High pressure valves for the market of the future “Hydrogen technologies”

Cost-efficient solutions will be in high demand for the market of the future “Hydrogen applications” in particular for the automotive field, be it for the corresponding test laboratories, testing equipment of fuel cells and equipment components. This article indicates possible fields of applications and shows examples for valves in the hydrogen field.

beside electric drives the fuel cell is regarded as a suitable alternative for providing power for commercially used automobiles and commercial vehicles as well as private automobiles. This applies in particular to the Asian market. For example, Toyota this year announced a series vehicle for 2015 which will be available in Japan and later on in the USA and Europe for the equivalent of EUR 50,000.

In Germany, the number of vehicles is initially to be limited to 100 units as the appropriate infrastructure for refueling units needs to be assured. Hyundai and its SUV ix35 as well as Honda, are expected to follow [Source: Heise]. In Japan alone, the infrastructure for hydrogen refueling will be extended by another 80 stations over the next two years, adding to the already existing 20 stations. Circa 35 additional stations are planned in Germany.

In order to achieve a high energy density and thus a high storage volume to increase the range of the vehicles, high operating pressures need to be switched and controlled. The requirements for safety and reliability are proportionately high.

The present usual filling pressure of up to 35 MPa for many of the currently operated vehicles also needs to be covered in future. A filling pressure of up to 70 MPa must also be taken into account as this is the standard demanded by the dispenser manufacturers. Often both filling pressures are combined by the manufacturers in one dispenser.

As these pressure stages have different requirements in terms of valve technology, it is a reasonable proposition to also use different valves. Of course, valves of up to 70 MPa can also handle lower pressures up to “only” 35 MPa. However, the qualification of these valves is different and equipment costs can be reduced when selecting the appropriate pressure stage.

The filling pressure – the relevant pressure for designing the valves and components – gives the design pressure of the equipment which needs to be taken into account by the manufacturer of the equipment. The usual pressure stages for equipment are 20 MPa, 40 MPa and 82 MPa. The basis for calculating the safety of the valves is the design pressure stage, not the filling pressure stage.

The components required for the various hydrogen applications range from low pressure valves to high pressure solenoid valves for a pressure range up to 90 MPa. A pressure range up to 120 MPa is possible here when using a pressure-controlled design. GSR Ventiltechnik can offer these valve solutions as individual valves with the required connection variants such as BSP, NPT, SAE or Autoclave.

Also available are valves in cartridge design as demanded by the market, as well as precisely adapted customized solutions. Demanding valve block combinations consisting of several system components are also part of the product portfolio. These combine a variety of functions. The internal connections prevent the numerous possible sources of leakage. The arrangement of the assembly components and connection points is performed according to customer specifications.

In addition to the solenoid valves, further functional units such as safety valves, measured value transmitter, filters, pressure gauges, manual valves, etc., can be inte-
grated. Therefore, the compactness of a valve block offers considerable advantages compared to pipe versions.

The functional safety of the corresponding component has absolute priority in hydrogen applications. Possible pressure losses or the generation of an explosive atmosphere in closed spaces must be avoided. Special attention is paid to these sensitive requirements when designing the valves. Several years of development work shaped the design and machining of the seat gaskets and pistons for the hydrogen valves which are subjected to considerable loads and switching frequencies. These requirements can be complied with by conducting stability simulations to find the suitable materials and to optimize the design. Furthermore, numerous tests were conducted for the seal gasket with a variety of materials and geometries.

A further important design factor for the required high pressure valves (>40 MPa) is the selection of suitable materials to meet the special temperature requirements -40°C. Material embrittlement due to hydrogen must be taken into account and avoided as far as possible. For example, in Japan, the selection of suitable stainless steels with a high nickel equivalence is stipulated as these achieved the highest service life under constant use.

Many years of experience in the development of valves for natural gas refueling forms the basis for GSR engineers to apply their knowledge to the design of components for the demanding hydrogen field. The results are the direct pressure-controlled series 8/100 valves, as well as the servo-controlled solenoid valve of the 3/122 series. These two valve types use the same fittings as the corresponding CNG valves. Both valve types can switch the usual equipment design pressure stage on the market of 40 MPa and a filling pressure of 35 MPa.

The next higher equipment design pressure stage for refueling equipment at 82 MPa with a filling pressure of 70 MPa is also covered by the 8/100 series and the solenoid valve Type 3/071. For applications in test laboratories, test equipment for fuel cells and power-to-gas plants, the product portfolio also includes a special solenoid valve for low volume flows and a pressure range up to 90 MPa.

The advantages of pneumatic poppet valves and solenoid valves are obvious:

- The compact design allows space-saving equipment construction of the installed valves.
- Poppet valves include a fail-safe function as a matter of principle, i.e. through spring-loading, they switch the power supply or control air to default in case of failure. The default setting can either be NC (Normally Closed) or NO (Normally Open) and thus serves the safety requirements of the equipment operators without expensive and complex options.
- GSR valves do not have laterally stressed (or torsion-stressed) dynamic sealing elements. This lends the valves a considerably higher service life.
- The design of poppet valves allows a simple replacement of wear parts such as pistons and seal gaskets, without requiring disassembly of the entire valve. This increases service-friendliness and reduces maintenance costs.
- Solenoid valves merely require a power supply to control the valve. Control air, as required for pneumatic drives, is not necessary with and ensures smart equipment integration. The integration of compressors to generate compressed air and the provision of compressed air via pipes and switching elements is unnecessary.

**THE DISPENSER STANDARD**

The pressure controlled valves type 8/100 [Figure 1] with a nominal seat width of 4 mm, 8 mm or 15 mm are used for the common filling pressures in hydrogen refueling equipment.

![Figure 1: Valve type 8/100 to 40 MPa and 70 MPa filling pressure](image1)

![Figure 2: Valve type 3/122 to 45 MPa filling pressure](image2)
The simple and robust design allows their use under difficult operating conditions. For example, the mounting position is optional. Moving parts subject to wear are reduced and can be replaced simply.

The directly controlled drive also enables switching of the valve without requiring differential pressure. In addition, this valve type offers the option of bidirectional flow, similar to a ball valve. Thus, a single valve can be used as cutoff valve for filling and emptying storage tanks.

This servo-controlled valve (Figure 2) combines the above mentioned advantages of a solenoid valve with specialization for the hydrogen field.

Designed specifically for hydrogen applications, the valve type 3/071 is constructed for use at temperatures to -40°C, high flow rates and high pressures.

THE EXPERTS FOR HIGH PRESSURE RANGES

The valve type 8/100 with a filling pressure up to 120 MPa (Figure 3) is the specialist for high pressure ranges and corresponds to the valve type of the standard dispenser range up to 70 MPa. However, a larger actuator is used to achieve the higher pressure range of 120 MPa. This valve design is intended specifically for use in storage tanks or in testing and inspection equipment as stop valve. Thus, all conventional equipment in the hydrogen field can be served in its entirety.

This valve variant was designed specifically for testing and powertogas equipment. The valve can be supplied with a small nominal seat width, i.e. 0.5 mm, and is therefore exceptionally well suited for high pressures and frequent switching at relatively low volume flows. Its use at temperatures up to -40°C is guaranteed.

The valves for the pressure range >45 MPa are fitted as standard with 9/16-18 UNF Autoclave connections for high pressure hydrogen applications. The corresponding solenoids are also available as standard in ATEX design, or with FM approval for the North American market.

THE COMPANY

Since 1971 GSR Ventiltechnik GmbH & Co. KG has been developing, manufacturing and distributing valves and fittings for nearly all applications. The strength is the production of special valves according to customer’s request. Together with its customers the company develops system solutions and engineers them.

GSR’s core competency is the fast development of special valve solutions meeting customer’s requirements in all fields of valve technology. Over 35 years, the company’s engineers have developed more than 3000 special valves which can reliably be fitted in nearly all technologies under different conditions. Due to the fact that all the core components are produced on modern machines, it is possible to fabricate custom-made items. However GSR is also in a position to manufacture its regular series of valves to the highest quality, at short notice. All business is performed in accordance with DIN EN ISO 9001 which is continuously controlled and improved by the company’s quality management.