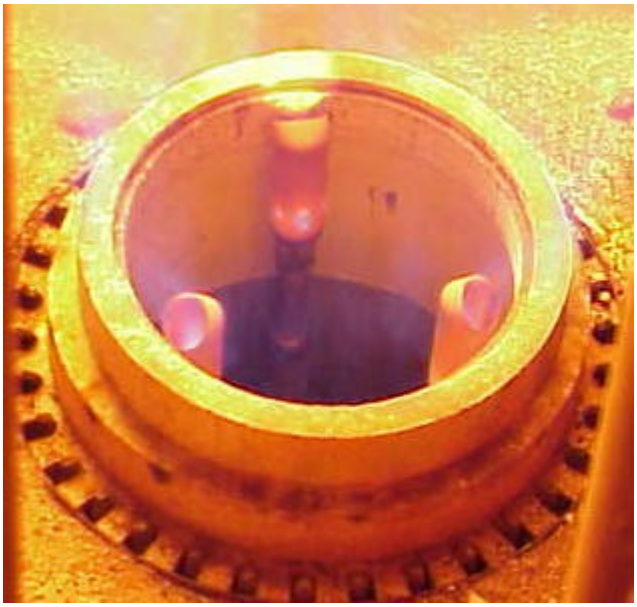
Zeeco Burner Division

Combustion Test Facility

22151 East 91st Street • Broken Arrow, OK 74014 USA
Phone: 918-258-8551 • Fax: 918-251-5519 • sales@zeeco.com
www.zeeco.com

Combustion Testing at Zeeco

At Zeeco, our goal is to provide the best combustion equipment for the lowest price. In order to achieve this goal, our staff continually works to improve our equipment designs and quality control in order to increase product performance while reducing the overall cost of the equipment.



GLSF Free Jet Burner in operation at the Zeeco Test Facility.

It is our world class “HANDS ON” type design skills, quality products and especially our responsiveness to our customer’s needs that puts Zeeco ahead of our competition. Zeeco understands that customer satisfaction is key to the success of our company. One method of understanding customer needs is to spend valuable time with our customers. Demonstrating our burners in operation at our test facility allows us to work hand in hand with our customers to tailor our product for their application. We encourage feedback from our customers and work hard to implement requested changes into our product design or method of doing business.

In keeping with the “hands-on” concept of designing combustion equipment, Zeeco has constructed thirteen (13) combustion test furnaces. These furnaces are capable of testing a wide variety of burners and of accurately simulating field conditions. This helps us produce superior equipment. Producing superior equipment means that we meet both performance and emissions requirements and that field emission data closely matches test data.

Zeeco Test Facility in 2001. Test furnaces No. 11, 12 and 13 have since been added.

As worldwide emission requirements have become more stringent, Zeeco has used our test facility to develop some of the lowest emission burners on the market today. In keeping with industry demands, we have begun testing multiple burners in a single furnace in order to optimize our burners for the actual spacing in which they will be installed. **We have five test furnaces capable of firing two or more burners. Three of which can fire more than seven (7) test burners at a single time.**

Research and Development

Research and development work is continually underway at Zeeco's test facility. We endeavor to stay ahead of rapidly changing emission requirements and our customers' evolving needs and expectations. Our burner R&D work of the past three years has resulted in numerous patent applications perhaps the most in the burner industry. Our current R&D work focuses on the following aspects of our burners' design and operation:

- Reducing combustion emissions
- Understanding multiple burner interaction
- Reducing fuel consumption
- Finding alternative methods for liquid fuel atomization
- Making equipment more compact
- Improving turndown
- Firing a wider range of fuels
- Optimizing flame shape
- Optimizing flame length
- Optimizing flame width
- Reducing number of items requiring maintenance
- Reducing overall maintenance cost
- Lengthening equipment life
- Finding better construction methods

Zeeco research and development has resulted in three generations of ultra low emission burners since 1994. Expect to see many new generations of Zeeco burners which are designed to meet both government regulations and our customers' needs for quality equipment that is easy to operate and maintain and reasonably priced.

GLSF Free Jet Burners in Test Furnace No. 1. The Free Jet line of extreme NOx reduction burners is the latest generation (3rd) of Zeeco ultra low emission technology and a product of Zeeco's ongoing Research & Development program.

Combustion Performance Testing of Production Burners

Many customers require combustion performance testing of burners which they have ordered for a specific application. Testing a production burner in Zeeco's test facility allows them to review the performance of a burner before it goes to the field. Observing a burner in operation under closely simulated field conditions allows Zeeco and our clients to make improvements that can be incorporated into the final product. The equipment is then optimized for its exact operating criteria.

Combustion Performance Test Procedure

The first step in the combustion performance test is a detailed Test Procedure. The test procedure spells out the conditions under which the burner is to be tested and the performance criteria that it must meet. Zeeco prepares the test procedure very early in the order execution process so that our customer has time to review it carefully prior to the beginning of any test setup.

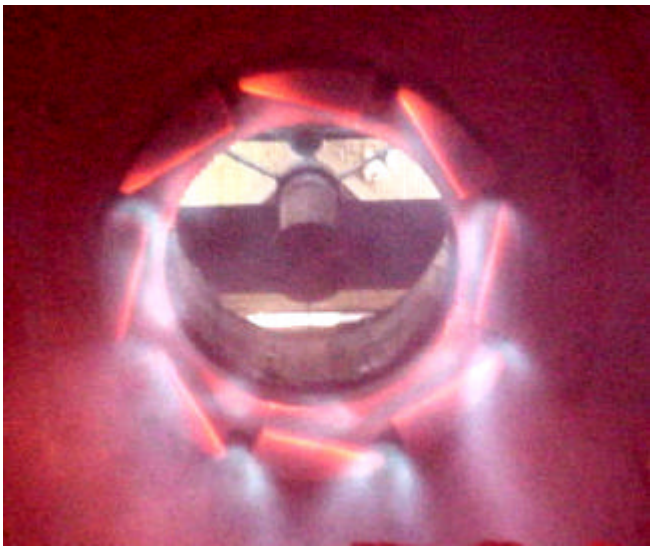
The aspects of the test procedure that must be agreed upon with our customers are:

1. Fuels to be tested

2. Configuration in which the equipment is to be tested, i.e. floor mounted firing upwards, side mounted firing horizontally, top mounted firing downwards, side mounted firing upwards

3. Number and type of measurements to be taken and recorded

4. Temperature inside the test furnace



GLSF Min-Emission burner firing in the horizontal position in Test Furnace No. 1. The Zeeco test facility has the capability to fire burners in the upwards, downwards, horizontal and horizontally mounted, vertically fired positions.

Test Fuels: Multiple liquid and gaseous components are available in our test facility for use in simulating the characteristics of our customers' fuels.

1. Fuel gases are typically simulated by blending Tulsa natural gas (TNG), hydrogen (H2) and propane (C3H8). These are blended in proportions to closely match the specific gravity and lower heating value (LHV) of the actual fuel gas. Additional components such as nitrogen (N2), carbon dioxide (CO2), propylene (C3H6), butane (C4H10), butene (C4H8) and pentane (C5H12) can also be utilized.

2. Liquid fuels are generally simulated with No. 6 oil, No. 2 oil, naphtha, pentane, gasoline and kerosene. We will also allow customers to send us their own liquids for testing.

Simulated fuel gas components are metered with orifice runs. This accurately meters the components so that the lower heating value (LHV) and specific gravity (SG) of the test fuel closely matches that of the actual fuel gas. The components typically used for fuel gas simulation are Tulsa Natural Gas (TNG), hydrogen (H2) and propane (C3H8).

Test Points: The burner must be demonstrated over its operational range with each test fuel. A typical test includes recording performance and emission data at the following points for each test fuel:

1. Maximum heat release
2. Normal heat release
3. Minimum heat release
4. Absolute minimum heat release

Recorded Data: The following items may be recorded for each test point. The actual number of items recorded depends on the type of burner being tested and the requirements of the customer.

1. Fuel gas composition
2. Fuel oil composition
3. Fuel pressure
4. Fuel temperature
5. Fuel composition
6. Steam pressure
7. Steam temperature
8. Steam flow rate
9. Combustion air temperature
10. Ambient temperature
11. Barometric temperature
12. Humidity
13. Furnace draft (air)
14. Burner throat delta P (air)
15. Total burner delta P (air)
16. Oxygen (O_2) concentration in firebox
17. Carbon monoxide (CO) emissions
18. NOx emissions
19. Heat flux
20. Furnace temperature (top of furnace)
21. Furnace temperature (burner level)
22. Furnace temperature (stack)
23. Flame length (visual)
24. Flame length (using CO probe)
25. Flame width (visual)
26. Calibration certification
27. Noise emissions

Zeeco Data Acquisition Center. Analytical equipment is available to measure NO, NO2, NOx, CO, CO2 and O2. Test facility engineers work closely with the customer, Zeeco sales, project management and combustion equipment designers to ensure that the tested equipment meets all of the specified requirements.

Optional Emissions Measurements: If required, Zeeco will provide measurement of SOx, particulate, UHC and VOC emissions during testing.

Test Conditions versus Actual Conditions:
We use the following guidelines for closely simulating the actual furnace environment and for correlating our data to field conditions.

1. The test furnace internal temperature at maximum burner heat release will be +/ - 200°F (93.3°C) of the actual furnace temperature as stated in the customer's data sheets.

2. For applications with specified combustion air temperatures of less than 150°F (65.6°C), ambient air will used for the combustion test.

3. For applications with specified fuel gas temperatures of less than 150°F (65.6°C), the test fuels will be at ambient temperature.

4. The measured combustion air pressure drop will be corrected for the difference between the test facility and jobsite altitude and ambient temperature.

5. Correction will be made in the fuel gas properties for the test site versus specified jobsite fuel temperature.

6. The measured NOx emissions will be corrected to the actual furnace temperature as stated in the customer's data sheets.

7. When firing liquid fuels, the NOx emissions will be corrected for the test fuel nitrogen concentration versus the actual fuel nitrogen concentration as stated in the customer's data sheets.

Instrumentation for Testing

Zeeco utilizes the following instrumentation at our test facility. These instruments and a frequent calibration program help us to ensure that our test results are accurate and repeatable.

- Yokogawa differential pressure transmitter model # EJA110A
- Rosemount 1151 smart pressure transmitter model #1151GP9S22B1
- TEL-TRU 0-250 F dial thermometer model #GT300R34100466
- Ashcroft 0-250 F dial thermometer model #30E160R060
- WIKA 0-60 psig pressure gauge model #232.34
- Ashcroft 0-60 psig pressure gauge model #25W-1005 PH
- MEDTHERM Corporation heat flux probe MODEL #64P (ZNSW60) 30SB-48-21385
- Fluke multi-meter model #87
- Dwyer incline manometer model # 172
- INOTEK 36" thermocouple model # K630-36U-00-32-1
- Allen Bradley panel view model #550

Analytical equipment is regularly spanned to ensure that the information being recorded is accurate. The Zeeco test facility is ISO 9001 certified to ensure quality products and services for our customers.

Zeeco Combustion Test Facility – ISO 9001 Certified

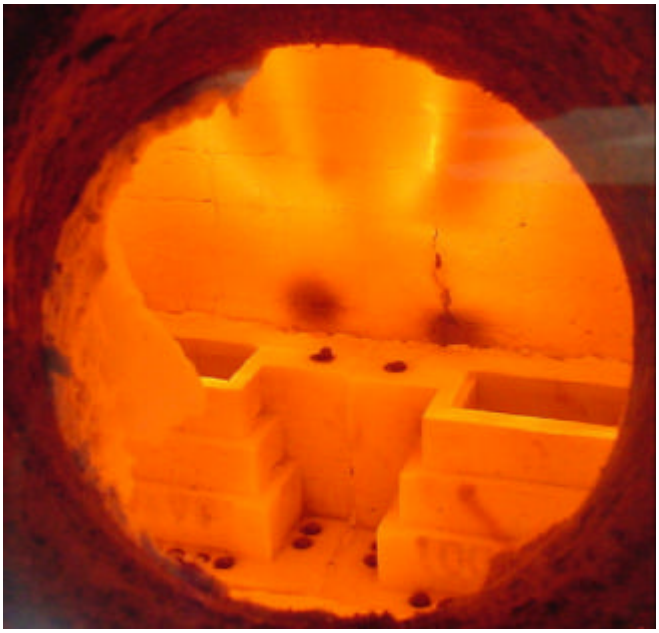
Specialty Testing

Multiple Burner Testing

Three (3) GLSF Free Jet, round flame burners in Test Furnace No 13. Testing multiple burners is sometimes required when very low emission levels are required. This assists in understanding how burner spacing and flame interaction affect NOx, CO, flame length and general burner performance.

The demand for testing multiple burners simultaneously has increased in recent years. For furnace configurations with very tight burner spacing, testing multiple burners gives a more accurate indication of actual field performance. In cases where extremely low emissions performance is required, multiple burner tests are also worth the extra time and expense. The operating parameters that can be more closely simulated through multiple burner testing are:

1. Flame interaction between burners – When multiple burners are mounted in a test heater on the spacing that will be used in the field, it can be determined if there will be any flame interaction and what the results of the interaction may be.
2. Temperature between burners – Helps determine if there may be areas with higher than expected temperatures and the effect on emissions.
3. Oxygen levels – Helps determine if there are areas with higher or lower O_2 concentrations than expected and the effect on emissions.
4. CO levels– Helps determine if there are areas with higher or lower CO concentrations than expected and the effect on emissions.
5. Flame Length – Helps determine if the flame length will be influenced by the interaction between burners.



Two (2) GLSF Free Jet, flat flame burners tested side by side in Test Furnace No. 11.

Burner Testing for Ethylene Cracking Applications

Zeeco has four test furnaces that are specifically tailored for the unique requirements of burners used in ethylene cracking service. Plans are currently underway for the construction of a fifth such furnace. Zeeco has focused a significant amount of effort on developing burners for ethylene cracking applications and as a result these have become one of our most popular burner lines.

Test Furnace No. 11 (foreground right). This ethylene cracking test furnace was built by Zeeco in conjunction with ExxonMobil. This furnace can also be used for testing burners for refinery applications. Also shown in the picture is Test Furnace No. 9 (foreground left) which is used for ethylene cracking, reforming and refinery application testing.

Test Furnace No. 7. This furnace is primarily used for ethylene cracking applications. Test furnaces 7 and 11 are identical except for the number of cooling tubes used to achieve the desired firebox temperature. Test furnace No. 7 and No. 11 have locations on the upper levels to mount two radiant wall burners so testing can be completed with hearth burners and radiant wall burners.

Test Furnace No. 1. This furnace is used for testing burners in many different applications. This furnace can be used to fire multiple burners horizontally and vertically. This unit can also be used to test high heat release forced draft burners.

Test Furnace No. 3. This vertical cylindrical furnace is primarily used for testing burners for refining applications. This test furnace has water tubes on approximately 1/3 of its internal diameter to better simulate the temperature profile in an actual vertical cylindrical furnace. Such testing gives a better simulation of NOx emissions.

Test Furnace No. 4. This vertical cylindrical furnace is used for testing smaller heat release process burners for refining applications. This test furnace has water tubes on approximately 1/3 of its internal diameter to better simulate the temperature profile in an actual vertical cylindrical furnace. Such testing gives a better simulation of NOx emissions.

Test Furnace No 5. This furnace is used for horizontal testing of burners for water bath furnaces for ethylene glycol applications. This test furnace has water jacket for cooling the firebox. Zeeco's other test furnaces use water tubes. Water tubes provide a more accurate firebox temperature simulation which provides a more reliable simulation of NOx emissions.

Test Furnace No. 6. This furnace is used for testing incineration equipment. Waste gas can be injected into this test furnace to more accurately simulate the actual incineration process. This testing capability has allowed Zeeco to successfully undertake some of the toughest incineration jobs in the world.

Test Furnace No. 7. This furnace is primarily used for ethylene cracking applications. Test furnaces 7 and 11 are identical except for the number of cooling tubes used to achieve the desired firebox temperature. Test furnace No. 7 and No. 11 have locations on the upper levels to mount two radiant wall burners so testing can be completed with hearth burners and radiant wall burners.

Test Furnace No. 8. This furnace is designed for testing radiant wall burners that are used in ethylene cracking and reforming applications. This furnace is designed primarily for single burner testing but is also capable of multiple burner testing depending on the operating requirements.

Test Furnace No. 11. Zeeco constructed this furnace in conjunction with ExxonMobil. ExxonMobil has utilized this furnace extensively to test Zeeco ultra low emission burners for their applications requiring extremely low NOx levels.

Test Furnace No. 9. This cabin furnace is used to test burners designed for ethylene cracking and reforming processes and for burners used in refining applications.

Zeeco Combustion Test Facility – ISO 9001 Certified

Test Furnace No. 12. This test furnace is designed for multiple burner testing. The dimensions of this vertical cylindrical heater are 17.5 feet (5334 mm) outside diameter x 40 feet (12,192 mm) tall. This furnace can operate with fired duties of up to 100 MM Btu/hr (25.2 MM Kcal/hr).

Test Furnace No. 13. This test furnace is designed for multiple burner testing. The dimensions of this cabin furnace are 26.75 feet (8153 mm) long X 7.5 feet (2286 mm) wide X 16 feet (4877 mm) tall. This furnace can operate with fired duties of up to 100 MM Btu/hr (25.2 MM kcal/hr).

Simulated turbine exhaust setup. Zeeco can use heat absorption to lower the temperature of the simulated TEG to approximately the same temperature as the actual installation.

Propane Tank. Zeeco has the ability to store large quantities of propane, hydrogen, No. 2 oil, and No. 6 oil so that testing can be completed in a timely manner and can be expedited in the event of an aggressive delivery schedule.

Combustion air pre-heaters. These are capable of producing simulated air temperatures of up to 800^{o}F (427^{o}C). Combustion air preheat can be applied to up-fired, down-fired and side-fired applications.

Carbon Dioxide Tank. Test fuels can be simulated by mixing natural gas (mostly methane), hydrogen, and propane together to match the lower heating value (LHV) and specific gravity (SG) of the actual fuel. Some fuels require other components such as nitrogen, carbon dioxide, butane, butane, etc.