Valve Interlocks - The Alternative Option for the Safe Control of Plant and Equipment

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Introduction

In the current electrical / electronically orientated world it is often forgotten that the control of equipment for both safety and process systems is very often reliant on a power source (mains / battery electricity, air or hydraulic) to operate correctly.

This situation is not always practical as power is not always available at a desired operating location or is too costly to install. An alternative to the use of electrical / DCS control / pneumatic / hydraulic of equipment including machines and valves is the use of mechanical trapped key interlocks (TKI's). These devices use the mechanical exchange of coded operating keys to control the operation of lock(s) which in turn allow or prevent the opening / operation or access to equipment (switches, machines, valves, protective cages etc.). The sequenced operation of the interlock keys allows the incorporation of a number of items in an interlock system.

Simple Interlock Systems

A very simple example of the use of trapped key interlocks (TK'I's) is in an electrical application as shown in the logic below. Fig 1). Similar systems can be used in pipelines – Fig 2) where valves fitted with interlocks control the flow in pipelines. This illustrates how systems have evolved from simple electrical switches to include valves and pipeline applications amongst others.

Fig 1) Electrical System – 2 switches with one key (A1) between the switches – only one circuit can be connected at any one time.

Or

Fig 2) A pair of pipelines with only one in service at a time – both open at changeover – three keys being used to completely control the system operation.
These and other applications can be seen in many industries including oil, gas, petrochemical, power, and water just to name a few. By careful design TKI systems logic can be created to meet any operational and safety requirements within a plant.

**What are Valve Interlocks?**

Interlocks as supplied for use with valves are ‘add-on’ devices which mount directly on to the valves stem in place of the originally supplied valve operating handwheel or lever, without any modification to the valve. The design of the mounting does not infringe on any valve manufacturers warranties in the case of new valves. The mount design allowing for a lock to be installed at any time, including, if necessary, onto ‘live’ in service valves.

Valve interlocks for use in plant applications are usually constructed in stainless steel to withstand severe environmental conditions, and are supplied with robust coded operating keys which are used to lock a valve in the open and / or closed position.

The degree of safety achieved in a TKI system depends almost entirely upon the accuracy and quality of the locks and keys used. To achieve these parameters TKI’s must meet certain basic requirements which are distinctly different from a normal commercial type of lock.

The basic requirements of TKI include:

1. No interlock key will operate any interlock other than those within a system having the same key codes as the key.

2. The key should be removable only in a predetermined position (typically when the locking bolt is extended), or in the case of a valve interlock only when the valve is in the correct position (valve open or closed). These parameters can also be dependent on the requirements of the equipment to which the interlock is mounted together with the overall design of the interlock system.

3. One of the most important features of a TKI is that the key cannot be removed from it during the operation of the lock bolt or rotation in the case of a valve interlock. A conventional lockset may allow free removal of the key regardless of the position of the lock assembly. The function of a TKI, however, dictates that the key must be held (trapped) in the lock cylinder unless the locking bolt / valve is at a predetermined position. Possession of the key ensures that the associated device has been locked in a known position.

Fig 3) & Fig 4) illustrate typical interlocks and keys. Fig 3) shows the KIRK® type HD key and a stainless steel bolt lock. Fig 4) KIRK® Eagle Valve Interlocks - type ‘QT’ for 90°/180° movement valves - butterfly, ball, plug etc.) and type ‘MT’ for multi-turn valves (gate, globe, diaphragm, or gearbox operated).
An Interlock System

An interlock system is when two or more TKI units are operated in conjunction with each other. Or alternatively an interlock system can be a group or series of interlocking devices applied to associated equipment in such a manner as to prevent or allow operation of the equipment, in a predetermined sequence only.

The locks employed in interlock systems are, specifically, devices applied to two or more relatively movable parts, preventing or allowing movement of one part only when another part is locked in a predetermined position.

Interlock systems are utilized to mitigate human error by preventing an authorized operator from performing an unauthorized or unsafe operation. They are applicable to practically any field wherein human life, plant or property could be endangered by an improper operation or improper sequence of operations of equipment. Interlock systems are also employed to protect and maintain valuable equipment and operating processes within production environments.

TKI’s can be used as both safety devices and equipment operating controls. They are an important factor in present-day management because of the general desire to provide safe working conditions and reduce the possibility of human error. The changing scope of safety legislature together with possible reductions in insurance rates when safety devices are used provide added incentives for the use of TKI’s.

Typical Standard Applications

In the chemical, petrochemical, refining and other related industries there are many different applications for TKI’s which are more involved than the simple valve interlock system shown in Fig 2) above. Below are logic details of some the common systems which are used in these industries, consisting either of only valve interlocks or a combination of valve and TKI locks.
Fig 5) Interlocking of dual pressure relief valves to ensure a path to a flare / discharge pipework is always maintained.

This type of system is commonly used for dual relief valves in place of the use of costly / difficult to operate 3-way valve systems or the use of line blinds/blank flanges. Using the principle of key exchange from lock to lock, the valves are sequentially operated to open / closed positions to control the relief system always maintaining a safe path to flare or atmosphere.

Another common system is the control of the safe opening/closing of a pig trap – launcher or receiver where the criteria is to ensure that the trap is isolated, drained of any liquids, vented of any vapors / pressure and, if required purged of any hazardous gases (hydrogen sulfide etc.), prior to the trap door or closure being opened. Modern day pipelines can operate at high pressure with or without sour gasses present so the consequences of incorrect operation can be serious and sometimes fatal. Fig 6) below is a simple system for controlling a pig launcher, more sophisticated systems can be designed dependent on the trap process operational requirements. The sequence of key movements shown in the example is linear, should the sequence be non-linear, such as when sour gas needs to be purged from the trap, hardware devices such as a Nonlinear Transfer Unit (NLTU) can utilized. A NLTU is a stepping key release unit which will only release interlock keys in a predetermined sequence e.g. Keys A, B, E, D, A etc. as opposed to the linear movement A, B, C, D etc. shown.
**Fig 6)** Simple Pig Launcher Interlock System to control access and launching procedures safely.

**Complete Valve /Trapped Key Systems**

In addition to the above applications common areas for the use of valve interlocks are:

1) Product separation – ensuring that products do not get mixed / trashed when using common pipework.
2) Loading/unloading systems for road, rail or seagoing tankers, to ensure that the correct procedures are followed.
3) Motor Pump Start-up Controls – to ensure that a pump is not started with the isolation valves closed.

As systems become more involved it is necessary to introduce other trapped key interlock products to enable complete safe operation of the application. These items can be any of the following or combinations of them, key to integrate with the valve locks:

a) Bolt Locks – as the name implies retractable bolt locks which are operated by the key to impede or allow an item to be operated.
b) Access Locks – to prevent the opening or closing of a door or access point (cage, vessel closure etc.)
c) Transfer Blocks or Panels – units which allow one or more keys to be entered into them to release a number of keys.
d) Nonlinear Transfer Units – stepping units which only allow the insertion/release of keys in a predetermine sequence which does not have to be linear.
e) Electrical Switch Interlocks – for signal or power switching for motors or controls. Units available to meet various loads, for internal or external mounting and various operating standards.
f) Solenoid Key Release Units – these only release a lock key when a signal is given to the solenoid from a remote location. Allows interlocks to be incorporated into DCS and similar controls. Various mounting arrangements are available to meet operational / environmental conditions.

g) Time Delay & Stop Motion Unis – units only release a key after preset time period or after a machine or motor has come to a complete standstill.

These are just some of the standard items available, customized units can be designed to meet special operational or environmental conditions. The complexity of an interlock system is usually determined by the extent of control to be included to prevent operator error or plant damage.

An example of an application which can be either ‘simple’ or ‘involved’ is the decoking of a cracking furnace. After a period of use it is necessary to remove the coke build-up in the furnace by combustion with decoke air. This process requires that all process feed supplied to the furnace are isolated prior to introducing the decoke air. Fig 7) shows a ‘simple’ lock (using single key interlocks – lockable in only one position open or closed) systems where the feeds all have to be closed and the keys entered into a transfer block to release a key to allow opening of the decoke air supply. In this system the isolation valves / line blinds can be operated in any order prior to the keys being entered into the transfer block.

If an ‘involved system, as shown in Fig 8), is required this would include items such as Nonlinear Transfer Units and Transfer Blocks together with dual key (lockable in both the open and closed positions) and single key valve locks with line blind locks. The interlock system is designed so that it can only be operated in correct sequence, forcing the operator to follow that path. In addition isolation valves vents/drain have been included in the system.

As interlocking systems are designed to meet client/customer requirements it is essential that at all stages during the concept/creation of the logic system that all parties (engineering, operations, safety and maintenance) are involved in checking and proving that the proposed system meets all plant/operational requirements. Costly rectification work can occur if inadequate reviews take place.

Fig 7) ‘Simple’ Furnace Decoking Logic.
Essential Record Keeping and Operational Controls

To ensure complete control and safe operation of any interlock system the following data and controls should be in place:

A complete record maintained of all interlock supplied to a particular end user including key numbers, interlock models and in the case of valve interlocks, the valve details for each interlock supplied. These records should be maintained by the interlock manufacturer and supplier at the installation location. The reason for these records is to ensure that duplicate key codes are not supplied to the same location in different interlock systems. It will also assist in the supply of replacement items should they become damaged or the keys lost.

In addition, at the site all nonoperational keys (spare or installation keys) should always be removed from a system prior to commissioning of the system. If spare keys have been included in the scope of supply, they should be kept securely locked away and only issued under strict controls.

Should an operational key be lost it should only be replaced under strict control. Most suppliers will require a signed indemnity from the operating company before they will supply a duplicate key to a system.

Conclusion

Valve interlocks either used alone or in conjunction with other trapped key interlock products can provide a complete safety and / or process control system that requires no power to operate at any time.

With the products available together with the design and engineering facilities at hand, any application can be produced to customer specifications to ensure that a safe working environment is maintained.

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