KNIGHTHAWK TECH NOTES

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" Pipe Stress Loads on Rotating and Static Equipment – The Nozzles Don't Always Fail But is it Costing you Money? "

When designing or maintaining Petrochemical, Pulp & Paper, and Power Equipment, pipe stress is most always a consideration and the ASME Code governs it. However, to a great extent it is unknown what the range of problems associated with pipe stress issues really are. What should be included in a pipe stress analysis and the "real world" details that affect the results is also not well understood. Issues and seminars are available to address pipe stress and discuss the Code; however in many cases the details that are present in production that effect the design are not often discussed. Seeing and experiencing the real world makes a difference.

Many entities have rules of thumb governing when pipe stress should be performed on a particular project. They might say, "An evaluation below 250 °F or below 3 inch nominal diameter is not required to perform a pipe flexibility analysis for non lethal services". While these statements are meaningful and have good intentions, they can allow problems to go undetected. A good example follows. Several years ago, we worked on a problem concerning a maintenance issue with some water circulation pumps. Very frequently, the pumps would misalign and vibration would start, this can severely damage a pump. Another example would be if the temperature was only 180 °F and the pressure was only 100 psi, you would not expect pipe stress to be a problem. But because the pipe was 48 inches in diameter and it was close-coupled to the pumps, there was no room for any thermal expansion. The large pipes simply pushed the pumps around, causing failure and downtime.

A good analysis is fine, but what if the installation in the field is not correct? One "famous" case in the business occurred after all inlet high temperature pump lines were analyzed, constructed, and put into service. Pipe supports failed and pumps were misaligned, and overall some interesting challenges occurred. The solution to fix the problems was simple, the "locking pins" on spring hangers that were left in after construction needed to be removed. Whoops!!

Then there were other cases where things were not so easy to see. In some systems, under transient conditions, hot streams can meet colder steams causing low cycle thermal fatigue. In another case a compressor train would work fine for months, however when a "blue northerner" or heavy rain would occur, heavy vibration was experienced that would sometimes shut the plant down. The problem was the temperature change would misalign the drive turbine enough to cause vibration.

One of our favorite "pets" during failure analysis is observing the disconnect between the pipe stress engineers and structural designers. Most often, a pipe stress engineer will incorporate all these theoretical restraints and anchors. Unless otherwise accounted for, the numerical model assumes a numerical value of "0" displacement at these points. Based on that "0" displacement; a load is calculated and given to Civil Engineering to design supports to meet design specifications. Here is where the disconnect begins. The structural engineers will then use that load but allow deflection. When the unit is installed in the real world, load transformation occurs where the loads may be higher on the equipment nozzles because the supports that were intended to have little displacement.

One lack of understanding in the business is that basically the normal design conditions should be evaluated only. The thought is that any weird or unusual stuff will just have to be taken care during operation and startup. Not always true! One example is acoustical analysis of piping systems. For example, it is known in the industry that reciprocating pumps and compressor can cause vibration in piping systems. Ignorance is not an excuse when these systems are installed and fail. The design does not meet Code if it is installed without an acoustical analysis. Another good example is pressure relief systems. In many cases, when a relief valve blows,, the transient pressure-momentum conditions cause a dynamic impulse that can break supports or damage equipment. These loads must be calculated and accounted for in the mechanical design.

The load cases that must be considered include but are not limited to the following:

1. Thermal
2. Pressure
3. Wind Load
4. Occasional loading
5. Earthquake
6. Miscellaneous conditions such as acoustical resonance, flow induced vibration, water hammer or steam hammer, etc.

The major problem with piping and its connection to rotating equipment is not that the pipe will break, but that the equipment nozzles will be overloaded. Again, the "compressor nozzle" most likely will not break, but sufficient deflection can be introduced to cause misalignment or internal "rubbing". The supports of critical systems should be analyzed with a finite element system to evaluate using the spring constants calculated for boundary conditions.

Well we cannot cover everything about piping in one article, but we recommend that a qualified pipe stress engineer should review every critical piping system in an industrial environment.

Please visit our website for a list of current projects.

Cliff's Notes:

KnightHawk has one of the best crews around to evaluate critical applications in pipe stress. We are a one stop shop and able to look at the "real world" details that will insure the safety and reliability of a critical system.

2009 has been a challenging year for many companies. I want to wish everyone a Merry Christmas and Happy New Year. May God Bless you and your family. We look forward to working with you in 2010.

Cliff Knight