Virginia City Hybrid Energy Center
Response to Data Request
Bruce Buckheit, Member, Virginia Air Pollution Control Board

Question (Page No. 11-12):

CFB boilers have naturally low emissions for SO2. This is because the fluidized bed contains limestone, the same material l used in the scrubber to remove SO2. The literature confirms that CFB boilers can remove in excess of 90 per cent of the sulfur in the fuel. The capture rate within the CFB boiler is a function of the calcium to sulfur ratio in the bed. A representative value for such performance would be in the range of 92 per cent see attached documents. Based on this level of control, there have been plants permitted in the past where no additional controls were required. Dominion has proposed to incorporate a “spray dryer absorber or “dry scrubber” that it asserts will remove 95 per cent of the sulfur that is not captured in the limestone bed of the CFB. On paper, the combined removal efficiency of this two-part system is 99.6% DEQ acknowledges that dry scrubbers “typically” attain a 95% removal rate, but, without stating a specific underlying value for the CFB contribution, assigns an overall removal efficiency of 98% to the system. This leads DEQ to assign a permit limit that is five times greater than the theoretically achievable rate.

Back calculating from the overall efficiency and the claimed 95% removal efficiency for the SDA, reveals that DEQ’s proposed emission level assumes only a 60% capture rate for the CFB portion of the system, far less than the literature would suggest. There are occasions where the capture efficiency of a control device is fixed and so an error in the emission limit might not affect real world emissions. However, where CFB contribution to overall performance is dependent on the amount of calcium injected and spray dryer performance is dependent on the rate of limestone injection an overly lax emission limitation could lead to increased emissions. The chart below illustrates the emission levels that have been achieved by existing units and does not necessarily establish what those units could achieve.

An issue can arise where inlet loadings to a pollution control system are so low that the system can no longer achieve the percentage removal levels that might be expected at higher loads. I suspect that the dry scrubber might not be able to achieve 95% efficiency in this application, and if this is the case the permit should reflect this fact. These issues may be resolved by reviewing existing documentation maintained either by Dominion or the system vendor concerning the design and performance of the CFB itself and of the dry scrubber system. In particular, those portions of the procurement documentation concerning three narrow points may be sufficient to resolve the issue: (1) the design of the atomizer system (are rotary atomizers employed?); (2) the anticipated SO2 inlet loading to the SDA; and (3) the overall SO2 system performance (a) requested in the RFB;(b) set out in the contract; and (c) any guaranteed performance for the system.

Response:

The 98% SO_2 control efficiency proposed by Dominion is based on 80% SO_2 control in the boiler and 90% control from the flue gas desulfurization system (FGD). 1 - (1-0.8) X (1-0.9) = 98% The SO_2 emission limits were based on 2.28% sulfur content coal and the above described control efficiency.

The VCHEC has guaranteed an equivalent 98% removal of SO_2 from the combustion system proposed which includes a state of the art CFB boiler, a dry FGD and a fabric filter. SO_2 removal of greater than 98% can be achieved by the proposed system under ideal conditions. In fact, to assure meeting the existing permit limits of 0.15 lb/MMBtu on a three hour basis and 0.12 lb/MMBtu on a 24 hour basis for SO_2, the plant will routinely operate at a lower emission rate. The reduction will be accomplished through the interaction of the CFB boiler, a dry FGD and a fabric filter. Different parts of this system will be employed under different operating conditions to assure compliance with the emission limits at all times. As correctly stated on page 12 of the comment,

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As the SO_2 control efficiency within the boiler increases, the more difficult it becomes to control the increasingly lower emissions coming into the FGD. When stating that "DEQ has assigned a permit limit that is five times greater than the theoretically achievable rate," the commenter is assuming the highest possible control efficiency for each portion of the system (boiler and FGD). Assuming no control in the boiler, 95% control in the FGD is possible. 92% control in the boiler is very optimistic and based on discussions with the boiler and control vendors, not consistently achievable. It is unrealistic to consistently expect 92% control in the boiler and 95% in the FGD. There are times when each of these controls will exceed 92% and 95% and possibly concurrently, but to maintain the combined 99.6% control efficiency continuously is not realistic which is why no CFB permit has an SO_2 limit based on 99.6% control. It is not appropriate to take the individual components separately as these two controls act as a system.

The emission rates for the VCHEC have been carefully crafted by the VDEQ to assure the lowest overall impact on the environment. It is recognized that there is an interaction of emissions of SO_2, CO, NOx and VOC as well as other non criteria pollutants. Over-controlling any one emission will have the effect of increasing others as noted in the previous response. For SO_2, control in the boiler is achieved by maintaining a high calcium to sulfur ratio. The higher the ratio is, the better the SO_2 removal will be. As we approach very high removal rates, the effectiveness of additional calcium diminishes. The effectiveness is reduced due to the need for physical contact between the remaining sulfur and the calcium to have a reaction. The excess calcium is carried over with the flue gas into the dry FGD and assist in providing additional calcium to react with the remaining sulfur. The dry FGD efficiency is also dependent on physical contact of the sulfur and the calcium to react. If the concentration of sulfur entering the dry FGD is low, the percent removal will be decreased. The last opportunity for capture of the sulfur is when the flue gas passes through the calcium rich filter cake on the fabric filter bags. The VCHEC anticipates excess calcium must be present throughout the system in order to consistently meet the proposed emission rates for SO_2.

According to the boiler vendor (Foster Wheeler), increasing limestone injection increases thermal NOx. An increase in thermal NOx requires an increase in ammonia injection to maintain compliance with the NOx limit. An increase in ammonia injection results in ammonia slip to a rate at which operations are negatively affected, i.e. forming of ammonium bisulfates which results in corrosion and pluggage of the preheater.

The calcium is added to the boiler by injecting limestone that is calcined to release the free calcium. This process releases CO and absorbs heat from the boiler, requiring additional fuel.

There are other operating conditions that will affect the balance of the SO_2 removal in the boiler. Sulfur is an impurity in the coal and is not uniformly distributed. VCHEC anticipates times when coal sulfur content will spike on a short-term basis. It will take time for the excess sulfur to be detected and additional limestone injected and calcined to control the emissions. During this period, the percent removal in the boiler will be less than optimal, but the control in the dry FGD will automatically increase. Because the coal will be fed from a bunker that will hold at least 8 hours of fuel, it will not be possible to stop feeding the higher sulfur coal that is already in the bunker, so the facility will have to be able handle the excursion within the 3 hour and 24 hour averaging periods.

Even though this facility is designed as a base load facility, it will have to respond to the electrical demand from the PJM Grid and will need to be able to throttle down to low loads during off peak electrical periods. Operation at loads from 50% to 75% will reduce the amount of mixing in the bed as the fluidizing air flow is reduced. This will reduce the contact of the sulfur and the calcium and result in a lower capture in the boiler bed. This reduced control will have to be compensated for in the dry FGD to maintain the permit limit. It is common to try and over compensate for the lower efficiency of the boiler by increasing the free calcium in the spray dryer to spike the FGD's efficiency. Since the flow rate has been reduced, the amount of lime slurry in the scrubber will need to be reduced to eliminate wetting the fabric filter bags, thus the lime concentration in the slurry will need to be increased to the maximum design level to achieve the permit limits for SO_2.

The dry FGD units will also need to be maintained. The unit will have a high speed lime slurry distributor that is designed to provide maximum surface contact with the droplets of the lime slurry and the sulfur in the flue gas. The nozzles in this unit wear and need to be replaced on a routine basis. During the replacement of the distributor, there is a 15 to 20 minute period of time when lime slurry is not being delivered to the spray dryer. This brief period of time when the efficiency of the dry FGD is reduced will need to be compensated for to meet the 3 hour emission rate.

During startup, the limestone in the boiler bed will not have been calcined and thus the calcium will not be available to react with the sulfur, thus removal rates will be very low until enough heat has been developed to start the reaction. The dry FGD will also not be functioning until the exit temperature of the boiler is high enough to evaporate the lime slurry that is injected. For this reason, the boilers were specially designed to operate on ultra-low sulfur diesel for as long a period as possible in order to minimize coal operation at low loads during startup.