KNIGHTHAWK TECH NOTES

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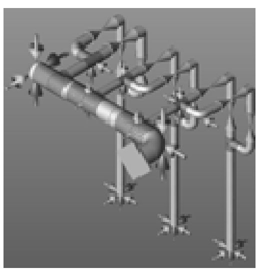
"Critical Pipe Stress "

Once again at your production facility operators have approached you about a 1600° F line where the pipe shoe has come off of the structural steel and jammed against a beam and caused a failure of the structural steel. Working in operations you have heard from the "old timers" that this happens every two or three years. As the production engineer in charge of the area, your main concern is the failure of the pipe or breech of process containment, as loss of hydrocarbon would be of great concern. When one of the operators was on coffee break you asked him to determine to his best recollection when this happened. After that you looked at historical run data and determined that this occurred most often when there were more shut downs. The next step was to talk to the plant engineering folks about the design. They said a pipe stress analysis had been run by the engineering contractor, that it was audited and everything and there are no pipe stress problems.



This is common in plant operations where piping experiences remarkable thermal growth and the piping system was analyzed by an elastic approach. The piping was experiencing what is called "thermal walking". When the plant was shutting down, the pipe would not return to the original position. When a subsequent thermal cycle was experienced the pipe would simply displace further. An elastic pipe stress analysis cannot take or determine a condition of thermal walking because "elastic" means it will return to its original position. "Thermal walking" in piping systems has led to failure of piping systems and has caused remarkable events at production facilities. The piping in question was operating in the elastic-plastic region. This means that the pipe was operating within the stress-rupture curves and with each thermal cycle it would experience permanent deformation. Such a system is deemed "critical pipe stress" because of the operating pressures and temperatures.

Such a problem is best analyzed using the finite element method (FEM) that considers the plastic deformation of the pipe. In years past this was unthinkable and considered too costly, but it is no longer the case with the advanced software and computer horsepower available today. Today pipe stress models can be created using FEM and accurate responses can be developed for critical pipe stress situations in a relatively short period of time. The other large advantage is that the FEM captures localized secondary stress in piping components that typical elastic based software does not consider. When using the FEM both a heat transfer and structural stress analysis is performed to obtain accurate results. The following steps are a methodology for tackling critical pipe stress.

1. Develop a process specification on what the operation and design conditions will be. This would include startup and shutdown operations.
2. Consult with materials engineers to determine the best material for the application that considers both reliability and economics.
3. Develop an elastic pipe stress model just to determine the overall layout required.
4. Execute an elastic-plastic model to consider the plasticity effects in the system.
5. Put in supports and limit stops to control any anticipated "thermal walking". This might involve putting in an entire floating system.
6. Refine the model to look at secondary stress points such at piping hardware attachments. Also consider welded joints where there is a change of material. This can be considered in the FEM as well.
7. Perform a detailed check and inspect the line after startup to insure that the line is behaving as anticipated.

As with any critical application make sure the design is supervised and approved by a professional engineer that is competent in this area of expertise.

Cliff's Notes: KnightHawk has performed some of the most complex critical pipe stress in the industry. This includes but is not limited to high temperature and high pressure systems operating in the stress-rupture regions. KnightHawk has performed such analysis for petrochemical, nuclear, offshore, and the Defense Advanced Research Projects Agency. We are your one stop shop when considering complex heat transfer effects, mechanical, and materials selection.

On a personal note our hearts and prayers go out to the Japanese people due to the earthquake, Tsunami, and Nuclear Plant challenges. If you cannot help directly, I urge you to donate to the Red Cross. We work for companies based in Tokyo and our hearts go out to all of them and those affected.

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KnightHawk Project Update

- Critical Pipe Stress – Petrochemical
- Bearing Fluid Flow Analysis – Subsea
- Gas Pipeline Coupling Failure – Oil & Gas
- Water Pump Failure Analysis – Nuclear
- Motor Thermal Analysis – Subsea
- Hydrolyzer Analysis – Petrochemical
- Centrifugal Compressor Failure Analysis – Petrochemical
- Gas Plant Explosion – Oil & Gas
- Deaerator Efficiency – Petrochemical
- Jacketed Reactor Vessel Design – Petrochemical
- Vessel Destructive Testing – Oil & Gas
- Critical Pipe Stress – Petrochemical
- Corrosion Analysis – Gas Pipeline
- Flare System Analysis – Petrochemical
- Reactor Failure Analysis – Petrochemical
- Balanced Torque Measurements – Power
- Oxidizer Redesign & Reconstruction – Petrochemical
- Creep Tensile Testing – Communications
- Gasifier Equipment Design – Power
- Pump Vibration Analysis – Petrochemical
- High Temperature Molten Salt Tank Design – Green Energy
- TLE Inlet Cone Design – Petrochemical
- Bearing Design – Heavy Manufacturing
- Vaporizer Design – Petrochemical
- Transient Fluid Dynamics – Petrochemical
- Waste Heat Boiler – Petrochemical