

Boiler and Combustion Safety— What You Don't Know Can Kill You!

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An industrial explosion kills six in Michigan, another kills four in Virginia, and the list goes on. These are only two very tragic, recent national headlines. The *National Fire Protection Journal* (NFPA) reports that explosions and fires cost American industry hundreds of millions of dollars a year. Unfortunately, society and individual companies usually act on these issues only after some very large and tragic event occurs.

For the non-combustion person, this article reviews basic gas train safety controls and concepts and provides an understanding of the most common problems we have found through our inspections and safety testing of more than 9,000 gas trains, the training of thousands of skilled trades people, and the development of corporate combustion equipment safety programs for some of the world's largest companies.

Most facilities do not have personnel properly trained in combustion equipment maintenance, start-up or shut-down procedures, and/or equipment operations. Most sites also do not follow proper interlock and safety testing guidelines even though they are mandated by law. Boiler safety laws passed by a number of states hoped to help this. Boiler inspections are mandated to be carried out in states and municipalities that have boiler safety laws. These are called jurisdictional inspections. In most states these laws call for inspecting, but not testing, only the pressure vessel part of each boiler system. In 26 states ASME CSD-1 (American Society for Mechanical Engineers, Controls and Safety Devices Code for Automatically Fired Boilers) is an adopted code. It mandates actual operational combustion safety systems testing for units up to 12.5 million btu's per hour input (MMBTUH). Some states have also adopted NFPA 85 (National Fire Protection Association, Boiler and Combustion Systems Hazards Code) for units that are over 12.5 MMBTUH. This code also requires safety systems testing. In these states, jurisdictional inspectors may ask to see evidence of the required gas train and safety interlock testing. However, it is beyond their work scope to do any of this testing.

“But It Was Just Inspected!”

Interviews of people close to boiler explosions or fires will commonly contain the phrase, “but it was just inspected.”



In their hearts they believe that everything humanly possible was done to avoid a catastrophe. Owners and operators think that a jurisdictional boiler inspection is the magic bullet or armor shield against problems, when in many cases it is not. Very few realize what a typical mandated jurisdictional boiler inspection is and is not. Many large industrial clients are realizing that these mandated inspections are not enough to protect their most important assets—the lives of their employees. Some of these companies now have fuels and combustion equipment

safety programs that go well beyond minimal legally mandated requirements. These “self audit” combustion system programs usually include an analysis for code compliance, installation deficiencies, interlock testing, screening for maintenance practices that can be impacting safety, and assessing technological advances that can improve safety.



This equipment, in this condition, has been approved to operate “as is” by current jurisdictional inspection practices.

Grandfathering Old Equipment

Jurisdictional inspectors often have their hands tied when it comes to what they can ask someone to do. What they are inspecting for is often limited by exactly the letter of the law. For example, in many cases they can only evaluate equipment for its code compliance for when it was installed. *Code compliance is usually not retroactive.* Safety codes have committees and evolve for a reason. It is because the technical world finds out how to do things better over time. It is a shame that none of this has to ever get implemented.

There is typically no screening for how far away from the most recent codes the old “grandfathered” technology is. Passing a jurisdictional inspection sometimes means that you could be “technically” in compliance with archaic and antiquated equipment that is 50 or more years old. This could be equipment that requires many manual steps to operate safely and puts your site at serious risk of improper manual start-up or shutdown daily. You could walk away from this kind of inspection being technically “in compliance” but nowhere near the current codes level of safety.

Consider also that unless you are in an ASME CSD-1 or NFPA 85 state, inspections rarely address gas trains and/or fuel system issues. Interlock and gas train testing is usually assumed to be a responsibility of the owner in these non-code states. You can imagine that the level of compliance with these little known testing requirements is much

less in states where the issue of testing is not even on the table on a regular basis.

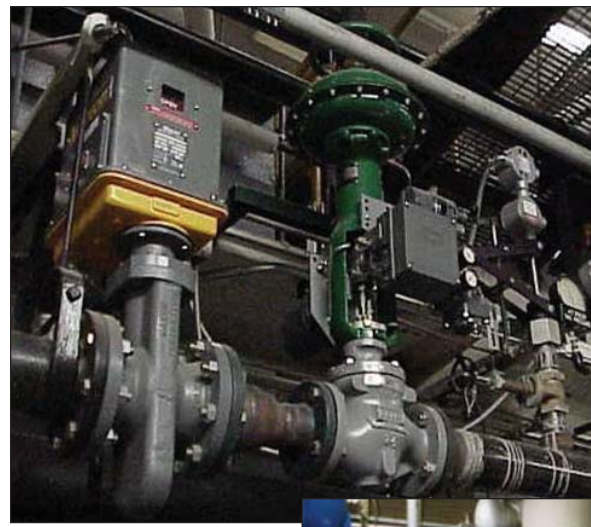
During most inspections archaic equipment like this 60-year-old boiler do not typically get screened for safety upgrades to firing controls.

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What Is Interlock Testing? Why Does It Matter?

Burning fuels can be useful to mankind as long as it is with a controlled process. Control means that combustion takes place where we want it, when we want it, and at the rate we want it. The complicated looking series of valves, piping, wires, and switches that comprise the “gas train” installed on gas-fired equipment is what attempts to do this.

Gas trains regulate the amount and the pressure of gas to burners. They also keep gas out of the combustion chamber whenever equipment is cycled or shut off. This is accomplished with a series of regulators, flow control valves and special shutoff valves. The shutoff valves are designed for very low leakage and are spring loaded to close. These are the safety shutoff valves. Larger gas trains require dual valves and some also have a vent between these for added safety. The vent and its piping are provided to allow automatic shutoff valve leakage a place to go outside the build-



Typical gas train with safety interlock components.



Most inspections today are only annual at best and only related to pressure vessels.

ing when the equipment is cycled or shut off. It is only supposed to open when the equipment is off. The specific configuration that you have most likely depends on your insurer and local code requirements.

Gas trains also have a number of components that try and make sure that safe light-offs take place and that shutdowns occur immediately if anything goes wrong during the operation of the equipment. They do this with a series of special switches that look for conditions that could be dangerous. For example, too high or too low gas pressures being sent to the burner should trip gas pressure switches and cause the unit to shut down. These should also be switches to make sure



Typical flame scanners that monitor conditions.



Typical high/low gas pressure switches to verify gas pressures are in the proper range.

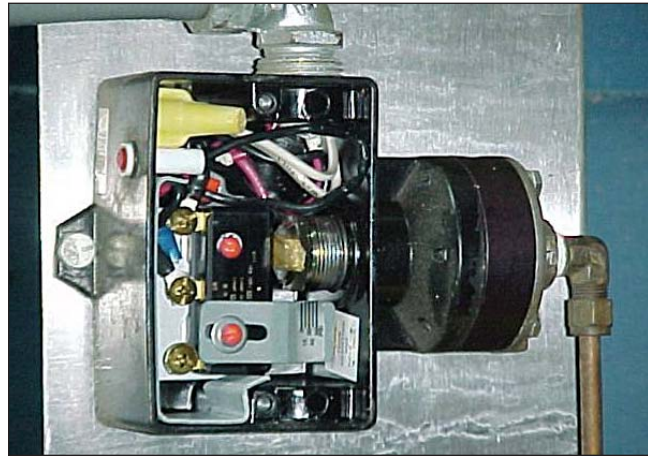
that airflows are correct for purging residual combustibles prior to light-off and to make sure airflow is correct during operation.

Flame-sensing components also usually exist to make sure that flames are present when they are supposed to be present and not at a wrong time. Other components for sensing that the fuel valve is at low fire position prior to light-off may be present along with furnace pressure switches, high temperature limits, high steam pressure limits, and/or water level cut-offs (depending on the type of equipment).

All of these components are logically linked or interlocked to a BMS (burner management system) controller. The BMS is the brain that supervises and sequences all of the light-off efforts including the timing and adequacy of the purge prior to light-off and the time intervals allowed for getting pilots and main flames lit. The BMS then acts as your sentinel of safety and monitors all of the switch and



The BMS or burner management system is the brains that monitors/directs safe firing and operations.



People get creative to defeat safety controls. Here is a Popsicle stick stuck into an air switch to force it always open.

safety conditions that are available waiting to direct the fuel valves to close if there is a problem.

Our typical circumstance is to find that no one at a site is aware of regular testing requirements specified by codes. In most cases we find that sites do some level of testing, but it is rarely regular. The level of comprehensiveness varies depending on who is in charge and that person's knowledge of the equipment or systems. If someone knowledgeable is doing the right thing, we often find that job rotations and turnover do not guarantee that this diligence will be in place for many years at a particular site. Because of this we have not found much consistency amongst sites under anyone's corporate umbrella.

We Can Again Meaningfully Decrease Fuel/Combustion Incidents, Here's How:

Natural gas and combustion equipment safety continues to be a black art among many users. Most sites have personnel that are not adequately trained in either the safe start-up and shut down of equipment, daily operations, or proper testing and maintenance. A survey of industrial users found that less than 10% actually perform manufacturer or code required preventive maintenance including testing of critically important safety interlocks. The combination of these two circumstances (poor training and improper maintenance) can spell disaster and it has in numerous facilities. When assessing your site's level of combustion equipment risk, remember the following:

Most of the explosions and fire incidents, by far, have historically been due to human error. All of the safeties and interlock equipment in the world will not help if you attempt to bypass or jumper-out safety controls. There is no possible substitute for proper training. Training has to include mock upset and hazard recognition drills. Your site needs training even if you will have contractors doing preventive maintenance work.

Start-up and shut down are your biggest risks. You need clearly written procedures that everyone understands

and agrees with so that consistent safe practices are in place with every shift and every employee.

Make sure that you do regular and complete interlock and fuel train valve tightness testing. Jurisdictional inspectors, even where they are mandated to be around, cannot be at your facility every day. Combustion equipment safety testing needs to be part of your organization's culture regardless of what it costs and what the perceived hurdles are. You should comply with code requirements for testing even if they are not enforceable in your area.

Create corporate guidelines for third party combustion equipment reviews and commissioning for newly acquired equipment or for major upgrades. Now that you see how little review and attention combustion equipment may receive from the time it is specified to when its really operating you may want a dedicated professional review of the process.

Upgrade equipment for safeties sake. Do not wait for a problem and let attorneys dictate when this happens.

It takes a lot of effort to change culture and practices that have evolved over decades. In the beginning, you will probably get a lot of the same old, "Gee, we have been doing it this way for years" stories. Our clients have found the first year of having a comprehensive combustion equip-

ment testing and training program to be painful. It takes a lot of effort and faith to fix things that "ain't broke" to some people. Certainly the financial wizards will need lots of hand holding when it comes to upgrading equipment just for the sake of safety even though the upgrade may not increase throughput. Although, in many cases it will.

Once an incident occurs it means years of court cases, job losses, changes, higher insurance rates, and maybe even criminal litigation. It also takes years to overcome the stigma of possible safety credibility to employees and the community. Start with a review of your equipment state of protection relative to current codes. We call this a "gap analysis." Prioritize your needs and address them at a comfortable pace. Conduct a human "gap analysis" to identify the state of knowledge and skills regarding your operations and maintenance staff. Make training a regular and serious effort. The bottom line is that implementing comprehensive combustion equipment safety programs saves lives. The right thing to do is to be proactive. This is not the thing to do under the duress of catastrophes and death.

John Puskar, P.E., of Combustion Safety, Inc. (www.combustionsafety.com) was a presenter at the recent Texas A&M Oil Mill Operator's Short Course in St. Louis, Missouri. Contact information for Combustion Safety, Inc.: Valerie Madarasz: 216-749-2992; e-mail: vmadarasz@combustionsafety.com. ■