EXECUTIVE SUMMARY

Long service life of rotary joints and adjacent flexible hoses can be achieved by following basic installation guidelines. This is particularly important with self-supported rotary pressure joints that are used for paper dryers. General installation guidelines are provided. These guidelines cover rotary joint mounting, anti-rotation rod configurations, flexible hose configurations, flexible hose selection, and piping installation work. Each of the guidelines can be ignored to some degree and acceptable service life may still be achieved. The loss in service life from not following the guidelines, however, is progressive. As more of the guidelines are ignored, the service life becomes shorter. Breaking all of the rules by a large amount will invariably result in poor service life and potentially lead to catastrophic failures.
INTRODUCTION

This white paper presents the basic principles for installing self-supported rotary joints on steam-heated dryers. While the topics presented are applicable to various types of steam-heated cylinders and rotary joints, the paper focuses on self-supported rotary pressure joints used in the paper industry. General guidelines are provided for achieving long service life both for rotary joints and for the adjacent flexible hoses. These guidelines are not rigid rules. Each of the guidelines can be disregarded to some degree and acceptable service life may still be achieved. Indeed, very few commercial installations follow all of these guidelines exactly. The loss in service life from not following the guidelines is often progressive. As more of the guidelines are ignored, the service life becomes shorter and shorter. Breaking all of the rules by a large amount will invariably result in poor service life and potentially lead to catastrophic failures. As a result, although the guidelines are not considered absolutes, they do form the best recommendations for the best installation and the best possible service life.

Definitions

1. Rotary joint: A device that provides a seal between a stationary pipe and a rotating drum, cylinder, or vessel, allowing a fluid to flow into and/or out of the rotating part.
2. Pressure joint: A rotary joint in which an internal seal ring carries the entire force created by the internal fluid pressure tending to push the stationary body against the rotary joint nipple.
3. Flexible hose: A hose that is designed to hold the steam pressure and provide some flexibility in the position of the rotary joint. Rigid metal pipes, by contrast, are not designed to flex in response to movement of the rotary joints.
4. Open gear: Refers to type of dryer drive configuration in which the gears connecting adjacent paper dryers are in the open and not enclosed in cast iron gear cases.
5. Closed gear: Refers to a type of dryer drive configuration in which the gears connecting adjacent paper dryers are enclosed in cast iron gear cases which also hold the dryer bearings that support the drying cylinders.

Safety Precautions

The installation, maintenance, adjustment, and operation of rotary joints on paper machine dryer sections and related equipment should only be performed by properly trained personnel. Such work should be done in strict compliance with mill safety and machine operating guidelines as well as lockout/tag out procedures as they apply.

When working around steam piping, particular attention should be given to the potential for contact with steam leaks and hot uninsulated surfaces. Burn hazards can exist even with insulated surfaces, as hot condensate can drip from piping leaks and very hot surfaces may be exposed in areas adjacent to insulation.
Paper machine dryers are heated by steam from the inside. Steam enters the dryer through a rotary joint then through a hollow dryer journal. The condensed steam ("condensate") leaves the dryer through an internal syphon, passing through the dryer journal and then the rotary joint. The rotary joints used on paper dryers can be either single flow joints (one rotary joint for the steam supply and another rotary joint for the condensate drainage) or dual flow joints (one rotary joint with two passages – one for the steam and the other for the condensate).

A cross-section of a typical paper dryer is shown in Figure 1. This dryer is shown with a single-flow, self-supported rotary joint.

Figure 1. Paper dryer with single-flow rotary joint.
TYPES OF ROTARY JOINTS

The two types of rotary joints used on paper machine dryers are *externally-supported* rotary joints and *self-supported* rotary joints.

Externally-supported rotary joints rely on external stationary framing to support the body (housing) of the rotary joint. The external support can be a pair of rods connected either to the dryer support frame or to a floor-mounted support stand. The external support can also be a shelf bracket, either overhung, side-hung, or underhung, from the dryer support frame. The external support can also be a ring bracket rigidly attached to the dryer bearing housing cover. This is often the preferred mounting arrangement for externally-supported rotary joints. Examples of these external supports are shown in the following figures.

![Figure 2. Rotary joint body supported by two support rods.](image)

![Figure 3. Rotary joint body supported by overhung bracket](image)
Self-supported rotary joints are directly and rigidly attached to the end of the dryer journal via the rotary joint nipple. The rotary joint is supported using either roller bearings or carbon graphite support bushings installed around the nipple. Most self-supported rotary joints used in paper drying have carbon graphite support bushings. In these rotary joints, and in most externally-supported rotary joints using
support rods, all of the axial pressure force pushing the body against the nipple is carried through the seal ring. These self-supported rotary joints are called “pressure joints.”

Self-supported joints are commonly used in applications where there is no suitable external support frame. A common application is a dryer section with open gears connecting adjacent dryers. These open gears are normally located on the outboard side of the dryer bearing housings, preventing the dryer bearing housings or dryer framing from being used to support the rotary joint.

Figure 6 shows an example of self-supported rotary joints attached to the ends of the dryer journals of an open gear dryer section.

![Self-supported rotary joint on an open gear dryer section.](image)

Self-supported joints require more care to install than externally-supported rotary joints. Further, the operating life of a self-supported rotary joint and the connecting flexible metal hoses is more dependent on the piping configuration and the quality of the installation relative to externally-supported rotary joints. Figure 7 shows piping strains, improper torque restraint, and rotary joint misalignment are the most common causes of low service life of conventional self-supported rotary joints.
Figure 7. Common causes of poor rotary pressure joint life.

This highlights the need for careful attention to installation details: Flexible hose design, torque restraint design, and rotary joint alignment.

GENERAL INSTALLATION PRINCIPLES FOR SELF-SUPPORTING ROTARY JOINTS

The operating reliability of a self-supported rotary joint depends on the quality of the rotary joint installation. It is important the centerline of the rotary joint nipple be concentric and coaxial with the centerline of the rotating dryer journal. If there is any eccentricity, the joint will exhibit run-out when it is placed into service. This run-out, as discussed later in this paper, puts extra stress on the internal support bushings (carbon graphite “guides”) or bearings as well as the flexible metal hoses and associated piping. Proper flex hoses and torque restraints minimize the detrimental effects that are caused by rotary joint runout.
Suitable concentricity is generally achieved by having a close tolerance pocket or “counterbore” that mates with the end of the nipple of the rotary joint. This counterbore may be machined directly into the end of the dryer journal or be machined into a separate journal adaptor flange which is in turn bolted to the end of the dryer journal.

In the latter case, it is important the journal adaptor flange also be concentric with the centerline of the rotating dryer journal. If there is any eccentricity with the journal adaptor flange, the eccentricity will result in radial run-out of the rotary joint nipple when the rotary joint is mounted to that flange. Suitable concentricity of the journal adaptor flange can be achieved by having a close tolerance pilot fit, either an outside diameter pilot or an inside diameter pilot. Either one can help keep the centerline of the counterbore concentric to the centerline of the dryer journal.

Concentricity, however, is not enough. The axis of rotation of the rotary joint must also be coaxial with the axis of rotation of the dryer journal. If these two axes are not both concentric and coaxial, the rotary joint will not only have radial run-out, but also have axial run-out (“wobble”). Both radial run-out and axial run-out are detrimental to the service life of the rotary joint and the adjacent flexible hoses.

Although concentricity can often be achieved with suitable pilot fits, a proper coaxial fit depends heavily on the quality of the mating parts and the quality of the installation.

Specifically:

- The end of the dryer journal must be flat and perpendicular to the axis of rotation of the dryer journal.
- The gasket surface between the end of the dryer journal and the journal adaptor flange must be clean and free of any burrs, remaining gasket material, or other debris.
- The gasket between the journal and the adaptor flange must have uniform and predictable compression.
- The gasket must remain rigid under compression and not “creep” and allow the flange to loosen over time.
- The journal adaptor flange fasteners must be tightened progressively and tightened evenly in a star pattern.
- The fasteners must be properly lubricated and tightened to the recommended torque specification.
- Fasteners must have sufficient thread engagement to hold the journal adaptor flange in place.
- The tapped holes in the end of the dryer journal must be clean and have sufficient depth for the fasteners.
- The pilot diameters must provide sufficient clearance to facilitate assembly without allowing significant radial offset.

Once the mounting surface is prepared, the rotary joint can be installed on the dryer. The rotary joint nipple can be threaded into the end of the dryer journal or into the journal adaptor flange. Normally, the nipple thread is right-handed for dryers rotating in the counter-clockwise direction and left-handed for dryers rotating in the clockwise direction. This helps to prevent the nipple from backing out of its threaded connection.

The rotary joint nipple can also be mounted to the end of the dryer journal or the journal adaptor flange using a quick-connect flange (“Q-flange”). The Q-flange mounting can be used on dryers rotating in either the clockwise or the counter-clockwise direction. Although the Q-flange is generally easier to install than a threaded connection, careful attention must still be given to how the Q-flange is tightened. The Q-flange nuts must be properly lubricated, tightened progressively, tightened evenly in a star pattern, and tightened to the recommended torque specification. The gap between the Q-flange and the journal adaptor flange should be checked with an appropriate feeler gauge to confirm the gap is uniform, as shown in Figure 9.

![Figure 9. Rotary joint with a quick-release Q-flange.](image)

Once the rotary joint is mounted to the dryer journal, run-out can be checked by rotating the dryer. In most cases, however, this will not be practical. Correspondingly, a successful installation normally is achieved by careful attention to the installation procedures and not based on a system of subsequent quality measurements.
Because there is no external support for a self-supported rotary joint, some provision must be made to keep the rotary joint body from rotating. These provisions are called “torque restraint” or “anti-torque” or “anti-rotation” devices. A common torque restraint is a stiff smooth rod that extends from a special bracket or lug hole on the body or head of the rotary joint to a stationary external surface. In some cases, the “torque rod” will extend from one rotary joint to an adjacent rotary joint, as shown in Figure 10, thereby preventing the bodies of both joints from rotating and putting stress on the flexible hoses. A torque rod should not pass through the lug holes of more than two rotary joints.

A torque rod can be used to restrain a single rotary joint. In this case, the torque rod should be fastened to the lug hole and allowed to float along a rigid frame that prevents rotation of the rotary joint, but allows the rotary joint to move away from the machine. The torque rod should be located to the right on rotary joints that turn clockwise and on the left on rotary joints that turn counterclockwise, as shown in Figure 11. If the rotary joint runs temporarily in reverse, the torque rod should be located in a slot that prevents rotation in either direction, as shown in the same figure.
Figure 11. Torque rod restraint for clockwise rotation (top) and counterclockwise rotation (bottom).

The rods must be sufficiently rigid (sufficiently large in diameter) so they do not bend or allow the rotary joint body to rotate. The rods can be heavy wall pipe, but are ideally solid steel rods. All-thread rods are not recommended, because they can act as files and damage the lug holes. The lug holes in the rotary joint body should be in good condition and provide a tight fit to the torque rod. Rotary joint bodies with worn lug holes should be replaced. The rotary joint manufacturer should be consulted for the recommended size of the torque rod. The values in the table in Figure 12 provide an approximate guide.

<table>
<thead>
<tr>
<th>Rotary Joint Size</th>
<th>Typical Anti-Rotation Rod Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sch. 80 Pipe</td>
</tr>
<tr>
<td>1-1/4&quot;</td>
<td>1/4&quot;</td>
</tr>
<tr>
<td>1-1/2&quot;</td>
<td>1/4&quot;</td>
</tr>
<tr>
<td>2&quot;</td>
<td>1/4&quot;</td>
</tr>
<tr>
<td>2-1/2&quot;</td>
<td>1/2&quot;</td>
</tr>
<tr>
<td>3&quot;</td>
<td>3/4&quot;</td>
</tr>
<tr>
<td>3-1/2&quot;</td>
<td>3/4&quot;</td>
</tr>
<tr>
<td>4&quot;</td>
<td>1-1/4&quot;</td>
</tr>
<tr>
<td>5&quot;</td>
<td>1-1/2&quot;</td>
</tr>
</tbody>
</table>

Figure 12. Anti-rotation rod size.

Even with careful installation, there will still be some amount of rotary joint radial run-out and axial run-out. Further, as the seal ring wears, the body of a pressure joint will start to move away from the dryer. The torque rod must be able to prevent the body from rotating, but not inhibit the movement of the body in an axial or radial direction.
Figure 13 shows a torque rod extending from one rotary joint to another. Note the torque rod prevents the rotary joint body from rotating, but it does not restrict its motion in the axial and radial directions. This accommodates rotary joint radial run-out and axial run-out. It also accommodates seal ring wear and any axial movement of the drying cylinder. Equally important, it prevents the rotary joint body from twisting the adjacent flexible hoses and applying excessive loads on them. Flexible hoses, particularly those that are small in diameter and very flexible, are unable to withstand twisting forces. The hoses will bend, kink, stretch, fatigue, and ultimately break if there is inadequate torque restraint on the rotary joint.

The torque rod should be of sufficient length to maintain proper orientation of the flexible hose connections as the rotary joint moves through the entire range of motion that results from the radial and axial run-out. The reaction force that is applied by the torque rod to the slotted bracket will be inversely proportional to the distance from the slotted bracket to the rotary joint centerline. Good service life in typical paper dryer applications is obtained with approximately 2 to 3 feet between the rotary joint centerline and the slotted bracket.

The slotted bracket should provide substantial contact area for the torque rod to rest against. A narrow contact area will allow the torque rod to wear into the bracket and potentially restrict the relative motion
The operating reliability of a self-supported rotary joint depends not only on the quality of the rotary joint and its installation and torque restraint, but also on the quality of the piping design, the flexible hose, and their installation. As previously noted, even with careful installation procedures, there will be some amount of eccentricity and non-coaxiality between the dryer journal axis and the rotary joint nipple axis. Further, as the internal seal ring wears, the body of a self-supported rotary joint will slowly move away from the dryer journal. The piping that connects the steam and condensate lines to the rotary joint must be able to accommodate all of these movements.

Flexible metal hoses are used to provide this accommodation. Flexible hoses consist of two rigid ends (each either flanged or threaded) and a convoluted (“corrugated”) metal hose with a metal braiding to help carry the pressure load. Typical flexible metal hoses are shown in Figure 14.

The top hose in this figure has two flanges. Typically, one of these two flanges would be fixed (it does not rotate with respect to the hose) and the other flange would be a loose “lap” flange (the flange is free to rotate around the stub end of the flexible hose to align the bolt holes). The lap flange allows the two flanges to be connected to the adjacent flanges without twisting the flexible hose.

The bottom hose in this figure has two threaded ends. Threaded ends can be directly connected to conventional threaded pipe fittings. Threaded hoses are suitable for most paper dryer steam and condensate applications.

The hose in the middle has one threaded end and one flanged end (a lap flange).

The selection of the hose configuration often depends on whether the connections on the rotary joint are flanged or threaded and whether the adjacent piping has flanged or threaded connections.
Although flexible metal hose is very common, there are a number of important criteria requiring selection:

- **Size**: The flexible hose must have a sufficient diameter to accommodate the required flow rates.
- **Rating**: The flexible hose must have sufficient pressure rating to meet the application conditions.
- **Length**: The flexible hose must be long enough to accommodate the rotary joint movement.
- **Construction**: The flexible hose must be durable under the actual operating conditions.
- **Flexibility**: The flexible hose must have sufficient flexibility to handle the rotary joint misalignment.
- **Configuration**: The flexible hose may be compound (two hoses at a 90° angle) or looped (single length).
- **Orientation**: The flexible hose should not leave a “trap” for condensate to accumulate.
- **Installation**: The flexible hose should be installed with minimum residual stresses. That is, they should not be compressed, stretched, bent, or twisted when they are being installed.
- **Corrosion and Erosion Resistance**: The flexible hose materials should be selected to ensure corrosion and erosion resistance for steam and condensate service.
- **Fatigue Resistance**: The flexible hose materials and manufacturing standards must be suitable to withstand the cyclic loading that results from rotary joint run-out.

All of these criteria are important and all of them are interrelated when it comes to service life. A large diameter hose, for example, will not be as flexible as a smaller diameter hose, but can accommodate equal misalignment if it is long enough. Correspondingly, a compound hose is normally the best configuration, but a single long hose may have enough flexibility that a compound hose is not required.
The selection of the diameter of a flexible metal hose depends first of all on the flow requirements. The pressure drop through a flexible metal hose can be 2 to 4 times higher than the flow through a similar size pipe. The velocities through a flexible hose should be kept low to avoid excessive pressure drop. The guideline for flow velocity depends on the fluid. Higher velocities are acceptable for dry steam flow. Further, higher velocities are allowable when the steam pressure is low. The guidelines for velocities for dry steam flow are:

<table>
<thead>
<tr>
<th>Steam pressure (psig)</th>
<th>Recommended velocity (fpm)</th>
<th>Maximum velocity (fpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 25</td>
<td>5,000</td>
<td>12,000</td>
</tr>
<tr>
<td>25 to 90</td>
<td>4,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Over 90</td>
<td>3,000</td>
<td>8,000</td>
</tr>
</tbody>
</table>

The velocities must be lower when sizing for condensate flow. For the bi-phase flow of steam and condensate, the maximum allowable velocity is significantly lower than the limits for dry steam flow because of the higher density of the mixture and the propensity for hose and piping erosion. The recommended flow velocity for a bi-phase mixture is 2,000 fpm. The maximum velocity is 4,000 fpm.

These flow velocities should be reduced by up to 50% if the flexible hose has a 90° bend (less reduction for a lesser bend angle). Flexible metal hose diameters may be increased to match the connection size of the rotary joint or the supply and drain piping, but should not be decreased in size.

The pressure rating of flexible metal hose depends on the hose material, braiding construction, and connection configurations. Maximum allowable pressure ratings are supplied by the flexible hose manufacturer and it is typically 25% or less of the expected burst pressure. In general, flexible metal hoses used for paper dryer applications should not have service ratings less than 150 psig. Note the pressure rating of a flanged flexible hose is typically limited by the rating of the flange. The pressure rating of a flexible hose with threaded ends depends on the size of the hose and the temperature of the steam. Flexible hose ratings are shown in Figure 15 for a common commercial 401M stainless steel convolute, single-braided flexible hose configuration.
The recommended length of a flexible metal hose depends on the amount of movement the hose must accommodate, the configuration of the hose, the expected hose offset, and the expected static and intermittent bend radii. The recommended length also depends on the flexibility of the hose which in turn depends on the hose diameter, material, braiding construction, and connection configurations. There is an infinite number of such combinations. It is impossible to map out the impact of each interdependent factor.

However, for a typical hose configuration that follows normal best practices, Figure 16 is a reasonable guide for the minimum recommended lengths for common flexible metal hoses:

<table>
<thead>
<tr>
<th>Hose Size</th>
<th>Minimum Length, inch</th>
<th>Static Bend Radius, inch</th>
<th>Intermittent Bend Radius, Inch</th>
<th>Maximum Hose Offset, inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot;</td>
<td>10</td>
<td>1.50</td>
<td>6</td>
<td>1.50</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>12</td>
<td>2.12</td>
<td>8</td>
<td>0.94</td>
</tr>
<tr>
<td>1&quot;</td>
<td>15</td>
<td>2.75</td>
<td>9</td>
<td>1.63</td>
</tr>
<tr>
<td>1-1/4&quot;</td>
<td>18</td>
<td>3.25</td>
<td>10</td>
<td>2.13</td>
</tr>
<tr>
<td>1-1/2&quot;</td>
<td>18</td>
<td>3.75</td>
<td>12</td>
<td>1.94</td>
</tr>
<tr>
<td>2&quot;</td>
<td>21</td>
<td>5.00</td>
<td>15</td>
<td>2.13</td>
</tr>
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<td>7.00</td>
<td>14</td>
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<td>17</td>
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<td>16.50</td>
<td>33</td>
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</tr>
<tr>
<td>8&quot;</td>
<td>36</td>
<td>21.50</td>
<td>43</td>
<td>2.44</td>
</tr>
</tbody>
</table>

For fluid temperatures less than 400 °F

Figure 15. Flexible hose pressure ratings.

Figure 16. Minimum recommended lengths for common flexible metal hoses.
The various flexible hose parameters are shown in Figure 17. The overall hose length is shown as “X”. The active hose length is shown as “L”. The offset is shown as “Y”. And the bend radius is shown as “R”.

There is a wide range of construction options for flexible metal hose. Two typical hose materials are brass and stainless steel. Stainless steel hose is the most common today for paper dryer applications. The hose convolute (corrugation) shape can also vary. Some convolute construction have more flexibility and higher pressure ratings than others. The metal braiding can also vary. Some hoses have single braiding while others have multiple layers of braiding. The hose braiding not only increases the pressure rating, but it also limits the amount of elastic elongation under pressure. As noted previously, the type of end fittings includes fixed flanges, loose flanges, and threaded ends. Flexible metal hose can also be supplied with a Teflon liner. A Teflon lined hose is more flexible, the Teflon liner minimizes the flow resistance, and the hose is less susceptible to erosion. It cannot, however, restrain the rotation of the rotary joint. Proper anti-rotation rods (“torque rods”) are still required for this.

Figure 17. Active hose length, bend radius, and offset parameters.

FLEXIBLE HOSE CONSTRUCTION
There are also many possible configurations of flexible hose. Some of these configurations are better than others when used with rotary joints. The best configurations can be identified by the following best practices:

- Flexible hoses are connected directly to the rotary joints, without intermediate pipes, fittings, and unions.
- Adjacent rigid piping is supported independently of the rotary joint.
- The primary mode of flexible hose motion is bending (not stretching, compressing, or twisting).
- The flexible hose does not bend more than its rated minimum bend radius.
- The flexible hose does not push or pull on the rotary joint over the full range of motion that results from rotary joint run-out.
- The configuration has two flexible hoses with a 90° elbow in between them (“compound hose configuration”).
  - The vertical hose allows for horizontal motion.
  - The horizontal hose allows for vertical motion.
- Dual flow joints have the flexible hose connections on opposite sides of the rotary joint body, to minimize hydraulic loading on the joints.

The best configuration for paper dryer applications consists of two flexible metal hoses with a 90° elbow between them. An example of these “compound” hoses is shown in Figure 18 for two single-flow joints. Note that neither of the two hoses in this compound hose configuration are pushing or pulling on the rotary joint. All of the horizontal, vertical, and axial motion of the rotary joint is accommodated by simple bending of the two flexible hoses.

![Figure 18. Compound flexible metal hose with single-flow rotary joints.](image-url)
Two examples of compound hoses are shown in Figure 19 for dual-flow joints. In the first figure, the supply header is above the rotary joint and the condensate (drain) header is below the rotary joint. This is ideal. In the other figure, the supply and the drain headers are both above the rotary joint. This can also work, but condensate does not drain from the rotary joint when the machine is shut down. As with the compound hoses shown above for the single flow rotary joint, neither of the compound hoses in these dual-flow applications are pushing or pulling on the rotary joint. All of the vertical, horizontal, and axial motion of the rotary joint is accommodated by simple bending of the two flexible hoses.

Another option for flexible hose configuration is to supply one flexible hose for each connection, but configure the hose with a large bend, as shown in Figure 20. In the three examples, each for single-flow rotary joints, the flexible hose is installed with a loop rather than two straight runs. When properly configured, the single-loop flexible hose allows for rotary joint radial run-out, axial run-out, seal ring wear, and header movements, all with the bend radius remaining above the minimum amount for the particular hose diameter, length, and construction.
Another example of a bent-hose configuration is shown in Figure 21, this one for a dual-flow rotary joint. The single-loop hose configuration is shown next to a compound hose configuration for comparison. Note the single flexible hose also allows for rotary joint and header movements. This configuration, however, requires longer active hose lengths and a hose construction that can comfortably provide the required minimum bend radius.

![Diagram of Dual-flow rotary joint with flexible metal hose installed using a large bend.](image)

Figure 21. Dual-flow rotary joint with flexible metal hose installed using a large bend.

The hose rating, flexibility, fatigue strength, and service life depend on the hose construction and can be quite varied among the manufacturers of flexible hoses. Many factors affect rotary joint and flexible hose life and each configuration and construction decision will have an interactive and cumulative effect. The rotary joint and flexible hose suppliers should be involved in discussions of the myriad of options.
REFERENCES

There are a number of problems that can shorten the operating life of self-supported rotary joints and flexible hoses. These include inadequate installation, poor piping design, and improper maintenance. The table below was prepared to assist with troubleshooting common problems.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible causes</th>
</tr>
</thead>
</table>
| Rotary joint radial run-out (Joint axis is not concentric with the journal axis) | • Journal adaptor flange does not have a pilot fit on the journal  
• Journal adaptor flange OD pilot is loose  
• Journal adaptor flange ID pilot is loose  
• Journal adaptor flange OD pilot fit does not extend beyond chamfer  
• Journal adaptor flange does not have a concentric nipple fit  
• Rotary joint nipple is too small for the adaptor flange counterbore |
| Rotary joint axial run-out (Joint axis is not co-axial with the journal axis) | • End of dryer journal is not square to the journal axis  
• Journal - adaptor flange gasket surface is not clean  
• Q-flange was not tightened evenly (star-pattern, progressive torque, require torque values)  
• Rotary joint nipple is bent (not likely)  
• Rotary joint guide bushings are heavily worn |
| Rotary joint nipple failures | • Run-out exceeds hose movement capability  
• Improper torque restraints  
• Rotary joint installed without flexible metal hoses  
• Flexible hose applying excessive force to the rotary joint  
• Header weight is being supported by the rotary joint  
• Rotary joint nipple material does not meet specifications  
• Rotary joint nipple wall is not thick enough  
• Rotary joint guides are worn allowing the body to cut the nipple |
<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible causes</th>
</tr>
</thead>
</table>
| Flexible hose failures | • Flexible hose is too stiff  
• Flexible hose is too short  
• Flexible hose rating is too low  
• Defective flexible hose  
• Flexible hose was installed in tension  
• Flexible hose was installed in compression  
• Excessive rotary joint radial run-out  
• Excessive rotary joint axial run-out  
• Torque rod is too flexible, too short, or bent  
• Torque rod clearance is too large inside the torque lug  
• Torque rod and/or torque lug are worn  
• Above are aggravated by high dryer speed (rpm)  
• Above are aggravated by high operating steam pressure |
| Rapid rotary joint carbon graphite guide wear | • Flexible hose is too stiff  
• Flexible hose is too short and pulls on the rotary joint  
• Flexible hose is too long and pushes on the rotary joint  
• Excessive rotary joint radial run-out  
• Excessive rotary joint axial run-out  
• Improper torque restraint  
• Excessively superheated steam |
| Rapid rotary joint carbon graphite seal wear | • Unqualified seal ring material  
• Incorrect rotary joint for the machine speed and pressure  
• Carbon support guides are worn  
• Rotary joint is repaired with worn or unqualified parts  
• Excessive steam temperature (dry, superheated steam)  
• Seal loading spring is too stiff  
• Torque rod limits movement of the joint body |
| Rotary joint flange and Q-flange failures (cracking, bolts breaking, bolts loosenning) | • Flexible hose is too stiff  
• Flexible hose is too short  
• Flexible hose was installed in tension  
• Flexible hose was installed in compression  
• Excessive rotary joint run-out  
• Excessive rotary joint wobble  
• Torque rod is too flexible  
• Torque rod and torque lug are worn  
• Bolts do not have correct rating  
• Bolts are not long enough  
• Tapped holes are not deep enough  
• Incorrect gaskets, relaxation of the gasket material  
• Bolts not correctly tightened |
Kadant Johnson is a global leader in the design, manufacture, and service of dryer drainage systems, rotary joints, syphon systems, and related equipment for the dryer section of the paper machine. For more information about Kadant Johnson products and services, email info@kadant.com or visit www.kadant.com.

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