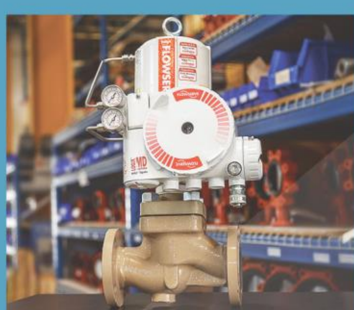
The Advantages of SSKGVs in Hydrometallurgy









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Abstract

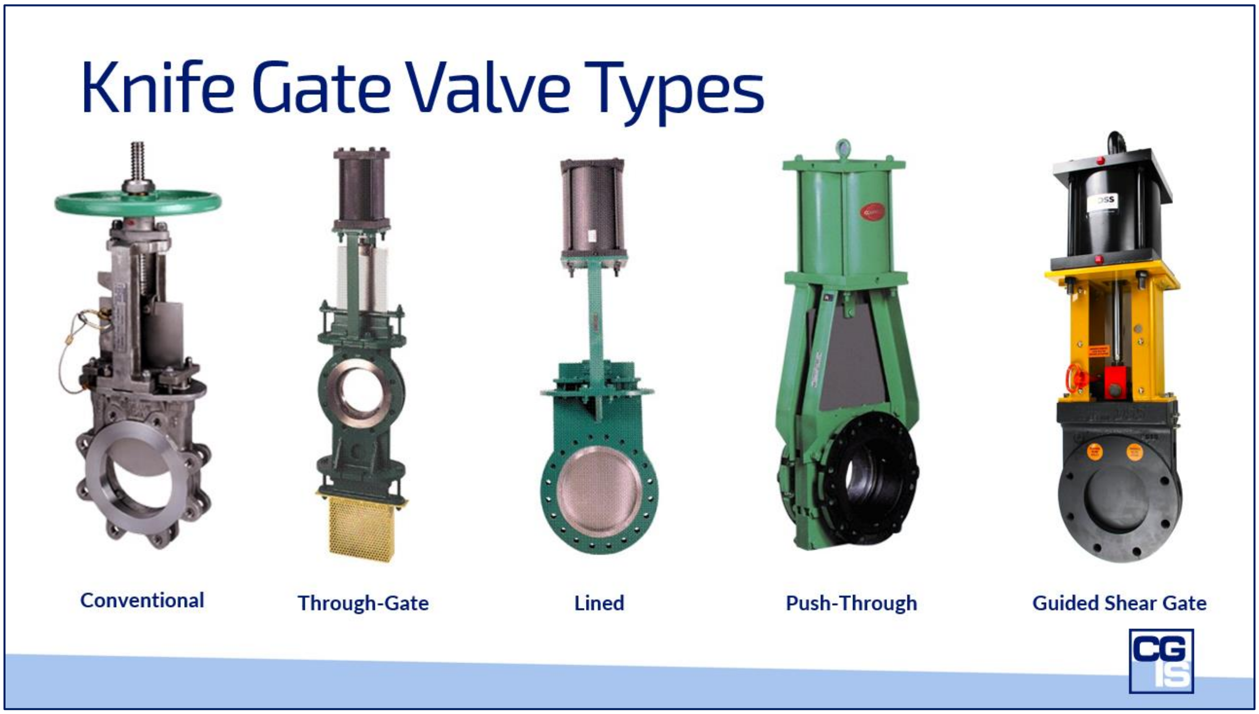
The hydrometallurgy industry is full of severe service applications that require technology that can handle corrosive materials, scaling of solids, high differential pressure situations, elevated temperatures and frequent cycling. Unfortunately, often the valve selected for these applications is chosen based on the price to purchase and general specification information, without proper consideration being placed on service life and the costs associated with being the single point of failure for an entire operation. This paper will discuss the importance of using Severe Service Knife Gate Valves (SSKGVs) in specific hydrometallurgy applications, and the features of these SSKGVs which make them the safest and most reliable option on the market. The presentation will draw on four decades of industry experience from one of Canada's leading valve experts.

Keywords

Hydrometallurgy, Severe Service Knife Gate Valves, Guided Shear Gates, Push-Through Knife Gates, Manufacturers Standardization Society, Severe Service Valve, Standard Practice, HPAL, Pox, POL, Atmospheric Leaching

Introduction – The Journey

Knife gate valves have been around for over one hundred years. Originally developed by Stafsjo in Sweden for the Pulp & Paper industry to handle fibrous wood slurries, knife gates continued to evolve for other applications including hydrometallurgy during the 1970's and beyond. Of the five distinct types shown below, only one has the design and capability to be used successfully in the hydrometallurgical processes; this one is known as the Guided Shear Gate (GSG) and is the most capable of the knife gate valves, earning it the distinction of a Severe Service Knife Gate Valve (SSKGV).



Knife Gate Valve Types

Guided shear gates were invented in Switzerland in 1960. Advances to this original design came from Canada, the USA and Australia during the 1990's and have culminated with the 5th generation design in 2017 and currently produced by DSS Valves Inc. in Michigan, USA.

DSS Valves - Severe Service Knife Gate Valve

Using Teck's Trail Smelter (originally known as Cominco) as a full-size test laboratory, GSGs were first used on many hydrometallurgical circuits including sulphide leach. Here they dealt with the heavy gypsum (calcium sulfate dihydrate) precipitation far better than any other style of knife gate or sleeve-lined plug valve which was also used. Learning how to fit the basic design to the individual processes at Cominco, where twenty-three unique processes were used to produce refined zinc, lead, silver, cadmium, germanium, fertilizer, indium and a host of other valuable metals and materials, provided a deep breadth of knowledge that was available to export to Australia in the early 2000's. At that time the largest of three existing High

Pressure Acid Leach (HPAL) plants was hobbled due to massive valve failures.

A resulting lawsuit provided the next leap of learning when the author was hired as an expert witness and he was given access to the P&IDs and flowsheets of Murrin Murrin. These tools showed the fantastic opportunity that was found in these challenging plants and the installation of GSGs began in earnest in these hydrometallurgical process plants. There was instant improvement with this type of knife gate over the incumbent types of Lined, Push-Through and Conventional. The originally supplied knife gates to Murrin Murrin became known as “black death” due to their near complete failures which also had significant collateral damage to the surrounding pipe and equipment.

A Bit of History

The invention of the knife gate was to fill a need in a slurry where the solids where challenging due to their physical presence. The solids were soft pulp fibres and would clog other styles of valves like wedge gates. An inexpensive yet capable valve design was created to deal with the continuous presence of a solid and used a sharp gate tip to drive through the mass.

Leaking Murrin Knife Gate Valve

Twenty years later, an American company manufactured and patented a similar valve and the “knife gate” was created. Similarly to the original Swedish invention, this valve was destined to the Pulp & Paper industry. It was designed to operate in fairly low pressures to 10 barG (150-psig). It’s “tightness” on closure was never high, leakage past the seat would eventually be plugged by the fibrous pulp stocks it was intended to isolate. It was at best a general purpose valve, certainly not high performance or severe service. But it satisfied a need for an inexpensive valve to buy.

Shortly thereafter, also in the United States, another version of the original knife gate was patented by the Clarkson company and the world’s first Mining industry knife gate was introduced. It is known today as the Push-Through knife gate and is by far the most numerous of valves used in mining. Two elastomeric sleeves contain the mining slurries and allow the gate to pass through for closure. It was a “tight” isolation valve that could seal equally well in either direction. When used in neutral pH, low pressure (10 barG (150-psig), low cycle applications, it was very successful.

Two more knife gate valve designs were introduced before 1960 and added abilities for different applications. The first was the lined knife gate which used a corrosion resistant liner inside a non-corrosion resistant body and a corrosion resistant gate. The advantage was a reduced cost using the typical ductile iron or carbon steel body. The second was the Through-Gate which enhanced the original knife gate's design to accept higher concentrations of pulp stock.

In 1960 in Europe, the fifth and highest performance knife gate valve was patented and was introduced as a bi-directional zero leakage guided knife gate valve. So, nearly sixty years ago, the world had a newer valve type with five variants; all known as knife gates, yet curiously, only one of the five could actually cut.

The first industry specification for knife gate valves was published by the Manufacturers Standardization Society (MSS) and called MSS SP-81; this was initially issued in 1975. The Standard identified carbon and stainless steel bodied conventional Bonnetless knife gate valves 3" through 24" rated to 10 barG (150-psig). Today another 5 Standard Practices describing knife gate valves are in use, taking the original valve capabilities to ASME Class 600 (PN100) and offering zero leakage isolation, a far cry from SP-81's allowable 40cc/inch of diameter/minute (if there was at least 40-psig differential pressure in the preferred direction).

The newer Standard Practices for knife gate valves are:

- SP-146 (2014) High Pressure Lug and Wafer Type Iron and Ductile Iron Knife Gate Valves
- SP-148 (2014) Low Pressure Flanged or Lugged Carbon Steel and Iron or Ductile Iron, Cast or Fabricated Bonnetless Knife Gate Valves without Liners
- SP-152 (2017) Knife Gate Valves for Double Block and Bleed
- SP-154 (2018) Low Pressure Knife Gate Valves for Double Block and Bleed

Additionally, MSS published in 2016 the first Standard Practice for pressure testing knife gate valves in which general purpose and severe service knife gates were identified. This Standard is SP-151 (2016) and provides us with some guidance about which type of knife gate valve should be used in applications that are either challenging or basic ones with little consequence of isolation failure.

Gaining Knowledge in Hydrometallurgical Applications

Early in 1996, the author was supplying isolation and control valves to Cominco (now Teck Resources). Cominco then was one of the world's largest smelters and produced over twenty-three metals, alloys and materials including their primary production of Lead and Zinc. Each of the twenty-three plants on the site had their own valve standards and strategies. In 1997, we won a five-year supply agreement to bring modern valve technologies to the 100-year old facility; the mandate being to improve plant performances by improving valve performance; the cost of ownership as OPEX being the key decision driver.

Over that 100-years, there was a vast variation in the valves that were used to isolate and control the process, most of the valve types developed in the industrial revolution. In the several years prior to the contract, the author had been taught a fundamentally critical precept – "the application dictates the valve". Armed with the directive to improve valve performance, this revealed a communication gap that often explained why vales failed to provide the owners with what they wanted. Over the next several years, this gap was explored and refined and has been extremely useful in extending improved valve performance over much longer life cycles, reducing OPEX to ensure plant profitability. During this learning phase, it was also demonstrated time and time again that there was no perfect valve.

Sulphide 4 in Conventional KGV with Through Leakage

All industrial processes can be identified using three categories of valve criticality – Commodity, General Purpose and Severe Service. Some processes may have a very large population of commodity valves due to the unchallenging nature of the applications; while others may have the opposite and nearly every application challenges the functionality and life cycle of the valves. Hydrometallurgy as a general rule, has a need for more of the Severe Service Valves (SSVs) than commodities, however, an acceptable industry standards does not exist to provide a clear definition of what these are. This has now been remedied by the MSS with PN-16-20, a Standard Practice to Define Severe Service Valves.

Back at Cominco, there were several plants that were continuously changing valves that they had used for years, the "replace in kind" (RIK) practice. One plant was the Sulphide Leach Plant (SLP). A pipefitter by trade, Jim Portz, was the new Operating Superintendent when the contract was let. He had inherited a number of "bad actors" in his plant, many of them knife gates. The Cominco Approved Manufacturers List (AML) had two knife gate types approved, a conventional knife gate (KGV) and a Push-Through knife gate (PTKGV).

Jim's detailed knowledge of the plant processes along with his deep understanding of how valves functioned allowed us to begin the work to upgrade the plant reliability. His first target was four 10" Push-Throughs, which true to their name, pushed through acidic discharge on every stroke. This discharge was the bane of the plant's workers as many had been caught under its sudden deluge.

He installed a Guided Shear Gate (GSG) an 1996 and it quickly proved that it was a significant upgrade and a detailed plan was put into place to change out all the bad actors. Today there are more than one thousand GSGs providing the Trail Smelter with much better control of its operations.

We had always known that there was no perfect valve and even the GSGs struggled in one application; zinc precipitation. It reinforced the notion that the application dictates the valve and removed the hubris of trusting only one solution.

Push-Through Free Discharging Acidic Quench

Push-Through Discharge at Marsulex

With the strength of the relationship powering us, we began to ask different questions. We knew the basic function of all valves falls between Isolation and Control. The control valve specification is generally compete and offers all of the information about the system to allow proper selection. The isolation valve on the other hand usually only provided the static end points of the process, e.g. maximum pressure, temperature and connection size. What has been missing from most datasheets for isolation valves is the number of cycles, normal operating position and scale or precipitation rates or potentials.

All isolation valves have four actual states of being:

1. Normally Open
2. Normally Closed
3. Transitioning between Open and Closed
4. Transitioning between Closed and Open

All four of these states have differing physical demands. It was studying this aspect and factoring it into the valve selection process that gave us a better tool to improve facility performance by providing valve technologies that gave better isolation or control functions for longer run time. Plant reliability went up, in many cases dramatically; and because the company was more interested in OPEX, it removed the handcuffs that often prevented the proper CAPEX purchase, although the author has hundreds of cases where CAPEX was actually less than the valve it replaced, and OPEX was also significantly reduced. It DOES NOT always cost more for the right solution.

An important component of the valve improvement program was to analyze valves that were removed from process and find out why they needed removal. Valve failure root cause analysis started to offer some general clues to prevent the next solution from suffering the same fates.

Knife gates had a very mixed review as an isolation valve, yet continue to be used in various industries including hydrometallurgy. But as we have seen, there are five distinct types and only one actually acts as a knife and cuts, so four should be eliminated from any application where there is scale or other precipitation. However, our industry language has not differentiated the types from the general category of knife gate valves and this single fact has produced some stunning failures.

In 2002, a magical phone call was fielded by the author and a single question was asked “do you know anything about valves in scaling applications?” Of course I did after all those years dealing with the heavy gypsum precipitation at Cominco, so naturally the answer was –Yes! That got me hired as an expert witness in the Murrin Murrin lawsuit.

Fluor Anaconda

During the year prior to the actual lawsuit, all the P&IDs and Process Flowsheets were made available and it was this phenomenal opportunity that forced attention on this wonderful field of process design and execution. Murrin Murrin was/is a nickel laterite mine with High Pressure Acid Leach (HPAL) as its principal process. The facility started up in 1998 and quickly failed to produce the nickel tonnages promised by the EPCM which was the death of the founding company. Many of the causes of plant failure were valve related and a significant black spot were knife gates. The biggest culprit was knick-named “Black Death”.

Reviewing the designs and valve selections, it became apparent that the maxim “most valve failures are not from poor valves, but from poor valve selection. This was the case at Murrin Murrin, and in the years since start up, little improvement was evident as the plant continued to use “knife gates”, just not the right ones.

It was around this time that BHP-Billiton had a desire to build their own HPAL plant for a laterite property in Western Australia. The project director was concerned they would run into the same grief as Murrin Murrin and was keen to learn from the actions and findings in the lawsuit. Listening to the reasons of failure, and the promise of a solution, he made a brave decision to divide the knife gate vales into Severe Service Knife Gate Valves (SSKGV) and General Purpose knife gate valves (KGV).

In 2005 we received the order for the SSKGVs while the bulk of the knife gates went to a general purpose knife gate supplier. In the years after start up, the GSGs proved to be as good as or better than as promised. Even after the sale to First Quantum Minerals and the subsequent start-up, the GSGs proved their value by continuing to provide the isolation the plant needed, most without any maintenance or service. The least long-lived achieved two years before seat replacement, while over 80% have never been removed or serviced. It was this incredible improvement over the Murrin Murrin styles of knife gate that won Ramu and later Dynatec Madagascar’s Ambatovy, the most successful installation of GSGs to date.

What is a Guided Shear Gate and why is it a Severe Service Knife Gate Valve?

All valves perform a duty. Their ability to perform varies by valve type and internal design features and materials. In addition, knowledge and experience play a significant part in any successful installation.

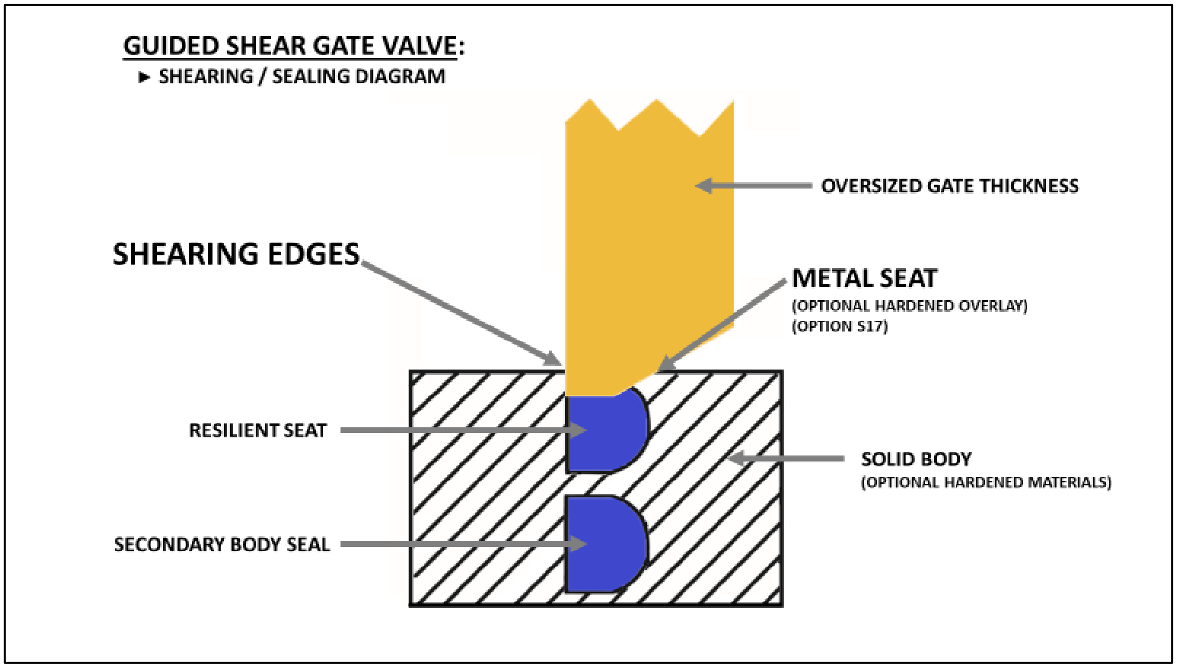
Over the many years the author has studied valves, and in particular, knife gate valves. Accurate descriptions and consistent communication regarding the specifications of the valve required and the attributes of the application it needs to perform in have always played a big role in valve selection. Unfortunately, the valve industry on a whole has consistently been lazy with language, allowing subjective words to serve as official terminology, leading to a false sense of security for the buyer and the seller.

Two phrases that continue to grate in my ears are – “tight shut-off” and “high-performance”. Both sound good, but neither is objective or measurable.

Knife gates are perhaps the worst offender of offering security without any basis of fact. The original knife gates were designed to be a low cost valve with moderate isolation abilities of low pressure (<10 Barg; 150-psig), low cycle (<50/year). The name “knife gate” should normally provide the understanding that this valve was designed to cut like a knife. The fact that the original patent never had that feature as a design requirement is curious, but it was a clever marketing concept. If you look closely at the original knife gate, you will see that the sharp knife edge was not there to cut, it was there to wedge. In fact the first knife gate should have been given the name Single Direction Wedge Gate.

The first true mining application knife gate, patented by Clarkson, also has a sharp knife gate tip; but again, it is not for cutting, it is for separating and dividing the two sleeves.

The invention of the GSG came about largely through the frustration of the other types of knife gates, none of which could actually cut to handle heavy slurries effectively. The inventor used the concept of a guillotine or shear to effectively cut though any solids, provided there was sufficient thrust. The gate tip was fashioned as a chisel tip and a 2-piece machined body guided the gate to its shear point and eventual full travel into the resilient and secondary metal seat. The gate is prevented from deflecting upstream or downstream and seals axially against the resilient seat, ensuring bi-directional zero leakage. Now high fibrous, suspended or dissolved solids slurries could be handled routinely.



DSS Guided Shear Gate - Shearing Illustration

The disadvantage of the GSG is that the body is wetted by the process, unlike the Lined KGV or the Push-Through. In these valve types a liner or the elastomeric sleeves protect the pressure retaining body from the process and therefore can be selected as inexpensive non-corrosive resistant materials like Ductile Iron or Carbon Steel.

However, in actual use in hydrometallurgical applications, neither valve type has proven to be a viable solution. In fact, both have been fantastically unsuccessful in the facilities that used them. The original gains of cost savings were completely consumed by the massive failures that occur during the valve's operations. Lined valves are attacked externally from stem leakage and Push-Throughs discharge acid solutions to atmosphere and nearby piping and equipment or the plant floor. The Push-Through's discharge containment feature is ineffective or costs so much that it adds far more than simply selecting the proper knife gate valve in the first place.

The GSG's general selection process is reasonably simple; choose a body material equal to a more resistant that the pipe it is installed in (if metal piping) or a body construction that has a <20 mpy (0.508 mm/yr) corrosion factor; choose a gate material that has a corrosion resistance of <1 mpy (0.0254 mm/yr); select a corrosion and temperature resistant resilient elastomer or polymer (we use a resilient fluoropolymer as a standard) and select an operator or actuator that can handle the changes in thrust from the precipitation of solids.

Studying the various deposits on valves in hydrometallurgy, we have learned to treat the moving surfaces of the valve with a finish that reduces the effect of that deposit on thrust increase, while being very conservative in actuator or operator selection. The treatment involves a surface preparation and then baked-on fluorocarbon finish which makes the surface slippery to the deposit. One extreme case is shown below where 250mm (10-inch) Class 300 Titanium Gr 12 GSGs are mounted with 550mm (22-inch) pneumatic cylinders so they could cut through a solid deposit of 25mm of nickel sulphide scale. They did, consistently, when required!

Ravensthorpe 10in T12 Heavy Scale GSG

Hydrometallurgical process plants are often challenging from corrosion outside the pipe. The GSG has a design that helps reduce the negative effects from external corrosive sources. The manual version has a non-rising stem, protected by Lexan covers on the bonnet. These ensure that the stem and stem-nut stay clean and available to translate the human torque into thrust efficiently. When automated with pneumatic, hydraulic, or electric-hydraulic cylinders, the cylinder- rods are also protected as are the limit or proximity sensors.

The GSG is designed to be a plant asset, to be maintained and serviced, and to provide consistent and reliable isolation of the various processes the plant needs to remain safe, profitable and environmentally sound. Chosen correctly, the GSG can radically reduce OPEX, and if carefully selected during initial design, can even contribute positively to the CAPEX limits new projects are held captive to.

Summary

The Guided Shear Gate (GSG) is the only true Severe Service Knife Gate Valve (SSKGV); none of the other four forms are capable of successfully dealing with the pressures, number of cycles, solids deposition or corrosiveness like the GSG does.

GSGs have been demonstrated to be a significantly successful valve type in hydrometallurgy. They are installed in large quantities in all existing HPAL plants except the two in the Philippines, as well as in the largest of the POx and POL plants and many Atmospheric Leach Plants.

The true cutting and shearing capability of the gate tip ensures total closure, with of course, proper consideration of the closing force of the actuation or operator.

GSGs are easily serviced and repaired at a low-cost percentage against the original valve cost, encouraging the facility to service and repair locally using their own work force.

The GSG is designed for true ASME B16.34 pressures in Class 150, 300, 600 and 900, although limited to 260c (500f) due to the preferred use of elastomer and polymer seat materials. The GSG is capable of replacing much more expensive metal seated ball valves, sleeve lined plug valves and other valve types on nearly all hydrometallurgical applications, particularly pregnant acidic solutions. GSGs have been used on an autoclave circuit as liquor heater and feed isolation valves, but not autoclave discharge isolation which is still the domain of metal seated ball valves.

Originally designed for slurries and high solids applications, GSGs are also successful on clean solutions like acid and sea water.

The GSG is designed to provide the tightest isolation class – “Zero Leakage” – bi-directionally and eliminate external emissions or discharges. The GSG is the highest performance KGV of the five types and provides designers and facility owners with an extremely powerful weapon to solve problems that hydrometallurgical severe service applications bring to bear.

With over 15,000 installations globally, the GSG is a true partner in hydrometallurgy.

Ross Waters

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