Safety practice

Maintaining bursting discs and pressure safety valves — it's more complicated than you think

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Summary

Bursting discs (BD) and pressure safety valves (PSV) are often our last line of defence in avoiding catastrophic damage to equipment and major accidents caused by high or low pressure. We hope that they never need to operate but when required they really need to be reliable. We put a lot of effort into determining relief requirements and specifying the appropriate device. In doing this we realise that BD need to be replaced and PSV need to be tested and maintained on a regular basis. However, this maintenance activity may be more complicated than you think. The problem is that we cannot usually test a BD or PSV in service and have to trust they will operate when required. This paper will highlight some issues you need to be aware of if you want to have confidence that BD and PSV are reliable in practice.

Keywords: Bursting discs, pressure safety valves, maintenance

What are bursting discs and pressure safety valves?

BD and PSV are fitted to systems where it has been identified that an unplanned event may mean the pressure experienced could exceed the designed capability. They are normally in the closed position so that the content of the system is contained. If the concern is high pressure the BD or PSV will open to allow fluid from the system to be released, which will reduce the pressure. If the concern is low pressure (vacuum) the BD or PSV will open to allow fluid to flow into the system.

A BD uses a membrane that is designed to fail at a predetermined pressure. It is a sacrificial item as it cannot reclose after activation.

A PSV is held in the closed position by a spring (or similar) that exerts a force that is sufficient under normal conditions but will allow the valve to open at a predetermined pressure. PSVs can close again once the pressure has been restored to normal, although it is usually considered good practice to maintain a PSV after it has operated as this may have affected the pressure settings and valve seats.

BD and PSV are usually specified as the last layer of protection for avoiding damage to systems caused by high or low pressure. They are in addition to:

- good engineering design to ensure systems can withstand the expected pressure range;
- basic process control system and operating procedures to ensure operation within the defined pressure envelope;
- process alarms to notify operators early of excursions so that they can take action to return the pressure to normal;
- Safety Instrumented Systems (SIS) that will automatically take action if a pressure excursion continues.

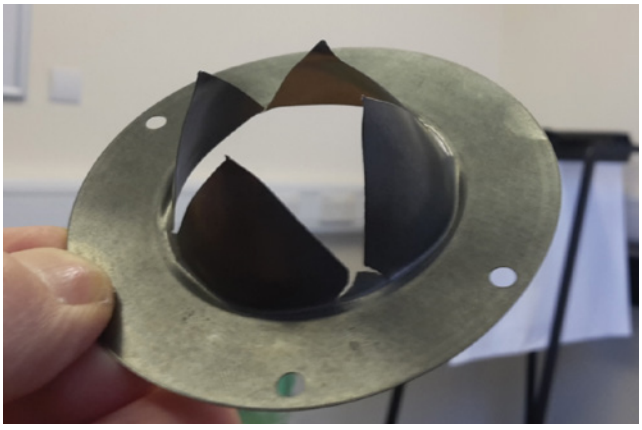

Figure 1: Bursting disk after operation

One of the issues with BD and PSV is that they cannot be tested in service to prove that they will actually work on demand (there are techniques that do allow online testing of PSV such as "Trevi test" but this is usually only for certain types of system such as high pressure steam and do not satisfy all maintenance requirements including internal inspection). Also, as a last line of defence they operate very infrequently so we do not have much operational data to prove their reliability. The reality is we simply have to trust that they will work when required.

Preparing BD and PSV for maintenance

Although the main focus of this paper is on the actual maintenance activity, preparation cannot be overlooked. Both BD and PSV are installed as part of the pressure envelope of the system they protect. Hence, removal involves breaking joints, which introduces the potential for loss of containment.

In an ideal world BD and PSV maintenance would only be carried out when the associated equipment has been shut down, isolated and depressurised. This means the potential for loss of containment when breaking the joints is minimised, although it should be noted that if the BD or PSV relieves to

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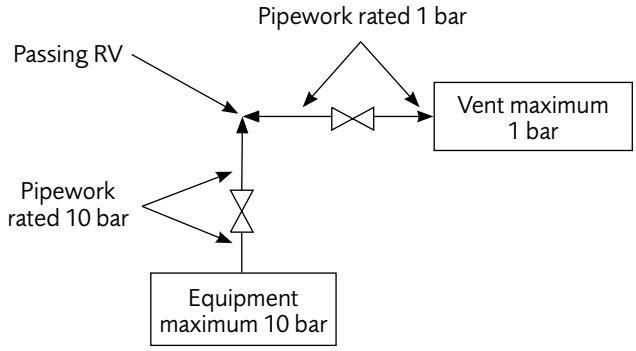

Figure 2: Why the PSV inlet valve must always be closed before the outlet

a vent system or other equipment that this will also need to be shut down. An added advantage is that issues about protecting systems from pressure excursions when the BD or PSV are under maintenance are reduced, although it should be noted that this is not a fool proof solution as demonstrated so tragically in the Piper Alpha disaster where the removal of an PSV led to the initial loss of containment because it was relying on an isolation of a pump that was returned to service before the PSV was refitted.

If a BD or PSV is going to be maintained whilst the associated system is online it will need to be isolated, usually by closing valves. It is essential in this case that protection against high pressure continues, which is often achieved by having a spare arranged in parallel with interlocked valves used to ensure one BD or PSV is in service at all times.

Proving the integrity of an isolation on a BD or PSV is often difficult. This is especially the case on the outlet if connected to a vent system as there is often no pressure at the time when the test is required, but it cannot be guaranteed that back pressure will not be generated by flows from other connected equipment.

Another thing to bear in mind is that outlet pipework on BD and PSV is often rated for vent pressures, which can be significantly lower than the normal or maximum pressure from the system. Therefore, if a valve is closed on the outlet and there is a leakage flow through the BD or PSV the outlet pipework may be over pressurised, which may result in a loss of containment. The key message in this circumstance is that the inlet valve must always be closed before the outlet.

Possible issues with maintenance of BD and PSV

Maintenance of BDs involves removing the existing disc and replacing with a new one. Whilst this may sound simple there are a number of potential issues.

PSVs are usually sent to a workshop (either on site or remote) where they are maintained before being returned to site for refitting. In some cases, a new PSV may be fitted, either because it is a single use design or the existing one is found to be in an unsuitable condition for refitting. In other cases, a spare PSV may be fitted, which reduces the time that the system is left without a PSV but does introduce some potential issues with tracking the location of specific PSVs and keeping historical performance data.

In some cases, a BD may be removed, subjected to a visual inspection and refitted. In most cases they are replaced with a new one.

Transport to workshop (PSV only)

Often the primary concern when preparing a PSV for transport (especially one in hazardous service) is protection of the people handling it. Hence, it is normal to subject it to some form of decontamination, especially if the workshop is offsite. The problem is that one of the first things done as part of the maintenance routine is a 'pop test.' This tests the pressure at which the PSV operates and is an important check to confirm the reliability of the PSVs being used. However, decontaminating the PSV means it arrives in the workshop in a different state than it was when installed and hence the test may not be a true reflection of its reliability.

Another way that the pop test can be compromised is if the PSV is damaged in transit. When a PSV is being sent to the workshop it is easy to think that it does not need to be looked after as it is going to be maintained anyway. But again, impacts and other shocks whilst in transit can affect the pop test result. A challenge is that sites often do not keep a stock of suitable packaging material, and so people tend to improvise.

When sending the PSV to the workshop it is essential that it can be identified reliably. If serial numbers or other labels are missing or illegible it is possible that PSVs may be mixed up in the workshop and the wrong one returned or sent to the wrong location. Also, it is essential that information is supplied about the correct settings for the PSV. There can be a tendency to simply refer to the previous test certificate. However, this can mean a single mistake results in a PSV being set incorrectly for the remainder of its life and so original design data should always be referred to.

PSV maintenance

There are a number of mistakes that can happen during PSV maintenance. The main concern is setting the PSV to the wrong pressure. This can happen due to paperwork errors, misidentification of the PSV, failure to take into account temperature or back pressure effects, using the wrong test fluid or the technician simply carrying out adjustments incorrectly. Unfortunately it can be difficult to discover these errors. This highlights the criticality of quality systems operated at the workshop. Assurance requires far more than setting up procedures for an in-house workshop or choosing an accredited supplier. You really need to have a far more hands-on approach to monitoring what goes on during PSV maintenance including confirming the technicians are competent and the equipment being used is suitable and in good condition. Audits should cover the whole process from the moment the PSV arrives at the workshop.

BD manufacture

The issues raised with PSV maintenance above can apply to BD manufacture. Errors made in the process, including providing incorrect paperwork can have catastrophic consequences. Again, confirming effective quality systems are in place and working is critical.

Receiving a BD or PSV to site

BDs and PSVs are sensitive pieces of equipment and need to be handled carefully when being transported from the factory or workshop. They need to be packaged properly. BDs should be kept flat and PSVs upright. Unfortunately, this is not always

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Figure 3: Example of a PSV with flanges covered in tape and stored on its side

the case and damage caused in transit may be impossible to detect. The result can be a BD is damaged or a PSV's setting is affected, which can mean they will operate at the wrong pressure.

Another issue specific to PSVs is that contamination can enter through the inlet or outlet and so these should be covered for transit. Unfortunately, the methods used to do this can cause even greater problems. Tape is sometimes used, which if not removed completely can enter the mechanism of the PSV and may affect its operation.

Plugs are often inserted that may be left in when the PSV is fitted causing a blockage that may prevent operation. There are very good plastic caps available that fit into flange bolt holes so that it is impossible to fit the PSV with them still in place. This seems to be a very good solution and should be standard practice.

The person accepting a BD or PSV to site has an important role of checking its identification and condition on arrival including the type of packaging used, evidence of how the item has been handled in transit and the correct paperwork has been supplied. Also, they need handle the BD or PSV correctly and ensure the same quality standards are applied in the way the item is stored.

Figure 4: Example of a flange end cap that cannot be left inaccidentally (Image taken from https:/dubaiyellowpagesonline.com/comprods/783069/stud-hole-fitting-flange-protection-cover-8-inch-with-150-to-2500-class.htm)

Transporting BD and PSV around site needs to be considered. This includes to and from stores, and to the worksite when ready for fitting.

Fitting a BD or PSV

There are a number of important actions and checks that need to be carried out before a BD or PSV is fitted.

One critical check that is sometimes overlooked is to confirm that the plant side inlet and outlet pipework is clear and not blocked. Unfortunately, pipework design often means the ability to check this is restricted. Also, if blockages are found they should be subject to further investigation to determine the root cause as blockages in service can restrict the ability of a BD or PSV to relieve pressure.

It is essential to remove all packaging from the BD or PSV. BDs often have a protective membrane for transit and storage, which if left on can prevent it operating when required. A PSVs inlet and outlet must be clear of contamination and all packing material must be removed fully.

Fitting a BD the correct way round is critical to ensure they operate at the correct pressure. Whilst most will be fitted with the concave side towards the inlet this is not always the case (e.g. reverse buckling discs) and so particular care is required. Also, BDs are usually fitted into a carrier, which may have a direction of flow indication but this may not confirm that the BD has been fitted correctly in the carrier.

The last check before fitting is to ensure that the correct BD or PSV is being fitted. This should include a final check of design data and paperwork provided; confirming that all serial and tag numbers match up.

Standard joint making methods should apply to fitting a BD or PSV. However, it should be noted that the ability to check joint integrity is likely to be difficult, especially on the outlet side which will normally be at a low pressure. This can also apply to the inlet on spared items because the BD or PSV may be left isolated until required at a later date.

The final step should be to ensure the BD or PSV is left in the correct state of isolation. In some cases, this will mean it should be fully de-isolated so that it is providing protection to the equipment. In other cases, the relief path may be part of a wider isolation (i.e. isolating a vessel from a vent system), which means it must be left isolated with systems in place to ensure it is included in the de-isolation procedure when the equipment is being returned to service. A spare BD or PSV may be left isolated at its inlet and/or outlet.

Paperwork

There is inevitably some paperwork associated with BD and PSV maintenance. It is important because it creates a historical record of activities and can be used to demonstrate reliability and current condition. Paperwork should undergo independent checks before being filed. Key things to confirm include that the correct item was fitted in the right place and that its specifications match the design specification. Maintaining a log sheet for the full life of the BD or PSV is useful as it allows historical information to be reviewed easily, which can help to identify recurring issues (e.g. problems with fouling or PSV failing its pop test every time it is maintained).

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Conclusions

BD and PSV are safety critical items. They are our last line of defence, preventing potential catastrophe when all other controls have failed — but they are also precision items that can fail and have to be handled carefully.

Particular issues to be aware of include:

- We cannot test BDs or PSVs when in service, so we have to trust they will work when required;
- It may be impossible to confirm the integrity of an isolation before breaking a joint to remove a BD or PSV, especially on the outlet side that is normally at atmospheric pressure;
- Outlet pipework is often rated much lower than the system pressure and so the inlet side must always be isolated before the outlet;
- Pop tests of PSVs are important for confirming reliability but the results can be compromised when the PSV is decontaminated for transport or by damage in transit;
- Beware of setting PSVs according to their last certification instead of checking with original design data as this can perpetuate errors for years to come;
- BD and PSV manufacture and PSV maintenance requires very high quality standards, going far beyond standard supplier checks;
- The way BDs and PSVs are packaged and transported is critical;
- Items used to cover flanges of PSVs could cause a blockage that would prevent it from operating when required. End caps are available that remove most of this risk;
- The person accepting the BD and PSV on site has a critical role in checking its condition on arrival including packaging and paperwork;
- Storage and handling whilst on site are also important;
- Inlet and outlet pipework must be checked for blockage before fitting the BD and PSV;
- The BD must be fitted the correct way around, but the domed side cannot be relied on as an indication;
- It is not always possible to confirm joint integrity after fitting a BD or PSV;
- The BD or PSV must be left in the correct state of isolation, which will depend on the particular circumstances;
- Independent checks of paperwork should be carried out after fitting a BD or PSV.

One observation is that the trend towards sending PSVs offsite for maintenance introduces a number of issues that could be avoided by keeping them onsite.

Finally, an inherently safe solution is to design all systems so that they can withstand the maximum pressure that could possibly occur. However, this would be very expensive and so BDs and PSVs are likely to always have a role. Also, increasing maximum design pressures and not fitting relief devices would allow systems to reach higher pressures and so the overall risk may actually be greater.

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