Economics, Design, and Operation of Sewage-Treatment Plants

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In view of all the stress placed on post-war planning and construction, it was thought that a word of warning might not be amiss. It is not the purpose of this paper to discuss details of design or construction, but to suggest that a little work and thought at the time of planning may save thousands of dollars in the cost of operation each year. What is true respecting the construction of sewage-treatment plants is also true of other projects as well. Very often, city and state officials criticize the operator of a utility because that utility does not operate at as low a rate as others in the vicinity or elsewhere in the state. The operator, no matter how good he is, cannot make up for all the mistakes in the design of a plant. All he can do is to operate it as efficiently as the design will permit. May we discuss this thesis from the standpoint of a sewage-treatment works, since that is the utility in which the writer is most interested?

From observation of various plants throughout the country, it would seem that there is a tendency to see how many mechanical gadgets can be crammed into a given space to accomplish even the simplest of operations.

On the intercepting sewers there is a tendency to design for small capacities and then install mechanical regulators to try to eliminate storm flows when they occur. Any mechanical device requires maintenance and, if neglected, will only be a source of trouble. By-pass weirs give much less trouble when they can be installed. If sanitary flows enter a stream without treatment because of a faulty regulator, then the purpose of the disposal plant is defeated. It should be remembered, however, that as far as the treatment works is concerned, it costs just as much to treat storm water as it does to treat a strong sewage. In some localities, the gradient of the sewers is such that a storm flow will flush out the sewers, and the raw solids at the treatment plant will be increased. In other localities, where the fall in all the sewerage system is sufficient to keep all the sewers fairly clean, a material reduction of solids will result from a rain and only a slight rainfall will cause a decrease in the amount of gas produced by the digestors.

Lift stations should not be built if there is any way to avoid them as they require attention daily and, if of sufficient size, may require the services of an operator twenty-four hours a day. The pumps may become clogged and the service of a man badly needed somewhere else be required for some time to remove the obstructions. The capacities of the pumps in these stations should be such that they will maintain as near an even rate of flow as possible and not create surges at the treatment works. In stations where the rate of flow varies considerably, more than one pump should be installed and the capacities designed to care for the variations. The wet well should be large enough to take care of momentary surges. By a little planning, the capacities of the pumps and the wet well can be so arranged that a very even rate of flow results.

A lift station at Richmond was constructed to lift sewage from a part of the city without any regard to the effect it would have at the treatment works, since at the time of construction, a treatment works was not in existence. As a result, two 600 G.P.M. pumps were installed in connection with a wet well. Either pump could empty the well in a matter of ten minutes, even at periods of high flows in the sewers. This resulted in surges at the treatment works of from 1½ to two M.G.D. which caused trouble in screen operation, grease removal, and worst of all, in maintaining a proper supply of air to the aerators. These pumps have been throttled down and so controlled by means of separate floats that they no longer cause trouble. They do require daily attention of an operator. One of our post-war projects is the elimination of this station by the construction of a sewer which was not thought practical before, since it would be at a depth of sixty feet in some places.

Pumps should always be protected by a screen to prevent entrance of harmful objects into the pump impeller. In some installations, grit may become a vital problem and should be removed ahead of the pumps wherever possible.

If grit is likely to be encountered in any quantities, its mechanical removal is desirable. Manual removal should be avoided if there is any appreciable amount to be removed. In most localities where there are combined sewers, the amount of grit will average between one and two cubic feet per M.G.D. flow. The mechanical removal will be more complete over a period of days and certainly will improve the morale of the plant personnel. In this we speak from experience.

For the removal of coarse solids, there is a tendency to use comminutors instead of bar screens. Much can be said for each type. The cost of repair to comminutors is very high. Most of the bar screens, however, involve the removal of screenings, but this can easily be accomplished by grinding and returning the shredded material to the sewage flow. Screenings may also be burned or buried. Consideration should be given to the manner in which the rakes of mechanically-cleaned screens are to be operated. One method is by means of a time clock allowing the rake to operate at set intervals. This method is satisfactory unless there is some waste which causes heavy loading of the screens at various unpredictable times. If this condition exists, then a float control should be used just ahead of the screen.

Primary clarifiers do not offer much of a problem except that suitable grease-removal equipment should be provided. I have seen some tanks where no easy means of grease removal was provided; yet it was one of the vital problems in the plant operation. Grease removal is a dirty, unsightly operation at best, and adequate means should be provided to handle the disposing of the grease properly. When separate sludge-digestion tanks are used, the grease can be decomposed in them with the raw sludge, but should be dewatered as much as possible before entering the digestors. Any collecting mechanisms should be installed with the idea always in mind that they may have to be removed for repair. The sludge pits of the primary clarifiers should be sufficiently large to hold enough sludge to allow thickening. One plant was constructed not far from Richmond which had such small pits that it was necessary to draw the sludge every couple of hours, so that it was impossible to get a thick primary sludge.

If Imhoff tanks are used, they should be constructed to allow reversal of flow in the flow-through chambers, thus permitting a more uniform distribution of the raw sludge over the digestion compartment. There should be adequate sludge-storage space and as easy a means of sludge removal as possible.

Pumps for handling raw sludge should be very carefully studied, as the sludge is hard to pump even when coarse material has been reduced to a minimum. Special pumps have been designed and should be used rather than standard pumps. If the sludge is to be drawn by gravity instead of by pumping, it will be found advisable to connect a stream or water line to the sludge piping so that additional pressure can be applied. It is a very good idea that the piping be so arranged that water can be pumped through the lines to flush them. The use of tees with a blank flange instead of an ell should be employed on all lines carrying sludge or grease.

Separate sludge-digestion tanks are a source of cheap power and can effect a very substantial reduction in operating costs. The gas produced by these units at the Richmond plant has resulted in a reduction of from $500 to $600 per month in the operating cost. The digestion tanks, to give the best results, should have at least 4.5 cubic feet per capita, and if waste activated sludge and ground garbage are to be taken care of, a capacity of about seven cubic feet per capita should be provided. Ground garbage should be introduced directly into the digestors with the grit removed. If ground garbage is introduced into the sewers, it will create an added load on the secondary and may cause a grease problem. Ground garbage, when added to digestors, will in most cases double the gas production. Care should be taken in the construction of the heating systems of the digestors to avoid the use of two or more different metals which could cause electrolysis to occur. There was one plant where aluminum heating coils and connecting piping were used in the digestor, since aluminum is supposed to be resistant to corrosion from contact with the sewage. In order to circulate the heating water, a standard cast-iron-bodied pump was used. The result was that, after one year, the aluminum pipe in the digestor was full of holes and had to be replaced.

One important consideration in the operation of a sewage-treatment plant is that of sludge disposal. The simplest method is disposal in the liquid form which requires no investment in dry beds or filter equipment. Liquid sludge can profitably be hauled in 1,000 or more gallons for three or four miles from the treatment works. The most prevalent form of disposal is by air-drying on sand beds which are either open or covered. In the construction of the dry beds, provision should be made for removal of the sludge from the beds, also for liquid removal.

Filters are of some advantage in saving ground but certainly increase the amount of mechanical equipment and add to the number of employees required to operate the plant.

By far the most costly and far from the easiest method of disposal of sludge is incineration. There are three incinerators in Indiana, none of which are in operation because of the excessive cost of operation. The incinerator at one location has been replaced with dry beds, while the other two have been replaced by liquid disposals.

In some of the sea coast cities, digested sludge is hauled out to sea and dumped.

Secondary treatment should be of a type that will give the degree of treatment desired. Trickling filters followed by secondary clarifiers give good effluents, but the secondary treatment which consistently gives high removals of solids and biochemical oxygen demands is the activated-sludge process. The Gugenheime process, which is a combination of chemical and activated-sludge processes, has been claimed to be almost a treat-all process, but the plants in this state seem to fall a little short. After all, the proof of the process is the degree of treatment obtained for a given operating cost. This is indicated by the cost of removal per 1,000 lbs. of biochemical oxygen demand and the biochemical oxygen demand and solids content of the effluent leaving the plant.

Some items which do not mean much in the construction mean a great deal to the operator. One of these is the installation of connecting wiring. All wiring should be installed to allow easy replacement, as it is almost impossible to prevent moisture from eventually getting into even the best wiring. All connecting piping should be installed with the idea of accessibility and to allow for future plant expansion as well as ease of flushing. Too many engineers have lost sight of the fact that sewage-treatment plants are designed for the treatment of sewage rather than to be mechanical marvels. Some designers fail to provide sufficient room around equipment to permit easy maintenance. It is also necessary that storage space be provided for oil, grease, lawn mowers, portable pumps, and other necessary equipment.

In conclusion, may we suggest that when you are doing your postwar planning, keep in mind that a little thought on the design may mean thousands of dollars in operating costs. When the design of the Richmond plant was being considered, Mr. S. W. Hodgin, who was City Engineer at that time, and still is, insisted that the plant should be placed so that advantage could be taken of the contour of the ground. As a result, gravity aerators were installed in the aeration tanks which effect a saving of about $15 per day. There is no pumping of raw sludge, but this is offset by the fact that the return sludge has to be pumped against a static head of about 22 feet.

Keep in mind that the men who operate sewage-treatment plants may have some very fine ideas on good design, as they often have to correct poorly-designed units.

The real proof of the efficiency of a design is its ability to produce a good effluent consistently and at a low operating cost.