Automated Valves: Optimization of Process Control and Profits

Günter Öxler
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Introduction

Automated Valves: Optimization of Process Control and Profits

Valves, both manual and automated, are important capital equipment components of many industries. Wherever goods and materials are manufactured, processed, or packaged, the process more frequently than not relies on fluid automation components. Process industries (including chemicals, petroleum refining, food and beverages, pulp and paper), resource industries (including crude petroleum and natural gas production and mining), public utility industries (including electric, gas, co-generation, water, sewage and sanitation), as well as construction industries, bottling and dispensing, laundry, and countless more rely on a variety of valves to control both their process flow and their profits.

Valves typically account for somewhere between 5 and 10% of capital spending in most end-use sectors. This critical investment requires proper engineering optimization. Selecting a valve best suited for the unique application at hand can result in greater production efficiency, lower emissions and leakage, decreased maintenance and downtime, lower installation costs, and overall productivity improvement.

Companies across the process, resource, and public utility industries are realizing the financial, operational, and even environmental benefits of automated valves. In order to stay competitive in the global marketplace, these companies are modernizing and automating their production processes and increasing their operating efficiencies. By transitioning from manual to automated valve systems, these companies experience the immediate and long-lasting impact that automated valves have on the ease of use, reliability, speed, and cost-effectiveness of their flow processes.

Ease of Use
• Automated valves regulate flow systems according to pre-set values. They do not, therefore, require further proportional balancing and they require less repeat maintenance to monitor and re-calibrate.

Reliability
• Properly engineered fluid automation products often result in improved repeatability, flow rates, and throughput.

Speed
• Valves that perform closer to spec the first time and every time allow for a faster pace of operations.
• The reliability of automated valves reduces the chances of unplanned plant outages or downtime.

Cost Effectiveness
• Automated valves often only need to be installed at terminals, and not at distribution lines, branches and risers.
  This cuts down on installation costs.
• Purchase of standard valves in conjunction with sensors and actuators can mean buying unnecessary features.
• Automated valves often result in decreased maintenance costs and reduced power consumption.

Selecting the right automated valve for your particular application is determined by a number of factors and requires a company knowledgeable of both their products and your needs. The pressure, viscosity, corrosiveness, degree of acceptable resistance to flow, frequency of valve use, scale of operation, precision of control required, safety, acceptable leakage rates, and many other factors determine which valves are suitable for a given environment.

We, at Assured Automation, are happy to provide this selection of articles written by Günter Öxler to assist engineers, plant managers, and companies in the selection of the proper automated components. Mr. Öxler has a long history in the valve industry. He graduated in Process Engineering and Mechanical Engineering in Stuttgart, Germany, holds an MBA degree in VWA as well as a Controlling degree and is a REFA Specialist.

Assured Automation is a leading value-added distributor of automated valves and flow meters. Our trained technicians and customer support representatives can help you select the type of valve that best suits your unique application needs. In addition, our online valve-configurator can help you determine the optimum fit for pipe size, pressure rating, corrosion resistance, and more.

Advanced automated valves that are constructed from top-grade materials, like those sold by Assured Automation, can help your company perform to spec and realize maximum plant efficiency and profit.
How to prepare butterfly valves with pneumatic part turn actuator for shipment and storage

This time I want to come back to the topic - storage and shipping of valves, as I have received several mails asking for a simple and cheap solution to eliminate trouble and work on the job-site during installation, commissioning and start-up procedures – especially on butterfly valves with a soft seat where one faces lots of problems such as sticking, blocking the disc and finally failures because of this, as there are defects in the liner due to mechanical impact.

First of all this does not really matter when using double acting pneumatic actuators or manual drives and electric actuators as one can easily keep the valve open a few degrees after the final pressure / function testing in the workshop. So, as explained in previous write ups, open the valve slightly so that the rubber liner is no longer under compression and the disc does not overlap the face-to-face dimension of the butterfly valve followed by packing and shipment.

If it’s on fail-safe butterfly valve either fail-to-close and/or fail-to-open one has the problem that either the liner is under full compression (the springs inside the actuator keep the disc closed against the full differential pressure ∆p) or the springs keep the valve and disc respectively in the fully open position. Neither situation is really acceptable for supply / delivery to the job-site. The liner will be stuck to the disc in the closed position and will be damaged and/or the disc kept in the open position and subject to mechanical damage during handling. Once again we can imagine a shipment from Asia to Europe or the other way round. The valve sets are tested and packed followed by shipment by sea which takes a minimum of 6 weeks, including customs clearance. After that the valves may be stored in the warehouse of a stockist or on the job-site for further installation. This can be for weeks, months or even years. Again we have several choices to eliminate damage of the valves e.g. we can adjust the spring return actuators in a way that the end-position adjustment inside the actuators will be blocked before the disc touches the liner – BUT this requires skilled and trained people as mechanical work with adjustment has to be done on the site, plus testing equipment as the pressure & function test has to be done once again to guarantee a proper and perfect functioning of the valve sets which is also very time intensive.

It’s a serious problem, especially in countries and/or job sites where there are not the valve specialists available to do those adjustments, re-adjustments and so on, and subject to lots of failures during commissioning and start-up. The valve is no longer tight which means leakage and can also run into the danger of cavitation or closes too tightly so that the torque of the
actuator is no longer able to overcome the break-away force of the valve – both situations are unacceptable as they reduce the lifetime of the valves and related equipment tremendously. It’s a small issue with a high impact and there are some simple actions I would suggest to take to easily eliminate these problems.

It doesn’t really matter if it’s a fail-to-open or a fail-to close valve set with pneumatics actuator. We just have to block the rotation of the disc in a position that prevents the valve disc from closing / compressing the liner and /or the disc from staying fully open.

Additionally we have to make sure that it is easily removed by untrained people on site without damaging any part of the unit, as well as getting it cheaply or, let’s say, for the lowest cost possible.

In the following pictures you can see a possible solution which blocks the rotation of the actuator shaft – my main focus is always to influence a function where it starts.

Do not block the valve as there are couplings in between with tolerances and, finally, anything which blocks the disc from rotation will lead to damage to the liner and/or the disc. The red disc (Figure 1) you can see on top of the actuator or the bracket (Figure 2) can be easily made of plywood or any other cheap material, just to withstand the spring forces. With the pin attached to the disc/bracket you can easily adjust the rotation angle and block the valve’s rotation in the end, an appropriate angle of roughly 90° – 5° degrees = 85° to fix the rotating pistons at that point = angle α at which the disc is just off-set from the rubber-liner and does not overlap the face-to-face size of the valve. You do not even have to fix the red disc as it is held and clamped by the spring force.

After installation in the pipe on-site it is only necessary to open the valve, remove the disc and that’s it. The valve is working perfectly!

Meet Günter Öxler

Günter Öxler has a long history within the valve industry. He graduated in Process Engineering and Mechanical Engineering in Stuttgart, Germany, holds a MBA degree in VWA as well as a Controlling degree and is a REFA Specialist. For more than 25 years, Günter Öxler has worked for several companies in the valve business, companies such as J.M.Voith GmbH (Hydropower and Paper Machinery), Erhard GmbH (R+D Process Valves and project engineering), and Festo AG & Co. KG (Project Manager and Project Engineer Process Automation). He is also member of the IWA, ISA, and VDI German Engineer and he is multilingual as he speaks 5 languages, among which are German, English, French, Italian and Spanish. Günter can be contacted under: OEX@DE.FESTO.COM
In my editorial in the June 2008 issue of Valve World, I asked a question with regard to the difference between horizontally or vertically applied butterfly valves. Within our office, there were two schools of thought. The first was that it would make sense to have two ways of application and the second was that it would not matter in which way a valve is applied and that vertical was chosen for whatever reasons. So I asked you, our valued readers, to help me out with this question and give me, or rather us, a clear and comprehensible answer.

In the course of the last two months we have received several emails from you with answers to this question. Basically all emails had the same content which was: Yes, there is a difference and there is also a specific reason for having some valves horizontally applied and others vertically. Amongst those who sent in an answer were Mr Günter Öxler, from Festo Didactic GmbH & Co. KG, and Mr Mark Goodfellow, from Valve Sales Limited. We spoke with them and asked them to explain the different installations to us.

Contaminated liquids

“A concentric butterfly valve with a disc in a horizontal or vertical plane in a straight length of pipe will not create a problem and hydraulically will make no difference. However, care must be taken with shaft orientation when installing a concentric disc butterfly valve downstream of a bend, reducer and pump outlet to avoid problems caused by pressure imbalance over the valve disc due to the different fluid velocity. This can cause large vibrations in pipe work and damage to the valve,” starts Mr Goodfellow and he continues: “Other damages can occur when vertical applications are combined with contaminated liquids, for example water or oil containing sand, gravels, rust, lime and so on. The settling sediment will gather around the bottom bearing and this works like a sandpaper between disc and liner. This reduces the lifetime and eventually results in a leaking valve.” Mr Öxler adds: “Another problem which can occur with vertical installations is due to the size of the butterfly valve. If the valve is very big, approx. > DN 200, there can be as well a significant axial force, initiated by the weight of the disc and the stem, working in the direction of the bottom liner area with a similar result. If these valves are now installed horizontally you eliminate both negative influences on the lifetime of the liner / disc. In a horizontal installation, all the contaminants are flushed out when the valves are slightly opened as soon as there is a slight flow of the media.

Easier maintenance

Sometimes, however, there is another reason for horizontal applications of butterfly valves, especially on eccentric butterfly valves. “If, for example, one is dealing with a bigger sized double flanged and double eccentric valves, about > DN 1200 then usually those valves are supplied with an exchangeable sealing and / or seat ring which is normally installed on the disc,” explains Mr Öxler and he concludes: “For future maintenance actions – requiring the exchange of the sealing / seat – it is not necessary to remove the valve from the pipeline anymore. The maintenance crew can go inside, after reduced pressure and drained line, with the valve fully open and exchange the seat / sealing very quickly and easily.”

Several examples of correct and incorrect applications of butterfly valves in flow systems, taken from Tomoe Valve Company Installation Operating and Maintenance manual.
Double eccentric Butterfly Valves
the real difference in valve design and valve performance in detail

The double eccentric Butterfly Valve design is nowadays a very common design for double flanged Butterfly Valves as it needs a certain face-to-face dimension. In the following discussion we will find out what are the special design criteria we have to look on to avoid insufficient performance of a Butterfly Valve we purchased. The attached drawing / picture shows a typical double eccentric Butterfly Valve (see figure 1.)

So first of all – what does it mean, “double eccentric”? It means that the valve sealing and the shaft axis are separated in 2 directions / levels (see figure 2.)

The picture shows exactly the 2 dimensional distance of the shaft axis to the valve axis – where the deviation is A + B.

The reason for this design is:
• To allow a fully circular and uninterrupted sealing around the disc (wafer type valve as centric type valves have the shaft going directly through the sealing / seat area) which is the A eccentricity.
• Additionally the 2nd eccentricity which allows the disc to fully separate from the seat as soon as a turning angle of roughly 5 degrees is made – which leads directly to less friction and therefore less wear & tear of the sealing and the seat – the result is a much longer lifetime than for a centric type.

The basics must, of course, refer to standard qualifications of the manufacturing company as there is a certification according to ISO 9001 and the market specific standards for the different countries such as AWWA standard for butterfly valves to be used in drinking water lines for example. There are multiple standards for nearly every single use of the valves. These standards are related to the material of the body, disc & rubber, the composition of the coating to be in line with drinking water regulations and approvals and so on. But what is not clearly described in these standards are those details referring to the design or to a proper function throughout a complete lifetime which could be expected such as a design-life for ON-OFF valves of 50 years.

As my first topic I want to point out that it is important to view the internal streamlined geometrical design of the valve body. Especially view and inspect in detail the area around the seat – where the sealing takes place between the valve body and valve disc (see figure 3). We need to take care that this geometry has no sudden interruption, edges or cavities where the water flow has an “abnormal” flow direction and is not streamlined.
The reason why is very simple as a pinned connection cannot take as much shear force created by the torque as a keyed shaft connection.

Just think of a valve in a water pressure line and imagine a water hammer situation? Or even more damaging, the blocking of the disc during the closing action by a wooden stick or similar part and the overstress created in the shaft/disc connection.

In addition we have to think about the exchange of spare parts!

A pinned connection always requires a combined drilling of disc and shaft in 1 machining step where a proper machined keyway always fits with different counterparts = exchangeability is guaranteed — of course it might be a little more expensive but what is it worth to increase the safety?

What is more in our mind than a perfect sealing with zero leakage for the medium?

Right, so we also need to have a special look at this detail. As with all eccentric butterfly valves, it is a complete round shaped sealing with no interruption (see figures 1 – 4). What has to be the absolute priority in this function is the friction we create with the design — plus — the required compression of the sealing in the closed position and finally a proper adjustability in the closed position according to the existing media pressure to reach maximum lifetime of the sealing and, along with that, a minimum torque requirement for the actuating system.

An optimum in design is a stainless seat in the valve body. This can be either rolled in or welded, both technologies having advantages and disadvantages, combined with a profile rubber ring attached (not an O-ring as the compression is too high) and hold in place with a clamping ring. For the clamping ring make sure that it is adjustable in the compression of the profile ring (see Figure 5).

With the space “X” prepared in the sealing arrangement the compression of the sealing ring is possible and results in a force F which then gives the appropriate compression against the media pressure.

The performance of this valve is much higher than a non-adjustable one and results in such advantages as extended lifetime compared with the lowest possible torque which reduces the investment in automation equipment like gearboxes and actuators.

The final topic for this subject is the shaft sealing which separates the media from the environment/outside area.

Proper design usually has a separation of the 2 functions “bearing” & “sealing” (see Figure 6).

The bearing is done using a common design and material selection — but needs to be maintenance free — no greasing & lubrication must be necessary / allowed.

Sealing is made, for example, with a complete set of O-rings “caged” in an assembly set so that an exchange is made possible without removing or disassembling the shaft — shown in part no.1.

The only problem with this design is, that in the case of removing the drive (gearbox, pneumatic/electric actuator) the complete cage, including the O-rings, will be blown out by the media pressure with resultant leakage.

To prevent this, the good design incorporates clamping of the cage set to avoid these problems, making maintenance and refurbishing quite simple and easy.

Summary

A butterfly does not make a butterfly valve and, when designing butterfly valves not only as centric but as eccentric, double and triple eccentric it’s not easy to select the right valve, but more difficult. With this description I hope I have given you a guideline — especially for double eccentric butterfly valves — so that, as an end-user, you will have more understanding to help in selecting the right technology.

Meet Günter Öxler

Günter Öxler has a long history within the valve industry. He graduated in Process Engineering and Mechanical Engineering in Stuttgart, Germany, holds a MBA degree in VWA as well as a controlling degree and is a REFA specialist. For more than 25 years, Günter has worked for several companies in the valve business. He is also a member of the IWA, ISA and VDI German Engineer.

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If we consider a process installation – for example a water treatment plant, refinery, sugar processing plant and so on – we face problems if there should be, for any reason, a failure in the power supply. It could be due to electricity failure e.g. as a result of weather conditions or a drop in the power supply, pneumatic air failure caused by faulty design, air tube damage and so on. This article looks at some current technologies and where we need to take care by designing and selecting the appropriate technology. The design of electric actuators for process control valves is based on more than 50 years’ experience in the field so we already have more or less advanced features available. All actuators are fitted with a manual override. These are either designed for permanent use (see figure 1) or with infrequent use (see figure 2). The correct actuators need to be selected for their intended use. We need to ascertain whether the actuator will be used frequently for manual operation or just once in a while. For the design of the electric drives manual override I do not intend to go into this too deeply in this article as it is a well known technology (please feel free to contact me by e-mail, however, if you would like me to return to this topic in a later issue of Valve World).

A more neglected field has been the pneumatic process actuator side. Generally, pneumatic energy itself is a secondary level energy which can be stored for a certain period and is, by itself, more or less failsafe. Therefore many installations rely on the stored compressed air to have the process under control, even during a power failure in the air compressor system for several hours. This is definitely the best solution to stabilise a process in a safety position – there is no doubt about that! Just imagine having to set a number of pneumatic actuators manually in a safety position? Nevertheless there are some reasons to consider manual overrides in addition! After several years in the process business, every one of us has had experience during commissioning of there being no electricity available – which means waiting until the power for the pneumatic drives becomes available – “OR” – having a manual override on the individual actuators available to at least have the possibility of adjusting the process actuators together with the valves and/or do segment wise start-up of the process itself by opening and closing the process valves manually. Another reason, whilst we are talking “PRO” manual override, is a malfunction of the equipment itself – this could be a damaged piece of air supply pipe/tube, damaged connection thread / fitting, maintenance on the valve set having no air supply available to name but some. Because of the reason described above – pneumatic air being a secondary level energy – the manual override was not always not considered to be very important and therefore the solutions weren’t made very sophisticated – until now! Mainly they were made by adding just a simple gearbox between the Process Valve and the actuator (see figure 3). This solution offers a manual hand-wheel, but it does have several problems such as:

- alignment failures as we see 3 interfaces with adding tolerances to the vertical alignment

Because the reason described above – pneumatic air being a secondary level energy – the manual override was not always not considered to be very important and therefore the solutions weren’t made very sophisticated – until now!
• size matters
• requires a clutch to engage/disengage the gearbox
• material selection for corrosive atmospheres
• price & costs for the whole unit and
• last, but not least, the problem of using in explosive areas

Another option in the past was to simply attach a manual lever to the actuator shaft – which causes severe damage to the drive shaft of the actuator, especially if the shaft is made of aluminium or equivalent materials – therefore I do not propose to look too deeply at this technology (see the application figure 4 in a palm oil application). Some may say it will increase the spare-part supply! Lately we have seen in the market a better option which goes in the direction of the e-drives, a perfectly incorporated manual override inside the pneumatic drive itself (see figure-5). This option eliminates the problems usually caused by the gearbox version.

The force to “PUSH” & “PULL” the actuator in either “ON” or “OFF” position is directly indicated on the piston without the fluctuation failures and with a much smaller space demand and easy access (see Figure-6).

This version is also applicable for the double acting as well as for the single acting drives with spring return fail-safe action.

No wear & tear on the shaft with unacceptable side load to the valve/actuator drive shaft assembly. Careful note must be taken on the technique inside the actuator: Special attention must be give to the way of indicating the force of the manual drive to the piston!

The design must be done in a way so that the force is indicated to most of the surface of the piston so as to avoid damage to the material as it occurs by punctual implementation!

Explosive safety is guaranteed as well and maintenance is not excessive for those units.

The advantages are immediately evident:
• small size extension of the valve/actuator set
• limited force indicated by the hand-wheel – no possible damage to the valve and actuator
• visual direct indication of the position
• low friction losses during operation (manual)
• no additional corrosion problems
• an explosive safe unit as per basic lay-out of the actuator and many more...

There is, however, one disadvantage which needs a special mention:

As with all these solutions, the hand-wheel must be set after the manual operation in the neutral position to guarantee the automatic function afterwards. Failure to do this will result in the loss of the set valve operation.

It is essential to bring the manual unit to the “NEUTRAL” position.

One possibility could be to apply a limit switch to the “NEUTRAL” position which is connected to the process control system to avoid a malfunction after the operation! This will be the perfect solution if a manual override is necessary for proper functioning of the process with all the usual and required possibilities we see regarding function, reliability, corrosion protection and explosive safety.
Scotch Yoke or Rack-and-Pinion pneumatic part-turn actuator?

Further to one of my previous discussions regarding pneumatic part-turn actuators, in this issue I would like to take the opportunity to report on the best choice between the different technical solutions offered by pneumatic part-turn actuators.

By Günter Öxler

Figure 1

Basically the so called scotch yoke actuator delivers the transmission from a linear movement into a rotary action, known as part-turn action, by means of a lever arrangement (see figure 1).

No gear shaft, no gear rack on the piston. This makes the machining independent from any material to be used for the shaft – just think of the difference in machining stainless steel teeth and/or aluminium teeth on a shaft! Difficult if we look at hobbing and a pressure balanced shaft – so called floating shaft (see figure 2) – which makes the shaft blow out safely and reduces the wear & tear tremendously.

The result is a wider material selection for the shaft as only turning & drilling is necessary and a perfect solution with low wear and tear. All the used materials can be selected according to the operating conditions and can be hardened – just think on the cam disk in combination with the bearing pin in the piston (see figure 3). Frequently those actuators will reach a lifecycle time of millions of cycles. My experience shows an application with 50 Mio cycles within 6 months (glass bottle production line).

If we talk about wear & tear we should not underestimate the abrasion within the gear transmission. The aluminium particles, together with the oil / grease inside the actuator, form a grinding paste which results in an even faster damage of the actuator and, in the worst case, as well the abrasives infiltrate the compressed air system and damage upstream/downstream components such as solenoid valves; valve terminals etc.

Once again we have to consider that when using pressure dependant sealing rings and/or slide rings with graphite/Teflon compound material a lubrication of the air is no longer necessary so that the effect of having abrasives inside the actuator is less destructive as well as a reduction in the maintenance (refilling & draining of oil).

The lever arrangement is responsible for the different output torque compared to a rack-and-pinion actuator (linear, constant torque curve) (see figure 4). The diagram shows the exact difference in effective output torque in both actuator systems. It is important to note that the scotch yoke actuator delivers a 20% higher break-away torque from the zero position – where any soft seated valve requires the highest available torque.
(e.g. Butterfly Valves) whereas, along the rotary movement, the available torque goes down to a value 45% lower after 50% travel and increases at the end slightly to 75% of the starting torque which benefits the torque requirement of soft seated ball valves.

The benefit for the user is either a smaller actuator or a higher break away torque considering the same diameter of the piston in the actuator – resulting in cost benefit and space saving.

Why two different systems?
Most of the suppliers will define the two different actuator systems in a way that uses rack-and-pinion actuator for CONTROL purposes – because of its linearity, and the scotch-yoke actuator for ON-OFF applications as the scotch-yoke actuator is unable to hold intermediate positions. If we look on a common torque curve of a butterfly or ball valve, (as seen in figure 5), we will see that these valves have a reduced torque demand during the travel – resulting from the balanced tendency to open or close initiated by the media stream and the circumstance that 75% of the torque requirement in a soft seated valve is generated by the seat. But please do not forget about the previously mentioned design criteria: “NO O-Ring sealing as a dynamic sealing”. The best option is a pressure dependant lip sealing as it delivers the least possible leakage. Second best is a combination of an O-Ring with a graphite/PTFE slide ring which reduces the friction in a slip-stick effect (see figure 6). This gives the best possible result for smooth operation and precise use of valve-controllers.

There are also, of course, limitations to the scotch-yoke system. If it is necessary to operate 3-way or 4-way valves which requires a turning angle of 180° it is not possible to use a scotch yoke actuator as the lever arrangement does not allow turning > 95°. However, considering all the benefits of a Scotch-Yoke actuator, it is the best choice in automating valves with a 90° turning angle such as butterfly, ball and plug valves for ON-OFF as well as for control applications.
How to design process valves with adjustable speed control for the opening and closing sequence

Practically everyone of us working in the field and/or design of process equipment which includes piping systems and process valves has had the problem of finding the correct opening and closing time for the valves to be included in the system. The cause could be a hammer inside the liquid guided piping system, a need for a slow reaction of the control valve in combination with a fast action in emergency situations.

Let’s have a look at the technology available for an adjustable speed characteristic of any type of process valve – either linear or rotary actuated – or if there is a request to have a different opening & closing speed (time).

 Basically when an engineer/designer thinks about process valve actuation the first choice is electric actuators as this has been a common solution for many decades, well approved, well implemented and accepted. In the main, if we are talking about electric actuators in the Process Industry these are 3-phase AC motors of 400V/50Hz with an enclosure rating of minimum IP67 – which directly goes with a fixed output speed (see some of my previous columns). The e-drives act directly on trapezoidal threads where they are on linear actuated valves, or on shafts (reduction by internal gearboxes inside the actuator) e.g. Butterfly Valves. This goes with fixed and longer opening times. Manufacturers of those actuators offer a wide range of different output speed ratings such as 11rpm; 22rpm; 45rpm and so on. As you can imagine this means the designer has to calculate the required speed of every single process valve plus actuator to realise perfect functionality of the process itself. A wrong assumption of the process parameters and/or changing parameters throughout the lifetime of the process equipment can lead directly to a malfunction caused by too fast or too low action of the drive train!

The only solution to getting this under control is by using phase controlled electric actuators but this is an expensive choice and the electric control is more complicated. Also, it has the added problem that the fastest speed is always connected to mechanical gears which means that, for instance, a butterfly valve of the size DN200 is not able to close with an electric drive within 1 second or less – the minimum required time is around 5 seconds. In some applications there is a need for fast acting valves. Just think about discharge valves in the food processing industry with a requirement to remove contaminants like...
metal parts; the faster the action is, the less product is lost. Here we are talking about 0.2 seconds for 1 circuit!

Or take a water supply line with a length of 20km – to avoid water hammer you might need an expensive pressure calculation to design the perfect opening / closing time of the valve.

Using electric drives can be slightly problematic and some parameters cannot be matched at all!

An simpler option is to use pneumatic actuators (once again) of the latest and best technology – see Figure 1. (refer also to my previous contributions in Valve World Magazine)

Remember that compressed air is usually fast acting inside piping systems and can be controlled easily as there will be no cavitation/erosion inside the throttles and flow control devices, and speeds of up to 25 metres/sec are achievable as standard.

Both drive systems, linear as well as rotary pneumatic drives, are basically linear moving pistons – pushed by an air cushion. Acting in both directions is carried out simply by putting compressed air in one of the two chambers.

The only question now is how to adjust the speed of the piston movement?

Some might say to control the volume of the in-flowing air, which is not a bad idea at all. The only problem here is the friction of the seals and bearings – so called slip stick effect – which creates a step movement of the drives which is not acceptable.

So a better idea is to control the out-flowing air from the reverse side of the piston so that the piston is restrained between 2 air cushions which will eliminate the step movement and the reverse action is “not” throttled by this so called outlet control device. This means to control a pneumatic actuator we need always 2 outlet control devices – see Figure 2.

The pictured small outlet control “valve” as shown in detail in figure 3 is acting in one direction only – the 2nd line is fully open and does not limit the flow velocity/quantity and is easily adjustable by means of a screwdriver. No electrical control or PLC system is required and it is easy to use.

These small devices are available in all sizes with threads for any kind of pneumatic drive and they are available at a price which is far removed from that where we have to calculate for a phase control on an electric actuator.

Figure 4 shows a part-turn-actuator with 2 of these outlet throttle devices to control both directions independently which means, for example, opening in 1 second and closing in 30 seconds.

But that’s not all!

In case we need to make changes during commissioning or start-up (even years later) the closing/opening time of the process valve is just as simple by using a screw driver to re-adjust the outlet control device to the appropriate value!

If there is a concern that an unauthorised person may misuse the device, it can be placed in a lockable cabinet a few metres away from the actuator and works just as well without any reduction in performance!

Next we look at a system which works on pneumatic air.

Think of a safety circuit within the steam generation. The steam valve is slow moving – opening in 10 seconds and closing in 25 seconds.

During an emergency shutdown this valve must close in 1 sec to avoid an out-blow of hot steam and/or over pressure in the vessel. What a challenge!

But now with our knowledge of pneumatic air-circuits and control possibilities we find a simple and easy solution: we just by-pass the outlet control valve for the closing circuit, which usually slows down the movement, by using an additional 3/2 way valve connected to the electric circuit and/or to the pressure line, with free outlet non-throttled, and there we go! The actuator moves in less than 1 sec. to the closed position of the process valve. As soon as the system goes back to “normal” working conditions the actuator, in combination with the process valve, is working as before since the solenoid valve is reset automatically.
How to operate valves absolutely fail-safe without a power supply or control system

Water guided pipelines for long distances for example in turbine feeding lines, water transmission lines from dams to water treatment plants and/or outlets of water reservoirs, require an absolute fail-safe closing function of control valves (e.g. butterfly valves, ball valves & needle valves). These valves are mostly located in remote areas where there is no electrical power and/or control circuit available. With a so called weight-loaded hydraulic actuating system and a connected mechanical detecting system this function can be realised perfectly.

The basic design is done with an electric control which is also operable from remote areas via a PLC or equivalent (see Figure 1).

But the real speciality of this actuator concept is used wherever valves have to be firmly closed or opened even if the energy necessary for operating the valve (usually electric power) fails. Weight-loaded hydraulic actuators are equipped with an "energy reservoir". The operating energy necessary for closing or opening the valve once, is always available acting through a weight-loaded lever.

Valves equipped with a weight-loaded hydraulic actuator are used as:

- Combined Pump Guard and Non-Return Valve
- Reservoir Level Safety Valve
- Turbine Inlet Safety Device (Emergency)
- Isolating Valve (upstream of the turbine)
- Dump Valve (Emergency Feeding Line in Water Supply and Fire Extinguishing Plants)

Combined pump guard and non-return valve
A combined pump guard and non-return valve is an isolating device which is installed in the pump delivery line downstream of pumps and avoids a backflow of the discharged medium when the pumps stop (reverse rotation of the pump). The closing element can be moved in a specific manner by means of the weight-loaded hydraulic actuator (forced release, as against valves with freely swinging closing element, as, e.g., check valves). A lever hub with weight-loaded lever is positively connected with the drive shaft. All hydraulic components, such as electric pump, manual oil pump, isolating and damping device, are directly mounted to the cylinder using small tubing. The damping device is rigidly fixed to the cylinder by means of a control block without any tubing, so undamped closing of the valve is not possible even in the case of a burst in the control line.

The cylinder acts as operating and damping cylinder. The valve is hydraulically maintained in the "operating position" (weight-loaded lever lifted). Opening the main valve causes lowering of the weight-loaded lever.

The lowering velocity during the first damping zone (approx. 70% of the cylinder travel) can be adjusted at 2 different flow control valves. Flow control valves keep the flow rate constant independent of the differential pressure. This principle permits controlled closing velocities. Controlled closing velocities are often necessary when closing the valve in order to keep the increase of pressure (water hammer) in the
pipeline within an admissible range for closing times as short as possible (see Figure 2).

For compensating the difference in flow rate between the cylinder chamber on the rod side and on the piston side and for receiving a small oil reserve for losses due to leakage the actuator is equipped with a compensating tank with oil level sight control.

Mechanical solution with differential pressure transmitter (Figure 3)

At pitostatic tubes, probes, venturi nozzles and standardized nozzles, flow produces a differential pressure which can be received at the bores for pressure measuring of the units. The differential pressure is proportional to the flow velocity in the pipeline. This differential pressure is evaluated in a control device. In case of over-velocity the control device transmits a mechanical hydraulic signal to the pilot valves of the weight-loaded hydraulic actuator.

Switching over of the pilot valves causes lowering of the weight-loaded lever and closing of the valve. Closing is effected with graded velocity. During the 1st step, the valve is to close as quick as possible in order to minimize the outflow rate. During the 2nd step of the travel till CLOSED position), the valve is closed slowly for avoiding water hammer in the pipeline.

Mechanical solution with Paddle Trip Mechanism (Figure 4)

Flow produces an impact pressure on the bowl. This leads to a movement of the paddle trip lever. This rotation is transmitted through the paddle trip body to the outside where a weight-loaded lever runs on a cam disc. After a certain movement of the paddle trip lever the weight-loaded lever of the paddle trip mechanism drops from the cam disc. The rotation of the weight-loaded lever of the paddle trip mechanism opens a ball valve which is installed as a pilot valve in the hydraulic circuit of the weight-loaded hydraulic-actuator. Opening of the pilot valve causes the valve / actuator to close.

Summary

Weight-loaded hydraulic actuators are mounted to valves which have to perform with high security. By means of the lifted weight-loaded lever the operating energy for a single valve movement is provided for secure action at all times. Controlled closing velocities allow quick decrease of the flow in the pipeline so during a 2nd step soft isolating of the pipeline is guaranteed. Pressure increase in the pipeline can therefore be safely limited.

Construction using small tubing as well as the use of control blocks rigidly fixed on the cylinder offer the security that the closing process of the valve is damped even in case of a burst in the control line. The introduced design of the weight-loaded hydraulic actuator offers various advantages as a tubeless assembly to avoid damage of fluid-lines resulting in malfunction, full functionality without power supply and control connection – therefore highly fail-safe – allows installations in remote areas as it can be commissioned and ready to work with manual pre-setting only.

Can be attached to any valve that requires a part-turn-action of 90° maximum which is usually a butterfly, ball or needle valve (Larner Johnson / Plunger Valves) – see Figure 5 – and works fully independently. A reset after an emergency shutdown can be done easily by means of a manual hydraulic pump.

To avoid impermissible action of personnel all valves and functions shall be secured by padlock. The last picture shows assembly as a pump non return valve (taking over the full function of a check valve) in a cooling circuit of a refinery in Tubruk / Libya – see Figure 6 – fully equipped with additional sensors / limit switches for monitoring in the control room.

Meet Günter Öxler

Günter Öxler has a long history within the valve industry. He graduated in Process Engineering and Mechanical Engineering in Stuttgart, Germany, holds an MBA degree in VWA as well as a Controlling degree and is a REFA Specialist. For more than 25 years, Günter Öxler has worked for several companies in the valve business, companies such as J.M. Voith GmbH (Hydropower and Paper Machinery), Erhard GmbH (R+D Process Valves and project engineering), and Festo AG & Co. KG (Project Manager and Project Engineer Process Automation). He is also member of the IWA, ISA, and VDI German Engineer and he is multilingual as he speaks 5 languages, among which are German, English, French, Italian and Spanish. Günter can be contacted under: OEX@DE.FESTO.COM
Manual operation and manual override – are they really necessary?

Why are engineers asking for manual operation on drive systems and what is the reason for having a manual override on automated process valves?

Since process valves are subject to automation, during tending, most planning engineers, operators and consultants frequently require a manual override on those automated process valves. Is it just an unwillingness to believe in the technical reliability of automation and actuating systems or is there really a reason to have this option available?

To find an answer for this question we look back at the history of the process industry and process automation. Everybody has some concerns when we talk about an automated system and its reliability as we all have some knowledge on power failure in our private lives – just think about a lightning strike at night while we are watching an interesting TV-show. At the very least the power supply to our TV set is cut-off and we have to sit in candlelight. For most of us it’s normal but disturbing that we depend so highly on those hidden utility supplies in a black box. So in the case of automated valves we feel much more comfortable when there is a possibility available to have an access to the system where we can interact “manually” in case of any failure.

The 20th century saw the introduction of much automation in industrial facilities. Within the process industries it started mainly after the 2nd World War – with Electricity!

The first automation of process valves began with electric actuators. At that time the reliability of those systems was, let’s face it, on a low level and the networks were slightly unstable, so it was common for the power supply to be interrupted. To guarantee a control possibility, even if only a stop / closing or opening function, it is absolutely necessary to have a manual override available to put the process valve in a fail-safe position. There is a good chance this will not be the case if those valves / actuator are not installed in a safety circuit where a proper and fast action, depending on the process parameters, is required (please see the article in Valve World June 2009: How to operate valves absolutely fail-safe – without a power supply or control system).

On the other side the electric actuators need a manual hand-wheel/override during adjustment of the process valve and during commissioning and start-up of the process since there is usually no power available during this condition and/or for safety reasons (see figure 1 – electric actuated process valve)

One very specialised solution for ensuring a fail-safe power supply would be a power pack with batteries on a DC motor – but that is very, very expensive and needs extensive maintenance.

With the progression and boom in automation in the process industry another option for drive systems to process valves came up – the pneumatic.
The manufacturer's voice

air-operated system. Definitely it was not a new technology (we have seen pneumatic drives for as long as electric operated systems have been around) but the '80s of the last century saw the latest improvement influenced by factory automation systems – proper and long lasting compressor devices, drying systems to avoid freezing and corrosion in the air supply system, absolutely leakage free air tubing systems (leakage costs a great deal of money) and finally slip-stick free sealing systems for devices such as cylinders and part-turn actuators. For the consulting engineers as well as for the design engineers and operators it was clear that a manual override – hand-wheel – available, due to their decades of experience with electric actuators, as the pneumatic drive system, was just another way of actuating a process valve. Mainly it has been and still is just a lack of information about pneumatic air automation!

If we look first at the industrial facilities of the automotive industry, food industry and so on, here nobody will think about running all these pneumatic actuators with a hand-wheel as they have never used electric actuators before because they were not able to fulfill the needs in these locations of fast action, high frequency, long lifetime, corrosion resistance and, last but not least, fail-safety! (see Figure 2 – pneumatic operated process valve)

Wow – what a difference! All the requirements we have in process automation are available in factories within the manufacturing industry.

Pneumatic air has the advantage that throughout the factory (whether it’s manufacturing or a processing plant) the medium to run an actuator respective to a process valve is available anywhere and the production of the medium is done somewhere outside the process – which makes it highly reliable. Additionally no high voltage is necessary inside the processing area, only an air-pipe network which is frequently of plastics (if necessary steel, stainless steel) plus a low voltage signal wiring for SCADA systems and monitoring.

The compressed air is usually supplied with a pressure between 7 – 8.5 bar and is produced with redundant compressor systems (maintenance free as it is oil-free air) and the wonderful thing about compressed air is that it can be stored in tanks.

This tank in a process area is the “battery pack”, if we compare it to an electrical system, and feeds the process valve actuating systems with the compressed air guaranteeing a proper function along the designed black-out-condition coverage which is usually 1 to 2 hrs but can be extended to several hours and is just a question of the sizing of the tank.

The whole and complete SCADA respective PLC systems run on a low voltage 24V/DC system anyway which can have a power back-up system of a small battery pack in the control room (see Figure 3 – pneumatic circuit in process automation)

Such a combination always guarantees proper control of the system in the case of power failure without using a single manual override on a pneumatic actuator - which is just wasting money and increasing the need for maintenance of those installations.

Besides that, the installation, commissioning & start-up is done manually with just a wrench for the end position adjustment (usually done during installation in the workshop as no torque adjustment, running direction check is required).

If the safety related standard requires an absolute fail-safe function of OPEN, CLOSE or HOLD it is common to use spring-return actuators as they do not even need pneumatic air to reach the defined safety position!

Comparing a common installation of electric actuators and a pneumatic installation as shown in figure 3, the pneumatic system shows a much higher availability than an electrically operated system, even if we do not find any manual override on the actuator itself.

In the next issue we will focus on the influence of pneumatics on safety as well as SiL (Safety integrity Level issues) to IEC 61511.

Meet Günter Öxler

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Günter can be contacted under OEX@DE.FESTO.COM
This article compares the costs of automation of a Water Treatment Plant between pneumatic and electric Actuator technology for process valves based on quality equipment in process valve manufacturing. It is based on a realistic and near-application example and shows the enormous cost advantage of using pneumatic actuators and automation technology.

The comparison is not only based on a direct comparison between electrical actuators versus pneumatic actuators, but includes all equipment and technical infrastructure necessary for automation with one or other actuation technology.

This procedure mirrors the way of thinking of a company who is producing both actuators and the complete range of valves as well: only a complete overview of a (automation) project allows the finding of a cost effective and customer-specific system-solution. An important part of this is the completeness of the delivery-program for one or other technology (pneumatic or electrical).

The final chapter “Pneumatic energy supply” gives a brief overview of the most important questions regarding the compressed air supply and compressed air costs.

1. Suppositions for the sample calculation

The basis of the cost comparison is a water treatment plant with 8 fixed bed filters. This example can be projected to many applications in the industrial and municipal water and wastewater treatment.

Characteristics of the Water-Treatment Plant:
- 8 fixed-bed filter (e.g. sandfilter, activated carbon filter)
- 7 butterfly valves per filter tank, On-Off characteristic
- Space required by filter plant: 16 x 11 m
- Media In-line pressure 3 bar
- Fully automatic, safe operation is required

For every filter tank (i.e.: x 8) are installed:
1. Raw water influent
   Butterfly valve DN 125
2. Filtrate effluent
   Butterfly valve DN 125
3. Rinsing water feed
   Butterfly valve DN 150
4. Rinsing air feed
   Butterfly valve DN 100
5. Sludge water discharge
   Butterfly valve DN 250
6. (De-)Aeration
   Butterfly valve DN 80
7. Pre-run discharge
   Butterfly valve DN 80
Additional for the Whole plant (x2)
8. Raw water distribution
   Butterfly valve DN 250
The Butterfly Valves are automated either with pneumatic single acting quarter turn actuators or with electrical actuators.

Note:
Single acting pneumatic actuators allow opening or closing of valves with an integrated spring pack. That means: even after a breakdown of the supply with electrical energy or compressed air a defined behaviour of the valve is realizable and this way high operational safety is given. When using electrical actuators, this function is only possible when a battery buffered power supply is installed (Costs!).

The pneumatic actuators are calculated for a differential pressure of 8.4 bar to make sure that the valves open or close under all possible operating conditions.

But the standard and calculated base is a pneumatic pressure of 5.6 bars whereas the supply pressure of the compressor is 8.4 bar. The difference is used as compensational pressure to guarantee several cycles of any specific actuator to run under break-down and/or shut-down conditions of the pneumatic compressor.

A defined movement of valves with pneumatic actuators can also be realized with double acting quarter turn actuators, when a single stable solenoid valve and a compressed air reserve tank is used.
Interpretation of the suppositional prices:
• The prices are average market prices of actuators for contractors.
• All prices defined without valve – easy to compare.
• Prices of the electrical actuator include the motor-control and cabinet part.
• A correct comparison of same functions of electrical installation is only possible this way.
• All prices in Euro per piece, based on prices in Germany.
• Total calculation is proven by international contractors and is confirmed.

Control of the actuators:
• Control with PLC.
• For controlling the pneumatic actuators – any state-of-the art valve terminals (or single solenoid valves on a sub-base) are provided e.g. Camozzi, and so on:

1. 4 x cabinet each with 14 x 3/2 monostable Solenoid-valves and each terminal for 2 filters
2. 1 x cabinet with 4 x 3/2 monostable Solenoid-valves

Both alternatives (see below) can be offered with either multi pin (parallel I/O) or Field-Bus-Interface. The valve terminals are completely mounted and inspected, including accessories. Calculated accessories are:
- Maintenance unit, Fittings, Noise Reducer, Cable and Connectors.

We calculate 2 possible basic installations:
1. Conventional wiring by using the parallel I/O-level (Multi-Pin)
2. Up to date solution with Fieldbus (Proflbus, Interbus-S, …)

Interim Result:
The resulting difference is 30591.-€ to the benefit of pneumatic, including higher operational safety by using spring packs in the actuators. Double acting actuators are more economically priced. It is important to be aware of the high robustness, the added explosion-proof abilities and the service and maintenance-free construction of pneumatic actuators. Additionally, pneumatic actuators are overload-safe, provide continuous load operation and are designed for 100% operation time. Operation modes like S2, S3 etc and over-
temperature are not applicable in the case of pneumatic actuators.

Additionally, a very important fact to be considered is that all pneumatic actuators come as oil-free actuators. The reason is:
• Lubrication inside the air system creates a slip stick effect inside the actuators in the long term, which causes a step-wise actuation and prevents smooth non-stop running of the actuators. With oiled air control of the actuators is difficult – in the long run impossible.
• Needs constant lubricated air maintenance of the used components including compressors, actuators and solenoid valves.

Result / requirement: maintenance-free means NON-LUBRICATED air and oil-free compressor systems.

2. Cost estimation
2.1 Original costs of the actuators
2.2 Costs for Controlling and Installation by using Parallel I/O-level-wiring
Listed are the costs for controlling with PLC, installation and mounting of the actuators. The calculated length of cables and tubes result from the supposed size of the filter plant. Further we have supposed, that the cabinets are installed near the filter tanks. Costs for the cabinet itself are not calculated, only necessary equipment to control the actuators.

Interim Result:
The resulting difference is 36116.-€ to the benefit of Pneumatic. This cost advantage is mainly based on the lower quantity of I/O’s for controlling the pneumatic actuators with the PLC. Lower quantity of I/O’s means additional reduction of Engineering, Programming and Documentation efforts. As a result of this, the efforts to configure the PLC by using pneumatic actuators is lower because less I/O’s have to be designed and configured. Additional advantage for the operator: Less complex plant and plant control and therefore less possibilities to create mistakes/ failure. When designing big plants, fewer I/O’s have more effect on the costs of the PLC and peripheral equipment.

2.3 Costs for Controlling and Installation with Fieldbus
Interim Result:
The automation concept with Fieldbus again shows that pneumatic installation has big advantages compared with electrical installation: the cost advantage.
is more than twice the advantage of conventional installation.

Using Fieldbus reduces the costs for both actuator technologies regarding installation and wiring, improves the monitoring of the system and has a big time advantage in installation when upgrading or modernizing the plant and when optimizing or improving the process.

2.4 Summarising the costs

Result:
The cost-advantage of the pneumatic solution is factor 1.9 and 2.5 higher than the electric solution. Double acting actuators, instead of using single acting actuators, increase this cost advantage.

Comparison Parallel-wiring to Fieldbus: The Fieldbus technique for pneumatic installation has a cost advantage of approx. 10%. This relatively low cost advantage is shown from the comparison between multi-pin-connected valve terminals and Fieldbus connected valve terminals.

Please note, the Valve terminals themselves already have a high integration rate. If a single solenoid valve solution were compared with the Fieldbus installation, the cost advantage for Fieldbus would be much higher.

The comparison with parallel wiring to Fieldbus installation in the case of electric actuators shows only a small advantage for the Fieldbus system.

This is the result of the characteristic of installations with electric actuators, every actuator is a single Fieldbus participant (compare: a valve terminal for up to 26 valves is one participant only).

Additionally pneumatic has the following main advantages:
- Small requirement of space
- Smaller volume of cabinets
- Less complex, “simple” and robust technology
- Overload-safe and 100% operating time
- Higher operational safety by using air as second energy-supply
- Fewer spare parts required
- Lower engineering-and programming costs
- Lower maintenance costs
- Transparent, easy to manage process

<table>
<thead>
<tr>
<th>What is installed</th>
<th>Costs per Piece</th>
<th>P-Actuators</th>
<th>E-Actuators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actuators</td>
<td>--</td>
<td>23165</td>
<td>53756</td>
</tr>
<tr>
<td>Valve terminal complete, incl. multi-pin-connector and cable, maintenance unit</td>
<td>--</td>
<td>7200</td>
<td>--</td>
</tr>
<tr>
<td>PLC installation each with 32 I/O channels</td>
<td>500</td>
<td>3000</td>
<td>9500</td>
</tr>
<tr>
<td>3-Row cage clamp connector incl. installation</td>
<td>2</td>
<td>360</td>
<td>--</td>
</tr>
<tr>
<td>P-Actuators 180 Pcs.</td>
<td>2</td>
<td>1260</td>
<td>1260</td>
</tr>
<tr>
<td>E-Actuators 580 Pcs.</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>I/O cable in cabinet</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>P-Actuators 6 Pcs.</td>
<td>80</td>
<td>480</td>
<td>--</td>
</tr>
<tr>
<td>E-Actuators 19 Pcs.</td>
<td>80</td>
<td>1520</td>
<td>1520</td>
</tr>
<tr>
<td>Installation time PLC I/O in terminals</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>P-Actuators 180 hrs.</td>
<td>35/hr</td>
<td>630</td>
<td>630</td>
</tr>
<tr>
<td>E-Actuators 580 hrs.</td>
<td>35/hr</td>
<td>2030</td>
<td>2030</td>
</tr>
<tr>
<td>Pneumatic ring-pipe</td>
<td>5/m</td>
<td>400</td>
<td>--</td>
</tr>
<tr>
<td>T-Distributor 4 Piece</td>
<td>12.5</td>
<td>50</td>
<td>--</td>
</tr>
<tr>
<td>P-Subdistributor 8mm , appr. 50m</td>
<td>1/m</td>
<td>50</td>
<td>--</td>
</tr>
<tr>
<td>Connections P-Actuators 8mm , appr. 120m</td>
<td>1/m</td>
<td>120</td>
<td>--</td>
</tr>
<tr>
<td>P-Instant-connectors, QuickStar</td>
<td>--</td>
<td>180</td>
<td>--</td>
</tr>
<tr>
<td>Plastic-cable tunnel/platform appr. 70m</td>
<td>10/m</td>
<td>700</td>
<td>700</td>
</tr>
<tr>
<td>Installation time Connector with Limit switch</td>
<td>35/Hour</td>
<td>210</td>
<td>--</td>
</tr>
<tr>
<td>Motorcable 5x1.5 appr. 200m</td>
<td>1.5</td>
<td>--</td>
<td>300</td>
</tr>
<tr>
<td>Controlcable 15 x 0.75 appr. 200m</td>
<td>1.5</td>
<td>--</td>
<td>700</td>
</tr>
<tr>
<td>Motorterminal (58 E-Actuators x 5 terminals )</td>
<td>2.5</td>
<td>--</td>
<td>725</td>
</tr>
<tr>
<td>Incl. Installation, total 290 connections</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Connect control cables to E-Actuator</td>
<td>35/hr</td>
<td>--</td>
<td>420</td>
</tr>
<tr>
<td>Connect Motorcables to E-Actuator</td>
<td>35/hr</td>
<td>--</td>
<td>350</td>
</tr>
<tr>
<td>Test I/O cables/tubing (pneum) start up</td>
<td>50/hr</td>
<td>1200</td>
<td>2600</td>
</tr>
<tr>
<td>Total</td>
<td>37745</td>
<td>73861</td>
<td>--</td>
</tr>
</tbody>
</table>

1 P-Actuators : per actuator 2 PLC In (end position) and 1 PLC Out (valve), resulting in 58 actuators = 174 PLC I/O’s. No monitoring signals necessary as pneumatic actuators are overload safe and designed for 100% power-on-time.
2 E-Actuators : Wiring to PLC includes torque, over-temperature and end-position monitoring. Resulting I/O’s approx. 10 per Actuator, for 58 Actuators = 580 PLC I/O’s
3 I/O channel x 3 cores x 2 terminals per 1 min.
4 P-Actuators 180 channels x 1080 min. = 18 hours
5 E-Actuators 580 channels x 3480 min. = 58 hours
6 Motorcables x 3 connects x 3 poles x 1 min.
7 58 P-Actuators x 2 connectors x 3 poles x 1 min.
8 P-Actuators x 3 cores x 1 min.
9 Motorcable x 3 sides (motor + cabinet)
10 Motorcable x 3 sides (motor + cabinet) x 5 poles x 2 sides
11 Motorcable x 3 sides (motor + cabinet) x 5 poles x 2 sides
12 Motorcable x 3 sides (motor + cabinet) x 5 poles x 2 sides
13 Motorcable x 3 sides (motor + cabinet) x 5 poles x 2 sides
14 Motorcable x 3 sides (motor + cabinet) x 5 poles x 2 sides
15 Motorcable x 3 sides (motor + cabinet) x 5 poles x 2 sides
16 Motorcable x 3 sides (motor + cabinet) x 5 poles x 2 sides
17 Motorcable x 3 sides (motor + cabinet) x 5 poles x 2 sides
18 Motorcable x 3 sides (motor + cabinet) x 5 poles x 2 sides
19 Motorcable x 3 sides (motor + cabinet) x 5 poles x 2 sides
20 Motorcable x 3 sides (motor + cabinet) x 5 poles x 2 sides
21 Motorcable x 3 sides (motor + cabinet) x 5 poles x 2 sides

Fieldbus technique for pneumatic installation has a cost advantage of approx. 10%. This relatively low cost advantage is shown from the comparison between multi-pin-connected valve terminals and Fieldbus connected valve terminals.
2.5 Original Costs of Controllable Actuators

The valves and actuators in our example work in ON-Off-characteristic. But besides this, applications for controlled actuators (analogous characteristic) are very common. In water treatment plants, industrial wastewater treatment plants and especially in the chemical industry, controlled valves with pneumatic quarter turn actuators are very often used. In our example, the filtrate effluent could be controlled.

For controlling a valve, the quarter turn actuator is equipped with a positioner. Example: Butterfly valve DN 125.

Comparison between electric and pneumatic solution:

### 3. Pneumatic Energy-supply

Pneumatic actuators are driven with compressed air and compressed air does not come free. In fact the quality of the compressed air is nearly as important as the quality of an electrical power supply for the long-term maintenance-free working of actuators.

The preparation of compressed air should contain:
- Compressor with filter
- Tank for compressed air
- Dryer
- Maintenance unit
- Installation should have somewhere to drain the condensate.

**Dimensioning - how?**

The following tips are to give direction, to get a feeling for the dimensioning of a compressed air supply.

**Compressor:**

The basis for choosing a compressor is the required pressure and air volume of the installation.

Finding the effective output of a compressor:

1. Specify the maximum consumption of all compressed air consumers per time unit (worst case specification, how many actuators at the same time?).
2. Estimate the additional required compressed air consumption for the next 10 years.
3. Calculate leakage (10% for new plants).

Summarizing 1 to 3 is the total...
### Type of installation | Total Pneumatic | Total Electric | Difference
---|---|---|---
Parallel wiring using I/O - level | 37745 | 73861 | 36116
Controlling with Fieldbus | 34022 | 87121 | 53099

### Installation

<table>
<thead>
<tr>
<th></th>
<th>P-Actuator</th>
<th>E-Actuator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actuator for butterfly valve DN 125</td>
<td>236</td>
<td>1302 l</td>
</tr>
<tr>
<td>Electro-pneumatic positioner incl. end position feed back, end position switches 4-20 mA I/O</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1236</td>
<td>1302</td>
</tr>
</tbody>
</table>

Controlable E-Actuator incl. gear

Example: Air consumption of a water treatment plant:

<table>
<thead>
<tr>
<th>Valve</th>
<th>DN</th>
<th>Air consumption standardized litre (NI) at 6 bar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw-water supply</td>
<td>125</td>
<td>4</td>
</tr>
<tr>
<td>Filtrate effluent</td>
<td>125</td>
<td>4</td>
</tr>
<tr>
<td>Rinsing water supply</td>
<td>150</td>
<td>8</td>
</tr>
<tr>
<td>Rinsing air supply</td>
<td>100</td>
<td>4</td>
</tr>
<tr>
<td>Sludge water drain</td>
<td>250</td>
<td>15</td>
</tr>
<tr>
<td>(De-)aeration</td>
<td>80</td>
<td>3</td>
</tr>
<tr>
<td>Pre-run</td>
<td>80</td>
<td>3</td>
</tr>
<tr>
<td>Total per filter</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>x 8 filter</td>
<td>328</td>
<td></td>
</tr>
<tr>
<td>Raw water distribution</td>
<td>250</td>
<td>15</td>
</tr>
<tr>
<td>Total raw water distribution</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

**Total consumption (all actuators operating at the same time):**

358 NI

Supposition: all valves open once a day, including leakage appr. 800 NI / day

Consumption/minute: 0.6 NI / min.

---

Power supply costs:

\[0.27 \text{ kW} \times 1.5 \text{ h/day} \times 365 \text{ days/a} \times 0.10 \text{ Eur/KWh} = \text{ appr. 15 Eur/year}\]

Why is a bigger compressor often used? Often additional air is needed, for example to rinse the fixed bed filter with air, to work with a filter press in wastewater systems. But very often the reason is a high uncertainty in dimensioning the system.

### 4. Conclusion

We have shown an intelligent pneumatic system for automation of a water treatment plant and the high cost advantage of pneumatic compared to electrical installations. But why is the electrical installation often preferred? It’s important always to look at the whole system. In a tender today it’s usual to divide the electrical part, the cabinet part and the single valve-actuator part. Working this way, the total costs of an electrical system can’t be seen. Pneumatic systems are often seen as a unit and that way seem to be more expensive.

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Simplify Your Process Control Solution
Example given for a valve control solution in a batching system for printer ink!

This write-up will give you an idea of where specialized knowledge and top quality material is required to fulfill specific needs in the process industry. It is not the job of a process engineer to get the job done by using more-and-more electric control equipment - NO - it is his / our responsibility to keep it as simple as possible which makes the system highly resistant against malfunction and defects - and absolutely cost-effective.

As an example to show what this means I am using a printer ink mixing & batching machine. Machines for production – batch production - of printer ink are specially designed as they need very reliable components with an extraordinary lifetime and perfect quality. A machine is only as good as the weakest component in it (see figure-1).

The parameters out of the production / batching process of the ink are not really sensitive as we mainly talk about ambient temperature around +20° to + 40°C. The cycle time is around 1 x / 5 minutes!

Chemical resistance is the major point:
• The standard ink compounds are not seriously aggressive and basic elastomere will work.
• It is the cheapest solution - EPDM! (of course FKM / Viton will do as well, but increases the costs)
• Problem: only the solvent which gives the ink the right consistency. For most

of the solvents as well EPDM is the right choice

Attention:
We have to take very special care of the circumstance that the described herein coaxial valves are fitted with EPDM Seals - which means these seals are not able to work with most of the common lubricants and use with the ink media also does not allow the use of Silicon as a lubricant. In maintenance work and / or exchange of the sealing sets great care has to be taken with the issue that no lubrication is used, otherwise the seals will expand under the influence of the lubricant and the coaxial valve will become stuck within a very short time and the seals will be damaged further as the valve is no longer moving!

In these ink batching machines we find quite a number of valves:
1. 3-piece stainless steel ball valves – sizes ranging from 1” up to 2”
2. Ball Valves – 2-piece body with female thread connection made of brass from 1/2” up to 2”
3. Coaxial-Valves ranging from ½” up to 2” with EPDM Seals.
4. NAMUR solenoid Valves

Figure 2 shows the installation - inflow - to one of the various batching stations. Figure 3 shows a coaxial valve for fast - ON / OFF action, responsible for opening and / or closing the media flow. Above each coaxial valve we can see a standard.
3-piece stainless steel ball valve and, as a specialty, these ball valves are equipped with a manual lever in a different position - and no positioner or process controller is installed!
The reason for the different positions is that the batching of the ink requires almost 10 different media with all having a different density as well as a different percentage in the finished batch, so it is necessary to adjust the inflowing quantity to the appropriate volume.
During the commissioning and start-up of the machinery all these valves are set according to the individual requirements and process parameters of each batching machine.
Of course this can also be done with sophisticated process controllers but this will increase the costs as well as the complexity of the control system and results in a tremendous increase to the investment in:
• Hardware
• I/O s in the PLC system
• Programming the Software
• And, last but not least, increasing the maintenance work, stock holding & much more.

Solving these requirements by using an electronic control system will lead to many more failure possibilities, at the same time influencing the possible reachable SIL - Level. The question of what SIL has to do with an ink batching machine is a good one, and the answer is as for the process itself: use simple, understandable and non-complex examples to explain an issue. With the example of the ink batching machine we can easily understand the problem we have to solve and the background. After a proper understanding of the easier problem we are able to apply it the same way to much more complex problems - which is real & practical

Meet Günter Öxler
Günter Öxler is a freelancer to the Process Industry and has a long history within the valve industry. He graduated in Process Engineering and Mechanical Engineering in Stuttgart, Germany, holds a MBA degree in VWA as well as a controlling degree and is a REFA specialist. For more than 25 years, Günter has worked for several companies in the valve business. He is also a member of the IWA, ISA and VDI German Engineer.
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One more time: keep it as simple as possible but efficient.

Figure 4