FLUID SEALING ASSOCIATION FSA

From the voice of the fluid sealing industry

SEALING SENSE

5th Anniversary

How do expansion joints improve performance of mechanical seals?

This month's *Sealing Sense* was contributed by FSA Members Marty Rogin and Jim Richter.

The March 2009 *Sealing Sense* concluded that pipe strain can cause failure of the packing or mechanical seal since they are both sensitive to misalignments introduced by pipe strain. A further study in the same article found that up to 70 percent of pump failures could be attributed to excessive strain on pump casings. Unacceptable strain was defined in the study as any forces from the pipe that will cause equipment deformation of more than 0.002 in.

This article will examine the stresses and forces induced by thermal strain on pump systems and provide guidance on relieving these potentially damaging loads.

Assembly Procedure—Then & Now

Long ago, it was normal for pipefitters to assemble pump and pipe manifolds on the jobsite. First, the pump would be set in place. Then, the pipe and fittings would organically "grow" from the pump as pieces were added. Everything around the pump fit together, and *free bolting* was common. (Free bolting is where flange bolts slide into place with no interference, in accordance with ANSI/ASME B31.3)

Today, to save time and money, a great deal of piping is prefabricated offsite. The assembled piping is installed at the pump, and any misalignment is accepted. Unfortunately, this means that most fitters' toolboxes contain a set of drift pins and the ever popular *come-a-long*. When bearing or seal failures occur more often than expected, it can be an indication that these tools were used.

Thermal Effects of Connected Pipe

The effects of misalignment are compounded if the system is subjected to a change in temperature without accommodating for pipe movement. The consequent stresses and bending moments can easily exceed pump manufacturers' allowable limits.

Consider the simple piping arrangement in Figure 1. The pump is directly connected to straight, anchored pipe sections. Straight pipe sections can generate tremendous axial reaction forces when subjected to temperature changes. Pipe anchors can be designed to accommodate these loads, but pump components, while functioning as anchors, cannot handle this loading.

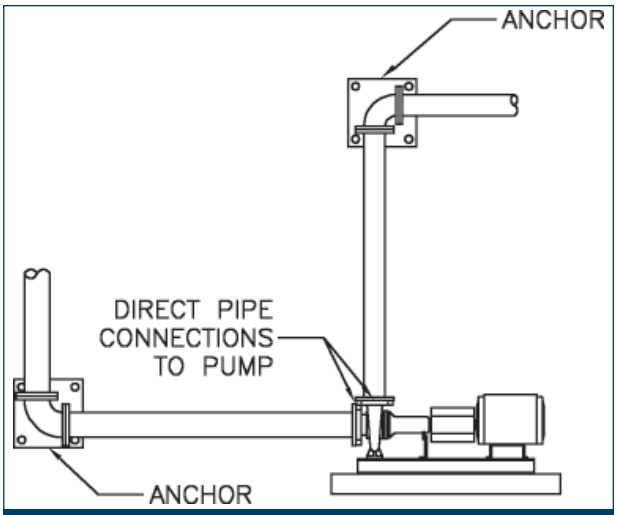

Figure 1. Problem Piping Arrangement

Table 1 summarizes the stresses and resulting reaction forces in a straight piece of schedule 40 carbon steel pipe subjected to a 100 deg F temperature rise. The pipe is assumed to be 10 ft long.

Note there are only axial reaction forces at the pipe ends. No reaction moments are generated due to the geometry of the pipe layout. There are also reactions due to the weight of the pipe and fluid. These forces, while not negligible, are normally much less than the forces due to thermal expansion and are ignored in this example.

If a flange connection leaks after a few on-off cycles, these reaction loads could be crushing the gasket and causing the leak.

Rubber Expansion Joints to the Rescue

The terms rubber expansion joints and flexible pipe connectors are often used interchangeably. While they are both

Table 1.
Pipe Reaction Forces

NPS	Force (lb)
4	55,252
5	74,850
6	97,157
8	146,210
10	207,293
12	274,074
14	324,851

effectively *flexible connectors*, there is a distinction between the two devices. Expansion joints are usually designed with arches to allow for compression, extension, offset and angular movement. A flexible pipe connector is a straight rubber pipe primarily designed to absorb noise and vibration in a piping system.

Although expansion joints introduce another set of design considerations, mostly a pressure thrust component, the expansion joint will absorb almost all of the reaction force.

If expansion joints are added to the piping, the pipes are allowed to expand with little resistance. The forces on the pump casing are now due to the pressure across the largest area of the connector (pressure thrust) and the spring force of the elastic expansion joint. The spring force is normally much less than the pressure force.

Table 2 summarizes the reaction forces generated by an expansion joint in the same piping arrangement shown in Figure 1.

For a given pipe size, the reaction force generated by a rubber expansion joint is significantly less than a direct-piped installation. Isolating the pump from the piping with a rubber expansion joint prevents damage from thermal movement as well as absorbs noise and vibration.

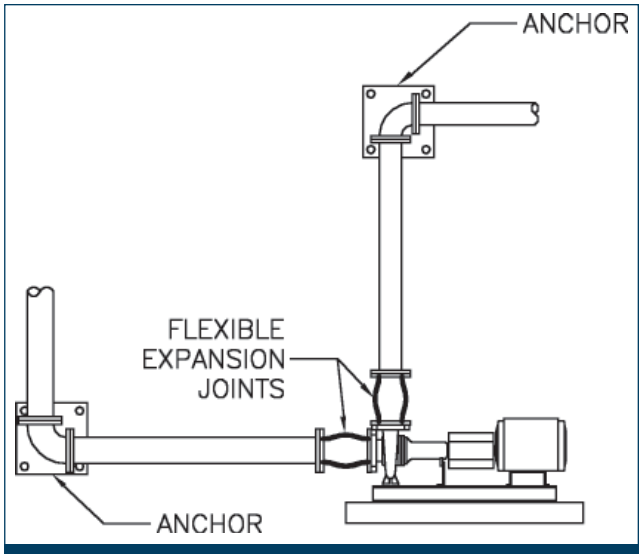

Figure 2. Better piping arrangement

Design Considerations

Application of rubber expansion joints also presents a challenge. When the joint is pressurized, it wants to expand in diameter. Fabric coupled with metal reinforcing when required minimizes this phenomenon. It also wants to elongate. If the joint is not restrained in the axial plane, control rods should be

Fluid Sealing Association

Sealing Sense is produced by the **Fluid Sealing Association** as part of our commitment to industry consensus technical education for pump users, contractors, distributors, OEMs and reps. As a source of technical information on sealing systems and devices, and in cooperation with the **European Sealing Association**, the FSA also supports development of harmonized standards in all areas of fluid sealing technology. The education is provided in the public interest to enable a balanced assessment of the most effective solutions to pump systems technology issues on rational Total Life Cycle Cost principles.

The **Piping Systems Non-Metallic Expansion Joint** division of the FSA is one of six with a specific product technology focus. As part of their mission they develop publications such as the newly revised seventh edition *Technical Handbook Non-Metallic Expansion Joints and Flexible Pipe Connectors* and the *Non-Metallic Piping Expansion Joint Installation Guide*. The former provides construction, installation and application details while the latter is a "hands-on" simplified guide for maintenance operators and engineers. Both are primers intended to complement manufacturer's documents produced by the member companies. In addition, standards such as *FSA-NMEJ-701-06 Non-Metallic Expansion Joint Hydrotesting and Vacuum Testing, FSA-NMEJ-702-98 Rubber Flanged Non-Metallic Expansion Joint Installation, Maintenance, and Storage*, and *FSA-NMEJ-703-99 Specifications of Elastomers Used in Piping Systems Non-Metallic Expansion Joints* have been developed in response to important user issues.

The following members of the **Piping Systems Non-Metallic Expansion Joint** sponsor this *Sealing Sense*:

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Table 2. Pipe Reaction Forces—Expansion Joint

Pipe Diameter (NPS)	Pressure (psi)	Expansion Joint Effective Area (sq in)	Pressure Force (lb)	Thermal Expansion (in)	Spring Rate (lb/in)	Spring Force (lb)	Total Joint Force (lb)
4	100	20	2000	0.076	812	62	2062
5	100	32	3200	0.076	1312	100	3300
6	100	43	4300	0.076	1336	101	4401
8	100	66	6600	0.076	1728	131	6731
10	100	101	10100	0.076	1426	108	10208
12	100	154	15400	0.076	1826	139	15539
14	100	179	17900	0.076	1950	148	18048

added to prevent this expansion.

Expansion joints should be on both the suction and discharge sides of the pump to isolate the pump properly. Expansion joint manufacturers can provide guidance on selection and installation.

Conclusion

A pump installed with flexible rubber expansion joints will be subject to lower thermally induced pipe stresses and will be acoustically and dynamically isolated from the piping system. The system will last longer and require less maintenance than an arrangement that is not isolated.

Next Month: *What are M & Y gasket design constants, and how are they used?*

We invite your questions on sealing issues and will provide best efforts answers based on FSA publications. Please direct your questions to: sealingsensequestions@fluidsealing.com.

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