THE VALVE COMPANY

INDUSTRY PAPER
NOVEMBER, 2021

UNDERSTANDING WHY BONDED URETHANE LINER PROVIDES SUPERIOR PERFORMANCE

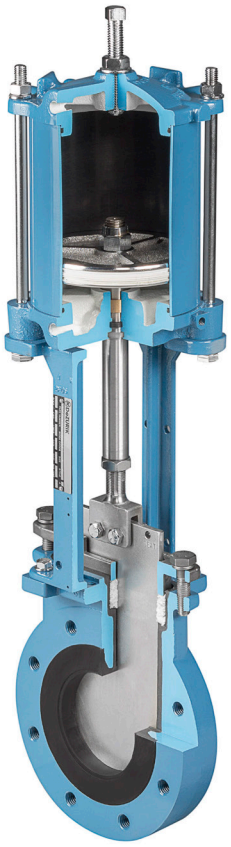
Urethane Properties & Performance

Urethane is an engineered product and a member of the rubber family. Like other rubber materials, urethane has the ability to endure large deformation and recover from the deforming force; more simply known as elasticity. Urethane will perform better in applications where superior abrasion and tear resistance are required because urethanes can be formulated to provide higher load-bearing capacity and elasticity, resisting compression set. Urethanes can also be formulated to provide superior resistance to greases, oils, oxygen and ozone. In addition, specific formulations can also withstand exposure to outdoor elements including sunlight.

Urethane has a number of manufacturing benefits as it starts out as a liquid. Two parts, a prepolymer and a curative, are heated and mixed to generate a chemical reaction forming a solid product. The basic process allows for ratio variations to create specific characteristics that solve application problems. Liquid is an easily poured material simplifying tooling and casting. However, the most important benefit of starting with the raw liquid process is the ability to bond urethane to other materials, most often to metal. This benefit can solve many application issues and provide superior performance advantages, particularly with knife gate valves.

In pursuit of the best performing solution, DeZURIK selected a third-party consulting firm to compare performance characteristics of the urethane liner bonded to the knife gate valve body verses the non-bonded urethane liner. The consulting firm performed a series of stress tests to identify performance characteristics between the two designs. The stress tests included:

- Maximum Principal Stress Test
- Hoop Stress Test
- Strain Test
- Von Mises Stress Calculations



DeZURIK KUL Urethane Knife Gate Valves have a continuous bonded urethane liner throughout the entire body, chest, packing chamber and flange face area.

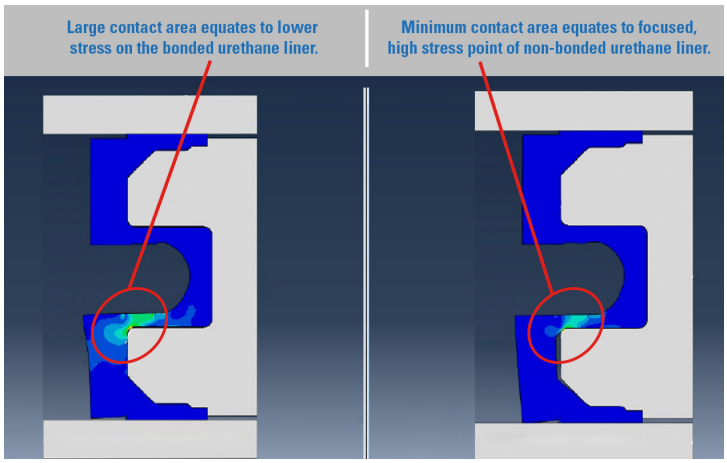
All wetted surfaces of DeZURIK KUL Urethane Knife Gate Valve Bodies are lined with urethane. The bonding process enhances the mechanical and abrasion resistance properties of the urethane, which creates a robust seat seal in harsh slurry services.

1. Maximum Principal Stress Test

In the Maximum Principal Stress test, the maximum line pressure of 250 psi was applied to one side of the fully-closed gate to simulate isolation which results in concentrated loads on the seating area of the urethane lining. Limited stress was observed in the seating area of the bonded-in liner. The maximum principle stress proved to be nearly four times greater on the non-bonded liner versus the bonded liner. This is critical to the life of the valve as many valves are used for isolation and closed for months, sometimes years before cycling. Continuous force against the gate, created by the line pressure, can reduce the life of the non-bonded liner due to increased stress on the liner.

The Finite Element Analysis image shows two screen outputs comparing the Maximum Principal Stress between the bonded and non-bonded liner. The image on the left shows the stress spread across a large area, reducing the force across the bonded liner. The image on the right shows a much smaller area of stress, focused where the gate seats into the non-bonded liner. The non-bonded liner moves under pressure from the gate compressing it against a small portion of the body behind it. This focused area of stress is nearly four times greater compared to the stress of the bonded liner. These FEA results are inline with lab tests of non-bonding urethane lining in a high-pressure knife gate valve which resulted in a compromised urethane liner at the illustrated area within a few load cycles in comparison to a bonded urethane liner which performed very well.

	Max Principal Stress (MPa)
BONDED LINER	15
NON-BONDED LINER	56



The Bonded Urethane Liner on the left shows stress spread across a large area, reducing force across the bonded liner. The Non-Bonded Liner on the right shows a focused area of contact equating to four times greater stress than the bonded liner.

2. Hoop Stress Test

The Hoop Stress test is performed with the gate in the fully open position and 250 psi pressure is applied to the port of the valve body. This is a static condition test revealing how the liner performs under compressive force, representing line or system pressure. The bonded liner performed slightly better because of the direct, bonded contact with the valve body compared to a non-bonded liner which can move and distort slightly. Under static pressure conditions which have distributed loading throughout, either type of urethane lining is acceptable. However, very few process systems operate in a static condition. Every system will have higher stresses in specific locations during various operating conditions therefore a bonded liner is preferred.

3. Strain Test

The Strain Test measures elongation of the liner during valve cycling and compares it to the yield point of the material. To prevent failure of the liner, strain of the liner in the valve body must be lower than the yield point of the material. The bonded liner strain was 90% of the yield point, under the critical value to prevent liner failure. The non-bonded liner strain was 158% of the yield point, over the critical value for failure of the liner. This test result supports a longer life expectancy of the bonded-in liner compared to a non-bonded liner and is even more critical when valves are automated as they typically are cycled more often. Higher cycle frequency of a non-bonded urethane liner will subsequently cause it to fail much sooner than its bonded competitor.

4. Von Mises Stress

The Von Mises Stress combines the three tests and is used to calculate a Factor of Safety which is defined as a number greater than 1. The bonded liner again proved superior with a Factor of Safety of 1.64 while the non-bonded liner did not meet the Factor of Safety with a number of 0.66. The bonded urethane liner has a 67% higher Factor of Safety than the non-bonded liner. Simply stated, the liner test results strongly support that a bonded urethane liner outperforms a non-bonded liner under the same typical service conditions.

	Max Principal Stress (MPa)	Hoop (pressure) Stress (MPa)	Strain (mm/mm)	Von Mises Results (MPa)
BONDED LINER	15	2.03	.66	25
NON-BONDED LINER	56	2.06	1.16	62

$\sigma_y = 41\ MPa$

$Factor\ of\ Safety = \frac{\sigma_y}{Von\ Mises}$, must be greater than 1

Bonded Liner Factor of Safety = 1.64
Non-Bonded Liner Factor of Safety = 0.66

Added Benefits of Bonded Urethane Liners

In addition to the bonded liner's performance, there are other benefits to the knife gate valve with a bonded-in liner. Bonded-in liners can be easily utilized in a one-piece cast body design which provides superior strength compared to the two-piece body style typically used with non-bonded liners. Higher line pressure capability is also available with a cast one-piece body. There is one less joint in the piping system equating to one less potential leak path. When the urethane liner reaches the end of its performance life, the body continues to maintain the media within the piping system.

Conclusion

Urethane is an engineered product that is both abrasion and tear resistant. In DeZURIK's pursuit to manufacture a premium Urethane Lined Knife Gate Valve, we identified through the 3rd party testing that a bonded urethane liner outperformed the non-bonded liner by far. The bonded liner proved superior passing both the combined loads and strain tests while the non-bonded liner failed both tests. DeZURIK further weighed the perceived advantage of rebuilding a non-bonded liner valve. In reality, once the superior performing urethane material is compromised, the underlying exposed metal of the valve body erodes at a rapid rate whether bonded or non-bonded. Most often, the body requires replacement and nullifies the repairability of the non-bonded liner designed valve. Thus, DeZURIK chose to utilize a bonded liner, integrated into the one-piece body design creating the KUL Bonded Urethane Lined Valve that is an unbeatable valve in slurry service performance.