Article Note: This is an Article I liked alot, written by Bill Spohn of Testo Instruments, Inc. and orginally published on Cole-Parmer.

Working with your digital combustion analyzer

What you can expect and why you need to use one

By Bill Spohn, Testo, Inc.

If you feel that you can "eyeball-test a flame" well enough to perform service on heating equipment, you really need to read this article right now. I shudder to think how you may be determining if a circuit is live! (Actually, you probably shudder when performing that test, too!)

Proper installation and maintenance of today's oil burners require that combustion mixtures of fuel and air are set and maintained properly. To ensure this, testing should be performed on almost every unit that you see in the course of service, and certainly on an annual basis. Appropriate draft, temperature and CO2 (carbon dioxide) readings are essential to verify proper operation. Typically, a smoke spot reading is also taken to help perform a basic combustion assessment. In addition, more and more technicians routinely take CO (carbon monoxide) readings in the building and the flue gas as a part of their regular test procedures to help insure safe operation for the home or building owner.

While comparison of annual efficiency test results gives insight into the overall health of a heating system, it can also help the owner justify the cost of new heating equipment by seeing the potential savings through annual fuel expenses. In the last five years or so, many heating oil companies have made the decision to upgrade their field service staff's manual testers to electronic digital flue gas analyzers. Traditionally, oil burner technicians have used manual combustion efficiency test equipment (or wet kit) for field service. These kits generally consist of a stack thermometer, draft gauge, wet chemical CO2 tester, slide rule and smoke pump. Although this equipment has served the industry well over the years, the need for faster, more accurate, real time flue gas analysis has become evident.

THE BASIC NEED

Tuning a system should happen in real time, not "after the fact" with a very highly "averaged" sample. (Each squeeze of a wet kit bulb represents a different snapshot of the flue gas. A traditional test blends all those snapshots together into one reading.)

Only digital analyzers allow you to take real time tests. "You cannot do a test at startup with a wet kit; it is physically impossible to take the sample fast enough and do the slide rule calculation. I consider start-up testing more important than steady-state testing when it

comes to equipment reliability. Reliability relates directly to customer satisfaction in the form of reduced call-backs," states Gary Sippin, President of Sippin Energy Products, Monroe, CT. Clean start-ups and shut-downs for an oil fired system are keys to reducing, or eliminating equipment fouling, possibly the biggest contributor to poor reliability.

TIME IS MONEY

While a traditional test kit may cost you less to buy, it costs you more to use. "We've done time trials in the field and it only takes 5 minutes, from start to finish, doing a combustion test with our Testo 325," says Sippin. "That includes set-up, measuring, (all calculations are automatic) recording and adjusting, twice, as well as taking a smoke test and a draft test. Compare that to an average of over 17 minutes with a wet-kit and you can see why we went electronic. We have found that saving several minutes per call can really add up in the long run."

Although you can get more than one hundred oxygen tests (or 300 CO2 tests) from a bottle of fluid, care must be taken in storage, handling and shipping of the fluid, as bad fluids yield bad results. Additionally, fluids may leak or evaporate from a wet kit causing inaccurate readings. The consumable cost with wet kits is about 20 to 30 cents per test and the fluids can be kept for no more that a year. The legal and environmentally conscious disposal of the chemicals in wet kits requires that they be treated as a hazardous waste. Typical costs are between $20 to $30 per bottle plus shipping costs for corrosive materials.

In comparison, electrochemical oxygen sensors cost from $60 to $150 and allow one to do a virtually unlimited number of tests in a two-year period. Remember, testing with electrochemical oxygen sensors gives digital results in less than a minute.

The historical method for testing for carbon monoxide is with length-of-stain indicator tubes. Testing with these tubes requires breaking both ends of a glass tube and manually pumping a sampler to get an average reading, not in real time. Tubes cost about $4-5 per test.

COMPLETE TESTING

With a digital analyzer, a technician can dial in a heating system, adjusting CO2, O2, CO, and stack temperature to achieve the desired settings. All competent oil burner technicians realize that visual flame analysis is not a valid way of tuning an oil burner, and, in fact, is nearly impossible on many positive pressure systems. Traditional measurements require you to become part of the analysis, interpreting fluid levels, reading needles, calculating with a slide rule, etc. That is not the role of today's technician, who should be interpreting the results and correcting the situation, working at peak efficiency.

BUILT-IN CO TESTING

Technicians can use the CO feature to detect carbon monoxide in the vent or conditioned air

and to "dial-in" a cleaner, smoke free system. "We have drawn a reliable relationship between the presence of carbon monoxide and smoke (in oil heating systems). Although this does not eliminate the need to use a smoke spot test, it does indicate whether smoke is being produced during the normal operation of the oil burner, and provides a much more accurate analysis of smoke and particle emissions," states Sippin.

IMPROVING IMAGE

In comparison, electrochemical CO sensors cost from $115 to $250 and allow an operator to do a virtually unlimited number of tests in a two to three-year period. And again, testing with electrochemical CO sensors gives you digital results in less than a minute. The heating oil business, largely, has been looked upon as an "old fashioned" industry.

"From the customer's point of view, our industry has not progressed as rapidly with regard to technology as other equipment service industries –for example the automotive service industry –has," states Tom Santa, President of Santa Fuel, Bridgeport, CT. "It's pure marketing. The proper use of modern tools can do wonders to improve your image," continues Santa.

GOOD NOTES

With the small portable, IR thermal printer, flue gas result readings can be printed on the spot and attached to the homeowner's service records. This is very impressive and very professional and validates the technician's performance findings. "Again, today's consumer is used to high tech. Show them your printed results; explain what they mean. This is a tremendous way to build confidence and trust," explains Santa.

RUGGED RELIABILITY

Like every industry, digital flue gas analyzers certainly went through their growing pains. However, today's products are built to last and sell at a fraction of where they did a decade ago.

Difficulty in following critical maintenance procedures associated with manual flue gas kits has been cause for many dealers to switch to digital flue gas analyzers. "We found that on a regular basis, most of the liquid CO2 analyzers were not maintained and filled properly with liquid. This would produce false readings (we found over half of our flue gas analyzer kits low on liquid)," states Sippin.

"Secondly, because manual flue gas kits do not allow for real time combustion analysis, technicians who are in a rush may not take the extra time to re-tune the burner properly if their 'after the fact' readings aren't ideal. This is perhaps one of the most disturbing facts of life in the heating oil business. The reality is that the "tune-up" is higher priority than the clean-up during a preventative maintenance call," concludes Sippin.

WEIGHT A MINUTE

From cell-phones to pagers to calculators and computers, the size and weight of today's electronic products are dramatically shrinking. A typical electronic tester weighs about 1.25 pounds–six with the case. Compare that to about 18 pounds for the standard oil test kit. And the electronic tester has fewer parts–two, usually, compared to between eight and ten for a typical kit (instruments, probes, etc.). Storage space is considerably less with the former as well.

REALISTIC COSTS

Realistically, a combustion analyzer should be looked at with total lifecycle costs in mind. Beyond the cost of acquiring the product with all the features and accessories you need to do an efficient and professional job, you will need to keep it in "good tune" to be able to get the most our of your investment.

Beyond the $1000 (typical kit) cost for a high quality, digital combustion analyzer with a case and printer, over the course of eight years, it may cost you from $500 to $3000 more in service costs, depending on which analyzer brand you choose, how much you use the equipment and how well you care for it.

FOR SERVICE

Most digital analyzer makers recommend factory service, usually the best route since an experienced technician (with all the manufacturer's resources) will be able to review and quickly diagnose the problem. But this top-notch service, as mentioned above, is costly and requires you to relinquish the analyzer during the service period. Some manufacturers provide kits to replace sensors and for simple repairs. It may be a viable option, as the analyzer downtime is virtually eliminated.

CALIBRATION TIME

Several electronic sensors are embedded in today's digital analyzers. There are four main sensor types: Two of the sensors, temperature and pressure, are solid-state and, therefore, do not require calibration or adjustment unless mishandled or damaged. The other two are electrochemical gas sensors that detect CO and Oxygen'; they are essentially miniature, self contained chemical labs. As such, the chemical reactions may change with varying conditions including the age of the sensor and its storage conditions.*

Therefore, the electrochemical sensors will need periodic calibration to provide you with accurate results. Oxygen sensors are auto-calibrated by the analyzer at start up in most analyzer models. Usually a warning sign is given if the sensor is not able to be calibrated, thus protecting you from bad test results. If an oxygen sensor needs to be replaced, you can expect to pay from $60 to $150 depending upon model.

You can expect a little over two years service life out of today's oxygen sensors (most new oxygen sensors are warranted for two years.) Despite what you may have heard, unfortunately, it is not possible to significantly extend the service life of today's oxygen sensor by refrigeration or oxygen deprivation. Sensors have a shelf life, so should not be purchased and stored for extended periods. Although it might be desirable to keep a spare on hand, an unused sensor can expire in less than three years without any fault on your part.

Carbon monoxide sensors usually last from three to five years if well cared for. To achieve optimum accuracy, CO sensors will require periodic (every 6 to 12 months) recalibration. We recommend an annual calibration check. This re-calibration is best performed by a factory trained service technician, as it involves the use of expensive and toxic reference gases, costly gas valves and regulators, proper equipment setup including exhaust fans and training that is hard to justify for most contractors. You can expect this calibration to cost from $75 to $150 or more depending upon what components are deemed to be at fault. CO sensors are typically priced at $250 to $300.

WHAT YOU CAN DO TO KEEP THINGS OPTIMIZED

Know your analyzer: Study the manual, take the time to learn the ins and outs of the product during a quiet period, before you expect it to perform for you. Remember: you are part of the combustion analysis process; how you set up, use and maintain the meter as well as how you interpret the results is crucial to getting good measurements. Be sure to follow the manufacturer's recommended maintenance and service procedures.

Digital analyzers come with several layers of protection for keeping all the components intact and properly functioning for you. These include the basic housing and construction of the analyzer), a slip over "boot", usually with a magnet (to keep the unit hands free, in-sight and out of harms way) and a carry case, usually with a nest designed to cradle the analyzer. In addition, most manufacturers ask that you not expose the analyzer for extended periods of time at or below freezing temperatures, as this has an impact on sensor life. Take a moment to note these features of your new or prospective analyzer and be sure to USE all features properly.

WET CONDITIONS

Typically, every digital analyzer has a means to remove excess moisture from the gas sample to protect the pump and sensors. This condensate removal system (typically called a water trap) will need to be emptied when nearing the "full mark". The rate at which the water trap fills up depends upon the amount of moisture in the gas sample and the flow rate through the analyzer; therefore it is difficult to estimate how long it will take to fill it up. At a minimum, the water trap should be emptied after testing when you are preparing to leave the worksite. Remember, the water in this trap will be mildly acidic due to some of the flue gas components.

FILTERED INFO

In addition to water removal, many digital analyzers include a way to trap particles in the flue gas stream before they reach your pump and sensors. Just like an air filter in your car or truck, you must periodically change this filter to keep your system optimized. Depending on the type of heating equipment you service and how often you do a combustion test, filter replacement may be a frequent activity. Be sure to look for a filter that is easily seen and replaced.

INSTRUMENT STORAGE AND HANDLING

Electrochemical analyzers rely on a chemical reaction similar to a car battery. Like a car battery, when they are cold, they are less energetic. Most analyzers are compensated to handle operating in a wide temperature range, but they all have their limits. When it gets too cold, they can freeze. When they get too hot, they overreact. The normal operating range for most flue gas analyzers is between 40° and 110°F. So, if it is going to be very, very cold… don't store it in your truck or unheated garage as you may freeze it and damage it. Bring it inside overnight. In the summer, don't leave it inside your truck since temperatures can reach over 135°.

FRESH ADVICE

The best friend (besides you) for your digital flue gas analyzer is fresh air. Fresh air is the best way to rinse or clean the toxic gases from the sensors. These gases, left exposed to the sensors over time, will shorten their life expectancy. Therefore it is wise to run fresh air through your analyzer for several minutes after running any flue gas test. It is also recommended that any time you are not actively taking a measurement, turn your analyzer pump "off" until you are ready to take a reading.

Fresh air is used as the zero reference for calibrating the CO sensor and setting the oxygen sensor at 20.9%. If the "zero-reference" fresh air has CO contamination (as sometimes occurs in a house) the analyzer zero point be set wrong and you will never see those contaminations. If ambient CO is suspected, start the analyzer (which will zero it) outside or anywhere the air is known to be clean. And never calibrate the analyzer when the probe is in the stack–this is NOT FRESH AIR!

In the most basic sense, a digital analyzer uses temperature and oxygen sensor data and a series of fuel specific equations to arrive at efficiency readings. Two temperature inputs are needed, the air temperature before (combustion air) and after combustion (past the last heat exchanger). The combustion air temperature is usually assumed to be constant during a combustion test and at the same temperature as the ambient air. Therefore, this value is taken as a "snapshot" during instrument warm up. So, be sure to have your probe in an area representing the temperature of the combustion air. If you need to continuously measure combustion air temperature, dynamic readings are accepted by most analyzers through the

use of a second thermocouple attached to the analyzer and suspended in the combustion air stream. This provides for continuous updates of differential temperature for use in the combustion equations.

**Digital combustion analyzers use an oxygen sensor and a fuel-based calculation to give you a calculated CO2 reading. This requires that you be sure to enter the correct fuel code choice when prompted to by your digital analyzer.*

The author, Bill Spohn, is the HVAC Product Manager for Testo, Inc. which makes handheld analyzers. He has an MS in Mechanical Engineering, is a licensed Engineer in PA, and has designed and marketed test instruments for over 15 years. Testo manufactures over 50 digital hand held instruments for HVAC/R diagnostics. This article is excerpted from an article the author wrote for Oilheating in 2000.