WPCA NEWS
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www.wpca.info

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Executive Summary

Precipitator Power Supplies: Use of 60 Hz TR's at 400 Hz

By H. J. DelGatto, Redkoh Industries (h.delgatto@hotmail.com)

Converting the SCR's to mid-frequency IGBT's for existing TR sets, could be a solution to getting more power to the plates for all ESPs without the expense of converting single phase 480 watt to 3 phase systems. However, consideration should be given to assessing the correct derating factor for 60 Hz TR's being converted to 40 Hz. ***Full Story….***

Hybrid Dry-Wet ESP™ Approach offers Reduced Opacity

By James "Buzz" Reynolds, Vice-President, Wet Electrostatic Precipitators, Siemens Energy, Inc (Jamesreynolds@siemens.com)

An alternative approach to installing fabric filters to meet more stringent regulations is the addition of a wet ESP field after the existing dry ESP. This option is viable for plants with limited space, fan capacity and capital. EPRI is currently funding a pilot scale R&D project of the Hybrid Dry-Wet ESP technology at Southern Company's Plant Miller. Initial testing of mercury showed >95% removal of particulate mercury. ***Full Story….***

Detection Limits in Stack Testing: Bringing It All Together

By Scott Evans, Clean Air Engineering (sevans@cleansir.com)

In the last two articles of this series, some of the theoretical foundations of detection were established. The top ten points to remember were listed. The article goes on to show how one uses this information to deal with detection issues that come up when measuring low concentrations. ***Full Story….***

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Precipitator Power Supplies

Use of 60 Hz TR's at 400 Hz

By H. J. DelGatto, Redkoh Industries
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Introduction

Since the 1990's the use of higher frequency Switch Mode Power Supplies (SMPS) has gained increased acceptance in the Electrostatic Precipitation industry. Several High Frequency SMPS systems available operate under resonant mode technology with resonant frequencies in the 20,000 Hz range. Other products, Medium Frequency Power Supplies (MFPS), are available operating in the more modest frequency 400 Hz. Both of these approaches offer the important benefit of decreased voltage (KV) ripple which results in increased average KV and increased average power delivered to the ESP field. In practically all cases, the increased power results in better ESP performance and decreased emissions.

Figure 1:

ESP Field Ripple Reduction and Time Constants

The charging of an ESP field is essentially a pulsing technology. The KV is pulsed by the power supply. The decay of the KV occurs between pulses and the amount of decay results in ripple, and is a function of the characteristics of the ESP field, as well as the flue gas and the collected particle build up. The ripple magnitude is dependent upon the effective capacitance of the field and the effective resistance of the field. The multiplication of these two parameters is referred to as the time constant and is the time required for the voltage to lose 63% of its value if allowed to decay. For example if the voltage was charged to 100 KV in one such time constant the voltage would decay to 37 KV. The time constants of a ESP field varies with all operating conditions of the field. A time constant of about 20 to 50 milliseconds is commonly observed. For a field with a 50 msec time constant a 60 Hz TR would yield about 15% P-P ripple and an average voltage of 92 KV. An MFPS, 400 Hz system yields approx 2 % ripple with average of 99 KV and a 3 KHz yields < 1% ripple with an average voltage of 99.8KV. The 3 KHz is used in this discussion since resonate mode SMPS resonate at frequencies of 20,000Hz but actually pulse at a lower rate.

Kilo Hertz SMPS Systems

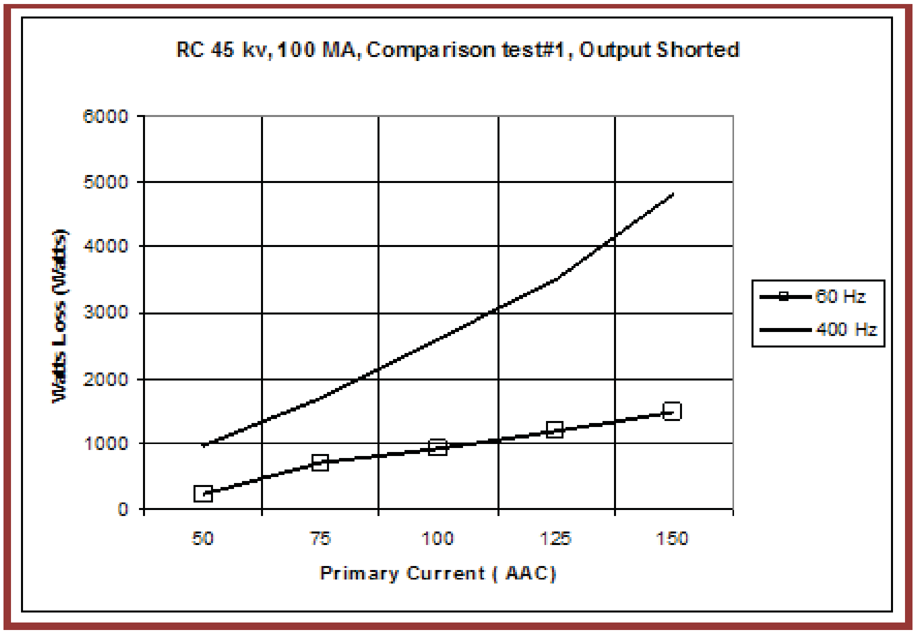
In order to make use of the higher KHz frequency a complete change over of the TR, CLR and Control is required. The higher frequency SMPS are smaller and lighter then the 60Hz TR's they replace and necessarily integrate the electronics, the power switching transistors (IGBT's) with the step up transformer and rectifier assemblies. The complete package must be mounted as close as possible to the ESP field since long conductor path between the SMPS and the load (ESP Field) cannot be easily tolerated. Because of these requirements, three phase (3 Φ) AC 480VAC feed must be routed to the location of the power supply, which is usually on the roof top of the ESP. Readout and controls for such installations is accommodated through the use of digital communication links between the SMPS on the roof and a convenient location for personnel observation and recording.

Unlike the higher frequency KHz SMPS requiring the complete change out of all old 60 Hz components and rerouting of power feeds; the 400 Hz, MFPS permits the use of many of the existing components as well as the use of in place power and readout facilities. A most important possibility for change over to a 400Hz MFPS system is the potential for the use of the existing 60Hz TR and the existing field wiring.

400 Hz MFPS Systems

The lower frequency (400 Hz) MFPS TR offers a modest level of size and weight reduction as compared to a 60 HZ TR. As is described the above example MFPS provides ripple reduction very close to that of the higher (KHz) frequency units. Often time the need for additional field power is accompanied by a situation where the existing TR is running well below the TR ratings. In such cases, especially when the existing 60 Hz TR is in good shape the use of the old TR at 400 Hz should be investigated.

This approach permits the use of existing equipment locations and may also permit the use of existing controls and CLR's. The installation can simply consist of removing the SCR assemblies and replacing the SCR assembly with an IGBT inverter system. The question of whether or not the existing TR can be used depends upon many factors, most important of which is the TR current rating and the operating level. Unquestionably the TR rating must be reduced by some level to allow such use at 400 Hz without over heating.



Actual Test Data and Results

Lab tests were conducted using two different TR's, approximately 20 years old, which were sold under the Research-Cottrell label. Tests were conducted by running the same TR under short circuit secondary conditions at the rated current both under SCR 60 Hz control and under MFPS control. The TR's are both rated at 45KV and 1000 ma. Watt loss was measured using a lab type wattmeter connected to the primary voltage and current. The tests were done at different locations by different test teams using different set up.

The chart is from data taken using a shorted TR output. The primary was driven by a conventional a SCR controlled power feed for the 60 Hz data and a 400 Hz, MFPS controller for the 400 Hz data. The data shows loss at rated current of 4,800 watts at 400 Hz and 1,500 watts at 60 Hz. If the estimated magnetizing loss is added back in the results show about 2,500 watts at 60 Hz and 5,300 watts at 400 Hz.

A similar test was done at a alternate location using a sine wave excitation for a similar TR. The shorted output readings for that test were approximately 910 watts at 60 Hz verses 2,500 watts at 400 Hz. If the magnetizing losses are again added back the data indicated losses of about 2,000 watts verses 3,000 watts.

Summary and Conclusions:

A theoretical analysis of the implications of using conventional 60Hz TR at the higher frequency of 400 Hz was conducted. In addition, two (2) different lab tests were conducted to produce actual loss data from older Research-Cottrell TR's rated at 45KV and 1000 ma. The mathematical analysis indicated that the TR will perform well under the higher frequency but will experience somewhat increased losses. The increased losses from the paper study indicate an increase in loss of from 50% to 100%. Experimental data using sinusoid power yielded an increase of 50%. Experimental data using phase controlled SCR's at 60 Hz and actual TR Controller at 400 Hz yielded an increase in loss of 100%.

The conclusion thus offered is that:

- 60Hz TR may be used at 400 Hz higher frequency providing they are suitably de-rated to preclude over heating.
- The amount of de-rating necessary depends upon the environment at which the TR is subject to.
- *It is recommended that using a 60 Hz TR at 400 Hz can be done up to 50% of its nameplate milli-amp rating. The 50% de-rating results in the unit operating within its design temperature limits.*
- *Using the TR above 50% may be possible but it is recommended that temperature rise tests be conducted prior to long term use at such higher ratings.*

Hybrid Dry-Wet ESP™ Approach offers Reduced Opacity

By James "Buzz" Reynolds, Vice-President,
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An issue now confronting coal-fired power plants with undersized dry ESPs or where low NOx burners have been installed with greater levels of unburned carbon in the fly ash, is visible opacity. Additionally, some state regulatory agencies are starting to require less than 20% opacity levels and EPA's PM$_{2.5}$ regulations will start to apply in the coming years both of which will require greater control of fine particulate (PM$_{2.5}$). To meet these emission challenges, conventional wisdom says that a fabric filter should be installed to capture the fine particulate. However, this option may not be viable for those plants with limited space, fan capacity and capital.

An alternative approach to consider is addition of a wet ESP field after the existing dry ESP. The Hybrid Dry-Wet ESP™ uses little additional space if the wet field is added after the dry ESP or perhaps even within the same footprint, should the last field of the dry be replaced and retrofitted with a wet field. Because of the open design of a wet ESP, which is similar to that of a dry ESP, only ½ " w.c. pressure drop is added, allowing for use of the existing fan. Finally, adding a wet ESP field after the dry ESP has no impact on upstream equipment or contamination of fly ash.

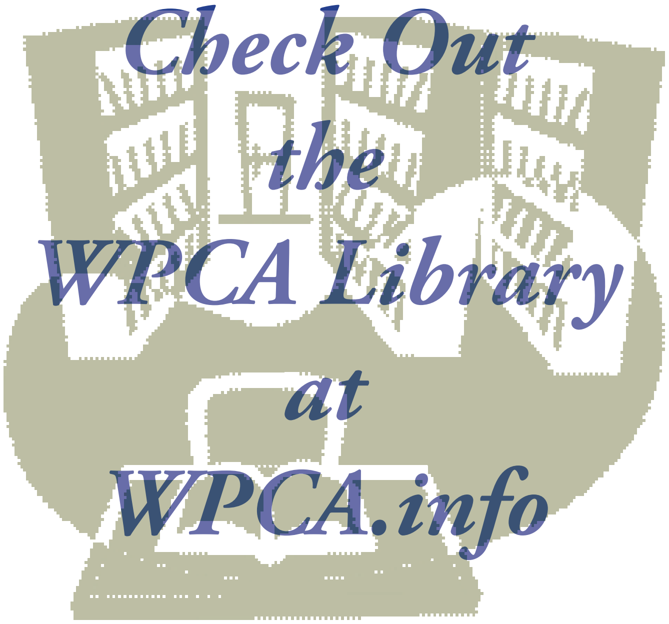
Wet ESP technology is a well-established technology for control of sub-micron particles, mists and droplets meant to be used as a final polishing device. While dry ESPs can typically achieve 100 mg/nm^3 removal of PM$_{2.5}$ and FGD systems can achieve levels of 30 mg/nm^3, wet ESP technology can achieve emission levels down to 5 mg/nm^3 and less than 10% opacity levels. Additionally, a wet ESP can remove sulfuric acid and some mercury.

Unlike typical wet ESP applications where the wet ESP follows a wet scrubber and the gas is saturated, the Hybrid Dry-Wet ESP™ approach requires keeping the flue gas temperature well above saturation, so as not to create any corrosion issues in downstream carbon steel duct or in the stack. The wet ESP module itself would be constructed of a high-grade stainless steel because of the use of water to keep its collection surfaces wet and clean. A wastewater recycle system is needed to treat the wastewater, concentrating the pollutants captured and making a smaller volume of waste. The treated wastewater is recycled back into the wet ESP, minimizing the bleed stream.

The Electric Power Research Institute is currently funding a pilot scale R&D project of the Hybrid Dry-Wet ESP technology at Southern Company's Plant Miller, which burns PRB coal. Initial testing on mercury showed >95% removal of particulate mercury, a proxy for fine PM, with the addition an irrigated wet ESP field operating at @200F after the dry ESP.

Figure 3:

The Hybrid Dry-Wet ESP approach should be considered by older, smaller plants with undersized dry ESPs where installing fabric filters is problematic to achieve the co-benefits of PM 2.5 and SO$_3$ removal for opacity reduction.



Detection Limits in Stack Testing: Bringing It All Together

By Scott Evans, Clean Air Engineering
(sevans@cleansir.com)

In the last two articles of this series, some of the theoretical foundations of detection limits were established. The top ten points to remember are:

1. Detection limits are an indicator of measurement variability (precision) near zero. They are all about repeatability, not accuracy (bias). The assumption is that the measurement is free of significant bias.
2. Stack testing involves both field sampling and laboratory analysis. Most of the variability for a test method occurs with sampling, not with analysis. Detection limits based solely on the variability of laboratory analysis are, therefore, far lower than the actual "in-stack" detection limits. The detection limits stated in most EPA methods are based solely on the laboratory portion of the method.
3. Reliance on detection limits found in Reference Methods promotes the expectation that meaningful measurements can be made at unrealistically low levels.
4. EPA guidance on "in-stack detection limits" does not solve the problem. All EPA suggests is to take the unrealistically low analytical detection limit and multiply it by a flow rate resulting in an unrealistically low mass emission rate.
5. When an emission limit or a performance guarantee is set below the true in-stack detection limit, you do not need to perform a stack test to determine compliance. Just flip a coin. It's cheaper and the result is the same.
6. Deciding where to set a detection limit is a matter of policy, not science.
7. Detection limits are defined differently by different organizations. If your lab data indicates a non-detect, find out from the lab exactly what that means.
8. Data that is less than an established detection limit contains valuable information and should not be censored (i.e. no "< x"). Always ask your lab to provide raw (uncensored) data.
9. Extending sampling time does not necessarily result in lower detection limits for test methods with sampling bias issues (e.g. Method 8, Method 202).
10. The only way to determine whether or not you are measuring noise is with paired sampling trains. When in doubt, double up.

So how does one use this information to deal with detection issues that come up when measuring low concentrations? In this final article, we will address common issues that arise when looking at stack test data.

Laboratory Non-detects

If paired trains are not used, the only indication of detection limit comes from the lab data. It is important to remember that laboratory detection limits are not based on the samples you submit. They are based on detection limit studies that are conducted periodically by the lab. Labs are continually trying to minimize their detection limits by controlling variables that can affect results. This is great for the lab data, but not so great if these ever-lower detection limits are used as an indicator of what you can actually measure in the stack. The fact that your lab results are above the lab detection limit is no guarantee that you are not measuring noise.

But in many cases, lab detection limits are all you have. So how do you handle lab non-detects? First, try to avoid them altogether. In some cases, if you know the concentrations will be very low, you can extend the sampling time to collect more of the desired analyte. But be careful here. Longer sampling times can also increase bias in methods that produce sampling artifacts. It is pointless, for example, to extend the sampling time for Method 8 testing on a coal-fired power plant. Use of Method 8 in this situation is bad enough as it is, but when you sample for longer periods of time, the bias produced by the oxidation of SO_2 to SO_3 simply increases as the test goes on. You will certainly get a result at the end of the test, but it is anyone's guess how much of that result is actual SO_3/H_2SO_4 in the stack and how much is sampling induced bias. Method 202 for condensable particulate suffers the same problem.

Let's assume that you have done everything you can but the lab data still comes back as non-detect. Most test methods are silent on how to deal with non-detects. EPA's Emission Measurement Center states on its website that "No general guidance can address all the possibilities, so you must decide how to handle this on a case-by-case basis." Therefore, it is important when measuring low-level analytes, that the testing stakeholders clearly establish how lab non-detects will be handled.

Possibilities for handling non-detects include:

1. Reporting actual raw data values with associated detection uncertainty (my preferred approach discussed in previous parts of this series)
2. Reporting all non-detects as the detection limit with a less than sign (i.e. <3.5). While this is the most conservative approach, it is impossible to incorporate

the less than sign in future applications of the data (e.g. dispersion modeling) so the sign may be dropped if the data are used in further analysis. Use of this value without the sign implies higher emissions (sometimes significantly higher) than are actually present.

3. Use something other than the detection limit (i.e. zero or half the detection limit) along with the less than sign.

There are many reasons why censoring data at the detection limit or other value is not a good idea. These have been discussed in previous parts of this series. But there is another caution in the use of this approach that has not been discussed. Many manual stack test methods involve rinsing various parts of the sampling apparatus as part of the sample recovery procedure. Some methods may result in two or even three "rinse samples" which may be analyzed separately. The analytical results from these rinses are then added together at some point in the data reduction process to produce a final total result. Therefore, if multiple rinse samples come back as non-detects from the lab and the lab detection limit is substituted for each one, the positive bias created by using the detection limit in place of the actual data is multiplied. This increases the possibility that a limit or guarantee may be breached even though "real" emissions may be far less.

Hopefully it is evident that lab non-detects may cause many issues of limits or guarantees are set too low. So what can you do to try to avoid these issues? Laboratories know what their detection limits are for a given analytical method and a given analyte. Before the test, ask the lab what their limit is. You will likely have to convert from something like μg/L to the engineering units for the test. Once this is done, if the laboratory detection limit is less than the permit or guarantee limit, then theoretically you should be fine. If the laboratory detection limit is above the permit or guarantee limit, you have several choices.

1. Look at the possibility of extending sampling time to achieve a lower detection limit (see caution above).
2. Look at alternative analytical techniques that could provide a lower detection limit.
3. Find another lab. Detection limits are lab specific, some labs may claim lower limits.

However (and I know I have said this many times, but its important), results above the laboratory detection limits do not guarantee you are not measuring noise because they do not include the sampling variability.

General Guidance for Low Level Testing

It should be clear by now that testing at very low levels for any analyte is a very challenging task. The best way to avoid detection limit issues and biases is to minimize factors that affect test results. The following are some thoughts for improving the odds of collecting useful data at low concentrations.

1. Experience, experience, experience. There is no substitute for experience when performing low concentration measurements. Often very small problems in testing performance translate into very big errors in data. When contracting for testing, make sure to ask about tester experience with low level testing. Company experience is almost irrelevant. You want to know the experience of the actual individuals who will be doing the testing for your project. While it is no guarantee of quality, use of firms accredited to the ASTM D7036 testing competency standard may improve the odds of collecting good data. Similarly, laboratories doing the analysis should be accredited either to ISO 17025 or to the NELAC standards. Specify these accreditations in your contracts.

2. Watch out for small biases. Most EPA test methods are not designed for low level testing. Many methods can be improved with modifications. For example, with some analytical methods, use of a glass fiber filter can cause about a 0.3 ppm positive bias in sulfates. This bias is insignificant when measuring at higher concentrations but what if your limit is 0.5 ppm? Then it becomes a big deal. Substituting quartz filters solves the problem. Review the test methods to be used for your project in advance with your tester to identify and correct any potential bias issues. Do not assume that a standard, unmodified EPA method will do the job.

3. Use of blanks. Contamination is one of, if not the predominant, issue at low concentrations. All reagents used should be analyzed for contamination immediately <u>prior</u> to the test. Field reagent blanks should also be submitted with the lab samples. Consider taking a train blank at least once during the test program.

4. Cleanliness is paramount. Strict adherence to glassware cleaning procedures is critical to minimizing glassware contamination. If necessary, enhanced glassware cleaning procedures (e.g. prolonged baking, extra rinses) may be implemented. Also, a clean area for field glassware prep and sample recovery is important. An often overlooked issue is the cleanliness of the sample line used. Lines used for sampling dirty, high concentration sources should not be used for low-level tests.

Conclusion

For the first 30 or 40 years of air emissions testing, there was never a major concern over detection limits or low level testing. There were not a lot of low-level sources around to measure. But, as we bump up against detection limits more and more as limits go lower and lower, it becomes more important to understand how to collect valid data and how interpret results at these very low levels. When measuring low level sources today, we face problems with inadequate test methods, inadequate testers, and inadequate knowledge. Some of the method problems may be solved as technology improves, particularly as continuous monitors replace manual source test methods. Testing companies will continue to improve their low level testing abilities as they develop better quality systems and gain more experience. And finally, I hope this series improved your knowledge of a few of these issues as well.

WPCA Illinois Technical APC Seminar

August 3-4, 2010 / Crown Plaza Springfield Hotel, Springfield, IL

Registration information at www.wpca.info

Why Attend

A WPCA Operating and Maintenance Seminar focused on the unique Illinois Air Pollution Control problems. Discuss with other users and industry experts issues related to mercury, SOx, particulate and SO_3 control by the following equipment:

- **Electrostatic Precipitators**
- **Fabric Filters**
- **Dry Scrubbers**
- **Wet Scrubbers**

Who should Attend

Air Pollution Control (APC) equipment users will find the technical networking and O&M expert presentations at the WPCA Seminar an invaluable tool to handle APC problems at their generating plants. The solutions and contacts obtained at the seminar go beyond the two day meeting and helps throughout the year.

When/how should you Attend

- August 3-4, 2010
- www.wpca.info - register online
- Crown Plaza Springfield Hotel, Springfield, IL
- Room rate: $110.00 / block name: WPCA Regional Seminar
  - One day registration: $100.00
  - Two day registration: $175.00

WPCA Illinois Technical APC Seminar

August 3-4, 2010 / Crown Plaza Springfield Hotel, Springfield, IL

Tuesday – August 3, 2010

8:00-9:00	Registration	
9:00-9:15	**Welcome** *by Rich Staehle, Marsulex and Chairman of WPCA*	
9:15-9:30	**Safety Tip** *by Scott Williams, Duke Energy (President of WPCA)*	
9:30-10:30	Impact of Combustion on Particulate Collection *by TBD*	
10:30-11:00	Break	
11:00-12:00	90% Mercury Removal - Control Technologies *by TBD*	
12:00-1:00	Lunch for all attendees	
1:00-2:45	**ESP Workshop** ESP Fundaments; ESP controls; TR selection; gas distribution	**Fabric Filter Workshop** Fabric Filter Fundaments; baglife; baglife assessment; FF O&M
2:45-3:00	Break	
3:00-4:00	ESP O&M	FF O&M
4:00-5:00	Biomass Co-firing in Illinios	

Wednesday – August 4, 2010

8:00-9:00	Registration	
9:00-10:00	Ash Ponds etc.....what does the future hold?	
10:00-10:30	Break	
10:30-11:15	SO3 Mitigation	
11:15-12:00	**HAPS/MACT**	
12:00-1:00	Lunch for all attendees	
1:00-2:45	**Wet Scrubber Workshop** Wet Scrubber Chemistry	**Dry Scrubber Workshop** Dry Scrubber Fundamentals
2:45-3:00	Break	
3:00-4:00	Wet Scrubber O&M	Dry Scrubber O&M
4:00-5:00	CFB Scrubbers - way of the future?	

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