MARSH JLT SPECIALTY

Energy & Power

Risk Engineering Position Paper
Remotely Operated Emergency Isolation Valves (ROEIVS)

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MARSH

CONTENTS

Introduction

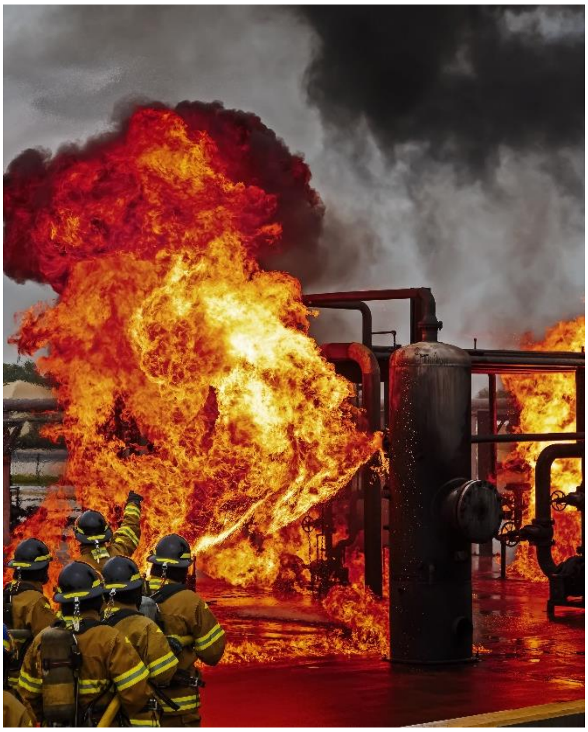
A major fire can occur in any installation that handles large quantities of hydrocarbons.

There have been numerous large, damaging fires where a loss of containment made available large quantities of material to fuel the fire and/or create an explosive vapor cloud. In addition to fire and explosion risks, some processes pose a risk of accidental release of toxic and/or environmentally damaging materials.

Inherently safer design aims to reduce the quantities of hazardous substances processed or stored. For existing installations, options for inherently safer processes will be more limited. Large inventories of liquid hold-up in the process plant are often required to provide surge capacity to allow the plant's smooth operation, and residence time for reactions or separation of liquids and gases. When liquids are highly hazardous, due to their natural properties combined with the process operating conditions, they represent a serious risk during a loss of containment from the system.

The ability to promptly and safely isolate inventories is a key design consideration and risk-control measure. The proven method for isolation is by remotely operated emergency isolation valves (ROEIVs), also known as remotely operated shut-off valves (ROSOVs).

ROEIVs are safety-critical equipment and should be evaluated and maintained as such. Their primary purpose is to provide effective, and timely, isolation of plant items containing hazardous substances in the event of the primary containment system failing (including leaks from pipework and associated fittings, and pump seals). Many small incidents have escalated into major losses because personnel were unable to reach, and close, manual block valves safely or quickly enough, leading to unconstrained supply of fuel to the fire.



This paper's objective is to define the standards that would be rated as "very good" with respect to the application of ROEIVs in the oil, gas, and petrochemical industry, and includes a number of case studies. These standards are incorporated in the Marsh JLT Specialty energy risk ranking criteria. This paper is applicable to new projects and retrospective upgrades of existing facilities. In addition, it can be used to support and define risk improvement recommendations, and improve companies' emergency response systems.

SECTION ONE

Specific Requirements

No single criteria for the application of ROEIVs can be used in all circumstances.

General Criteria

The usual approach to making practical decisions regarding the requirement for remote isolation is to review any relevant guidance (either published or internal), or undertake a qualitative/quantitative risk assessment of the situation, and the various factors involved (the assessment's detail and sophistication will depend on the location's complexity and the hazards/risks involved).

There are many different types of hazardous oil and gas, petrochemical, and chemical facilities in operation, with great variations in complexity, design, layout, age and operation — each presenting different variables to consider. ROEIVs may be installed between the inventory and the point of expected leakage, but it is not always practicable to specify an emergency isolation valve between every inventory and every leakage point. In fact, it is undesirable to do so, since every such device itself introduces further chances of leakage. The decision as to whether a ROEIV is required depends, therefore, on the expected size, consequence, and probability of a leak.

There is no single factor upon which the decision to incorporate an ROEIV should be based. Inventory is an important factor, but not the only one, and factors will vary between installations.

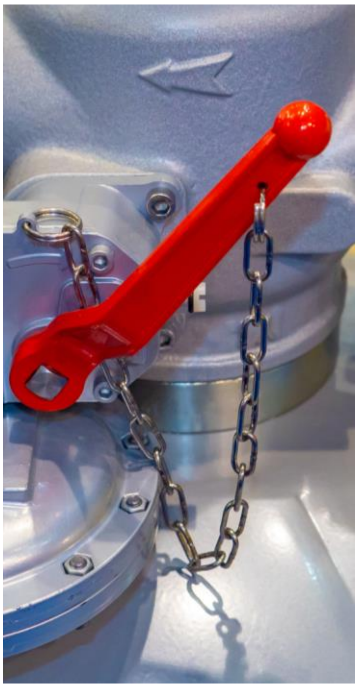
There should be a site or corporate design standard that specifies the requirements for remote isolation of large inventories. These should include considerations of risks such as the following:

For flammable materials:

- The process conditions relative to the material properties — operating temperature and pressure relative to the product boiling point, flash point, and auto-ignition temperature (a superheated flammable liquid that will flash when let down to atmospheric pressure is a greater hazard).
- The type of inventory — in the process areas or in storage (process inventories tend to be more hazardous).
- The possibility of isolating the inventory by other means and sufficiently quickly, such as manual valves at safe locations.
- The operating inventory.
- Proximity to sources of ignition and/or to high-value, high consequence areas of process plant.
- Accessibility to the area within the plant, and levels of congestion within it.

For toxic/environmentally harmful materials:

- Proximity to areas/buildings with high rates of occupancy.
- Proximity to environmentally sensitive areas such as watercourses.



The remote isolation standard should consider other design features of the associated system, such as double mechanical seals on pumps, emergency depressurization and blowdown, fire and gas detection coverage, active and passive fire protection, and so on.

The potential for escalation is much greater for flammable substances, particularly in facilities with significant areas of congestion due to closely spaced units, pipework, and other structures. When ignition occurs in a congested area, there is increased risk of a vapor-cloud explosion (VCE). The overpressure from a VCE may critically damage facilities, leading to further loss of containment and potential casualties. A spill fire is another major scenario that can occur following a loss of containment on a process facility. The correct application of ROEIVs should reduce the magnitude of a loss of containment.

Criteria for Prioritization of Retrofitting ROEIVs in Existing Plants

The design decisions for an existing facility are often more complex than for a new installation. An existing plant, designed and constructed possibly decades ago, is unlikely to have the number of ROEIVs in the locations most expected by the insurance industry. Consequently, insurance risk improvement recommendations are commonly made.

The facility owner is generally expected to make improvements to address the highest risks first. This can be an extended process, due to practical issues such as: delays caused by the need to fit in with turnaround cycles; lack of physical space for new ROEIVs or actuators on existing valves; the potential requirement for bracing to support additional equipment; physical space required for passive fire protection. In addition, of course, all changes to an existing facility have to be evaluated through a rigorous management of change process.

Property insurance tends to focus on potential consequences of a loss of containment, particularly of light hydrocarbons able to form a vapor cloud, and heavier hydrocarbons likely to auto-ignite. Therefore, technical measures of material volumes and properties tend to drive the insurance approach. Pump-seal failures are frequent causes of losses of containment, therefore the table below prioritizes large inventories upstream of pumps. However, losses of containment occur through other causes, for example, undetected corrosion (internal or external), fabrication defects, and poor control of work/inadequate process isolation practice during plant maintenance. ROEIVs are therefore expected on large inventories regardless of whether a pump is downstream or not.

Insurance Industry’s Typical Key Technical Criteria (Flammable Materials)

Process material	Vessel liquid contents (m^3)	Pump in outlet	Distance between vessel and pump (m)	ROEIV expected	Manual valve acceptable
Light hydrocarbons (for example, LPGs) liable to produce a vapor-cloud	> 7	✓	> 15	-	✓
	> 7	✓	< 15	✓	-
	> 20	-	-	✓	-
Material above auto-ignition temperature	> 10	✓	> 15	-	✓
	> 10	✓	< 15	✓	-
	> 30	-	-	✓	-
Other flammable hydrocarbons	> 15	✓	> 15	-	✓
	> 15	✓	< 15	✓	-
	> 50	-	-	✓	-

Notes:
1. Units: $1m^3$ ≈ 264 US gal/15m ≈ 50 ft.
2. A manual valve is acceptable if the location is safely accessible.
3. The decision whether a ROEIV is needed should usually be per a PHA or similar risk assessment process.
4. The ROEIV installation should also comply with the requirements discussed in the body of the document.

To prioritize improvements, the facility owner would consider such technical measures together with assessments of the property value/business criticality of the plant's areas where the inventories are located, the potential for escalation, the speed and effectiveness of the emergency response, and so on. Separately, the facility's license to operate may require installation of ROEIVs to reduce risk to third parties outside the facility fence.

Application Criteria

Engineering standards specify possible requirements of a ROEIV, including:

Situation	Typical application criteria
Columns	• Bottom outlet of columns with large inventories of hot fluids above auto-ignition temperature, for example, crude and vacuum distillation columns, main fractionators of fluid catalytic crackers, and visbreakers. • Bottom outlet of columns with very large inventories of oil, for example, oil quench towers of ethylene plants. • Bottom outlet of fractionation columns containing large inventories of vaporizing fluids that would form explosive vapor clouds; for example, stabilizers/debutanizers, depropanizers, deethanizers, naphtha splitters, and so on.
Vessels	• Vessels containing greater than 7m^3 (≈1,800 US gal) of light hydrocarbons and with downstream pumps with seals. • Vessels containing greater than 10m^3 (≈2,600 US gal) of hydrocarbons operating at above auto-ignition temperature and with downstream pumps with seals. • Vessels containing greater than 15m^3 (≈4,000 US gal) of hydrocarbons operating above their flash point and with downstream pumps with seals. • Vessels containing greater than 20m^3 (≈5,300 US gal) of LPG-type material. • Vessels containing greater than 30m^3 (≈8,000 US gal) of material above auto-ignition temperature. • Vessels containing greater than 50m^3 (≈13,000 US gal) of hydrocarbons operating above their flash point.
Heaters/furnaces	• Each fuel gas or oil line to fired heaters and boilers. • At least one manual isolation valve outside battery limits for each fuel gas or oil line is typically specified. • Process side feed line to a fired heater that contains flammable fluid. The ROEIV should be located outside the firewall or fire zone, which contains the heater. • If the pressure is above 1,000 psi (≈70 barg), then install remotely operated block valves and a furnace overpressure system that can be activated from inside the control room.
Atmospheric storage tanks	• All atmospheric storage tanks containing product with a flashpoint below the ambient storage temperature should have ROEIVs on the inlet and outlet connections of the tank. Other tank connections such as recycle lines should be risk assessed as appropriate. This is normally associated with overfill protection, in which case the ROEIV on the inlet line is activated by the independent high-level switch. • Remote tank farms often have remotely operated valves for operational purposes, as they save on the travel time and also eliminate the physical effort required in manually operating large valves. These can be used as ROEIVs if adequately fire-protected.
Pressurized/ refrigerated storage vessels	• All pressurized/refrigerated storage vessels should have ROEIVs on the inlet and outlet connections. This is normally associated with overfill protection, and the ROEIV on the inlet line is activated by the independent high-level switch on the vessel. In new spheres, this valve should be a welded-in-place valve on the base of the sphere, with the actuator outside of the bund. If a retrofit, the ROEIV should be close to the vessel.

Situation	Typical application criteria
Compressors	• At the inlet and outlet of the compressor train driven by a single motor, turbine, or engine greater than 200 HP (150 kW) handling flammable or toxic materials, and a line diameter larger than 250 mm (ROEIVs to the inlet and outlet of a compressor is dependent on the flammability of the gas, its pressure, and the quantity of gas in the associated piping and vessels). • When the compressor capacity is larger than 1,000 HP (750 kW), the ROEIV must be located at least 7.5 meters from compressor, if piping layout allows it. • ROEIV facilities should be considered on larger multi-stage compressors for the inter-stage lines, when the normal operating volume of the inter-stage separators is larger than 4 cubic meters (~1,000 US gal) each.
Pipelines	• Long pipelines transporting hazardous products should be protected with ROEIVs at either end. These should be additional to any hydraulic/power-operated maintenance isolation valves. • On LPG lines above 50mm diameter. • Pressurized lines entering or leaving the battery limits of the plant, except the flare lines and the relief valves headers. • Cross-country pipelines. Consideration should also be given to providing intermediate valves along the length of the pipeline.
Marine terminals	• Install ROEIVs on all loading arms so the arm or pipeline can be isolated in case of hose or arm failure, mechanical damage, fire exposure, or an emergency on a tanker being loaded. • Use valves appropriate to the product being loaded or unloaded. • Install fail-safe ball valves on each side of the connecting flanges of all loading arms handling flammable liquids, such as crude oil, kerosene, and liquefied petroleum gas (LPG).

Installation of ROEIVs should be also considered where one or more of the following conditions apply:

- Access to the area for fire-fighting purposes is particularly limited.
- Other fire-sensitive equipment and/or flammable inventories are located nearby.
- The potential release point, typically a pump, is located beneath other equipment such as pipe racks or fin-fan coolers.
- The potential release point is located close to potential sources of ignition.
- The quantitative risk analysis, based on dispersion and VCE modelling, show that a release of the vessel contents in an area of severe confinement would result in a major loss that exceeds the corporate limits.

The ROEIV should be installed close to the liquid hydrocarbon inventory (for example, vessel outlet nozzle, column bottom liquid product nozzle). However, the location has to be practicable and allow safe maintenance of the ROEIV, which may require it to be located, for example, outside the skirt of a column.

Remote isolation facilities on pumps are usually required for the suction side of the pump only, thus isolating the upstream inventory. It is assumed that any potential downstream inventory is prevented from discharging backwards by the expected presence of a non-return valve just downstream of the pump. For applications where the integrity of such a check valve is critical (for example, when downstream inventory is at high pressure conditions), it is important to ensure that the functionality of the check valve is periodically tested, as per specific inspection schedule.

Operation of Isolation Valves

Isolation valves can be operated in the following four modes:

1. Local automatic — some isolation valves may be automatic, but locally actuated. In this case, the actuation device may be a fusible-link or fusible-tubing arrangement.

2. Remote automatic — based on a sensing element, logic solver, and output signal to close the valve. In most cases, these automatic valves are designed to fail-safe. Automatic isolation can be associated with the automatic activation of a shutdown system for equipment or a process unit.

3. Remote manual — when unit or equipment isolation valves are not safe to approach or, for example, in elevated locations, they are activated manually from a remote location at least 15 meters horizontally from the protected equipment, considering the area to be protected.

4. Local manual — manual unit and equipment isolation valves may be operated by a handle or by an actuator. Typically, these single action actuators are powered by air and have a spring-to-close design.

With regard to the type of valve used as a ROEIV, relevant features are the torque required to operate it and the leak tightness. Valves should be provided with actuators, and be capable of being manually operated. If butterfly valves are considered, they should be demonstrably fit-for-service. The preferred valve type for remote isolation valve facilities is a tight shut-off ball type valve.

A key feature of any valve used for emergency isolation is the ability to achieve and maintain tight shut off within an appropriate timescale, and potentially under fire exposure conditions. A commonly used valve type for remote isolation is a quarter-turn fire-safe ball-type valve. It is important that each valve and actuator system is chosen to meet the specific requirements of the installation. Diaphragm-operated valves should never be used.

The closure of a ROEIV is not instantaneous. An electrically operated valve typically takes about a minute to close; a pneumatically/spring-operated ball valve somewhat less; and a pneumatically/hydraulically operated gate valve somewhat more. It is anticipated that isolation will be achieved within 15 minutes. Passive fire protection of the valve should allow 20-30 minutes of direct flame impingement without affecting its operation. Once closed, the ROEIV should remain closed and leak-tight to a reasonably good tolerance: this typically requires metallic seats to back up any elastomeric seating materials. The speed of operation should be as fast as practical without damaging the valve or subjecting the system to excessive hydraulic shock (that is, hammer). A valve-position indicator for each ROEIV at the distributed control system (DCS), or panel, is helpful to confirm when an ROIEV has fully activated.

One advantage of manual activation is that the most appropriate measure for dealing with a release can be intelligently assessed. Manual activation is often justified by the requirement to avoid spurious trips associated with automatic systems; well-designed automatic system with sufficient redundancy may, however, allow a high-reliability automated response. Manual activation must have the location of push buttons such that they do not endanger the employee. They should be accessible and in a safe and suitable place in relation to the hazardous event that may occur (usually >/=15 meters horizontal distance from the likely leakage point). There should normally be at least two alternate activation points, which should be readily identifiable both on the plant (for example, labelling), and in all relevant operating instructions.

Advantages of automatic activation include faster isolation and reduced human error. Facilities for manual activation, on emergency escape routes, for example, should be provided as backup to automatic activation, and this can result in a faster response in some circumstances.

Very few installations have a completely separate emergency isolation system. In general, isolation valves form part of the overall shutdown/isolation philosophy. One of the main reasons why detection systems are rarely configured to initiate automatic closure of valves is to avoid spurious shutdowns. In most cases, the initiation of isolation is manual. ROEIVs should be regarded as part of the complete shutdown system and not a standalone item.

ROEIV Actuation

The valve actuator is driven by an electrical motor, a pneumatic or hydraulic rotation motor, a hydraulic or pneumatic piston, or by a spring on air failure. Based on industry experience, for new ROV installations, the preferred actuation drive would be of the hydraulic type. Where installed, pneumatic actuation systems should employ a motor or piston operation, and not a diaphragm system, which is shown to be more often prone to failure. Electric actuation is quite often used for conversion of manual valves to ROVs, however, this type of drive is not recommended for pumps handling high temperature fluids.

An ROEIV may be installed as a new valve or by motorization of an existing valve. The valve may be arranged so that air, hydraulic, or electrical power is required to keep it open or, alternatively, to close it. The valve failure mode on loss of motive force should be decided via HAZOP.

If ROEIVs are air-actuated, it must be ensured that the air supply is reliable and the air-backup capacity can move all the valves through two complete cycles, under fire conditions. Pneumatic actuators with a spring-to-fail-safe may be preferable subject to HAZOP: these will fail closed in the event of loss of instrument air. Fail-closed is typically the desired action to prevent a loss of containment event, but if upstream, for example, a pump should be interlocked with the pump motor. Actuators should be sized for maximum upstream process pressure and 0 psig downstream.

If the valves are actuated by an electrical motor, the energy source must come from the unit emergency circuit and/or the installation. The emergency generator's capacity must be verified. Power may also be supplied from the preferential system, in case there is no emergency circuit available. Electric power actuation is quite often used for conversion of manual valves to ROEIVs.

If the valves are actuated by a hydraulic piston, arrangements must be made so that in case of loss of electricity, the hydraulic oil's pressure would be sufficient to actuate at least the critical valves.

There appears to be little evidence suggesting that either pneumatic or electrical operation is more reliable. However, it is desirable to ensure the valve actuator is sufficiently powerful, particularly on dirty fluids, slurries, and so on.

The power sources for the electronic or pneumatic signal transmission system must be highly reliable. This reliability must be consistent with the specified safety integrity level, or equal to the power supply utilized in the control room. Activation should be hardwired and independent of the DCS.

Incident Summary #1

US, Texas — Refinery Propane Fire

Nineteen people were injured (three of them seriously) in the incident, and around 400 workers were evacuated from the refinery. The plant was immediately shut down and remained shut for several weeks.

A breach in a pipeline on a propane deasphalter was the likely cause of a major fire at the refinery. Fire damage was largely contained to the propane deasphalting unit and associated piping. The effect of the blaze was exacerbated by the subsequent failure of a pipe rack, on which some of the support beams had not been fireproofed.

The U.S. Chemical Safety and Hazard Investigation Board (CSB), issued a final report that mentioned lack of emergency isolation as a key contributing factor to the magnitude of the loss.

Although actuators should be designed to fail-safe, it is important to consider the provision of a secondary motive source in case of failure of the primary source, if required by the risk of the incident escalation. This typically would require an auxiliary hydraulic pump for hydraulic systems; excess accumulator capacity for pneumatic systems; and an auxiliary power supply for electric systems.

When the main emergency “stop button” is located in the control room, an additional stop button must be installed near to the remotely actuated valve but at a safe distance and location. When the main emergency stop button is located in the field, there should not be additional stop buttons unless they are required for operational reasons.

If solids could be in the fluid being handled, the actuator size selected should be larger than normally recommended by the manufacturer for the clean-fluid duty. The size of the actuator is crucial to meeting the safety requirements specification of the ROEIV. Under-sizing may result in the valve not fully operating on demand: however, oversizing may result in damage to the valve or actuator assembly. The design must show an understanding of the safety requirements and be based on the complete system characteristics.

Activation locations should be clearly identified. The field actuation panel should include a valve position indicator. It is also good practice to include a valve position indicator on the ROEIV stem.

Incident Summary #2

US — Olefins Production Unit

The explosion knocked down several operators, and burned two (one seriously) exiting the unit. Flames from the fire reached more than 500 feet in the air. The extensive damage shut down the Olefins unit for five months.

In the early afternoon, a trailer towed by a forklift snagged and pulled a small drain valve out of a strainer in a liquid propylene system. Escaping propylene rapidly vaporized, forming a large flammable vapor cloud. The CSB issued a final report that mentioned that had a remotely actuated valve been installed upstream of the pumps, the incident would likely have ended quickly, possibly even before ignition occurred.

Passive Fire Protection

Remote isolation valve installations should be designed to withstand fire exposures, as they are most likely to be required to operate in fire conditions. The possible exception to this is when they are fire-safe valves designed to fail closed during fire exposure. If the control wiring used to activate ROEIVs during a fire could be exposed to the fire, the wiring should be protected against a 20-to-30-minute fire exposure and certified to UL 1709 (or functional equivalent). If activation of the systems would not be necessary during any fire to which it might be exposed, then protection of the wiring is not required for emergency response purposes.

Valves installed in the fire zone should be fire-safe rated, and typically be metal-seated ball valves. Gate valves and high-performance butterfly valves may be determined as acceptable, but the valve selected shall be tested and conform to API specification 6FA, fire test for valves, or an equivalent standard test. To increase the probability of a ROEIV operating properly, passive fire protection should be considered for both the power and signal lines connected to the valve. The valve's motor operator should be sufficiently fire-protected to provide time for the valve to fully open or close (the stem of a long stem valve should be protected).

If the emergency isolation valve closes on loss of power, it is not generally necessary to provide fire protection on the air or electrical power lines to it (but should be able to fail to their fail-safe position when under a fire challenge). However, if power is needed to close the valve, the power lines should be provided with 20-to-30-minute protection, and a latching device installed to keep the valve closed if the power lines are destroyed. The 20-to-30-minute protection allows the operator time to decide whether to close the valve.

Fireproofing of actuators and valve stem can be achieved by enclosure in an insulated box, or wrapping with special insulating material. In addition, the thermal cut-out relays usually provided with electric motor actuators should be removed from any ROEIV electrical-power-driven actuator, as it would, of course, be more important to ensure the drive operates under high temperature conditions rather than be protected and thus prevent the ROEIV’s operation.

Where a ROEIV is installed in larger bore piping systems, there is a risk that spring hangers would fail under fire conditions, leading to overloaded flange joints and leaks or failures. This would reduce or nullify the effectiveness of the ROEIV. Therefore, to ensure adequate support of such piping systems under fire conditions, it may be necessary to install fireproofed catch beams.

Incident Summary #3

Australia, Geelong — Refinery

US$20 million

A roller bearing failed in a reduced crude oil pump operating at 354°C (670°F) in a crude oil unit that initiated the fractures of the pump’s motor shaft and bearing brackets. The pump casing then ruptured, allowing a release of hot oil that auto-ignited. Since the pump was only equipped with manually operated suction valves, which could not be reached, and the column had no isolation valve, the crude oil in the column was released, fueling the fire.

Use of Control Valves for Emergency Isolation

In some cases a control valve is used for emergency isolation. Such a valve is not an ideal isolation valve, because a control valve often does not give a tight shut-off, especially after operation. However, where a control valve is installed, it may be difficult to justify a separate emergency isolation valve. If a control valve is used for this purpose, there should be a separate manual control for isolation; the manual mode of the controller should not be used.

Emergency isolation valves need to be able to achieve and maintain tight shut-off. Some control valves are designed to provide a "throttling" action, and these do not always provide a sufficiently tight seal. Other types of valve used — for example, in the control of batch transfers — may achieve a tight seal. Failure of a dual function valve may compromise both functions, and a postulated failure of the control valve may itself lead to a requirement for an emergency isolation valve.

The functions of process control and emergency isolation should therefore normally be kept separate. Ultimately, the test will be whether the system can deliver the required safety integrity level/reliability with a dual-function valve.

Incident Summary #4

US, Texas — Refinery

US$103 million

A seal failure on a pump for a crude unit atmospheric tower resulted in a fire. A second product release occurred before the pump could be isolated and shut down.

SECTION TWO

Reliability, Integrity, and Cost

Inspection, Testing, and Maintenance

The frequency of inspection and testing required will depend greatly on the confidence held in the compatibility of the valve with the process fluids and conditions. This confidence may be obtained through previous operational experience, testing, knowledge of basic materials compatibility, or a combination of these. Establishing how systems can fail provides useful information for inclusion in testing and maintenance arrangements. Common factors identified in previous industrial incidents where isolation systems failed include:

- Inadequate maintenance.
- Failure to test equipment periodically.
- Failure of isolation valves to close on demand.
- Failure of valves on closure, leaking internally.
- Inappropriate spacing between valves — inventory between valves too large.
- Design failures.
- Inaccessibility of valves.
- Poor documentation of the location of emergency valves.
- Inadequate training of emergency crews on the operation of valves.

These factors fall into two broad areas, namely 1) reliability, and 2) maintainability. The historical accident record indicates that these issues need to be considered carefully when making an assessment of plant isolation (see *Incident Summary #5* below).

Incident Summary #5

Spain, Tarragona Petrochemical Plant

US$14 million

A leak was detected in the cooling/heating water jacket for the upper-zone reactor tubes in this ethylene plant. Reactors and separators were being depressurized when a loud pop was heard. Operators, believing the pop was a further leak, actuated the emergency isolation dump system for the reactor. The oxygen and ethylene feeds were closed, and ethylene was released through reactor vents. The source of ignition for the ethylene gas was the failure of insulation on electrical wiring for a remotely operated dump isolation valve. The valve should have operated without electrical sparking. This illustrates the need for inspection, testing, and maintenance of these safety-critical systems

Another factor to consider is that the installation of new additional equipment on a plant will increase the demands placed on maintenance scheduling. This includes the need to carry out regular testing to identify unrevealed failures that may affect the operation of equipment. Valves that remain in the open position for considerable periods can be supplied with a partial stroke mechanism. This allows the valve to be partially operated, thereby overcoming problems of high torque levels as a result of, for example, creep of the polymer components, which may prevent the valve from operating.

Any installation of equipment on an existing plant poses potential hazards, which need to be assessed as part of the ROEIV-decision-making process. The location of isolation valves will inevitably place them inside the hazard zone.

Reliability and integrity of this equipment is paramount if isolation is to be successful. Not only does the equipment need to operate on demand, but possibly under harsh conditions. Installed ROEIVs must always be maintained in a condition that will ensure satisfactory operation when called upon. It is important, therefore, to ensure that appropriate testing facilities are available and used as per an established inspection and testing schedule. For critical ROEIVs, which form part of major ESD systems, on-line testing facilities should be available to ensure frequent testing of operability without disturbing process operations.

It is also critical to ensure that operators are trained in the correct operation of ROEIVs as part of normal operation or emergency shutdown procedures. ROEIVs are important components of the pressure system. They should be included in the pressure-system register and regularly tested and maintained. Training and competence assurance, availability of clear operating procedures and other job aids, and levels supervision are all factors to consider.

Cost Benefit Analysis

The costs of installing the valves, actuators, and control connections — including digging, cable, and trenches — naturally vary with the plant’s remoteness from the control center and other complexities of installation. Installation costs can be between one and a half and three times the cost of valves and actuator units. There may also be costs associated with commissioning safety studies, testing, and reliability work, but these are normally hidden among general operating costs.

Maintenance costs vary between 5% and 15% of the cost of the installed equipment. Staff training in using ROEIVs would be a standard part of any normal operating procedures. Concern has been expressed by some of the industry that retrofitting ROEIVs to existing plant could result in production/process downtime incurring financial losses. However, to avoid disruption, ROEIVs could be installed at normal-cycle maintenance periods, thereby avoiding the need for any additional process disruption or downtime.

The benefits of installing ROEIVs include preventing fatalities and injuries, property damage, and less tangible considerations such as damage to a company's reputation. Additionally, an accident may cause subsequent plant downtime that results in business interruption costs (refer to the industry losses in the incident summaries).

Cost-benefit considerations should be used to determine if the measure will cost-effectively reduce the risk. The ALARP approach advocated by the UK's Health and Safety Executive (HSE) may be used. For a new installation, priority should be given to reasonably practicable measures to prevent the escape of the hazardous substance from the primary containment system (vessel, pump, pipework, and so on), over the provision of secondary containment. For existing installations where the current provision does not meet the standards set out in this guidance, the installation should be upgraded so far as is practicable.

When assessing the risk to reduce, the current situation should be compared with the cost of achieving the risk reduction. Any measures already in place may be considered when establishing the current level of risk (without a ROEIV).

Of course, where the risk from a site is assessed as greater than the HSE's broadly unacceptable region of 10^{-3}/yr., then if fitting a ROEIV or some alternative measure reduces the risk, it must be undertaken. In all other cases, financial criteria will need to be used in the decision-making process.

Incident Summary #6

Success Story

Emergency isolation valve installed for risk quality improvement in an aromatic plant.

A large fire loss was prevented by remote-operated emergency isolation valve installation a large-scale aromatics plant, following a Marsh risk engineer's risk improvement recommendation. Fire was extinguished within 15 minutes, unlike a previous fire incident lasting more than 30 hours without ROEIVs.

SECTION THREE

Reference to Industry Standards

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APPENDIX A
Self-Assessment Checklist

The following checklist is a quick tool that a site can use to test its existing processes for good practice:

Item
Procedure
Is there a corporate or site design standard that specifies the requirements for remote isolation of hazardous inventories?
Supporting Infrastructure
Are the following factors taken into consideration on the requirement of ROEIV:
• The nature of the hazardous material — flammable, explosive, toxic, corrosive, or environmentally harmful.
• The process conditions relative to the product properties — operating temperature and pressure relative to the product boiling point, flash point, and auto-ignition temperature.
• The type of inventory — process vessel or storage vessel.
• Possibility of isolating the inventory by other means, such as on the feed to the unit, or of pumping the inventory away.
• The capacity of the vessel — normal operating inventory.
• The source of ignition (for flammable).
• The potential leak paths.
• The time factor.
• The likely dispersion pattern of toxins.
• The potential impact of the hydrocarbon's leak.
Is the following equipment considered on the ROEIV application:
• Columns.
• Vessels.
• Pumps.
• Heaters/furnaces.
• Atmospheric storage tanks.
• Pressurized/refrigerated storage vessels.
• Compressors.
• Pipelines.
• Marine terminals.
Supporting Infrastructure
Passive fire protection considerations:
• Fail and fire-safe actuation consistently applied.
• Actuators and instrumentation to actuator fireproofed for 20-30 minutes in fire-hazardous zones.
• Cabling underground to beneath valve with fireproofed connection.
Stewardship
• Is the corporate or site design standard periodically reviewed?
• Is there an audit process to ensure that the corporate or site design standard is consistently applied on ROIV application?
• Do KPIs describe the operation, inspection, and maintenance of the ROEIV?

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