Avoiding Problems With Trona for SO_3 Mitigation

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Summary

The effort to reduce NO_x emissions from coal-fired power plants via selective catalytic reactors (SCRs) has resulted in the unintended consequence of oxidizing SO_2 to SO_3 and thereby increasing total SO_3 emissions. Although the higher stack SO_3 concentrations are still very low (measured in ppm) the emissions can sometimes produce a highly visible secondary (typically blue) plume, which, although unregulated, is nonetheless perceived by many to be problematic. Efforts to reduce the SO_3 levels to a point where no secondary SO_3 plume is visible can impede particulate collection for sites that employ electrostatic precipitators (ESPs) due to the relationship between SO_3 and resistivity in cold-side ESP applications. American Electric Power (AEP) has pioneered the sodium-based alkali Trona for SO_3 mitigation to avoid resistivity problems associated with many alkalis. Trona has been used successfully at the General James M. Gavin Plant near Cheshire, Ohio for almost 3 years and is being implemented on a fleet-wide basis.

AEP's SO_3 mitigation system employs dry Trona injection upstream of the ESP. This system replaced two other systems that were operated in tandem: one injecting a magnesium hydroxide slurry into the furnace, and the other injecting hydrated lime upstream of the ESP. Trona was selected due to its combined characteristics of being highly reactive and being compatible with existing ESPs. Furthermore, dry sorbent injection is preferable to liquid injections due to the ease of handling, reduced risk of fouling downstream duct or equipment, and improved safety (including lower conveying pressures).

SO_3 measurement is conducted using the controlled condensation method. Measurements at the stack indicated that lower SO_3 levels were attainable with Trona injection than with magnesium and lime combined. There were no significant opacity excursions with Trona despite the lower SO3 levels.

Despite all of the above successes, there have been two fundamental problems with Trona use, and both have been resolved: material handling difficulties, and deposition problems.

The material handling issues included problems with fluidity (flow interruptions), rat holing, agglomeration, unloading problems, and inadvertent material degradation. Vendor support to overcome these issues was sought, however, their input was of limited usefulness. The vendor repeated denied that moisture adsorption was an issue because Trona is not hygroscopic. This is technically true; unlike quicklime that can slake in the air, Trona's chemical affinity for water is satisfied. However, AEP has conducted field and laboratory testing to identify the root causes of the material handing problems and moisture adsorption was identified as a major contributor. Both moisture and temperature control are especially critical to overcome the material handling challenges that have plagued Trona systems in the past. AEP has filed a patent on their unique processes for handling and injecting Trona.

In addition to material handing problems, the most challenging problem, duct deposition, has likewise been overcome. Deposition was not observed during the testing phase. It was noticed only after several months of operation when the unit was down for a forced outage due to a tube leak. No corrective measures or cleaning was conducted. After several more weeks of operation, another tube leak again forced an outage and during this second outage, it was noticed that flow distribution screen located upstream of the ESP became severely plugged on one side, causing severe damage to the first ESP field. The damage was a result of plate failures from self-excited vibrations caused by localized high flue gas velocities due to the plugged screen.

AEP was hopeful that the Trona vendor could resolve the deposition issue, but this problem was the first of its kind. AEP commenced an investigation to resolve the issue, however, the investigation proved to be more difficult than expected. Observations in the ducts showed that the “hot” side of the duct had deposition, while the “cold” side of the duct did not. Deposition was removed for analysis. X-ray diffraction (XRD) was attempted, but the samples were amorphous. Thus, XRD could not identify any crystalline structures to identify with the deposits. It was apparent that the vast amount of the deposition was actually flyash. The agglomeration of this ash was apparently caused by a minute amount of another element. Elemental analysis and pH readings led AEP to believe that sodium bisulfate could be forming. AEP directed the modeling of the chemical kinetics to explore AEP’s theory. The Trona vendor found a phase diagram for various sodium formations relative to SO_3 concentration and temperature. The phase diagram was related to deposits found in a Kraft boiler, so it was not directly applicable to the Gavin site. However, the kinetic modeling, pH, elemental analysis, and the phase diagram all pointed to liquid sodium bisulfate formation as a possible cause for the ash agglomeration and deposition. Deposition coupons were fabricated and installed in the duct. Deposition data was taken almost daily. This data was consistent with duct observations that indicated the deposition was temperature related.

Design changes were made to the Trona injection system to test AEP’s theory. CFD modeling determined that some turning vanes could be removed without significantly impacting differential pressures at duct turns. Removal of unnecessary turning vanes reduced the surface area on which deposition could form. This was done on all three ducts on both units. Quench air was introduced on one of three ducts on one unit to keep the peak flue gas below the critical temperature. On another duct without quench air, rapping was installed on one of the ESP distribution screens. Results after one ozone season of operation was successful. The duct with the quench air experienced almost no deposition and required no on-line cleaning. Ducts without quench air had measurable deposits and required some on-line cleaning to avoid plugging of turning vanes. The ESP screen was kept clean by the mechanical rappers. The modifications were then installed universally to the other ducts and ESP screens at the site.

Trona injection technology is now being implemented on a fleet-wide basis.

AEP has filed for a patent on this technology and is currently entering into non-exclusive licenses to disseminate the technology throughout the industry. It is AEP’s desire that if others utilize Trona injection for SO_3 control they design the system per AEP’s specifications. It is hoped that this will ensure uniformity among users and consistent, reliable results.