

GREEN PAPER CENTRIFUGAL PUMP EXPLOSIONS

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Background

Although not well documented, under certain operating conditions, ANY brand or type of centrifugal pump can explode, whether it is a centrifugal slurry pump or a basic centrifugal water pump.

Generally, when a centrifugal pump is over-pressurised with a liquid it will simply crack and dangerous conditions are not normally encountered (if ever). This is because liquids can generally be considered as being 'non compressible', so when the pump pressure retaining components crack, the fluid does not rapidly expand. The pump just starts leaking.

In contrast, if the centrifugal pump is sealing a gas, which centrifugal pumps are not designed to do, the pressure retaining components may explode when the gas rapidly expands on exit from the failed component. This is an extremely rare condition but is becoming more frequent in the field of centrifugal slurry pumping and KETO is working with customers in an effort to make your site safer.

Operating parameters that cause explosion

The famous paddle wheel experiments conducted by James Joule in 1849 resulted in the development of the First Law of Thermodynamics. In it, paddle wheels were spun in water and the temperature of the water increased.

If a pump is 'dead headed' the impeller spins in the volute, causing the temperature of the liquid contained to increase over a period of time. If the pump suction and discharge lines are closed, there is nowhere for the liquid to go. If the impeller continues to be spun the liquid temperature increases until steam is formed. Unless the steam is relieved by some means, or the pump is stopped before the casing burst pressure is reached, a pump explosion will result.

Photos of explosions

Until recently, pump explosions were not well documented and very seldom highlighted. Many companies, and indeed many pump suppliers, were not even aware the problem existed. In contrast, some mining companies, as those in the platinum industry where slurries are prone to bogging, reported periods when they were averaging one pump explosion every month! These sites took charge of the problem and modified their systems so their people are no longer at risk.

To date, no KETO Pump has ever exploded. In over 100 years of manufacturing centrifugal pumps, many water pump companies have never had a pump explosion reported, however this is no the case with most slurry pump manufacturers. It is our sincere hope that by helping to educate people about

reducing or overcoming the risk of explosion that not only will KETO pumps never explode, nor will any centrifugal pumps in your plant.

Bulyannulu Gold Mine in Tanzania – July 2004

We have started with a Process Water Pump duty to highlight pump explosions are not confined to slurry pump applications. This explosion occurred as operators had closed the suction and discharge valves on the standby pump without ‘tagging out’ the unit. The control room started the standby pump remotely, not knowing the valves were shut. After a few hours a loud explosion was felt and the following photos were taken.



Duty Pump with ‘Remains’ of Standby Pump

Shrapnel from standby pump volute disappeared, reports indicated pieces were found 100m outside the bunded area and had punched holes through razor wire fence. The two pumps above should look the same. The piping to the suction tank was bent, as was the suction tank at the pipe inlet.



Suction Tank and Piping Bent

Island Creek Coal Company, Virginia, USA - 28 January 2002

Sadly, this was a fatal accident. A fine coal transfer pump became blocked after standing for two days. It was started without gland service water and quickly overheated. When the operator stopped the pump, the gland service water entered the red hot all metal casing creating steam exploding the pump killing the operator



Pump Exploded Causing Fatality

Bong Mine Liberia: 14/12 pump exploded destroying pump house roof



Roof Damaged by 14/12 Explosion



Remains of Pump in Pumphouse



Roof in Background with Fragments Outside

No.8 Gold plant, AngloGold CD frame water pump – 2000



West Float & Acid Plant - February 2001. Calcine water pump



North 1 Gold Plant – January 2003 Carbon transfer pump



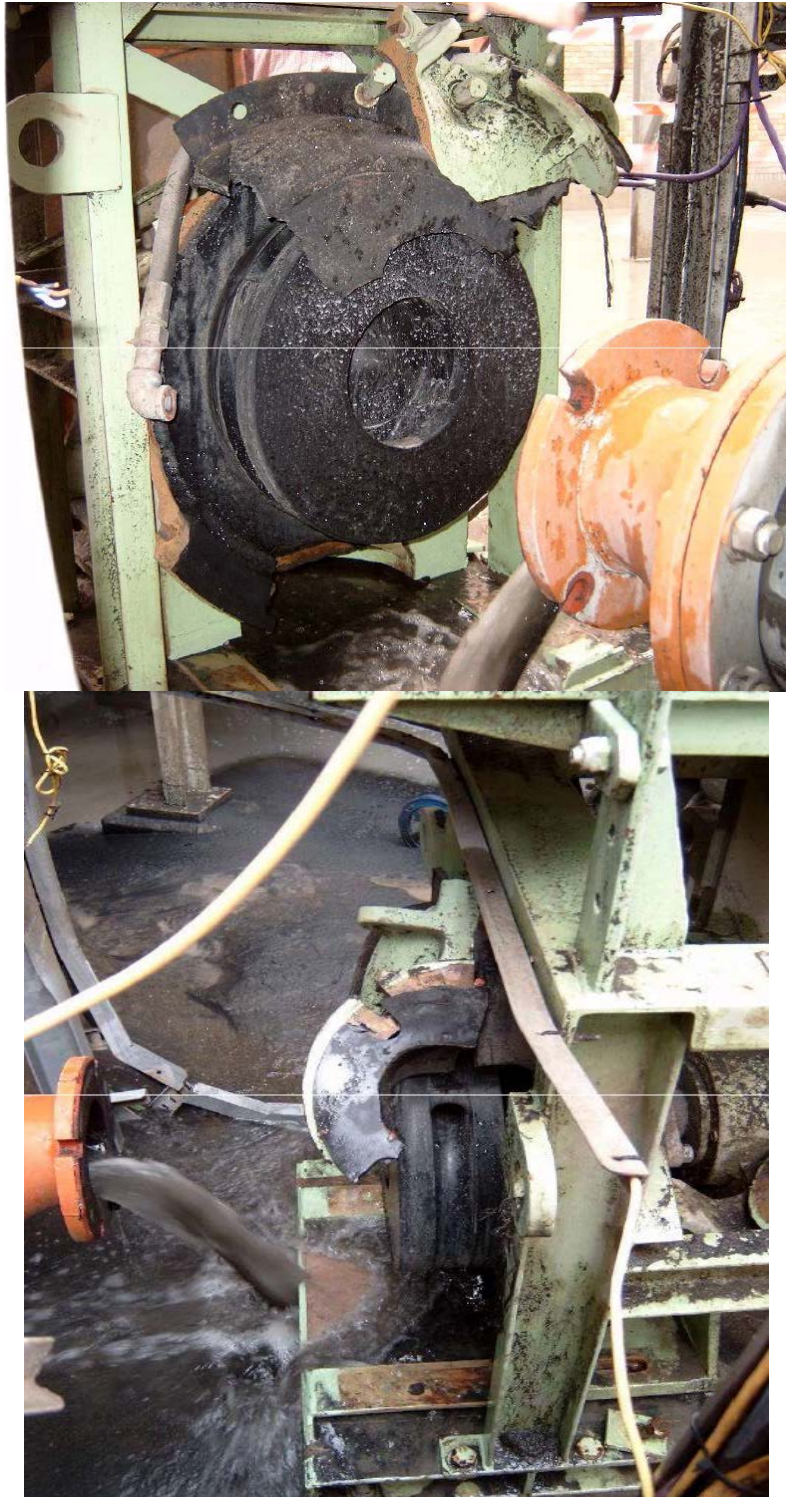
Apprentice with facial injuries caused from the carbon dust during the explosion.

Namdeb, Namibia- March 1999 Residue transfer pump



Modikwa 25- October 2003 Platinum UG2 transfer pump

Operator in area loses 3 toes.



Other reported incidents without photos

1. Chilled water brine pump at a US nuclear defence facility – Aug 98; 300 kW motor; 189l/s - ran for 2h before failure. Valves closed for maintenance – pump inadvertently started.
2. Underground at a US mine, a sand pump exploded when delivery and suction were blocked. A miner standing 10m away was seriously injured.
3. Underground at US mine. Explosion felt 280m away. 80kg of pump material was not found.
4. Fatality in Australia when the leading brand slurry pump exploded. No records.
5. North 2 Gold Plant - November 2001. Cyanide transfer pump.
6. West Float & Acid Plant - February 2001. Calcine water pump.
7. North 1 Gold Plant – January 2003. Carbon transfer pump.
8. North 2 Gold Plant - November 2001. Cyanide transfer pump.
9. West Float & Acid Plant - February 2001. Calcine water pump.
10. North 1 Gold Plant – January 2003. Carbon transfer pump.
11. Slimes transfer pump at Namdeb diamond mine in Namibia on 3 March 1999.

Anecdotal evidence indicates pumps are exploding more frequently than in the past. This may be due to better global communication, but other factors could attribute to the phenomenon as:

- (a) **Automated Valves:** Many sites now use automated valves and some are not interlocked to prevent them being closed when the pump is remotely started.
- (b) **Variable Speed Drives:** If the speed is slowed to an extent that flow stops and plugs the lines, explosions may result (note variable speed drives can be used to advantage as detailed later).
- (c) **Mechanical Seals:** In years gone by, gland packing may have ‘blown’ out of this water pump before the casing reached its burst pressure. Mechanical seals can often have a burst pressure exceeding the casing burst pressure, resulting a higher risk of explosion (although still extremely rare on clean liquid pumps).

The risk associated with clean liquid pumps is very remote, and good site practice makes it a rare case. The risk is however increased when applied to slurries.

Explosion risk in slurry pumps

Unlike clean liquid pumps, slurry pumps can be ‘bogged’, particularly when pumping very thick slurry that is close to settling out in the pipework. If the slurry in the pipeline slows to such a condition that plugs form, the flow can be reduced to such a condition that the pipework becomes totally blocked, which forms the same conditions seen in Item 3 above: an explosion becomes possible.

In the event the pipework is fully blocked, the time taken for the liquid in the pump to boil depends on the size of the electric motor being used and the amount of liquid in the pump, and the specific heat of the liquid.

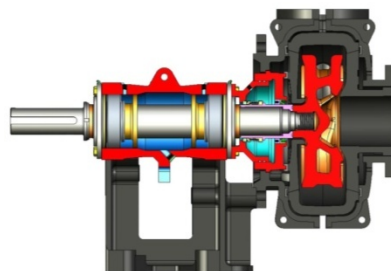
Generally the larger the motor, the faster the wet end heats up and the shorter time for an explosion to occur. The time taken for the liquid to heat in the wet end varies, but will NEVER be instantaneous.

Tests on common pump sizes (6x4 and 8x6) have found the time for the water to start boiling exceeds 15 minutes, then another 15 minutes until the pressure in the pump is reaching the maximum allowable working pressure. Additional time is then needed before the pump would get to its burst pressure. These figures are to be taken with caution as in each instance the time period depends on site conditions.

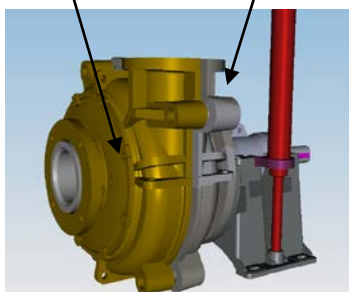
Severe duty slurry pump design

KETO slurry pumps have an external 'cover plate' and 'frame plate' which pull together around the liners via 'cover plate bolts'. They act as pressure retaining devices located 'outside' the slurry. They are thereby not subject to the usual corrosion and erosion allowance that applies to solid case pumps supplied by some others.

KETO Slurry Pump

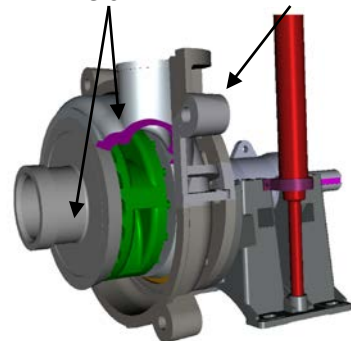


Cover Plate Frame Plate



KETO Assembled

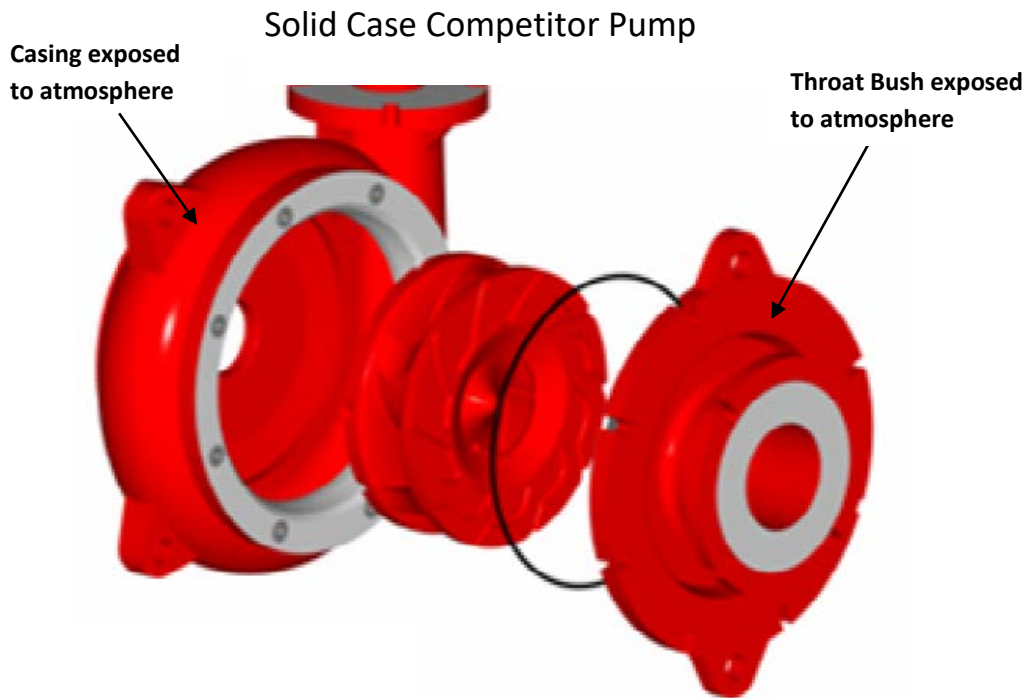
Liners Frame Plate



KETO with Cover Plate Removed

A solid case pump has the liner in direct exposure to the 'atmosphere'. As it wears, the maximum allowable working pressure reduces. In KETO's opinion, this does not enable the safety factors required for the pump to operate against a 'dead head' for a period of time, during which time the temperature and pressure

is increasing, as the pump may be worn to such a condition that it is already close to its burst pressure.



All HS series KETO pumps may have liners in either metal or an elastomeric material. All are contained in the same cover plate and frame plate.

Elastomeric lined pumps having a lower maximum allowable working pressure than their metal counterparts. This is due to the liners starting to leak at a lower pressure. In most instances, the liners will begin to soften and weep well before the casing and frame plate reach their burst point (but not always).

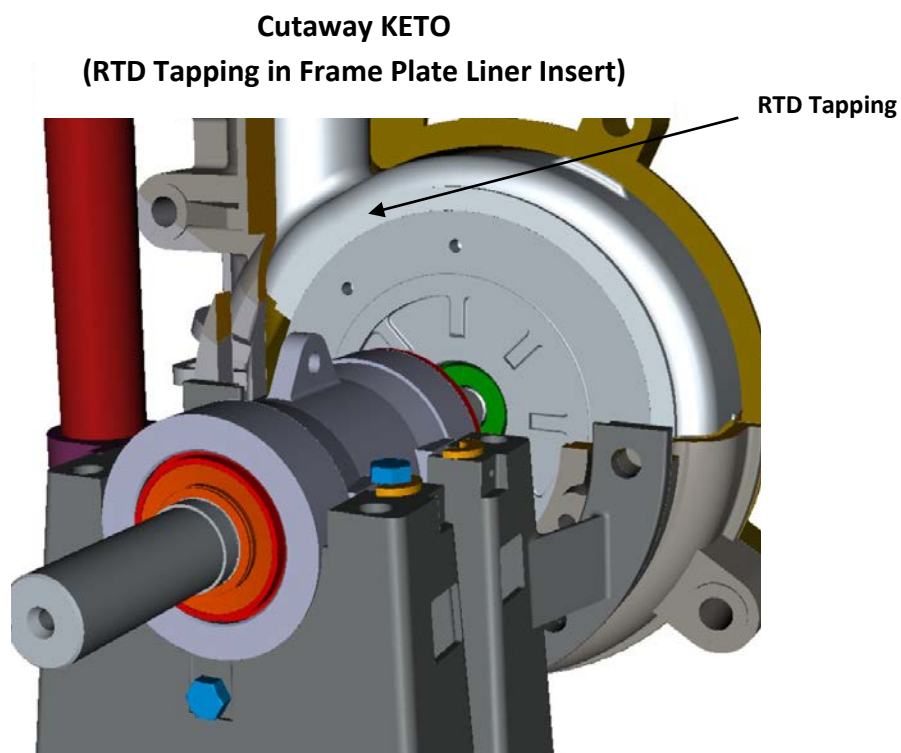
It is far more common for metal lined pumps to 'explode' as they are usually used for more aggressive slurries at higher temperatures and pressures.

KETO overpressure protection recommendations

Thermal cut out protection

As a KETO slurry pump user, the safety of our customers is paramount. Although it costs us more to produce, all our metal lined pumps supplied from July 2010 contain locations to fit RTD's (Patent Pending). The RTD's are also available with the pumps as an optional extra.

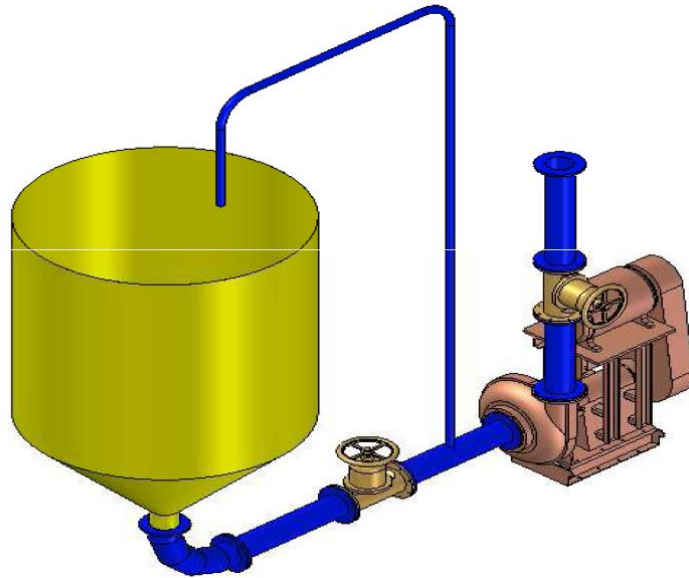
The thermal cut out protection has the advantage in new installations of using variable speed drive to help unblock plugs which is detailed later.



Standby protection

For all centrifugal pump applications where the pipes on the suction and discharge have the potential to become blocked, and suction heads are less than the usual 15m, we recommend ALL installations are fitted with a standpipe.

The standpipe is installed between any device, such as a valve and the pump so that the pump can 'relieve' through the standpipe in conditions of overpressure. The standpipe is usually piped back to the suction tank at a level above the operating level so that the pump can still be easily drained for maintenance without the potential for syphoning.



Standby Pipe Returning to Tank



Standby Pipe Directly Vertical

The standpipe need not be returned to the suction tank but must be at least as high as the maximum liquid level, with the exit away from walkways and the like as in the event of the pipes blocking the standpipe will vent steam.

Our standard recommendation is to use a concentric reducer from the suction pipe to the stand pipe. The stand pipe can be 50mm in diameter and the concentric reducer increasing the size to about 80% to 100% of the suction pipe diameter. Firstly this allows any air to be easily captured and also make it difficult for solids to build up in the entrance to the stand pipe. d80 and larger particles will not have the velocity to enter the stand-pipe (as the suction should always be

larger diameter than the discharge, and as the critical velocity is always calculated on the discharge diameter, hence using d80 as against d50).

Bursting disc protection

If the slurry pumped has a higher than usual risk of blockage occurring, and a standpipe isn't feasible (such as series pumps), standard readily available bursting discs are recommend. The bursting discs should be located on the suction lines as close to the pump inlet as possible (at a location where no obstruction occurs). For industries like that have a propensity to scale, special consideration needs to be given about the suitability of the bursting disc.



Typical Graphite Bursting Disc



Bursting Disc Installed

Protection against plugging by using variable speed drives

KETO highly recommends the use of variable speed drives on slurry pumps. Refer KETO White Paper 'Using Variable Speed Drives on KETO Slurry Pumps' for further details.

Variable speed drives can be used to pump slurry at the most efficient rate, enabling the flow to be just above the critical velocity. It is important however that the variable speed drive does not enable the pump to operate slower than needed to prevent the slurry settling in the pipes. If it does, then again a 'blocked' inlet and discharge may occur.

The beauty of using a variable speed drive on slurries is they can be used to 'clear' the pipe. KETO's RTD protection device can be used to determine if a plug is forming in the pipe. Skilled and trained operators can speed the pump up and remove the potential blockage thereby preventing the conditions for an explosion to occur in the first place and preventing the need for having to shut the plant down and unblock the pipe. KETO recommends that if this control method is used the Patented KETO RTD control is used in conjunction with a standpipe or simple bursting disc.

Upgrade kits

The design engineers at KETO have endeavoured to reduce the risk of explosion on your site WITHOUT having to spend larger sums on special pressure relief systems built into the pumps which can be expensive to install, complex to operate and difficult to maintain, and expensive to upgrade existing plant. It is even possible to use the safety systems developed by KETO in leading competitor equipment without the need for expensive upgrades. The KETO components with the Patent Pending thermal protection devices can simply be used to replace your existing liners when they are worn.

We welcome enquiries to assist upgrading all site equipment to make the industry safer for all.

Things to consider

KETO highly recommend people associated with pumps are trained on the hazards of operating pumps with closed suction.

When pumps have been operating against a closed valve ALWAYS ensure they have had time to cool down before releasing any pipework. There may well be steam or hot slurry in the units that could cause injury.

Unless a pressure relief valve is fitted NEVER use check valves on the inlet of fabricated priming tanks that are sometimes used to prime pit dewatering pumps. If the discharge check valve leaks, and the check valve on the inlet of the priming tank takes the full pressure, the priming tanks designed for suction pressure (vacuum) can explode. The author of this paper has seen a 40mm thick priming tank lid supplied by others blown clear out of a 120m deep open cut mine.

The engineers at KETO and all our distributors do our utmost to help make your plants safer. In helping to train people and recommend systems to reduce the risk of explosion on your site, we, nor any of our employees, distributors, or their employees can accept any liability for the inherent risks associated with centrifugal pump explosions.

Acknowledgements

KETO wish to extend our many thanks to Don Higginson for the advice given via KETO Pumps South Africa in developing this paper, along with Brian O' Conner from Anglo Platinum who has been compiling detailed information about pump explosions around the globe. Our congratulations are extended to Anglo Platinum for making not only their own plants safer, but sharing information with other pump users to make the industry safer for all. We welcome photos and information from other sites so that we can continue to document and help reduce the risks associated with slurry pumping.
