AUTOMATION OF VALVES
SELECTION OF ACTUATORS

EXaL TECHNOLOGY

CONTENT

		Page
1	Introduction	2
2	Selection of actuators	3
3	Manual actuators	4
4	Hydraulic actuators	5
5	Pneumatic actuators	6
6	Electric actuators	7
7	Other type of actuators	8
8	Fire protection	8
9	Information required for the selection of an actuator	9
10	Automation of actuators	10

1. Introduction

For the actuation of industrial valves in the industries like oil & gas, mining, energy, chemical, pharmaceutical, food & beverages. As examples can be used many types of actuators, like manual, electric, pneumatic, hydraulic, etc.

An actuator is a component installed on the top of the valve for automatically moving and controlling the valve. The performance of a valve is largely dependent on its actuator. Several factors are important to consider when selecting an actuator.
The most important ones are:

- Available energy supply (electric, pneumatic, or hydraulic) at the installation site at reasonable costs
- Frequency of operation
- Critical and security functions required for the operation.
- Required torque by the valve to be automated, which is directly related to size and operating pressure.

The valves must perform several functions, some of them are:

- To move the valve to the required position, according to the requirements of operation
- To keep the valve in the desired position (open, closed, or intermediate)
- Provide the necessary force or torque to close the valve completely so the required leakage level can be achieved.
- To secure the complete opening or closing of the valve, or in the case of control valves to maintain the desired position.
- When required, to secure that the valve is brought to a safety position in case of emergency or when the air, oil or electrical supply fails.
- Secure that the valve is operated in the required time for opening or closing.
- Be able to communicate remotely with a control room.
- In case of electric and hydraulic actuators the explosion protection regulations must be performed, especially in the oil & gas industry.

In general, the standard parameters to select an actuator are: availability of an energy source, required torque and size of the valve, failure position, actuation time and frequency, simplicity of operation, control accessories, installation requirements (e.g in explosive area) and cost

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2. Selection of actuators

The following parameters can affect the type of actuator that should be selected for a valve:

1. **Availability at the site of an energy supply:** pneumatic, electric, or hydraulic

2. **Size and required torque:** Large size and high-pressure class valves (such as a 30″ Class 1500 ball valve) require high torque for operation. Selection of a very large pneumatic actuator for such a large valve is not economical, a hydraulic or electric actuator can be better choice in this case.

3. **Failure mode**: If the valve has to be moved to a safe position in case of an emergency, actuators with spring return functions should be used, which means that upon power or signal failure, or emergency signal, the spring moves the valve to a predetermined safe position (open or closed)

4. **Speed of operation**: Electrical actuators operate valves more slowly than pneumatic and hydraulic actuators, so an electrical actuator may not be an appropriate choice if an operations speed of 1 in./sec or faster when this is required by the process.

5. **Frequency and ease of operation**: when a valve must be operated frequently it makes sense to use an actuator instead of manual operation.

6. **Control accessories**: Control accessories in electrical actuators are integrated into the actuator, unlike pneumatic and hydraulic actuators. In fact, electrical actuators do not require any space for control accessories, which is an advantage.

7. **Hazardous areas**: Different hazard zones and classes are defined based on present of flammable gases or vapours. In this case special considerations must be taken for all additional accessories when pneumatic or hydraulic actuators are used. At the electric actuators this parameter is simple because normally all electric components are encapsulated in the same housing, so that only one component has to be for installation in hazardous areas, because it is understood that all the internal components comply with the regulations.

8. **Costs**: If compressed air is available, and the valves to be automated are small or middle size, and the pressure class is not to high, pneumatic actuators is the most economical solution. If electrical power is available, and the valves have large diameters or high-pressure class, and there is no requirement of fast actuation and fail-safe function, electric actuators are the most economical solution.
   NOTE: Electric actuators with spring return fail safe function are available but restricted in the torque.
   If hydraulic oil is available, the valves are of large size, high pressure class, quick operating time is required, as well as fail safe functions, hydraulic actuators are the most economical solution.

The selection of the most optimal actuator for a specific application must be done taking all the above-mentioned considerations.

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3. Manual actuators

Valves can be actuated manually with a lever or with a manual gear.
The actuation with lever is restricted to small valves with reduced torque, the manual force that can be applied on the lever is restricted.
The operation with gears allows the use of manual operation for any size and torque value, but the operation time, depending of the ratio of the gear, is normally very long.
Valves which are operated manually by an operator, must be freely accessible.
An installation of a position indicator is possible at most of the manual actuators.

Advantages of manual actuators

- Low cost, wide range of torque

Disadvantages of manual actuators

- An operator must be physically at the valve site for the actuation.

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4. Hydraulic actuators

Hydraulic actuators are normally used for large size and high-pressure valves, where the required torque is big, as well as when it is required to bring the valve into a safe position in case of emergency or power failure.
They require oil at high pressure, which can be provided by HPU´s (Hydraulic Pressure Units) which can be installed separately to the actuator and provide hydraulic oil to one or more actuators installed at maximal 100 m. It is also possible to install the HPU directly on the actuator.

Advantages of hydraulic actuators:

- Hydraulic actuators are smaller than pneumatic actuators since oil pressure is higher than compressed air, so less oil is required for moving the spring compared to air. However, the hydraulic actuator uses higher pressures. For example, the air pressure in pneumatic actuators is 5.5–9 bar, which is much lower than oil pressure which is normally between 100 and 200 bar.
- Hydraulic actuators are good choice for large size and high-pressure class valves having high force or torque requirements for operation at high speed and fail-safe function.
- Hydraulic actuators are more precise in the positioning of the valve than pneumatic actuators since hydraulic oil is not compressible.
- Hydraulic actuators have a higher degree of corrosion protection compared to air or gas, which is important in corrosive environments such as offshore.

Disadvantages of hydraulic actuators:

- They require hydraulic oil supply by an HPU (Hydraulic Power Unit), external or integrated into the actuator. This increases the cost of the system.
- The high pressure of hydraulic fluid is complex to manage, requiring many safety and environmental precautions.
- Special features like partial stroke test can only be achieved with additional equipment, like positioners or mechanical partial stroke devices.
- The cost of the complete system of hydraulic actuators is higher compared to pneumatic or electric actuators.

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5. Pneumatic actuators

Pneumatic actuators are normally used for small and middle-sized valves, where the required torque is not so high. They are used when there is a requirement of high operation speed and when a failsafe function in emergency or when the air supply fails.
In small valves they are the cheapest solution for the actuation of a valve, especially when compressed air is available at the plant.
The required air supply limits the distance between actuators, normally pneumatic actuators are used in plants, and less in pipelines. An important factor for the correct functioning of pneumatic actuators is the air or gas supply, the dimensioning of the supply must consider the requirement of all the actuators and other users of air This fact that very often is underestimated and can produce severe problems when at the plant many users of compressed air consumes it at the same time.

Advantages of pneumatic actuators:

- Pneumatic actuators run on compressed air, which is a readily available safe fluid and environmentally friendly unlike oil, so they could be the best option in hazardous areas.
- Control systems of pneumatic actuators are relatively inexpensive and more compact compared to hydraulic actuators.
- This actuator provides high speed operation and returning to a safe position in case of emergency and when the air supply is lost.

Disadvantages of pneumatic actuators:

- Pneumatic actuators require more space when installed on valves of medium or large diameter or at high pressure ranges, especially when they have a spring return fail safe function.
- Air is a compressible fluid, which can jeopardize the accuracy of the positioning of the valve.
- Special features like partial stroke test can only be achieved with additional equipment, like positioners of mechanical partial stroke devices.

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6. Electric actuators

Electric actuators can be used anywhere, they only require electric power, which normally is easy to transport, at least much easier than air or oil.
Electric actuators can operate valves with a quarter turn movement (90°) for valves like ball, plug and butterfly, a multi-turn movement for valves like gate or some globe valve types and linear movement for valves like globe or gate valves.
They can operate nearly every type, size, and pressure class valve, either directly or through a gear.

Advantages of electrical actuators:

- Electrical power is relatively inexpensive.
- Electrical actuators provide good accuracy on valve movement and functioning, and it is possible to monitor the opening percentage of the valve without additional equipment.
- All control components are integrated into the actuator, unlike pneumatic and hydraulic actuators.
- Special features like partial stroke test are normally standard
- Internal diagnostics of the actuator are normally standard
- electrical actuators are cheaper, more compact, and lighter than hydraulic actuators.

Disadvantages of electrical actuators:

- Electric actuators cannot operate a valve in short times like hydraulic or pneumatic actuators
- Electrical actuators contain more complex and sensitive components compared to pneumatic and hydraulic actuators.
- Electrical actuators are not as economical as pneumatic actuators

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7. Other types of actuators

For special applications following actuators can be used:

- Gas over oil
- Direct gas operated
- Subsea

Gas over oil and gas operated actuators are used in gas pipelines in which the transported gas is used to supply the actuator.
Direct gas operated actuators are used in gas pipelines, but the local regulations for these types of application must be considered (emission of gas to the atmosphere)
For subsea installation manual gears and hydraulic actuators are the most common ones, but the special installation and operation conditions must be taken into account during the selection of the correct actuator, for example the possibility to actuate the valve with a ROV (Remote Operated Vehicle) or with other means.

8. Fire protection

When the valves and the actuator are installed in hazardous areas it may be suitable to protect them in case of fire. This protection should permit the function of the valve also when it is surrounded by fire. The valve itself for these applications is normally fire safe, which means that without further protection the function is guaranteed for at least one function, and the hermeticity towards the environment is maintained.
Actuators normally do not have this characteristic, so an additional protection may be required.
This protection can be achieved by:
Covering the actuator completely with fire protection blanket or installing the actuator into a fire resisting box. Normally these blankets or boxes are tested to a temperature of more than 1.000°C during 20 minutes, temperature and exposure time which should not affect the actuators performance. The blankets are normally installed on site after the installation of the valve/actuator assembly into the pipe.
To include the valve into the protection is possible, but it has to be taken care that the valve and the actuator have separate fire protections, to prevent a heat transfer from the valve to the actuator during normal service.

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9. Information required for the selection of an actuator

For the selection of an actuator to be mounted on a valve, following information is required:

1. Torque or force values required by the valve at the maximum operating conditions.
   - Break to close
   - Run to close
   - End to close
   - Break to open
   - Run to open
   - End to open
2. MAST value (Maximum torque that the valve stem can resist)
3. Type of actuator required (electric, pneumatic, hydraulic)
4. Operating time to open and to close the valve
5. Service type like SDV (Shut down valve), ESDV (emergency shut down), flow control, etc.
6. Mechanical connection between valve and actuator (according to ISO 5211 or with a drawing of the top works of the valve).
7. Quantity of expected operations in a certain period.
8. For modulating service, the type of control required.
9. Ambient temperature range
10. Environnemental conditions like agressive ambient (e.g. marine), height above sea level, etc.
11. Installation / protection system of the automation components
12. Requirement of failsafe position in case of emergency or failure of the supply.

Note: Depending of the required actuator, additional information may be necessary.

For the operation of the actuators of valves from a centralized control room following considerations must be followed:

- Information that is sent from the valve/actuator to the control room
- Information which sent from the control room to the valve/actuator
- Technology used for the information transfer

Information from the valve/actuator to the control room

- Position of the valve (open, close, or intermediate position)
- Diagnostic information of the actuator

Information from the control room to the valve/actuator

- Order to bring the valve to a certain position (open, close, intermediate position)
- Special actions, e.g. partial stroke test.

Data transfer technology

- Conventional analog and digital signals
- Bus systems: Profibus, Fieldbus Foundation, HART, MODBUS, etc.

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10. Automation of actuators

For the automation of the actuation of valves, a number of components are required, depending on the required functions, which are mainly:

- On-off service
- Modulating service

Components are required depend on the function and the type of actuator selected.

Automation of manual actuators
Because the action to move the valve is done manually by an operator, what can be done additionally is to send a signal of the position of the valve to the control room.
A partial stroke test can be done using a mechanical manual partial stroke device.

Automation of hydraulic actuators
The operation of a hydraulic actuator is done through an HPU (Hydraulic Power Unit), either installed separately to the actuator or integrated into the actuator.
The HPU has, for the main function, a hydraulic pump, which brings the hydraulic pressure to the operating pressure of 100 up to 200 bar (normally), and the necessary solenoid valves for the control. Additionally, supervision elements of the hydraulic system are normally used, like pressure measurement, oil level, etc.
When a certain amount of actuation cycles must be secured also when the hydraulic oil pump is not working, e.g. because of a power loss, pressure reservoirs must be included.
For the position indication, limit switches or positioners are installed on the actuator.
Remote partial stroke test requires a positioner or a limit switch box with this feature.

Automation of pneumatic actuators
For the operation of a pneumatic actuator compressed air in enough quantity and pressure is required. Components like filter/pressure regulators, air tanks as reservoirs in case of failure of the air supply are normally used. For the control function solenoid valves, booster valves and shut off valves must be defined according to the service.
Additional safety components like fire fuses are optional and used when the specific local conditions require them.
For the position indication, limit switches or positioners are installed on the actuator.
Remote partial stroke test requires a positioner or a limit switch box with this feature

Automation of electric actuators.
Normally electric actuators include all the required functions for the service, including the partial stroke test and diagnostic information that can be sent to the control room. It is necessary to define the function (on-off or modulating) and the service type of the motor (S2 or S4)

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