KNIGHTHAWK TECH NOTES

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Just Patch it Up

You have just recently graduated from college in engineering, and you are excited about your new job at a large scale production facility. Like any "new hand" that is working the facility you are put with the old gray hair guys to mentor you and get you up to speed about the "real world". Being an area engineer and responsible for the maintenance at a world scale facility can be a tall challenge.

Recently, one of the towers was found to be experiencing an unexplained rapid corrosion/erosion, and there are questions of mechanical integrity as well as to what the root cause of the problem may be. To mitigate the problems with the tower so the plant can get up and running, a fillet weld patch was installed on the outside of the vessel. At the morning production meeting the plant manager asked you to follow up and ensure the fix is safe, and in accordance with all governing rules and regulations, as well as in compliance with Company policy. After all a leak in this vessel would be an EPA reportable event, and could be a safety hazard. Your immediate boss tells you that this should be your number one priority, and gives you directions. While you are grateful that your boss gave you some directions, you are used to a GPS and prefer to have specifics. You develop a plan, and the first items you collect are the following:

- There are process safety management guidelines from OSHA.
- Then you find applicable ASME, NBIC, and API Codes that the experienced hands turn you on to.
- Next you find the Company policy, which basically defers to the Code.

One of the first considerations for a problem of this magnitude is simply what is causing the problem. An erosion rate has to be determined, and that determination must have good basis. After all, your plant manager instructed you, he did not want any leaks or failures. In this situation the repair of the vessel must meet the design requirements of the vessel, or in other words the nameplate conditions must be met. In the case at hand a patch was put on, but the cause of the problem was not known nor the erosion rate. Therefore, a root cause failure analysis should be conducted immediately to determine what the source of the problem is. A root cause investigation team in this situation may consist of, but not necessarily be limited to, the following personnel:

- Fixed Equipment Engineer
- Metallurgist
- Inspector
- Production Engineer
- Process Engineer
- Site Safety Engineer

A mechanical analysis of the patched vessel must be performed to validate the structural integrity. Depending on the situation, since corrosion was found all over the vessel, a Level 3 Fitness for Service (FFS) might be performed. This would include the patch, and no credit would be taken for the area behind the patch. Therefore, the patch must hold the load. In general only flush patches are allowed as a permanent fix, so the fillet welded patch can only be used until the next planned outage, or as the team and analysis deems necessary. In effect, the fillet welded patch becomes a temporary patch. If the analysis determines the temporary patch that was installed cannot satisfy the acceptance criteria established by the investigation team, an unplanned outage might be necessary to rectify the situation. Now the next issue is what is the root cause? Once the cause and a solution is determined, the date of the planned outage can be set accordingly. Let's assume for this case the cause of the erosion/corrosion is complex, and by hand calculations the measured vessel wall thicknesses are below the minimum required for structural integrity.

In general the way to handle a problem like this may be as follows:

1. During an outage take detailed readings of the vessel.
2. Perform a preliminary analysis of the vessel to determine if there is a structural problem with eroded thicknesses as measured. In this case, a finite element analysis would have to be performed to assess the conditions. If a patch is put on, also validate the thickness and areas covered. It is advised to take no credit for the metal under the patch to be conservative.
3. Perform a RCA to determine the cause of the problem and the corrosion rate.
4. Perform a FFS Level 3 analysis using the thicknesses measured and the erosion rate including the date of the planned outage.
5. In service monitoring might need to be performed to insure the corrosion or erosion rate is under control and in line with the FFS analysis assumptions. This may be thickness readings, or in some case it might be thermal imaging if there is a sufficient temperature gradient to make this useful.
6. Field Engineering and analysis should be conducted to insure a safe replacement and repair of the patch.
7. Detailed review and approval should be conducted by the investigative team to ensure all the bases are covered.

Every situation is unique and should be reviewed on a case by case basis. Any solution should be in accordance with the Code.

These types of problems are often complex and challenging and should be reviewed and approved by a professional engineer with experience with these type problems.

KnightHawk Project Update

- Titanium Tower FFS – Petrochemical
- Brittle Fracture Analysis – Petrochemical
- Screw Mixer Failure – Petrochemical
- Depentanizer Tower FFS – Petrochemical
- Well Bore Flow Analysis – Oil & Gas
- Motor Bearing Failure – Water Treatment
- Bearing Fluid Flow Analysis – Subsea
- Riser Stack Analysis – Offshore
- Gas Pipeline Coupling Failure – Oil & Gas
- BOP Analysis – Subsea
- Motor Thermal Analysis – Subsea
- Pump Vibration Analysis – Petrochemical
- Deaerator Efficiency – Petrochemical
- Vessel Destructive Testing – Oil & Gas
- Critical Pipe Stress – Petrochemical
- Corrosion Analysis – Gas Pipeline
- Centrifugal Pump Rotor Reverse Engineering – Petrochemical
- Reactor Failure Analysis – Petrochemical
- Balanced Torque Measurements – Power
- Creep Tensile Testing – Communications
- Gasifier Equipment Design – Power
- High Temperature Molten Salt Tank Design – Green Energy
- Transient Fluid Dynamics – Petrochemical
- Waste Heat Boiler – Petrochemical

Cliff's Notes: KnightHawk is one of the premier resources for Fitness for Service analysis for both static and rotating equipment. We have experts in mechanical, metallurgical & materials (including fracture mechanics), process, and controls. KnightHawk was performing Level 3 analysis of equipment before the Code existed. We are truly a one stop shop that can get the job done.

July 2, 1991, KnightHawk Engineering opened for business. Today, 20 years latter we are going strong and better than ever. We have the right people, tools, and knowhow to assist your company operate safely and reliably.

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