

# Rigid Couplings for Precision Motion Control Applications

William Hewitson, Vice President of Operations with Ruland Manufacturing, explains why choosing the proper rigid coupling for servo applications is an important component of system design.



*Precision honed bores for better alignment, fit and holding power*



*Step Bore Rigid Couplings connect shafts with different diameters*

Rigid couplings historically have been imprecise, inexpensive, and often home made components for simple shaft to shaft connections. It is not surprising therefore, that in the past many people would not consider using rigid couplings in a servo application. However, smaller sized rigid couplings, especially those in aluminum, are increasingly being used in motion control applications due to their high torque capacity, stiffness, and zero backlash. It is important though, that unlike their common counterparts, the rigid couplings used have the precision and features necessary for low-maintenance and accurate performance.

As the name implies, rigid couplings, which are sometimes called sleeve couplings, are torsionally stiff couplings with virtually zero windup under torque loads, but they are also rigid under loads caused by misalignment. If any misalignment is present in the system the forces will cause the shafts, bearings or coupling to fail prematurely. This also means that the couplings cannot be run at extremely high

RPM's since they cannot compensate for any thermal changes in the shafts that can be caused by heat build-up from high speed use. However, in situations where misalignment can be tightly controlled rigid couplings offer excellent performance characteristics in servo applications.

A sometimes overlooked advantage of rigid couplings is they can be used to establish shaft alignment in misaligned systems. To establish shaft alignment the motor and component mounts need to be loosened to ensure there is free movement. Then the shafts need to be connected with the rigid coupling which, if precisely made, will align the shafts. Lastly, center the components on any remaining free play and tighten the mounts.

### **Required Features for Motion Control**

There are several features required of rigid couplings to ensure proper performance in motion control applications. The most important feature is that the coupling itself does not introduce misalignment

into a system where it cannot be absorbed without damage to bearings and seals. The strictest control of shaft alignment will result when the bores are honed, since honing assures that both bores are collinear. Honing also corrects any residual distortions caused by stresses introduced during the manufacturing process, resulting in a round, precisely sized bore. Proper sizing and geometry assures a larger percentage of shaft contact and greater torque transmission ability.

The simplest form of rigid couplings has set screws to fasten the coupling to the shaft through screw impingement. The problem with set screw rigid couplings is any adjustment of the set screw causes damage to the shaft. Clamp style rigid couplings are a better option since they wrap around the shaft to provide high torsional holding power without damaging the shaft. Two-piece clamp style rigid couplings have the additional benefits of allowing for disassembly and maintenance without removal of other components. When the hardware on a two-piece rigid



*The cross-cut facilitates greater holding power*

coupling is opposing, the coupling can be operated at higher RPM due to its balanced design. As a guideline, one-piece rigid couplings can be evaluated for applications up to 3000 RPM. The guideline can be increased to 4000 RPM when a two-piece style with opposing hardware is used.

Rigid couplings lack a mechanism to absorb the vibration inherent in many mechanical systems. Vibrations can cause hardware to loosen and torque transmission ability to diminish during normal use. Placing a nylon treatment on the screw threads can reduce the effect of vibration on the hardware for increased coupling reliability. The nylon also provides the necessary difference in material to prevent galling of the screw threads in stainless steel couplings.

### Proper Installation and Special Design

Most clamp style rigid couplings have been designed with cap screws close to one another and arranged in pairs. Especially when combined with a cross-cut, this design facilitates greater holding power and also accommodates slight deviations in

the size of the two shafts being connected. It is recommended that this style of coupling be installed by tightening the paired screws alternately in several steps. This is because the close proximity of the screws results in a mutuality of the hoop stress developed in the coupling by each screw. As each screw is tightened it tends to relax any tension developed by its companion. Alternately tightening the screws in several steps distributes the tension more evenly, assuring a tighter fit and the desired holding power.



*Three-Piece Rigid Couplings are designed for easy maintenance*

A less common but sometimes useful type of rigid coupling is the three-piece clamp style. This design allows for more convenient exchange or adjustment of coupled shafts, particularly where the shaft cannot be axially detached. Either side of the coupling can be detached and the shaft removed without disturbing the other shaft connection. The three-piece rigid coupling design also accommodates a slightly larger variation between the sizes of the shafts being connected by clamping totally independently on the two shafts.

An alternative to traditional rigid couplings, the double wide shaft collar can be used in applications where space is limited. Compared to a rigid coupling the double wide collar has a reduced torque capability due to its use of a single cap screw per shaft. However, the compact size of the collar reduces inertia making it ideal for motion control applications.

### In Conclusion

Choosing the proper rigid coupling for servo applications is an important component of system design. For this reason coupling selection involves matching to different performance factors, such as shaft misalignment, torque, stiffness, RPM, and space requirements. Each style of rigid coupling has its own individual characteristics which make it ideal for certain applications. A single style of rigid coupling cannot be utilized in every application leading to a wide offering of styles, sizes, and materials. This gives the design engineer the ability to select the best possible rigid coupling to maximize system performance and durability.



*Double Wide Shaft Collars can be used as compact rigid couplings*

| Performance Parameters of Rigid Couplings |                    |                      |                        |                    |              |
|---|--------------------|----------------------|------------------------|--------------------|--------------|
| Torsional Rigidity                        | Torsional Strength | Maintenance Required | Electrically Isolating | Bearing Loads      | Inertia      |
| High                                      | High               | No                   | No                     | High               | Varies       |
| Constant Velocity                         | Zero Backlash      | Cost                 | Angular Misalign.      | Parallel Misalign. | Axial Motion |
| Yes                                       | Yes                | Low                  | Zero                   | Zero               | Zero         |

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