

Screening out the undesirables **LPA Screens: Utilities Need a Proven Solution**

By Hans Hartenstein, Project Manager, Steag LLC

The presence of LPA (large particle ash) or popcorn ash poses a serious concern for many coal-fired utility boiler operators after retrofitting their units with high-dust SCR systems. LPA is formed in the boiler and can be easily carried over into the SCR reactor. As LPA is introduced to the SCR reactor it frequently causes:

- **Catalyst pluggage, which leads to**
 - **Flue gas maldistribution**
 - **Loss of SCR performance through loss of available DeNOx potential**
 - **Unacceptable NH₃ slip**
 - **Excessive pressure drop**
- **Catalyst erosion damage**

Many unsuccessful attempts were made in the industry experimenting with various types of LPA screens, i.e. hard framed, flat screens (straight or angled) and flexible curtain type screens (straight). None of them appear to perform satisfactorily in the long term.
continued on page 5



Figure 1:
Steag's Patented LPA Screen Design

School's in! **Back to FGD Basics**

By Ronald Richard, Consultant, EPSCO International Ltd.

Today's power plant operators are faced with many pressures. Knowledgeable people are taking early retirement offers. Operating and maintenance budgets are being cut. Staffing levels are being reduced. The time between maintenance outages has been extended. FGD operators are looking for the "magic cure-all" that will solve all their operating and maintenance problems.

I have seen major improvements in scrubber efficiency and reliability and major reductions of operating and maintenance costs just because the scrubber operators put a renewed emphasis on the basic design parameters of their system. In some cases they have forgotten the basics, but in today's environment many of the scrubber operators are new in their jobs and don't know the basics. I will only be able to cover a few of the items in this article.

pH

In a limestone scrubber, one is faced with two opposing

curves in relation to pH. At a lower pH, the limestone dissolves more quickly and is used more fully, but the SO₂ removal is less. At a higher pH, more SO₂ is removed, but less of the limestone is utilized. The two curves cross at a pH near 5.4 depending on system specifics. If the cost of reagent is of most importance, the system can be operated at a slightly lower pH. If the need for high SO₂ removal is of most importance, the system can be operated at a slightly higher pH.

continued on page 5



Ammonium Sulfate Scrubbing	page 2
Data Overload	page 2
Hybrid Dry-Wet ESP™	page 3
Correct ESP Control Response	page 4

Ammonia's not just for NOx anymore! Ammonium Sulfate Scrubbing

By Michael Walsh, Vice President of Engineering, Marsulex Environmental Technologies

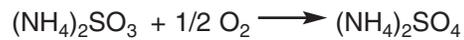
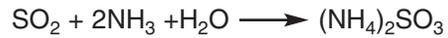
In Marsulex's patented "AS" (ammonium sulfate) FGD process, SO₂ scrubbing is accomplished using a solution of AS in a spray tower. Anhydrous or aqueous ammonia is used as the reagent for SO₂ absorption. The FGD byproduct is a high quality, marketable chemical widely used as crop fertilizer.

Primary SO₂ reaction products are converted to AS through forced oxidation in the absorber. The scrubbing liquor becomes saturated with AS, and AS is continually crystallized in suspension. By maintaining proper liquor recirculation rates and liquor pH, ammonia slip from the FGD is kept at acceptably low levels

A bleed stream from the absorber is first dewatered in a set of hydroclones followed by a centrifuge to generate an AS product cake of approximately 98%+ solids. The recovered liquid is recycled to the absorber. This centrifuge cake is further processed in a dryer/cooler and subsequent compaction granulator to make final ammonium sulfate product with <0.5% moisture content. The dried AS fertilizer granules are the final byproduct.

Figure 2:

Ammonium Sulfate Process Chemistry



For every pound of SO₂ removed:

- Need one-half pound Ammonia
- Produces two pounds of Ammonium Sulfate

One pound Ammonia generate four pounds Ammonium Sulfate

4:1 product / feed ratio generates favorable economic leverage

Process Chemistry

The absorber is a contacting device between hot flue gas (typically >325° F) and saturated AS scrubbing liquor (130-150° F). *continued on page 6*

Do you know your coal flow? Data Overload

By Alan Paschedag, Manager, Engineering, Advanced Burner Technologies

The basis for the good design of low NOx burners is reliable data and good judgment. You may then ask, when is too much data a problem? I'm glad you asked. When presented with data that conflicts itself, a dilemma arises as to which of the collected data is most accurate. Data overload!

As the NOx levels keep plummeting, relying on accurate design data becomes much more critical than it has ever been. At the currently achievable NOx levels every 0.01 lb/MBTU of NOx require extremely accurate design information as well as precise control of all parameters during the operation of the equipment.

Coal-fired boilers comprise a high percentage of utility boilers that are targets for retrofits involving low NOx burners. Coal flow and the associated primary air flow both figure prominently into the design and performance of new low NOx burners being installed in an existing boiler. Therefore, accurate determination of the coal flows upon which the design will be based are imperative.

Coal flow sounds like a simple enough operating parameter

"Coal flow sounds like a simple enough operating parameter to obtain. The difficulty is in the number of ways available to determine the coal flow."

to obtain. The difficulty is in the number of ways available to determine the coal flow.

Coal flow can be measured utilizing a dirty air pitot, a rotoprobe or one of the new microwave devices. Typically only one of these methods is chosen for measuring the coal flow

in the coal pipes leaving the pulverizer. This test would be run prior to designing new burners to establish the design coal flow rates.

Even this seemingly straight forward method of determining coal flow may be complicated by off design boiler conditions. When the boiler operation is impaired or limited during baseline testing (performed to confirm design conditions), the resulting coal flow does not represent the "normal" coal flow. Measuring the coal flow under impaired conditions results in adding another uncertainty to the determination of the actual design condition coal flow. The coal feeders, which feed raw coal into the pulverizers, have a factory weighing and calibration system built in. The feeders are calibrated and coal flow is then a function of the feeder speed.

continued on page 7

An ESP that's not "all wet"

Hybrid Dry-Wet ESP™ Approach offers Multi-Pollutant Capability

By James "Buzz" Reynolds, Vice-President, Wet Electrostatic Precipitators, Wheelabrator Air Pollution Control Inc.

One issue now confronting coal-fired power plants burning sub-bituminous and lignite coal with only dry ESPs installed is the high level of elemental mercury concentration. Secondly, where low NO_x burners have been installed and the level of unburned carbon in the flyash has increased,

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/Nm³ removal of PM 2.5 and FGD systems can achieve levels of 30 mg/Nm³, wet ESP technology can achieve emission levels down to 5 mg/Nm³ and less than 10% opacity levels. Additionally, a wet ESP also provides trace removal of SO₂ and mercury.



Figure 3: Hybrid Dry-Wet ESP™

opacity will have also increased. Finally, EPA and the states will begin to regulate PM 2.5 starting in 2007. To meet these emission challenges, conventional wisdom says that a fabric filter with carbon injection should be installed. However, this option may not be viable for those plants with limited space, fan capacity and capital.

An alternative approach is to add a wet ESP field after the existing dry ESP. This Hybrid Dry-Wet ESP™ (Figure 3) concept offers the ability to collect multiple pollutants. 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 1/2 inch w.c. pressure drop is added, minimizing energy costs. Due to the wet ESP's small size and lack of moving parts, maintenance and capital costs are only marginally affected. There is no impact on upstream equipment or contamination of fly ash.

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 (EPRI) 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 total mercury showed 40%-50% removal with a plasma enhancement technology incorporated. No PM 2.5 or SO₃ testing was done at this time. Further testing will be done in the fall of 2005 and spring of 2006.

The Hybrid Dry-Wet ESP™ approach should be considered by older, smaller plants with undersized dry ESPs where installing fabric filters is problematic, reduction of PM 2.5 and SO₃ is needed to reduce opacity and some mercury control is required. 🌐

For more information, contact James "Buzz" Reynolds at jreynolds@wpc.aquilex.com

Believe it... or not! Correct Electrostatic Precipitator Control Response ...Wrong Reason

By Paul Ford and Peter Aa, Redkoh Industries

Ever had that feeling that something's "NOT QUITE RIGHT" with your Precipitator Controls System?

You've spent many hours staring at the meters, had operators take massive amounts of electrical reading data, used the serial link to gather huge amounts of "real-time" data, spent weeks analyzing it all and still felt that something's happening that you can't quite pinpoint? You have the same controls at a sister plant or unit and all is just fine over there, so you know there's nothing inherently wrong with the design.

Even So!...Poor precipitator performance can in a great many of the instances be traced back to a TR control that is not operating properly. The hard part is to find out exactly **what** is not working properly.

Here is an example of what we are talking about:

A perfectly timed and controlled response in the face of a non-existent condition can really mislead you. In this scope picture (Figure 4) we can see that the secondary current (the bottom trace – positive signal) is reduced at some point. The secondary voltage trace (top – negative signal) is also reduced. At first glance, this looks like a spark has occurred.... **WRONG!**

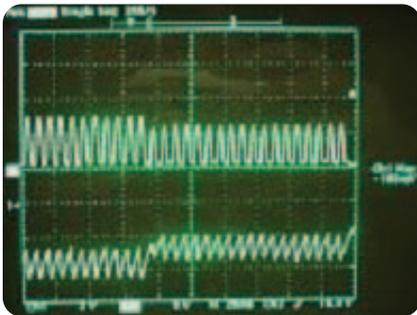


Figure 4: Has a spark occurred...or not?

The rate of decay of the kV signal is too slow. It's a perfectly normal decay. Seeing this event on the panel meters would not alert you to this and would let you think a normal spark event was being taken care of.

So what might have happened?

One possibility is the misinterpretation of a system's zero-crossing detector (the circuit that tells the control when the half cycle of supply is about to start/finish). When zero crossing timing points are misread by TR controls, the microprocessors get confused. They suddenly find that they are being told to fire or hold-off on firing the SCRs (silicone controlled rectifiers) at times when not expected. Too early a zero cross can cause a pulse of current that looks like a spark or an arc and can set off the controls' response system (Figure 4).

It's not uncommon for a microprocessor based system to lock up completely in the face of multiple zero crosses in a single half cycle.

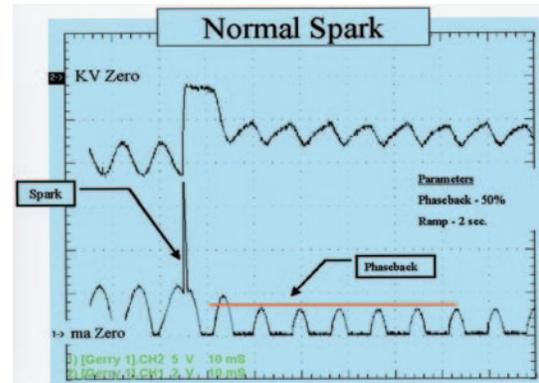


Figure 5: A genuine spark

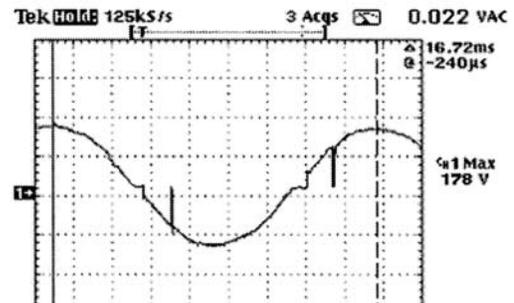


Figure 6: Signal from scope on the control voltage from TR cabinet

So how can we conclude that the Zero Cross Detector might be the cause of such problems?

Well! Here's a signal you might see if you were to put a scope on the control voltage for your TR cabinet (Figure 6). As can be seen, the AC supply waveform is being interfered with...source of interference unknown, but interfered with nonetheless. In a clean waveform, the voltage passes through zero twice. In Figure 6, we can see 3 zero crossing events. A control that is designed to recognize such an event correctly detects them and then, may or may not take some action. Since this kind of event may often not be practically solved at the source, it becomes the control's job to differentiate between a valid and an invalid zero cross: a task not always easily accomplished. 🌐

Should you feel your control might be acting on poor data, why not hook up a scope and try this out? If you have any feedback you wish to share, feel free to email us at peteraa@redkoh.com

LPA Screens: Utilities Need a Proven Solution *continued from front page*

However, a universally proven LPA screen design was already developed in 1996 after LPA problems at both 760 MW units at Steag's Voerde Power Station in Germany plugged up the installed honeycomb catalyst and caused severe erosion damage. In an attempt to solve this problem, extensive CFD and physical modeling was performed to address the root cause of the LPA formation and carry over to the SCR reactor. The modeling activities addressed specific issues such as geometric scale and the relationship between the model and full-scale installation including pressure drop. As a result of the modeling, modifications and/or additions to areas such as the boiler's economizer hopper, economizer outlet and the downstream ductwork were made to allow for continuous and reliable removal of the LPA and safe operation of the SCR system. Unfortunately, none of these efforts resulted in a reliable long-term solution. Flat screens either plugged up, eroded away very quickly, or both.

After several failed attempts, an LPA screen design was developed which reliably and continuously prevented the intrusion of LPA into the SCR reactor by effectively removing the LPA from the flue gas stream without the LPA screens plugging up or being eroded away. Typically, such LPA screens are installed at the boiler's economizer outlet utilizing the economizer hopper for the continuous extraction of the removed LPA. The special design features of these patented LPA screens are:

- ▲ A pleated design, which ensures a most advantageous angle of attack of the LPA onto the screen and a low flue gas flow velocity through the LPA screens resulting in a low pressure drop.
- ▲ A hinged design (typically at the top of the economizer outlet duct), which allows for the LPA screens to be rapped frequently in order to remove LPA that gets caught in the screens.
- ▲ A modular design, which allows for the use of numerous different types of screen materials depending on the flue gas velocity. Screen materials typically used include:
 - ◆ Uncoated or coated stainless steel wire mesh screens

- ◆ Uncoated or coated stainless steel perforated or slotted plates
- ◆ Uncoated or coated stainless steel wedge wire
- ◆ Fully ceramic screens

Coating materials used include various commercially available types of metallic coatings such as ConformaClad, MetalSpray, etc. as well as enamel coatings. The selection of the correct screen design and material must be made depending on the particular application and the actually present flue gas velocity through the LPA screens.

After installing these LPA screen designs, the Voerde Power Station had no more problems with LPA intrusion into the SCR systems since 1996. Subsequently, numerous other coal-fired units equipped with SCR systems in Europe as well as the United States were supplied with these LPA screens.

In spring 2005, prior to the 2005 ozone season, two bituminous coal-fired units, one in northern Indiana and one in southern Ohio, were successfully equipped with this patented LPA screen design. In one unit, uncoated stainless steel wire mesh screen inlays were used, since the average flue gas velocity in the economizer outlet duct was found to be no more than about 60 ft/sec. As a result of an average flue gas velocity in the economizer outlet duct of at least 75 ft/sec, wire mesh screen inlays with a highly erosion resistant metal spray coating were employed. Both units have been in operation since May 2005 and have not experienced any operational problems. Even though this hinged and pleated LPA screen design is mostly self-cleaning, fully automated rapper systems were installed on these base loaded units, which ensure that no LPA remains on the LPA screens during operation. Additional coal-fired units in the eastern United States will be retrofitted with the LPA screen design before the 2006 ozone season, thus providing a successfully proven and reliable solution for many utilities' LPA problems. 

For more information, contact Hans Hartenstein at hhartenstein@steagllc.com

Back to FGD Basics *continued from front page*

In a lime scrubber one has the freedom to raise pH to obtain the desired SO₂ removal. This is tempered by the fact that the pH scale is logarithmic. Small changes in pH can lead to significant consumption of the high priced lime. In a forced oxidized system producing gypsum, high pH can also require the addition of acid in the oxidizer to grow proper gypsum crystals.

The pH should be measured continuously and indicated on the scrubber control board. By their nature, pH instruments require constant maintenance. A high flow across the measur-

ing electrode can erode the surface away. A low flow across the measuring electrode can allow scaling to occur which will effect the reading. The pH values should be checked at least daily by another instrument.

Solids

To have sufficient "seed crystals" for proper crystal growth, the percent solids in the scrubber tower should be in the 15% - 20% range. Some systems were designed to operate in the 8% - 10% range, but if the pumps can handle the additional

solids, there are benefits to operating in the higher range. Solids percentage should be measured manually at least once per shift or a continuous solids monitor can be installed.

Oxidation

Past work has shown that to minimize scaling in the tower and to optimize solids dewatering processes, the percent oxidation to sulfate must be greater than 95% or less than 18%. Air can be added to increase oxidation (forced oxidation) to form columnar gypsum crystals. Elemental sulfur or sodium thio-sulfate can be added to lower oxidation (inhibited oxidation) to form plate type calcium sulfite crystals. Either one of these crystals dewater easily. Between these two ranges co-precipitate sulfite/sulfate crystals form. Under the microscope they look like balls covered with spines. Because of this they will not dewater easily. They also have a tendency to precipitate on all the internal surfaces of the tower.

Limestone Grinding

Some of the first scrubbers were designed with limestone

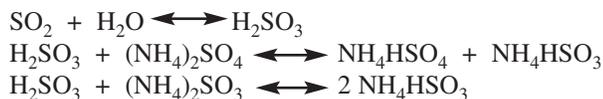
grinding that produced a 200 mesh product. It was soon discovered that this product was too coarse with too little surface area to dissolve well during the length of time it was in the scrubber tower. It was discovered that a 325 mesh product was required. There is a huge difference between a product where 90% of the particles pass a 325 mesh screen vs. a product where 80% of the particles pass a 325 mesh screen. To maintain a 90% product, every part of the milling process must be controlled carefully. Mill balls must be added once or twice a week to maintain proper ball charge. Product hydroclones must be maintained with proper apex openings and checked for pluggage each shift. Limestone "bond work index" and feed rate can have a large effect on the final product size. It can prove very cost effective to install a particle size monitor to indicate changes in the final product. 🌐

For a complete copy of Ron Richard's 2005 APC Round Table presentation, contact Ron Richard at ron.richard@enerfab.com

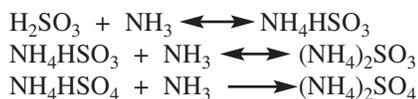
Ammonium Sulfate Scrubbing *continued from page 2*

AS is highly soluble and the liquor contains approximately 44-48% dissolved AS (depending on temperature). As the flue gas and liquor approach equilibrium, water evaporation causes precipitation and growth of AS crystals and the flue gas cools down to adiabatic saturation temperature.

The removal of SO₂ from the flue gas occurs in the absorber spray zone where a spray of ammonium sulfate solution controlled at a pH range of 4.9 - 5.9, reacts with SO₂ to form ammonium bisulfite/bisulfate in accordance with the following reactions:



Ammonia is injected to the bottom of the reaction tank to neutralize the acidic species according to:



Oxidation air is injected into the bottom of the absorber to oxidize the sulfite to sulfate according to:

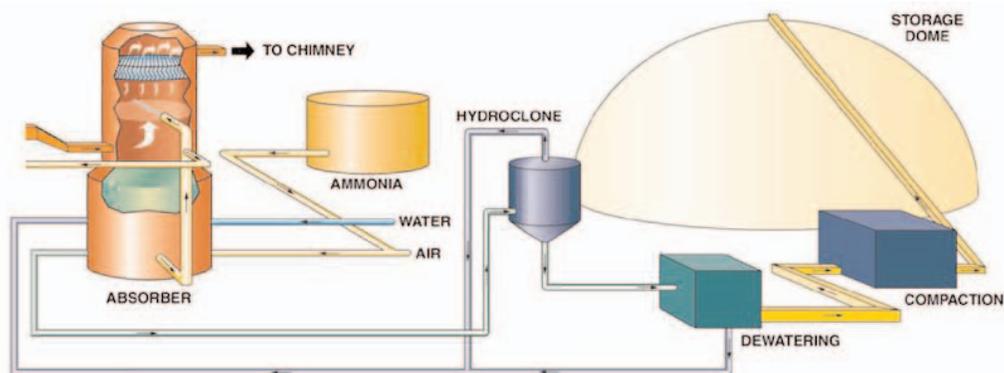


Figure 7: The Marsulex Ammonium Sulfate Process



Nitrogen content of the AS product is approximately 21% weight while sulfur content is approximately 24% weight. When applied to soils, the sulfur constituent of the AS acts as a catalyst which increases the rate of nitrogen uptake by various crops.

Advantages of the Marsulex AS FGD System

The AS FGD system is designed with conventional critical equipment redundancy similar to that of limestone FGD systems. This similarity upstream of the centrifuge allows flexibility to design the AS FGD to use either limestone or ammonia as a reagent. Additionally, the water soluble chemistry of ammonium sulfate precludes the type of internal solids buildup potential as exists with limestone scrubbing. Ammonia, being more reactive than limestone, is capable of

achieving sustainable, high 97%+ removal efficiencies at extremely high fuel sulfur contents. Marsulex has demonstrated the full scale, commercial success of the AS process on high sulfur (7+%) fuel application since 1996. Availability/acceptability of ammonia as a reagent and byproduct AS fertilizer revenues are among plant specific

evaluation criteria for selecting the Marsulex AS FGD technology. 

For more information, contact Michael Walsh at mwalsh@marsulex.com

Data Overload *continued from page 2*

Since coal flow is an important operating parameter for the plant, indication of coal flow is part of the plant's control system. This is typically programmed into the control system from the coal feeders. Here again, there are functions in the control system to convert the feeder information for use by the control system. In some cases corrections have been made to the control system programming that have carried over and require reprogramming.

Coal flow can also be calculated based on the heat input to the boiler. By calculating the heat input required at a given load and the established boiler efficiency, the coal flow can then be calculated. In this case, a coal analysis would be required to determine the heating value of the incoming coal. This is particularly susceptible to confusion if the boiler was tested in a "distressed" condition.

OK, let's recap.

Coal flow is determined by test equipment, coal feeder equipment, the control system and by calculation. The coal flow and heat input of the burners are closely related, the common bond being the heating value of the coal. Heating value is determined through laboratory testing of a coal sample taken during operation of the boiler. As coal samples are relatively small compared to the quantity of coal burned by the boiler, the heating value of a given sample can vary by up to 10% or more from that of samples taken from different coal bunkers, mills or feeders.

As the heating value of the coal varies, more or less coal is required to achieve a given boiler load. This raises another question. Not only must the correct coal flow be measured but the correct coal flow to maintain a boiler load must be determined. As the number of coal sources utilized for a single plant increases so does the variation in the coal flow required at any given boiler load. Conversely, if a single coal source were utilized, the coal properties would be much more uniform. Mixing of fuels types makes this analysis extremely difficult.

Now that we have discussed the measurement techniques and the issues with heating value and coal flow, where do we go? The good news is that typically, the various indications of coal flow are within acceptable tolerances. When some or all of the coal flow measurements disagree more than would be expected, good judgment (or retesting) is used to obtain what

is considered reliable data. Most of the data checks can be accomplished by verifying the sources of the data.

As far as the measured coal flow, any calibrations of the equipment can be checked. Any special circumstances of the coal flow can be identified (test ports too close to a bend in the coal conduit). Coal feeder calibrations can be verified and checked.

The analysis of the coal sample can be checked against plant documentation of received coal. In addition, there are typical analyses for coals from various mines.

Once again, let's recap.

We have measured the coal flow, taken coal feeder data, control system data and performed a coal heating value analysis. Each of these data points have been reviewed to verify the recorded information or identify an error in the data collection. If any errors were identified, we can stop here and determine the coal flow based on our research.

However, if there is still a substantial discrepancy, most likely some retesting will be necessary. During the review process, it should have been possible to identify which data is most suspect. It is possible to retest any single method of data measurement. The challenge is to insure that the retest conditions are the same as that of the original test. Perhaps the test could be run between two methods to verify the accuracy of one against the other.

With sufficient analysis of the original data, retesting should provide acceptable data measurement. In addition to the multiplicity of measurement techniques, today's data collection systems make it easy to collect mass quantities of data. With data collection systems capable of collecting data every couple of seconds, it is easy to accumulate millions of data points. Data overload!

For every test there is a reasonable approach to the test methods and the amount of data required to provide reasonable and accurate information for the design of the affected system. This is the best compromise of too much information and good judgement! 

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