

Enumeration of Supervisory Control and Data Acquisition Systems for Pneumatic Actuated Knife Gate Valves with Fail Safe Systems

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ABSTRACT

Any flow line has a specific intent. As a result of accurate input of various parameters like flow rate, flow temperature and so on, the intended chemical reactions or other output actions can be carried out successfully. Energy is a basic requirement to initiate, sustain and conclude a flow. This energy can be in various forms and it is a system requirement to supply continuous energy to ensure energy conversion with minimum entropy change. While planning a project, these considerations need greater attention as a part of risk assessment considering unlikely events like failure of electrical power or any other source of energy. This paves way to design of systems considering fail safe conditions. Supervisory control and data acquisition systems can add an additional dimension to the effectiveness of these systems. This paper intends to highlight enumeration of Supervisory Control And Data Acquisition system for various fail safe systems considering various conditions. A number of possibilities emerging from the three types of failures namely electric current, air supply and a combination of both have been considered to satisfy the three fail safe conditions of fail to open, fail to close and fail to stay put. A conclusion shall be drawn thereafter to get a generalized idea of the design of Supervisory Control And Data Acquisition systems for fail safe systems.

KEYWORDS: Valve, Control, Data, Actuation, Automation, Fail safe

INTRODUCTION

Pneumatic operated Knife Gate Valves are recently gaining larger preference due to their adaptability with supervisory control and data acquisition systems i.e. SCADA. With the help of various additional accessories, a wide range of parameters related to the flow can be controlled at the click of a button. SCADA has indeed eased the working of manually operating the valve situated at a remote location. With the contemporary technology, it is possible to control and supervise an actuator located miles away with the help of linked networks through SCADA.

A. Need for SCADA in failsafe systems

Knife Gate Valves are used in a wide range of applications ranging from powders and slurries to chemicals and reactive materials. The success of every process depends heavily on the precision and up to a greater extent, the accuracy of the process parameter that has been maintained during the course of the fluid flow through the line. Depending on such studies, there are requests from the end users for provision of a failsafe system in the valves.

SCADA can provide a dual benefit in terms of comprehension and control. By this, it is intended to initiate immediate action from a control room located at a distance from the site. Additionally, one can monitor and initiate corrective actions without the requirement of physical presence of technicians thereby paving way towards a sustainable system.

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Fail safe systems ensure supply on required energy of actuation to satisfy the required fail condition as demanded by the application.

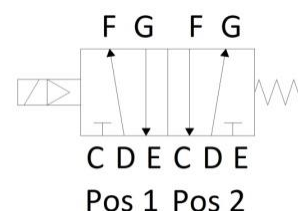
B. Auxiliary equipment and pneumatic circuit accessories

As stated earlier, fail safe systems play the role of an external source of energy or actuation so that the desired action is performed. Certain accessories are necessary for this action which have been elaborated as follows.

B.A. Solenoid operated Direction control Valve

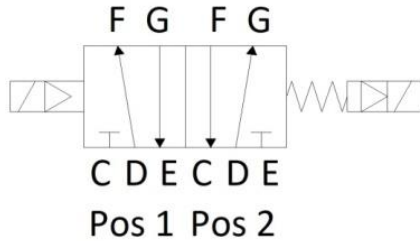
These direction control valves play the role of channelizing the air in a desired manner so as to carry out actuation of a pneumatic cylinder actuator. This study shall be limited to linear double acting pneumatic cylinder actuators only.

Following figure shows a 5/2 way single coil spring return solenoid valve.



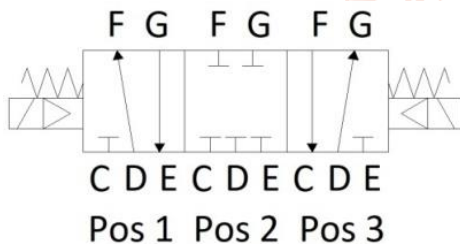
In this type, there are five ports and two positions. The ports of the actuator are connected to F and G while depending on the position, ports C, D, E may perform the role of inlet, exhaust and shut off. On energizing and de-energizing the coil, the mechanism shifts back of forth to facilitate opening and closing of the pneumatic actuated valve.

Following figure shows a 5/2 way double coil spring return solenoid valve.



The construction of this type of solenoid is similar to that of the previous with an additional separate coil for each position added to it. It is possible to set either of the positions by energizing either of the coils connected in suitable logic such that only one coil is energized at a time and the home position of the valve is clearly defined and set prior to the initialization.

Following figure shows a 5/3 way double coil spring return solenoid valve.



In this type, there are five ports and three positions. This valve can be used in lieu of an electro pneumatic positioner due to its mid shut off position. This position can be set to be the home position which can facilitate opening of the flow area for a desired percentage. Opening and closing actions can be performed by energizing either of the coils set in a logic to ensure only one coil is energized at a time.

Apart from Solenoid Valves, another important accessory used in fail safe systems is an accumulator tank. This acts as an auxiliary source of compressed air and is connected to the air input line.

These accessories shall be used in combinations to demonstrate facilitation of failsafe systems in the following sections.

C. Electric current supply failure

Accessories like solenoid valve, limit switches, proximity sensors and all other such transducers work on electric current. In large scale plants, the power supply is designed such that different sections receive electric current differently in order to ensure that the entire plant is not under a complete electric current failure. By this half of the work regarding the fail safe systems is done but the balance half needs to be planned in advance as a part of risk assessment so that in a particular section experiences electric power failure, there are necessary checks and measures in place.

D. Air supply failure

It may happen that due to failure of smooth functioning of the air compressor and the compressed air supply circuit, air at the required pressure may not be available at the actuator end. This calls for auxiliary storage sources like accumulator tanks.

E. Combined electric current and air supply failure

Although rare, this event may cause severe damage and can bring the unit to a standstill. In this, there is a combined failure due to a major problem in one of the energy input systems.

F. Fail to open condition

This condition requires opening of the gate in event or failure of any kind. This is applicable to applications where the flow media has the property of solidification or clogging if stagnant. It may lead to accumulation of the flow media in the intricacies of the body and cause permanent damage to the internals. This may include emulsions, gels and so on.

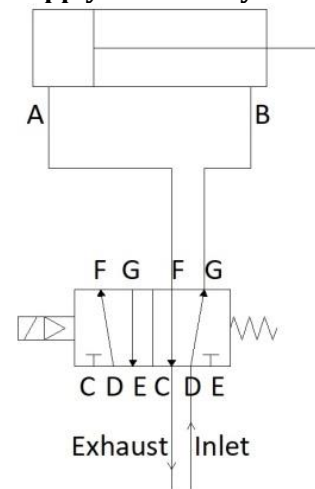
G. Fail to close condition

This condition requires closing of the gate in event or failure of any kind. Certain flow lines are designed such that the quantity of fluid flowing through a given section governs the further processes. In case of chemical manufacturing plants, the kinetics of the reaction depend largely on the rate at which reactants are being mixed. In such cases, on account of failure, there may be untoward events like aggravation of reactions at a further stage due to excess inflow of reactants. Such applications demand for fail to close conditions.

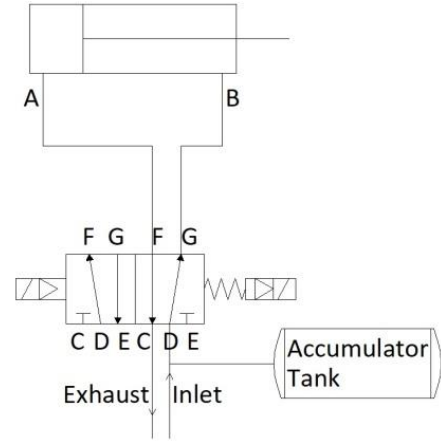
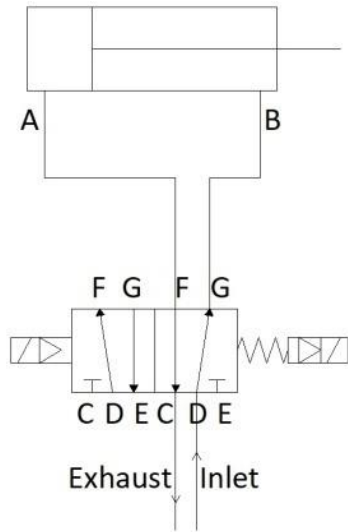
H. Fail to stay put condition

This condition requires that the gate remains in its position in event or failure of any kind. There are applications wherein equalization of the line pressure may be the designed risk in event of system failure. Such applications do require fail to stay put condition. Applications that need pressure relief come under this category.

I.A. SCADA for Fail to open considering electric current supply failure only



Using a single solenoid 5/2 way spring return valve, this condition can easily be achieved by connecting the ports as shown in the figure. On energizing the coil, the actuator closes the door. In event of electric current supply failure, the valve returns to the home position by spring action and opens the valve.



With certain modifications, similar actions can be carried out with a double coil solenoid valve as shown in the above figure.

Similarly, using a double solenoid 5/2 way spring return valve, a similar action can be achieved. In this case too, spring action can bring the valve to its home position and facilitate the opening of the gate.

Since this action requires an executive command from the interface, necessary programming needs to be done well in advance considering the adversaries.

SCADA systems can monitor the successful opening by employing sensors and establishing communication with the same until power is restored. This action does not require any executive command from the interface.

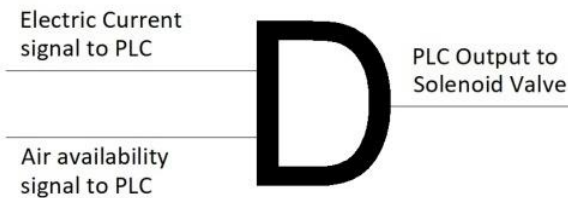
I.C. SCADA for Fail to open considering electric current and air supply failure

This case can be considered to be a special case of air supply failure. The pneumatic circuits can be designed similar to that designed for air supply failure with the logic set such that absence of electric current shall initiate the fail safe action. This can be included as a backup module in SCADA.

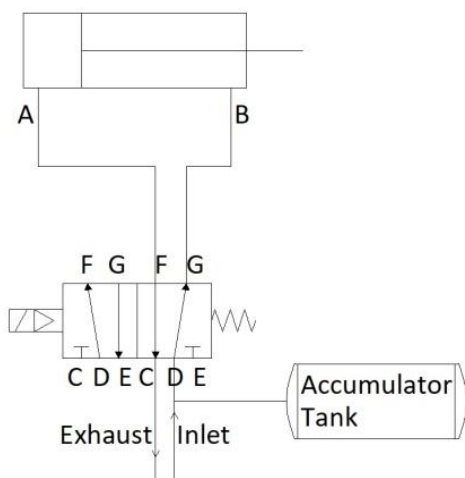
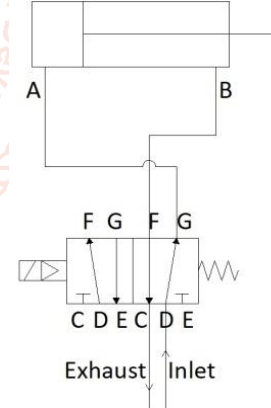
I.B. SCADA for Fail to open considering air supply failure only

In this case, it may be noted that it is only the air supply that is going to fail while the electric current supply is still on.

J.A. SCADA for Fail to close considering electric current supply failure only



Thus a logic can be designed as shown in the figure to send suitable signals to the solenoid valve. In this case, the solenoid valve needs to be operated by the interface.



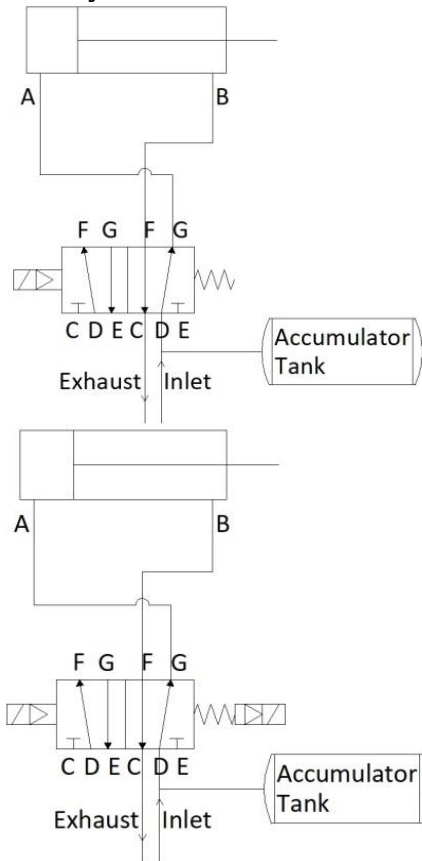
In this case, the logic will send signals to the solenoid valve to return to its home position by means of spring action. Once the same is done, air from the accumulator tank can be employed to initiate the necessary action.

The basic arrangement of pneumatic circuit elements is similar to that observed in fail to open condition. The only variation to be noted is that the connection of the ports is interchanged to facilitate the closing action.

In the circuit with single coil solenoid valve, on energizing the coil, the valve is opened and in event of electric current failure, spring action brings back the solenoid valve to its home position where the port connections facilitate the fail to close action.

For the double coil solenoid valve, according to the pre set logic, the coils are energized and in event of failure of electric current, the solenoid valve returns to its home position by spring action and the port connections facilitate the fail to close action.

J.B. SCADA for Fail to close considering air supply failure only



The basic arrangement of pneumatic circuit elements is similar to that observed in fail to open condition. The only variation to be noted is that the connection of the ports is interchanged to facilitate the closing action.

The PLC logic is applicable in this case too. Signals from the electric supply and the air supply are processed to get the input signal to the solenoid valve.

When the coil is energized, the solenoid valve initiates action to open the door. In event of air supply failure, the PLC logic enables the solenoid valve signal to be cut off such that it returns to the home position by means of the spring action and in that position, the air from accumulator tank can be used to facilitate the fail to close action.

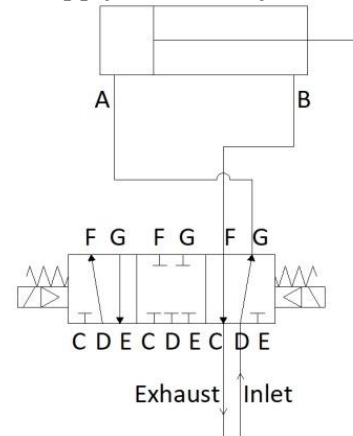
Since this action does require intervention, necessary circuitry needs to be done in advance.

J.C. SCADA for Fail to close considering electric current and air supply failure

This case can be considered to be a special case of air supply failure. The pneumatic circuits can be designed similar to that

designed for air supply failure with the logic set such that absence of electric current shall initiate the fail safe action. This can be included as a backup module in SCADA.

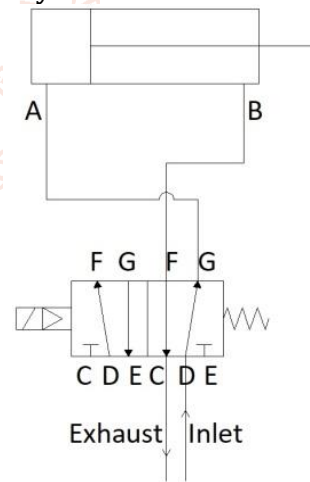
K.A. SCADA for Fail to stay put considering electric current supply failure only



In order to achieve this fail safe condition, a double coil 5/3 way solenoid valve is recommended with mid position shut off being the home position. On actuating, either of the coils, desired open or close action can be achieved, while in event of failure of electric current supply, the solenoid valve comes to the mid position, thereby blocking the ports and facilitating the fail to stay put condition.

SCADA systems can be designed to monitor the stability of the gate in this case considering various flow parameters.

K.B. SCADA for Fail to stay put considering air supply failure only

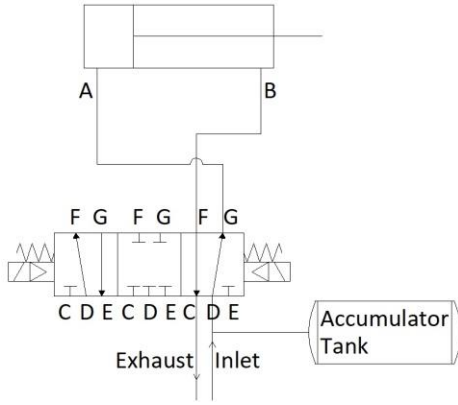


The circuit may look non intuitive but the findings mentioned here are a part of an experiment conducted using the circuit elements.

A single coil 5/2 way solenoid valve can be used to facilitate the fail to stay put condition. When the air supply is cut off while the current supply is still active, the cylinder piston travels for a distance of 5 to 10 mm and stops once the pressure on both sides is balanced in the pneumatic cylinder. This easily facilitates the fail to stay put action.

SCADA can be designed in such a way that there is minimum travel of the piston once the air supply fails and the action can be achieved instantly. Feedback systems can be helpful to ensure success of the fail safe action.

K.C. SCADA for Fail to stay put considering electric current and air supply failure



This can be considered as a special case of electric current failure. The circuit is similar to it. The only additional circuit element is the accumulator tank which is optional but is recommended as in some cases, electrical power supply may be restored first and it may take some time to restore the air supply.

When there is failure of electrical current supply and air supply, the spring action brings the solenoid valve to its home position where all the ports are blocked and the stay put action is achieved. Accumulator tank may be helpful to temporarily operate the valve in event only electrical supply is restored first.

Conclusion

Thus it can be concluded that for most of the fail safe systems, the criterion can be brought down to electric current failure and the desired fail safe action can be executed. While it is

necessary to ensure that failure of power and air does not take place, it is equally important to ensure emergency preparedness in such events by designing the SCADA to take care of the same.

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