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Pipe stress loads — Are they costing you money?

When designing or maintaining petrochemical, pulp and paper, and power equipment, pipe stress is most always a consideration. However, to a great extent it is not known what the range of problems associated with pipe stress issues really are. It is also not well understood what should be included in a pipe stress analysis. Many issues and seminars are available to address pipe stress, but unfortunately individuals who have never worked in a production facility conduct these analyses in many cases. 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 cause problems. A good example is as follows. Several years ago I worked on a problem concerning a maintenance issue with some water circulation pumps. Very frequently the pumps would misalign and vibration would start, sometimes the pumps would wreck. The temperature was only 180 F and the pressure was only 100 psi. Pipe stress should not be a problem right? Well, wrong. It was a pipe stress problem and it was simple: the pipe was 48 inches in diameter and it was close coupled to the pumps. There was no room for any thermal expansion, and the large pipes would simply push the pumps around, causing failure and downtime.

A good analysis is fine, but what if it is not installed right in the field? One "famous" case in the business was when all these high temperature lines were analyzed, constructed and put into service. Pipe supports failed. Pumps were misaligned and overall some interesting challenges occurred. Well, the solution to fix all the problems was simple; the "locking pins" that should have been removed after construction were left in. Whoops!

Then there are other cases where things are not so easy to see. In some systems, under transient conditions, hot streams can meet colder streams 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 changes would cause the drive turbine to move enough to cause vibration.

One lack of understanding in the business is that basically the normal design conditions should be evaluated only. Any weird or unusual stuff will just have to be taken care of during operation and start-up. Not always true! One example is acoustical analysis of piping systems. For example, it is known in industry that reciprocating pumps and compressors can cause vibration in piping systems. Ignorance is not an excuse when these systems are installed and fail. The design never met code if it was installed without an acoustical analysis. Another good example is pressure relief systems. In many cases, when a relief valve blows down 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, flow-induced vibration, waterhammer or steamhammer, etc.

The major problem with piping and its connection to rotating equipment is not that the pipe will break, but 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 "rubbing."

We can't cover everything about piping in one article, but it is recommended a qualified pipe stress engineer should review every critical piping system in an industrial environment.

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