Safety practice

Process isolation – it's more complicated than you think

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Summary

Properly planned and implemented isolations are required to provide a barrier between the plant/equipment being worked on and the sources of the hazardous substances and conditions. These isolations are usually achieved in the first instance by closing valves, but more robust methods may be required depending on the nature of the hazard and the work to be carried out. Unfortunately, isolation procedures adopted by some companies are not fully up to the expected standard. In particular, many people do not properly understand the sequence of steps required to prove valve integrity and are content as long as the correct valves are closed and secured before beginning work.

This article reminds readers that process isolation is not necessarily as straightforward as expected and runs through the steps to achieve correct and proven isolations.

Keywords: Process isolation, valve integrity

Introduction

Process plant and equipment will often contain hazardous substances and conditions. If intrusive work has to be carried out, typically maintenance, there is a chance that hazards may be released that cause harm to people in the vicinity. In order to reduce the risks, properly planned and implemented isolations are required that provide a barrier between the source of the hazard and the plant or equipment being worked on. These isolations are usually achieved in the first instance by closing valves, but more robust methods may also be required such as inserting spades or removing pipework depending on the nature of the hazard and the work to be carried out. Also, part of the isolation procedure includes removing any hazard contained within the equipment, which may require draining, venting and/or purging with an inert substance.

In 1997 a document was published titled 'The Safe Isolation of Plant and Equipment.' Whilst endorsed by the Health and Safety Executive (HSE), it had actually been developed by the Oil Industry Advisory Committee (OIAC). In other words, the regulator was not telling industry how to isolate plant and equipment, and instead industry was explaining what it did (or at least what it thought it should do).

The original document set out a method for determining what form of isolation should be used – ranging from single valve through to 'positive isolation' using spades and blanks – depending on the duty of the plant and the task being performed. It formalised the use of 'double block and bleed,' pointing out that valve integrity needs to be proven if an isolation is to be relied upon.

The original OIAC document has been updated and published by HSE as Health and Safety Guidance Document (HSG) 253[1] and many companies have developed their own, in-house isolation standards. It appears that in the years since 1997 the HSE have accepted industries suggestions and converted them into requirements. Also, companies agreed to comply.

Given that the requirements have been clear for some time and accepted by industry it would be reasonable to assume that compliance has been achieved; but experience has shown that companies' isolation procedures often fall short of the requirements, particularly for proving the integrity of valves. Also, people often do not fully understand why adherence to a strict sequence of steps is required when isolating plant and equipment.

An 'interesting' example

Isolating a pig receiver in preparation for opening the door provides an excellent example to demonstrate the potential difficulties in achieving a suitable isolation. It is universally accepted as a critical activity requiring a high degree of integrity. The sketch below demonstrates that the receiver will need to be isolated from the pipeline at both its inlet and in its kicker line. Given that the pipeline is likely to be live and possibly at high pressure, there can be no doubt that a proven isolation will be required. A double block and bleed arrangement can be used for this.

A level of complexity is introduced when we recognise that there is more to the isolation than simply shutting valves. In this case the receiver will need to be depressurised, drained, purged and vented. Closed vent and drain systems are often required so that hazardous material can be removed in a safe way. These create additional process connections that require isolation. A further complication is created by overpressure protection provided by a relief valve connected to the vent header. This will need to be isolated, but should remain available for as long as possible to ensure protection is provided.

The sequence of steps required to isolate this pig receiver is summarised below. It should be noted that this is actually a simplified scenario because in reality there may be additional items to consider including a balance line, multiple drain points and purge connections.

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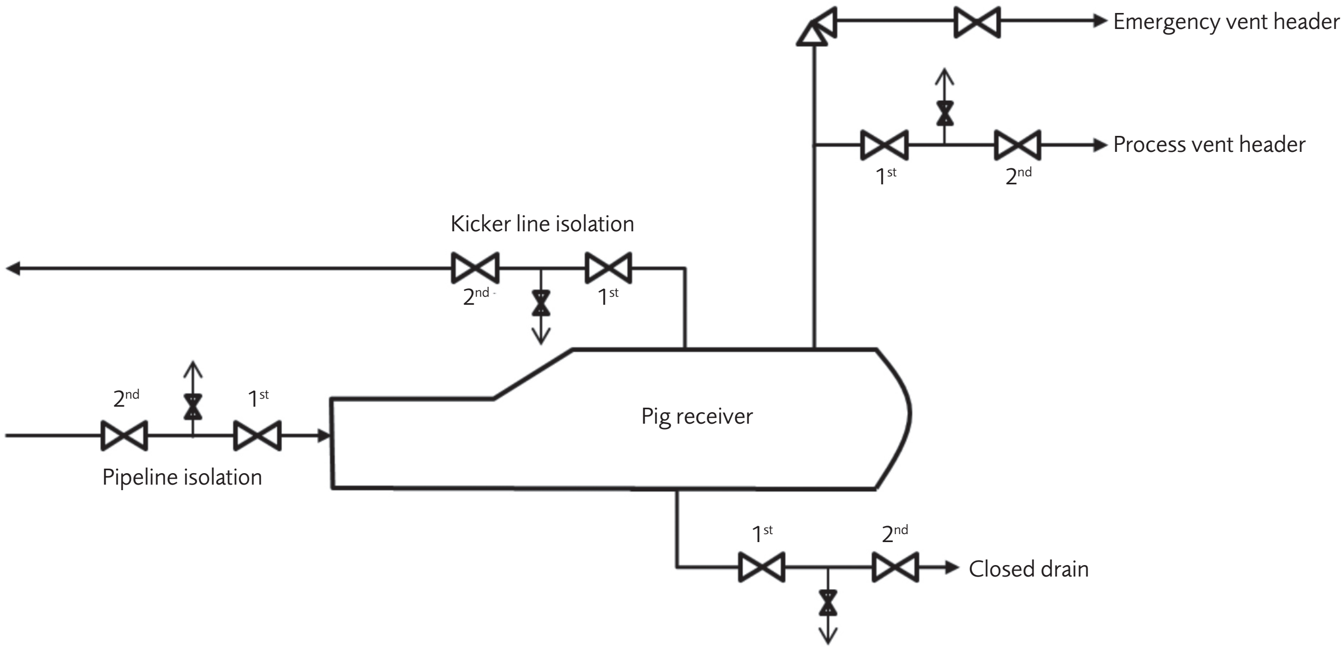

Sequence of events

The sequence of steps followed to isolate the pig receiver can be summarised as follows:

- Drain, vent and purge the receiver;
- Prove the integrity of isolations.

How complicated can that be?

Drain the receiver

To drain the receiver we will usually want pressure to force liquids through to the closed drain system. There is no reason why we need to isolate from the pipeline to do this. Therefore our first step can be:

1. Open two drain valves.

It is somewhat ironic that we will start our isolation by removing the existing isolations on the pipework between the receiver and closed drain system, but this is unavoidable. Once we are happy that draining is complete we can close those valves, but we need to think about how we can prove their integrity.

A double block and bleed isolation will normally be required on the pipework to the closed drain system because of the high pressure inside the pig receiver. This provides us with the opportunity to prove the integrity of the two block valves as follows:

2. Shut both drain valves.
3. Leave for a short time.
4. Confirm pressure is present between the isolation valves – if there is no pressure it indicates that the second isolation valve (furthest from the pig receiver) has passed.
5. Open the bleed valve to vent pressure.
6. Reclose the bleed valve.
7. Leave for a short time.
8. Confirm *no* pressure is present – if pressure is present it indicates that the first isolation valve (closest to the pig receiver) has passed.
9. Open bleed valve to complete the double block and bleed isolation between pig receiver and closed drain system.

This sequence of steps is clearly achievable but is reliant on the operator to understand how the integrity of the valves can be proven. A pressure gauge located between the isolation valves can make this easier. However, they are not always available, which means the operator has to be quite alert to detect pressure when proving the second isolation valve and lack of pressure when proving the first isolation valve.

However, there is a potentially fundamental problem with the proposed sequence of events – it only tests the integrity of the isolation valves in the direction from the pig receiver to the closed drain system. When we open the receiver we actually want protection against a pressure in the closed drain system (i.e. the opposite direction). The problem is that the pressure in the closed drain system will normally be far less than its potential, which means there is not a readily available source of pressure to prove valve integrity in the 'correct' direction from closed drain to pig receiver.

There are ways of proving the integrity of the first isolation valve in this direction. They include:

- Leave the space between the isolation valves pressurised until after the pig receiver has been depressurised. This will require the first isolation valve to be reopened and closed after its initial integrity check.
- Use an external source to pressurise the space between the isolation valves. Nitrogen from a utility system or cylinders would be suitable for this.

Proving integrity of drain valves in both directions is not straightforward and is probably easy to overlook; and on a standard double block and bleed isolation on a closed drain system, it is not actually possible to prove the integrity of the second isolation valve in the correct direction.

Prepare to depressurise the receiver

At this stage, the receiver has been drained but is open to the pipeline. It needs to be depressurised to the vent header. To prepare for this it is necessary to isolate it from the pipeline, but the sequences of steps must allow us to prove valve integrity. The following steps should be completed:

10. Shut first isolation valve on pipeline (closest to receiver);
11. Shut first isolation valve on kicker line (closest to receiver).

Depressurise the receiver

The sequence of steps followed when depressurising the receiver has to allow valve integrity to be proven. This can be achieved as follows:

12. Open process vent line first isolation valve (closest to receiver) to pressurise space between vent line valves.
13 Reclose first valve.
14. Leave for a short time.
15. Confirm pressure is present between the valves – if there is no pressure it indicates that the second isolation valve (furthest from the receiver) has passed.
16. Open the bleed valve or second isolation valve to vent pressure.
17. Reclose valve.
18. Leave for a short time.
19. Confirm *no* pressure is present – if pressure is present it indicates that the first isolation valve (closest to the pig receiver) has passed.
20. Open both isolation valves to depressurise receiver to process vent system.
21. When depressurised, reclose both isolation valves.
22. Open bleed valve to complete the double block and bleed isolation between pig receiver and closed vent system.

Once again there is the issue that valve integrity has only been proven in one direction (i.e. from receiver to process vent header) when it is the other direction that needs to be checked. Unlike the drain valves, it is not possible to use process gas to test integrity because the receiver cannot be depressurised without opening the valves that need to be tested. Another source pressure can be used, but once again integrity of the second isolation valve cannot be proven in the correct direction.

Although the receiver has now been depressurised it still contains process gases and will require purging before opening. However, this cannot be completed until the receiver is fully isolated.

Complete main isolations

At this stage, the receiver will only have single valve isolations on the pipeline connection and kicker line. Their integrity has not yet been proven. The following sequence of steps will allow the isolation to be completed whilst proving valve integrity:

23. Leave the receiver for some time and monitor pressure – if pressure builds up it indicates that the first isolation valve from pipeline or on kicker line has passed.
24. Shut second isolation valve on pipeline (furthest from receiver).
25. Shut second isolation valve on kicker line (furthest from receiver).
26. Open the bleed valve between pipeline isolation valves to vent pressure.
27. Reclose bleed valve.
28. Leave for a short time.
29. Confirm *no* pressure is present – if pressure is present it indicates that the second isolation valve on pipeline (furthest from the pig receiver) has passed.
30. Open the bleed valve between kicker line isolation valves to vent pressure.
31. Reclose bleed valve.
32. Leave for a short time.
33. Confirm *no* pressure is present – if pressure is present it indicates that the second isolation valve (furthest from the pig receiver) has passed.

Isolate emergency vent connection

The emergency vent connection should always remain available as long as possible so that the pig receiver is protected against overpressure until fully isolated from the process. However, it will need to be isolated in case the vent header is pressurised by relief from another part of the process, and a relief valve cannot normally be considered as an isolation. Hence the next step is:

34. Shut isolation valve in emergency vent connection.

Unfortunately, the fact that there is no pressure in the receiver makes proving integrity of the isolation valve difficult. Also, the same issues exist regarding proving integrity in the correct direction, from the vent header.

Isolations are complete

The good news is that after completing the 34 steps listed above, the pig receiver will be isolated from all process connections. It is important to recognise that this has not included any purging with inert gases that would normally be required. However, there are often further complications that can add to the problems already identified.

Double seated valves

There are valves that claim to offer a double block and bleed arrangement in a single unit. The problem is that the two isolation barriers are usually operated together. The sequence of steps shown above for isolating the pig receiver required valves to be shut in a defined order so that their integrity can

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be proven. This is not possible with a double seated valve. Therefore, a design solution that was probably intended to make life easier has actually introduced an additional complexity and potential risk.

Spectacle blinds

It is quite normal to have spectacle blinds or equivalent inserted in sections of pipework used infrequently. For a pig receiver a positive isolation may be normally required to protect a low pressure closed drain system from a high pressure pipeline.

Opening a spectacle blind involves break of containment, which should only be carried out with proven isolations. For the pig receiver it would be possible to prove integrity of the first isolation valve (closest to the receiver) by venting the space between the valves then checking that no pressure builds up. It would be very difficult to prove the integrity of the second isolation valve. Also, it is important to recognise that being a drain line the possibility of liquids and solids building up in the pipework and valves may cause further problems.

Interlocks

It would probably be considered a requirement to interlock certain valves on a pig receiver. People often assume this means that the potential for human error has been eliminated – unfortunately it is not quite that simple.

Normally, interlocks can only ensure that valves are in a certain position before a step can be performed. For a pig receiver, the key requirement is that all isolation valves are closed before the door is open. That is the requirement, but it is important to recognise that certain valves have to be opened and closed in preparing the receiver to open. As an example of a potential problem, the interlocks on the receiver door may be satisfied without it having been drained or vented.

Another potential problem is that an interlock being satisfied because an isolation valve is closed does not mean its integrity has been proven. This highlights that people carrying out an isolation must have a full understanding of the procedure and the limited protection provided by interlocks.

Another factor to consider is the complexity introduced by interlocks. It is certainly possible to make them more sophisticated by using key exchange units and similar, which can allow more comprehensive controls to be provided. However, this can introduce problems because they get so complicated that people struggle to understand what they are doing. Also, the components used in comprehensive interlock systems can be prone to failure that can mean people feel compelled to use formal and informal methods of bypassing them.

Everyone needs to understand that interlocks do not remove the human factor from critical tasks and that a balance needs to be struck between increased levels of protection vs. complexity.

Case study

In June 2002, two crew members on board the passenger cruise ship Queen Elizabeth 2 were badly scalded when boiling water suddenly discharged from a pipeline. One of the men subsequently died as a result of his injuries.

The men were in the process of cleaning a main steam stop valve on an oil-fired boiler that was being prepared for survey. The investigation found that the isolation valve to the engine room steam ring main was leaking, which caused localised heating of trapped condensate (water) in the pipework. This was subsequently released when the steam stop valve was dismantled. Work on the valve had been allowed to proceed without confirming isolation. This was partly because the risks associated with leaking valves had not been fully considered and because the design did not include drain connections that could have been used to prove the isolation integrity.

Conclusions

The purpose of this paper was to emphasise that achieving process isolations is often more complicated than many people realise. In particular the sequence of steps required to prove valve integrity is often not understood fully, with people being happy as long as the correct valves are closed and secured before the work requiring the isolation can begin.

HSG 253 includes specific requirements for proving isolations, including:

- Each part of the isolation should be proved separately, e.g. prove each valve in a double block and bleed scheme;
- Each part should be proved to the highest pressure which can be expected within the system during the work activity. Particular care is required when there is a low differential pressure across valves where the sealing mechanism is activated by pressure; and
- Where possible, each part of the isolation should be proved in the direction of the expected pressure differential.

It appears that companies and individuals have accepted the guidance as relevant and correct but have not checked whether they can be applied in practice and/or whether the requirements are being followed. The concern is that this creates a large disconnect between theory and practice, which could result in risks being underestimated and hence improperly controlled. The solution is not simple, but being open about when the guidance cannot be followed will at least ensure alternative methods are developed that achieve similar levels of risk control.

Reference

HSG 253 – The Safe Isolation of Plant and Equipment. Second edition Published by HSE in 2006. Available to download at http://www.hseni.gov.uk/hsg253_the_safe_isolation_of_plant_and_equipment.pdf

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