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Basic Gas Train Safety Controls and Concepts

Over the past few years, there have been numerous tragic industrial explosions across the United States. The National Fire Protection Association (NFPA) reports that catastrophic fires and explosions cost industrial facilities hundreds of millions of dollars annually. Yet, these statistics say nothing of the thousands of smaller events that occur and go unrecorded, such as boiler fires, process oven failures, and the damages and injuries from these events. Unfortunately, action is often only taken on these issues after some very large and tragic event occurs.

Combustion equipment safety is critical to the daily operation of all facilities and the safety of every employee, yet awareness on this topic is lacking simply because it is complicated and misunderstood. It takes diligence and understanding to protect employees, facilities and industrial organizations from combustion-related incidents involving fuel-fired equipment.

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, the pressure vessel part of each boiler system only. 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 BTUs 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 12.5MMBTUH. 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.

Jurisdictional Inspections

People close to explosions or fires will commonly utter the phrase, “but it was just inspected.” Many assume that a jurisdictional boiler inspection is sufficient enough to guard them against problems, when in fact, in many cases it is not. Very few realize what a typical mandated jurisdictional boiler inspection is and is not. Many large

industrial organizations are realizing that these mandated inspections are not enough to protect their most important assets – 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.

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, 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’s because the technical world finds out how to do things better over time.

There is typically no screening for how far away from the most recent codes the old “grandfathered” technology has become. 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 presents serious risk of improper manual start-up or shutdown daily. Equipment could be “in compliance” with this kind of inspection, but quite far from 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. 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.

When it comes to process ovens, space-heating equipment, furnaces and other heat-based industrial processes, there are specific guidelines for levels of fuel train protection, safety and testing. These are spelled out in NFPA 86 (Standard for Ovens and Furnaces). However, as in the case of boilers, very few people know about them. Often, these are custom pieces of equipment with safety controls that are assembled from components and not pre-engineered catalog systems. Unlike boiler systems, there are no jurisdictional programs in the United States to inspect or mandate safety testing for non-boiler fuel-fired equipment.

What is Interlock Testing & why does it Matter?

Burning fuels is useful as long as it’s 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 shutoff valves. The shutoff valves are designed for very low leakage and are spring loaded to close. 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 building when the equipment is cycled or shut off. It is only supposed to open when the equipment is off. Specific configurations at each site most likely depend on insurers and local code requirements.

Gas trains also have a number of components that try to 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 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 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 exist to make sure that flames are present when they are supposed to be, 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 safety conditions that are available waiting to direct the fuel valves to close if there’s a problem.

All of this equipment is supposed to be checked on a regular basis by law, but with maintenance budgets among the first be cut, proper checkouts and testing are seldom performed. Codes and manufacturers define what the testing frequencies should be for different types of components and safety systems. Frequencies of required inspection/testing range from daily for some items like observing flames, to annually for some block and bleed valve tightness testing requirements.

Many factors contribute to improper safety testing. Often no one at a site is aware of regular testing requirements specified by codes. Sites may 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, job rotations and turnover don’t guarantee that this diligence will be in place for many years. Under the corporate umbrella, consistent testing is not common.

Where Did the Codes/Industry Protections Come From?

The early 1800s saw boilers and pressure vessels as being at the root of many catastrophes. This created a public uproar and a call for the technical community to provide new guidelines, laws and infrastructure to protect the public. Groups like the ASME and NFPA stepped up and changed the world with new pressure vessel and fuel train requirements. Pressure vessel and combustion-related incidents dropped dramatically since that time. However, today there are still dozens of tragedies, hundreds of injuries, and billions of dollars in annual fuel and combustion equipment system losses worldwide due to a lack of knowledge, enforcement of laws and codes, training and proper maintenance.

Training

Numerous sites assume training is something that happens on-the-job in an informal sense; it's information that gets passed on from person to person over coffee or in between baseball scores. There may have been training years ago when the equipment was new, but now maybe only half of those people are still around.

Codes offer little specific direction regarding training other than to say that training is absolutely required and that it should be done either annually or regularly. The American Society of Mechanical Engineers (ASME) boiler code in Section VII, Subsection C2.110 says "safe and reliable operation [of boiler] is dependent … upon the skill and attentiveness of the operator and the maintenance personnel. Operating skill implies knowledge of fundamentals, and a suitable background of training and experience. Regularly scheduled auto-manual changeover, manual operation, and mock emergency drills to prevent loss of these skills are recommended" (ASME 2015). This kind of training, and especially the mock, upset troubleshooting, and emergency parts are especially ignored in most training programs even though they are clearly among the most important things that operators and maintenance staffs should understand.

The National Fire Protection Association's NFPA 85, also identifies some requirements for boiler operator and maintenance training (NFPA 85, 2015). This information is helpful, but again rarely ever finds its way into boiler operator training programs. Even more peculiar is that where boiler operator licensing is required, licensing exams have very little information, if any at all, related to fuel train safety or maintenance. Instead, these exams and the training for them focus almost exclusively on water and pressure vessel issues.

Preventive Maintenance

A comprehensive preventive maintenance program is your biggest defense and another vital part of staying safe.

Deterioration and aging have a grave impact on combustion equipment safety. Countless things happen that make combustion equipment less safe with every minute of operation. Dirt accumulates in combustion air fans and burners, which changes

fuel/air ratios. Gas valves get a little less tight every time equipment is cycled. Pressure switch diaphragms and contacts age. Water level controls accumulate sludge.

These are all examples of possible operational or maintenance issues that could spell trouble for industrial sites and personnel. The problem is that very few sites maintain the specific expertise required for proper combustion systems maintenance. The skills and knowledge required to do this work safely are considerable. These people must do this work regularly to stay sharp, not once or twice a year. They also need frequent training and specialized tools like flue gas analyzers that require annual calibration and expensive maintenance. Most sites lack people with these skills and/or do not have them properly equipped. In many cases, these people know enough to be dangerous. Unless properly trained, do not allow maintenance personnel or operators try to do things like tune burners, change out firing rate control valves, and/or replace burner management systems.

Sites that don't want to have these problems with in-house staff sometimes blindly rely on contractors. However, before allowing someone to touch combustion equipment that you own and operate, you and your staff must have some core level of knowledge regarding safe practices before even hiring the right contractor. Ask questions about the specific level of training and experience that the person coming to the job has had, make sure this person is not going to learn on your equipment.

Regardless of who completes the equipment's maintenance, another issue is maintaining documentation. This means panel drawings, switch set points, purge times and even component model numbers and operational manuals. Many incidents have occurred from improper troubleshooting of problems because information was not readily available.

Decreasing Fuel/Combustion Incidents

Most sites have personnel that are not adequately trained in either the safe start-up/shutdown of equipment, daily operations, or proper testing and maintenance. The combination of these two circumstances (poor training and improper maintenance) can spell disaster, and it has in numerous facilities. When assessing the level of combustion equipment risk, remember the following:

1. **Most explosions and fire incidents are due to human error.** All of the safeties and interlock equipment in the world won't help if someone attempts 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. Site personnel need training even if contractors will be doing the preventive maintenance work.

2. **Start-up and shutdown are the biggest risks.** Clearly written procedures that everyone understands and agrees with are necessary so that consistent safe practices are in place with every shift and every employee.

3. **Conduct regular and complete interlock and fuel train valve tightness testing.** Jurisdictional inspectors, even where they are mandated to be around, cannot be at a facility every day. Combustion equipment safety testing needs to be part of an organization's culture regardless of what it costs and what the perceived hurdles are. Comply with code requirements for testing even if they are not enforceable in your area.

4. **Create corporate guidelines for third party combustion equipment reviews and commissioning for newly acquired equipment or for major upgrades.** With the little review and attention combustion equipment may receive from the time it's specified to when it's operating, it is worthwhile for a dedicated professional to review the process.

5. **Upgrade equipment for safety's sake.** Do not wait for a problems and allow attorneys to dictate when this happens.

It takes effort to change culture and practices that have evolved over decades. And it is common for industrial organizations to find the first year of having a comprehensive combustion equipment testing and training program to be painful. Certainly, the financial stakeholders will need persuading 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 and 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 the equipment's state of protection relative to current codes, also known as 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.