MILITARY AND AEROSPACE SPLINE COUPLINGS MACHINED FROM DUPONT™ VESPEL® PARTS & SHAPES

A Proven Technology for Reducing Spline Wear and Increasing Service Life

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CURBELL PLASTICS

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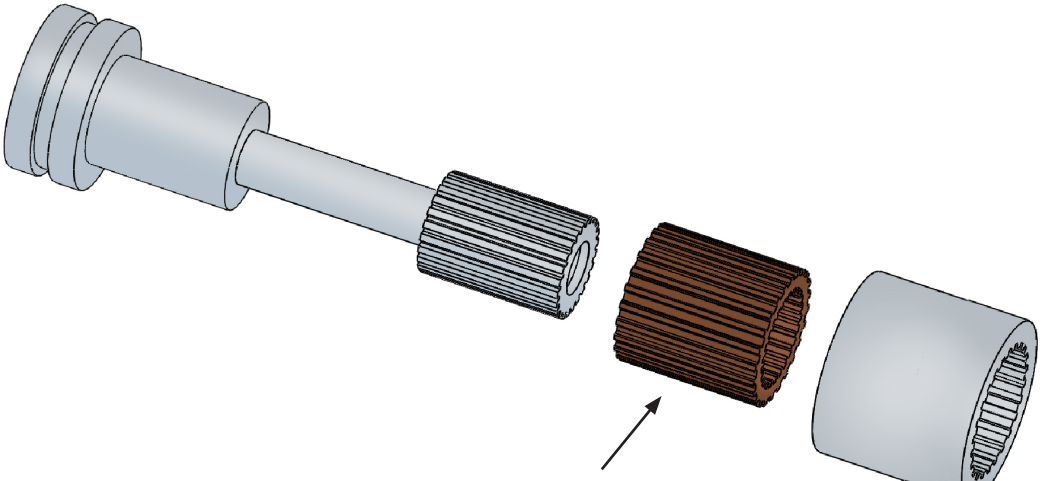
Power transmission shafts that drive generators, hydraulic pumps, and other equipment on fixed wing aircraft, helicopters, and military ground vehicles are connected to one another by splines. Early metal-to-metal spline connections exhibited accelerated wear and had to be replaced with unacceptable frequency [1,4]. To ensure reliability and reduce maintenance costs, spline couplings machined from DuPont™ Vespel® SP-1 polyimide have surged in popularity since the 1970s.

DuPont™ Vespel® spline couplings go by several names including shaft adapters, muffs, or various combinations of the aforementioned terms. They are machined components that fit to the outside of one metal shaft and the inside of a mating metal shaft as shown below.

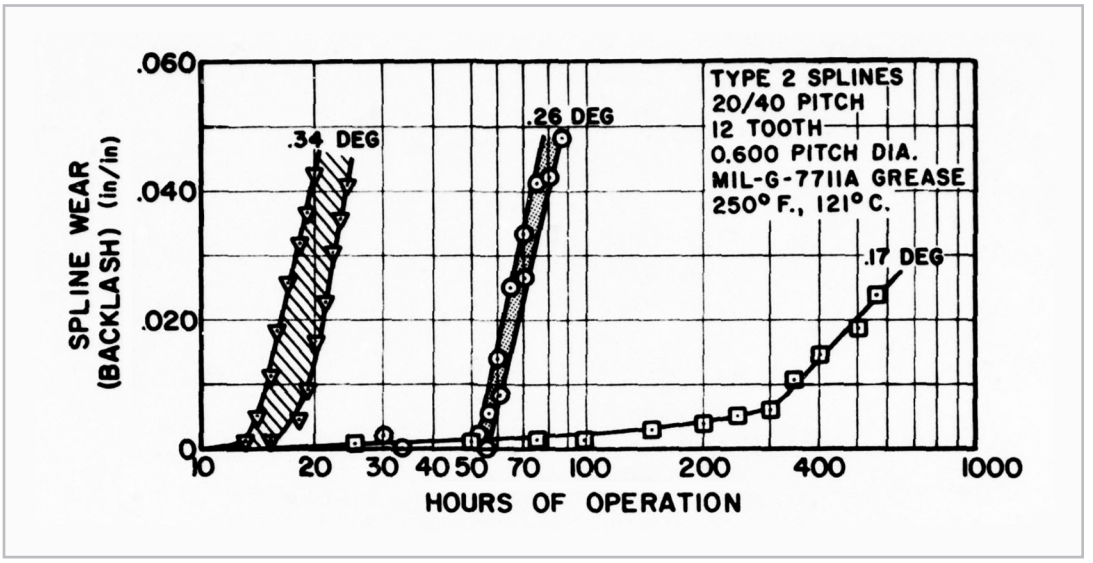


DuPont™ Vespel® Spline Coupling

ACCELERATED WEAR IN SPLINE CONNECTIONS

A major cause of accelerated wear in spline connections is misalignment. Metallic splines must remain almost perfectly aligned during operation to ensure long life. In practice however, due to variability in both manufacturing and installation, splines are typically misaligned to some degree and wear rates increase exponentially [1,4]. Data produced by the Naval Air Test Center showing wear rates for lubricated metallic splines at three different levels of misalignment are presented in Figure 1 below [4,5,6].

Figure 1. Wear of Lubricated Metal Splines with Various Degrees of Misalignment [4,5,6]



Standard grease lubricated involute spline accelerated wear due to angular misalignment. (350 in.-lb. (39.5 N-m) applied torque at 4400 RPM)

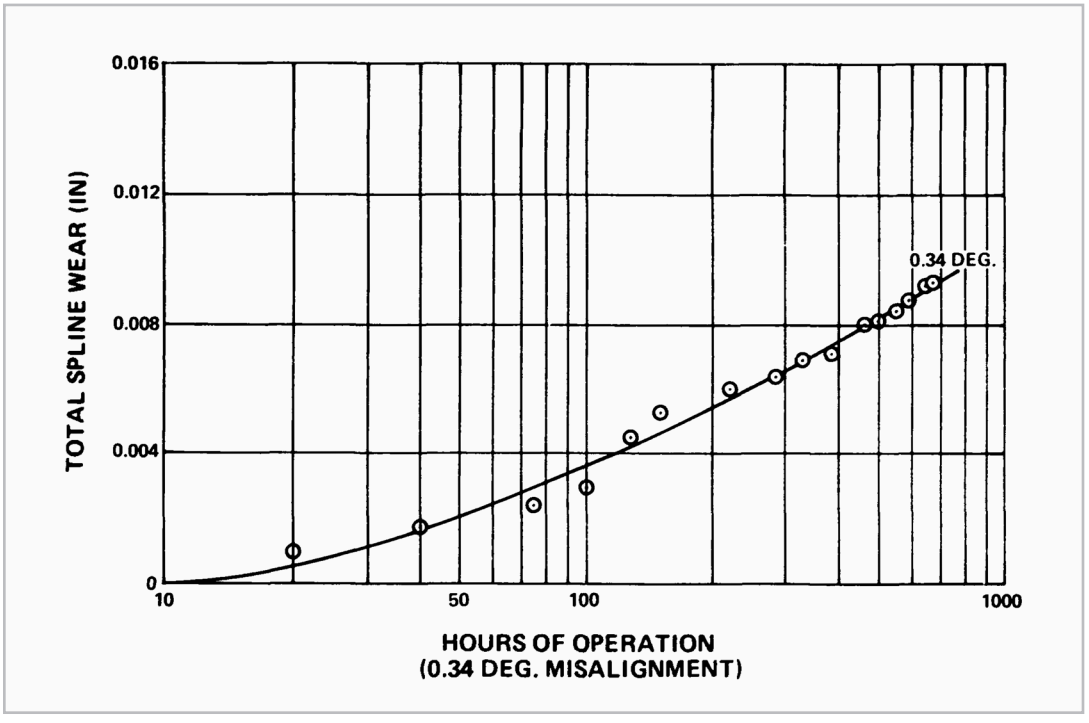
Source: Loker (1976)

Metal on metal spline connections may exhibit excessive wear and fatigue, particularly when shafts are misaligned.

Vespel® SP-1 is a high performance plastic known for its high compressive strength, creep resistance, ductility, low wear rate, and reliable performance throughout a wide range of temperatures. It is described in a number of military standards for non-metallic spline adapters including MS14169 (AS) for circular splines [6,7] and MS14184 (AS) for flat sided splines [6,8].

DuPont™ Vespel® polyimide is capable of accommodating misalignment because of its ability to deform elastically in compression and redistribute loads more evenly [4]. Figure 2 [5,6] depicts wear data for DuPont™ Vespel® splines at 0.34 degrees of misalignment, the worst situation included in Figure 1. This ability to operate with a high degree of misalignment results in longer wear life. In some applications, splines connected with adapters made from DuPont™ Vespel® polyimide exhibit 50 times the wear life of lubricated metal on metal spline connections [2,5]. Circular DuPont™ Vespel® spline couplings with a crowned geometry have the additional benefit of reducing stress on bearings for both the drive and driven machinery when shafts are misaligned [4].

Figure 2. Spline Wear with a DuPont™ Vespel® Spline Adapter at 0.34 Degrees of Misalignment [5,6]



Laboratory induced spline wear of unlubricated, internally and externally involute splined, polyimide plastic bushing showing the reduction in wear rate.

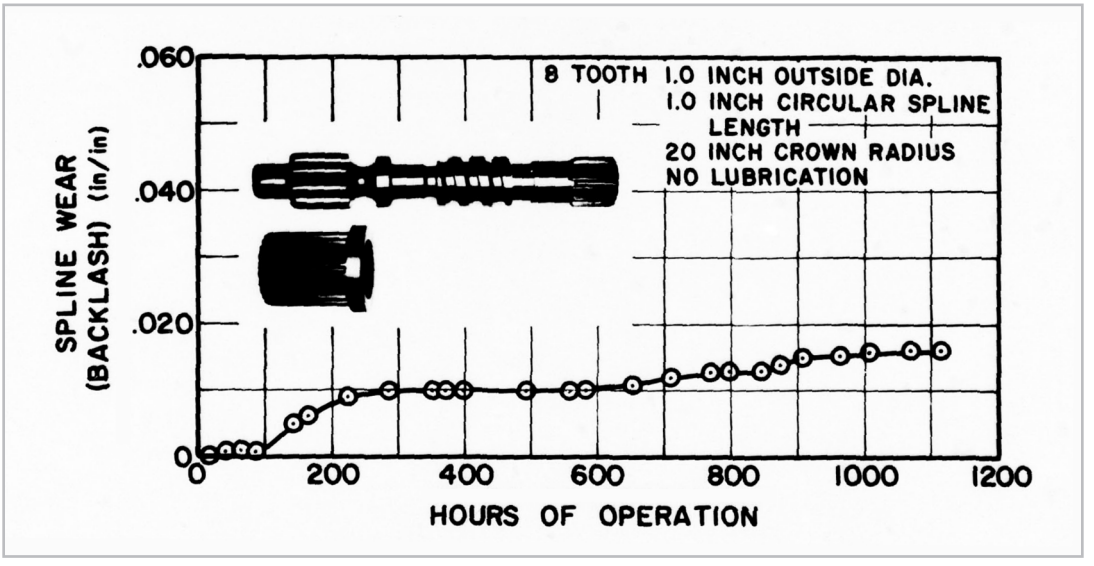
Source: Loker (1978)

LUBRICATION

Another important consideration related to metal on metal spline wear is the requirement for lubrication. Some studies have suggested that metallic splines should be re-lubricated after every 25 hours of operation to maintain low wear rates [4]. Beyond the obvious implications of high maintenance costs and significant downtime, there is also an increased likelihood of the parts becoming accidentally misaligned during such frequent maintenance operations. Moreover, lubricants can actually accelerate spline wear by retaining abrasive particles at the interface of the mating parts [1,4].

Vespel® SP-1 does not require lubrication and splines with DuPont™ Vespel® adapters tend to exhibit very little wear following an initial break-in period as shown in Figure 3 [4]. Another advantage of Vespel® SP-1 is it tends to be less abrasive to the mating metal spline teeth. DuPont™ Vespel® polyimide also naturally dampens vibration, which results in quieter operation [6].

Figure 3. Splines with DuPont™ Vespel® Spline Adapters Exhibit Minimal Wear After an Initial Break-in Period [4]



Laboratory endurance test of circular spline operated at an angular misalignment of 20 minutes. (F-4 aircraft constant speed drive shaft) (360 in.-lb. (40.7 N-m) applied torque at 6000 RPM)

Source: Loker (1976)

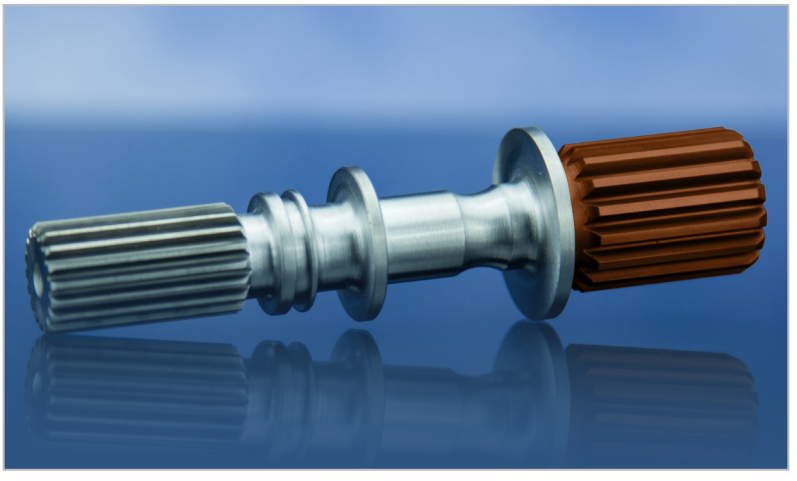
SUMMARY

In summary, spline couplings made from DuPont™ Vespel® polyimide offer a number of advantages when compared with metal on metal spline connections:

- Decades of actual flight testing on various aircraft types
- Better accommodates misalignment compared with metal on metal spline connections
- Reduced stress on bearings due to misalignment
- Require no lubrication
- Increased mean time between failures and reduced maintenance and downtime
- Increased power system reliability
- Reduced abrasion on mating components
- Easy to machine to precise geometries
- Reduce noise and vibration

For More Information

Contact Curbell Plastics for more detailed information on any of the topics discussed in this paper. For technical inquiries regarding DuPont™ Vespel® parts & shapes or any of our other high performance plastics you can contact the authors of this paper or use our online Ask a Plastics Expert form.



ABOUT AUTHENTIC DUPONT™ VESPEL® SHAPES

Curbell Plastics is an authorized distributor of Authentic DuPont™ Vespel® polyimide shapes (rod, plaque, bar, balls).

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TECHNICAL EXPERTISE

Curbell white papers are intended to provide engineers and designers with basic information about the engineering polymers available as sheet, rod, tube, and film stock from Curbell Plastics. We invite you to contact Curbell via e-mail at **technicalsupport@curbellplastics.com** to discuss applications in detail.

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