Safety practice

Double block and bleed – it's more complicated than you think

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Summary

The double block and bleed method of valve isolation has become almost the default method of isolation in the process industry. However, there are limitations and misunderstandings in the methods of proving integrity. This paper highlights several ways in which double block and bleed isolations can fail, resulting in hazards with major accident potential. Key learning points include:

- Implementing an isolation involves more than simply closing some valves;
- Multiple failures can and do occur — and because valves are often of the same type and in the same service, common cause failures are an issue;
- Valve integrity must be proven and this requires pressure. There will be times when no pressure is available from the process, or it is only available from the wrong direction;
- Reducing the risk to personnel carrying out maintenance will often be transferred to those implementing the isolation.

Keywords: Isolation, valve

This paper follows one published previously in LPB titled *Process isolation – it's more complicated than you think* (LPB231, pg 19, June 2013). In that paper I took a fairly general look at the way process plant and equipment is isolated for intrusive maintenance, and used an example of a pig receiver to illustrate that achieving a suitably effective isolation is more complicated than it may appear. Also, I referred to the HSE guidance document HSG 253 *The Safe Isolation of Plant and Equipment*, pointing out that full compliance of this document is not easy to achieve.

I have written this follow-up paper to illustrate that even our 'default' method of isolation, double block and bleed, does not automatically achieve an effective isolation.

What is double block and bleed?

'Double block and bleed' is a method of valve isolation that involves closing two valves to create a double barrier between the source of hazard and a break of containment. A bleed valve between the two block valves is used to monitor the isolation and to bleed any pressure that may build up in the space between the block valves.

The advantage of this form of isolation is that two valves have to fail before a loss of containment can occur. The likelihood of this is relatively low, although it is not zero (especially when common cause failures are considered) and even if both valves fail, the primary valve (the one nearest the source of pressure) will reduce the pressure that the secondary valve is exposed to and hence reduce the rate of release.

However, this paper will illustrate several ways in which double block and bleed isolations can fail, resulting in hazards with major accident potential.

Proving isolations

The reality is that valves can and do leak or 'pass.' Proving the integrity of an isolation is essential if the risks of major accident hazards are to be reduced to As Low As Reasonably Practicable (ALARP). The methods used to prove integrity must be carefully considered when planning an isolation, and the people implementing the isolation need to have a good understanding of how it is achieved.

Proving integrity typically involves pressurising the point of isolation and checking for signs of leaks. How this is achieved will depend on circumstances, including the status of the plant at the time of isolation and whilst maintenance is being carried out.

The two aims when proving an isolation are to:

- expose the isolation to the pressure that it may experience whilst in use;
- check the integrity of the isolation in the 'correct' direction with regards to the potential source of pressure.

These two aims cannot always be achieved in an effective way. The risks this creates have to be considered when selecting and designing the isolation. Generally, credit cannot be taken for an isolation that has not been proven. However, a risk based approach means that some credit can be taken for partial proving, providing other controls including mitigation, are implemented.

Issues with double block and bleed

The role of double block and bleed appears to be fully accepted across the process industry. For example:

- Plant designers know they need to provide two block valves with a vent or drain valve in between on all process connections to items of plant and equipment;
- Maintenance planners know they need to identify the appropriate block and bleed valves when providing

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instructions on how to isolate plant and equipment;

- Operators know they have to close two valves and open a bleed when isolating plant and equipment.

However, the limitations and the methods of proving integrity are not understood so widely. In particular, the sequence of steps to be performed to achieve, prove and secure the isolation is not recognised; or the risks that result if these are not followed. This situation is perpetuated because loss of containment occurs only rarely when implementing an isolation. However, given the potential consequence is loss of containment and major accident hazard, a low likelihood does not mean the risk is low.

What can go wrong?

A series of incidents is described below that illustrates a number of scenarios where double block and bleed isolations can fail. They relate to an item of equipment handling high pressure gas that requires isolation for short-term maintenance. Following each incident the method of isolation was modified to prevent recurrence. However, although the cause of previous incidents was removed, different problems occurred as a result. (I have to admit this sequence of incidents did not really happen. However, each incident has actually occurred).

Figure 1 shows the original configuration of the system. The main features to note include:

- The item to be maintained includes a vent, drain and pressure gauge that are used when preparing the item for maintenance;
- Double block and bleed is provided on the inlet to the item to be maintained;
- The bleed valve is connected to a vent header, which provides a path to depressurise the interspace between primary and secondary isolation valves.

Incident 1

The item to be maintained was isolated by shutting the primary and secondary valves and opening the bleed to the vent header. The bleed was then closed so that there were two valves between vent header and the item to be maintained. The item to be maintained was then drained and vented before being opened.

During the maintenance activity, a gas release occurred when the vent header had become pressurised due to venting from another system on the plant.

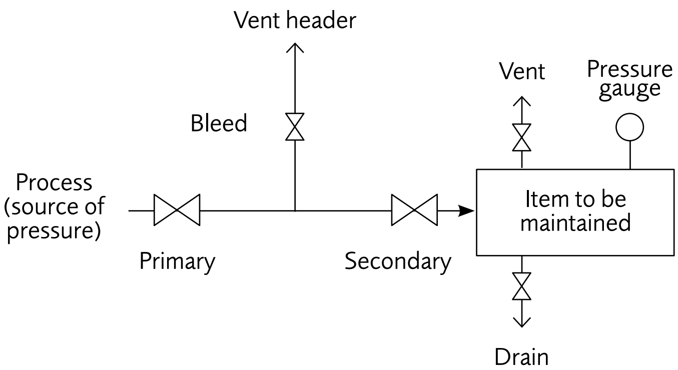

Figure 1 – Original configuration - bleed to vent header

The investigation identified that the method of isolation meant that the integrity of neither the bleed nor secondary valves had been tested. Because they both leaked, pressure in the vent header was able to pass to the maintenance location.

This scenario had not been considered credible because it required three apparently independent events to occur (i.e. vent header being pressurised and two valves leaking). However, this incident illustrated that low likelihood does not mean that such an event cannot happen. Given the potential consequences, the associated risks were considered to be significant. As a result it was stipulated that integrity of all valves shall be tested in future whenever isolating this item for maintenance.

Incident 2

Following incident 1 the following procedure was adopted for proving the integrity of the valves used to form the double block and bleed:

1. Shut secondary isolation valve;
2. Depressurise the item to be maintained;
3. Confirm plant does not re-pressurise, thus proving the secondary isolation valve is not leaking;
4. Shut the primary isolation valve;
5. Confirm pressure in the interspace between block valves does not fall, thus proving the bleed valve is not leaking;
6. Open the bleed valve to de-presssurise the interspace to the vent header; then close the bleed valve;
7. Ensure the pressure in the interspace does not rise, thus proving the primary isolation valve is not leaking;
8. Open the bleed valve routinely during the maintenance activity to relieve any pressure build-up in the inter-space, to confirm the primary isolation valve was not leaking.

At this point, it was assumed that the integrity of all valves had been proven and so the full requirements for a double block and bleed isolation had been satisfied.

Having implemented this procedure a near miss was raised because it was pointed out that the bleed valve had only been tested in the 'wrong' direction. It had used pressure from the main process whereas the vent header was a potential source of pressure during maintenance if venting occurred. Also, because the bleed valve was being opened and closed (to relieve pressure build-up) after it had been tested, the validity of the test would have been compromised. The basis of the near miss was that two valves with proven integrity were required between all sources of pressure and the maintenance location, but the sequence of events meant that integrity had been proven for only one valve (the secondary isolation valve) when considering the vent header as the source of pressure.

As a result of this incident it was decided that a bleed connected to the vent header was not acceptable and a local vent would be used instead.

Incident 3

Figure 2 shows the modification made following incident 2 to provide a local bleed point.

The same steps would be followed as above so that the secondary isolation valve would be tested and the bleed valve would be left closed but opened intermittently.

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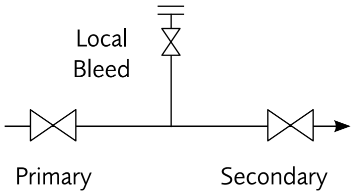

Figure 2 – Modified pipework to provide a local bleed

The pressure of the gas and distance between block valves meant a reasonable quantity of gas would be vented when proving integrity of the primary valve. The bleed valve was located near to a plant road.

Whilst implementing the isolation, gas was detected on the road. This was raised as a high potential incident because a passing vehicle could have provided a source of ignition resulting in a fire or explosion. The investigation report specified that, in future, precautions shall be taken to avoid a gas cloud and potential ignition source occurring at the same location when venting gas to form an isolation.

Incident 4

The technician tasked with the isolation the next time the item required maintenance was aware of the recommendations from the previous incident. Their first thought was to close the road so that potential ignition sources were excluded, but this was considered to be impractical. As an alternative, they decided that routing the vent to an alternative 'safe' location would be a better solution, and would be consistent with the previous recommendation. They rigged up a length of pipe with a right angled joint so that the gas can be routed away and up, well away from the road. They used instrument tubing and compression fittings. These items were used widely across the site and fully rated for pressure (see figure 3).

Unfortunately the technician did not take into account the turning motion created by the high pressure gas flowing through the tubing during venting. The ad hoc arrangement started to 'unwind' at great speed and hit the technician, causing serious injury. Whilst the investigation did highlight errors made by the technician; it identified systemic failures related to the design and planning of isolations as root causes.

Incident 5

Further to the previous incidents, it was decided that a different method of proving valve integrity was required. It was concluded that, as long as the integrity of the primary isolation valve could be proven, the likelihood of the secondary valve experiencing a high pressure would be low, which would significantly reduce the potential for leakage. This could be further ensured by routinely depressurising the interspace between the valves, which would be an ongoing check of the primary valve integrity.

It was decided that an alternative source of pressure could be used to prove integrity of the secondary valve. Nitrogen was the obvious choice due to its availability. The arrangement is shown in figure 4 below. It included a vent from the nitrogen connection to allow depressurisation to atmosphere before disconnecting the nitrogen supply.

The following sequences of steps were defined:

1. Shut primary isolation valve;
2. Depressurise the item to be maintained via its vent;
3. Confirm the item does not re-pressurise, thus proving the primary isolation valve is not leaking;
4. Shut the secondary isolation valve;
5. Connect a nitrogen supply to the local bleed point;
6. Pressurise the interspace between primary and secondary with nitrogen to a modest pressure, that can be safely vented from a local vent (5 bar was selected);
7. Confirm pressure in the interspace does not fall, thus proving the secondary isolation valve is not leaking;
8. De-presssurise the interspace locally and close the bleed valve;
9. Disconnect nitrogen;
10. Open the bleed valve routinely to confirm the primary isolation valve was not leaking.

This method was implemented successfully. However, during a routine check using the bleed it was found that pressure was present at the interspace. This occurred because the primary isolation valve had leaked a small amount. Initially it was felt that this was not a problem because the secondary isolation valve was stopping gas flowing to the maintenance location. However, it was then pointed out that the secondary isolation valve had not been tested to the full process pressure and hence it could leak.

A near miss was raised because this may have allowed gas to pass to the maintenance location. Following this incident it was decided that it would be better to leave the bleed valve open so that the interspace could not be pressurised.

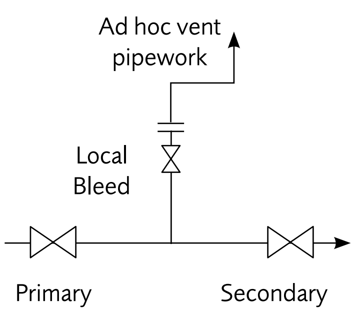

Figure 3 – Arrangement created to route vented gas away from the road

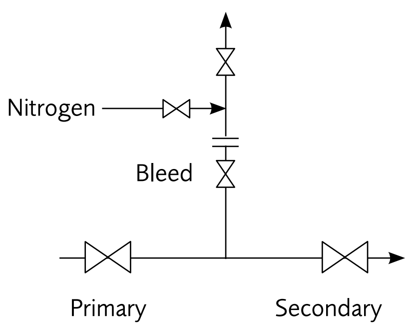

Figure 4 – Arrangement to use nitrogen to prove the integrity of the secondary valve

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Incident 6

Following the previous incident, the practice changed so that bleed valves were left open. A near miss was raised because it was pointed out that this resulted in an open end being created at the bleed with only a single valve isolation against the full process pressure. This did not comply with the company's isolation standard.

As a desperate measure, it was decided that physical isolation would be required in the future for the maintenance task. This would be achieved by removing a spool piece from the pipework. Blank flanges would be fitted to the open ends (see figure 5).

Incident 7

By this stage, everyone was happy that the use of a positive isolation must be the safest method possible. The double block and bleed was established to allow the spool to be removed and blank flanges fitted. As the intention of the blank flanges was to eliminate any potential for leakage, it was recognised that it would need to be serviced tested under pressure. This was achieved by de-isolating the double block and bleed. As expected, no leak occurred from the blank flange.

Once the maintenance task was completed the blank flange had to be removed and spool piece replaced. The double block and bleed was used to achieve this. When it came to testing the secondary isolation valve it was pointed out that there was no useful method because any gas flowing past the secondary valve would be to the small volume between valve and blank flange. This space would pressurise almost immediately so that a flow could not be detected and the leak could not be recognised.

The blank flange had to be removed under a single valve isolation, which did not comply with the isolation standard and so a near miss was raised.

Conclusion

The purpose of this paper was to illustrate that there are many ways that double block and bleed isolation can fail. The sequence of incidents showed that:

- Implementing an isolation involves more than simply closing some valves;
- Multiple failures can and do occur — and because valves are often of the same type and in the same service, common cause failures are an issue;
- Valve integrity must be proven and this requires pressure. There will be times when no pressure is available from the process, or it is only available from the wrong direction. Planning an isolation must take this into account;
- Reducing the risk to personnel carrying out maintenance will often be transferred to those implementing the isolation.

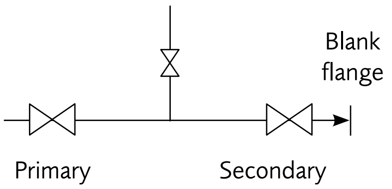

Figure 5 – Positive isolation

The reality is that the risks and means of controls are not always obvious, and each isolation needs to be carefully planned. This is not clearly explained in many companies' isolations standards or widely understood by designers or people planning or implementing isolations.

By focussing only on the means of isolation, people are likely to make poor decisions that can lead to an increase in the overall risk. A more onerous form of isolation is not necessarily the safest. For example, installing positive isolation (e.g. blind flange, spade or spool removal) will usually reduce the risk to someone performing a piece of work on the isolated equipment and it is reasonable to mandate this for high risk activities such as work in a confined space. However, the requirement to break containment at both installation and removal may create a greater risk.

Human factors must not be overlooked. In simple terms, the more complex an isolation becomes the more likely it is that unintended consequences will occur. If valves are difficult to access, compliance with an isolation instruction becomes difficult and may encourage people to select less reliable alternatives. And if valves are difficult to identify or are not arranged logically, the likelihood of simple selection errors is greatly increased.

Basic engineering and maintenance make a significant contribution to the risks associated with isolation. Fouling of valve seats and blockage of vents and drains are common problems on process plant and can have a significant impact on the reliability of an isolation. Selecting the correct types of valves; and sizing and arranging pipework for process and human factors are important during the design stage. Also, preventative and reactive maintenance during the plant's operating life is a critical factor.

Achieving double block and bleed on old plant can be particularly difficult because it was unlikely to have been considered during design. However, whilst newer plant is more likely to provide enough valves to achieve a double block and bleed, the reality is that designers do not fully understand the requirements and risks; and hence the requirements to assess each isolation remains.

A couple of key points to ponder:

- If your company isolation standard says it is compliant with HSG 253 it probably isn't, and it will be open to interpretation;
- If your company isolation standard says double block and bleed is your default method of isolation, you probably do not comply with it (even if it looks like you do);

Double block and bleed is not necessarily the safest method of valve isolation. A holistic view of the whole risk is required to decide this. In some cases (e.g. low pressure liquid systems) a single valve isolation may create less risk overall than double block and bleed.

Finally, a bonus point not directly related to process isolations. The sequence of incidents presented in this paper illustrates why investigations must be more than preventing your last incident. We all know that major accidents are complex events that occur due to multiple failures at all levels of organisations, and being too focussed on a single event without considering the wider issues can actually result in changes that increase instead of decrease risk.

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