LOOK, NO CLARIFIER!

by

J. E. Burguet, Chief Chemist
and
M. R. Hutson, Chemist
Mississippi Power & Light Company

INTRODUCTION

Clarifying Mississippi River Water With An Up Flow Filter

Baxter Wilson Steam Electric Station is located approximately two miles south of Vicksburg on the east bank of the Mississippi River. The plant's first unit is a 550 megawatt supercritical unit which went into operation December, 1966 and a second unit with a capability of 750 megawatt that went into operation in October, 1971. Condenser cooling is once-through using Mississippi River water. Make up water for boiler, sanitary and other plant uses was from the city of Vicksburg. An evaluation for producing the right quality water by an in-plant water treatment plant or other means was made in 1964; at that time, without taking in consideration other parameters which are the subjects of this paper, the economic evaluation favored the purchase of Vicksburg city water. See Table 1 for evaluation. Availability of ground and surface water was of no concern. The Mississippi River and ground water available in this area are plentiful; however, for our operation, the use of either source meant large investment in water treatment equipment, such as clarifiers plus the possibility of additional personnel for operation and maintenance and with either source, it created a problem with solid waste disposal for the company.

At another of our installations, where a clarifier was used to soften the well water for plant uses, we found that with the recent interest in environmental quality a different approach would have to be taken. In that instance the problem was successfully solved by replacement of the clarifier with ion exchange equipment.(1) At Baxter Wilson Steam Electric Station a different approach was taken after thorough re-evaluation.

Average water consumption prior to the addition of the second unit was 2,956,000 gallons per month at an average cost of $800.00 per month. With the addition of a second of a second unit the average cost per month jumped to $1,500. Although, this was a straight and expected linear increase, there were other parameters that had to be taken into consideration.

Vicksburg city water comes from 10 wells located on the River Harbor

Project. The water is of the best quality after treatment. The price is reasonable and competitive with other cities. However, the city found that in order to prevent fungus and bacterial growth for domestic users, a 10 ppm chlorine injection had to be maintained. Although this demand was 80 to 90 percent consumed by the time the water reached our facilities, the free chlorine left in the water--1 to 2 ppm--was sufficient to damage resins in our ion exchange equipment.

Modern power plants require very pure water. Generally speaking, distilled water is not pure enough. The use of ion exchange equipment is a must as the pressure and temperature of our modern day plants progressively increases with every new boiler/turbine generation. Normally, the water in our supercritical boilers must not have over 50 part per billion total contaminants. Under actual normal operating condition this usually runs between 10 to 12 parts per billion.

In order to accomplish this type of purity boiler make-up water passes through strong acid cation exchanger and a strong base anion exchanger. Effluent from this process enters the pre-boiler system at the condenser hotwell. Here it is picked up, together with the returned condensate and pumped by the condensate pump through mixed bed polishers which bring its Total Dissolved Solids to less than 50 parts per billion. Water then continues its route to the boiler. See Sketch I. As it is readily apparent the amount of equipment, operation, and quality of water is of extreme interest and importance to our company or any other generating utility. The make-up demineralizers are two trains producing 100,000 (approx.) gallons per regeneration each at a rate 100 GPM per train.

Resins used in these ion exchange units average $25.00/cu.ft. for cation to $65.00/cu.ft. for the anion resins. An investment of some $12,000. Replacement of this resin is generally assumed at 100% every five to seven years. At Baxter Wilson Steam Electric Station, due to the excessive chlorine in the water, two (2) loads of resin was damaged at a cost of $24,000 in a period of three years. Needless to say something had to be done. A new source of raw water had to be found not only for quality but to procure an independent source of water.

The use of an up flow filter is not a new idea. However, with very few exceptions most of the up flow filters are in secondary water and waste water treatment. Only three national firms offer this type of equipment and of the three, only one has experience and has demonstrated, the feasibility of this type of equipment for producing Mississippi River water of equal or better effluent quality than clarifier.

There are three major manufacturers of up flow filters, each with their own, patented devices that, in general, reflect the firm's particular philosophy of accomplishing the job. Our choice was made after minute engineering studies were made of the unit's internal and external hardware design, hydraulic consideration and after a field survey of each manufacturer's operating units performance on Mississippi River water. It is important to note, that the components of Mississippi River water suspended solids that effect the turbidity of the water are not exactly like, nor does it behave in the same manner, as for example, a lake, a small stream, the effluent of a process, etc. Fine particles appear to sustain their suspension tenaciously. A recent report states the following[2]

"Concentrations of sediment in Mississippi River water at Baton Rouge and Red River Landing range from about 10 to 2,500 mg/1 (milligrams per litter) with minimum concentrations usually occurring during low-flow periods in the late summer and fall and maximum concentrations occurring during high-flow periods in late winter or early spring."

"Sediment concentrations were less than 100/mg/1 seven percent of the time and exceeded 1,000 mg/1 eight percent of the time."

Note Table II where we conducted a simple sedement/time test.

Generally, an up-flow filter operation is rather simple at first sight. See Sketch II attached. Large gravel is placed on bottom and subsequent layers of graded smaller sized gravel and sand are placed in properly sized tank, generally round, and the appropriate collection device is mounted a few inches above the top of the last layer of sand. Tank may be open top or closed.

The difference in the operation between a regular, down-flow, conventional pressurized sand filter now becomes important. Unlike the down-flow pressure sand filter, the up-flow filter is designed for filtering throughout its entire bed. Where a down-flow filter is limited to its first couple of surface inches for filtering, we now have, by change of direction and other important engineering considerations, the entire bed, from the 1-1½" (size of gravel) to 10-20" mesh layer to the top of the GRID, located a few inches below the top of the fine sand layer, filtering or collecting the suspended solids. It is this GRID, and its <u>arch</u> <u>building</u> capacity across the paralled lateral openings, that prevents the lift or unpacking of the bed. By stabilizing the bed during a filtering run, the filter is used throughout its entire depth.

With this statement above it is now important to describe an operating cycle to understand this type of filter.

During a filtering cycle, called service cycle, water enters the bottom dish head of the filter, then through a series of spaced nozzles, water flow upwards through the bed and out of the sand, through the funnel collecting device, then to service. Here it will have to go into storage and repumped for service. During this time, a continuous feed of an approved potable water polymer is injected at a rate of 1.5 ppm per 100 ppm turbidity of the influent raw water. During this service cycle the unit's influent pressure; that is, the pressure of the incoming water will begin to increase to approximately 6.5 psi above the original pressure. At this time, if the unit has not passed its filtering capacity by producing an unacceptable turbidity in the finish water and based on several additional design consideration, the service cycle is ended. This may be a manual or visual check, or may be automated to immediately go into its next step. At this point there are some considerations that the designer or user must make. The next service cycle may be thirty minutes to one hour away. Either enough storage capacity is needed for continued use or a second unit is needed, or both. Because at our Baxter Wilson Steam Electric Station the storage facility at worse condition if five hours, plus a stand-by of unlimited quantity is available, only one completely automatic unit of 300 GPM capacity was installed. This filter is a completely automated system with the following features:

1. Chemical Feed System, which consists of tank, mixer and pump.

2. Flow control equipment with the ability to recycle.

3. Blower to supply air for the flush cycle.

4. Turbidimeter to indicate the water quality and control service cycles.

5. Independent air compressor for the air supply to the instruments and controls.

6. Control panel which consists of a programmer for timing the various regeneration stops and switch and solenoids for control of valves.

7. Recorder for the service flow.

8. Alarm system which indicates high turbidity low chemical level and low level in surge tank.

9. The system has its own chlorination system.

10. Surge tank and transfer pump to supply water to the elevated water tank.

11. The system is completely enclosed with exception of the filter tank.

It is important now to understand the next cycle; the flush, or clean up cycle. Once the unit is out of service cycle, the signal is received and all valves close and a timing programer device takes over. In the first step the unit drains to waste to a point below the funnel collecting device and stops draining. The unit is then air scrubbed by introducing air into the bottom distributor plate for approximately three minutes. Air scrubbing stops momentarily, unit is drained to waste and additional predetermined length of time then drain is closed; and air scrubbing is commenced again. One minute later flush water begins to flow from the bottom of the unit at the same place as in the service run, but at a rate of 23 GPM per square foot. At the same time the flush water is entering, air scrubbing is also introduced for a few seconds longer. Air scrubbing is now stopped and unit continues to flush to waste for ten to twenty minutes. This is repeated once and then unit is placed in its "Pre-Service Mode." In this cycle, the unit is flowing in the same mode as service with exception that the service inlet is closed and waste water outlet valve is opened until such time as acceptable finish water is produced, then the two valves reverse positions and the unit is back into service. Note Table III for sequence of operation.

There are many parameters that govern the length of the service run as well as the flush and pre-run cycle. These are tabulated as follows:

Service Cycle:

1. Raw water suspended solid level.

2. Polymer failure - due to improper ratio or physio-chemical reaction.

3. Flow characteristic or flow changes.

4. Entrained air.

5. Temperature of water.

Flush Cycle:

1. Over runs or overloading.

2. Quality of flush water-use of filtered water, if available enhanses the operation.

3. Temperature of water.

Tulane University Researchers(3) made a study, published in Southwest Water Works Journal, February, 1973 with some interesting results. This study shows a "considerable" reduction of coliform bacteria. The researchers conducted twenty-three service cycle runs within nine months to count the coliform bacteria with the following conclusion: "The average levels were below 35 colonies per 100 ml. In all cases the average levels were within a range that could be handled by chlorination."

It behooves state and municipal parties involved in the supply of water to the public to raise their sights from the old and trusted method of a clarifier, and its inherent problems. White spent lime has been a solid waste problem associated with many types of clarifier. True, the upflow filter does not chemically change the quality of the water from the original source—and this is certainly a consideration in design—but when the advantages are counted, at least for the three installations Mississippi Power & Light Company has studied, the upflow filter came in ahead of any other options.

In conclusion, we list the various considerations taken to arrive at our decision to install an upflow filter:

1. Digging a deep well was avoided.

2. Quality of ground water was known to need extensive treatment.

3. Diverting the needed 300 GPM from an 8,300 GPM continuous source was simple.

4. Chemical storage was avoided.

5. Chemical Waste disposal was avoided.

6. Chemical cost per 1000 gal. at highest river turbidity at approximately 1¢ against 5. to 7. ¢ for clarifier.

7. Space needed was considerably less with an upflow.

8. Full automation with greater reliability.

9. Manpower increase was avoided.

REFERENCES

1. Weak Cation Units Replace Cold Lime Reactor
By J. E. Burguet and Paul Goldstein
Presented to Seventh Environmental Engineering Conference at M.S.U.

2. Hydrologic and Quality Characteristics of the Lower Miss. River
Technical Report #5
U. S. Department of Interior

3. Turbidity and Bacterical Removal Through Up Flow Filteration
Dr. S. E. Steimle
Dr. A. M. Anderson
Mr. B. J. Haney
Presented 1972 Louisiana Water Pollution Control Association

TABLE I

BAXTER WILSON UNIT NO. 1
MISSISSIPPI POWER & LIGHT COMPANY

Required Capitalized Investment for
Various Raw Water Sources Adequate
for 500 MW Station

SOURCE:	WELL WATER	CITY WATER	CITY WATER PLUS RESERVE WELL
First Costs			
2 - 300 gpm wells	$ 43,000		
300 gpm clarifier and access. plus 150 gpm filters and pumps	32,000		
100 gpm filter bank for demin.	NR	$ 6,000	$ 6,000
Makeup demineralizer increment	Base	1,500	1,500
Erection and installation of equipment	32,000	3,000	18,000
Building for equipment	30,000		
300 gpm tie line to City Main (5,000 ft. of 8 in. @ $7.00)		35,000	35,000
1 - 300 gpm well			23,000
300 gpm iron removal plant			20,000
Total First Cost	$137,000	$ 45,500	$103,500
Annual Operating Costs			
Pumping Energy	$ 120	$ 0	$ 0
Chemicals	4,000	650	650
Labor @ $3.00/hr.	6,600	300	400
Maintenance - 1%	1,400	400	1,000
Purchase of City Water	0	14,300	14,300
Annual Operating Cost	$ 12,120	$ 15,650	$ 16,350
Capitalized Annual	$ 83,600	$108,000	$113,000
Total Capitalized Charge	$221,000	$154,000	$217,000

TABLE II

SEDIMENT VS TIME

A large sample of river water was taken and turbidity tests were run at certain time intervals.

	Time	Turbidity ppm
1.	0	150
2.	5 min.	150
3.	10 min.	150
4.	20 min.	141
5.	2 hrs.	129
6.	24 hrs.	50

*Instrument used was the Jackson Candle Unit.

TABLE III

SERVICE CYCLE

The filter operates at 100-300 GPM producing less than 1/ppm turbidity units water for approximately 75,000 gal.

FLUSH CYCLE

When the turbidity reaches a turbidity of more than 1 ppm or 6.5 pound pressure across the filter the flush cycle is initiated automatically.

STEPS OF FLUSH CYCLE

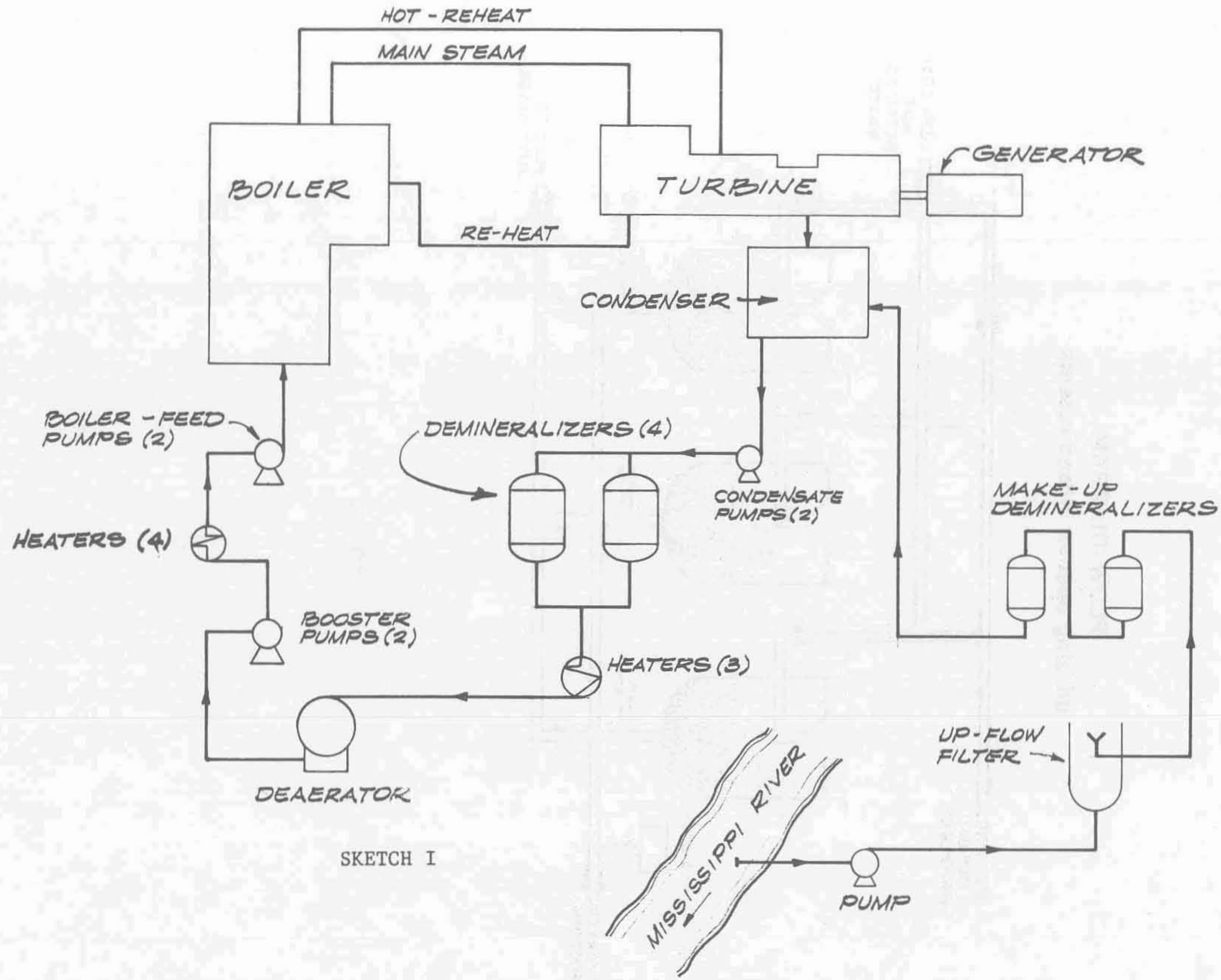
1. DRAIN - The vessel is drained to level to allow for flushing.
2. AIR - The air is forced (200 SCFM @ 10 psig) through to channel the bed for the water flush.
3. AIR-WATER - With the air still channeling the water is flushed through at 1200 GPM.
4. FLUSH - The air is stopped with the water flush at 1200 GPM. With the scouring action the dirt is dislodged from the bed.
5. SETTLE - The bed is allowed to settle back to normal position.
6. PRE-RUN - This step is the same as service, but the water is put to sewer until the proper quality is achieved.
7. SERVICE - When the water is 1 ppm or lower, the unit is put into service.

Listed below are actual functions and times as programmed:

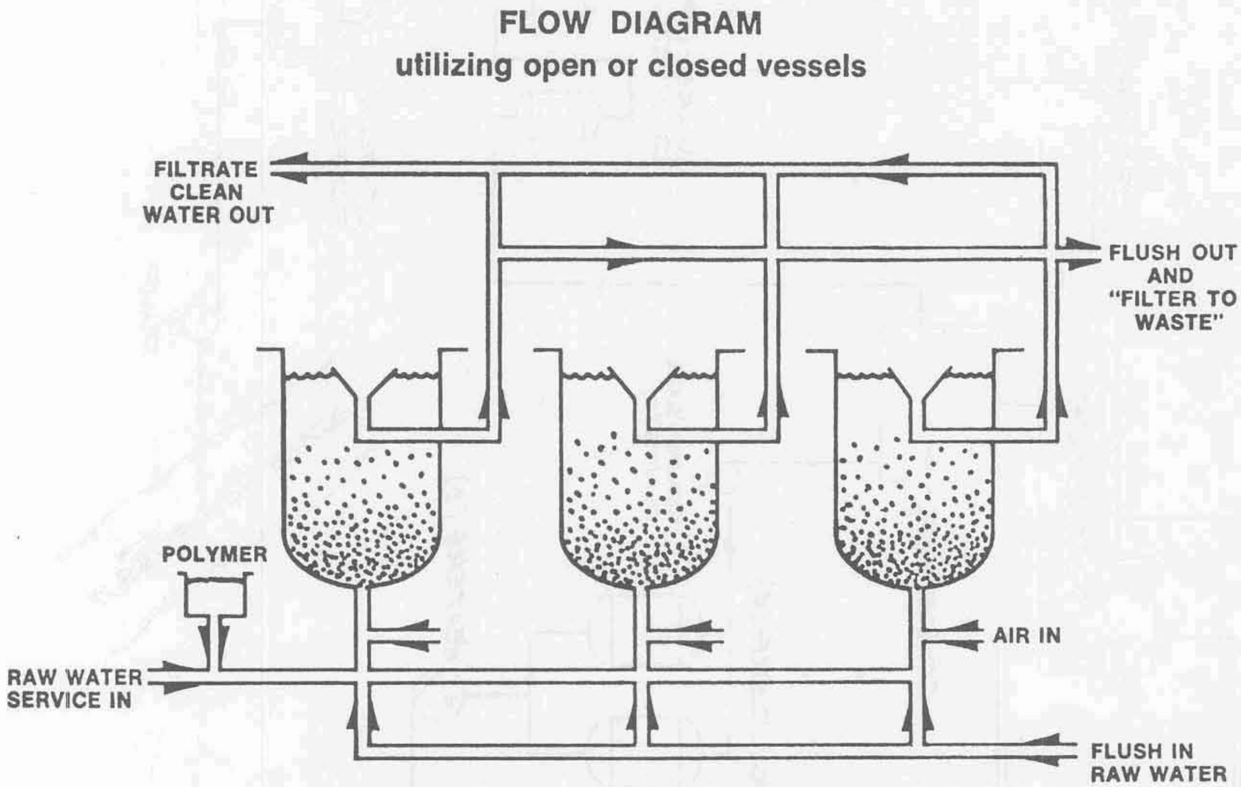
Step No.	Function	Time Setting/Min.
1	Pause	.5
2	Drain	4.5
3	Air	5.0
4	Drain	4.5
5	Air	5.0
6	Air-Flush	.75
7	Flush	7.0
8	Drain	4.0
9	Air	5.0
10	Air-Flush	.75

TABLE III (Cont.)

Step No.	Function	Time Setting/Min.
11	Flush	8.0
12	Settle	1.0
13	Pre-Run	10.0
14	Pre-Run	10.0
15	Pre-Run	10.0
16	Pre-Run	10.0
17	Pre-Run	5.0
18	Service	.25
	Total Time	91.25


HOT - REHEAT
MAIN STEAM
BOILER
RE-HEAT
TURBINE
GENERATOR
CONDENSER
BOILER - FEED PUMPS (2)
DEMINERALIZERS (4)
CONDENSATE PUMPS (2)
MAKE-UP DEMINERALIZERS
HEATERS (4)
BOOSTER PUMPS (2)
HEATERS (3)
DEAERATOR
UP-FLOW FILTER
MISSISSIPPI RIVER
PUMP

SKETCH I


FLOW DIAGRAM
utilizing open or closed vessels
FILTRATE
CLEAN
WATER OUT
FLUSH OUT
AND
"FILTER TO
WASTE"
POLYMER
AIR IN
RAW WATER
SERVICE IN
FLUSH IN
RAW WATER

SKETCH II