Ryton Fabric Degradation at Big Brown's COHPAC Baghouse

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INTRODUCTION

COHPAC (Compact Hybrid Particulate Collector) is in operation at TU Electric's Big Brown Station. COHPAC was chosen as the cost-effective retrofit technology to allow Big Brown to meet more stringent 20%, six minute average site specific opacity regulations that became effective in 1996. Big Brown has two 575 MW, supercritical boilers that fire a locally mined lignite coal. The original particulate control equipment consisted of 156 SCA electrostatic precipitators, later enhanced with dual flue gas conditioning (NH_3 and SO_3); downstream of which COHPAC has been installed.

Each COHPAC unit consists of four individual pulse-jet baghouses that are designed to operate at a maximum (net-net) air-to-cloth ratio of 15.5 ft/min with off-line cleaning. There are eight compartments in a baghouse, each with 312 bags for a total of nearly 20,000 bags. After two years of operation, bag life has not met expectations. Bag replacement must begin somewhere between 12 and 18 after start-up of operation.

The bags are made from 18 oz/yd^2 felted Ryton™ (Ryton) using a Ryton scrim for support. Ryton is a synthetic fiber made from polyphenylene sulfide (PPS). This fabric is successfully used worldwide in pulse-jet baghouses for both coal fired utilities and industrial applications. Compared to other fabrics in the same price range, Ryton offers excellent heat and chemical resistance.

The bag failures at Big Brown may be attributable to operating temperatures at the upper acceptable range for Ryton, chemical attack from flue gas conditions, and frequent, energetic pulse cleaning.

Unit Description

In November 1995 Unit 2 COHPAC was put into service at Big Brown. The second unit followed in April 1996. The layout of the two units is identical. Flue gas exiting each boiler travels either through the A-side or B-side air preheaters and air pollution control equipment. A layout of the electrostatic precipitators and COHPAC is presented in Figure 1. Coal and flue gas conditions to which the Ryton bags are exposed are summarized in Table 1.

Table 1
Typical COHPAC Flue Gas Conditions

Parameter	Operating Range
Ash Content	9 – 18 %
Heating Value	6000 – 7000 BTU/lb
Sulfur Content in Coal	0.47 – 0.8 by percentage weight
Maximum Flue Gas Temperature	385^{o}F
Minimum Flue Gas Temperature	260^{o}F
Flue Gas Moisture	15.5 %
Typical Inlet Particulate Loading	0.02 – 0.42 gr/scf
Flue Gas Conditioning	Wahlco SO_3/NH_3 System

Bag History

Significant loss of fabric strength was first noted on the A-side, Unit 2 bags 6 months after start-up. Fabric strength is measured following an ASTM standard test method called the Mullen Burst test. In this test, a piece of fabric is exposed to greater and greater pressure until the fabric bursts. The Mullen Burst is the pressure at which the fabric fails. Typical new Ryton fabric has a Mullen Burst of nominally 450 psi. After six months, the A-side bags had an average Mullen Burst value of 200 psi.

To track bag strength, bags are periodically removed from each of the 8 baghouses for destructive, Mullen Burst testing. Figure 2 presents average Mullen Burst values with respect to operating hours for each baghouse. One phenomenon that is puzzling and is under investigation is that bag failures occur earlier on the A-side of each boiler than the B-side. After 1 year of operation, nearly 50% of the A-side bags had failed on Unit 2. After the same period of time, only 4% of the B-side bags had failed. It is suspected that the difference between the two sides of the boilers is related to flue gas conditions, although preliminary review of the operating data has failed to reveal any obvious trends.

The original bag failure mechanism seen in baghouses 2-1 and 2-2 was apparently from wire-to-fabric abrasion. The failures began as slits on the small radius of the oval bag about 2 ft below the bag top. With time these slits often became 6 to 8 feet in length and eventually the bag became tattered from repeated pulsing. Although these failures were apparently from abrasion between the bag and the cage wires, weakening fabric strength has accelerated these failures. In comparison, test bags made of Tefaire™ felt installed under identical conditions as the Ryton fabric showed virtually no loss of strength from chemical degradation or any severe wire-to-fabric abrasion. Tefaire™ is not used as the primary fabric at Big Brown because of cost.

In addition to loss of strength of the fabric, there has also been a problem with shrinkage (or loss of elasticity) of the Ryton bags after 1 year of service. This phenomenon has forced the cages to rise off the tubesheet and interfere with rotation of the cleaning arm. When this occurs, the compartment must be isolated and the problem bags replaced or other corrective actions taken immediately. This problem is labor intensive, requires bag replacement even if the bags have not physically failed, and causes performance problems as pressure drop increases with isolated compartments. Interestingly, this unusual shrinkage became critical after operation at lower flue gas temperatures (less than 300^{o}F) in the winter.

A second severe problem caused by bag shrinkage is failure of the bottom discs. This failure is caused by the cage pushing through the fabric as the bags shrinks, in contrast to the bag raising the cage off the tubesheet. It is speculated that fabric strength was so weak that pressure from the cage weight ripped the bottom disc. This failure was even more devastating in terms of outlet opacity than the slits.

Suspected Causes

Flue gas constituents and temperature are suspected to contribute to the accelerated loss of fabric strength at Big Brown. Because of the severity of the problem, significant efforts are underway to identify the primary causes of the problem so that corrective measures can be evaluated.

Ryton (PPS) fibers are popular because of their ability to retain physical properties in the presence of harsh chemical environments[1]. Published tensile strength retention after exposure to acids, alkalis, organic solvents and oxidizing agents is very high. For this reason, Ryton seemed well suited for flue gas environments that are known to have some concentration of sulfuric acid under certain operating conditions (for example, when passing through the acid dew point during start-up and shut-down of the boiler).

It is also published, however, that strong oxidizing agents and elevated temperatures cause thermal oxidation resulting in strength loss of Ryton fiber[1]. The literature does show a significant loss of strength when Ryton fibers are exposed to nitric acid, concentrated sulfuric acid and free bromine. The bag failures at Big Brown involve oxidation of the PPS fiber.

It is suspected that concentrated sulfuric acid and possibly some other acid are the source of the chemical oxidation. The most obvious sources for these acids are from the combustion of lignite coal and from the flue gas conditioning system upstream of the electrostatic precipitator. Because there are many successful installations of Ryton fabric on coal fired boilers, the suspicion is that acidic particles from the flue gas conditioning may accelerate fabric degradation.

Investigative Efforts

Identifying the primary source of the oxidizing agent has been difficult because of the dynamic interaction between the boiler and the particulate control equipment (in this case, both the electrostatic precipitator and COHPAC). Dedicated efforts to establish and maintain operating procedures that minimize potentially harmful conditions are in place. Activities designed to identify and understand how flue gas conditions impact fabric life are also continuing. A brief description of some of these efforts is described below:

- Alternative fabrics are installed in several compartments to evaluate their ability to withstand flue gas and cleaning conditions at Big Brown. At this time there are over 10 different bag types installed.
- Cages made from perforated plate are installed. Testing has shown that the design that offers reduced bag wear at the lowest incremental cost is one where the existing bottom half of the wire cage is used and the top half is replaced with a 33% open area perforated plate. Perforated cages offer two advantages: 1) the smooth surface eliminates wire-to-bag wear, and 2) the perforated cage helps to better distribute the cleaning pulse along the length of the bag resulting in lower accelerations at the top.
- The Electric Power Research Institute is conducting laboratory testing of Ryton under simulated flue gas conditions. These tests provide information not only for Big Brown, but also for other potential installations.
- Fabric evaluation under many, varying conditions is being conducted in a prototype test fixture designed specifically for this site. Over 70 fabric swatches are being exposed to flue gas extracted from the host duct. Parameters that can be varied include temperature, chemical constituent of the flue gas, and operating conditions. This test should isolate and confirm the contribution of specific parameters to fabric loss of strength.
- Side stream evaluations using small baghouses are being considered to screen potential new products and sorbent injection. These devices allow for rapid screening of fabric performance in terms of pressure drop and collection efficiency.
- Modifying baghouse operation is being investigated. This includes using the bypass dampers to reduce the effective air-to-cloth ratio. Although this should not improve degradation which may result from chemical attack, it should reduce the cleaning frequency and thereby any wear caused by wire abrasion.

Conclusions

Ryton fabric installed in COHPAC at Big Brown experiences a loss of strength that greatly contributes to reduced bag life. The loss of strength appears to be caused by chemical attack from flue gas constituents. The acidic byproducts of SO_3 are the primary suspects at this time. SO_3 is present in the flue gas naturally and introduced with ammonia via the flue gas conditioning system.

1. Shuler, Charles, M. "Ryton™ Sulfar Fiber in Nonwoven Applications". Included in Phillips Fiber Corporation promotional material.

Figure 1
Big Brown Unit 2 Layout