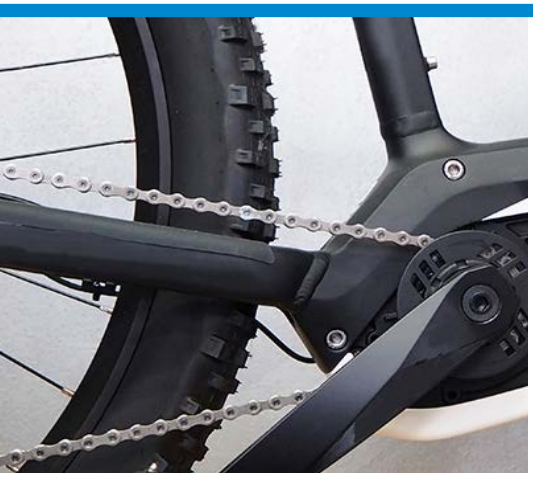
Low Wear, Low Friction

Want your products to be more reliable, produce less noise and have a longer lifetime? Delrin® has inherent low friction and good wear properties that can make it happen.

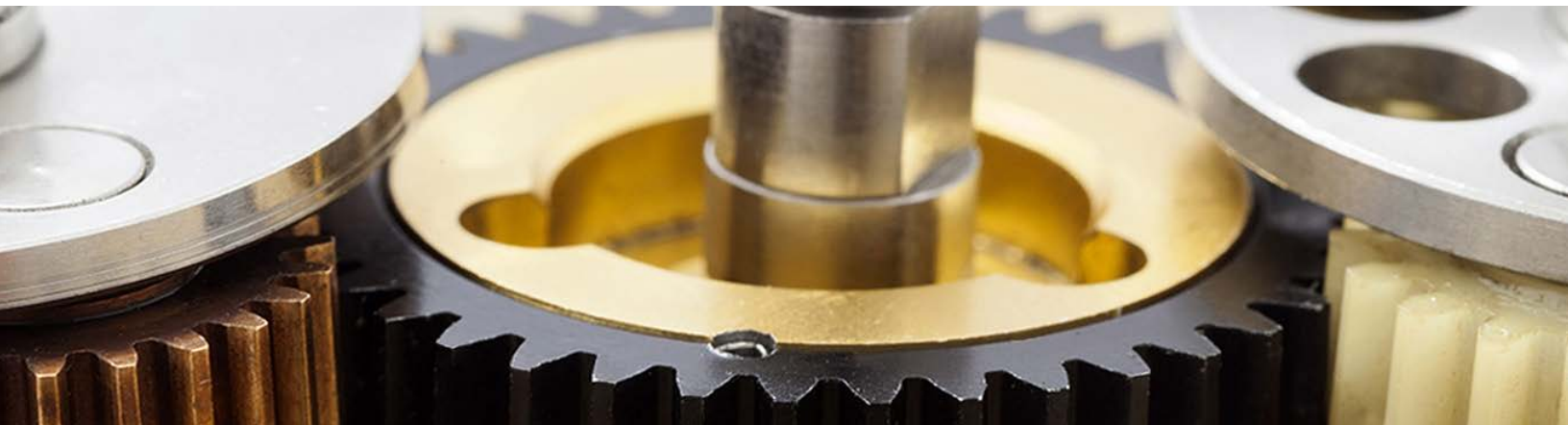












What's Inside

Introduction..... 3

Delrin® and tribology..... 4

Talking tribology..... 5

Friction..... 6

Noise..... 6

Understanding Delrin performance and the working environment..... 7

Why partner with Delrin? 9

Appendix: Delrin grade selection chart 10



Introduction

Working with Delrin® can give your products that extra competitive edge, offering key benefits such as:

- Lightweighting
- Resistance to corrosion and abrasion
- Self-lubrication
- Reduced molding costs
- Integral color
- Reduced finishing time
- Easier assembly
- Greater customer satisfaction

All these advantages add up to new opportunities in design, manufacturing and finished part costs.

Our team of experts will provide an unrivaled experience to help you optimize your design and select the best grade of Delrin to meet your needs. Delrin specialists will partner with your team from initial concept to full production, providing all the material advice and support you need along the way.



Figure 1.
Delrin low-wear, low-friction grades in conveyor chains allow for longer lifetime, smooth sliding of the conveyed goods, silent (squeak-free) motions and lubrication-free operations.

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Delrin® and tribology

Problems with wear, friction or noise? You're not alone—whenever two surfaces slide, roll or rub against each other, they can generate problems including worn surfaces, high-friction forces, heat buildup or squeak.

Delrin offers a wide range of internally lubricated or wear-resistant resins to help solve these problems. Wear-resistant and/or lubricated grades of Delrin acetal resin bring added value to applications:

- Parts have longer lifetimes due to reduced wear. Higher wear-resistant materials allow an increase of time before the need to change a critical part, reducing downtime and maintenance costs.
- Moving systems have higher efficiency due to less energy lost through friction. A low Coefficient of Friction (COF) between two sliding surfaces reduces the amount of energy transformed into heat or noise instead of motion. With Delrin, the motion becomes smoother and more efficient.
- By selecting the right material combinations, the load-bearing capacity is higher, and the sliding speed can be increased, making the system more reliable and powerful.
- System costs can be reduced by eliminating any external lubricant. Internally lubricated, also known as friction modified, Delrin grades can avoid the need for greases and lubricants, while guaranteeing consistent friction performance over the lifetime of the parts.
- Squeaking noise can be reduced below the audible limit. By choosing a grade with a low COF, Delrin parts can slide against each other without generating an audible squeak.

Choosing Delrin is a good starting point for applications in which wear and friction are design challenges. Standard Delrin inherently has one of the lowest COFs and one of the lowest wear rates when compared with other polymer types. Friction-modified grades of Delrin take the benefits even further. While a PTFE-modified grade is shown in Figure 2, it's just one of many options for low-friction grades.

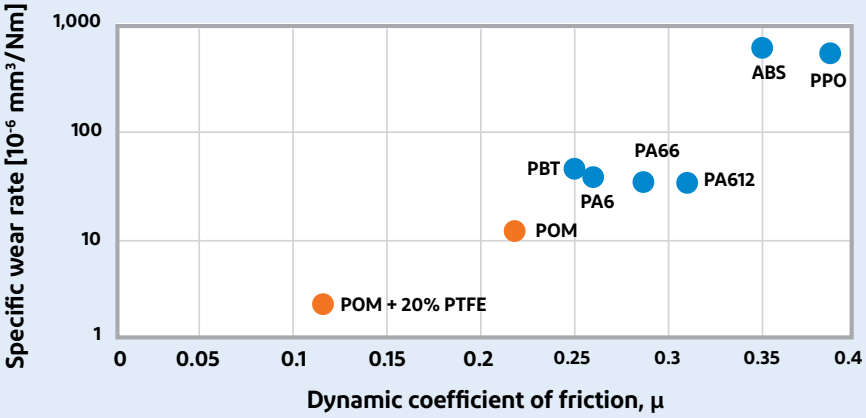
Delrin also offers outstanding mechanical properties including a unique balance of strength, stiffness and toughness not available in either metals or other plastics.

Delrin inherently has one of the lowest COFs and one of the lowest wear rates when compared with other polymer types.

Figure 2.

Typical wear rate vs. dynamic COF of polymer types against steel

Source: DuPont



Talking tribology

Tribology is the science of wear, friction and lubrication and how interacting surfaces behave in relative motion. Delrin® can help with each of these common issues.

Wear

Wear is the progressive loss of material due to interacting surfaces in relative motion. It is quantitatively measured as the specific wear rate Ws (defined as volume loss per sliding distance and load [10^{-6} mm^3/Nm]) of a material. Numerous distinct and independent mechanisms are involved in the wear of a polymer.

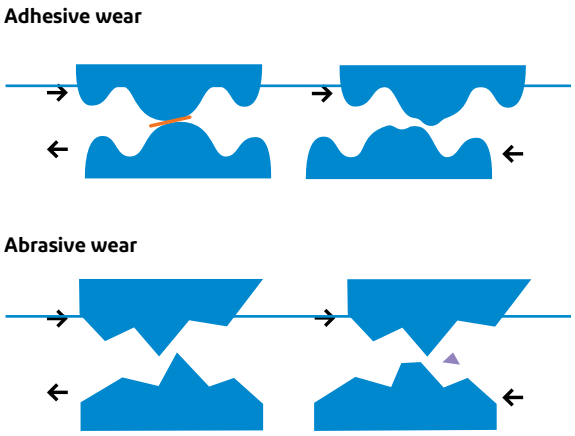
Primary mechanisms include:

- Adhesive wear—loss of polymer by transfer and adhesion to the countersurface due to frictional heating.
- Abrasive wear—cutting caused by hard irregularities on the countersurface.

As shown earlier in Figure 2, Delrin has a lower wear rate than other polymer families and can be further improved with low-friction additives or Delrin® 100KM with DuPont™ Kevlar® fibers.

Delrin® 100KM is a high-viscosity grade made with DuPont™ Kevlar® aramid fibers that exhibits low wear and friction loss. It does not create an aggressive wear medium like glass-fiber-reinforced materials as wear starts to occur.

Figure 3. Different wear mechanisms



Tribology is the science of wear, friction and lubrication and how interacting surfaces behave in relative motion.

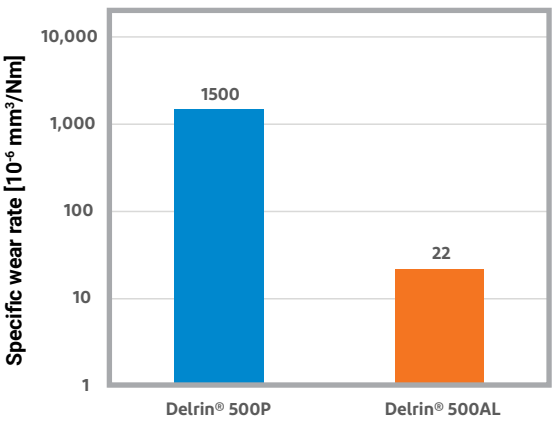
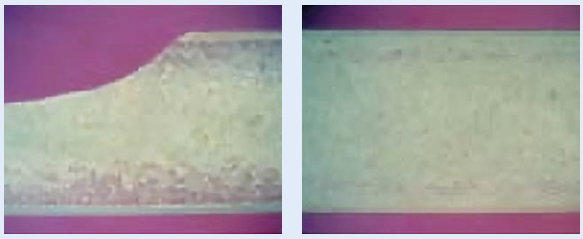


Figure 4.
Specific wear rate and wear track of Delrin® 500P and Delrin® 500AL after moving against itself

Source: DuPont



Delrin® 500P after wear test (test specimen)

Delrin® 500AL after wear test (test specimen)

Under equivalent test conditions, Delrin® 500AL shows very little wear, and consequently, no wear track can be seen.

Friction

Friction is a measure of the resistance to motion (loss of energy) of two interacting surfaces. The friction is quantitatively described by the COF (μ) which can be dynamic or static.

The COF between surfaces normally rises with increasing temperature and decreasing load. The energy lost due to friction can lead to an increase in temperature, to the emission of noise and/or to deformation of the contact area. In almost all cases, a lower COF will lead to a lower wear rate.

There are a number of low-friction modified grades available to mitigate these issues.

Delrin® Portfolio Category	Product	Description
High-viscosity	Delrin® 100AF	20% PTFE fibers
	Delrin® 100AL	Advanced lubrication
	Delrin® 100ALE	Advanced lubrication, low emissions
Medium-viscosity	Delrin® 500AF	20% PTFE fibers
	Delrin® 520MP	20% PTFE micropowder
	Delrin® 500CL	Chemical lubricant
	Delrin® 500AL	Advanced lubricant
	Delrin® 500SC	Silicone lubricant concentrate

Friction is a measure of the resistance to motion (loss of energy) of two interacting surfaces.

Noise

In many applications where a part is sliding, the noise emitted by the system is undesired and has to be reduced. Noise is a difficult concept to define and therefore it is important to distinguish the two main types of noise which are encountered.

- Mechanical noise is in fact not related to friction but to the impacts between moving parts. However, in the case of high-frequency movements, this type of noise can sound like squeaking. An improved design (e.g., of teeth in gears) can often reduce noise intensity.

  Another solution is to use a toughened material that has better damping properties.

- Squeaking is generated through friction and can therefore be linked to the COF value. As a general rule, one can say that if the dynamic COF is higher than the static one, the movement between the two surfaces can get discontinuous (slip-stick phenomenon). The noise is perceived as squeaking when this slip and stick happens at an audible frequency. Selecting a friction-modified Delrin allows you to run Delrin against itself without creating an audible squeak.

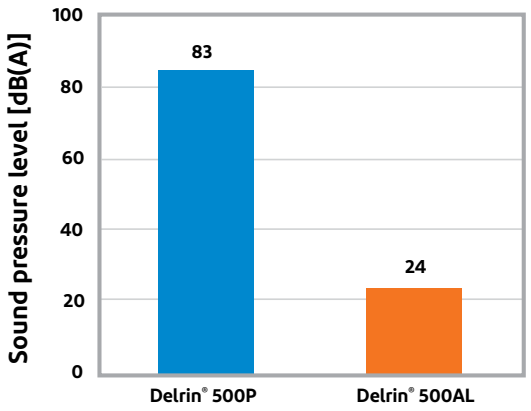


Figure 5.
Squeaking noise is measured for Delrin® 500P sliding against Delrin® 500P or Delrin® 500AL. Sound pressure level is reduced from 83dB(A) to 24dB(A), which is below the audible threshold.

Source: DuPont

Understanding Delrin® performance and the working environment

Working environment has perhaps the strongest influence on friction, wear and noise.

The main factors to consider are:

- Contact pressure (p) and contact force (load) at the surfaces
- Relative velocity of the surfaces (v)
- The countersurface

Additional considerations include:

- Temperature of the surfaces
- Geometry of motion (sliding, fretting, rolling)
- Nature of the motion (continuous, intermittent, reciprocating, etc.)
- Lubrication (initial, continuous, dry-running, moisture)

Selecting a Delrin grade for an application requires a detailed understanding of the tribological system. Standardized tests can give indications of the relative wear rates of polymers, but prototype testing is an essential stage in application development.

Selecting the best grade of Delrin

The intrinsically good wear resistance and frictional behavior of Delrin often means that the standard grade can be used without any internal or external lubrication. However, depending on needs and technical requirements, some customers may need to further improve on Delrin properties with other technologies (PTFE, silicone, DuPont™ Kevlar® aramid resin, chemical lubrication, etc.), to reduce wear or friction.

Choosing the perfect grade for your project may seem intimidating, but classifying them according to wear rate (Ws) and dynamic COF (μ) can help. It's also important to carefully control all other parameters like countersurface, sliding velocity, contact pressure, test method and environmental conditions.

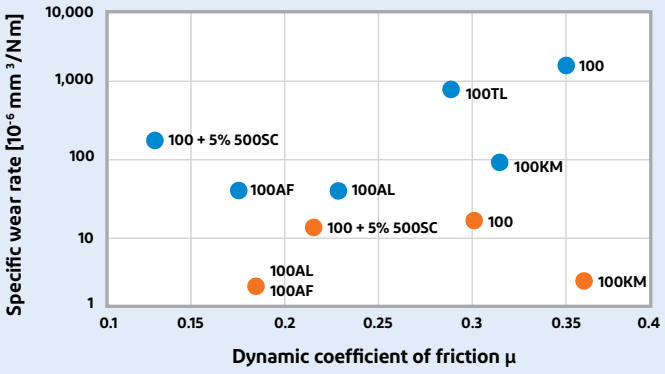
Low-wear/low-friction grades of Delrin are classified in the graph below according to their specific wear rate and COF measured against either a steel countersurface or against a countersurface made in the same grade of Delrin (i.e., against itself).

Choosing the perfect grade for your project may seem intimidating, but classifying them according to wear rate (Ws) and dynamic COF (μ) can help.

Figure 6. Wear rate vs. dynamic COF

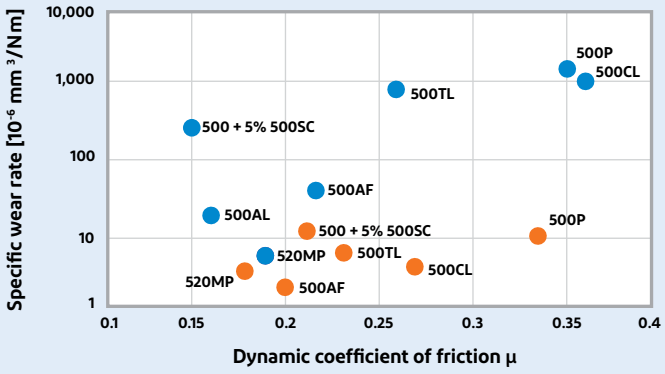
Source: Delrin

Blue: Delrin against itself
Orange: Delrin against steel



High-viscosity grades

Specific wear rate and COF against steel and against itself for Delrin acetal high-viscosity grades



Medium-viscosity grades

Specific wear rate and COF against steel and against itself for Delrin acetal medium-viscosity grades

Figure 6 not only shows the effect of the different technologies on wear rate and COF but also the effect of the countersurface.

The nature and finish of the countersurface strongly affect wear and friction. Two parameters that define the finish of a surface and which can easily be controlled are its roughness and its hardness.

- Generally, the harder the metal surface, the better the wear and friction behavior of the system
- The rougher the metal countersurface, the higher the wear

Against steel, the wear rate, as well as the COF of unmodified Delrin®, is much lower compared to the values measured against itself.

The use of different ingredients, however, makes it possible to close the performance gap and therefore open the possibility of using Delrin against other Delrin surfaces.

The graphs clearly demonstrate that the wear rate not only depends on the pv, but also if this pv is composed by high pressure/low speed or low pressure/high speed.

Influence of pressure (p) and sliding velocity (v)

Pressure (p) and sliding velocity (v) have a strong influence on the wear rate of a material. An increase in pressure generally leads to an increase in the wear rate and a decrease in friction, whereas an increase in sliding speed results in an increase in both wear and friction. Pv is often used to describe the severity of a wear situation since, at a given temperature, it is roughly proportional to the wear rate.

The very strong influence of pressure and speed on wear, as well as the improvements which can be achieved in this respect, are shown in Figures 7 and 8. The specific wear rate has been measured against steel at different combinations of speed and pressure. The graphs clearly demonstrate that the wear rate not only depends on the pv, but also if this pv is composed by high pressure/low speed or low pressure/high speed.

Figures 7 and 8 have the same axis for wear rate so that the advantage of a low-friction grade can be easily quantified.

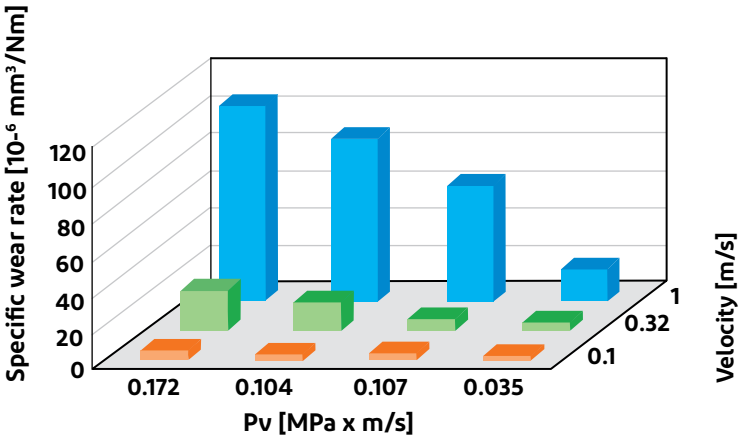


Figure 7.
Specific wear rate of Delrin® 500 against steel at different pv (method thrust washer)

Source: DuPont

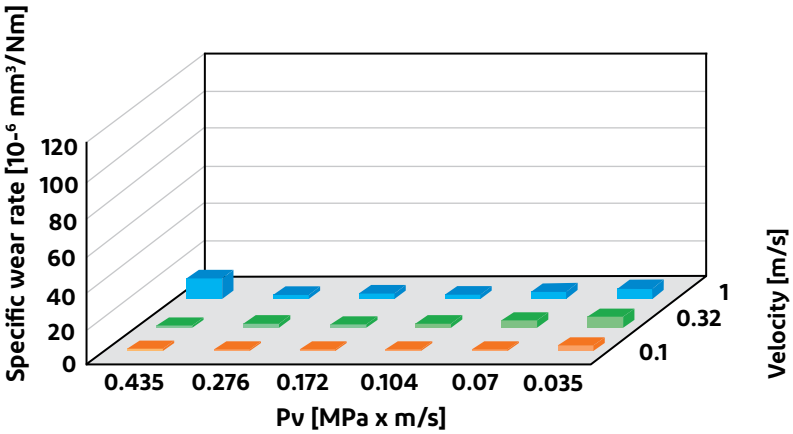


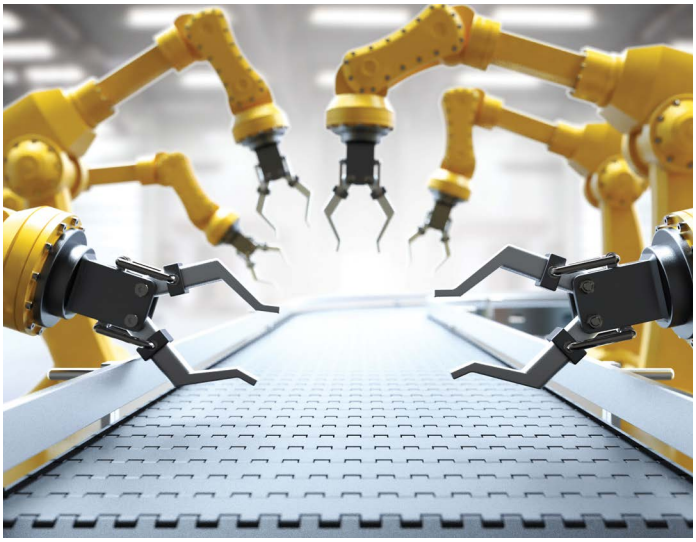
Figure 8.
Specific wear rate of Delrin® 520MP against steel at different pv (method thrust washer)

Source: DuPont

Why partner with Delrin®?

There are many factors to consider when designing products that have running surfaces. When Delrin specialists are involved as part of the design team, you'll not only have access to a wide variety of product grades and all of their benefits, but also a wealth of knowledge and resources including:

- Design and molding expertise along with technical support from a global network of interlinked technology laboratories
- Long experience in testing and selecting materials for tribological applications
- Worldwide support for polymer research and development, with more than 60 years of experience and innovation in acetal



To learn more, contact your Delrin representative or visit Delrin.com.

Delrin® is an industry-leading premium industrial polymer business. Grounded in strong innovation, Delrin is a category creator with a longstanding reputation for quality, reliability, supply and product performance. The iconic Delrin brand, coupled with proprietary technology and deep application expertise make us a leader in the high-end engineering polymer market. Delrin has exciting growth prospects from exposure to automation, actuation, healthcare, mobility and consumer applications.

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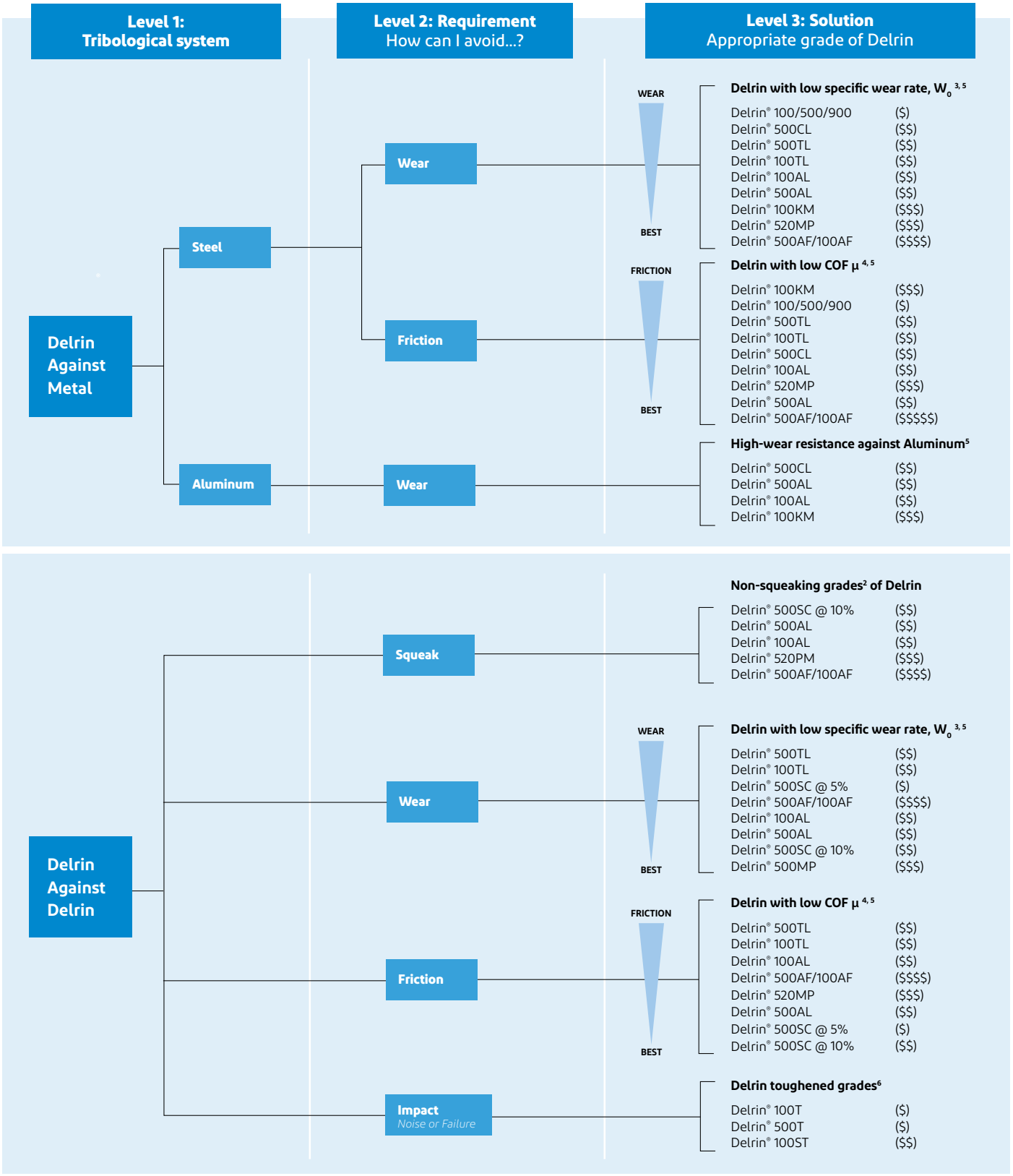
Appendix: Delrin® grade selection chart



1. Surface and countersurface are consisting of the same grade of Delrin.
2. For all resins listed, the noise emitted at 16 kHz is below 60 dB(A) (audible limit) at a sliding speed of 0,084 m/s and a pressure of 0,624 MPa in a reciprocating movement.
3. Resins are ranked by decreasing wear rate based on results from different test geometries and test conditions.
4. Resins are ranked by decreasing COF based on results from different test geometries and test conditions.
5. Price categorization by dollar signs.
6. Resins ranked by increasing toughness (ISO179:1993(E) 1eA: notched charpy impact strength).