Valve solutions for hydrogen applications

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Hydrogen is considered to be a versatile energy carrier of the future that does not emit direct greenhouse gases in use. At the same time, the medium hydrogen places high demands on valves. Hydrogen is the lightest element in the periodic table, has a high gravimetric energy density and can lead to material embrittlement under certain conditions. Key aspects to be considered when selecting valves for use in hydrogen are outlined in the following.

Hydrogen is not only a well-known element in the periodic table; it is also a well-established medium in industrial applications. As we move towards a decarbonised economy, potentially green, climate-neutral technologies are becoming also economically more and more attractive. Great hopes rest on green hydrogen as a versatile energy carrier that neither during production nor in use emits greenhouse gases that are harmful to the climate. Hydrogen thus has the potential to make inroads into applications that have so far been dominated by fossil fuels and that will remain comparatively challenging to electrify in the future.

To achieve set climate targets, it is not just the future demand in new applications but also the present demand in the chemical sector, refineries and other industrial plants that must be met with climate-neutral hydrogen.

For this purpose, a correspondingly large and climate-neutral hydrogen value chain will be essential, from production through storage and transport to utilisation. Conventional "grey" techno-

Fig. 1: Overview of selected valves for the hydrogen value chain (from left to right): the FABA-Plus globe valve, the STEVI Smart control valve with ARI PREMIO-Plus 2G electric actuator, the SAFE safety valve and the ZETRIX triple offset process valve.

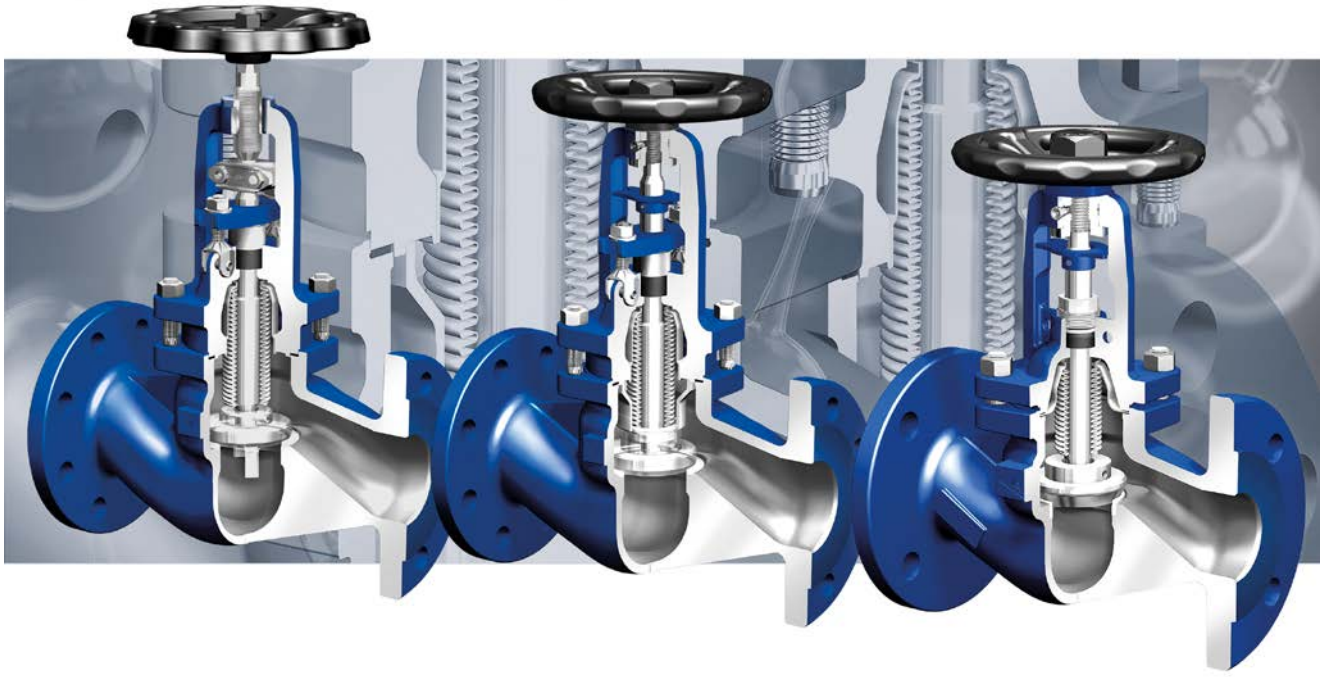

Fig. 2: Selection of stop valves with a bellows seal: the FABA-Supra C with two-piece stem and medium-flushed bellows (left), the FABA-Supra I with bellows cover (centre) and the FABA-Plus (right).

logies, on the other hand, can significantly reduce their climate-damaging emissions by capturing CO_2 and remain relevant for the market ramp-up of a hydrogen economy.

Valve manufacturers such as ARI-Armaturen with a broad portfolio of valves for control, isolation, safety and steam trapping can supply valve solutions for the entire hydrogen value chain. This applies both to hydrogen directly and to other media such as coolants, demineralised water, saturated steam, oxygen, heat transfer oils, to name but a few.

For equipment manufacturers, EPCs and operators, it is important that valves, piping and plant components are resistant to hydrogen and at the same time meet a range of other standard requirements (PED, ATEX, ISO 15848 / TA Luft, etc.). These directives and standards can serve customers as a starting point for specifications. Various institutions and industry associations are currently working on a standard specifically for hydrogen. Some manufacturers choose the term "H2-ready" to advertise valves that are suitable for use in hydrogen and issue manufacturer's declarations accordingly. ARI-Armaturen, too, has many years of experience with hydrogen applications and is happy to advise on valve selection and sizing (**Fig. 1**).

VALVE SELECTION FOR USE IN HYDROGEN

What factors should be taken into account when selecting valves for use in hydrogen?

As the lightest of all elements, hydrogen is highly diffusive: hydrogen atoms can diffuse through the crystal lattice of steel and be a cause of material embrittlement there. High-strength carbon steels have been shown to be particularly susceptible to this and are therefore not recommended. Austenitic stainless steels like those used by ARI-Armaturen, on the other hand, have proven to be suitable materials. Examples: 1.4408 (CF8M) and 1.4581 (CF10M) as cast materials or 1.4404 (316L) and 1.4571 (316Ti) for the internals. Nevertheless, especially at high temperatures, material selection needs to be tailored to the specific operating and design conditions.

Since hydrogen is highly volatile, very strict requirements apply to internal — and even more so to external — leak-tightness. The internal leak-tightness of metal-seated globe valves is achieved due to the "cut effect" (line contact sealing of the conical plug on the seat ring), which ensures that the valve closes tightly even when only little force is applied due to the very high contact pressure.

ARI-Armaturen confirms internal leak-tightness by testing according to EN 12266, leakage rate A. Testing to other standards such as API 598 is possible at the customer's request. In addition to air / nitrogen, these tests can also be carried out using helium or — in consultation with the customer — forming gas as the test fluid. External leak-tightness is ensured by seals that have been tried and tested over many years and are certified in accordance with ISO 15848, respectively TA Luft. Particularly for stem seal systems, ARI-Armaturen for many years offers a comprehensive portfolio of bellows seal technologies, due to serving a broad range of industries. The double-wall bellows used are designed for up to 100,000 double cycles, depending on the series.

Customized maintenance-free bellows solutions are, for example, equipped with reinforced bellows welded to the upper part of the body or with a bellows cover for increased resistance to water hammer (**Fig. 2**).

Fig. 3: ZETRIX triple offset process valve, shown here in double flanged, butt-weld end and lug type versions (from left to right).

ARI-Armaturen additionally offers a TA Luft packing with spring-loaded gland seal for various globe and quarter turn valves to ensure optimal external leak-tightness.
When looking at the valve as a whole, it is important not to forget the bonnet seal. State-of-the-art graphite seals are used in standard and seals specially certified for hydrogen are optionally employed in consultation with customers.
For the connection to the pipe and hence also for minimising emissions, ARI-Armaturen has a variety of solutions available, for instance the standard B1 flanges acc. to EN 1092 or optionally as a tongue-and-groove, Ring Type Joint, etc. as well as many valves with butt-weld ends. Double flanged, butt-weld ends and lug type connections are shown in Fig. 3, taking the ZETRIX triple offset process valve as an example.

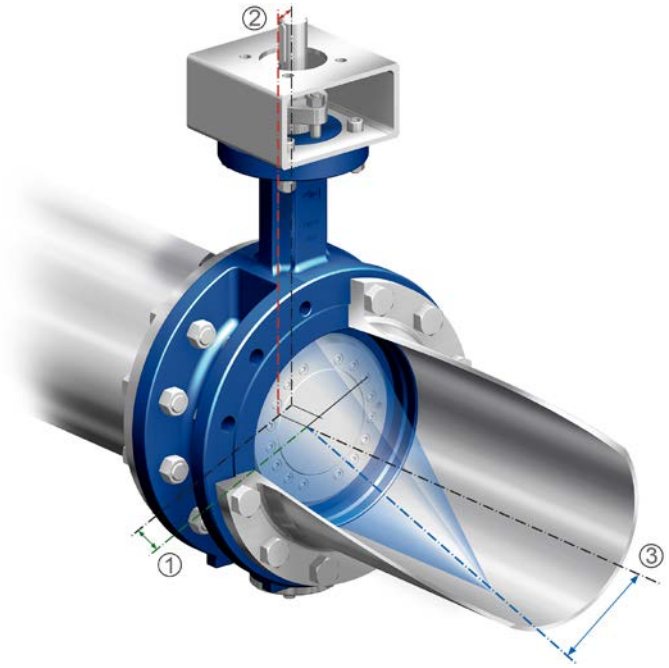

Fig. 4: Overview of the ZETRIX's three offsets.

TRIPLE OFFSET FOR DEMANDING APPLICATIONS

What is meant by "offset" and what are the advantages of a triple offset design? The rotating shaft of the disc is offset both from the centre line of the disc seat and body seal (first offset) and from the pipe's centre line (second offset). With triple offset valves, the seat's axis of rotation is also asymmetrically disposed to the pipe axis (third offset). This third offset and, in the case of ZETRIX, the geometry optimised courtesy of ARI-Armaturen's special software, results in maximum closing force with minimum expenditure of energy (Fig. 4). Furthermore, by executing a frictionless swivel movement into the seat, the sealing ring enables a significantly longer zero-leakage service life.
In other words, double offset valves cater for the basic segment, i.e. applications where the use of centred, soft-sealed butterfly valves is limited. Triple offset valves such as ZETRIX are ideal whenever a frictionless closing process, long service life and uninterrupted production processes are a must.

HYDROGEN APPLICATIONS

To meet the future demand for hydrogen, much more of it must be produced in a climate-neutral way. As a potentially

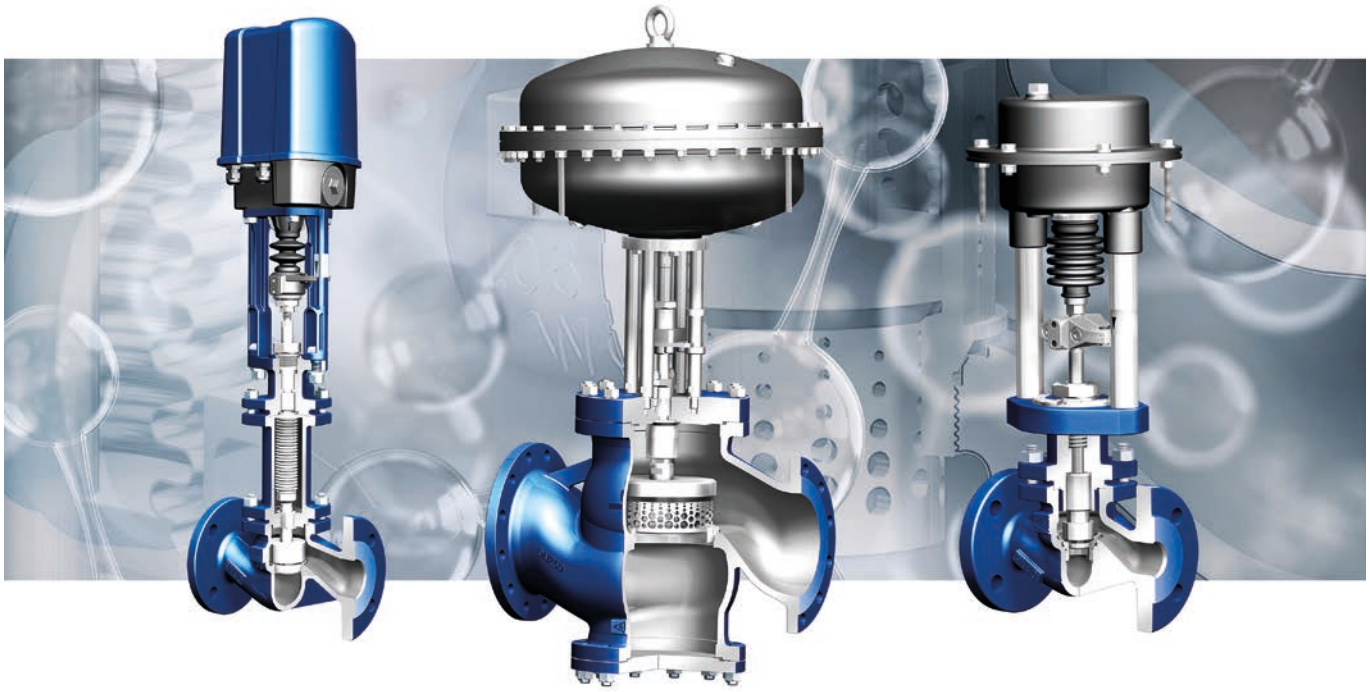

Fig. 5: The STEVI Smart control valve with ARI PREMIO-Plus 2G electric actuator and bellows stem seal (left), the pneumatically actuated STEVI Pro with perforated plug (centre) and the STEVI Vario, also pneumatically actuated (right).

green technology, considerable attention is therefore being paid to water electrolysis plants. Using electrical energy, water is divided into its two components: hydrogen and oxygen. For one can speak of "green" hydrogen, the electricity must come from renewable sources. Valve requirements in those plants are as varied as the media used — mainly process water on the reactant side and hydrogen and oxygen on the product side. The system is cooled via an additional cooling circuit. In addition to isolation valves such as bellows, stop or butterfly valves described above, which are used in all media, check valves are also required along with safety valves for overpressure protection and control valves for regulation.

Control valves with a stainless steel bellows stem seal are suitable for regulating applications where hydrogen is the medium. Valves for use in oxygen must be specially cleaned from grease and oil, then fitted with BAM-certified seals and tested. For cooling and process water, EPDM seal is generally used as stem seal . Either electric or pneumatic actuators are used depending on the available operating energy, any necessary safety functions and numerous other criteria (**Fig. 5**).

SUMMARY

ARI-Armaturen offers a large part of the required valves for water electrolysis plants — all from a single source and "Made in Germany". As a leading international developer, manufacturer and distributor of quality valves, ARI-Armaturen advises and supports users with customised solutions and many years of experience in a wide range of applications along the entire hydrogen value chain.

Meet us at:
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