Source Water Challenges from Three FGD Makeup Water Treatment Systems

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KEYWORDS

Flue Gas Desulfurization Makeup Water Treatment, Gravity Filtration, Seawater RO, Solids Removal

ABSTRACT

This presentation describes challenges faced by three FGD makeup water systems. Facility #1 pulls high quality stream water requiring only clarification and filtration. Facility #2 utilizes sanitary treatment effluent requiring further treatment, including chlorination, filtration, and ultraviolet disinfection. Facility #3 uses brackish water requiring desalination with solids removal.

INTRODUCTION

Since the introduction of the Clean Air Act Amendments in 1990, coal fired power plants have been implementing a new round of flue gas desulfurization (FGD) systems to meet the sulfur dioxide control requirements set forth. The 2004 Clean Air Interstate Rules furthered the need for FGD systems, with more stringent emissions controls, particularly on sulfur and nitrogen containing compounds. These rules pushed for FGD's to be installed in phases over the next twenty years at coal fired power plants around the country.

A significant number of the FGD installations are wet scrubber systems, utilizing limestone forced oxidation for removal of the pollutants (Edmunds 2008). The pollutants end up in the circulation water, which leads to a highly polluted waste stream that has to be constantly purged from the scrubber to limit the internal concentrations. This waste stream is high in chlorides,

supersaturated with sulfates, high in both dissolved and suspended solids. There is also the potential for heavy metals and organics depending on the coal source. To makeup for the circulating water being constantly purged from the system, a consistent and reliable makeup water source must be available to feed the scrubber system. The ideal source is low in chlorides, solids, and other pollutants expected to be added to the stream in the scrubbing process.

METHODOLOGY

This paper describes the challenges faced by three separate FGD installations with three distinctly different water sources. The varying source water and solutions required for each case will be compared and contrasted. Design features, along with overall project schedules and details, will be examined to further demonstrate how the source water availability can have an impact on the overall FGD project.

The three facilities discussed in this paper will be designated as Facility 1, Facility 2, and Facility 3. Some key source water characteristics for the three facilities are shown in Table I. Facility 1 utilizes municipal treatment plant effluent as source water. While this water is of a high-quality, local regulations stipulate further treatment prior to reuse, and additional solids removal is required as well. Facility 2 utilizes a natural stream as source water. This stream is a high-quality fishery and only requires solids removal prior to feeding the FGD. Facility 3 utilizes a brackish water source and has the most intensive treatment scheme. Solids removal and desalination are required to meet the makeup water discharge requirements.

Table I – Select Source Water Quality Parameters

Selected Parameters	Source Water Concentration at:		
	Facility 1	Facility 2	Facility 3
pH	6.3 – 6.8	6.7 – 8.0	6 – 9.2
Total dissolved solids (mg/L)	293	84 – 474	13,800
Total suspended solids (mg/L)	2.5 – 5.6	5 – 300	10 – 2,000
Total chloride (mg/L)	69 – 108	0.5 – 32.0	8,000
Sulfate (mg/L)	35.8	24 – 60	354
Turbidity, NTU	0.7 – 8.0	0.2 – 213.0	-
Coliform, MPN/100 mL	50 - 170	-	-

Table II – General Makeup Water Quality Requirements

Selected Parameters	Treated Water Requirement for:		
	Facility 1	Facility 2	Facility 3
pH	6.0 – 8.0	6.0 – 8.0	6.0 – 8.5
Total suspended solids (mg/L)	≤ 1	≤ 11	≤ 10
Total chloride (mg/L)	-	-	≤ 95
Turbidity, NTU	≤ 3.0	≤ 25	-
Coliform, MPN/100 mL	≤ 1	-	-

Each of the three facilities has similar requirements for the makeup water quality as shown in Table II. In general, the water must be low in turbidity, chlorides, and solids, along with having low concentrations of the main pollutants expected to be added to the stream in the FGD scrubbing process.

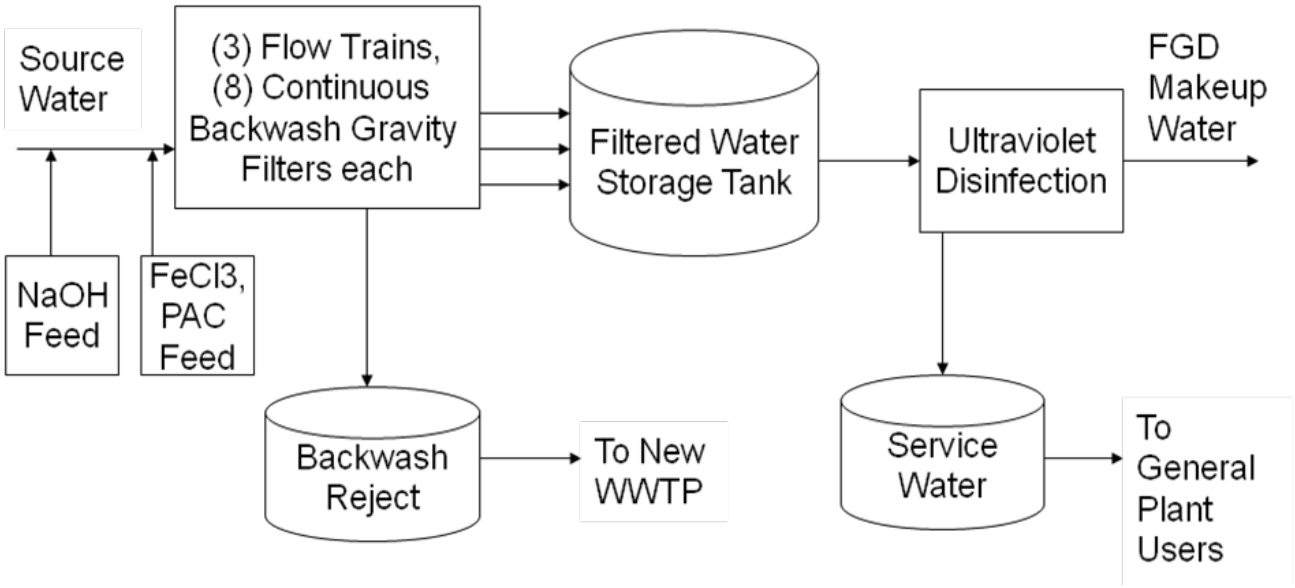
RESULTS AND DISCUSSION

FACILITY 1

The process flow diagram shown in Figure I identifies the primary and secondary flows through the makeup water treatment plant. The major treatment equipment includes the continuous backwash gravity filters and ultraviolet disinfection skid (UV). As noted earlier, the water source for Facility 1 is municipal treatment plant effluent that local regulations require to be treated further prior to reuse. The system is designed to treat 4,800 gallons per minute (gpm), but must be able to operate with a minimum flow rate of 1,345 gpm.

From the municipal treatment plant, a force main transports the makeup water influent flow to Facility 1. Pre-chlorination of this force main takes place near the municipal plant for coliform reduction and to prevent growth in the force main. The influent to Facility 1 is split between the three trains of continuous backwash gravity filters. These filters provide enhanced TSS and phosphorous reduction. The effluent of the gravity filters is collected in a holding tank prior to being pumped through the UV disinfection system for enhanced coliform removal. The UV effluent continues on to the FGD facility for use as makeup water. A portion of the disinfected effluent is diverted to a smaller storage tank to be used as plant service water. The backwash reject from the gravity filters is collected in a separate tank and is pumped to the FGD wastewater treatment plant. The entire system is located outdoors and had to be designed as such to handle both the summer and winter extreme weather conditions.

Figure I – Facility 1 Process Flow Diagram



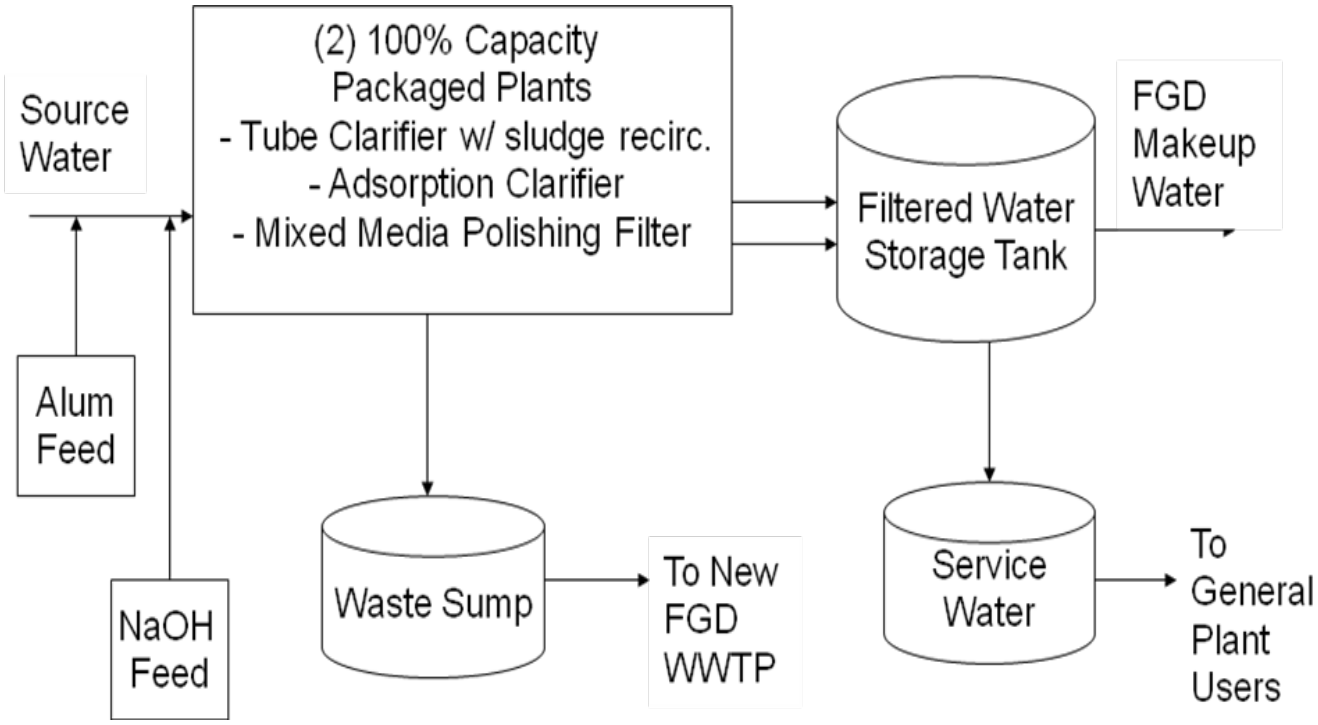
The design of Facility 1 was an ongoing process through the duration of the design build project. The process equipment design and procurement had a duration of approximately six months. Balance of plant engineering occurred over the next six months, and construction was completed approximately eight months after design was complete. The entire project schedule stretched out over about twenty months, and the system is currently going through wet testing. Startup and performance testing will occur over the next two months, as the project schedule and budget continue to remain intact as the project pushes towards completion.

FACILITY 2

The process flow diagram shown in Figure II shows the flow train through Facility 2. The major treatment equipment includes two packaged clarification and filtration units, with space for a third unit to be installed in the future. The water source for Facility 2 is a local stream that is typically of a high quality, and the treated water will be used as both makeup water at the FGD and service water for the site. The system is designed to treat 2,330 gallons per minute (gpm) but must be capable of providing anywhere from 0 – 100% of that flow to the FGD.

From the stream, a force main transports the influent flow to Facility 2. Sodium hypochlorite is injected into the stream to prevent biological growth in the pipeline and for primary disinfection. As the stream enters Facility 2, an automatic bypass is in place for times when the stream water meets the filtered water requirements. When the system is operational, the influent is split between the two packaged systems.

Figure II – Facility 2 Process Flow Diagram



Each flow train passes through a tube clarifier, followed by an adsorption clarifier, prior to flowing through a mixed media filter. The effluent of the system is utilized as makeup water for the FGD and service water for the plant. A portion of the sludge from the tube clarifier is reintroduced to the influent, while the remaining sludge is blown down to the waste sump. Flushing and backwash water from the other treatment processes is also blown down to the waste sump. The various waste streams are collected and used as a blending stream when additional makeup water is required, or they are sent to the wastewater treatment system. Due to space constraints at the site, both the clear well and waste sump were constructed below grade, with the treatment equipment, electrical equipment, and control room/lab housed in a building setting on top of the buried tanks.

Again, design of the facility was ongoing throughout the project as the system evolved to the finished product. Process design and procurement was completed in the first four months, followed by balance of plant engineering over the next six months. Construction and balance of plant engineering overlapped on this design build project and the facility was completed approximately 13 months after release of the contract. Again, the project is on budget; however, the schedule for the project has been extended from the original contract date. The system is currently in dry testing and startup will occur over the next two months, and facility 2 will be capable of providing

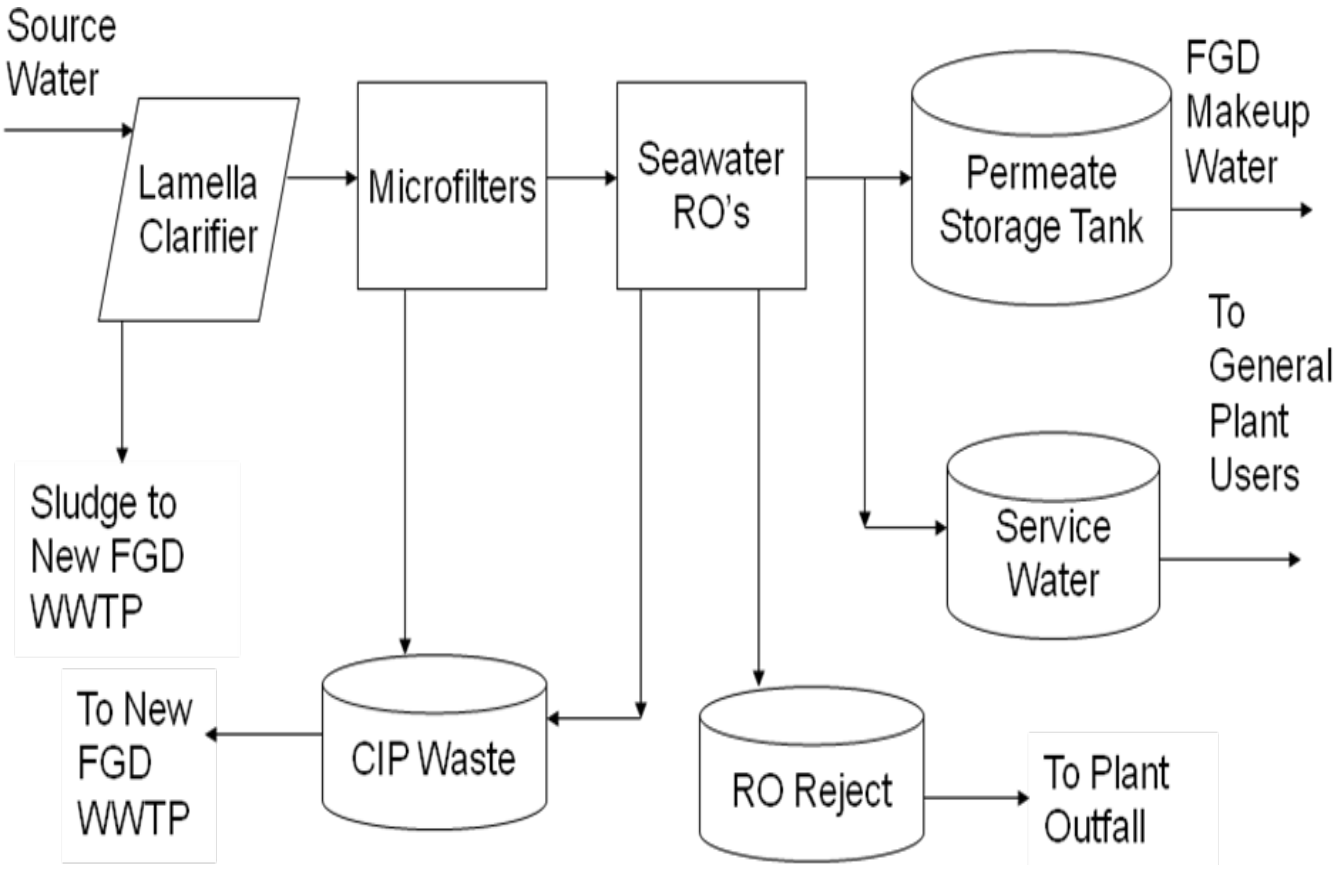
makeup water prior to the FGD being complete.

FACILITY 3

Facility 3 is the most complex of the three makeup water treatment systems as can be seen in the process flow diagram shown in Figure III. The source water is from a brackish river and both solids removal and desalination are required prior to using the stream as makeup water at the FGD. The system is designed to provide a maximum of 2,350 gpm and a normal flow of 1,560 gpm of makeup water to the FGD meeting the effluent requirements set forth in Table II. In order to meet these flow requirements, a pumping system delivering 4,500 gpm from the river intake had to be designed for the system as well.

The new pumping system from the existing river intake was designed to feed Facility 3. This system included sodium hypochlorite injection to prevent biological growth in the pipeline. From the intake pumping system, the influent enters Facility 3 with an option to feed one of three lamella clarifiers.

Figure III – Facility 3 Process Flow Diagram



The clarifiers are only expected to be used for primary solids removal during the rainy season when the highest solids loadings are anticipated. From the lamellas or the bypass, the stream is pumped through one of six micro filters prior to being pumped through one of six seawater reverse osmosis (RO) units. The RO permeate is collected in a new storage tank which will feed the FGD system as both makeup water and service water. Numerous clean in place skids are associated with this system for the micro filters and the ROs. The waste from the system is collected in a storage tank and combined with the FGD wastewater treatment system effluent prior to the WWTP effluent being reintroduced to the source water. Sludge from the lamella clarifiers, as well as the clean in place waste, are pumped to the FGD WWTP for treatment. Due to the high chlorides in the stream prior to the seawater ROs, the materials of construction are all non-metallic, and the seawater ROs utilize duplex stainless steel.

The schedule for this system was similar to Facility 2 which made it far more aggressive due to the complexity of the system. Process design and procurement was complete in the first three months in order to get the major process equipment on site per the schedule. Balance of plant engineering was complete six months later. Construction overlapped design and was completed 13 months after the contract was released. Dry testing of the system is underway and full startup should be complete within 3 months. The budget and schedule for the project were met, and the system will be ready to feed makeup water to the FGD prior to the FGD completion.

CONCLUSION

The source water quality can have a major effect on the treatment processes required for an FGD makeup water treatment facility. Because existing plants that are being retrofitted with FGD's cannot be relocated, the availability of high quality water in the quantities required can complicate the issue further. Taking a thorough look at what is available and ensuring the contract for the makeup water system is released in a timely manner can aid in avoiding FGD startup scheduling problems as well. Provided the time is available, a properly designed system will ensure the FGD can operate as designed without complications from the makeup water system.

REFERENCES

Edmunds, Chris, Treating FGD Purge Streams, Environmental Protection, November 7, 2008.