

**United Equipment Accessories, Inc.**  
**Solving Challenges from the Inside Out.™**



## **6 Questions to Ask Before Getting a Hydraulic Swivel**

## 6 Questions to Ask Before Getting a Hydraulic Swivel

Before getting a hydraulic swivel, there are certain questions that are helpful to ask to ensure you get the best swivel for your application. In this report, we feature answers from a couple of our design engineers to address the six questions we believe are some of the most important to ask.

### 1. Do I Need a Custom Hydraulic Swivel?

While searching for hydraulic swivels a quick peruse through the internet will yield many seemingly fruitful results. Many of the companies that offer hydraulic swivels have attractive looking websites. A global marketplace almost mandates companies present slick looking graphics for viewers to admire. The quest for a hydraulic swivel and/or slip ring brought you to the website, but what is it that gets you to take the next step? The next step usually depends on the type of customer that you are.

Every customer is unique, but we can classify many of the potential customers into groups. The first group are the customers who require a simple swivel for a custom assembly, usually they are able to modify the larger assembly to accommodate a cost-effective solution. These customers are apt to pick an 'off the shelf' style unit, as availability and cost is a considerable driving factor.

Another group of potential customers use an existing swivel, but for one reason or another, are looking for a new supplier. Price and availability are important to these customers, but also intangibles like customer service and commercial considerations as well as other unique requirements.

The last group are folks looking to develop a custom swivel for a new project they are working on. These individuals encompass all the previous requirements as well as additional engineering resources needed to develop a custom design suited specifically for their requirements.

### 2. How Does the Custom Hydraulic Swivel Process Work?

When a hydraulic swivel is needed, many applications require a custom hydraulic swivel be designed and built. We thought we would take some time to explain how the process of designing a custom hydraulic swivel works.

Designing a custom hydraulic swivel begins with communication between the client and the design engineer collecting information and asking questions. The client needs to provide general information such as number of ports, size of each port, the location and position of each port on the housing and spool, the operating pressure, and the function of each port.

Further discussion should be covered regarding the flow rate and the line velocity requirements of each port. Other points of concern are:

- How is the swivel to be assembled into the client's equipment?
- Where is the torque arm located in respect to the mounting flange on the swivel?
- Can the mounting flange be welded to the housing or bolted?
- Is the swivel painted? If so, what's the paint specification?
- If there is a slip ring included, what size of through hole is needed to pass through the wiring harness and connectors?
- Is the slip ring located above or below the swivel?

All of the collected information is then written up into a request for a quote.



The design engineer takes this information from the RFQ and begins the design layout process of the spool. The size of the through hole for the slip ring wiring harness and connectors needs to be determined and is located at the center of the swivel. The location of each port is laid out according to the client's request. The size of each hydraulic circuit is designed to accept a certain flow rate using the recommended pressure line velocity of 25 ft/sec and the return line velocity of 10 ft/sec; unless otherwise specified by the client.

The flow rate, line velocity and hole size all have an effect on the port size for each circuit. The area of each flow groove around the spool is 1.5x that of the deep drill. Care must be taken to provide enough wall thickness between the bottom of the flow grooves and the edge of each deep drill to maintain a 4:1 safety factor. The wall thickness is determined by the operating pressure of each circuit.

The sum of all the circuit holes and flow grooves determines the bore size of a swivel. The bore size determines if the cap seals are located in the housing or in the spool. For swivels with smaller bores, the cap seals are located in the spool and the flow groove can be located in the housing or shared between the housing and spool. Swivels with larger bores the cap seals are located in the housing and the flow groove can be located in the spool or shared between the spool and housing. The preference is for the seals to be located in the housing.

It is preferred that the location of the low pressure circuits be at the ends of the swivel with the high pressure circuits positioned inboard. An energizer and cap seal are located between each circuit. If a high pressure circuit is located at the end of the swivel, a weep needs to be provided and connected to the return line back to the tank. The wear ring is the bearing element of the swivel and prevents contact between the housing and spool. The purpose of U-Cup seal is to contain and prevent hydraulic fluids from exiting the swivel. At each end, and internal to the swivel, are the excluder seals which keep particulate from entering the swivel. External to the swivel, and at each end, we have a thrust washer and o-ring. The o-ring prevents the larger contaminants from entering the swivel and the thrust washer prevents metal contact between the housing and spool.

The housing is usually rigidly mounted while the spool is allowed to float within the housing while its rotation is constrained. The torque arm controls the rotation of the spool. When the mounting flange is welded onto the housing, the material is steel tubing; and when the mounting flange is bolted to the housing we can use ductile iron trepanned tube.

If there is a slip ring, we prefer it be mounted above the swivel. If it's located below, then a liquid tight connector needs to be added at the top of the swivel to prevent moisture from getting down into the slip ring. This is how the flow of the custom hydraulic swivel process works.

### 3. How Long Do Hydraulic Swivels Last?

In most applications that use hydraulic swivels, the parts of the swivel that wear the quickest are the seals. Therefore, any discussion of hydraulic swivel life would be insufficient without mention of seals. Many different aspects of the application have an effect on the seal life, sometimes the effects will be positive and others will be negative. Here is a list of items that are important to consider when thinking about the seal life, and then some details on each. UEA's seal supplier has witnessed these situations over the years and believes a lot of the failures are a result of one, or a combination, of these.

#### Hardware Finish

This is kind of a double edged sword, a finish too rough is likely to abrade the seal, thus reducing its life. However, if the finish is too smooth, the seal may not be lubricated adequately and build internal heat, thus leading to a reduced life. Basically, you want a surface with a good trade off in which you have enough valleys to hold oil. At the same time, you don't want the peaks of the surface profile to be sharp and rough, as this will abrade the seal. The specifications (surface finish) provided by our seal provider is based on in-housing endurance testing, as well as field experience. Every swivel shipped from UEA has documented surface finishes meeting our seal supplier's specs.



#### 6 Questions to Ask Before Getting a Hydraulic Swivel

*Written by: Brady Haugo, Senior Design Engineer & Tom Van Veldhuizen, Designer*

## Pressure

As the pressure in the system increases, the loading in the seal increases as well; thus, typically higher pressure applications tend to wear faster than that of lower pressure applications. On cap seals, in particular, the direction of pressure may have an effect, seals with the same pressure cycle on both sides wear very little. On the other hand, a seal that only sees pressure from one side will typically wear much faster than the seal with pressure from both sides. The pressure balances in a seal which has pressure from both sides, thus it doesn't have the loading in which the seal that only sees pressure from one side. UEA will offer guidance when designing hydraulic swivels to reduce negative effects of uneven seal loading, as well as pressure limitations.

## Temperature

High temperatures (those at or above the materials limit) tend to soften the material (plastics) and this could lead to increased wear; the wear rate of the material will typically increase as the temperature increases. Additionally, high temperatures tend to harden rubber materials and helps them take a compression set, thus reducing the seals interference and reducing its life. Cold temperatures don't usually affect the life of the seal, however depending on the materials used, leakage issues could result from cold temperatures. Temperature limits are discussed with our potential customers to eliminate temperature-induced problems. UEA does not have temperature issues within the construction and related industries.

## Fluid Compatibility

Depending on the reaction between the material and fluid, if it is incompatible, the conditions found are swelling and softening of the material. There can potentially be major interactions in which the material completely breaks down and the seals fail. For example, most urethane materials used in sealing can undergo hydrolysis, in which hot water breaks the urethane down. The result is a seal that is very brittle and it crumbles. Swivels supplied by UEA will not have compatibility issues. We require our customers to describe the material that will be flowing through the hydraulic swivel. If a customer wants to put some substance through the swivel that is out of the ordinary, UEA will discuss the situation with our seal supplier and formulate a solution.

## Lubrication

It's usually the lack of lubrication that has a negative effect on the seals. As lubrication helps to reduce the friction, also reducing heat buildup, the seal will last longer. Not enough lubrication has the opposite effects and would typically cause the seal to wear faster. The cap seals used in UEA swivels have lubrication grooves that allow rotary lubrication. Our cap seals also have side wall notches that allow increase seal shifting speed, which eliminates rare occurrences of a seal bypass situation.

## Contamination

Contamination or debris in the hydraulic system can have negative effects on seals. They act as an abrasive to the sealing components and hardware, and can abrade the seal and/or damage the hardware. UEA takes contamination seriously. Our swivels are assembled in a pharmaceutical grade clean room. This keeps foreign material from entering the swivel during assembly. We utilize excluder-type seals on both ends of the swivels, this eliminates contamination entering the swivel from the ends. We also plug all ports with port plugs before any swivel leaves the clean room, eliminating any intrusion through the ports. Our test oil is constantly monitored with a laser particle counter and meets the ISO standard 18-16-13. Contamination will not be an issue with UEA supplied hydraulic swivels.



## 6 Questions to Ask Before Getting a Hydraulic Swivel

*Written by: Brady Haugo, Senior Design Engineer & Tom Van Veldhuizen, Designer*

## Speed

The higher the speed, the more internal heat buildup the seal will have. High rotational speeds can lead to localized high temperatures that have a negative effect on the seals. As with hydraulic cylinders, the contact point is usually moving, so the area in which the heat must dissipate is much larger. It is advantageous to have continual oil or fluid movement within the swivel to help dissipate the heat. The larger the swivel diameter, the slower the max speed; not surprisingly, the smaller the swivel diameter, the faster it can spin. Depending on size, UEA will recommend a max speed. We have not had any situations where the speed has been limited by our seals within the construction/forestry and related industries. There are many more issues that can negatively affect swivel performance. Open communication between all parties is vital in creating a custom, long-lasting solution to your swivel requirements. We pride ourselves in having industry leading customer service, in which quick and open communication is key. We would love the opportunity to quote your next project requiring hydraulic swivels with or without electrical slip rings.

## 4. How Do I Know My Hydraulic Swivel Will Perform?

Once a hydraulic swivel has been designed, reviewed and machined, the housing and spool are moved to the clean room and all parts are pulled to make a complete assembly. Then the housing and spool are moved to the assembly machine. Here the spool is pushed into the housing using an air over oil system. The operator manually turns a crank which extends the cylinder rod and slowly advances the spool into the housing, while monitoring the pressure from a gauge until the spool is fully inserted. Doing this operation manually allows the operator to physically feel if there is any binding occurring, which may cause internal damage to the seals, housing and/or spool. The rest of the assembly is completed and the swivel is then placed into our production machine for torque and pressure tests.



Each swivel is prefilled with hydraulic fluid and rotated in both directions while the torque is monitored by load cells. Then the pressure of each circuit is tested at 1.5x the operating pressure, up to a maximum 7500 psi. The pressure is monitored by two pressure transducers, one for even and one for odd circuits. The cleanliness of the oil is continually monitored by an ICM at the 17/15/12 level, thus ensuring we keep the internal circuits of each swivel at a high cleanliness level. The torque, pressure and oil cleanliness are all stored and saved as a birth certificate for each swivel. The fluid in the swivel is then reclaimed back to our oil reservoir. Next, the swivel is removed and all ports are plugged and prepared for primer or primer and paint. Each one is individually banded to a crate, ready for shipping to each client.

Every step in the process provides the client with confidence that each swivel has been put together with the utmost care and will perform to expectations.

## ***What does UEA do to help ensure that your hydraulic swivel will perform at a high level?***

UEA kept hearing from potential customers, “You’ve only been designing and manufacturing hydraulic swivels for a few years. How can I be sure they’ll perform?” Hydraulic swivels, also known as hydraulic rotary manifolds, are precision components designed to transfer fluid from a stationary source to a rotating piece of machinery.

In response, we’ve begun in-house lifecycle testing for hydraulic swivels. The test stand allows years of field usage to be simulated in a matter of weeks vs. years. Now we can provide customers with hard facts about reliability and recorded data results based on their specific application conditions and operating testing parameters, before our designs and end products hit their production floor.

To my knowledge, no other manufacturer of hydraulic swivels offers this type of testing in-house.



## **6 Questions to Ask Before Getting a Hydraulic Swivel**

*Written by: Brady Haugo, Senior Design Engineer & Tom Van Veldhuizen, Designer*

Hydraulic swivel endurance testing involves examining a hydraulic swivel while it withstands varying pressure loads during rotations, and monitoring and measuring the specified parameters under such conditions for every cycle.

The test stand was built entirely in-house for the purpose of conducting accelerated life testing of hydraulic swivels. The stand's control program uses a test procedure that strictly follows a specified set of testing parameters. A myriad of sensors measure the response of the tested elements under simulated conditions for a specific period and for a certain threshold.

The test stand sits in a specially designed room that has its own ventilation system, automatic fire suppression, and a two-hour fire rating. Two webcams connected to the network provide 24-hour video surveillance.



The overall footprint is 87" wide x 54" deep x 96" high. It contains the test stand, which is 48" wide x 48" deep x 96" high; the test chamber itself where the actual testing is done is 40" x 40" x 50". Front and top doors are manually opened for the installation and removal of the swivel assemblies. The test chamber is enclosed using polycarbonate sheet and expanded flattened sheet metal on all sides. There's also three electric motor hydraulic pump units.

During various continuous pressure cycles, the swivel assembly is rotated by a hydraulic motor and has the capability to produce up to 1,500 ft-lbs of torque. This motor is driven by an electric motor-pump combination unit. The hydraulic motor and a torque arm are assembled to a turntable, which allows for degrees of freedom.

The torque readings are measured by a load cell connected between the torque arm and ground. The swivel rests on a drive plate, which has two drive pins that rotate the spool. The rotational speed of the swivel varies between 2-10 rpm. The housing is constrained to the frame of the machine with height adjustment square tubes. These are positioned for each individual swivel using acme screws along with a series of gearboxes. The frame is gusseted to handle the forces produced during the rotation of the swivel while the hydraulic passages are held under the high-pressure test cycles.

Hydraulic pressure testing of the swivel has three pressure ranges and is accomplished by using two electric motor-pump units. One controls the low and medium pressures while the other controls the high pressure range up to 5,000 psi. The pressures will alternate during the specified testing criteria to simulate the actual field operating functions of the swivel.

A data acquisition system measures and records torque and pressure cycles during the testing process. We look for pressure decay and any major variations in our torque readings during the testing. The ongoing testing period is monitored 24/7 both on- and off-site.

To try to simulate all possible field conditions cold startup tests are conducted at -40 degrees Fahrenheit and is accomplished by either cold soaking the swivel with liquid nitrogen or packing it with dry ice. The larger swivels are cold soaked while the smaller ones are packed with dry ice. The swivel will also be tested at 220 degrees Fahrenheit using heat blankets or heating cartridges. The temperature variations will be measured by using thermocouples.

The test stand has a 25-gallon reservoir and is water-cooled. The liquid level and temperature in the reservoir is monitored. Liquid cleanliness is also monitored with an ICM and maintained at the ISO 4406 requirement.



## 6 Questions to Ask Before Getting a Hydraulic Swivel

*Written by: Brady Haugo, Senior Design Engineer & Tom Van Veldhuizen, Designer*

The biggest advantage of the endurance test stand is confidence. We've always been confident in our hydraulic swivels. Now, with the advantage of our endurance test stand, customers and potential customers can be, too.

## 5. Hydraulic Swivels with Slip Rings: Which Combination Should You Choose?

You need a hydraulic swivel/slip ring combination unit. But with so many options, how do you know which combination is right for your application? I'm here to help you.

UEA routinely helps our customers choose between the three different types of hydraulic swivel slip ring combination units. While there's a lot to think about, the main objectives are to save you money and create an assembly that surpasses the requirements of the application.

It's important to understand the distinction between surpassing requirements and mindlessly over-engineering a product. We're not in the business of selling a one-size-fits-all solution. Our main advantage is our ability to create custom designs for our customers without needless additional costs.

There are three main styles of slip ring and hydraulic swivel combination units available: fully integrated, semi-integrated, and separated design.

### Fully integrated

Fully integrated combo units integrate the slip ring directly into the end of the hydraulic swivel. Externally, the unit looks to be just a hydraulic swivel with the telltale signs of an electrical harness coming out both ends. This style is best used with minimal slip ring circuits and a very critical requirement for sealing and protecting the slip ring components. This style is commonly used in the forestry industry.

#### Pros:

- It's the most robust, by a large margin; it's literally bulletproof.
- It employs the least amount of parts.

#### Cons:

- Due to its nature, only low amounts of slip ring circuits are cost effective.
- Removal of the slip ring can be trickier than the separated style.
- Additional engineering time is required.



### Semi-integrated

On semi-integrated combo units, the slip ring is mounted directly onto the end of a hydraulic swivel. However, the slip ring circuits are enclosed using our standard spun aluminum cover, not the swivel housing like the fully integrated version. This version is best suited for applications that have more slip ring circuits and less harsh requirements for sealing and protecting the electrical circuits, as well as designs with length restraints. This style is commonly used in the construction and railroad industry.

#### Pros:

- It allows us to fit the max amount of slip ring circuits into an application with length restrictions.
- It's the most cost effective style for large amounts of circuits.

#### Cons:

- It doesn't have the robustness of the fully integrated style.
- It has similar engineering time requirements as the fully integrated version.
- The harness exit location is not as free to change as the fully integrated version.



## 6 Questions to Ask Before Getting a Hydraulic Swivel

Written by: Brady Haugo, Senior Design Engineer & Tom Van Veldhuizen, Designer

## Separated design

Combo units with a separated design have the hydraulic swivel and slip ring separated by a mounting tube and flange. This is the classic style that has been used for decades. The two units can be separated easily and this style has the lowest heat transfer between the slip ring and swivel. It's best suited for applications with many slip ring circuits, low sealing, and protection requirements, as well as no stringent length requirements. This style also requires the least amount of upfront design work, so it's well suited for low yearly requirements—for example, less than 10 per year. This style is commonly used in the construction and railroad industry.

### Pros:

- It requires the least amount of engineering effort to join the two together.
- We can lengthen the mounting tube if other components are in the way.
- The additional space between the two units helps reduce heat transfer.
- Disassembly is visually straightforward; most mechanics are familiar with this style as it's been the standard for decades.

### Cons:

- It uses the most parts.
- It's typically the longest of the three.



The design team at UEA will give you the most practical option available by default. If you would like to use one style over the other, we will gladly turn your vision into reality.

## 6. What are the mounting requirements of hydraulic swivels?

The mounting requirements of a hydraulic swivel are a tad bit more important than a casual observer would ascertain from a brief observation. Mounting rigidity and swivel torque are important design considerations. In this blog, I will discuss torque and mounting rigidity and how they interact with each other.

### Swivel Torque

The rotational torque of the hydraulic swivel is what is required to overcome the resistance to turning. There are a few general concepts that one can use to judge the optimal hydraulic swivel rotational torque:

- There is a “breakaway” torque value when first starting the movement from a static position
- After the rotation has begun, the dynamic rotation value should be lower
- The friction between the seal and sealing surface creates resistance to turning
- The larger the seal diameter, the higher the resistance to turning
- The more seals, the higher the resistance to turning
- The higher the psi within the circuit, the higher the resistance to turning
- Seal geometry affects resistance to turning
- Seal material affects resistance to turning
- Non-pressurized ports create lowest resistance to turning
- Every other port pressurized creates highest resistance to turning
- All ports pressurized equally creates similar torque to non-pressurized configuration
- Different permutations of pressured ports will create a wide variety of swivel torques



## 6 Questions to Ask Before Getting a Hydraulic Swivel

Written by: Brady Haugo, Senior Design Engineer & Tom Van Veldhuizen, Designer

Steady state rotational torque isn't the only concern when dealing with mounting requirements of a hydraulic swivel. The seals within the swivel have static and dynamic friction. The static friction is higher than dynamic friction. Just like pushing a box across the floor, it is harder to start it moving than it is to keep it moving. The static resistance to rotation in a hydraulic swivel will be much higher than the dynamic resistance to rotation.

### Mounting Rigidity

The difference between static and dynamic friction is of great importance here. To better explain why this is very important I will describe a situation that can lead to the dreaded torque arm restraint chatter. The following would be a step-by-step description of how chatter develops within an assembly that contains a hydraulic swivel. I refer to the 'torque constraint assembly' as the method (typically a weldment) for driving the hydraulic swivel.

1. Rotating member begins to rotate based on operator inputs
2. Torque constraint assembly engages swivel and begins to put rotational force on swivel
3. High static friction within swivel creates large resistance to turning
4. Torque constraint assembly flexes slightly due to large resistance turning that swivel is creating
5. As force continues to increase, the swivel transitions from static to dynamic friction and begins to rotate. It actually snaps forward farther ahead due to the torque constraint assembly acting like a sling shot.
6. With the swivel farther ahead than the torque constraint assembly, it pauses for a brief moment
7. Torque constraint catches up and engages swivel
8. Cycle begins again at step number 2

The whole process happens many times per second (100Hz potentially) depending on the natural frequency of the torque constraint assembly. The natural frequency of the torque constraint assembly is usually within the audible range of humans, so when it is energized (steps 2-8), it makes a large noise that can be heard and felt.

I need to make a couple points that will provide the optimal mounting and torque restraint features in order to reduce the risk of several potential failure modes:

1. It is not the swivel that is chattering, it is the torque constraint assembly and mounting of the swivel that is the source of the chattering issue
2. This is NOT similar to a hydraulic cylinder that chatters in its linear application
  - When a hydraulic cylinder chatters, it is due to resistance to stroke and a 'spongy' fluid power circuit (this is an entirely different discussion)
3. The best ways to eliminate or prevent hydraulic swivel chatter and other mounting concerns are:
  - Increase robustness into the stationary solid mounting plate and mounting lugs
  - Increase torque arm constraint assembly rigidity
  - If a design requires a parallel to the axial center line of rotation, the length of a torque arm should be as short and robust as possible
  - Regardless of which end of the swivel faces up or down, choose first to orient your fixed stationary mounting and your rotating element close torque arm as close together as possible and stay as close to the center of the radial plane of the slewing ring as possible.

It would be difficult for UEA to provide design guidelines as there is a huge variety of different types of applications for hydraulic swivels. If you involve UEA designers early in the design process, we can provide additional design analysis and feedback to assist in creating a rigid mounting and torque constraint assembly. Torque constraint assembly flexation and natural frequency analysis can also be provided. Upfront teamwork and analysis will ensure your assembly and our hydraulic swivel will live together for many, many years!



### 6 Questions to Ask Before Getting a Hydraulic Swivel

*Written by: Brady Haugo, Senior Design Engineer & Tom Van Veldhuizen, Designer*

## **In Conclusion**

Understanding the answers to the above questions will help as you select your next hydraulic swivel. If you have any other questions, take the time to get them answered so you can get the best swivel for your application and do what you can to ensure it lasts as long as possible.

UEA employees strive to embody our company motto 'solving challenges from the inside out'. We are available to answer any questions you may have even before you consider requesting a quote. As you can tell by our motto, UEA is built to serve your design challenges. We will solve your problems by supplying custom designed and built hydraulic swivels and/or slip rings.

If you would like to request a quote, visit <http://www.uea-inc.com/request-a-quote/>.

If you would like to have a conversation with one of our other Hydraulic Swivel Engineers to discuss whether or not a custom or standard hydraulic swivel is necessary or any other question you may have, call us at 1-800-394-9986 and ask for a Hydraulic Swivel Engineer.

