

Lessons Learned

APEP Combustion Chamber Incident

What happened?

Two UCI employees were working in an Advanced Power and Energy Program (APEP) Lab/Room 101 when an unexpected, minor explosion occurred in the room's combustion chamber. One of the employees was beginning to prep for the next experiment after running three prior tests and turned off one of the natural gas lines but failed to close a second gas line feeding the chamber.

The combustion chamber was purged with 100% air flow and the air flow valve was then closed and the employee started to align the pilot to spark the ignitor. Once it was aligned, the employee turned back to the control board behind her to flip the ignitor switch and when the employee turned back toward the chamber, there was a minor explosion that broke a glass panel on the combustion chamber causing it to shatter and blow pieces out toward the employee.

The employee received a cut to the right hand with a piece of glass embedded at the bottom of the palm as well as a minor burn on the lower left side of the neck from the glass. The employee was treated on site with first aid before calling UCI police and eventually OCFA was dispatched. The employee was transported to the ER to remove the glass and treatment for the neck burn and has had several follow up appointments with Urgent Care doctors. There is still concern regarding a tingling sensation in the thumb and nerve damage is being looked into.

During the investigation of the incident, it was noted that a second gas line was recently added to the set-up as they were not getting a large enough flow and pressure in the chamber with a single gas line. Each line had their own separate on/off valve which feed into the main gas line for the chamber. Since one of the valves remained open, the chamber continued to be filled with natural gas causing the minor explosion when it was ignited.

Root Cause:

The root cause was human error/management system failures due to a lack of proper operational procedure for the combustion chamber. The incident could have been prevented if guidelines and standards in place were better understood and enforced by an existing standard operational procedure. A proper standard operating procedure would have enforced the shutdown of the gas line valve(s) and worked as a check against an open gas line.

Contributing Cause(s):

- There was no interlock or burner management system to keep gas away when burner is shut off.
- Missing adequate control and safety devices capable of preventing the flammable gases from entering or leaving the process or reaction system other than the intended time. The

system design is outdated and keep the employee from observing the chamber with ergonomic concerns

Corrective Actions and Recommendations:

- Combustion chamber, associated gas supply lines, and safety valves needs to be fully inspected for possible internal damage. This system shall be inspected by a qualified entity as meeting any relevant standards and regulatory requirements and to ensure that this system is suitable for its intended use.
- Upgrade the control device with a fail-safe Programmable Logic Controller (PLC) which will allow users to program all chamber functions to occur in safe-sequence without any human initiation of start-up or shut-down sequences. This would include an emergency stop and air purge of chamber.
- Install combustion gas meter near vent to make sure the chamber is gas free before ignition as well as magnehelic gauges on all exhaust ducts to provide instant visual confirmation exhaust fans are running and negative pressure is on exhaust duct at the furnace outlet indicating proper operation
- Replace windows with metal blanks or use heat resistant quartz glass on the interior window with blast resistant outer glass to prevent glass explosion
- Perform regular maintenance inspections of the combustion chamber with written documentation.
- Develop proper SOPs, including start-up, shut- down procedures and Lockout-Tagout (LOTO). EH&S will assist with LOTO.
- Update LHAT and review PPE requirements.
- Improve on ergonomics by placing all manual operational devices in front of researcher so they can watch the chamber without turning/twisting to the switchboard (recommended)