Column

Push-Through Knife Gates vs Guided Shear Gates in Mineral Processing

If it had been a one-off observation, this paper would never have been written. As it is; the same observations have been made in every hydrometallurgical plant we have visited. This observation is that one style of knife gate has been typically selected for use on the leaching circuits in solution mining and at PAL, POL and POx facilities and every single one of them have complaints.

By Ross Waters – President, CGIS

The complaints vary but essentially involve failures of the valve to last in service or that their discharge or emission of process causes collateral damage to themselves and surrounding equipment and potentially facility personnel.

To understand why this happens is to probe beneath the surface and to travel back through history. There the second invention – the Push-Through – of what is generally known as a knife gate, was prompted by the initial invention's poor quality isolation. We generally acknowledge that Rovalve invented the first knife gate in North America in the late 1950's. They invented it for the Pulp & Paper market. This valve is identified by its single wedging closure but was named knife gate despite the lack of any real cutting ability. Its principal advantage was that it was inexpensive to buy.

A US company saw an opportunity to improve this design for the Mining market and invented the world's first push-through elastomer sleeved knife gate; which ironically did not cut either; it simply divided the two sealing elastomeric sleeves as it moved from Open to Closed.

The ingenuity of the design was that the sleeves provided a completely isolated body and a bore lining that closely matched most of the pipe it was installed in.

When cycling closed, the gate's sharpened tip simply divided the sleeves apart and pushed through to the valve's closed position. Tight shut-off was provided by the elasticity of the sleeves pushing against the gate. Product was discharged either to atmosphere out the bottom or to an optional containment plate or collection system. The sleeves sealed against themselves in the valve's open position.

Depending on the valve size, the volume of discharge was reasonably small. However it needs to be noted that this discharge would increase as the valve aged, cycled and when internal pressures were higher. For instance, we recently tested a new 6-inch (150mm) push-through on our Control and Instrument Demonstrator (CID) flow loop and measured 25 ounces (750ml) of discharge from six cycles.

This discharge from a push-through knife gate is more of an annoyance as it is only sea-water and tailings on a tailings disposal pipeline in Chile.

This was an immediate success for mines that produced concentrates and tailings, generally with neutral or slightly alkaline pHs. Its success over the years made it the number one mining slurry valve over much of North and South America and as the years progressed, over much of the world; particularly when North and South American engineering companies designed these mines and mineral processing facilities.

Knife gates continued to evolve, and today there are five distinct types of knife gates, including the highest performance knife gate, the **Guided Shear Gate**. This style is the only one of the five that was actually designed to cut through solids. These solids could have been suspended solids like tailings and concentrates or precipitated solids like scales. And unlike push-through knife gates, nothing was transferred outside the body; no discharge or emission.

I became very involved with guided shear gate valves in 1995. We discovered a valve manufacturing company in Michigan, USA. They did not fully appreciate what their design could actually accomplish or what global applications were available for it. Their world was essentially the steel business and dirty applications in the mill's process.

For CGIS, this was not a negative, as it allowed our direct involvement with the manufacturer to tailor the valve to specific applications; - to be the valve designers. Part of that partnership allowed CGIS and the company to produce the world's first true Class 300 (50 bar) knife gate valves and later the Class 600 (100 bar). Recently we would be the first to achieve a SIL rating from Lloyds.

In 1995, two very distinct and significant events occurred for this style of knife gate; firstly, a large Canadian oil sands company had a need for several large 20-inch, (500mm) valves for 550-psig (37 bar) tailings blended with gypsum; secondly, we showed the valve to Cominco (now Teck Resources) in Trail BC, Canada.

The oil sands company was impressed with the robust design of a knife gate that pushed the operating pressures of a valve type that had previously been limited to 150-psig (10 bar) up to 740-psig (50 bar). Since those early days in 1995, they have purchased over 7,500 guided shear gate valves and this is the preferred slurry knife gate for their Tailings Recovery Operations (TRO).

In 1995 Cominco, a very complex metallurgical facility with 23 different metals being processed, was nearly 100 years old. The largest portion of the plant was Sulphide Leach used primarily to capture zinc. Its low pH sulphuric acid solutions with highly saturated dissolved gypsum caused significant issues for all isolation valves including the push-through knife gates that were then used.

This plant had a significant population of push-throughs and many were causing pain to the plant operation's superintendent. When he saw the guided shear gate and learned how it was different, he at first cautiously ordered one, then a few and then after several months successful operation, many. Today they have purchased more than 1,100 guided shear gate valves and use only a handful of push-throughs (all on neutral pH low pressure, low cycle applications).

It took until 2003 however to really get the message out, as up until that time our sliver of the world was the three western provinces of Canada, and hydrometallurgy was limited to only a handful of plants there. But 2002 produced a life altering opportunity. I was hired as an expert witness in a law suit in Australia between an engineering company and a mining company with their HPAL facility. It was over the engineering company's inability to deliver the design output they had promised on the acceptance of the project; much of that failure due to valve failures.

The opportunity arose after receiving access to the P&IDs and process flow sheets of the HPAL plant and realizing that this hydromet process was the most challenging of all of them and offered a phenomenal playground where Severe Service Isolation Valves (SSIVs) were an absolute necessity.

With what we learned we were able to convince BHP-Billiton, who had a project they wanted to bring to market called Ravensthorpe, that they could avoid the issues that crippled Murrin Murrin if they simply purchased properly specified guided shear gates. This they did, for all of the important applications in 2004/5 and despite selling the facility off to First Quantum Minerals in 2009 and having an

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18 month operation hiatus, the vast majority of those 179 guided shear gates are still operating as they did upon commissioning with zero or minimal maintenance. In fact, the first launder isolation valve came in for repair in early 2015; ten years after it was installed. It could have been put back into service with only the piston cylinder needing new seals; the valve body was virtually as-new, the seats and seals still pliable and intact.

This success led to several others in the hydromet world including Murrin Murrin, Ramu Nickel, BHP-Olympic Dam, Ecometales, Ambatovy and a small victory at Vale Long Harbour (a sad story for another day).

One question that can arise is why aren't guided shear gates everywhere and why are push-through valves still being specified and winning new projects, particularly hydromet ones?

That caused some soul searching. Up until this year, the author was the sole business development individual in CGIS and only one to travel internationally. This shortage of manpower severely limited the information available for designers and owners that there was a better design for their leaching applications: pressure and atmospheric. The company was one front man out in the world when the largest push-through manufacturers had legions of salesmen at every client's and engineering company's offices.

This is going to change now in a hurry as the Michigan company has been purchased by a global player with thousands of sales staff.

So, let's go back and look at some of the rationale that went into specifying a push-through knife gate for all applications including abrasive and corrosive slurries.

- The sleeves protected the body from the process allowing the use of inexpensive body materials like cast or ductile iron or carbon steel
- The original push-through Clarkson model KGA and now all of its copies, have a very strong and respected reputation in Mining
- The push-through companies used a large network of distributors and direct sales staff to get the message out everywhere
- You could add a discharge collection system or add a bolt-on closure flange to stop discharges.
- The old adage, you can't get fired for specifying/using "Green"; everyone uses them.

Having come to the understanding that there is no perfect valve and that the application dictates the valve; CGIS began to look at objective data that could be used to promote guided shear gates where it made more sense than a push-through.

We learned the following about push-throughs:

- The discharge on every stroke got larger
- The higher the pressure, the quicker the valve leaked/discharged on the Open position
- Scales and solids deposition were not dealt with very well
- Environmental considerations demanded collection of all discharges that were deemed harmful to the environment like acids and other corrosives
- Preventing acidic solution discharge by adding a bottom discharge closure required a corrosion resistant material, nullifying the sleeve-protection cost advantage for using a non-corrosion resistant body material
- Push-through designs require higher maintenance; some manufacturers want lubrication on every stroke – (who has the staff?)
- The sleeves are a large percentage of the cost of the valve so OPEX becomes financially significant
- In nearly all cases push-through designs are far more expensive than guided shear gates especially in hydromet, when all costs are compiled.

We had over twenty years of good data, representing more than 20,000 guided shear gates installed, and one-to-one comparisons on applications where the guided shear gate is head and shoulders above the operation and cost of any push-though. In 2013 a 16-inch Class 300 super-duplex test valve was installed in BHP-Billiton's Olympic Dam's acidic (and incredibly, slightly radioactive) tailings disposal line, originally for a six months or 300 cycle test. This would have provided three to six times the life of the push-throughs in use before.

The test valve was still in service after eighteen months and over 900 cycles. It was removed for inspection in January 2015, cleaned up and returned to service in February 2015 where it continues to operate today along with two others installed in the same circuit.

That's fifteen to thirty times longer than the engineering company's originally selected push-through. What is the financial impact of this? If we average the life extension recognizing it will still increase as the test valves haven't yet failed, we can confirm:

- Twenty-two times less purchases of a new set of sleeves every month or two
- Twenty-two times the savings of having a crew go out, shut down the positive displacement pumps; remove the valve, replace the sleeves, reinstall the valve, start the pumps back up
- Twenty-two times the loss of tailings removal
- Twenty-two times the savings from not having to contain the environmentally dangerous damaged parts
- Twenty-two times the loss of opportunity the maintenance crew had to do other work

This detailed and other data led to the guided shear gate manufacturing company becoming the world's first knife gate to obtain SIL 3; an honour and testament to its reliability and knowledge of what to supply in diverse applications.

The author wishes to stress that valves are rarely poorly made, nor are there perfect valves. It is simply that some valves are not appropriate for the application and over the years we learned the maxim "the application dictates the valve". Today many applications have spawned specific designs, materials and features. The more severe the service the fewer the number of products available to solve them.

The severe nature of the world of hydrometallurgy demands specialized designs that can withstand the corrosiveness and solids build-ups that occur; all in an environmentally benign fashion; and that can only happen when the correct valve technology is provided.

The Aussies had it right when they coined "fit for purpose". That might cause a ton of angst in many countries where equipment is expected to work, but in all cases, suppliers need to step up and be counted to ensure the end-user stays in business and their process works without constant shut-down, danger to their employees or environmental damage.

The application dictates the valve! Let's all ensure we know what the valve is capable of and where it shouldn't be used. If that means pushing back a bit harder when buying on cost is the driver, we all owe it to ourselves to have a deeper, complete and more detailed argument. "Technically acceptable" must consider all aspects of the valves in question so that procurement doesn't buy a failure.

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About the Author

Ross Waters is a voting member of ASTM on the G04 Gaseous Oxygen Committee and serves on Manufacturers Standardization Society (MSS) as a task force member on C-114 Steel Valves and C-409 Knife Gates. Currently Ross is a member of the task force to write and publish a new Standard on Severe Service Valve Testing.