INTERNATIONAL
FILTRATION NEWS
Your Global Source

January/February 2016
Volume 35 No. 1
www.filtnews.com

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The Benefits of Third Party Fabric and Bag Quality Assurance/Quality Control

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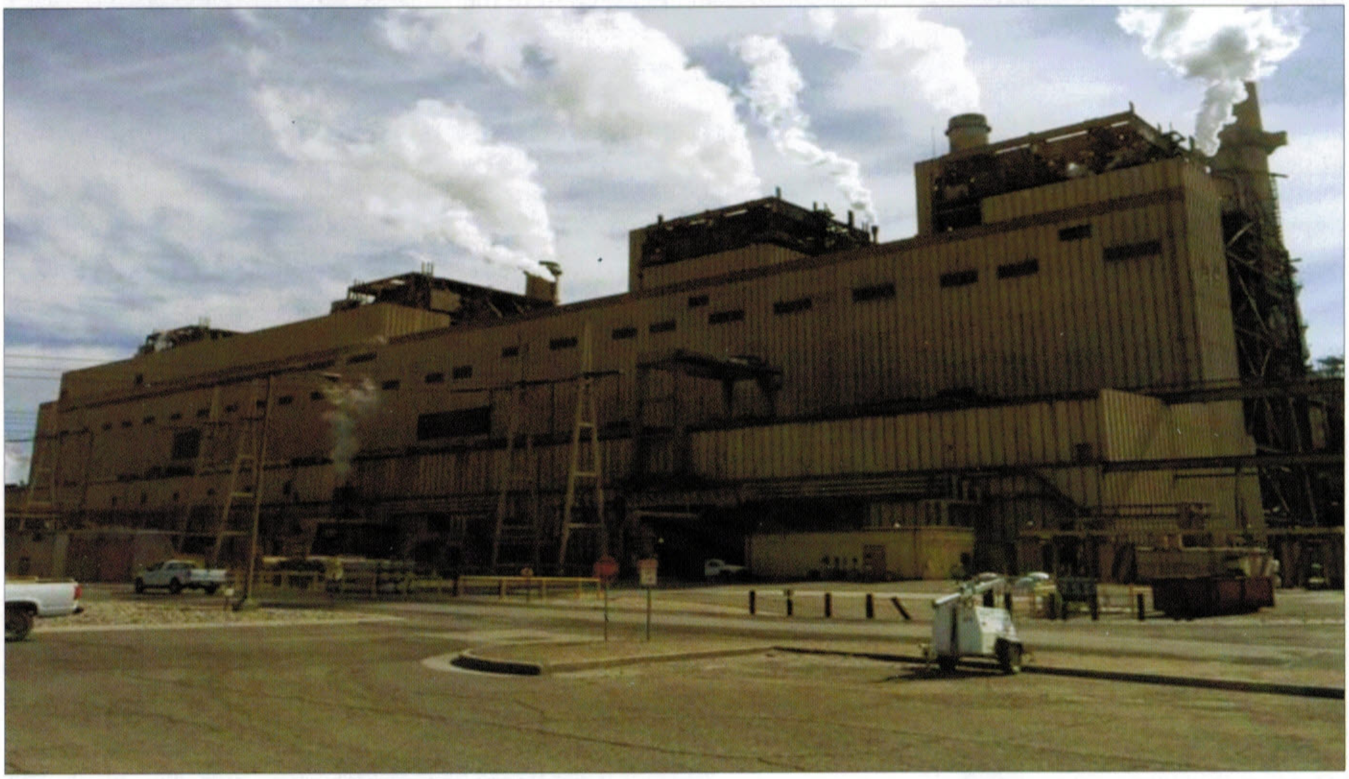

Photo 1. PNM San Juan Generating Station Baghouses

Fabric filters (or baghouses) are gradually becoming the preferred technology choice to retrofit or replace aging electrostatic precipitators (ESP's) for the enhanced control of particulate matter (PM) emissions from coal-fired boilers (CFB). The heart of any baghouse is the filter bag, with filter bag replacement typically being one of the largest operating expenses of the baghouse system. Millions of dollars are spent each year on new bag sets, yet only recently have third party quality assurance/quality control (QA/QC) programs been employed to ensure that what is provided matches what has been ordered. The team approach, which doesn't end with the purchase of the new bag set, but is sustained during and long after the installation to monitor strength and flow characteristics of the bag set, track bag failures, identify the root cause of bag failure(s), and apprise the team of innovations in the filter industry, which may be applicable to future bag sets. The following provides a case history showing the merits of such a program.

PNM SAN JUAN GENERATING STATION

The Public Service Company of New Mexico (PNM) San Juan Generating Station (SJGS) is located in Waterflow, New Mexico, and is comprised of four, pulverized coal boilers that are each firing New Mexico, low-sulfur, bituminous coal. SJGS Units 1 and 2 are sister units, as are SJGS Units 3 and 4.

Units 1 and 2 are Foster Wheeler, pressurized draft, front wall-fired boilers rated at 350 MW each. Unit 1 was commissioned into service in 1976 and Unit 2 was commissioned into service in 1973. SJGS Units 3 and 4 are each 550 MW rated Babcock & Wilcox (B&W), pressurized draft, and opposed wall-fired boilers. Unit 3 was commissioned into service in 1979 and Unit 4 was commissioned into service in 1982.

All four units have similar basic process flows. Each unit was originally designed to control PM emissions through the use of a stacked hot-side electrostatic precipitator (HESP) upstream of the air preheater. Each unit is equipped with four, regenerative air preheaters: two for primary air and two for secondary air. In 1998, all four units were retrofitted with wet flue gas desulfurization (WFGD) systems, provided by B&W, for control of SO2 emissions. During 2007-2009, the units were each retrofitted with B&W pulse jet fabric filter technology upstream of the WFGD systems to control the PM emissions from the units. At that time the fields in the HESP's were de-energized and used as dropout boxes for the collected ash. It is estimated that of the total ash in the fuel, approximately 50-55% reaches each pulse jet fabric filter. Between 2007 and 2009, all four units were retrofitted with low nitrogen oxide (NOx) burners with over-fire air (OFA) to reduce NOx formation in the boilers and powder activated carbon (PAC) injection upstream of the fabric filters to reduce mercury emissions.

BAGHOUSE HISTORY AND DESCRIPTION

Typically, utility coal-fired boiler baghouses have either reverse air or pulse jet bag cleaning systems. PNM identified during the engineering phase of the Environmental Project that the baghouse design allowed for using the same bag specifications and dimensions for the new baghouses (4 total).

At PNM SJGS Units 3 and 4 boilers, each have identical state-of-the-art ten compartment pulse jet filters with 1,386 bags per compartment and bags that are 10 meters in length. Unit 4 baghouse went into service in October 2007 and Unit 3 in March 2008.

Units 1 and 2 boilers each have eight compartment pulse jet fabric filters, with 1,088 bags per compartment, and 10 meter long bags. Unit 1 baghouse went into service in October 2008 and Unit 2 in March 2009.

Standard laboratory testing conducted by ETS of used or failed filter bags from some of the San Juan Units in 2009 indicated that the fabric permeability of the OEM supplied filter media was beginning to deteriorate. Permeability is a measure of fabric porosity or openness, usually expressed in cubic feet per minute (cfm) of air through a square foot of filter media at a differential pressure of 0.5 inches water gauge (WG). The permeability of the used bags was measured at three different fabric conditions: as-received, after vacuuming the collection side at 10 inches WG, and after vacuuming the collection side at 30 inches WG. The permeability values obtained for the vacuumed fabric give a relative indication of the overall ability of the fabric to be cleaned. Normally, bags that show good permeability recovery in response to vacuuming also show good in-situ dust cake release and flow recovery in response to normal pulse cleaning in the baghouse.

Due to the poor permeability recovery of the used filter bags, microscopic analysis was also conducted on samples of fabric from the used filter bags. The microscopic inspections revealed dust penetration through 100% of the fabric cross-section in some areas. Assuming that the used bags sent for analysis were representative of the entire bag set, it was anticipated that increased operating differential pressure (pressure drop) and/or increased emissions were likely.

Due to particular site-specific considerations at San Juan, it was determined that the original bag set, a PPS/P84 blend, would be changed to scrim-supported, polyphenylene sulfide (PPS) felt with an ePTFE membrane[1] for replacement bag sets. The goal of the bag replacement for PNM was to improve bag life and meet or improve upon design pressure drop requirements.

REASONS FOR CONTRACTING

Due to the lack of "in-house filter bag and baghouse expertise" and the high dollar risk of "not getting it right the first time," PNM decided to enlist the help of ETS, Inc., an independent baghouse consultant specializing in testing, training, troubleshooting and testimony. The reasons for developing a third party fabric and bag QA/QC program were to improve transparency, consistency, comparability, completeness, and confidence in what was supplied vs. the purchasing contract. The process started with the development of a customized and detailed technical specification for the procurement of the replacement filter bags. Once the competitive proposals were received from the prospective bidders, a technical comparison was conducted to ensure that all of the bag specifications were met and any exceptions or technical differences were duly noted. Upon PNM's selection of the successful bidder, conference calls were held between all parties directly involved in the bag manufacturing and QA/QC program in order to convey all of the relevant information.

This team approach has been very successful in minimizing potential adversarial situations because at the start of the project everyone understood and accepted their roles. Even today, bag failure analyses are reviewed as a team (PNM, ETS & bag supplier) to identify the root cause of failure and monitor current condition of the installed bags.

IMPORTANCE OF SPECIFICATIONS

The development of a customized technical specification listing all of the specific elements required for the fabric, filter bag, sewing thread and hardware is key to successful bag procurement/performance and is the basis for the QA/QC program. These specifications are typically submitted with the RFP to the prospective bidders to help "level the playing field" so that all of the critical operating parameters are discussed and agreed to in the bag supplier's bid package. The details and comprehensive breadth of the specifications are critical. Drawings and/or quantitative acceptable tolerances should be defined and required for acceptance of components and finished products. Without the specification, there can be no recourse with vendors.

Typical components of the specification include: plant-specific technical/operating information, materials of construction for fabric, thread and hardware, performance requirements of components (e.g., strength/flow properties of fabric and strength/ construction of thread), and dimensional requirements for the bags and hardware. Additionally, any requests for filter bag warranties should be specified. These warranties may cover items such as overall bag life, particulate emissions, and/or differential pressure.

PURPOSE AND DESCRIPTION

The baghouse owner should initiate a third party QA/QC program to help ensure that the fabric, bags, thread and hardware all meet their customized technical specifications, protect their new bag set, provide documentation in case of litigation, and obtain unbiased representation. These statements are by no means a condemnation of fabric suppliers, membrane suppliers, and or bag manufacturers; it merely recognizes that normal manufacturing differences may produce variations in the products beyond the particular tolerance limits specified in the purchaser's contract.

It is estimated that the cost of a "typical" QA/QC program is between 4-6% of the cost of the new bag set (variables include the type of bags, number and length of bags, bag vendors, level of QA/QC inspections, etc.), but there are four primary savings associated with conducting third party fabric, bag and hardware QA/QC program that should be pointed out:

1. Maximize filter bag life

How much savings would it be if a facility were able to obtain another year of bag life? If user could achieve 5 years of bag life instead of 4 years because a rigorous QA/QC program eliminated inferior fabric/bags before installation (and by conducting periodic bag monitoring user can ascertain the current bag strength/permeability and trend over time), would that be of value?

2. Minimize pressure drop

Based on a volume of 3.4 million acfm through the baghouse of a recent client, it was roughly calculated that every 1" increase in pressure drop cost the facility about $400K per year for the additional fan electricity consumption.

3. Improve product quality

An often overlooked benefit of an independent party QA/QC program is that when the bag manufacturing workers (who are directly involved in bag fabrication) are aware that third party representatives will be randomly checking their outputs, workmanship during the bag construction and fabrication stages is of heightened quality. On-site inspections of new bags at the manufacturing facility or at the ETS lab of samples provided per the contract specifications have identified issues early on in the process, which were addressed prior to delivery to the San Juan Generating Station.

4. Minimize downtime[2]

A single fabric hole, a single patch of missing membrane, and/or rolls of fabric outside of the permeability specifications can ruin an entire fabric filter bag set upon baghouse start-up.

As far as the benefits of a QA/QC program, basically it helps protect the interests of the client (PNM in this case). In a QA/QC testing program, minimum acceptable tolerances and written specifications for the fabric, thread, hardware and constructed bags are documented and agreed to before construction, and delivery of the final bag set is dependent upon tested results. A QA/QC is analogous to health insurance for the baghouse, and a simple physical (QA/QC program) is the best mechanism to ensure bags are in the best shape they can be prior to entering stressful service life. Obviously, the higher percentage of fabric/bags that are inspected gives user better certainty of catching any defects. The level of protection is a risk/reward activity and is customized for each client. Unplanned outages always cost more than preventative maintenance, and like in a physical, it's better to catch potential problems up-front before they snowball into something more disastrous.

QA/QC RESULTS AND BAG LIFE

The results of QA/QC testing from multiple programs since 2009 conducted by ETS for PNM's San Juan Generating Station have shown differences in the quality of products from various suppliers. Some of the fabric issues identified prior to production of the finished bags included shrinkage values not meeting the maximum tolerances and permeability values falling outside of specified ranges. Sample inspections during fabrication of the finished bags detected items such as dimensional discrepancies (e.g., bag length and cuff width), membrane damage/abrasion, membrane delamination, extra needle holes extending down into the bag body from the top cuff seam, and sections of missing thread in the middle row of the three-needle vertical bag seam stitching.

Less than 0.007% of the total bags (13,860 per unit) installed on Units 3 and 4 in 2010 and 2011 have failed. Current random bag testing has identified no issues with permeability, shrinkage or dust penetration. The new PPS felt with ePTFE membrane bags were installed in Unit 2 baghouse in 2012 and Unit 1 in 2013/2014.

New bag installation (100%) is normally accomplished during scheduled unit outages by experienced contractor personnel. Subsequent failed bag replacements or bags collected for testing is done by experienced PNM personnel. Each realizes the importance of proper bag installation to avoid new bag damage from membrane and/or fabric abrasion. Examples include using protective sleeves during installation and proper cage segment assembly and alignment.

BAG MONITORING, FAILURE MAPPING

Once the bag set is installed and operating, a bag-monitoring program should be established. The monitoring program normally includes at a minimum permeability and strength testing. The strength and flow testing should be routinely conducted in order to develop trend lines over time and as a comparison to the original new fabric test values.

Permeability measurements of

used bags can, by varying the amount of vacuuming help to determine if the bags are gradually blinding or have lost membrane functionality. The M.I.T. flex endurance test has traditionally been used to help determine the rate of deterioration of woven fiberglass bags due to the inherent abrasiveness of glass fibers. ETS has also found the M.I.T. flex test to be very useful in the evaluation of many nonwoven fabrics and their ability to withstand flexing against a wire cage during pulse cleaning cycles. For nearly all filter bag fabric types, this test can be a leading indicator that the fabric is nearing the end of its useful service life. Each program is custom designed in terms of tests conducted as well as frequency and location of bag "pulls."

The bag-monitoring program is a crucial element and cost saver when it comes to bag replacement timing. Bag monitoring has as its purpose: 1) to determine the retention of strength and flow characteristics of a bag set with on-stream time, 2) aid in determining the useful life and scheduling the replacement of a bag set, and 3) provide a tool in assisting the client in troubleshooting a baghouse.

In addition to a routine bag monitoring program, PNM created bag failure maps by baghouse and compartment in order to track bag failures by exact tube-sheet location and date of failure. Identification of specific bag failures by location and date can be a very useful tool in diagnosing high localized velocities, wear patterns, cleaning inefficiencies, etc., in particular compartments.

Photo 2. ETS' personel testing new bags for PNM's San Juan Generationg Station.

MAXIMIZING BAG LIFE

The initial baghouse design detail is critical and key in the choice of a conservative gas-to-cloth ratio. The filter bags are the heart of the baghouse, with the bag replacement typically being one of the largest operating expenses, and there are six activities, which are vital to high-level emission control and long lasting bags. The six activities include:

1. **Bag Selection** – Select media for the inlet gas constituents and process operation.

2. **Specification** – Specify filter media, thread, bag and hardware.

3. **Quality Assurance/Quality Control** – Develop QA/QC program to ensure what is delivered meets the specification.

4. **Installation** – Oversee the installation of the bags and perform leak tests. N.B. Pulse jet bags with an ePTFE membrane should always be installed using protective sleeves in the tube-sheet hole to prevent damage to the membrane.

5. **Bag Monitoring** – Perform bag testing periodically. Increase frequency if strength or permeability decline steeply.

6. **Identify and Correct** – Immediately fix any leaks or high pressure drop.

While many if not all of these may seem obvious, it is the depth of detail, breadth, rigor and consistent application that is the difference between success and failure. Preventing the dust from entering the clean side of the baghouse is the critical output of the six activities. Especially in the case of the pulse jet baghouse, dust on the clean side is a guarantee of greatly shortened bag life and loss of compliance.

Going forward, as the emission codes increase and become more stringent, the role of QA/QC testing will continue to increase in value. Additional test methods addressing added speciation and condensation products will evolve. New innovations in multi-component felted media may require additional test method development as well. The cost of such programs will be additive, thus making the trade-off between reducing cost by reducing the sampling frequency vs. increasing the risk of missing faulty product locations more difficult. The challenge will be to keep the cost of a QA/QC program under 6% of the bag set costs.

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