a rule, between 1.2 and 3.5 bar, rise to a defined limit. Over a pressure level of around 4 bar, pressure sensors trigger a discharge of gaseous hydrogen, with large-scale stationary tanks able to maintain their cooling for 4 to 5 months without boil-off. To make use of the escaping hydrogen, several cryotanks can be integrated in a surrounding pressure container.

Because of its high energy density, LH_2 is suitable for refuelling vehicles that need to travel long distances. For the use of LH_2 in lorries and trains, stainless-steel tank systems are being developed, working with operational pressures below 10 bar and further reducing boil-off losses. In comparison to high-pressure vessels, they have marked weight advantages thanks to their lower storage pressure.

Pressure vessels for the transcritical storage of liquid hydrogen (CcH_2)

Concepts are being investigated for the compressed storage of cryogenic hydrogen. At very low temperatures of around -220 °C and with very high pressure, up to 1,000 bar, the volumetric density of hydrogen increases once again. The technical requirements of these pressure vessels are correspondingly high, as they must both be able to regulate the temperature like a cryotank and possess the stability of a high-pressure container.

Gaseous hydrogen in metal hydride storage

Metal hydride storage allows the storage of gaseous hydrogen in minimal space. To this end, metals are used that exothermically bind hydrogen at a chemical level and release it again when heated.

In contrast to storage in high-pressure or cryotanks with the accompanying expenditure on sealing, liquefaction and operational safety, storage in metal hydrides allows an opportunity to use much lower pressure levels while retaining high volumetric energy density.

In research projects like the EU-supported HyCARE Project, prototypes are generated to show the potential of metal hydride storage. Here, the same pressure-resistant shell is used as that for low-pressure gas tanks. To take up 50 kilograms of hydrogen, a tank volume of just 1 to 2 cubic metres is required.

Our services

From designing pressure vessels, tanks and test modules to approving hydrogen vehicles and executing all recurring inspections – with our comprehensive services in the field of testing, inspection and certification, we will support you in the following phases of your project:

	Concept / planning	Production	Operation
Inspection of calculated functionality demonstrations of valves and pumps	■		
Design testing of H_2 tanks (pressure vessels)	■		
Design testing of HyCARE test module (pressure vessels)	■		
Production monitoring at manufacturers and during construction; execution of recurring inspections; testing/pre-testing of manufacturer documents; quality assessment of manufacturers for the production of H_2 components		■	
DGR approval of rupture discs and valves to EU ordinance 406/2010; type approval of H_2 vehicles to directive 2007/46/EC and ordinance 79/2009		■	
Recurring inspections of H_2 containers			■
Recurring non-destructive testing of H_2 storage vessels (Westfalen Gas, Linde) by acoustic and ultrasound testing as a replacement for strength testing with a regard to hydrogen-induced corrosion			■
Initial and recurring tests of pressure tanks			■
Initial and recurring tests of pressure vessels and steam boilers			■
Damage assessments/damage mechanisms			■

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