TREATMENT OF DOMESTIC SEWAGE AT OFFSHORE LOCATIONS

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INTRODUCTION

Until recently, the oil industry had not been confronted with the problem of having to provide sewage treatment facilities on its offshore platforms in the Gulf of Mexico or at its land based operations in the coastal marshes. However, in late 1970, with the advent of Federal regulation and the EPA, the increased activity of the Louisiana Stream Control Commission and the Department of Health in this area, and the issuance of OCS Order No. 8 by the United States Department of the Interior, Geological Survey, Conservation Division, Branch of Oil and Gas Operations, Gulf Coast Region (U.S.G.S.), the necessity for sewage treatment had become readily apparent.

In an effort to cope with this new problem, the numerous companies affected began the search for equipment which would be suitable for effecting results in compliance with the standards set. Chevron Oil Company retained Linfield and Hunter, Inc., Consulting Engineers, to assist in the interpretation of the new requirements, to establish criteria, to select equipment, to prepare specifications for the procurement of equipment, and to assist in the preparation of approval requests to the regulatory agency having jurisdiction over the location to be provided with treatment facilities.

Discussions with the personnel of regulatory agencies yielded that their requirements were different. EPA in 1970 was in the process of establishing standards. The Stream Control Commission had established its requirements based on watercourse condition and its proposed usage. The Department of Health requested that every attempt should be made to produce effluents with 30 mg/l BOD, 30 mg/l suspended solids, and 1 mg/l chlorine residual after 30 minutes retention. The U.S.G.S. requirements might best be presented by quoting the portion of OCS Order No. 8 which deals with sewage treatment.

> "Sewage disposal systems shall be installed and used in all cases where sewage is discharged into the Gulf of Mexico. Sewage is defined as human body wastes and the wastes from toilets and other receptacles intended to receive or retain

body wastes. Following sewage treatment, the effluent shall contain 50 ppm or less of biochemical oxygen demand (BOD), 150 ppm or less of suspended solids, and shall have a minimum chlorine residual of 1.0 mg/liter after a minimum retention time of fifteen minutes."

All the effort expended has been directed toward compliance with both State and Federal requirements. Bay Marchand Field, located offshore from Grand Isle, Louisiana, and operated by the Lafourche Producing Division of Chevron Oil Company, Harvey, Louisiana, was only one of a number of fields supplied with sewage treatment facilities, but was the one which provided the setting for the problems which propagated the study reported in this paper. The problems emerged from this area because of its unique and variable occupancy patterns. In most offshore areas, operating personnel are housed in central bunkhouses and are transported to and from their assigned platforms, whereas in the Bay Marchand Field, these people live where they work.

EARLY DECISIONS

Our preliminary investigation of the operations to be provided with sewage treatment facilities yielded that occupancies ranged from two-man gauging stations to 80-man bunkhouses and that they were located on river banks, in the salt marshes, as well as offshore. One of the major concerns in the selection of equipment and processes for these various operations was one of esthetics, especially for the offshore locations. These structures are extremely crowded with equipment, piping, instrumentation and supplies and any facility installed would of necessity be close to both living and working areas. Process or equipment failures could cause serious social problems for structure population, as there is no easy egress from the type of nuisance which would result. A second important consideration was the variability of occupancy and its effect on treatment unit operation. Bunkhouses are not normally manned to full capacity and oversized treatment units could develop operational difficulties during extended periods of low occupancy.

After much investigation and discussion of occupancy variation with both supervisory personnel and equipment manufacturers and consideration of regulatory agency requirements, it was decided that wherever practical all domestic wastes (water closets, urinals, lavatories, showers, laundry, kitchen, and miscellaneous) generated at the operations in question would be treated. Criteria for determining applied loads and selecting equipment were established by Chevron and approved by U.S.G.S. and the Louisiana State Department of Health. Criteria adopted for determining the applied loads at each facility were as follows:

Hydraulic:

60 gpcd for personnel quartered on a structure

20 gpcd for transients

Organic:

0.20 # BOD/capita/day for personnel quartered on a structure

0.05 # BOD/capita/day for transients

Packaged type extended aeration treatment units were selected for all offshore structures which had applied organic loads of sufficient magnitude to sustain satisfactory performance of units having a minimum aeration tank size of 1500 gallons. Marshland facilities were also provided with extended aeration plants when loading conditions were suitable and conditions for the construction of stabilization ponds were unsuitable. Stabilization ponds were applied where practicable. Small facilities where loads were lower than those which could be handled by the extended aeration plants were provided with electric incinerating toilets for the disposal of body wastes (excreta) and other liquid wastes were discharged to the receiving watercourse without treatment.

The criteria used for sizing extended aeration plants (EAP) and stabilization ponds was as follows:

EAP:

Aeration Tank	10 to 20 # BOD/1000 cubic feet of volume
Clarifier	4 to 6 hours retention of aeration tank volume Surface overflow rate - less than 1000 gpd/sf
Chlorine Contact Tank	30 minute retention of 4 times average flow based on 24 hour retention of aeration tank volume
Ponds:	Two cells Depth - 5 feet maximum; 3 feet minimum First Cell Loading - 50 # BOD/Acre/Day Second Cell Loading - 40% of surface of first cell Chlorination - as required

PROGRESS AND PROBLEMS

After establishing criteria, the subsequent time period was utilized for preparing specifications, allocating funds, advertising for bids, evaluating bids, procuring equipment, scrutinizing shop drawings and expediting the delivery and installation of the equipment.

In Bay Marchand, extended aeration plants were installed and made operational on platforms with occupancies ranging from 12 to 80 men.

Installation of the electric toilets which had been recommended for the other manned platforms had been delayed due to equipment delivery problems.

Once some of this equipment had been installed and operating for a time, it became apparent that its performance was not up to original expectations. Extended aeration plants had been experiencing a variety of operation and maintenance problems due to the unfamiliarity of field personnel with this type of equipment, as well as some mechanical difficulties. The electric toilet, after about 4 months of trial operation, was removed from service as it was considered to be unsuitable for the conditions under which it was applied. U.S.G.S. was apprised of this problem and granted a departure to permit evaluation of alternative means of handling the small sewage load.

PROGRAM

Development of suitable treatment facilities for the small load was not considered an easy task as many methods were investigated prior to deciding on the use of the electric toilet. The extended aeration plant was discarded originally because most sewage treatment "experts," engineers and manufacturers alike, expressed doubt that such small plants could be made to perform satisfactorily. However, after much discussion, it was decided that the extended aeration process should be tried and that a program to accomplish the following should be implemented:

1. Produce satisfactory effluents at existing extended aeration plant installations.

2. Develop a schedule and a procedure for testing extended aeration plant operations, both existing and new.

3. Select, procure, and install three extended aeration plants in the 500 gallon size range for evaluation.

The authors of this paper were assigned the responsibility for administration and execution of this program.

Initial efforts were directed toward producing satisfactory operations at the existing extended aeration plant installations, as it was felt that if this could be effected, some degree of success might be achieved with the smaller plants. If the causes of the deficiencies in the large plants could be ascertained and remedied, some of the potential problems with the small units might be anticipated and dealt with during the start-up period. Observation and testing of the large plants also provided the opportunity to develop and demonstrate the procedures to be employed in evaluating the small units and made it possible to relate physical appearance and parameters to operating condition.

After two or three months of observing, testing, and adjusting the large extended aeration plants, satisfactory process conditions were obtained. Dissolved oxygen concentrations were found to be above suggested minimums, oxygen uptake rates were indicative of thriving biomasses, sludge concentration by volume was within the recommended range, and aeration tank color and odor and plant effluent appearance were as described for a well operating plant (by the manufacturers). Latest labroatory tests on composite effluent samples indicated that these plants were producing acceptable treatment. See Table I for tabulation.

After achieving some progress toward satisfactory operation of the large extended aeration plants, work on the other items of the program previously outlined was commenced. During this period, a market search was initiated to ascertain the availability of and to locate suppliers for the small extended aeration plants (500 gallon size). Several sources were located and two units were selected for evaluation. One had 360 gallon capacity; the other, 600 gallon. Finding a third unit suitable for testing was becoming difficult, but the appearance of a new product, fixed media activated sludge, presented an alternative. After studying the principles of operation of this new product, it was decided that, since the program undertaken was intended to determine the suitability of treatment methods and the product possessed some features deemed desirable for offshore use, the new unit should be evaluated under field conditions.

OBSERVATIONS

Once a decision had been reached as to what equipment was to be evaluated, steps were taken to procure and install the units on the platforms chosen as test sites. However, a number of problems (operational, technical, equipment, logistic, transportation, etc.) had been encountered during the course of this project which have somewhat hampered the achievement of the systematic progress originally anticipated.

In spite of all the problems, some progress has been made. A large amount of qualitative type information dealing with process control and testing procedures and a limited amount of quantitative data have been accumulated. The qualitative information is too voluminous for elaboration in this paper, but has, generally, been associated with the following:

1. control of aeration,
2. solid-liquid separation and sludge return,
3. clarifier operation (inlet and outlet hydraulics, energy dissipation for quiescence, scum retention, and surface skimmers),
4. chlorination,
5. characterization of influent flow,
6. sampling and testing, and
7. development of operation and maintenance procedures.

The quantitative data is not considered statistically significant, but does indicate the magnitude and character of the type of loads which are being applied to sewage treatment equipment in offshore situations. Data are tabulated in Table II. The data presented has resulted from the testing of twenty-four hour composite samples. The first four samples collected from the platform designated REX and the first two from AAX were composited from grab samples caught at intervals at the discretion of a technician. The last four from REX and the last two from AAX were composited from samples collected by a flow sensitive automatic sampler, designed by the authors. Scrutiny of some of the other parameters tested indicated that the sampler was not catching a representative portion of the constituent solids, thereby, making the BOD values reported somewhat lower than those actually present. The flow reported was obtained from physical measurements and represents a reasonably accurate description of actual conditions.

Observation of flow encompassed not only the determination of quantity, but also, the development of patterns so that the rate of application of the flow through the plant could be ascertained.

The difference in the observed values of # BOD/day/capita (0.17) and the established criteria (0.20) was probably due to the fact that the original criteria was chosen for large bunkhouses with commercial type laundry equipment and complete cafeteria style kitchens, whereas, the platforms studied were low occupancy small bunkhouses with no laundry facilities and small domestic type kitchens. The difference might be attributable to the fact that low BOD's were obtained when the automatic sampler was used, but comparison of the average value, 656 mg/l (Table II), with other published figures for similar occupancy and water consumption yields that the average value is representative. A July 1971 publication, "Treatment and Disposal of Vessel Sanitary Wastes," of the National Research Council, National Academy of Sciences - National Academy of Engineering, indicates that sewage, composed of both body and domestic wastes from shipboard occupants, has a constituent BOD of approximately 650 mg/l when the quantity generated is 35 gpcd. Scrutiny of some data obtained when spot checking influents of the large extended aeration plants yielded that the # BOD/capita/day averaged about 0.26. The reliability of this value may be suspect as it was derived from only three observations.

Even though the numbers relating to applied load parameters do not coincide with the criteria established, it is still felt that, based on the relative magnitudes of the values, the small number of observations, and the degree of success achieved with the large plants studied, the use of 0.20 # BOD/capita/day is valid for the determination of design applied loads.

Effluent test results have not been presented or discussed as the evaluation of the equipment under study is incomplete and a report on the progress to date would be premature. Satisfactory operation of small biological treatment units offshore is still uncertain at this time, although there have been some indications of success probability.

In an effort to capitalize on our limited successes and to accelerate the rate of progress, a small extended aeration treatment plant was designed by the authors. This unit is comprised of the mechanical equipment and liquid retention compartments necessary for the propagation of a biological system, the features found to be desirable from an operation and maintenance standpoint, and the special electrical and structural requirements necessary for the offshore environment. It has been built and is presently installed at a test site. It has been observed, but not tested as it has only been in operation a short time and there is little evidence of a biological system. Observation and testing will commence when the aeration tank solids concentration reaches a suitable level.

CONCLUSIONS

This paper has presented information of a general nature which describes the problems encountered in trying to provide adequate sewage treatment facilities for offshore platforms. Some of the following may not have been elaborated in the text because they involve specifics, but they are nonetheless significant.

1. The criteria adopted for the determination of applied loads are valid for design.

2. Equipment for a particular application should be sized so that its unit organic loading is between 10 and 20 # BOD/1000 cf of aeration tank volume, with values of 15 to 20 being the most desirable.

3. Clarifiers should be sized for a minimum hydraulic design load of 5 gpm and an upflow rate of 500 gpd/sf in order to minimize the effects of surges and peak flows.

4. Sewage pumps have proven to be a maintenance problem offshore, especially level controls. They also contribute to problems with clarifier operation. Sewage treatment plants of the sizes required offshore should be fed by gravity or provided with some sort of means for metering flow to prevent excessive solids discharge from the plant during pumping periods.

5. Informed personnel and routine maintenance are essential to successful extended aeration plant operation.

6. The standard designs of extended aeration treatment plants larger than 1500 gallons, modified for offshore use (electrically and structurally) have been shown to be capable of producing acceptable effluents when applied in accordance with the criteria stated above.

7. Small extended aeration plants have under some circumstances shown evidence of their capability to provide a substantial degree of treatment; and under other circumstances, a complete lack of capability. These plants are susceptible to overloading, are less able to handle "shock" loads (especially hydraulic), and can be killed easily by harsh cleaners (bleach, Lysol, etc.). Definite conclusions regarding their applicability cannot be drawn at this time as evaluation is still in progress.

REFERENCES

1. Eckenfelder, W. W., Jr., Water Quality Engineering for Practicing Engineers, Barnes and Noble, New York, 1970.

2. Louisiana Stream Control Commission, "Water Quality Criteria and Plan for Implementation, State of Louisiana," 1968.

3. National Sanitation Foundation, "Package Plant Criteria Development, Part I: Extended Aeration," FWPCA Demonstration Grant Project WPD-74, September 1966.

4. National Research Council, National Academy of Sciences - National Academy of Engineering, "Treatment and Disposal of Vessel Sanitary Wastes," Maritime Administration, July 1971.

5. Sawyer, C. N., and McCarty, P. L., Chemistry for Sanitary Engineers, Second Edition, McGraw-Hill, New York, 1967.

6. Standard Methods for the Examination of Water and Wastewater, 13th Edition, American Public Health Association, New York,

7. Stewart, Mervin J., et al, "Effect of Varying Salinity on the Extended Aeration Process," Journal WPCF 34:11:1161 (November 1962).

EFFLUENT PARAMETER	PLANT SIZE		
	1500 GPD	4000 GPD	8000 GPD
BOD_5 (mg/l)	20	15	20
Suspended Solids (mg/l)	40	20	30

TABLE I

LABORATORY TEST RESULTS
COMPOSITE EFFLUENT SAMPLES

TABLE II

INFLUENT CHARACTERIZATION DATA TABULATION

PLATFORM	OCCUPANCY*	FLOW+ GPD	INFLUENT BOD ** mg/l	INFLUENT BOD #/day	BOD #/day/capita	FLOW GPCD
REX	7	153	481	0.61	0.09	22
	7	106	1185	1.04	0.15	15
	7	186	885	1.37	0.20	27
	7	167	976	1.36	0.19	24
	7	300	385	0.96	0.14	43
	7	270	447	1.01	0.14	38
	7	240	439	0.88	0.12	34
	7	240	498	1.00	0.14	34
AAX	4	205	622	1.06	0.26	51
	4	163	1148	1.56	0.39	41
	5	138	475	0.49	0.10	27
	5	205	379	0.65	0.13	41
AVERAGE			656		0.17	33

* Number of men quartered on the platform on the date of observation.
\+ Measured flow - Time required to fill a measured volume was recorded.
** Five day BOD was determined in accordance with the procedure outlined in Standard Methods.