Control Valve Actuator Options

Today’s Actuators Offer Imposed Performance With Lower Life-Cycle Costs.
The Challenge Is Choosing the Right One for the Application.

George Ritz, Contributing Editor

This article is the first in a two-part series examining the state of the art in control valve actuators and their current application guidelines in the process industries. Part I deals with the mechanical aspects of valve actuator options. Part II, in next month’s issue of CONTROL, will cover the benefits of using the latest generation of smart, digitally controlled actuators.

Over the past several years, valve actuators have received relatively little attention while process control specialists concentrated on controllers, sensors, and other components of the control loop. This is borne out by the unglamorous nickname “pig iron” assigned to the actuator/control valve unit. With the onset of the smart-valve generation, it suddenly appears that the control valve actuator may get more respect along with its new electronics degree.

Today the available actuator menu includes four basic types of mechanical actuators (Table I) which recently have been enhanced with onboard micro-processors. Some of the improvements available to end users include a wider source of power options, quicker response, tighter control, easier maintenance, improved life cycle costs, and a host of others.

Selecting the proper actuator for a given application depends heavily on matching it to the valve or other driven equipment. The process control engineer is well advised to take advantage of vendors’ experience gained over many years of selecting the most effective valve/actuator package for a wide variety of service requirements.

A good example of this is the recent rise in popularity of the pneumatic piston actuator and quarter-turn valve combination. The package offers many advantages (see Table I) along with excellent control, compact silhouette, easier maintenance, and most importantly, improved valve-stem emissions control.

Application checklist

A quick review of the actuator characteristics listed in Table I indicates which actuator type is best suited for a particular application. For example, the spring and diaphragm (S&D) and pneumatic piston actuators (Table I) which recently have been enhanced with onboard micro-processors.

Table I. Mechanical Valve Actuator Characteristics

<table>
<thead>
<tr>
<th>TYPE SOURCE</th>
<th>POWER SERVICES</th>
<th>RANGE OF TORQUE CAPABILITIES</th>
<th>THRUST OR APPLICATION</th>
<th>VALVE TYPE</th>
<th>STIFFNESS</th>
<th>MATERIALS OF CONSTRUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring and diaphragm</td>
<td>Air to 30 psig, spring return</td>
<td>Throttling, on-off general service</td>
<td>Light to moderate</td>
<td>Vertical direct, rotary with linkage</td>
<td>Low to moderate</td>
<td>Various elastomeric diaphragms and frame materials</td>
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<tr>
<td>Pneumatic Piston</td>
<td>Air to 50-150 psig, opposed pistons</td>
<td>Throttling, on-off general service</td>
<td>Moderate to high</td>
<td>Vertical direct, rotary with linkage</td>
<td>Moderate to high</td>
<td>Available in CS, SS, corrosion-resistant materials</td>
</tr>
<tr>
<td>Electric Motor Operated</td>
<td>Electric motor and gear train</td>
<td>Limited throttling good on-off service</td>
<td>Very high</td>
<td>Best on larger remote rotary valves</td>
<td>Very high</td>
<td>CS, SS, aluminum and epoxy filled composites</td>
</tr>
<tr>
<td>Electro-Hydraulic</td>
<td>Electric motor and pump</td>
<td>Good in throttling services</td>
<td>Moderate to very high</td>
<td>Vertical direct, rotary w/ linkage, handles dampers well</td>
<td>High</td>
<td>Available in various materials to suit environment</td>
</tr>
</tbody>
</table>
matic piston (PP) actuators are well suited for low to moderate thrust required by small to medium sized valves. This covers about 80% of process plant applications.

Electric motor and electrohydraulic actuators’ strong points are high thrust for larger valves where there is no convenient air supply. This makes them most appropriate in large utility, pipe line, and remote location services.

The lack of inherent fail-safe operation continues to limit the application of electrically-driven actuators from capturing more of the lower-thrust, hazardous-service applications that are so prevalent in process plants. Electrohydraulic actuators can meet the fail-safe requirement with an added spring in one of the pistons, so their use can be advantageous in solving some unique positioner applications within the process plant.

The key elements to consider when selecting an actuator/control valve combination include:
- Type of service-on/off or throttling;
- Power source-air, electric, or other;
- Loop stability requirements;
- Input signal compatibility;
- Actuator thrust requirements;
- Size and weight considerations;
- Safety requirements (e.g. fail-safe operation, area classification, etc.);
- Operating environment-heat, vibration, corrosion, etc.;
- Dead band and hysteresis factors;
- Use of accessories (e.g., positioners, micro switches, handwheels, microprocessors, etc.);
- Ease of maintenance; and,
- Economic factors-first cost, maintenance costs, and life-cycle costs.

The type of service has a direct bearing on the selection of the actuator for on/off or throttling service. Any of the actuators types listed in Table I are suitable for on/off service. Operating speed, tight shut-off, and fail-safe operation are also vital in this type of service.

Throttling action introduces the accuracy factor; the valve must be able to hold intermediate control points in response to a variable signal. The workhorse in this application for light thrust units is the S&D actuator, which may do the job without a positioner. If high thrust is required, a double-acting PP actuator with a suitable positioner will probably offer the most reliable and economical approach.

For high thrust, fail-safe operation as well as close control in a difficult environment-the more expensive electrohydraulic actuator may be appropriate. More challenging control application requiring greater loop stability might warrant consideration of a “smart” actuator with an onboard microcomputer. (These devices and their advantages will be covered in more detail in the second article of this series.)

Size and weight are the main disadvantages of the S&D actuator (and to a lesser degree the PP actuator) on large-sized valves. If the application area is not restrictive to a large silhouette, the S&D or the PP actuator is probably the way to go. The moderate cost of a supporting structure along with the higher actuator cost may still not be great enough to upset the economics of the S&D/PP selection.

One major area crucial to effective actuator selection is its ability to over-come stem resonance problems to maintain the process variable close to the control point. Factors affecting resonance (valve hunting) problems

<table>
<thead>
<tr>
<th>FAILSAFE ACTION</th>
<th>WEIGHT PER UNIT FORCE</th>
<th>PHYSICAL ENVELOPE</th>
<th>INITIAL COST</th>
<th>MAINTENANCE COST</th>
<th>AVAILABLE ACCESSORIES</th>
<th>RELIABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inherent due to built-in spring</td>
<td>high in large sizes</td>
<td>Require high vertical clearance</td>
<td>Low</td>
<td>Low</td>
<td>Positioners, limit switches, technology microprocessors</td>
<td>Excellent, simple, mature technology</td>
</tr>
<tr>
<td>Require spring or reserve air cylinders</td>
<td>Low</td>
<td>Moderately compact</td>
<td>Low to moderate</td>
<td>Low to moderate</td>
<td>Positioners, limit switches, technology microprocessors</td>
<td>Excellent, mature technology</td>
</tr>
<tr>
<td>Require stand-by power source</td>
<td>Moderate to high</td>
<td>Compact</td>
<td>High</td>
<td>Low to moderate remote operators positioners</td>
<td>Limit Switches, microprocessors, technology</td>
<td>Good depending on power source,</td>
</tr>
<tr>
<td>Require stand-by power source or spring</td>
<td>Moderate</td>
<td>Require high vertical clearance</td>
<td>Highest</td>
<td>Highest switches</td>
<td>Positioners, limit enhancement, multiple moving parts</td>
<td>Higher maintenance,</td>
</tr>
</tbody>
</table>

The table above shows the various fail-safe actions, weight per unit force, physical envelope, initial cost, maintenance cost, available accessories, and reliability of different types of actuators. It helps in making an informed decision based on the specific requirements of the process plant application.
Involving stiction (valve stem friction), actuator stiffness, stroking speed, plug-head buffeting, hysteresis, and other factors. Most of these problem areas, which are inherent in various actuators to some degree, are handled by effectively matching the actuator with a valve positioner. The applications engineer should do the best possible job of picking the most suitable actuator for the service—don’t unload any inherent actuator problems onto the positioner as a bolt-on cure-all.

**Sound decision-making**

Champion Paper, Inc. has discovered the importance of integrating a sound actuator/control valve unit in the control loops at its integrated paper mill in Houston, Texas. Champion’s corporate goals of product improvement, customer satisfaction, and rightsizing led the controls group to the realization that control valve performance offered the best opportunity for improved mill performance with the least capital expenditure.

“We found that 80-90% of our control problems were in control valve performance,” says control engineer Don Jordan. “Faulty control valve operation cannot be tweaked or adjusted out by the controller alone. Our approach has been to work with EnTech Control Engineering (a controls consultant based in

<table>
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<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
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<tr>
<td>SPRING AND DIAPHRAGM</td>
<td>Limited first cost</td>
</tr>
<tr>
<td>Lowest first cost</td>
<td>Limited force output</td>
</tr>
<tr>
<td>Operating simplicity and reliability</td>
<td>Large size and weight per unit force</td>
</tr>
<tr>
<td>throttles well without positioner</td>
<td>Low stiffness</td>
</tr>
<tr>
<td>Inherent fail-safe operation</td>
<td>Does not handle high ambient temperatures well</td>
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<tr>
<td>Low air pressure supply</td>
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<tr>
<td>Easily adjustable to local conditions</td>
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<tr>
<td>Few moving parts</td>
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<tr>
<td>Ease of maintenance</td>
<td></td>
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<tr>
<td>Most mature technology</td>
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<tr>
<th>PNEUMATIC PISTON</th>
<th>Requires spring or accessories for fail safe operation</th>
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<tbody>
<tr>
<td>High force and torque capacity</td>
<td>Requires high pressure air to operate</td>
</tr>
<tr>
<td>Moderately compact silhouette</td>
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<tr>
<td>Low weight to power ratio</td>
<td></td>
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<tr>
<td>Can stand high ambient temperatures</td>
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<tr>
<td>Fast stroking speed</td>
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<tr>
<td>Good throttling control</td>
<td></td>
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<tr>
<td>Few moving parts</td>
<td></td>
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<tr>
<td>Relatively high actuator stiffness</td>
<td></td>
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<tr>
<td>Available in smart valve configuration</td>
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<tr>
<td>Available in corrosion resistant materials</td>
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<tr>
<th>ELECTRIC MOTOR DRIVE</th>
<th>High first cost</th>
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<tbody>
<tr>
<td>High force output</td>
<td>Not inherently fail safe</td>
</tr>
<tr>
<td>Very high stiffness</td>
<td>Limited duty cycle of motor drive</td>
</tr>
<tr>
<td>Compact silhouette</td>
<td>Multiple moving parts</td>
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<tr>
<td>Slow stroking speed (if required)</td>
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<tr>
<td>Does not require air supply or I/P</td>
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<tr>
<td>Corrosion-resistant seals and construction are available</td>
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<tr>
<td>Infrared remote setting unit available</td>
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</tr>
<tr>
<td>Relatively mature technology</td>
<td></td>
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<tr>
<td>Good on large valves in remote locations</td>
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<thead>
<tr>
<th>ELECTROHYDRAULIC</th>
<th>Highest first cost</th>
</tr>
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<tbody>
<tr>
<td>High force output</td>
<td>Multiple moving parts, highest maintenance</td>
</tr>
<tr>
<td>High actuator stiffness</td>
<td>Fails safe only with spring or accessories</td>
</tr>
<tr>
<td>Excellent throttling ability</td>
<td>Least mature actuator technology</td>
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<tr>
<td>Fast stroking speed</td>
<td></td>
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<tr>
<td>Does not require air supply or I/P</td>
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<tr>
<td>Accepts harsh environments well</td>
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This solar powered electrohydraulic valve actuator develops 4,000-lb. of thrust and is used to control flow through a remote Venezuelan oil pipeline. (Rexa)

Toronto, Ontario) to do a plantwide audit on our control loops and train our people in correcting the problem areas. EnTech has developed a control valve dynamic specification, which we have found very valuable in solving our control valve tuning problems”.

EnTech has found that most control valve problems start with erroneous control valve selection during initial design. These problems get worse over time due to poor tuning and maintenance. The primary design error occurs when pyramiding capacity safety factors are cranked into the original specification of the control valve. That forces the valve to operate in its lower range most of the time.

Even periodic bench testing is not a complete solution to control valve problems because bench conditions differ significantly from actual operation. Existing loop problems and valve-disk buffeting can cancel the best of bench testing intentions. Continual auditing of control valves under operating conditions offers the most reliable solution to catching most of the problems.

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<td>CCI Atlanta Tel: (770) 965-9870</td>
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<td>Fax: (770) 995-9905</td>
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*Primary Address For Country