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Valve, Regulator, and Actuator Selection for Blue Hydrogen Applications

Successful blue hydrogen production depends on properly specified valves and related control equipment for reliable operations.

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EMERSON

1.0 What is blue hydrogen?

Hydrogen has fuelled all manner of cutting-edge endeavours, from the early balloonists to the Gemini and Apollo space programs. Decades later, a confluence of environmental challenges is enabling hydrogen to play a significant role in the world's energy strategy by decarbonizing energy sources to address the pressing challenges of global warming. The demand for hydrogen has been rising exponentially, but elemental hydrogen barely exists in the earth's atmosphere, making up about 0.00005% of the atmospheric air volume. This leaves industrial processes as the primary source for global hydrogen supplies. There are many ways to produce hydrogen, but the environmental impact of those options varies widely. Hydrogen industrial processes are often designated by colour, providing an indication of their environmental ramifications (Figure 1).

1.1 Green hydrogen

Green hydrogen utilizes non-carbon sources of electricity, such as wind and solar, to power electrolysis cells, which separate water into hydrogen and oxygen. Green hydrogen processes generate no additional greenhouse gases and are the most preferable source of hydrogen, but green hydrogen is also the most expensive type to produce.

Source	Feed Stock/ Electricity Source	Technology	CO_2 Emission	Color of Hydrogen
Fossil Fuels	Black Coal	Gasification	High	Black
Fossil Fuels	Brown Coal	Gasification	High	Brown
Fossil Fuels	Natural Gas	Reformer	High	Grey
Fossil Fuels	Natural Gas/ Coal	Reformer/ Gasification + CCS	Low	Blue
Water	Wind, Solar, Hydro, Geothermal	Electrolysis	Minimal	Green

Figure 1: Hydrogen can be produced using various methods. The colour assigned to each process indicates the greenhouse gas impact of each alternative, listed from worst to best.

1.2 Black and brown hydrogen

On the opposite end of the environmental spectrum are black and brown hydrogen, which use coal gasification to generate hydrogen. These are the least desirable hydrogen production methods since they generate large amounts of carbon dioxide (CO_2) and other greenhouse gases.

1.3 Grey hydrogen

Currently, the most common and least expensive method of hydrogen production is grey hydrogen, which combines methane (CH_4) with steam (H_2O) at high temperatures to create hydrogen, CO_2, and carbon monoxide (CO). This method usually involves a steam methane reforming process (SMR), and it is used in refineries and ammonia plants across the world to create abundant quantities of hydrogen.

The technology is well understood and mature, and the processes are proven to be reliable in use Unfortunately, the undesired greenhouse gases (CO_2 and CO) are typically vented to the atmosphere, along with additional CO_2 and CO created by the combustion of fuel gas, to power this highly endothermic reaction.

SMR and grey hydrogen production are an environmental improvement over black and brown hydrogen, but these processes generate far too much CO_2 and CO to meet global greenhouse gas targets.

1.4 Blue hydrogen

A more recently introduced method of production is blue hydrogen. This method utilizes the same or similar processes as grey hydrogen production, but it captures and stores most, if not all, of the resulting greenhouse gas emissions. While the method may not be as environmentally beneficial as green hydrogen, it can use existing SMR equipment and technologies to produce very high volumes of hydrogen with significantly reduced greenhouse gas emissions.

Existing SMR plants converted to produce blue instead of grey hydrogen must include the added cost of adding carbon capture. This added cost results in a price increase when upgrading from grey to blue hydrogen production, but it might shrink if government regulations begin taxing CO_2 and CO emissions directly, raising the cost of unmitigated grey hydrogen production. The difference might also shrink due to a new steam reforming technique called autothermal reforming (ATR). Both SMR and ATR are discussed in detail in the next section.

2.0 Methane reforming hydrogen processes

All methane reforming processes decompose methane (CH_4) into hydrogen using one of two main techniques: steam methane reforming (SMR) or autothermal reforming (ATR). There are differences and similarities between the two processes, and each has its pros and cons. Both are described here.

2.1 Blue hydrogen production using SMR

SMR is an older, more well understood, and much more pervasive technology than ATR, and it is used worldwide in refineries and ammonia plants. A process diagram of SMR is shown in Figure 2.

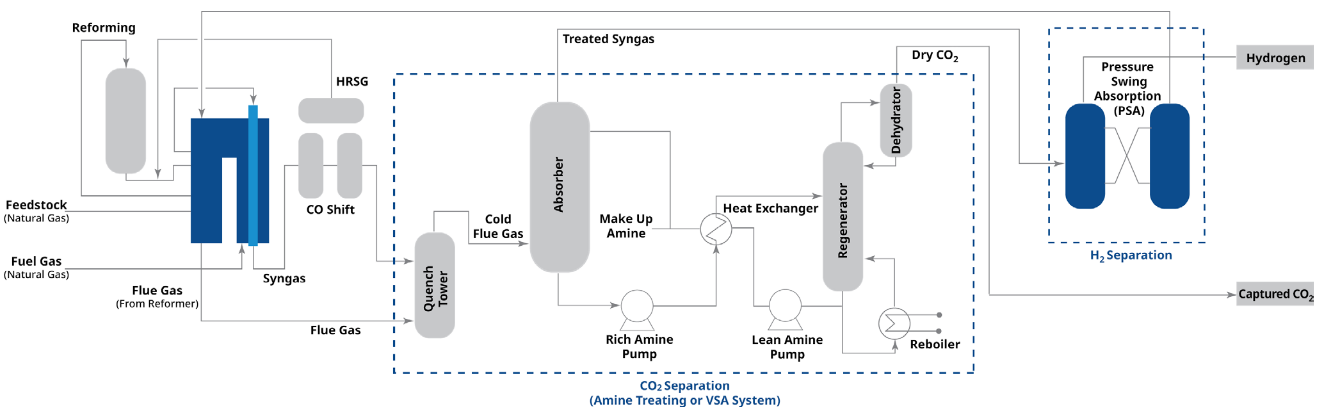

Figure 2: SMR combines methane and steam at very high temperatures to create hydrogen, CO_2, and CO. Shift converters change CO to CO_2, which is removed in the amine section. Hydrogen purity is controlled in the pressure swing adsorber unit downstream.

Natural gas is desulfurized and preheated, then mixed with high-pressure steam and heated further in the presence of a catalyst inside a fuel gas-fired reformer. The heat and catalyst decompose the methane (CH_4) and steam (H_2O) to create a synthesis gas (syngas) composed of hydrogen, CO_2, and CO. Shift converters react any remaining CO and water (H_2O) into CO_2 and hydrogen.

The purified syngas mixture then enters the amine absorber, where circulated amine liquid absorbs the CO_2. The hydrogen leaves the top of the absorber to be further purified in a pressure swing adsorber (PSA), while the CO_2-laden amine is heated and depressurized in the amine regenerator to separate the CO_2 from the liquid. The CO_2 is then released and vented, and the lean amine is cooled and returned to the amine absorber to process more syngas.

Grey hydrogen SMR production units do not capture CO_2, as shown in Figure 2, but instead simply vent the flue gas and amine CO_2 production to atmosphere. A blue hydrogen unit adds CO_2 recovery equipment to capture and ultimately store the CO_2 produced by the SMR. These extra process steps add capital and operating costs, but they allow an existing SMR unit to operate with a far reduced carbon footprint.

The chief advantages of SMR over ATR units are their well-understood operations and abundant presence worldwide. The additional cost of adding a CO_2 capture unit to an SMR is relatively small when compared to building a new plant. The disadvantage of an SMR is that complete carbon capture is rather difficult. The relatively concentrated and clean CO_2 leaving the amine unit is easy to capture, but the less concentrated and impure CO_2 associated with the flue gas is not so easily scrubbed and recovered.

Conversion of SMR systems to blue hydrogen production is relatively straightforward. The CO_2 from the amine unit is further scrubbed, pressurized, and liquified to transfer it to a carbon storage facility. If flue gas is ducted to the amine unit as shown in Figure 2, it may require further processing steps to clean the gas. Most SMR plants converted to produce blue hydrogen tend to focus on the CO_2 generated in the amine section, while venting the flue gas since it is so much more difficult and expensive to recover.

2.2 Blue hydrogen production using ATR

ATR is a newer process gaining traction in the blue hydrogen design arena. It utilizes many of the same steps as SMR, but it is more fuel efficient and creates a single concentrated CO_2 stream, rather than two as with SMR. Figure 3 shows a process diagram of ATR.

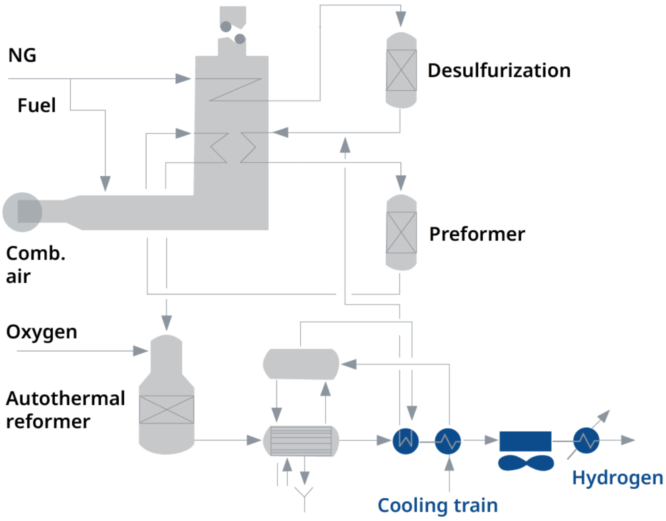

Figure 3: ATR combines methane and steam, and it then adds pure oxygen to create syngas at very high temperatures. The resulting syngas feeds amine and hydrogen purity sections, similar to the SMR process

Natural gas is desulfurized and preheated, and then mixed with high-pressure steam and heated further in the presence of a catalyst. This gas is then burned with pure oxygen to create a very high-temperature syngas. The difference between ATR and SMR is that the initial ATR steps require very little fuel, if any, with the bulk of the energy coming from the oxygen injection step. This reduces energy requirements and generates a single, pure, and concentrated CO_2 stream that is easily captured.

Downstream of the autothermal reformer, as shown in Figure 3, the SMR and ATR processes are essentially the same. The shift converters react any remaining CO and water into CO_2 and hydrogen, and the amine section absorbs the CO_2 from gas stream before the hydrogen is purified in the PSA.

The chief advantage of ATR units is they are more efficient than SMR for blue hydrogen production, and they make it possible to capture much more of the greenhouse gases than SMR. The disadvantage of ATR is the requirement of an oxygen source or an air separation unit. Also, far fewer ATR plant designs exist, so the technology is less mature and only now being brought into production. However, ATR is a promising and likely-preferred technology for future designs intended to produce blue hydrogen as it has been specifically designed for this service. There are several ATR plants in various stages of design and early construction across the globe.

3 Valves, regulators, and relief valves in blue hydrogen production

Whether using SMR or ATR technology, the blue hydrogen process poses a number of challenges for the automated valves, regulators, and safety valves that help control and protect the process. This section identifies those difficult process applications, and it offers a range of solutions to address those needs.

3.1 Hydrogen/synthesis gas isolation valves, regulators, and safety valves

The presence of hydrogen in the hot syngas stream around the reformers, and in the final product, creates significant challenges for control equipment. Hydrogen embrittlement can degrade the mechanical integrity and performance of the valves, and this can result in increased emissions and inefficiencies. High pressures and temperatures are also common, and the various gas components require a range of materials of construction to suit each application.

Properly selected manual or automated block valves must include the correct materials of construction, carry an API 607 certified firesafe rating, and may require SIL 3 certification for shutdown applications (Figure 4).

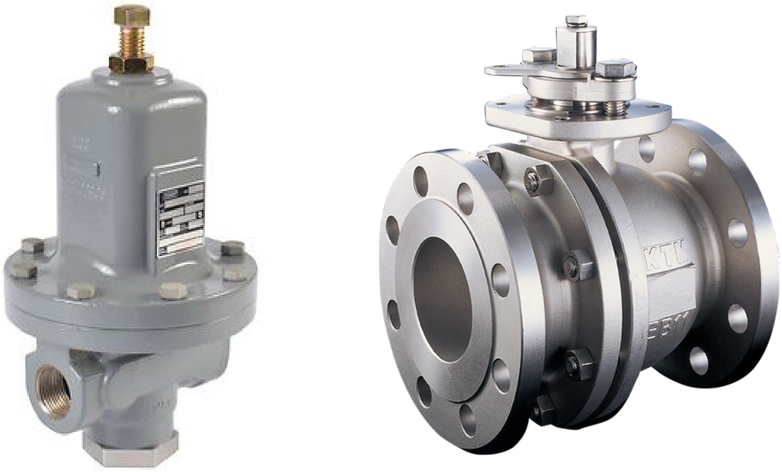

Figure 4: In hydrogen and syngas service, the proper materials of construction are critical. This Fisher™ Type MR95™ regulator (left) is available with a wide variety of internal materials. The KTM™ series (right) offers many body styles and a broad range of materials of construction, packing types, and certifications.

In this application, a good solution is the KTM ball valve with durable E-Seats for low temperature applications, and with Metaltite™ materials for high temperature applications. KTM valves have the required API and EN and SIL certifications, offer live-loaded low-emission packing, which is also fire safe certified, and have a proven track record in high-pressure and hydrogen service.

Depending on specific conditions and pipe sizes, a double eccentric C-ball valve or a triple offset metal-to-metal seated butterfly valve may also serve as isolation valve alternatives. Both valves are suitable for a wide range of temperatures, pressures, and fluid conditions, and both are inherently fire-resistant. These valves are discussed in more detail in section 3.3 below.

The wide range of material requirements can be a problem for regulator selection due to the limited range of options. Fortunately, some models, like the Fisher MR-95 regulator, can be specified in stainless steel, Monel, Hastelloy, and nickel-aluminium bronze to provide control across a wide range of pressures from 5 to 150 PSI.

High-capacity safety valves are often required for these processes, and these safety valves must seal tightly to avoid losing product. Additionally, the safety valves may operate close to their pressure setpoints, making a tight seal even more difficult to achieve and maintain. Enhanced seal tightness pilot operated safety valves, like the Anderson Greenwood™ 400/800 series, work well in these applications. These pilot-operated safety valves have very high capacity, and newer models allow a valve to operate within 2% of its setpoint with minimal leakage.

Properly selected manual or automated block valves must include the correct materials of construction, and carry an API 607 certified firesafe rating.

3.2 CO_2 Removal Unit Control Valves Selection

Whether SMR or ATR is used, the general processing steps are relatively similar between the two plant designs once the syngas has been produced. The key control valves associated with the carbon capture portion of the process are shown in Figure 5 below. Specific challenges and key performance parameters will be discussed for each valve type.

Properly selected manual or automated block valves must include the correct materials of construction, carry an API 607 certified firesafe rating, and may require SIL 3 certification for shutdown applications (Figure 4).

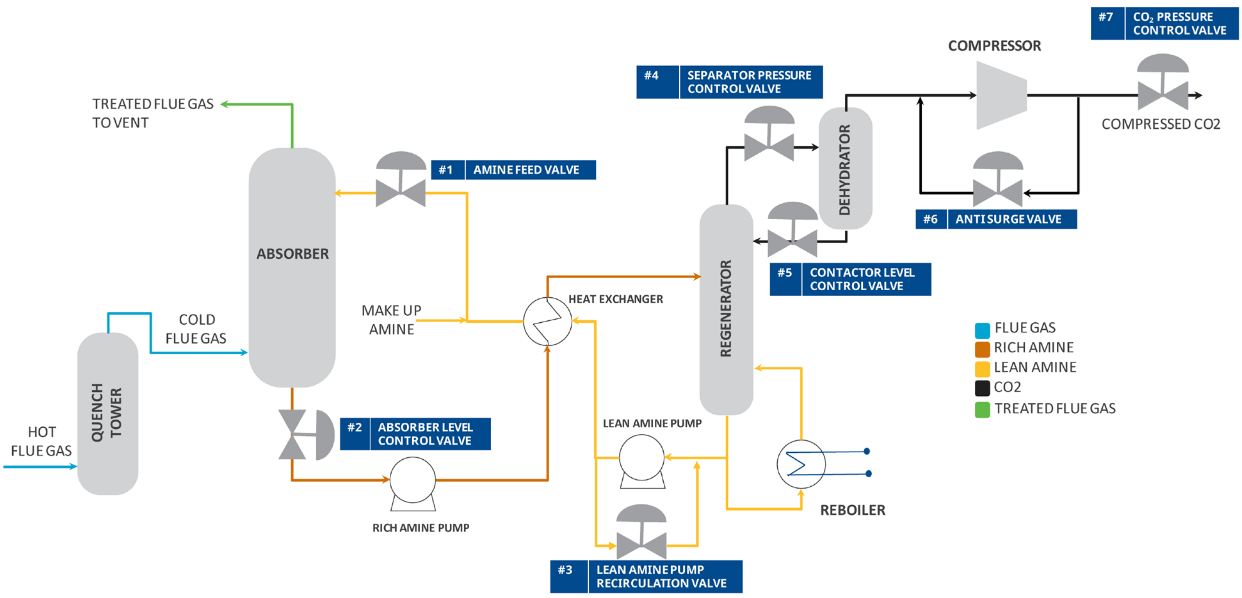

Figure 5: This diagram shows the critical control valves associated with the carbon capture portion of the process. Each valve location faces different process conditions and has its own set of difficulties.

3.2.1 Amine feed valve (#1)

To efficiently scrub CO_2 from the syngas, the lean amine feed valve must provide a consistent flow of amine to the top of the absorber, despite a high pressure drop and cavitating conditions. The best valve for this application will be a single-seated 316SS valve with hardened Alloy 6, anti-cavitation trim, and Enhanced ENVIRO-SEAL™ packing. A good choice for this application would be a Fisher™ ET or EWT valve (Figure 6).

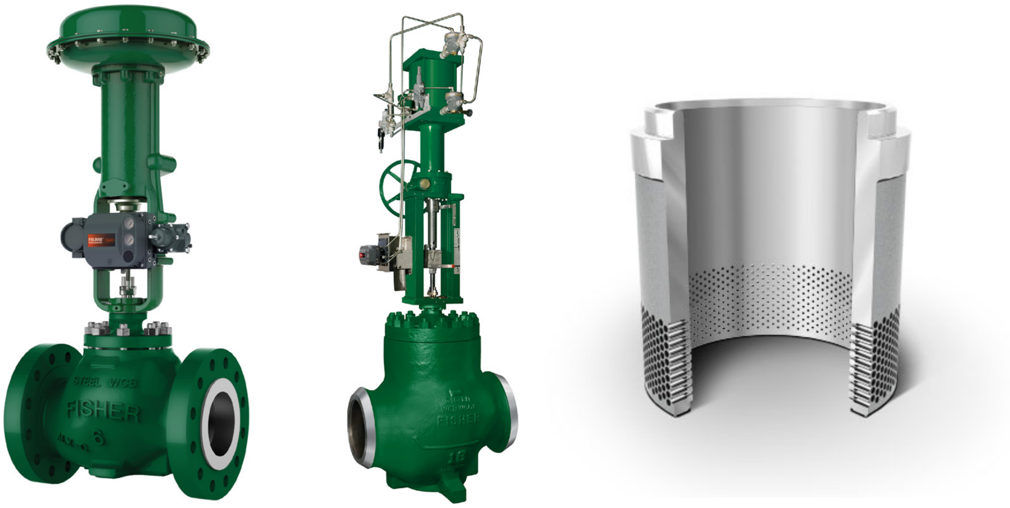

Figure 6: The lean amine feed valve is prone to cavitation and some level of corrosion. A 316 stainless Fisher ET (left) or EWT (middle) control valve with hardened anti-cavitation trim, like Cavitrol™ III (right), is a good choice for this application.

3.2.2 Absorber level control valve (#2)

This critical valve controls the liquid level in the CO_2 absorber and passes supersaturated, rich amine liquid to the amine regenerator. Even though the amine has not yet been pressurized or heated, the pressure drop across this valve tends to create cavitation and off-gassing, and the valve is subject to high levels of corrosion and erosion from crystallization in the solvent solution.

In this application, the same Fisher ET or EWT 316SS valve with a hardened Alloy 6 trim will work, but a noise-reducing Whisper I or III trim may be advised. Sizing this valve can be difficult due to the potential for two-phase flow, so consultation with an experienced automation valve provider is recommended to assist with body and trim size selection.

3.2.3 Lean amin pump recirculation valve (#3)

The challenge of this application is the valve remains closed most of the time, but it must instantly open as required to maintain pump flow during low flow conditions and avoid expensive pump damage. Tight shutoff is necessary since any leakage will reduce pump efficiency, and because the amine remains heated the valve is prone to cavitation.

The best valve for this application will be similar to the lean amine application (#1) described above. The addition of a high-diagnostic positioner can detect impending problems and alert staff should valve performance begin to degrade with respect to leakage.

3.2.4 Dehydrator control valves (#4 and #5)

The dehydrator is an important component of the CO_2 processing area since CO_2 pipelines will have a maximum water content specification (<100 ppm). Water in CO_2 will create long-term corrosion issues throughout the transportation network, so this specification is rigidly enforced.

In this area of the process, water content is higher, creating corrosion issues. There are also very high pressure drops, creating cavitation and high noise challenges. Proper selection of the material of construction and the body style is important.

The separator pressure control valve (#4) will be subject to high noise, so an attenuation trim like Whisper™ or WhisperFlo™ will be required. Depending on specific process design details, the dehydrator level control valve (#5) may experience cavitation and require an anti-cavitation trim. For either valve, a Fisher™ ET/HPT single-seated control valve will work well (Figure 7).

Figure 7: Dehydrator valves require 316SS bodies with 316SS or Alloy 6 trims to prevent corrosion, such as this single-seated Fisher ET or HPT (shown) valve. Valves around the CO_2 dehydrator may see noise and/or cavitation, and thus require low noise or anti-cavitation trims.

3.2.5 Antisurge Valve (#6)

Captured CO_2 must eventually be pressurized and liquefied to facilitate pipeline transport.

This process starts with large, multi-stage centrifugal compressors, which receive the incoming, dehydrated CO_2 and compress it to higher pressures. Centrifugal compressors are prone to a catastrophic condition called surge that occurs when either the compressor suction or discharge are restricted. Under these conditions, the gas flow through the compressor can reverse many times a second, destroying the turbine blades, bearings, and seals.

To avoid a low flow condition and the surge it creates, an antisurge valve is installed in parallel with the compressor. This valve will open to recycle discharge pressure back to the suction to maintain a minimum flow through the compressor. The challenge associated with an antisurge valve is that it remains normally closed but must open very quickly (often within a second or two) to pass a substantial portion of the compressor capacity through the valve. Antisurge valves tend to be large, so moving a very big valve that quickly with no overshoot is not easy.

Antisurge valves require a carefully designed trim to handle the very high flow, high pressure drop, and noise conditions. They also need oversized actuators with pneumatic boosters and high-capacity positioners to allow the valve to stroke very quickly and accurately. Antisurge valve performance is critical for compressor protection because if the antisurge fails to perform as required, the compressor will likely require months and significant expense to repair.

Depending on the specific process flows and pressure drops, a Fisher™ E/EW EA, or FB single-seated globe or angle valve may be required (Figure 8). Specialized, oversized actuators with high-capacity volume boosters and high-performance, high-diagnostic positioners are the norm. The valve must have very tight shutoff and then instantly open to pass high flow rates under high pressure drop conditions, so low noise trims are often required

Figure 8: An anti-surge control valve, like this Fisher Optimized easy-e™ EWT, is a critical component of gas compressor operations. High-diagnostic positioners with oversized actuators and volume boosters are typically required to meet the demanding response times

3.2.6 CO_2 flow/pressure control valve (#7)

Most captured CO_2 will eventually be injected into a pipeline for transport. This part of the process will typically operate in the supercritical regime under very high pressures. CO_2 is a strong solvent under these conditions, and it can enter and catastrophically damage certain elastomers. The valve may also see very high pressure drops during injection operations.

Full bore 600# class valves, such as the Fisher™ V260, and 900# class valves, such as the Fisher V280, are commonly used for these applications (Figure 9). O-ring and elastomer components must be carefully specified, and single- or double-stage noise attenuators may be necessary in applications with a very high pressure drop.

Figure 9: Pipeline applications typically require high-pressure, full-bore valves, such as the Fisher V260 (left) and V280 (middle). Applications with high pressure drop and excess noise often require single or multistage attenuation trims, such as the Cavitrol™ Hex (right).

3.3 Compressors safety valves selection

3.3.1 Hydrogen compressor safety valves

Due to standardisation and mandatory safety margins, safety valves are always oversized, relieving too much and so, wasting too much gas at each overpressure event. This large release can often cause the pressure to drop too fast and too low, causing undesirable interactions with the compressor control systems. To reduce these risks, the use of True-Modulating pilot operated safety valves for compressor protection, particularly on hydrogen service, has proven very successful.

A True-Modulating safety valve, like the Anderson Greenwood™ 400/800 Series (figure 10), will relieve only and exactly what the system needs: minimised gas losses, reduced noise and piping stress, and full pressure control. Furthermore, the potential for vibrations and pressure spikes on compressor applications often brings seat leakages, or even sudden openings of the safety valves, causing hazardous losses and unnecessarily high life-cycle costs. The pressure-balanced soft seat of the Anderson Greenwood pilot operated safety valves has addressed these issues for many decades by increasing seat tightness of up to 98% of the valve set point, reducing maintenance costs and improving the efficiency of the equipment. And in case of pressure spikes, the addition of an optional 'Pressure Spike Snubber' smooths the inlet pressure signal to the pilot, to keep the main valve stable and tight.

Figure 10: True-Modulating Pilot Operated Safety Valves reduce product losses to the strict minimum. If fitted with full monitoring like this Anderson Greenwood 400 Series with Flow Monitoring, they can also bring real-time information on flow and valve behaviour which are critical in improving reliability of the assets

3.3.2 CO_2 compressor safety salves

Most of the issues found on safety valves protecting CO_2 compressors are common to the ones on hydrogen compressors discussed above. On CO_2 services though, seat leakage could be seen as a lesser issue. On the contrary: seat leakage on CO_2 services can have dramatic consequences. Because CO_2 solidifies directly from gas at around -78ºC under atmospheric pressure, through simple Joule-Thomson effect, any seat leakage can create an accumulation of solid CO_2 ('dry-ice') in the exhaust of the valve that will dangerously restrict the flow path.

For the same reason, modulating safety valves are usually not recommended if there is a slight risk of solidification occurring at relieving conditions. As a modulating safety valve discharges only what is needed by the system, in case of small overpressure event the velocity of this small gas flow through the valve and its exhaust pipe will drop very quickly and could also cause dry-ice to build up: the flow path is reduced and thereby, in case of serious overpressure, the system will not be properly protected anymore.

For these reasons, the preferred strategy here has always been to select proper 'pop' or 'snap-acting' safety valves, like the Anderson Greenwood™ Series 80 (Figure 11) spring loaded valves or the Type 200 pilot operated valve, that will give a sharp and full opening right at the valve set point: the valve will then always discharge its full capacity, at high velocity, pushing out any solid forming. Also, these valves are always fitted with soft seats to dramatically reduce any risk of seat leakage well above the usual limits, while reducing service time and costs.

Figure 11: Proper 'snap'-acting' safety valves like this Anderson Greenwood Type 81 are preferred on CO_2 services when dry-ice formation is expected in the exhaust of the valve

3.4 PSA unit valves selection

Pressure Swing Adsorption (PSA) is a process in which a feed gas is separated into a product gas, usually hydrogen, and an off-gas. This is done by alternately pressurizing and depressurizing large vessels containing an adsorption media in a complex sequence. As a result, valves in PSA service see high cycle counts, bi-directional flow, and must achieve tight bi-directional shutoff.

The PSA process is based on the principle that adsorbents are capable of adsorbing more impurities at a higher gas-phase partial pressure than at a lower partial pressure. The impurities are adsorbed in a fixed-bed adsorber at high pressure and then rejected as the system pressure "swings" to a lower level. Hydrogen is not adsorbed. The ability to completely adsorb impurities allows the production of a hydrogen product with very high purity (99.9%).

The basic flow scheme of the PSA process is shown in Figure 12 below.

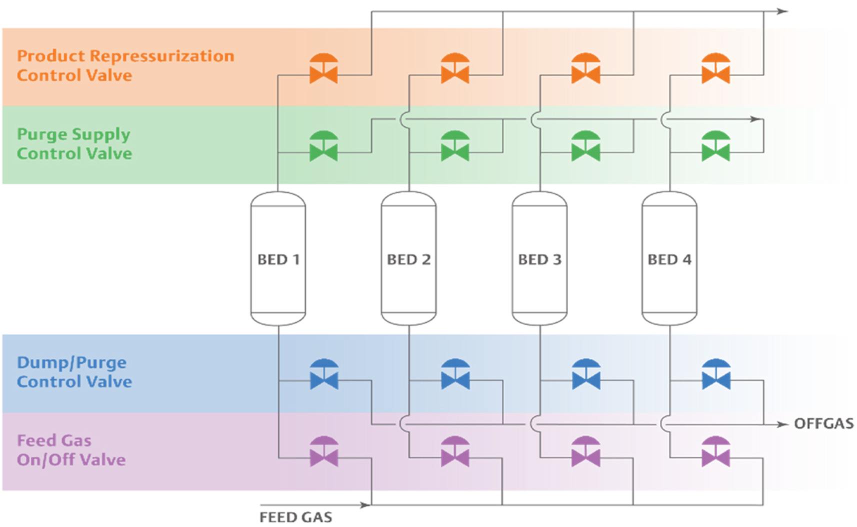

Figure 12: Four-Bed PSA Process Flow Diagram

The PSA unit is the backbone of many industries, providing uninterrupted vapor processing to meet the demand for high purity hydrogen.

Constant production of vapor requires an extremely high number of cycles, which can lead to damaging effects on the PSA process equipment.

Valves and actuators are expected to stroke as often as once every three minutes. Depending on the type and size of the PSA unit, the quantity and type of control valves will vary, creating diverse control valve issues. Those issue dramatically decrease efficiency of the PSA unit. For example, if leakage causes contamination from one PSA bed to another, industrial gas purity can be compromised.

Another challenge is that high-cycle applications are very abusive on control valve assemblies, forcing shorter timeframes between turnarounds and causing unplanned outages.

Emerson offers a breadth of extensively tested and proven-reliable isolation and control valve assemblies to help extend the lifecycle of high-cycle applications and maintain purity.

3.4.1 PSA unit isolation valves

The valves around the PSAs are subjected to very challenging service conditions. These valves are continuously cycled and must maintain virtually zero leakage and low emissions while ensuring isolation performance, despite high pressure and vacuum conditions, elevated temperatures, and the presence of erosive powdered bed media.

Compared to other automated valve designs, the triple offset Vanessa™ Series 30,000 TOV (Figure 13), provides a smaller footprint and less weight, improved operability, reduced fugitive emissions, and a longer valve life for this difficult application.

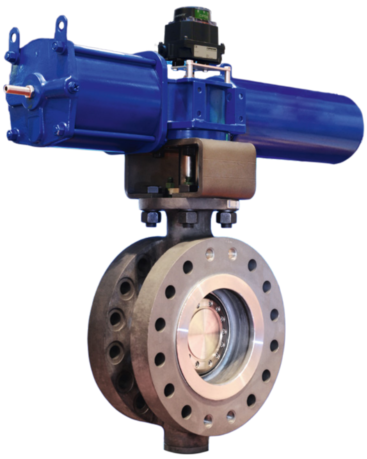

Figure 13: The metal-seated Vanessa Series 30,000 TOV provides zero leakage performance despite the reverse and variable pressures, extreme temperatures, and particulates present in PSA service.

Vanessa Series 30,000 TOV utilizes Stellite® grade 21 as a standard for valve body welding overlay to achieve higher resistance to galling, abrasion, erosion, and corrosion. This feature—combined with a solid seal ring, reinforced trim components, and live loaded packing—makes this valve the preferred choice for this application as it provides essentially zero leakage despite very difficult service conditions.

Another option for PSA isolation valves is the AEV™ ²XC double eccentric C-ball valve (Figure 14). It utilizes a double offset to create a zero-leakage seal that operates independently of applied pressure.

Figure 14: Double eccentric C-ball valves provide zero leakage, even in severe service applications, such as pressure swing adsorbers. The valves offer top entry and a hardened chromium carbide ball for long life. (AEV ²XC C-ball valve shown.)

A camming effect moves the C-ball away from the seat during the opening stroke to minimize wear when abrasives are present. The combination of fixed metal seats, mechanical sealing independent of process pressure, low wear, and a low emission design also works well in these difficult conditions.

3.4.2 PSA unit control valves

Two types of control valves are suitable for PSA applications: globe and rotary (butterfly) valves. Each should have features specifically designed for stringent leakage requirements and rapid cycling.

Fisher™ GX™ **Fisher™ easy-e™**

Figure 15

Globe valves (Figure 15) meet tight shut-off requirements with the use of durable soft seats that enable long-lasting Class VI shut-off per ANSI/FCI 70-2. To further ensure tight shut-off, contours of the unbalanced plug design should only contact the PTFE soft seat when shut-off is required. The seat ring centres the plug as it enters the seat, so the valve establishes a concentric seal. This also helps ensure prolonged valve trim over the life of the valve.

Rotary control valves, such as Fisher™ 8580 (Figure 16) meet critical shutoff requirements with the use of unique seal rings with pressure-assisted sealing action and spring-loaded shafts that center the disk in the seal. Low friction PTFE-lined PEEK bearings maximize control valve performance.

These three important features allow the control valves to be cycled over 1,000,000 times and achieve tight shutoff, making them ideal for high-cycle applications.

Figure 16: Fisher 8580 High Performance Butterfly Valve

Figure 17: Fisher DVC7K with diagnostics

A critical feature often overlooked when selecting the appropriate valves for PSA service is the diagnostic capability of the positioner (Figure 17). The ideal positioner is one capable of online, in-service, non-intrusive performance testing, real time monitoring, and data capture. This ensures earlier detection of valve degradation and gives technicians the troubleshooting tools necessary to make informed maintenance decisions. Fisher FIELDVUE™ digital valve controllers allow for monitoring of diagnostic and performance data such as friction, spring rate, and bench set.

This information gives a detailed picture of what is happening inside the valve as cycle counts reach and exceed 1,000,000 and helps to identify issues before they impact operations.

3.5 Remote pipeline valve actuators

Some automated pipeline valves may be installed in remote locations where instrument air is not available. In such applications, electric actuators, or actuators driven from pipeline pressure, are required (Figure 18). Lower torque requirements can be satisfied with modern electric actuators, with or without spring fail capability.

Figure 18: When air is not available, advanced electric actuators with or without spring fail assist are available (Bettis™ XTE top). For high torque applications, zero emission options, like the Shafer™ ECAT SHO (bottom), use pipeline gas pressure to drive actuator hydraulics.

Remote pipeline applications requiring high torque or involving multiple valves can utilize zero-emission hydraulic actuating systems, like the Shafer ECAT SHO. This unit utilizes pipeline pressure to drive hydraulic valves, and the pipeline gas is injected back into the pipe at the end of stroke, so there are no emissions.

3.6 CO_2 storage injection valves

During storage injection operations, the pressure may be very high, with some valves requiring class 1500, and even class 2500, pressure ratings. High noise and high pressure drop conditions are common, so low noise trims are commonly specified. High-capacity positioners and volume boosters may be necessary to meet fast stroking speed requirements. For these applications, high-pressure globe valves, such as the Fisher™ HP or EH with Whisper™ III or Whisper Flo trims, are a good option (Figure 19).

Figure 19: CO_2 injection applications often require 1500 or 2500 class valves with noise attenuating trims. High-speed actuator and positioner components may be necessary for some applications.

4 Key takeaways

The key advantage of blue hydrogen compared to traditional hydrogen production methods is the capture and storage of CO_2. The main technologies used to produce blue hydrogen are SMR and ATR.

SMR has been in use for decades, so it is very well understood, with many units operating worldwide, but its emissions are more difficult to capture than those produced by ATR. ATR is a newer technology and there are relatively few units operating worldwide, but its emissions are very simple to capture. This makes ATR the technology of choice for new blue hydrogen projects, but SMR will continue to be the most widely used technology for blue hydrogen production due to the large number of existing units.

When specifying the critical automated valves, regulators, and safety valves around a blue hydrogen plant, there are several process areas that pose significant challenges. The array of options can be overwhelming, but the details and design choices truly matter and will have lasting and positive impacts on the plant's reliability and profitability.

- Any gas steam containing hydrogen, such as product gas or syngas, poses a risk for hydrogen embrittlement. Valves, regulators, and safety valves in these services must be specified carefully when selecting materials of construction. KTM™ ball valves, MR-95™ regulators, and Anderson Greenwood™ 400/800 valves can be a good option.
- Many of the valves around the amine section are subject to cavitation, off-gassing, high noise, and high pressure drops and occasionally erosion. Valves with anti-cavitation trims and hardened internals are the norm. The best valve will vary depending on the specific application, but Fisher™ ET and EWT with low noise or anti cavitation trims work well in this application.
- Valves around the CO_2 dehydrator section will see high pressure drops and corrosion. Fisher ET or HPT valves with Alloy 6 internals work well in that application.
- If there are any antisurge valves, the user would be wise to consult their automation vendor. Antisurge valves are typically customed designed for the requirements of the specific application and require very specialized actuator components.
- Valves around the PSA face some of the most punishing conditions in the plant. The valves must maintain essentially zero leakage despite very high cycle rates, reversed pressure differential, high temperatures, and erosive dust. The Vanessa Series 30,000 TOV is well suited for this application and the double excentric AEV™ ^{2}XC C-ball valve is a good alternative.
- Pipeline valves typically require full bore valves with Class 600 and even Class 900 pressure ratings, and with specialized internal soft goods suitable for high pressure CO_2 service. The Fisher V260 and V280 ball valves are good choice for this pipeline service.
- If actuated valves must be installed in remote areas with no access to instrument air, spring fail-safe electric actuators like the Bettis™ RTS are a good option. If the torque or speed of response requirements exceed the capability of electric actuators, zero emission hydraulic systems powered by pipeline pressure, such as the Shafer™ ECAT SHO, are available.
- CO_2 injection valves can require class 1500 and even class 2500 valves. In these applications, high pressure globe valves, like the Fisher HP or EH with high-capacity positioners and low noise trims, work well.

Hydrogen process units have been operating for decades, but not at the scale envisioned in the future. Nonetheless, Emerson has extensive experience with these units, with much of their expertise applicable to the new processes described in this White Paper, namely the carbon capture and transport required to convert grey to blue hydrogen.

When designing the systems required to convert grey to blue hydrogen, operating companies would be wise to consult with a supplier that has extensive experience with hydrogen handling, along with the ability to apply this expertise worldwide at the scale required.

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