KNIGHTHAWK TECH NOTES

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"The Unlikely Structural Transient"

Your production facility is no different, than any other. It happened again and this time you are determined to get to the bottom of the problem. Structural piping and supports failed and operations may have to shut down due to risk. You are a maintenance engineer at a large petrochemical facility and the Maintenance Manager is on your back because operations are on his. This is the fourth time that this has come up this year. Every time you go out to the field all you find is broke parts, and everything is operating smoothly. Like any maintenance guy you take measurements and review all you can. Operations tell you that nothing has changed in the process, everything is the same. You have turned over every rock and all roads have led to a dead end.

How do you handle a problem like this? You feel the pressure and you have done everything that you can imagine. But, the job is just not getting done.

An approach to the problem may be as follows:

1. Select a root cause analysis team. For a problem like this, it should contain at least, but not necessarily limited to folks from engineering, maintenance, metallurgical, process, controls, and operations.

2. Historical Review: As was indicated earlier, the failure had occurred multiple times, but no evidence from the previous failure was kept because the shutdown was quick and the problem was fixed and everyone moved on. That means you use what you have and all you have is the recent failure parts. Discuss the failure with the operators. The operators believe that, in general all the failures were approximately the same. While the specifics of the failures were different, it involved broken supports and/or instrumentation.
3. Metallurgical and Materials Investigation: The first thing to do is to look at the evidence. That includes the broken pipe and supports. Send samples to a lab that can determine what type of fractures have occurred. Be careful to consider secondary consequential damage versus primary failure modes. This is important because secondary consequential damage may put you on a "wild goose chase". A good example may be that ductile overload is found along with fatigue. It could be either way for the primary modes. Was the forcing function and impulse, resonant in nature, or a time dependent function? The sequence of fractures must be characterized. In other words you have to determine what came first "the chicken or the egg". This can be done by identifying all possible scenarios that could occur. When looking at the fracture surface of a component the number and grouping of striations will give insight into the history in a fatigue situation. Also, whether there is corrosion or shiny metal embedded within the fracture surface will help evaluate what is going on. In this example problem, it is determined that a rapid fracture occurred.
4. Design Review: This can be done in parallel or after the metallurgical investigation is complete. The failure involved piping and supports so a pipe stress analysis is appropriate. During the design review, it is important to understand the behavior of the system. This will help in determining primary and secondary modes of failure. In this particular case, nothing was found in the design that would suggest a problem. It was also determined along with the metallurgical event that the supports had to fail first then the piping.
5. Field Services: It is decided to take data, but it bears no fruit. Everything is smooth and operations are working well. Sometimes this increases the level of frustration, but do not let that happen. It could be that it happens at some particular time, so doing long term monitoring may be the answer. This could be accomplished with telemetry and data sent directly to your computer in your office. For this example, it is a good idea to consider looking at process parameters as well, so you can capture what the process is doing at the same time. In this case, a transient pulse is found and it appeared to be random. Next it was decided to do the test again incorporating dynamic pressure transducers as well as static transducers. From that test it was found to be a pressure pulsation. Finally, now you have a direct correlation that it is coming from the process.
6. Process: The next step is to evaluate the process. Now the process guys swear up and down the pressure is steady and there is no pulsation in the system. They bring all sorts of plots showing how steady their process is with no pulsations. The problem with that is , the data is time averaged and the transient is just a few milliseconds. Based on this, the process dynamics have to be reviewed. What can cause a pulse in the system to create such a large load condition? The dynamic pressure was only 25% of static pressure, but over that large of a pipe area the loading can be high when it is transmitted to the supports. Finally, it is determined that a possible area of concern is a static mixer where multiple flow streams merge. A CFD model is developed to include the kinetics of the process at the mixing location.
7. Root Cause Analysis: Putting everything together, it was determined that the root cause was constituents flashing out in the static mixer in a low pressure zone. It occurs randomly because certain pressure/ temperatures within the operating range had to occur for the flashing to occur. In other words, all the stars had to align a certain way.

Problems like this often exist in industry. This problem would never have been found without finding out what the forcing function was and where it was coming from. Also, it was a multi physics problem with process interacting with mechanical. The problem was fixed by a simple modification to eliminate the low pressure zone.

All problems like this should be reviewed and approved by a professional engineer competent in failure analysis.

Cliff's Notes: KnightHawk has solved many problems like the one above. We have put together a multi physics team and can solve a problem like this in a matter of days. This includes field services, metallurgical/materials, CFD, and FEA. We provide a walk away solution.

It has been nearly two years since my Mongolia experience. My health is 100% and all the exercise has done well with me. I look forward to the rest of 2015! Take care and God bless.

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KnightHawk Project Update

- Test Rig Design – Oil & Gas
- Compressor High Vibration – Petrochemical
- Structural Vibration Due to Acoustics – Petro-chemical
- Vessel Flange Analysis – Petrochemical
- Steam Turbine Failure Analysis – Petrochemical
- Corrosion Testing – Oil & Gas
- High Temperature Vessel Design – Petro-chemical
- Critical Pipe Stress – Petrochemical
- Flue Gas Cooler – Petrochemical
- Thermal Oxidizer Mixing Analysis – Petro-chemical
- Transient Fluid Dynamics – Petrochemical
- API Tanks FFS – Petrochemical
- Structural Analysis – Petrochemical
- Transfer Line Exchanger – Petrochemical
- Piston Failure – Petrochemical
- Fit for Service Analysis – Petrochemical
- Tensile Testing – Manufacturing
- Compressor Failure – Petrochemical
- Storage Tank Failure Analysis – Oil & Gas
- Pump Failure – Petrochemical
- Reciprocating Compressor Failure – Petro-chemical
- Pump Vibration Analysis – Petrochemical
- Bearing Failure – Gas Pipeline
- Gas Plant Failure Analysis – Oil & Gas