# Discover How to Select the Ideal Grade of Delrin® for Your Engineering Components

**Delrin® provides reliability and high performance for your most challenging applications**









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# 1. Delrin® acetal

Delrin®, the world's first acetal resin, is a highly versatile engineering plastic with metal-like properties. It offers an excellent balance of desirable properties that bridge the gap between metals and ordinary plastics. In fact, Delrin is the stiffest, strongest and toughest engineering polymer available without glass or other reinforcement, enabling efficient design of thinner, lighter and longer-lasting parts in a broad range of demanding applications. Since its introduction in 1960, Delrin has been widely used around the world in many applications, such as automotive, appliance, construction, hardware, electronic and consumer goods industries. Delrin has gained widespread recognition for its reliability and performance in thousands of engineering components.

## Mechanical performance

Due to its very high crystallinity of up to 60%, Delrin is very resistant to creep, offers high mechanical strength and stiffness without reinforcement, and also offers exceptional fatigue and impact resistance. This makes Delrin an ideal choice for gears and snap fits and many other engineering components.

## Tribology performance

Low friction properties combined with low wear and low noise properties make Delrin well-suited for sliding applications.

## Wide in use temperature range

Delrin retains its outstanding toughness, fatigue and impact resistance from temperatures below -50°C up to 90°C; intermittent to 120°C. This makes Delrin an excellent material for automotive interior applications.

## Dimensional stability

Delrin is widely used for precision parts because of low moisture pick-up and very good dimensional stability.

## Low emission

Many Delrin grades meet the requirements for healthcare, food and cosmetics industries for emissions. Special modified grades are also available for meeting the strictest air quality standards of automotive cabins (2 ppm formaldehyde per VDA275).

## Sustainable

Delrin® Renewable Attributed base polymer is produced using 100% bio-feedstock from waste according to ISCC (International Sustainability and Carbon Certification) mass balance certification. It is manufactured with 100% certified renewable electricity and has the potential to be 100% recycled.

Delrin® Renewable Attributed has up to 75% lower global warming potential and up to 57% lower use of fossil resources compared to fossil-based POM while maintaining mechanical properties.

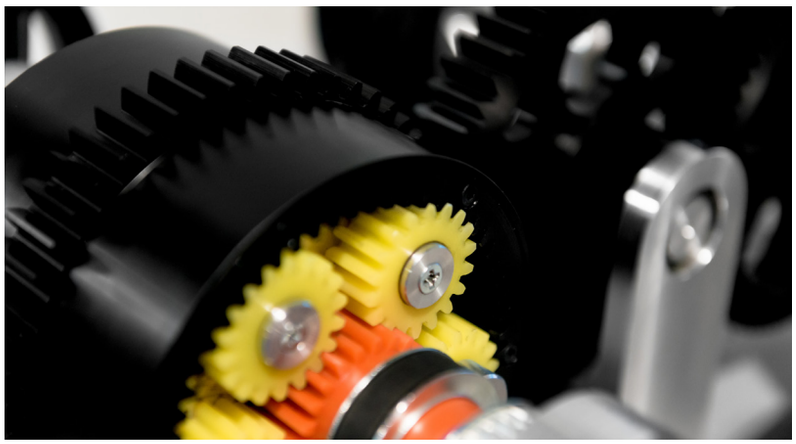

**Figure 1.1.** Delrin® makes mechanical gears lighter, quieter and longer-lasting

## 2. Applications

Delrin® offers a unique combination of properties and processing capabilities which help contribute to innovation for new applications. Customers look to Delrin to develop parts and products that help cut costs, improve performance, reduce weight and create new business opportunities.

The gear assembly in Figure 2.1 demonstrates the importance of the many characteristics of Delrin in the functionality of an application. The fine teeth require high strength, stiffness and creep resistance when an assembly is meant to be under long-term loads. The cyclic nature of gear assemblies require resistance to fatigue. The left-most gear in the assembly in Figure 2.1 indicates a back-and-forth functionality, signifying potential sudden stops, requiring superior toughness and impact resistance in the material. Precision assemblies require the dimensional stability of Delrin, through its low moisture pick-up. Even though plastic-on-plastic assemblies are generally not recommended due to adhesive wear, the AL (advanced lubricant) technology in Delrin® 100AL and 500AL allows the flexibility to do so.

**Figure 2.1.** Delrin® acetal homopolymers (Polyoxymethylene POM) successfully replaces metals—even in fine critical gears—with superior quality

Delrin provides outstanding performance in a wide variety of applications in automotive, healthcare and various other industrial and consumer products. Examples include:

- **Auto parts and systems** (Figure 2.2): Push buttons, pillar loops, actuator gears, door systems and various parts with excellent spring-back behavior like clips
- **Medical products** (Figure 2.3): Components in injection devices, inhalers, applicators for wearables and laboratory and hospital equipment
- **Consumer products** (Figure 2.4): Springs, ski bindings, fasteners, bearings, e-bike gears, lighter bodies, keyboard parts and remote vacuum cleaners
- **Industrial products** (Figure 2.5): Valves, clips, fasteners, bearings, irrigation, conveyor belts and stock shapes

**Figure 2.2.** Autoliv safety belt retractor bearing plate made with Delrin® 300TE

**Figure 2.3.** Delrin® provides excellent impact toughness, creep resistance and sliding performance for drug delivery devices

**Figure 2.4.** Ski bindings and clips made with Delrin® offer strength, stiffness and dimensional stability in harsh conditions

Photo: *Courtesy of Regina Catene Calibrate*

**Figure 2.5.** The enhanced tribology of Delrin® modified grades results in low wear, low friction and low noise

## 3. Product chemistry

Acetal is a simple molecule. The repeating unit is formaldehyde. It may be called acetal, polyacetal or polyformaldehyde, but the most common name is POM (polyoxymethylene). Though first discovered in the 1920s by DuPont, thermally stable versions of both homopolymer and copolymer acetal were not invented until the late 1950s. Homopolymer uses only formaldehyde to form the polymer chain and a second molecule to endcap the chain to stabilize it and control the molecular weight. Copolymer uses roughly 1% of a second monomer to stabilize the chain and form the endcaps. Even though it is more difficult to manufacture, DuPont chose to commercialize only the homopolymer under the Delrin® brand name for its higher mechanical performance relative to the copolymer version.

The copolymer process chemistry results in 92–99 wt% of linear polymer chains with a randomly inserted comonomer and 1–8% of low molecular weight cyclic oligomers. The comonomer hinders the natural tendency of the polymer to crystallize by disrupting the alignment (Figure 3.1) while the oligomers are absent from crystallization altogether. Copolymer typically exhibits 45–50% crystallinity.

The uniform backbone of Delrin acetal homopolymer allows it to participate in large scale crystallization aided by dipole-dipole interactions, tightly packing the polymer chains together, leading to roughly 55–60% crystallinity. The larger crystalline blocks of Delrin homopolymer lead to more interconnections (entanglements) between blocks. The tight network of crystalline blocks and entanglements is what gives rise to the short-term and long-term mechanical property dominance of Delrin homopolymer over acetal copolymer.

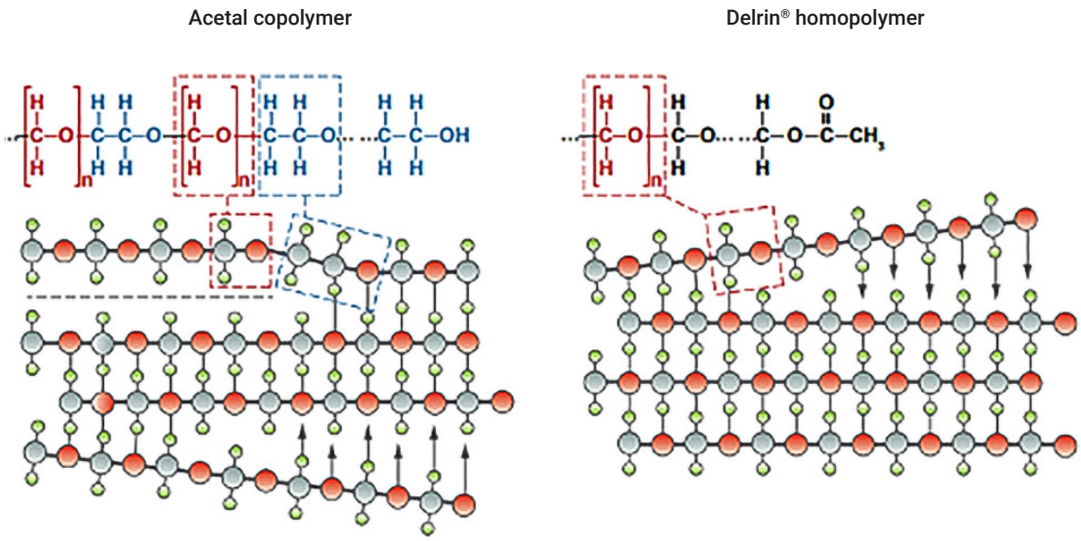


**Figure 3.1.** Crystalline structures of acetal copolymer versus acetal homopolymer

Figure 3.2 shows the difference in mechanical properties between Delrin® 500P NC010, the general purpose Delrin offering, versus those of the typical general purpose acetal copolymer (MVR = 8–9). Not only does the higher level of crystallinity increase the strength and toughness of the resin, but it does so with lower molecular weight polymer, resulting in a significant improvement in melt flow rate (MFR) and moldability. The differences between Delrin homopolymer and acetal copolymer are described in detail in the white paper, Delrin® Acetal Homopolymer – *How to Maximize the Property Advantages of Delrin® Acetal Homopolymer over Acetal Copolymer.*

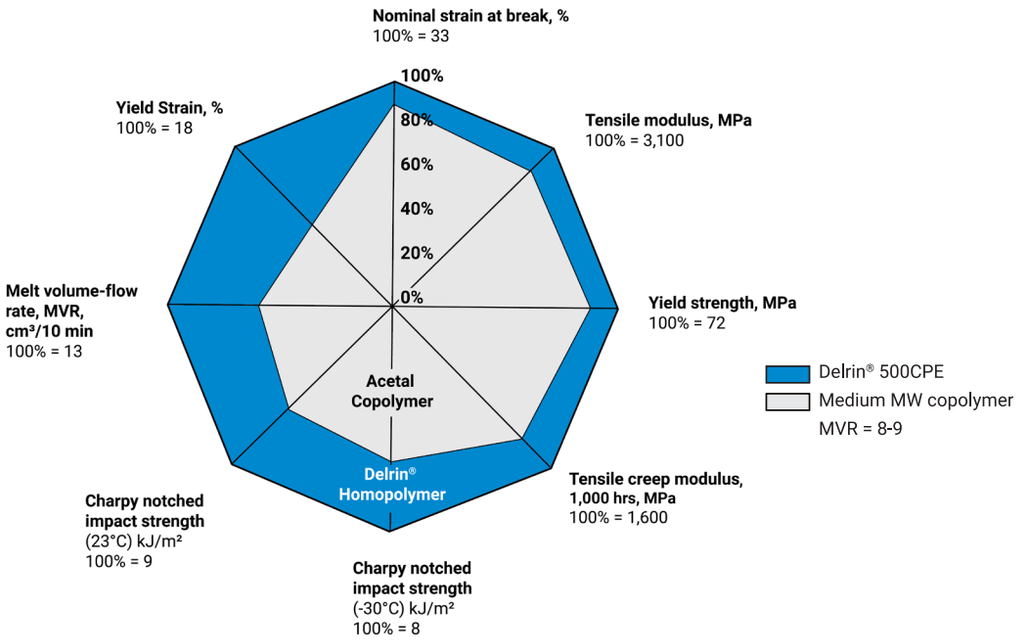


**Figure 3.2.** Mechanical properties of acetal copolymer versus Delrin® homopolymer

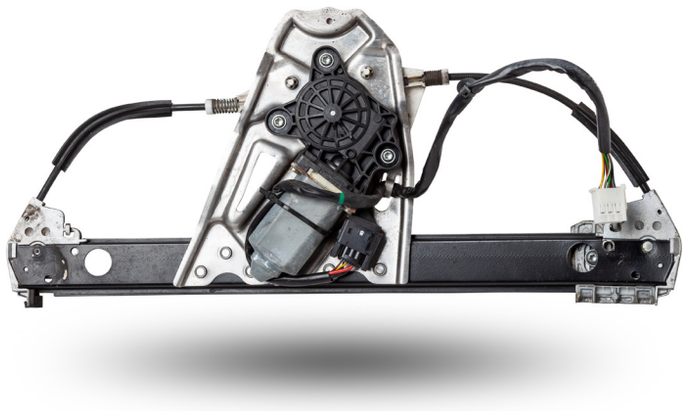

**Figure 3.3.** Low-wear, low-friction window regulator components made with Delrin® deliver long life and quiet operation

**Figure 3.4.** Select grades of Food Contact Compliant Delrin® combine safety with superior strength and wear resistance

# 4. Product line

Delrin® acetal homopolymer is available in four general families, based on molecular weight/flow rate. As shown in Table 4.1, the 100 family offers higher molecular weight, which leads to exceptional toughness, impact resistance and elongation at break. At the opposite end, the 900 family exhibits much higher flow rates, which is ideal for long parts with thin walls. The shorter polymer chains result in a higher crystallinity with fewer entanglements, leading to relatively moderate toughness.

A designer may desire to use the 100 family to get the best combination of strength and toughness, while a molder may prefer to use a lower molecular weight resin to ensure best part filling and appearance.

Preferred by designers ↑

| Flow family | Melt mass-flow rate (g/10 min) | Melt volume-flow rate ($cm^3$/10 min) |
|---|---|---|
| 100 | 2.4 | 2 |
| 300 | 7 | 6 |
| 500 | 15 | 13 |
| 900 | 25 | 21 |

↓ Preferred by molders

**Table 4.1.** Delrin® flow families

The spider chart in Figure 4.1 shows in more detail the differences between the flow families. The 100 family has slightly lower stiffness (tensile modulus), but greater toughness characteristics (charpy notched, yield strain and nominal strain at break).

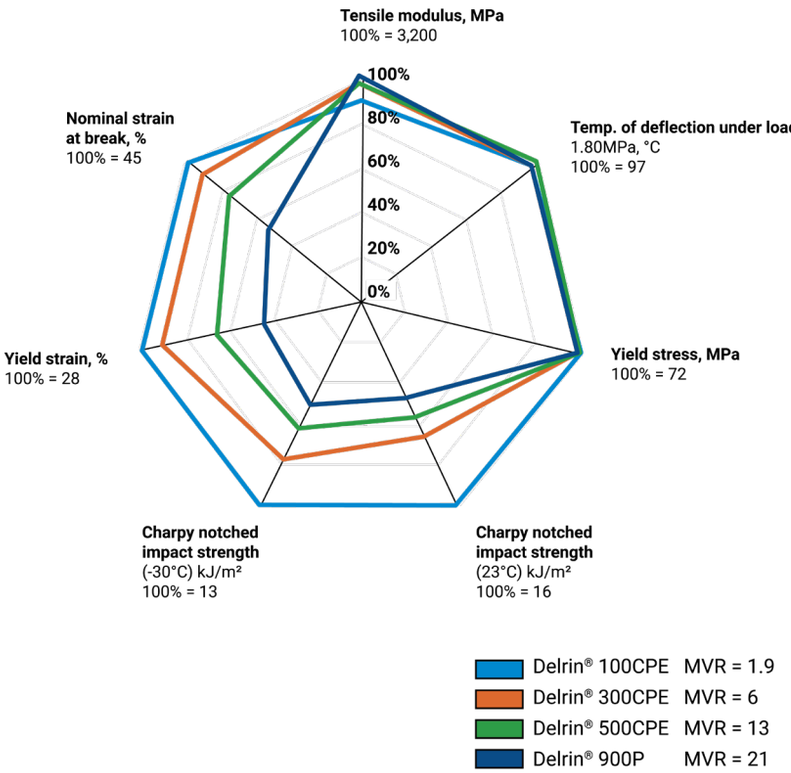


**Figure 4.1.** Mechanical properties of Delrin flow families—higher molecular weight results in higher toughness

Table 4.2 below illustrates, in greater detail, the general characteristics of the Delrin flow families as well as the types of compounded formulations available in each family. Table 4.3 lists the nomenclature used to indicate the various technologies available in the Delrin product line and their targeted uses. Table 4.4 lists a small selection of grades from the Delrin product line to illustrate the range of properties possible. The full set of properties of all grades in the Delrin portfolio can be found in the Delrin Product Data Sheet System (https://delrin.materialdatacenter.com).

| Flow family | General characteristics | Modified grades available for extended performance |
|---|---|---|
| 100 | • High viscosity acetal homopolymer for use in easy-to-fill molds (thick walls)<br>• Injection moldable and exhibits sufficient melt strength for extrusion<br>• Best combination of strength and toughness without modification | • Enhanced productivity<br>• Low emission<br>• Extrusion<br>• Toughened<br>• UV-stabilized<br>• Low wear/low friction<br>• Renewable Attributed |
| 300 | • Medium-high viscosity acetal homopolymer with an outstanding balance of ease of processing and mechanical performance | • Enhanced productivity<br>• Low emission<br>• Toughened<br>• UV-stabilized<br>• Antistatic<br>• Renewable Attributed |
| 500 | • General purpose medium viscosity acetal homopolymer with an optimum combination of flow and mechanical properties | • Enhanced productivity<br>• Low emission<br>• Toughened<br>• UV-stabilized<br>• Low wear/low friction<br>• Glass filled/reinforced<br>• Renewable Attributed |
| 900 | • Low viscosity acetal homopolymer for multi-cavity and thin wall molding<br>• Easy filling resin with slightly lower toughness than the 500 family | • Enhanced productivity |

**Table 4.2.** Compositions of Delrin® acetal resins

| Category | Technology nomenclature and description | | Applications |
|---|---|---|---|
| **Standard**<br>Outstanding ease of processing, great combination of strength and toughness | **#00/P/ CPE** | Unnucleated for best combination of strength and toughness | High-performance engineering components across all applications |
| | **#11DP** | Nucleated for faster cycle times, higher strength and stiffness for excellent creep and fatigue resistance and great dimensional stability with fewer voids but with lower toughness | |
| | **#27UV** | **UV-stabilized** for excellent mechanical property retention after prolonged UV exposure | Automotive interiors, sports equipment, etc. |
| | **150** | Nucleated for low porosity and stabilized for low die deposit in extrusion processing | Extruded sheet, rod, tubing (stock shapes) |
| **Impact modified**<br>Toughened for impact resistance in highly stressed parts | **T** | **Toughened** for improved impact resistance over base grade | Fasteners, lock systems, clips, latches, gears, straps |
| | **ST** | **Super-toughened** for maximum toughness against high impact loads or repeated impact, and useful for reducing noise, vibration and harshness (NVH) | |
| **Very low emission** | **E** | **Very low emission** version of many standard and impact modified grades listed above with same great properties as parent grade for low emission in molded parts | Auto interiors, cosmetics |
| **Low wear and low friction**<br>Grades with internally-compounded additives for low wear, low friction, (LW/LF) and low noise against metals and/or plastics | **CL** | **Chemical lubrication** for LW/LF against metals | Assemblies requiring contact/friction against metals or plastics |
| | **AL** | **Advanced lubrication** for LW/LF and low noise (squeak) against plastic | |
| | **TL** | **1.5% PTFE lubricated** for high-speed applications | Low coefficient of friction applications such as conveyor chain |
| | **MP** | **Up to 20% PTFE micro-powder** for high-pressure applications | |
| | **AF** | **20% PTFE Advanced fiber** for high-pressure and speed applications | |
| | **KM** | **DuPont™ Kevlar® modified** for low wear in abrasive environments | Low wear in abrasive environments, conveyors with grit present |
| | **SC** | **Silicone concentrate** of 20% silicone in Delrin® 500P for pellet-blending with any grade of Delrin® to achieve lower coefficient of friction | Provides surface lubrication for molded parts |
| **Highly filled or reinforced**<br>Designed with high filler content to serve specific functions | **ATB** | **Antistatic, toughened and black** carbon powder + toughener for flexibility and moderate conductivity | Conductive, static dissipative applications |
| | **GR** | **Up to 25% glass reinforced** for high heat deflection temperature, excellent creep and fatigue resistance, good notched impact properties, and higher stiffness and strength | Housings, screws, switches, levers, window hardware |
| | **MXD** | **Metal and X-ray detectable** for use in food processing | Conveyors, hoppers, food-handling tools |
| **For regulated industries** | **FG###** | **Food Contact Compliant Grade** with FDA and EFSA + GMP controls | Food contact, healthcare/ medical devices |
| | **SC6##** | **Special Control**, FG + meets USP Class VI and ISO 10993 (5 and 11), extended change controls | |
| | **PC6##** | **Premium Control**, SC + FDA drug and device master files, extended change controls | |
| **Improved sustainability** | **RA###** | **Renewable Attributed:** Base polymer produced from 100% bio-feedstock from waste (according to ISCC mass balance certification). 100% certified renewable electricity used for production. Up to 75% lower carbon footprint and up to 57% reduced use of fossil resources vs. fossil-based Delrin® | Across all applications |

Many grades of Delrin® meet NSF potable water contact requirements for Standard 14, Standard 51 and Standard 61. Current listing is available at nsf.org.

**Table 4.3.** Delrin® technology nomenclature descriptions

# Datasheet properties of selected Delrin® grades

| | Delrin® grade | Available in FG | Available in RA | MFR, g/10 min ISO 1133 | Tensile mod., MPa ISO 527 | Yield stress / [break stress], MPa ISO 527 | Yield strain / [break strain], % ISO 527 | Nominal strain at break, % ISO 527 | Charpy notched 23 °C, kJ/m², ISO 179 | Charpy notched -30 °C, kJ/m², ISO 179 | Deflection temp. under load, 1.8MPa, °C ISO 75 | Mold shrink, // , ⊥ % ISO 294 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow/moldability | 51HSE NC010 | | | 1 | 3000 | 73 | 26 | 36 | 7.6 | 7.1 | 99 | 2.3, 1.8 |
| | 100P NC010 | X | | 2.5 | 2900 | 70 | 26 | 45 | 15 | 14 | 95 | 2.2, 1.9 |
| | 100CPE NC010 | | X | 2.3 | 2900 | 71 | 28 | 45 | 16 | 13 | 95 | 2.2, 1.9 |
| | 111DP NC010 | X | | 2.4 | 3150 | 72 | 20 | 40 | 11 | 9.5 | 98 | 2.0, 1.9 |
| | 150 NC010 | X | X (RAFG) | 2.3 | 3200 | 73 | 22 | 40 | 11 | 9 | 99 | 1.8, 2.0 |
| | 300CPE NC010 | | X | 7 | 3100 | 71 | 25 | 40 | 10.5 | 10 | 97 | 2.1, 1.8 |
| | 311DP NC010 | X | | 7 | 3300 | 74 | 15 | 35 | 9 | 8 | 103 | 1.9, 1.8 |
| | 500P NC010 | X | X (RAFG) | 15 | 3100 | 71 | 17 | 30 | 9 | 8 | 93 | 2.0, 1.9 |
| | 500CPE NC010 | | X | 15 | 3100 | 72 | 18 | 33 | 10 | 8 | 97 | 2.0, 1.9 |
| | 511DP NC010 | X | X (RAFG) | 14 | 3500 | 75 | 12 | 25 | 7 | 6.5 | 105 | 1.9, 1.8 |
| | 511CPE NC010 | | X | 14 | 3500 | 75 | 13 | 25 | 7 | 6.5 | 105 | 1.8, 1.8 |
| | 900P NC010 | X | | 25 | 3300 | 71 | 12 | 23 | 8 | 7 | 94 | 1.9, 1.9 |
| | 911DP NC010 | X | | 24 | 3400 | 75 | 10 | 20 | 6.5 | 6 | 108 | 1.9, 1.8 |
| Toughness | 100ST NC010 | | | 2 | 1400 | 41 | 30 | >50 | 90 | 18 | 60 | 0.8, 1.1 |
| | 100STE NC010 | | | 2 | 1300 | 43 | 35 | >50 | 90 | 17 | 61 | 0.8, 1.1 |
| | 100TE NC010 | | | 2.2 | 1850 | 54 | 26 | >50 | 24 | 13 | 71 | 1.3, 1.5 |
| | 300TE NC010 | | | 7 | 1900 | 53 | 20 | 36 | 16 | 10 | 71 | 1.3, 1.5 |
| | 500T NC010 | | | 12 | 2300 | 56 | 18 | 35 | 14 | 9 | 78 | 1.7, 1.6 |
| Stiffness | 510GR NC000 | | | 11 | 5500 | [95] | [4.3] | | 5 | 5 | 164 | 1.0, 1.4 |
| | 525GR NC000 | | | 8 | 9500 | [160] | [3] | | 10 | 10 | 172 | 0.4, 1.2 |
| Specialty | 500CL NC010 | | | 15 | 3100 | 67 | 15 | 25 | 8 | 7 | 90 | 1.9, 1.8 |
| | 100ALE NC010 | | | 2.5 | 3000 | 70 | 18 | 40 | 10.5 | 8 | | 2.0, 1.7 |
| | 500AL NC010 | X | | 14 | 3000 | 66 | 11 | 23 | 7 | 6 | 97 | 1.8, 1.7 |
| | 520MP NC010 | | | 8 | 2800 | 53 | 13 | 15 | 4 | 4 | 94 | 1.9, 1.5 |
| | 500AF | | | 5 | 2800 | [50] | [10] | | 3 | 3 | 92 | 2.0, 1.4 |
| | 100AF | | | 0.9 | 2700 | [53] | [15] | | 5 | 4 | 87 | 2.1, 1.5 |
| | 100KM NC000 | | | 2 | 3100 | [65] | [15] | | 4.5 | 3.5 | 98 | 1.8, 1.5 |
| | 300AS BK000 | | | 5 | 9200 | 60 | 5 | 7 | 5 | 4 | 143 | 0.7, 1.5 |
| | 300ATB BK000 | | | 1 | 2500 | [51] | [18] | | 9 | 6 | 70 | 1.7, 1.5 |
| | 127UVE NC010 | | | 2.5 | 2900 | 71 | 25 | 45 | 14 | 10 | 91 | 2.1, 1.9 |
| | 327UVE NC010 | | | 7 | 3100 | 71 | 20 | 40 | 10 | 9 | 91 | 2.2, 1.9 |
| | SC655 NC010 | | X | 15 | 3100 | 71 | 17 | 30 | 9 | 8 | 93 | 2.0, 1.9 |
| | SC698 NC010 | | X | 21 | 3100 | 65 | 11 | 20 | 4 | 4 | 97 | 1.6, 1.8 |

For complete data, visit Delrin® Material Data Center at https://delrin.materialdatacenter.com. To learn more, contact your Delrin representative or visit Delrin.com.