Design, Construction, and Start-up Of a Biological Pretreatment Plant For a Large Pharmaceutical Manufacturing Facility

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On September 21, 1998, the U.S. Environmental Protection Agency (EPA) promulgated a new Pharmaceutical Effluent Guideline (PEG) and a National Emissions Standard for Hazardous Air Pollutants (NESHAP) for the pharmaceutical manufacturing industries. The EPA's PEG requirements gave pharmaceutical facilities discharging to publicly owned treatment works (POTWs) three years to meet strict pretreatment effluent requirements with respect to specific organic compounds.

As a result, alternative control technologies were evaluated for the Augusta, Georgia, manufacturing facility now owned by Pfizer Inc. Preliminary and detail design of the new wastewater treatment plant (WWTP) was completed and a fast-track construction and start-up schedule was implemented to meet regulatory deadlines.

An initial evaluation process looked at both conventional activated-sludge treatment and the Kaldnes moving bed biofilm reactor (MBBR) process. A pilot plant of the MBBR process was undertaken that showed successful treatment with several advantages and disadvantages regarding operational and maintenance issues (Camp et al., 2000).

The major difference between the two systems is that a suspended activated-sludge system requires clarification to settle biomass for recirculation back to the aeration tank or for periodic wasting, whereas the MBBR is a fixed-film system that does not require recirculation of biomass. The biomass in a fixed-film system is retained on the media or carrier elements in the biological reactor, and only biomass that is sloughed from the media flows out of the system with the treated effluent.

This feature was advantageous in selecting this technology for use in the WWTP because it has resulted in no solids handling or disposal for Pfizer, with the entire effluent discharged to the POTW. Pfizer's Industrial Discharge Permit has an effluent total suspended solids (TSS) limit of 200 mg/L, and it was determined in the pilot study and subsequent start-up that the overall facility discharge, which included the MBBR effluent and other utility streams that are not treated (i.e. cooling tower blowdown, boiler blowdown, non-contact cooling water, etc.), was below this limit.

Wastewater from a typical pharmaceutical manufacturing process can vary significantly in quality and flow because of the wide range of products that are produced at a single facility. This was true at the Pfizer facility, resulting in both engineering and operational challenges that needed to be overcome during design and start-up.

A PEG design team was commissioned with several plant departments represented and Environmental Resources Management Inc. (ERM) as their consultant. The design team implemented the project and scheduled action meetings to ensure that milestones and regulatory deadlines were met. Departments represented on the team included engineering, environmental, health and safety, finance, operations, and utilities.

The initial goals set by the team were to construct a facility that would be flexible to the changes in production cycles, ensure the ability to introduce new product lines with varying wastewater characteristics, provide maximum ease of operation and operator access for maintenance, and accomplish all of this within a tightly controlled budget.

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Preliminary Design

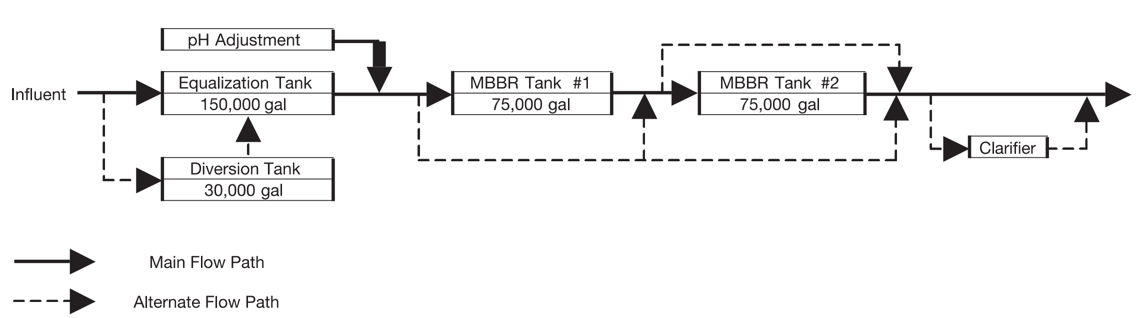
Prior to detail design activities, the initial efforts of the PEG design team focused on completing preliminary engineering and process design activities that would lead to a flexible WWTP operation constructed and placed in service. Some of these preliminary activities included:

1. Determination of affected waste streams from manufacturing operations and subsequent development of the WWTP design basis (i.e., flow rate and quality) were the first orders of business. Because of the batch nature of a typical pharmaceutical manufacturing process and the time gaps in production cycles of different products, this task was fairly tedious, requiring composite samples in several areas of the plant over a three-to-four-month period. The following design basis for the new WWTP was reached:

- Flow ....150,000 gpd
- COD ....3,000 lb/d
- BOD..1,300 lb/d
- TSS ....180 lb/d
- VOC Target Pollutants ....1,000 mg/L
- Ammonia..Highly Variable (0 – 25mg/L)

2. Development of a flexible process design was a key element of the project. Equalizing and diverting wastewater were important functions to allow maximum flexibility of the new WWTP. A 150,000-gallon equalization tank provided 24 hours of hydraulic detention at the design flow rate. Also, a 30,000-gallon diversion tank provided a location to store either high-strength or high/low pH wastewater from batch dumps or off-spec product. The diversion tank system was designed with variable-speed effluent pumps, allowing operators to slowly bleed wastewater into the equalization tank. TquaBT/F(ennumps,2(q)45((umps o)3567 688.(sp)-5(e)-)-16(ith v)-1(ar)-1mu522(T).1rd)7(h nau-5(.......(i

Figure 1. PEG WWTP Flow Schematic



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specialty contractors was utilized for bidding on each of the design packages. Typical detail design packages were completed for the new WWTP (i.e., civil and structural including foundations and pipe racks, mechanical equipment and piping, electrical and instrumentation, field and shop constructed tanks, and a new, two-story WWTP operations building).

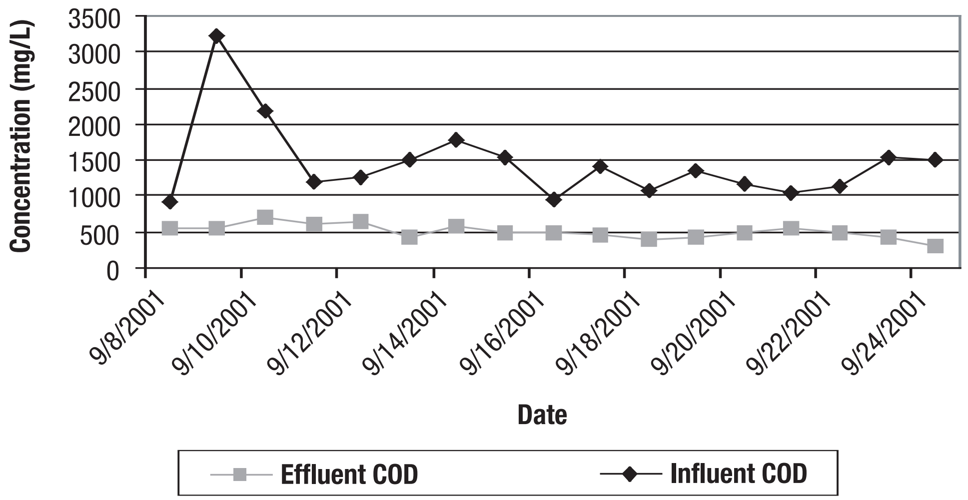
Typical to many large chemical manufacturing operations, this facility's automation and instrument monitoring system is via a Distributed Control System (DCS) from a central control room. Design and installation of the new WWTP benefited from having approved automation design procedures and selected instrument vendors already in place. A DCS was designed and installed in the new operations building to control the WTTP, which also allowed monitoring from the central control room. Local indication of process parameters at the treatment units, along with remote indication and control at the operation building, were key requests from the operators for ease of oversight.

Other detail design features of the new WWTP project included:

- Tank design standards that utilized both closed-top API-650 and UL-142 specifications. The equalization tank and aeration tanks were designed with the API-650 standard, and the diversion tank was designed with the UL-142 standard. The UL-142 (steel above-ground tanks for flammable or combustible liquids) provided extra flexibility for use of the diversion tank to store various types of wastewaters. The material of construction for each tank was 304L stainless steel.
- Variable frequency drives (VFDs) used on the positive displacement blowers and major centrifugal pumps. The use of VFDs on the blowers allowed the operators to trim the aeration horsepower when dissolved-oxygen levels in the MBBR tanks were higher than desired (normally due to low-strength wastewater).
- Jet mixing of the equalization tank and diversion tank with centrifugal pumps and eductor nozzles.
- pH adjustment with either 20-percent caustic or 98-percent sulfuric acid after the equalization tank effluent pumps. Adjustment of the wastewater pH was a critical design issue. Influent wastewater could be either high or low pH, depending on the production operations or the cleaning activities that were occurring in the manufacturing areas. Adjustment of pH was achieved using a static mixer with downstream pH probes and transmitters controlling chemical metering pumps.
- Nitrogen blanketing of the equalization and diversion tanks with pipe-away conservation vents to a thermal oxidizer for off-gas control.

Figure 2.

MBBR System Influent / Effluent COD at Startup



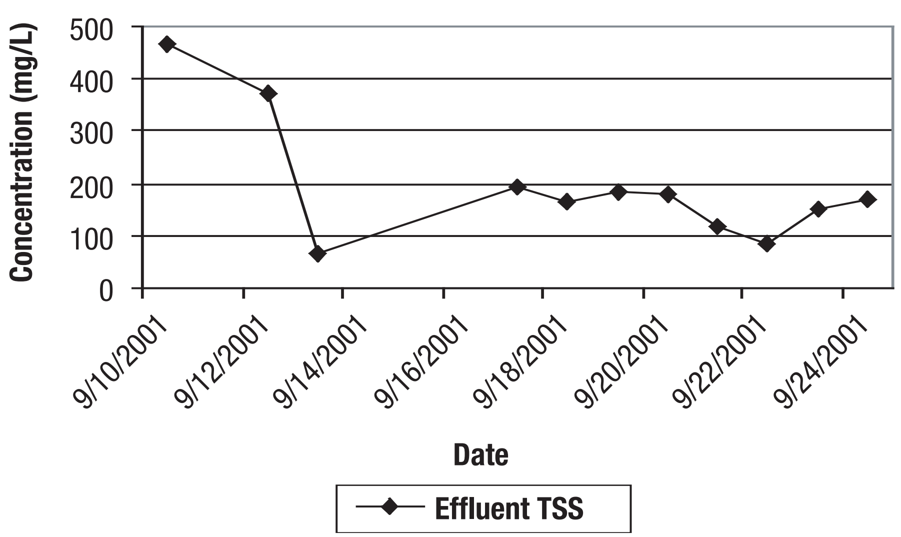
Construction activities for each design package were started almost immediately after it was completed. When feasible, the selected contractors were allowed to start developing their bids on 95-percent design packages, and final changes were sometimes made during initial phases of construction.

An important goal was to keep within the budget constraints of the original project planning documents. Implementing the project showed significant cost and time savings by using project managers from the company's engineering department to act as the overall construction coordinators. Also, the company purchased the major pieces of mechanical equipment (blowers, pumps, mixers, automatic valves, etc.) and instrument devices, providing them to the contractors as owner-supplied equipment. Because the owner had purchasing agreements with many of the equipment vendors, most of this equipment arrived on-site quicker without the typical markup applied by a general contractor.

This effort required close coordination between the ERM designers, equipment suppliers, contractors, and the owner. Submittals were reviewed by the design team and turned around in quick succession, sometimes in less than 24 hours. With the exception of a few minor instances, this design-construction procedure worked well with few coordination miscues among the contractors.

Figure 3

MBBR System Effluent TSS During Startup



System Start-up

Start-up of the system began on August 22, 2001, after an initial shakedown period which included leak testing of tanks and piping, mechanical checks of rotating equipment, instrument calibration, and electrical power testing. After the shakedown period, the following start-up sequence for the MBBR process commenced:

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- MBBR reactors were filled over a period of four days with raw wastewater, media, nutrients, and return activated sludge (RAS) from another facility.
- Day 1: Added 34 one-cubic-yard bags of media, 3,000 gallons of RAS from the local POTW, nutrients, and 22,000 gallons of wastewater to each reactor. Both reactors at 30 percent fill level. Aeration blowers were started.
- Day 2: Repeat of Day 1 additions, except enough wastewater was added to bring each reactor to the 50-percent fill level.
- Day 3: Repeat of Day 1 additions, except enough wastewater was added to bring each reactor to the 70-percent fill level
- Day 4: Repeat of Day 1 additions, except enough wastewater was added to bring each reactor to the 90-percent fill level.
- Day 5: Initiated flow to MBBR reactors at a rate of 25 gpm.

Observations noted during the start-up phase included the following:

- Biomass growth on the media was noted within seven to 14 days. At approximately 21 days, inspection of the media showed that sufficient growth was present to commence full, forward flow of the WWTP.
- Adding additional loads of RAS from the POTW periodically over the first two to three weeks helped establish growth on the media. Some of the RAS washed through the system; however, the addition of more biomass appeared to help saturate the media bed and allow more biomass to attach.
- Filling the reactors in the manner discussed above allowed the biomass time to begin attachment to the media and acclimation to the waste stream.
- Flow to the reactors was increased slowly as the biomass established on the media. Increasing flow too quickly could cause sloughing of the new-growth biomass.

Problems Encountered with Start-up

Several problems were encountered during start-up, including the following:

- Some equipment operational issues were encountered and corrected. Several of the chemical pumps were not delivering the stated flow at the desired pressure, which was caused by the installation contractor over-tightening the discharge piping, resulting in the ball check valves restricting the flow. The pressure-relief valves on the positive displacement blowers tended to open with a quick start on a blower. This situation was corrected by allowing a time-phase start-up of the blower, allowing water in the aeration piping to be "slowly" blown out of the submerged lines prior to reaching the blower operating air flow and pressure.
- Media initially tended to float and formed a barrier four to six feet thick on top of both MBBR aeration tanks periodically for the first three weeks. Mixing the tanks with blowers had to be increased and in some cases a fire hose was used to break up the barrier and get the media back into suspension.
- The manufacturing area dumped high-pH wastewater on several occasions during clean-up periods without notifying the WWTP operators. The design team quickly solved this problem by better educating the operations personnel.
- Slugs of high organic concentrations (solvents) were discharged from the manufacturing area on several occasions during the start-up period, which were greater than the emergency diversion and equalization tanks could handle. One slug load, in conjunction with a high surfactant concentration from cleaning operations, completely wiped out the biomass. Foaming was so severe from the soap that the reactors foamed over, and the system had to be reseeded with RAS from another biological treatment plant.

The following observations and improvements were made after the start-up period:

- The problem with floating media went away once a film of biomass was established on the media, slightly increasing the specific gravity of the mobilized bed and decreasing

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the hydrophobic tendency of the media. This allowed initial aeration and mixing requirements to be lowered, since additional agitation was no longer needed.

- Daily microscopic evaluation of media showed that a strong, diverse biomass was established within three to four weeks after start-up. Biomass included bacteria, rotifers, stalked ciliates, free-swimming ciliates, and flagellates.
- The company developed better communication procedures for early detection of releases of high organics from the manufacturing areas in conjunction with better coordination and operation of the emergency diversion and equalization tank systems.
- Manufacturing area personnel developed procedures and implemented programs concerning what could and could not be released to the new WWTP.
- MBBR system effluent concentrations were in compliance with the PEG categorical effluent standards by September 21, 2001. **Figure 2** shows the COD influent and effluent concentrations during start-up.
- Effluent TSS concentrations continued to decrease and were below the industrial permit limit of 200 mg/L by September 21, 2001. **Figure 3** shows the effluent TSS during start-up.

Conclusion

Design, construction, and start-up of a moving bed biofilm reactor for treatment of a pharmaceutical wastewater was successfully completed to meet the EPA's new Pharmaceutical Effluent Guideline (PEG).

Having the PEG design team consist of ERM and plant personnel from each of the pertinent departments allowed the project to be completed within a very short time frame. Any construction or start-up issues encountered by the team were quickly overcome. This coordinated team effort also allowed for minor changes and improvements to be made from operator input during the design and construction phases without delay, and to the satisfaction of the facility owner.

Communication between the WWTP operators and manufacturing and utility personnel improved. Better lines of communications between these groups in order for the PEG system to function properly allowed for more efficient plant operations.

References

- *Camp, W.W., C.H. Johnson, L.F. Tischler, J.B. Green, R.E. Gossett, 2000,* Evaluation of Moving Bed Biofilm Reactor (MBBR) Technology for the Removal of Volatile Organic Compounds*, 7th Annual Industrial Wastes Technical and Regulatory Conference, 2001 Proceedings.*