# SEWAGE TREATMENT PLANT DEPENDABILITY

With Special Reference

to the

ACTIVATED SLUDGE PROCESS

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## ACTIVATED SLUDGE PROCESS

I INTRODUCTION & CONCLUSION

Operational experience at dozens of sewage treatment plants has shown that, to achieve dependable, consistently satisfactory, municipal and industrial waste treatment plant performance, the owners should:

Retain the best possible consultants for design.

Hire the best trained, intelligent, dedicated, imaginative Superintendent and Operators available.

II DESIGN CONSIDERATIONS

Though this discussion emphasizes activated sludge treatment, the following four general design concepts have been found essential to plant dependability for practically all types of waste treatment plants.

Select the Proper Process Type.

Provide Generous Capacity.

Include Essential Flexibility.

Make Plant Truly Controllable.

## SELECT PROPER PROCESS TYPE

A. Early in the design stage, the engineer must exercise his best experienced professional judgment in selecting the Process Modification most appropriate to the known characteristics of the incoming wastes, and the effluent quality requirements.

The following illustrations, for example, are drawn from personal plant operation experiences:

1. The "Classic Activated Sludge Process" design - conforming generally to "10-States Standards",usually performs satisfactorily for "normal municipal wastes" where domestic sewage predominates.

   The "Classic Activated Sludge Process" is defined as the original activated sludge system; where all return sludge and all settled sewage enters the head end of the aeration tanks.

2. The "Complete Mix" modification has been found admirably suited for mixtures of domestic sewage and industrial wastes with highly variable characteristics and concentrations.

3. The "Step Aeration" modification permits an operator to select and change his basic process cycle to accommodate unexpected overloads, to adjust sludge solids distribution and to control mixed liquor sludge characteristics.

   To be truly effective; the "Step" design must permit controlled measured incremental sewage discharge to each aerator pass or compartment. It must also permit discharging 100 percent of the sewage into the head end of the aerator or to the last pass. Such an aerator can then be operated in either extreme - Classic Mode or Contact Stabilization Mode - or any place in the middle - according to the "Step" percentages that are selected - to meet actual loading and system demands.

4. Be sure to consider "Tertiary" or "Advanced Waste" treatment systems that may be necessary to meet special water quality criteria. This paper does not include discussion of these important features that are covered thoroughly by the Advanced Waste Treatment Research Laboratory in Cincinnati.

B. When in doubt - and who isn't at times? - Pilot!

The term "Pilot Studies," having a broad general meaning, could include:

1. Bench Scale. Waste treatability studies can be performed effectively and economically at Bench Scale.

2. Pilot Scale. A specially constructed small pilot plant (possibly 0.1 MGD or more capacity) may be needed if additional essential information is required. Such units can validate process suitability, relative tank sizes, and system dynamics for the proposed full size plant.

3. Demonstration Scale. In some cases, full sized plant units must be utilized to demonstrate the relative effectiveness of various facility arrangements. At times certain units in existing plants can be modified for such study before the design of plant additions is initiated. For example, it is impractical, if not impossible, to prove the suitability of various overflow weir arrangements for 150 ft. diameter final clarifiers from studies on 10-ft. diameter pilot scale models.

The type and extent of Pilot Studies will obviously depend upon effluent requirements; the specific information needed; and the size, complexity and cost of the treatment facilities to be constructed.

## PROVIDE GENEROUS CAPACITY

Design criteria such as, "10-States Standards" and others, should be interpreted skillfully, and used as intended. In other words, most suggestions in such manuals should be considered as minimum, and not maximum, requirements to achieve plant dependability and to provide essential factors of safety. Generous capacity is always welcomed by plant operators and by plant managers facing the necessity for day-in, day-out, dependable and acceptable plant performance and effluent quality. Surplus capacity, if any, that might be provided will in most cases be used up rapidly as the communities face unexpected rapid population growth and unpredictable development of new waste-producing industries within the area.

A. Some design criteria, based on 24-hour average flow and load, include appropriate diversity factors to accommodate the normal cyclic peaks that occur during each 24-hour period. Such 24-hour design capacities should be based on the averages anticipated during the maximum flow and loading producing week of the year. Obviously, any abnormally high short-term peak loads, that can be anticipated, must also be included in the design loading.

B. Accommodate full load with either one aerator or one clarifier out of service for maintenance. You all know that at times equipment units must be taken out of service for maintenance or repair. Out of dozens of activated sludge plants, I can only recall one or two that did not have a final clarifier down for maintenance at some time during my stay at the plant. In a four-tank design, for example, this means that clarifiers must be designed so that three of the four can successfully handle the estimated total design flow. Similarly, aeration capacity must be large enough so that three of the four aerators can handle the total estimated design load.

C. Provide multiple aerators and clarifiers; preferably four each for medium to large plants.

This is, of course, a corollary to the previously mentioned requirement.

Additionally, relative aerator to clarifier volumes [illegible] proportioned to retain a workable, properly balanced, plant when any one unit is taken out of service. Though discussions of relative aerator to clarifier volumes usually becomes controversial, my experience indicates that properly balanced operation can be obtained when the total aerator volume approximates twice the total clarifier volume. With this relationship, for example, full plant operation of a four-aerator/four-clarifier plant might require approximately fifty percent return sludge pumping. With one aerator out of service, the return sludge pumping demand might increase to 100 percent; and conversely, with one clarifier out of service, something in the neighborhood of thirty percent return sludge pumping might be required. Other process requirements, that will change when individual units are taken out of service, can usually be accommodated effectively under such circumstances.

D. Include the estimated <u>plant recycle</u> (thickener overflow, filter underflow, dilution flows, etc.) in the design load. In one extreme case, the additional flows imposed by effluent dilution of sludge thickener influent, scrubbing water for the furnaces, etc. approximated fifty percent of the incoming sewage flow volume. In most cases, such recycle flows can easily exceed ten percent and possibly approach twenty percent of design flows. These additional flows will influence aeration tank detention times and final clarifier overflow rates and must be considered in the design of adequately sized units.

E. <u>Sludge handling</u> facilities must be designed to accommodate the maximum (not the average) anticipated sludge quantities; and with units down for maintenance. Remember, sludge wasting requirements at activated sludge plants can vary greatly from day-to-day in response to sewage loads, process equilibrium, and mixed liquor sludge quality. At times, extremely high wasting rates, greatly in excess of the anticipated average, will be needed to restore process equilibrium when a system is sliding out of balance.

Generous sludge holding-equalizing tank capacity is essential and can reduce substantially the danger of periodic overloading of sludge processing equipment.

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## INCLUDE ESSENTIAL FLEXIBILITY

Design considerations that effect, and permit operating flexibility are presented in brief outline form. Though readily understood, and almost universally accepted, omission of one or more of these elements has been observed in all too many plants. Lack of essential flexibility frustrates operators and degrades effluent quality. Give the operator the tools he needs to modify anticipated control schedules in order to accommodate some of the unforeseen difficulties he will almost certainly face at times.

A. Process

1. If the activated sludge process is selected for secondary treatment; evaluate the relative advantages of both the "Classic" process and the "Complete Mix" modification with reference to the type and characteristics of the incoming raw wastes, and the plant performance requirements needed to meet final effluent and receiving water quality objectives.

2. Provide for "Step" operation of any "Classic" or conventional activated sludge system.

3. Be sure any "Step" design can be operated in all modes; from Classic, through variable step proportions, and to "Contact Stabilization".

4. Where practical, provide each aerator-clarifier combination (or each group of aerators and clarifiers) with its own separate return and waste sludge pumping facility.

B. Aeration Tanks

1. Provide truly effective mixing and oxygenation.

2. Assure against "coreing" and "dead areas" in aerators. Don't compromise by ineffective modifications of inappropriate basic aeration devices.

3. Provide truly controllable, measurable, variable outputs for mechanical aerators or air blowers.

4. Provide separate, controllable, metered air headers for each pass, or compartmented zone of the aeration tank. For example, don't connect the "A" pass (with its relatively high air demand) of one aerator and the "C" pass (with its relatively low air demand) of an adjacent aerator to a common air header.

5. Consider provision of recording D.O. meters. (Preferably actuating air blower controllers.)

6. Consider provision of mixed liquor solids concentration sensor and recorder. (Also similar for return sludge solids concentration.)

C. <u>Final Clarifiers</u>

1. Obviously - minimize excessive velocity currents and short-circuiting.

2. Don't skimp on surface area. Contemporary high capacity designs appear to require considerably less than the conventional 800 Gals/Day/Sq. Ft. overflow rate.

3. For large tanks (certainly for 100 feet in diameter and greater) provide appropriately located and properly spaced multiple effluent weir launders.

4. Provide effective surface scum collection and removal devices.

5. Consider 12 feet as a minimum practical side wall depth. (Despite calculable theory - shallow tanks aggrevate floc carry-over characteristics.)

6. Provide combination suction-scraper sludge collectors to minimize clarifier sludge detention time. (Be sure that the actual sludge withdrawal capacity equals at least 100 percent of design waste flow plus recycle.)

D. Return Sludge Pumping Facilities

Provide multiple, remotely adjustable, return sludge pumps capable of returning at least 100 percent of design waste plus recycle flow with one pump out of service for maintenance.

E. Excess Sludge Wasting

1. Provide metered, controllable, waste sludge pumps - separate from the return sludge pumps.

2. Be sure they can be operated at the low wasting rates required at times. (A valved interconnection to the return sludge pumping system can accommodate the exceptionally high wasting demands that occur occasionally.)

3. Provide a suitable valved interconnection to permit wasting either from the aerator outlet (mixed liquor) or from the clarifier sludge withdrawal system (return sludge).

F. Emergency Chemical Treatment

1. Provide feeders and piping to permit emergency application of chemicals to aerators or clarifiers ( and primary tanks).

2. For example - application of polymers and ferric chloride to the clarifier inlet has solved serious classic bulking; and apparently without destroying other desirable sludge characteristics.

G. Adjunct Facilities

1. General - This Section will only highlight general concepts concerning certain related plant facilities.

2. Primary Clarifiers - Don't skimp on size and surface overflow rates, especially if excess activated sludge is to be wasted to the primary clarifiers.

3. Sludge Handling Facilities

   a) Must be designed to handle maximum (not average) anticipated loads, with units down for maintenance.

   b) Must be provided with generous storage, or equalizing, tanks to accommodate periodic peak requirements that will at times exceed even estimated maximum loads.

   c) Then provide means for disposing of partially processed sludge during breakdowns.

      1) Take a sludge thickening - filtering - burning process, for example:

Be sure filtered sludge can be collected, conveyed out of the building and hauled away in case of serious furnace breakdown.

2) Consider, for example, sludge digestion: -

Provide facilities to collect, pump, and haul supernatant and partially digested sludge to prescribed land disposal if digestion or drying facilities are seriously overloaded.

3) Plan an "out" so that the secondary process and effluent quality need not be degraded by breakdown of other plant facilities.

4. Equalizing Tanks - In special situations (separate interceptors collecting slug-flow strong wastes) provide adequate raw waste holding tanks to permit uniform process loading throughout the 24-hour cycle.

5. Holding Ponds - Consider holding ponds for effluent polishing, or for storage and recycle of primary effluent, during periodic severe plant overloading.

## MAKE PLANT UNIT CONTROLLABLE

A. Meters

The activated sludge system is a controllable process that must include appropriate meters and accurately controllable equipment,gates, valves, pumps and blowers for optimum performance. More importantly; it should be developed and run by intelligent competent designers and operators.

1. Obviously - the most reliable, proper type, meters should be specified.

2. Throughout the plant, meters can range from the most simple elementary type to the highly sophisticated system; depending upon the specific output needed.

3. A single subcontractor should supply, and and be fully responsible for satisfactory performance of, the entire meter-controller package.

4. A qualified instrument technician should be included on the staff of all large plants. A capable technician, from within the community if possible, should be retained for periodic meter maintenance and emergency repair at smaller plants.

5. Separate independent meters are needed at each plant unit requiring control adjustment.

   A summator, in addition to read-out from individual meters, is helpful for multi-unit plants. But beware of a subtractor as the sole means of obtaining an essential third flow measurement from two other independent meters.

6. Beware of relying too greatly on so-called hydraulic similitude for balancing flows between multiple units. Individual meters and control gates are usually needed in critical areas.

7. When design contemplates a phased series of future additions, the meters provided [illegible] must be properly sized (small enough) to permit accurate measurement of the relatively low initial flow rates. When pipes are sized for future additions, it may be necessary to install replaceable meters in temporarily reduced pipe sections.

8. Be certain that metering is adequate to permit accurate control adjustments, maintain essential balance in multiple parallel plant units, to document plant performance, and to evaluate process and effluent quality requirements.

   a) Measure either plant influent or effluent separately. A back-up sensor and indicator on the other will be useful. Don't depend on mechanical addition of other internal meters for this value.

   b) Be sure that waters recycled within the plant are metered and can be accounted for. (Thickener influent and effluent, dilution water, furnace condenser spray, etc.)

   c) Provide individual meters for each of the following similar parallel plant features. (i.e. Four meters for influent flow to four parallel aerators.)

      1) Return Sludge Flow -

         To each Aerator.
         From each Clarifier.

      2) Waste Water Flow -

         To each Aerator.
         To each pass in "Step"(*).
         From each Clarifier(**).

      3) Mixed Liquor Flow
         To each Clarifier.

      4) Air Discharge -
         To each Aerator.
         To each "pass" of each Aerator(*).

      5) Waste Sludge - One meter for each individual aerator-clarifier battery.

(*) Can be calibrated manometers or simple indicating meters.
(**) Desirable, but can be eliminated if all other meters are provided.

B. Meter-Control Panel

1. General

In large multi-unit plants it is utterly impractical to adjust or balance flows manually at valve or pump locations that are almost always far removed from the meter panels.

A centrally located meter-control panel, wired to mechanical valve and pump actuators, permits accurate adjustment of critical flows while observing the metered response. This applies in principle, though not in degree, to small as well as large plants.

2. Remotely actuated controllers should be provided for:

a) Return and waste sludge pumps.
b) Proportioning waste water and return sludge flows to individual aerators.
c) Proportioning mixed liquor flow to, and return sludge withdrawal from, individual clarifiers.

C. Automatic Controllers

1. General

Density sensors coupled to automatic controllers should be provided as part of the adjunct sludge handling and disposal facilities. Such control, according to the operator's "set point" requirements greatly improves sludge thickener, digester, etc. performance and minimizes the supplementary recycle load on the secondary treatment facilities.

2. Other automatic controllers that can improve plant performance are:

a) Blower control by D.O. sensors.
b) Meter actuated controllers to proportion return sludge pumpage according to the cyclic incoming waste water flow rates.

e) Mixed liquor and return sludge concentration sensors are being developed to control return sludge pumping and solids distribution.

## III OPERATIONAL CONTROL

Any [illegible] the importance of operator or designer qualifications would be academic at best. It is unquestionably true that qualified operators are required to achieve the high quality effluent that can be produced by properly designed waste treatment plants. Of even greater importance; dedicated, experienced, operator ingenuity is needed to get the best out of plants that may suffer from certain design defects. Though some of the requirements for proper operational control discussed here may seem repetitious to a few, all of these elements have been observed again and again where conformance to such principles has enhanced pollution abatement immeasurably or, conversely, where neglect has degraded final effluent quality.

### PERSONNEL

1. Hire the best qualified people available.

2. Exert your greatest, and most effective, support to Operator Certification programs.

3. Send selected personnel to training courses and to similar treatment plants to upgrade their knowledge.

4. Conduct continuing in-house training.

5. Inspire all operators to recognize that consistent production of the best possible final effluent quality is their foremost job responsibility.

6. In medium to large activated sludge plants; be sure there is a staff position - somewhere between the Superintendent and crew chief positions - with the specific responsibility to evaluate plant performance, cause and effect relationships, and to direct process control operations.

7. Obviously; provide tools and facilities the staff needs to accomplish their objective.

DUTY DELEGATION

1. Practically every one is, or should be, aware of the need for properly planned safety, preventive maintenance, and emergency repair duty delegation.

2. Conduct critical reviews of routine operating procedures. Minimize less important activities to provide additional time to beef-up the more essential and productive operational tasks.

3. Be sure crew chiefs are fully aware of their specific responsibility and authority. Excess sludge wasting schedules, for example, are dictated by process and effluent quality requirements. Wasting adjustments should, therefore, be directed by the secondary process crew chief; not by (except in extreme emergency) the crew chief in charge of sludge handling.

4. Written Standing Orders and Special Instructions should be posted in the control office to avoid confusion among shift operators coming on duty around-the clock.

CONTROL TESTS

1. Again; all of us are aware of the need for conscientious, timely and proper sample collection.

2. Essential control tests should be run at least once every 8-hour shift; and more frequently when needed during troublesome times.

3. The control test series for activated sludge should include the all too frequently neglected following routines:

Aeration Tank D.O.
Clarifier sludge blanket depth.
Final effluent turbidity.
Mixed liquor sludge settlometer test.
Sludge concentration by centrifuge tests.

4. C[illegible] control demands from the [illegible] test series will describe process status and dictate the type and magnitude of control adjustments needed to maintain, or restore, proper process performance.

## PROCESS RELIABILITY

1. The senior staff member directing process control operations should:

   a. Summarize and evaluate all essential control test data, results of demand calculations, and extent of control adjustments daily.

   b. Develop (and keep up-to-date) running trend charts illustrating significant features of plant performance. For example:

      Plant Loading

      Sludge Settling Characteristics

      Sludge Concentration Characteristics

      Sludge Blanket Depth

      Final Effluent Turbidity, etc.

   c. Study trend charts and determine cause-effect relationships between process control and plant performance to:

      1) Document loadings or control procedures that have caused trouble and must be avoided in the future.

      2) Identify procedures that have proved successful and should be continued.

2. By conscientious, intelligent application of the basic operational requirements, discussed previously, the Director of a properly designed treatment plant will achieve consistently reliable plant performance and excellent final effluent quality.