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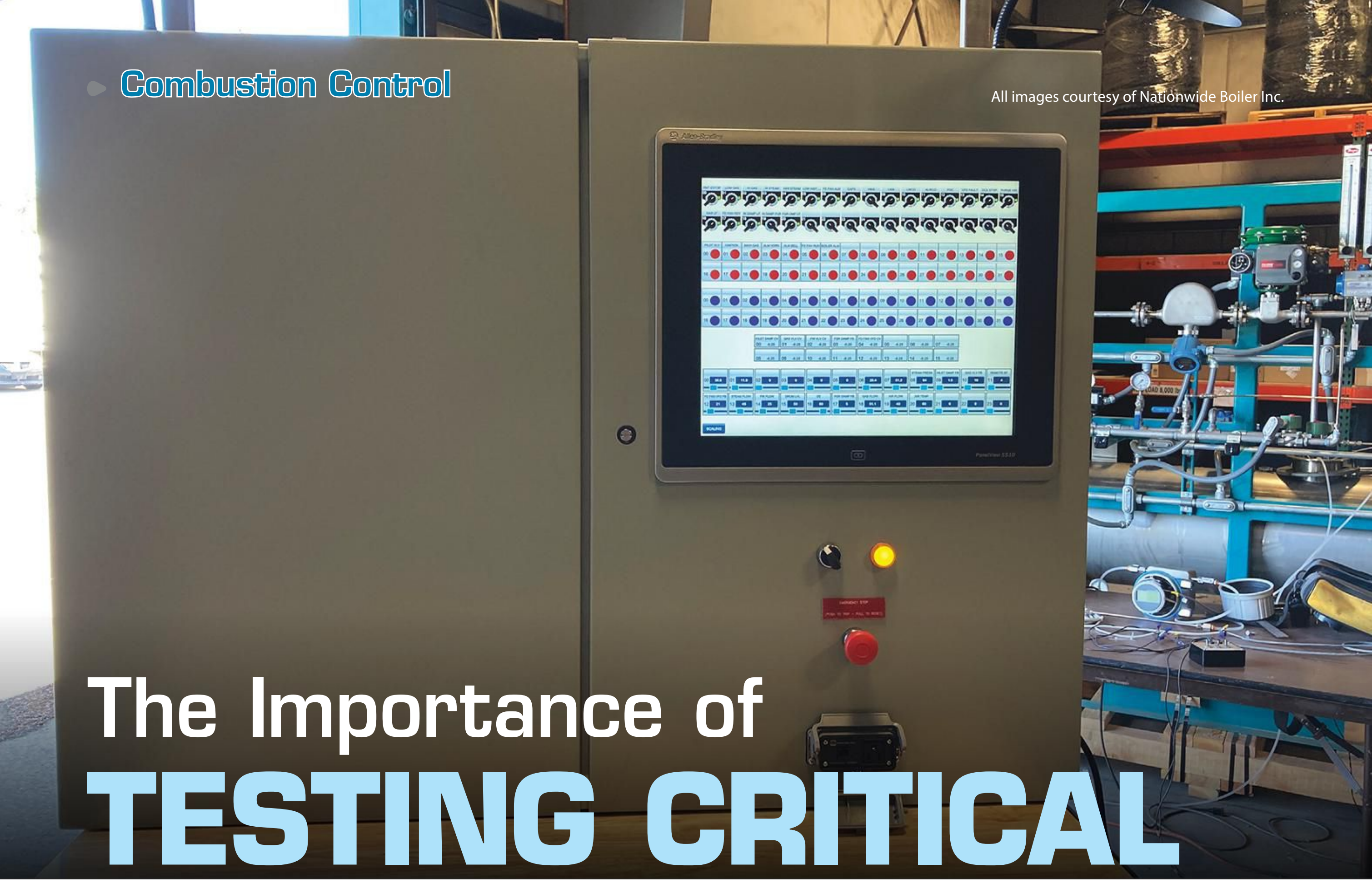

The Importance of TESTING CRITICAL CONTROL SYSTEMS

A functional acceptance test can help alleviate the risks associated with performing first-run testing of factory logic programming for combustion controls or burner management on fired equipment in the field. Performing such testing helps ensure the manufacturing process for critical control systems.

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Control systems that are responsible for the safety, startup sequencing and operating supervision of critical applications such as burner management, combustion control and boiler control systems must be designed to be both fail-safe and reliable.

To prove the functionality and reliability of these systems, manufacturers must perform a site acceptance test with the actual equipment once it is on-site and ready for commissioning. Testing is used to verify equipment performance in relation with other systems at the site.

Before the equipment is on-site, however, a functional acceptance test also may be required (or desired). It is performed at the manufacturing facility prior to shipping the system to the site.

Functional Acceptance Testing

A functional acceptance test – also known as a factory acceptance test, or FAT – is an essential element of the testing and acceptance of critical control systems. The level of testing performed for FAT can vary. Less extensive testing may involve simply checking the basic configuration with temporary wires. A more comprehensive FAT, by contrast, can involve complete system testing, where the manufacturer physically constructs and tests the system in a simulated operating capacity. The test typically is performed by quality managers, design engineers, operators and maintenance personnel.

The main goal of the FAT is to certify the performance of equipment built for a specific

FIGURE 1. Basic testing typically is performed via simulation rigs that utilize toggle switches to simulate discrete inputs to the system.

FIGURE 2. Technicians perform a full FAT for a system consisting of a burner management/combustion control system, fuel skid and selective catalytic reduction (SCR) system.

application. A second goal is to ensure that all design requirements are attained. A thorough functional acceptance test – where all of the system inputs and outputs (discrete and analog) can be simulated – provides a framework to prove that the system has been assembled, wired and designed properly. This is especially important when the system utilizes a programmable logic controller (PLC).

When performed in a shop environment, the results of the FAT can serve as the final determination of whether the system is ready to ship to the equipment buyer's site. A preliminary FAT also may allow the PLC programmer to more thoroughly test the system operation and catch any issues in the design.

Performing a preliminary FAT before the equipment is shipped offers other benefits. Field commissioning can be considerably shorter, and the risk of damaging the boiler or fired equipment upon startup is minimized. Performing the FAT also allows the startup and commissioning crew to get familiar with the equipment ahead of time. This adds a level a confidence to the end user that the control system has been thoroughly vetted at the factory.

Often – and not to be overlooked – the final step after an FAT is operator training. Operators can "test fly" the system without worry of damaging equipment, allowing them to identify operational issues that the engineering team may have overlooked. This step can add ownership to the system, helping to make for a smooth startup and commissioning of the new equipment.

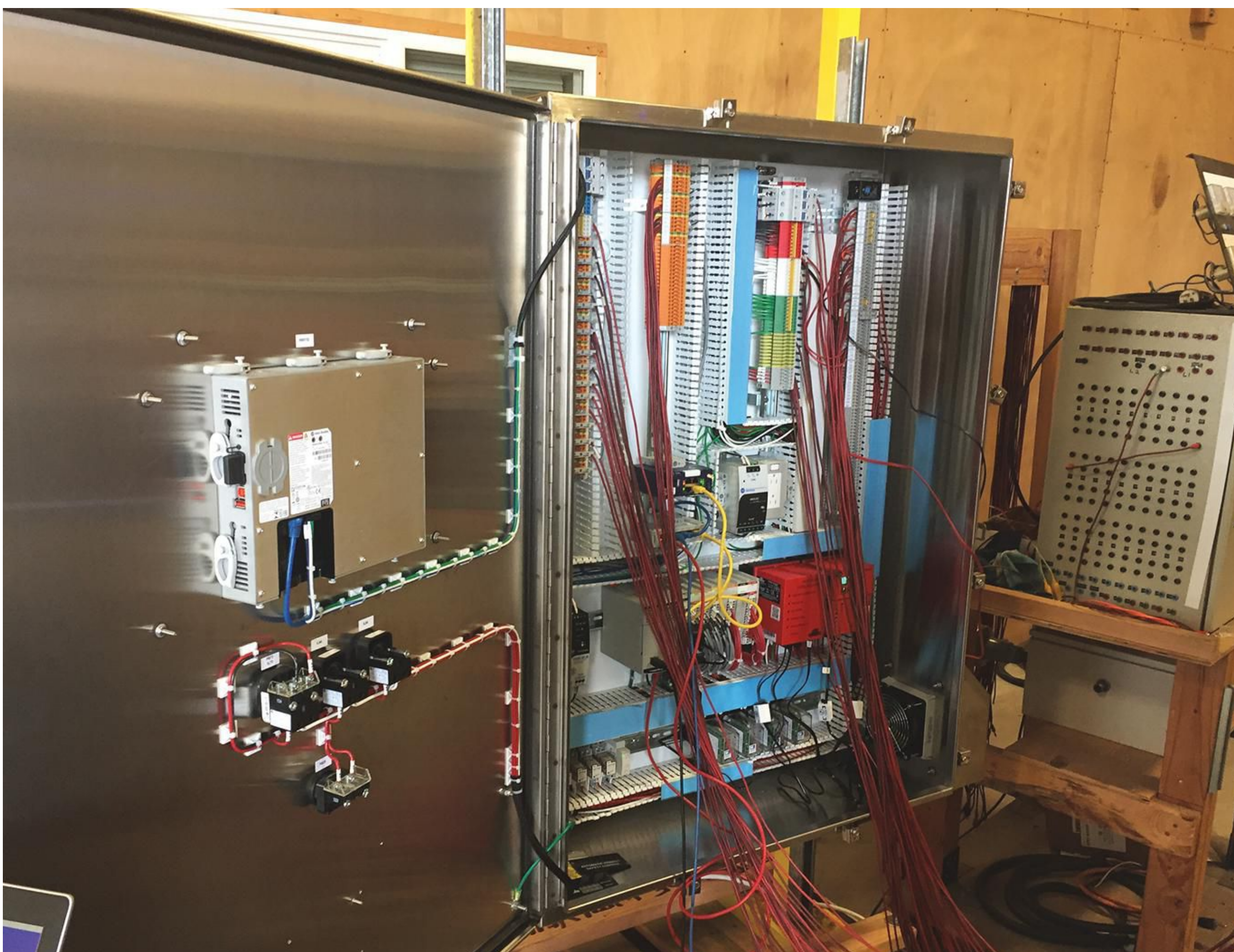
Standard FAT Simulation Devices

Basic testing typically is performed via simulation rigs that utilize toggle switches to simulate discrete inputs to the system. The testing rigs can be configured to allow different voltages as required by the system being tested. Pilot lights are used to mimic discrete outputs; however, actual loads are used wherever possible. For example, a prefabricated fuel train that was built for use with new fired equipment can be tested in conjunction with the burner-management system.

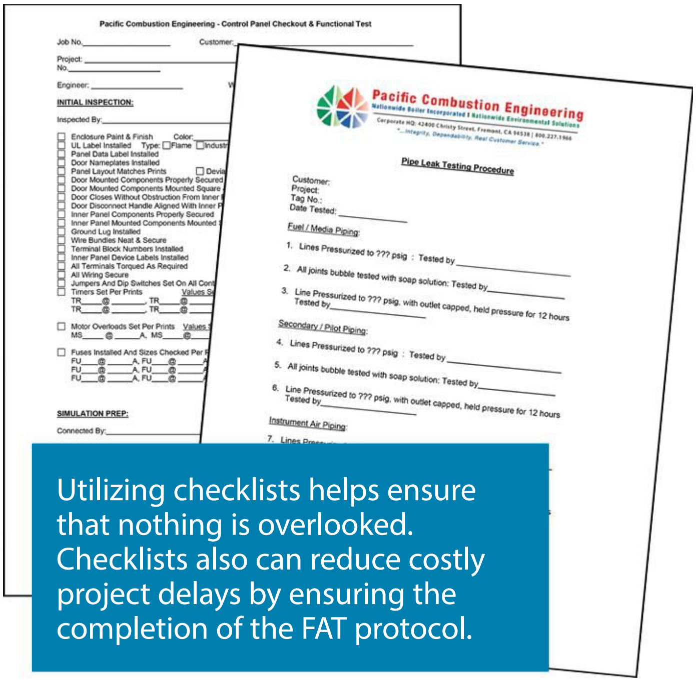
Analog inputs and outputs can be simulated with potentiometers driving voltage dividers for the inputs and analog meters for displaying outputs. A flame can be simulated by means of a UV source placed in a light box, to which the flame scanner is connected. Infrared simulation also can be accomplished with a pulsed infrared light source. An example of a test rig is shown in figure 1.

Technologies for Remote Testing

In the age of digital technologies and pandemic isolation requirements, companies have developed testing gear that allows for a



A thorough FAT, where all the inputs and outputs to the system can be simulated, will provide a framework to prove that the system has been assembled, wired and designed properly.



Utilizing checklists helps ensure that nothing is overlooked. Checklists also can reduce costly project delays by ensuring the completion of the FAT protocol.

remote, virtual FAT. For instance, one company has a test rig consisting of a human machine interface (HMI), which replaces the toggle switches, indicating lights, potentiometers and analog gauges. A PLC drives relays and consists of contacts that can be configured for the voltage that is required for input simulation. Outputs are displayed via selectable 120 VAC and 24 VDC terminals. Analog 4 to 20 mA inputs are selectable as either loop- or self-powered.

During the virtual FAT, a web portal is accessible by the equipment buyer through an audio/video link to the testing. In this way, the equipment buyer can remotely operate the test rig HMI screen. Links also can be furnished to the burner management/combustion control system PLC and HMI.

Figure 2 shows a sample remote-testing rig. Technicians can use such a rig to perform a full FAT for of systems with equipment such as burner management/combustion control technologies, a fuel skid and a selective catalytic reduction (SCR) system.

Tools for a Successful FAT

FAT testing can be challenging, which is why the process should be a highly organized routine that safeguards that all phases of the system are tested. The basic steps to complete the FAT include:

- Planning.
- Alignment.
- Risk assessment.
- Demonstration.
- Resolution and customization.

Planning. Start early and budget time and money for the FAT (both labor and materials). The equipment supplier and buyer should coordinate test timing so that it is convenient for both parties – and on track with the project schedule. The test plan should clearly illustrate the timing and sequence of tests or inspections based on the equipment specifications and functional requirements.

Alignment. Communication is key. Equipment manufacturers and buyers must make sure that their success criteria and expectations align. Items to be agreed upon include the intent of the FAT; which personnel and what resources will be on-site; and how long testing will occur. During manufacturing, the equipment supplier should clarify any project adjustments such as change orders to ensure a thorough understanding of the end user's production process. This will help ensure the ability to deliver on the equipment buyer's expectations.

Risk Assessment. A well-planned FAT will save time and money, but do not forget to assess any potential issues that could arise during the test and plan accordingly. Among the items to consider are identifying and eliminating safety hazards in the test area. Likewise, it is important to ensure that machinery nameplates are visible and emergency stop buttons are accessible. Generally, the equipment manufacturer should take any corrective actions that need to be addressed prior to testing.

When performed in a shop environment, the results of the FAT can serve as the final determination of whether the system is ready to ship to the equipment buyer's site. A preliminary FAT also may allow the PLC programmer to more thoroughly test the system operation and catch any issues in the design.

Demonstration. Once ready, begin the FAT and demonstrate equipment performance from startup to maintenance procedures.

Resolve Issues or Customize the System. If any issues are uncovered, or the end user requests additional customizations, the manufacturer can address and resolve them after testing. An official statement of acceptance should be signed by representatives from both the manufacturer and the equipment buyer.

In conclusion, it should be clear that the FAT can help identify overlooked faults in the design or construction of the equipment. Such faults might lead to installation problems on-site, thereby wreaking havoc on a project schedule or risking the overall system performance. Performing the FAT at the manufacturing facility can alleviate these risks. It is especially important in the manufacturing process for critical control systems.

It is worth noting that not all suppliers of burner management and combustion control systems provide factory logic testing or a formal FAT. Testing at this level can be expensive and add cost to a new system. However, would you really want to take a chance testing your critical systems for the first time on the actual fired equipment in the field? Fortunately in the pandemic era, advances in technology have made it possible to perform virtual FATs. This allows testing even when travel might not be an option. PH

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