NATIONAL FIELD INVESTIGATIONS CENTER
CINCINNATI

OPERATIONAL CONTROL PROCEDURES for the ACTIVATED SLUDGE PROCESS

PART I

OBSERVATIONS

APRIL 1973

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF ENFORCEMENT AND GENERAL COUNSEL

NATIONAL FIELD INVESTIGATIONS CENTER - CINCINNATI

OPERATIONAL CONTROL PROCEDURES

FOR THE

ACTIVATED SLUDGE PROCESS

PART I

OBSERVATIONS

by

Alfred W. West, P. E.
Chief, Waste Treatment Branch

APRIL 1973

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

OFFICE OF ENFORCEMENT AND GENERAL COUNSEL

FOREWORD

The Waste Treatment Branch of the National Field Investigations Center - Cincinnati is developing a series of pamphlets describing Operational Control Procedures for the Activated Sludge Process. This series will include Part I Observations, Part II Control Tests, Part III Calculation Procedures, Part IV Sludge Quality, Part V Process Control, and an Appendix. Each one of these individual parts will be released for distribution as soon as it is completed. The original five-part series may then be expanded to include case histories and refined process evaluation and control techniques.

This pamphlet has been developed as a reference for Activated Sludge Plant Control lectures I have presented at training sessions, symposia, and workshops. It is based on my personal conclusions reached while directing the operation of dozens of different activated sludge plants. This pamphlet is not necessarily an expression of Environmental Protection Agency policy or requirements.

The mention of trade names or commercial products in this pamphlet is for illustrative purposes and does not constitute endorsement or recommendation for use by the Environmental Protection Agency.

A. W. West

TABLE OF CONTENTS

OBJECTIVES

Aeration tanks and final clarifiers are studied perceptively for informative physical characteristics that help identify sludge quality and process status. They are scrutinized for clues that indicate the kind of control adjustments needed to achieve optimum plant performance. The inferences of such physical findings are used to supplement the results of other more specific control tests that dictate the direction and magnitude of the essential control adjustments.

INTRODUCTION

Much can be learned from simple but perceptive sensory observation of process features such as the type, color, and extent of foam on the aeration tank surface and the presence or lack of scums and rising floc particles in the final clarifiers. From such observations, a skilled operator usually can determine the basic phase his process is moving towards or is locked into. Such observations will make him aware of more generalized long-term requirements. They will help him reach proper conclusions from the results of other more specific control tests that are used to calculate process demands and to determine the type and extent of control adjustments that are actually needed.

The entire series of physical observations described in this section should be made each time the routine control tests are performed. The appearance of the final effluent and the aeration and clarifier tank contents should be examined at least once during each operator's eight-hour shift.

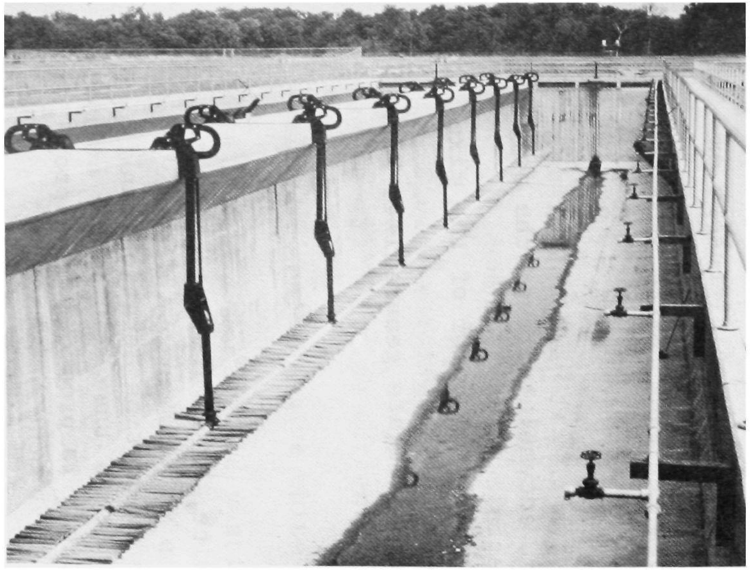
AERATION TANKS

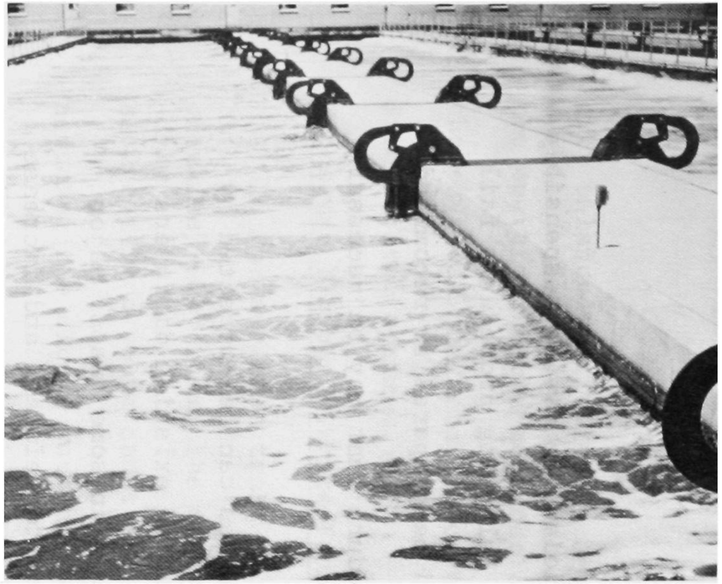
TURBULENCE

The operator should observe the entire aeration tank surface for turbulence. Though some of his conclusions will be subjective and based on past experience, the extent of surface turbulence will indicate whether or not all sewage, return sludge, and mixed liquor are thoroughly mixed throughout the entire aeration tank. Observable surface characteristics will imply whether or not dead spots or insufficiently mixed core areas may exist within the aeration tanks. The operator should maintain, increase, or decrease air discharge rates according to the conclusions he reaches from the results of such observations and from supplementary dissolved oxygen determinations.

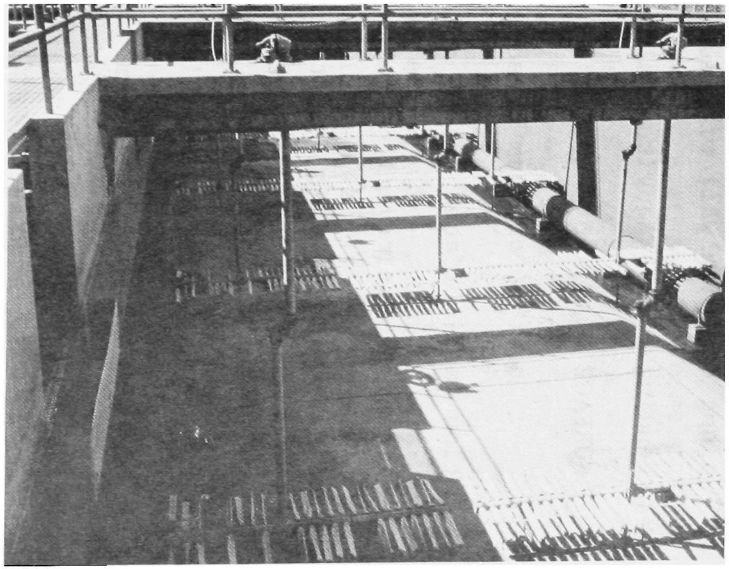
He obviously should reproportion air flow through headers or individual subheaders to correct any dead spots, unequal air distribution, or inadequately tapered aeration intensity that may have been observed.

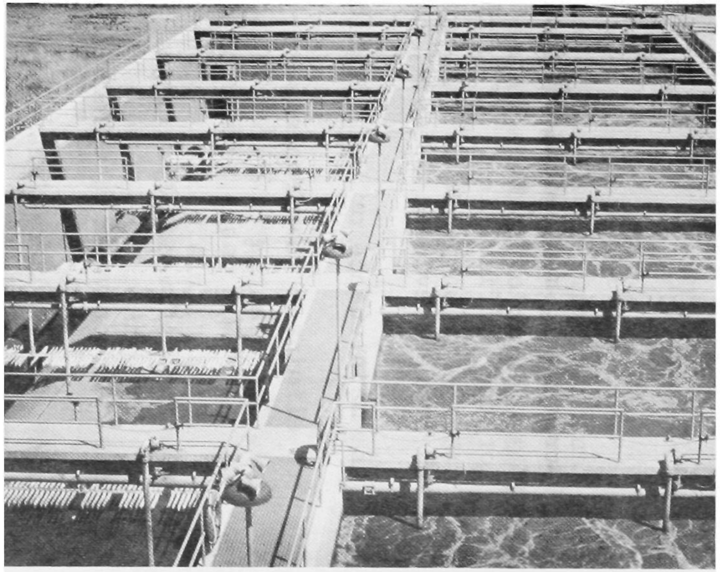
If serious mixing deficiencies prevail despite corrective air distribution adjustments, he should attempt to determine which





COMPRESSED AIR
SPIRAL FLOW





COMPRESSED AIR
CROSS ROLL

structural, mechanical or design deficiencies may be responsible for the difficulties. If normal air balancing procedures fail to correct evident defects, he should be prepared to recommend the maintenance or modification procedure that may be necessary to eliminate the problems.

In many cases, aeration deficiencies can be corrected by routine diffuser cleaning or by replacing existing diffusers with more effective maintenance free units. In some cases, major mechanical alterations may be required to relocate and increase the number of diffusers to mix and aerate the tank contents thoroughly. Overall process performance has been improved at some plants by replacing the single run of diffusers that extended along one side wall with multiple parallel runs of diffusers extending either longitudinally or across the tank bottom.

SURFACE FOAM AND SCUM

The type of foam or scum, if any, accumulated over the aeration tank surface, and to a lesser extent, the color of the mixed liquor sludge reveal process status and indicate generalized long-term sludge wasting requirements.

Fresh Crisp White Foam

Only a modest accumulation of white, or at least light colored, crisp appearing foam is usually evident on aeration tank surfaces when an excellent final effluent is produced by a properly balanced activated sludge process. Under such circumstances the operator should continue his successful control policies until the physical characteristics or the results of other control tests diverge from optimum.

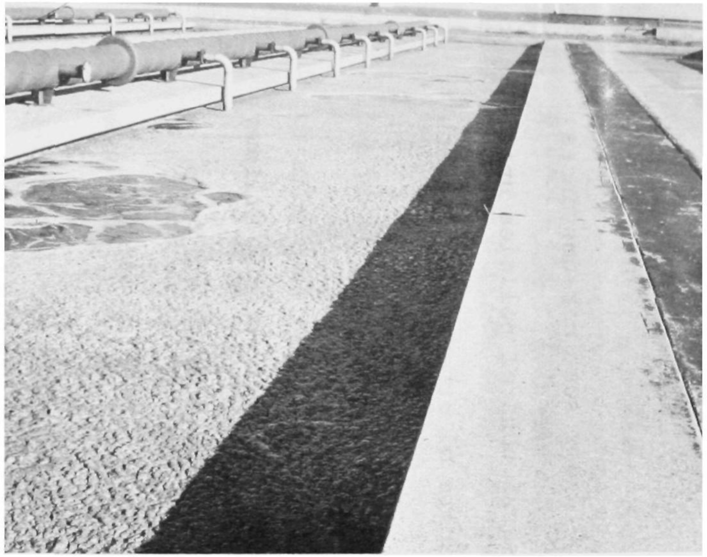
Excessive Billowing White Foam

If the aeration tanks are covered by thick voluminous billows of white sudsy foam, the operator can be quite certain that the sludge is too young and that sludge age should be increased by reducing the sludge wasting rate.

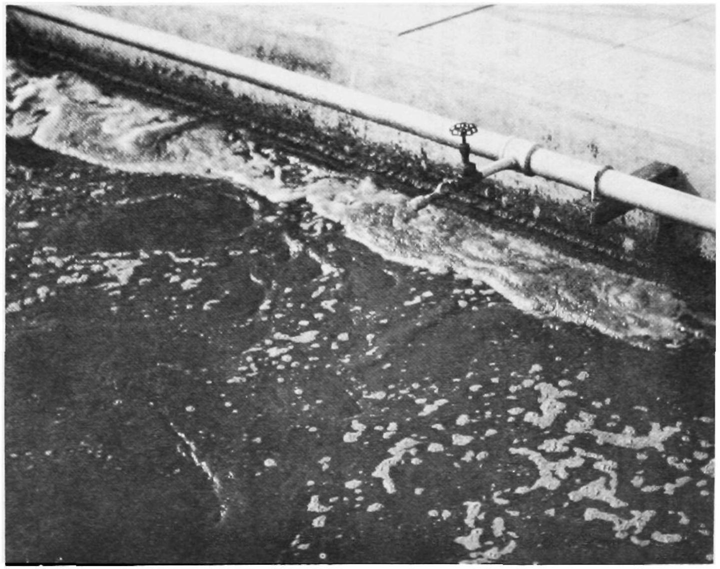
Sludge age, which is controlled by the sludge wasting rate, indicates the approximate number of days that the activated sludge remains in the system before being discarded. Prolonged excessive sludge wasting will reduce sludge age by increasing the proportionate amount of newly developed floc in the system. Conversely, unduly low wasting rates will increase the number of days the sludge is retained in the system and will increase the proportionate amount of older sludge.

Sludge wasting rates should be decreased only gradually on a day-to-day basis to correct the process imbalance that was revealed by the excessive white foam. Best results are usually obtained by reducing the wasting rate approximately twenty percent on each successive day until all observations and tests reveal improving trend lines. When positive improvement is noted, the operator should maintain the lowered wasting rate for

BILLOWY WHITE FOAM
(YOUNG SLUDGE)



THICK DARK TANK FOAM
(OLD SLUDGE)



DARK FOAM, BAD ODOR
(SEPTIC SLUDGE)

about three more days while the improving trends are confirmed. He should, of course, continue to plot and review process control and response trend lines which will alert him to subsequent control adjustment policy that may become necessary. As implied previously, wasting usually should not be discontinued completely. Exceptionally low sludge settling rates and classic sludge bulking that can accompany this type of foam generation may be corrected by reducing air discharge rates to lower the mixed liquor dissolved oxygen concentration to the 0.5 to 1.0 mg/l range.

Operators who have actually gone through this white foam cycle realize that not all foam is caused by detergents.

<u>Thick, Scummy, Dark Tan Foam</u>

At the other extreme, the operator may observe a more dense and somewhat greasy scummy layer of deep tan to brown foam covering the entire aeration tank surface. Such a foam almost always indicates that the sludge is too old and possibly over oxidized. The obvious answer is to increase sludge wasting rates. Here again, the sludge wasting rate should usually be increased modestly, possibly twenty percent per day, on a day-to-day basis while observing trend lines to determine the maximum wasting rate that should be maintained until the difficulties are overcome and the process is restored to proper balance.

Referring to the dark tan foam cover, many operators have recently voiced concern about the effects of massive Nocardia concentrations in aeration tank foams. Some of these scummy foams are, in fact, loaded with Nocardia, but I know of no case in which Nocardia caused the foam or the associated difficulties; they were there because they enjoyed the environment. Increased sludge wasting has eliminated both scums and Nocardia.

SLUDGE COLOR AND ODOR

At times a poor quality extremely dark brown-colored sludge, sometimes almost black, releasing hydrogen sulfide odors, may be observed in the aeration tanks. It does not take much experience to recognize this problem. Most operators would logically increase air discharge rates immediately to provide 2 - 3 mg/l DO throughout the tank contents. In severe cases, when such color and odor persists, despite proper control measures, they should question the adequacy of the aeration devices installed at their plants. Under such circumstances, the operator should clean or replace the existing diffusers and recommend appropriate mechanical modifications as discussed in the section on turbulence and mixing.

FINAL CLARIFIERS

The operator should also observe the final effluent and the clarifier water surface critically for additional clues to indicate process phase and balance, and to supplement the results of other control tests to determine sludge wasting and air control requirements.

FINAL EFFLUENT APPEARANCE

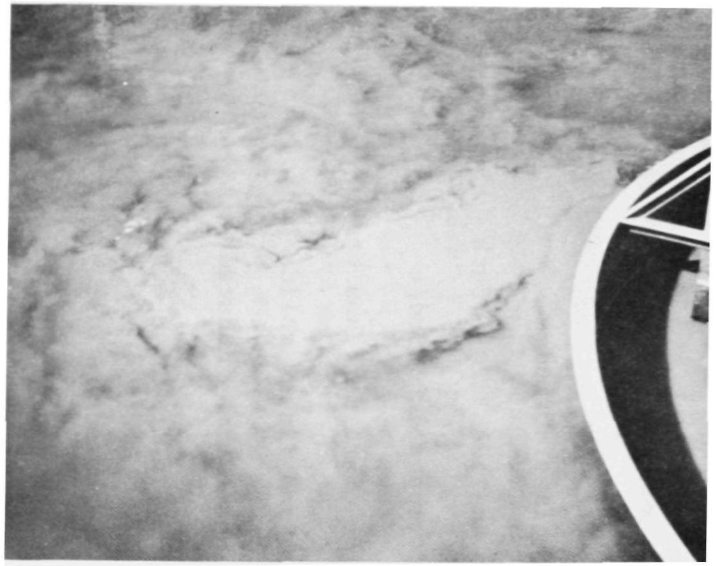
If the final effluent appears clear and attractive, or is improving day by day, obviously the operator should continue his present control policy if all control measurements are in the proper range.

Conversely, if it appears turbid or contains noticeable solids, he should modify his operational control policies and procedures. Though observation of poor effluent quality alone will not reveal specific control requirements, it signals the need for judicious review of control and response trend lines and for revised operating policies. Specific control adjustments will be dictated by the results of other control tests.

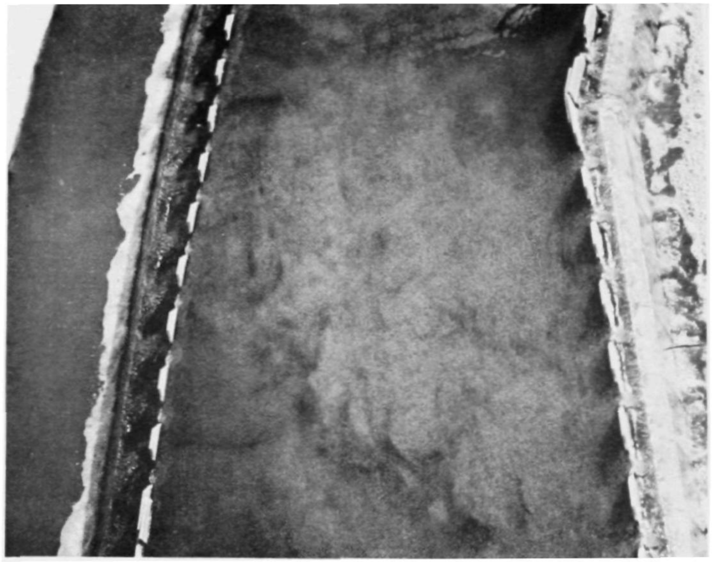
FINAL CLARIFIER SURFACE APPEARANCE

Sludge Bulking

Operators who have experienced true classic sludge bulking find it all too easy to remember and identify. Such conditions are evidenced by a homogeneous appearing sludge blanket that extends throughout the entire clarifier, and can be observed at the water surface while the mixed liquor solids pour out over the final effluent weirs. Though at times induced by shock loadings, and aided and abetted by ineffective aeration devices, classic sludge bulking usually is caused by improper operational control rather than by inadequate plant capacity. Furthermore, impending bulking usually can be recognized many



CLASSIC SLUDGE BULKING



SOLIDS WASH OUT

RISING CLUMPS

FLOATING ASH

days before it actually occurs by judicious use of the sludge depth blanket finder described in Part II Control Tests.

This type of bulking, which is practically always associated with young sludge, usually can be eliminated by reducing sludge wasting rates, increasing return sludge flow rates, and reducing air discharge down to the minimum rates that will still maintain aerobic conditions in the aeration tanks. Where appropriate flexibility has been designed into plants, bulking has also been eliminated by changing the process mode from conventional plug flow to step flow by introducing the primary effluent into the second or third bay of the aeration tank.

In some cases where such control adjustments have failed, emergency chemical treatment has cured classic sludge bulking. Some operators have successfully applied polymers and ferric chloride or alum to the mixed liquor entering the final clarifier without destroying desirable sludge characteristics. Laboratory jar tests should be performed to indicate the type of chemical, the dosage rate, and the pH range that will be most effective. If the chemical additives do not cure actual bulking in the final clarifiers, even though the sludge samples settled and compacted in the laboratory jar tests, the chemicals should be added at different points between the aeration tanks and the final clarifiers until best results are obtained. It is usually best to apply chemicals to the wet well preceding, or the pipe line leading to, the final clarifier.

Sludge Solids Washout

Excessive sludge washout over the final effluent weirs, when the upper surface of the sludge blanket is more than three feet below the clarifier water surface and when sludge settles properly in the laboratory, should not be confused with classic sludge bulking. At times this type of severe effluent degradation has been observed while the settlometer test revealed excellent sludge quality. In many multiple clarifier plants this has been caused by unequal mixed liquor flow into, or by unequal return sludge removal from, individual final clarifiers. Under such circumstances, every effort should be made to balance flows into and out of the clarifiers.

Solids washout has also been caused by hydraulic overloading and by improper clarifier inlet port arrangements and faulty final effluent weir locations. Differing from classic sludge bulking, this type of problem is more frequently caused by hydraulic overloads or inappropriate final clarifier design rather than by operational control procedures.

Clumping and Ashing

At times, large masses of sludge, possibly one foot in diameter, may be seen rising, then bursting, and finally spreading over the clarifier surface. This has sometimes been called "clumping." At other times, smaller sludge particles usually deep brown to gray in color, may rise and then spread over the tank surface. Some operators call this "ashing." This problem occurs when sludge age has been permitted to increase beyond the optimum equilibrium requirement of the process cycle and it can usually be eliminated by increasing sludge wasting rates. Reducing air discharge rates to the minimum levels that will still maintain aerobic conditions in the aeration tanks has also been helpful.

Straggler Floc

At times, small, almost transparent, very light fluffy, buoyant sludge particles (one-eighth to one-quarter inch in diameter) may be observed rising to the clarifier surface near the outlet weirs. This condition is usually intensified in a shallow clarifier and may be especially noticeable at high return sludge flow rates. When this type of straggler floc is observed while the final effluent is otherwise exceptionally clear, and particularly if it prevailed even during relatively low surface overflow rates, it implies that sludge age should be increased moderately towards optimum. Since this type of straggler floc usually occurs at relatively low mixed liquor solids concentrations and is usually intensified during the early morning hours, it is believed that these particles are fresh, low density portions of new sludge that has been built up over night. Straggler floc formation can be minimized, and usually eliminated, by reducing sludge wasting rates moderately to increase sludge age while return sludge and air discharge rates are controlled to meet process demands that are calculated from other control tests.

Pin Floc

At other times, very small compact pin floc, usually less than one-thirty-second of an inch in diameter, may be observed suspended throughout moderately turbid final clarifier tank contents. This is a strong indication that sludge age has been increased unduly, and the sludge has become over-oxidized. This will be confirmed by the settlometer test if rapidly settling discrete sludge particles appear granular rather than flocculant, and accumulate rather than compact while forming a settlometer sludge blanket. In essence, granular sludge particles were falling through a turbid liquor rather than compacting and squeezing out a clear final effluent.

When these final clarifier characteristics are confirmed by the settlometer test, the sludge wasting rate should be increased while return sludge flow is adjusted to meet other control test demands.

☆ U.S. GOVERNMENT PRINTING OFFICE 1973—758-487/1025