Integrating Valves and Actuators Optimizes Pneumatic Motion Control Efficiency

Integrated Valve and Actuator Control (IVAC) Simplifies, Enhances Pneumatic Control Systems
Historical motion control technology
The goal of moving things from one place to another efficiently has long been a human endeavor, driving progress from the invention of the wheel to the Industrial Revolution. Harnessing compressed air to lift, convey, push, open and close was in fact key to technological and industrial growth in the 20th century. Manufacturing, packaging and food processing are just a few industries that thrive because of pneumatic motion control.

However, traditional pneumatic technology is not free of challenges. Currently pneumatic control on machinery follows the pattern established years ago – a combination of valves or valve islands, actuators, flow controls and sensors along with the various connectors and accessories needed to make them all work together. In typical applications an average of 13 different components are required for each actuator function.

Common issues with industrial pneumatic motion control
Putting together a system from this many components builds in some inherent disadvantages and performance limitations.

First, there are multiple components to specify, acquire, install, maintain and replace. All of this consumes time, space and money.

Second, the actuator that moves the equipment and the valves that control the flow of air to the cylinders are often the last part of the machine to be installed. This means their placement is constrained by the machine design, resulting in inefficiencies and poor aesthetics.

Third, all these multiple components must be connected, requiring numerous tubes and wires. This complicates installation and maintenance and multiplies the number of potential failure points. It also makes cleaning more difficult.

Fourth, the size and complexity of the arrangement slows response times and wastes compressed air, increasing energy costs.

A new solution
Clearly, an integrated unit that combines the components and tubing in one module would be preferable. In fact, the demand for this solution is increasing in the food and beverage industry where hygiene is paramount and equipment, including actuators, is subject to frequent wash down. However, other industrial applications are subject to the inherent disadvantages of traditional pneumatic designs as well.

Prompted by customer feedback to address these challenges, Norgren, a global supplier of pneumatic motion and fluid control systems for over eighty years, set to work designing a module that could integrate all the components, connectors and tubing required.

Integrated Valve and Actuator Control (IVAC)
General description Working within the same footprint as a standard actuator, Norgren developed a modular motion control unit that combines the cylinder, pilot and control valves, position sensors and speed regulators in a single Integrated Valve and Actuator Control (IVAC) element.

In summary, the IVAC consists of
- Cylinder
- Pilot module seated on top with an M12 connection
- Control valve module encapsulating a glandless spool for directional control
- Adjustable speed and buffer cushioning for end-of-stroke damping
- Flow control for speed regulation
- Rear end cover with air supply port and mounting interface
- Integrated switches for position sensing
Figure 1 IVAC Exploded View

The configuration of all these functions in one efficient design results in an integrated unit with just one electrical connection, one compressed air connection and one exhaust port that fits in the same dimensions as a standard ISO 15552 or VDMA footprint actuator.
**Industrial and Cleanline models** By design, the IVAC is easier to clean than the standard array of cylinders, valves, connectors and accessories. The industrial, or semi-cleanline, model has external switches and an ingress protection (IP) rating of IP65. This means it is totally protected against ingress of solid objects, even dust, and can withstand low-pressure jets of water from any direction. This makes it easy to clean to the standards required in common industrial and manufacturing operations.

**Figure 2 Industrial IVAC**

For operations with high hygienic requirements and frequent washdowns typical of food handling, Norgren offers the IVAC in a cleanline version. With the integral switches (reed or solid state) and valve placed inside a smooth casing, there are no spaces or grooves to trap contaminants. The cleanline IVAC is rated IP67, meaning it can withstand not only water spray, but temporary immersion up to one meter deep. This is important where the IVAC is exposed not only to water for washdown but other liquids containing organic matter or sticky substances.

**Figure 3 Cleanline IVAC**
**Cylinder sizes** The IVAC is supplied with cylinders in standard ISO VDMA bore sizes ranging from 32 mm to 100 mm, the most widely used sizes. The integrated valves are sized to match the requirements of the cylinders.

Even with the valves and tubing integrated into one unit, the IVAC is designed to fit in the same footprint occupied by an existing actuator so it can be used to retrofit or upgrade a machine without additional engineering or design changes.

**Pilot valves** A module seated on top of the IVAC contains small pilot valves which are electrically operated. These valves pilot the movement of the main control valve that drives the cylinders. Combining the pilot valve module with the actuator module reduces tubing and space requirements. Only one M12 electrical connection is required. One pilot module can control multiple IVACs, so a cylinder-only version without the pilot valve module is also available.

**Glandless spool for valve functions** The IVAC relies on one of Norgren's key competencies, the glandless spool, for its valve functions. With the Teflon® coated inner and outer parts of the spool precisely matched, there are no rubber seals required. This gives the valve exceptionally long life, usually in excess of 200 million cycles, three to four times as many as a typical valve with a seal. However, should maintenance be desired, for example to change the functionality of the valve, the modular design of the IVAC makes it simple to remove the spool and install a new one.

**Flow controls for speed regulation** Typical actuators have a port for attaching a banjo to control the airflow in order to regulate the cylinder speed. In the IVAC, the flow control is built into the actuator end caps, so there is no protrusion. It also makes the flow control tamper resistant and reduces the chance of random operator error.

**Adjustable speed and buffer cushioning for end-of-stroke damping** The cylinder in the IVAC slows at the end of the stroke to minimize impact with the end cap. When the cylinder does reach the end of the stroke, it touches a buffer rather than making metal-to-metal contact, so there is no wear of metal parts. The cushioning speed and pressure are adjustable, according to the application.

**Reed or solid state switches for piston position sensing** When the actuator in the IVAC moves, it sends a signal back to the programmable logic control (PLC). The switch verifies that the actuator has moved. This switch is integrated inside the IVAC casing for the cleanline model in order to keep the profile smooth for easy cleaning and to prevent tampering. The switches are accessible under a screw head, should adjustments be required.

**ISO mounting rear end cover** The rear end of the IVAC comprises the air supply port and an ISO 15552 mounting interface. All connections are at one end of the IVAC, simplifying installation and streamlining the machine’s appearance.

**Benefits to OEMs and end users**

**Reduced energy consumption** Eliminating the tubing between valves and cylinders means the only air required for actuation resides in the cylinder itself. Air consumption per mm of stroke is optimized. Tests were conducted comparing the IVAC with a standard actuator driven by a valve island. The standard configuration used five meters of tubing with an inner diameter of 6mm. Test pressure was 6 bar and temperature was 20 degrees C. After 50 cycles, the IVAC had consumed 82 nominal liters of air, less than half of the 166 liters consumed by the standard actuator system.

The following table shows an example of how much money can be saved by substituting a single IVAC for a standard actuator installation. For operations that have dozens or even hundreds of actuators and run two or three shifts instead of one, the savings multiply exponentially. Additional savings not shown here come from the elimination of potential leak paths and wasted compressed air. The payback period for the IVAC can be calculated using actual energy costs and machine running time.
Our policy is one of continued research and development. We therefore reserve the right to amend, without notice, the specifications given in this document.

Table I: Sample Energy Savings Calculator

<table>
<thead>
<tr>
<th></th>
<th>Standard actuator driven by valve island</th>
<th>IVAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bore size</td>
<td>40 mm</td>
<td>40 mm</td>
</tr>
<tr>
<td>Stroke length</td>
<td>100 mm</td>
<td>100 mm</td>
</tr>
<tr>
<td>Piston rod diameter</td>
<td>25 mm</td>
<td>25 mm</td>
</tr>
<tr>
<td>Pressure</td>
<td>6 bar</td>
<td>6 bar</td>
</tr>
<tr>
<td>Tube ID</td>
<td>6 mm</td>
<td>6 mm</td>
</tr>
<tr>
<td>Tube length</td>
<td>5 m</td>
<td>0 meters</td>
</tr>
<tr>
<td>Number of cycles</td>
<td>30/minute</td>
<td>30/minute</td>
</tr>
<tr>
<td>Machine running time</td>
<td>8 hours/day</td>
<td>8 hours/day</td>
</tr>
<tr>
<td>Running days</td>
<td>225 days/year</td>
<td>225 days/year</td>
</tr>
<tr>
<td>Energy costs</td>
<td>$0.07/kilowatt hour</td>
<td>$0.07/kilowatt hour</td>
</tr>
<tr>
<td>Compressed air consumption</td>
<td>100 liters/minute</td>
<td>49 liters/minute</td>
</tr>
<tr>
<td>Compressed air use/year</td>
<td>10,800,000 liters</td>
<td>5,292,000 liters</td>
</tr>
<tr>
<td>Annual cost saving per actuator</td>
<td></td>
<td>$142.66</td>
</tr>
</tbody>
</table>

**Reduced installation time and cost** The IVAC module greatly simplifies installation, reducing labor time and cost. The IVAC eliminates the need for mounting valve islands to the machine framework or inside a cabinet. There is no pipework to run around the machine connecting each valve to each actuator. All that is required is a single ring main to provide an air supply to each IVAC unit. The result is simple, low cost installation of pneumatic components, as well as a cost-effective retrofit solution.

Figure 4 IVAC Installation

No mechanical design changes Norgren was able to engineer all the components that make up the IVAC into a unit that conforms to the latest ISO VDMA dimensions. This means the IVAC can be used in current machine designs without design changes. It also makes it highly suitable for retrofits, replacing the actuators and the excess tubing on existing equipment.
The combination of low installation costs and improved performance means the reduction of lifetime operating costs of the machine far outweighs the cost of the retrofit.

**Simplified product selection and ordering** Instead of compiling and evaluating cylinders, valves, sensors and accessories and ordering from multiple suppliers, OEMS and maintenance engineers can select one item – the IVAC. They simply specify the bore and stroke required for their operation. Norgren has already optimized the valves for each IVAC size, eliminating the practice of oversizing the valve, which increases operating costs by wasting compressed air.

**Increased uptime: cleanability** Equipment actuated by the IVAC can be cleaned and returned to service much more quickly than machines using the traditional pneumatic arrangement. Since the IVAC integrates the valves into the same unit as the actuator, there are no separate valves or valve islands or cabinets that house them to clean. Eliminating excess tubing also makes cleaning easier and faster.

The IVAC design is inherently easier to clean than traditional systems, and the cleanline IVAC takes this one step farther. The design was developed in conjunction with Ecolab, a supplier of cleaning fluids, to maximize cleanability. The cleanline’s 3.2 micron surface finish resists bacteria formation. The hard anodized barrel and end caps are corrosion resistant and present a smooth profile for easier washdowns.

**Increased uptime: simplified maintenance** The IVAC also increases productivity because its integrated configuration reduces the downtime required to diagnose a problem and put equipment back into operation. When the machine function in a conventional system fails, the equipment must be stopped while the actuator, valve, sensor and connection are all evaluated. In a system using an IVAC, the operator simply replaces the IVAC unit, restarts the machine and diagnoses the problem offline.

The modular construction of the IVAC also makes it simple to switch out components if necessary and return the unit to service more quickly.

**Faster response times** The time it takes for the actuator to move once an electrical signal is sent is much shorter for the IVAC than for a conventional actuator. Since the valve and cylinder are integrated, no time is required for air to fill the tubing between the valve and the actuator.

**Improved speed control** Flow controls are built into the actuator end caps, providing improved speed control by greatly reducing any air spring effect, especially when compared to the sandwich flow controls on valve islands. The integrated design eliminates the inefficiency inherent in controlling flow from a location removed from the actuator.

**Multipole or fieldbus connectivity** There is only one M12 connection for electrical output signals to the solenoids and input signals from the sensors. This can be used to connect into a hardwired system or to plug directly into a fieldbus system no matter which protocol is being used.

Figure 5 Splitter Cable
Safety  The IVAC integrates a pressure protection feature, which means the unit can be disassembled or removed safely without risk that trapped compressed air will cause damage or injury.

Improved machine aesthetics  The way a machine looks is more and more important. A sharp, uncluttered appearance gives the OEM equipment a more sophisticated look and for end users it makes plants look cleaner and more advanced.

Figure 6  IVAC in Kegging Machine

Because the pneumatic system is often the last piece of a machine to be installed, a traditional system is both visible and unsightly. Valve islands placed wherever they can fit look “added on” and excess tubing can look sloppy. The beauty of the IVAC is that all this is contained in one smooth package. This gives the machine a sharper, cleaner appearance that connotes quality.

IVAC: the future of pneumatic actuation
While the history of pneumatic actuation has been one of technological progress, it has been plagued by some inherent challenges: multiple components, complicated connections and complex installation and maintenance requirements. Recently, new demands for reduced air and energy consumption, faster response times, better hygiene control and improved aesthetics added to the impetus for an integrated solution.

The simplicity of the IVAC solves many of the problems presented by conventional pneumatic installations. It reduces the number of components required to one, saving time, space and money. It improves speed and efficiency while reducing size. It simplifies installation and maintenance. It improves machine and plant appearance. Most importantly, it reduces operating costs by reducing consumption of compressed air and energy.

Integrating all the components required for motion control – cylinders, valves, sensors, controllers and tubing – into one unit has clear advantages for food and beverage processing and other caustic environments. But the benefits carry over into any application where simplicity, size, energy savings and efficiency are important.

Richard Bull
Regional Product Marketing Manager - Americas
2012

“Teflon” is a registered trademark of the E.I du Pont de Nemours and Company