

BOOSTERS – LONG-TERM CONSIDERATIONS

by Ian Speer

Booster compressors have enjoyed wide usage over the past decade and as the fleet ages there are a number of important safety issues that arise.

We are all aware of the legal obligation to have pressure vessels and safety valves periodically inspected and or serviced. The reason for this activity is not disputed and there are few accidents as a result of failure of these items which is a testament to the effectiveness of the current regulatory system.

Within a booster there are a number of components which contain high pressure air. These components and the results of failures of these items are the subject of this paper as under certain conditions they can fail catastrophically. The results of several of these failures can be seen in the pictures in the appendix.

Analysis of a number of incidents points to a set of events occurring at one time and we will now consider each of the possible contributory factors.

1. Introduction of a fuel source into the booster.
2. Degradation of the system components due to corrosion.
3. Modifications to plant that result in the creation of internal non drained liquid traps.
4. Units operating at consistently higher temperatures as a result of degraded cooling system performance.
5. Accumulation of carbon inside components that can ignite given an overheat condition.
6. Wiring and shutdown systems degraded over time.
7. Faulty or non existent liquid drains and or poor attention to

regular servicing at points where condensate can or does collect.

8. Inadequate scrubbing/cleaning of the incoming compressed air stream that is being fed to the booster.
9. Loss of sump oil from within the booster. In this case external leaks are not a consideration as they will not lead to fuel in the boosters working cylinders.

We will now consider each of these items in turn and how they impact on the safe functioning of a booster.

Item 1

Almost without exception boosters used in our industry are fed with compressed air from two-stage, oil-injected rotary screw compressors. All of these compressors pass a small amount of oil out along with the compressed air they provide.

When the oil separation system in the compressor is in good condition the amount of oil that gets to the booster is very small and will not cause a problem if the booster and all of its systems are in good condition.

If, however, the primary compressor starts to pass large amounts of oil to the booster then we have a situation where a fuel source and hot compressed air is present. We know from experience that atomised fuel and hot air burns readily. Indeed many of us will have driven here in diesel powered vehicles.

In short fuel air mixtures in a booster are a lethal cocktail.

Item 2

The main system components in question are the air/air pre-cooler, the air/air intercooler if present and the air

to air aftercooler plus any pressure vessels or other types of scrubbers in the system.

Over time the coolers, particularly the interstage and discharge coolers suffer from internal corrosion, external corrosion and cyclic thermal and mechanical stresses. The net result is that the structural elements become weakened (as evidenced by commonly observed cracking and leakage near where the tubes enter the header of the cooler particularly in older units) and in the event of a pressure spike catastrophic failure can result.

Item 3

Given the long period that many units have been in service most will have been repaired and in many cases very substantially modified or altered in layout to meet space demands in changing applications.

It is not uncommon for system modifications to result in liquid traps or low points within a booster. Such locations can over time collect the minute oil particles that will inevitably be present in the incoming compressed air stream.

Over time oil accumulates and when a situation arises whereby very hot operating conditions and a glowing piece of carbon are present then the oil will burn or worse still explode.

Item 4

Over time the air/air coolers become internally corroded and or coated with foreign material as well as suffering from external corrosion of the cooling fins. Another more subtle but worse form of corrosion takes place between dissimilar metals such as where aluminium fins are wound onto steel tubes.

This corrosion is not visible and like the other areas previously mentioned effectively reduces the ability of the

cooler to dissipate heat to the atmosphere. Finally paint is a problem as many owners will have applied a number of coats of paint to their units over the years in an effort to protect them. There are specialised thermally conductive paints available for application to coolers and units should be effectively depainted prior to repainting.

The term depainting is used for good reason it does not include sand or abrasive cleaning it is a chemical process that removes both paint and many forms of corrosion without severe mechanical stresses.

Item 5

As small particles of oil will always be present in the air supplied to boosters and the temperature inside the booster particularly in the compression space and the pipework that conveys the hot compressed air to the coolers some of this oil will become baked onto these surfaces forming a layer of carbon which has several interesting properties. Carbon is flammable, it is an excellent insulator and in the presence of a high temperature oxygen rich airstream it will glow and act as an ignition source.

The net result is a unit that will run progressively hotter over time and at some point may well catch fire internally or explode. Not convinced blow onto hot coals and watch the results and a booster blows far more efficiently than you.

Item 6

All wiring and shutdown systems deteriorate over time as a result of exposure to heat, UV light, vibration and moisture which serves to accelerate corrosion on any exposed wiring connections.

In addition the actual temperature and pressure sensors that provide the shutdown signal become less accurate over time which may allow a booster to continue operating when it should otherwise have shutdown.

Item 7

Faulty or non existent liquid drains and or poor servicing procedures can result in a build up of liquids within the booster unit. At best mechanical damage may result if liquids get into the compression spaces. At worst fire or explosion may result.

Item 8

Inadequate scrubbing of the compressed air being fed to the booster. This problem is more common in older units and is a design shortcoming.

The lack of an effective system to collect incoming liquids and aerosol particles of oil as well as dust and dirt will shorten the functional life of the booster as well as predispose the unit to additional problems.

Item 9

Loss of sump oil from the booster unit/introduction of oil into the booster this is the big one. Simple overpressure structural failures in major components are very rare to the point that the author has not encountered an instance to date aside from failure of the HP discharge hoses.

Well, that is the bad news. The good news is that boosters are tremendous tools that can deliver wonderful increases in productivity enabling the economic exploration of many otherwise difficult targets.

We will now consider ways of addressing each of the eight areas outlined previously. In seeking solutions the aim has been to focus on the issues economically and to eliminate as far as possible the risk of catastrophic failures or explosions.

We can take heart from the fact that in almost every case of an explosion a number of the issues outlined have been present. Thus if we remove only one or two of the very important contributing problems immediately the balance can be addressed as and when the unit in question is due for servicing.

1 Introduction of a fuel source into the booster.

The oil consumption of ALL of the primary compressors should be checked and logged daily. If required the compressors should be topped up daily or if seldom used weekly and the volume of oil added recorded.

A clear pattern of oil consumption will emerge and any increase in oil consumption should be investigated. If the leak is external an informed judgment can be made about the hazards that the leak poses and the machine shutdown if that is deemed necessary.

If, however, the oil is being passed out of the compressor along with the compressed air and into the booster, the problem should be addressed quickly. The booster inlet drain should be checked and if the amount of oil being collected from the drain is not what is being lost from the compressor/s then the compressor/s should be shut down until repairs have been effected.

2 Degradation of the system components due to corrosion.

This is a difficult issue to address as the damage is primarily internal and the best indicators of problems are the need to repair cracking around the tube to header tank joints.

As the coolers age they do fail and it is common to see failures first occur 5 - 7 years after the unit was first put into service. Failures prior to this time will generally be related to vibration and poor installation issues whereas the corrosion failures start as the unit ages.

The solution simply is replacement with a similar or better still a new unit which has been designed to address many of the corrosion and loss of performance issues. Coolers have a finite life and their replacement should be budgeted into the operating cost of the unit in question.

- 3 Modifications to plant that result in the creation of internal non drained liquid traps.

Modifications to plant can result in the creation of cavities within the booster where oil can collect. An audit of the system to check for oil collected in low points will address this issue and if a problem is found a drain point can be added to prevent any build up of oil.

Drains can be automatic or manual and there are several excellent automatic drains with only one moving part thus eliminating floats and related service issues.

- 4 Units operating at consistently higher temperatures as a result of degraded cooling system performance.

Cooling systems that degrade over time are a real problem as they shorten the life of the booster valves and other components, as well as the hoses that transport the compressed air from the booster cylinders to the aftercooler and of course the main air discharge hose as well.

If you have access to a new booster then use a heat gun to measure the temperature drop across the same cooler on the new unit and compare it to the temperature drop across the older unit. Any large difference should be investigated starting with the cooling air flow.

If the temperature drop across the older unit is 20% less than for the new unit then the cooler should be cleaned and retested. If the temperature drop is still too low then the cooler should be replaced.

- 5 Accumulation of carbon inside components that can ignite given an overheat condition.

Carbon accumulation is difficult to locate without cutting up the cooler and it is normally associated with a reduced temperature drop across the cooler. The issues in 4 & 5 are best

dealt with by servicing the coolers after 4-5 years.

The units should be depainted, then the internals should be flushed with a carbon solvent first and a rust removal solution second and if there is a concern about possible blockage ultrasonic cleaning is effective in removing difficult to access encrusted material.

Finally the cooler should be pressure tested (hydro test) and then flushed with a anti-corrosive, non-flammable solution before the cooler is either reinstalled or put into storage. Paint the cooler with a suitable conductive paint.

- 6 Wiring and shutdown systems degraded over time.

Wiring and shutdown systems degrade over time. Most units will have been rewired once or more in their life, however, the shutdown temperature probes are critical items and should be calibrated or replaced every 3 years. This applies to both the interstage and discharge temperature gauge probes, or the whole gauge in the case of capillary type units.

- 7 Faulty or non-existent liquid drains and or poor attention to regular servicing at points where condensate can or does collect.

Some of the more complex older types of auto drains can be replaced with the simpler thermodynamic trap style of drain. Where manual drains are fitted they need to be cracked daily and must NOT be plugged.

A good idea is to fit a T piece and a small 1/2-inch manual drain beside the auto drain and that way one can quickly check that there is no build up of liquid and that the auto drain is indeed functioning correctly.

- 8 Inadequate scrubbing/cleaning of the incoming compressed air stream that is being fed to the booster.

This is a design problem and is unfortunately found on many older units as well as some more modern units. The solution will involve capital expenditure as well as a period in the workshop for the booster.

The reward for addressing this problem will be longer valve life, longer ring life and reduced operating costs. This is a far more important issue where the booster is frequently coupled and uncoupled with the possibility of dirt finding its way into the hoses and then into the booster.

Boosters that are permanently coupled to their primary compressors typically see valve and ring life in excess of 5000 hours or more whereas even careful operators who have to couple and uncouple hoses find 1500 hours for valves and rings hard to achieve.

- 8 Loss of sump oil from within the booster. In this case external leaks are not a consideration as they will not lead to fuel in the boosters working cylinders.

The final item to consider is loss of sump oil from the booster itself. If a booster starts consuming sump oil without any evident external leak the reason for the oil loss MUST be found promptly and made good.

Under certain conditions, sump oil can make its way past the booster rings and into the compression space where it can then either result in a fire or worse or be passed around inside the booster and accumulate to cause a problem if the drain system is not working correctly.

The common causes for oil passing into the compression space are-

- Worn rings
- One or more defective valves
- Worn cylinder bore/s
- Faulty unloading system on the booster

Modified control system that does not function correctly

Inadvertently shutting off the air feed to the booster while the unit is still running without having the bypass open resulting in a low pressure area above the booster pistons

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Too complex? Too hard? Can't be bothered? Ok, here is the cheap and dirty way to keep out of trouble until you can address the bigger issues.



- 1 Eliminate fuel (oil) from the booster by logging usage in the primary compressors and booster sump.
- 2 Investigate any abnormal oil consumption IMMEDIATELY.
- 3 Fit manual drains beside the automatic units to enable the driller to EASILY check this item every morning.
- 4 Have your high discharge temperature probes checked or simply replace them.
- 5 Check for liquid traps in the system.



If you do only 1 & 2 you will almost eliminate the possibility of an explosion and it will not cost more than five minutes per day.



If you choose to work through the list, over a period you will be rewarded by better mechanical availability as well as lower ongoing maintenance costs.

Still not convinced? Have a look at the following pictures. The owners of these units all had years of experience without major issues.



However, in each case, several improbable events occurred at one time with dramatic results.

Incredibly no one was hurt but there was collateral damage. We should treat these occurrences as a timely reminder – luck will not keep looking after us as an industry.