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An Evaluation of European Experience with the Rotating Biological Contactor

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AN EVALUATION OF EUROPEAN EXPERIENCE WITH THE ROTATING BIOLOGICAL CONTACTOR

prepared by

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for the

Water Pollution Control Directorate
Environmental Protection Service

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Review Notice

This report has been reviewed by the Water Pollution Control Directorate, Environmental Protection Service, and approved for publication. Approval does not necessarily reflect the views and policies of the Environmental Protection Service. Mention of trade names or commercial products does not constitute endorsement for use.

Abstract

This report presents a brief survey of European experience with the Rotating Biological Contactor process (RBC) applied to the secondary treatment of various industrial and domestic wastes. Field inspections of six operating plants in Germany, France and Denmark were conducted and their operation was reviewed with the relevant regulatory authorities wherever possible. The wastes being processed at these plants included distillery, brewery and dairy wastes. Pertinent data is summarized and presented in units in common use in Canada.

A survey was also made of the available North American and European literature on Rotating Biological Contactors. Abstracts of a number of publications are included as an appendix to this report.

Résumé

Le présent rapport donne un bref compte-rendu de l'expérience européenne du procédé du Rotating Biological Contactor appliqué au traitement secondaire de divers déchets industriels et domestiques. On a fait l'inspection sur le terrain de six usines en exploitation en Allemagne, en France et au Danemark et, partout où cela était possible, on a étudié leur fonctionnement avec les autorités de réglementation compétentes. Parmi les déchets traités dans ces usines, on compte les déchets de distillerie, de brasserie et de laiterie. On résume les données pertinentes et on les présente en unités d'usage courant au Canada.

On a aussi fait l'étude des ouvrages sur les contacteurs biologiques rotatifs disponibles en Amérique du Nord et en europe. Les résumés d'un certain nombre de publications sont donnés en annexe au rapport.

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CONCLUSIONS

The following conclusions have been made as a result of this study:

1. The Rotating Biological Contactor is a simple and reliable process to provide secondary treatment for a variety of industrial and municipal wastes. It has demonstrated this capability for a period of at least 5 years in the installations inspected, all of which appeared to have many additional years of effective life remaining.
2. The BOD_5 removal capacity of the operating installations inspected was slightly lower than the literature would suggest. All installations demonstrated the capability of achieving 80-90% removal with loading of 4-15 lb BOD_5 per day per 1000 ft^2 of discs.
3. The data available indicates that the RBC probably has a greater capacity to resist operating instability from shock loads than an activated sludge system but perhaps less than long detention time systems such as aerated lagoons. As an example one installation indicated that an occasional pH of 4.0 did not upset the operations.
4. The RBC offers a means of removing BOD with a much lower power consumption than activated sludge, aerated lagoons and other conventional biological treatment systems.
5. The maintenance of RBC equipment is generally simple as would be expected from low speed, low power rotating machinery. There were no significant special problems encountered with equipment maintenance at the plants inspected.
6. From discussion with German government officials, suppliers and plant operators there appeared to be no technical factors which would limit the size of an RBC waste treatment plant. The relationship between capacity and capital cost for RBC waste treatment plant is approximately linear, so that the economics appear to favour smaller RBC plants rather than large scale installations.

7. Alternative construction of the biological contact media are presently under development and may significantly reduce the cost of RBC installations.
8. The RBC process is as applicable in Canadian climates as activated sludge systems. The short retention time of the process will prevent freezing in the RBC and assist in avoiding icing in the clarifier.
9. The limited data available did not demonstrate any advantage of the RBC process over other treatment methods in the removal of nutrients. However, none of the plants inspected were attempting to remove nutrients with the RBC.
10. The solids produced in the RBC treatment systems were all digested anaerobically and disposed of as fertilizer. As a result no data was available on the dewatering of biological solids from the RBC.

1 INTRODUCTION

The Technology Development Branch of Environment Canada retained T.W. Beak Consultants Limited to report on European experience with Rotating Biological Contactors (RBC). The report follows inspection of six operating plants in Germany, France and Denmark by Mr. S.K. Gorur of Environment Canada and Mr. N. McCubbin of Beak Consultants.

The RBC has only recently become readily available in North America and while there is a wealth of literature it is almost all based on laboratory or small scale pilot studies. The literature on full scale operations is written for European use and therefore does not report on all the factors of interest to potential Canadian applications. A large proportion of all the literature is published by the suppliers of the RBC equipment. This report is an independent evaluation of the RBC process and experience in Europe.

2 DESCRIPTION OF RBC PROCESS

The Rotating Biological Contactor (RBC) can be described as a trickling filter in which the media is passed through the waste rather than vice versa.

The process is variously known as Rotating Biological Surface, Rotating Biological Disc, Immersion Dip Filter, Tauchtropfkoerper (German), BIOSPIRALE (French), BIO-DISC and BIO-SURF. The latter two are registered trade marks in Canada.

The normal form of RBC consists of a series of closely spaced discs anchored to a shaft which is supported just above the surface of the waste to be treated. The lower portion of each disc extends into the waste, while the upper portion of the disc rotates in the air. Thus a unit area of biomass is alternately submerged to absorb organics and then raised out of the liquid phase to absorb oxygen. The waste passing between the discs flows parallel to the adjacent faces of the discs which support a biological film typically 1/16-1/8" thick. The discs rotate slowly, typically 1 RPM for a 10' Ø disc, imparting a lifting action to the waste through the drag forces generated. This in turn causes turbulence in the waste adjacent to each disc face. Contact between waste and discs is thus not a single pass between adjacent surfaces but rather a rapid circulation of waste many times over several quadrants of the disc before the waste leaves the tank for the next stage of discs. Several

stages of discs are normally used in routine treatment.

Other configurations are under development employing "honeycomb" self supporting media or drums of open construction, such as wire mesh, packed with raschig rings or similar mass transfer media. One such application is described in this report.

3 HISTORICAL DEVELOPMENT

The Rotating Biological Contactor (RBC) was the subject of sporadic research prior to 1940, but due to lack of demand was never developed. Research was recommenced in 1955 at the Technical University of Stuttgart, West Germany, by Hans Hartmann and Franz Popel, (23). Commercial use of the process began in Europe in 1959 and today there are almost 1,000 installations, primarily in West Germany, France and Switzerland. These installations, ranging in size from a single residence to 10,000 lb BOD/day, treat domestic wastewater, industrial wastewater, and mixed industrial and domestic wastewaters. The vast majority of these installations treat loads under 250 lbs BOD/day.

In Europe, 2 and 3 meter diameter discs constructed of expanded polystyrene have been used almost exclusively in the process, with single buildings and concrete tankage.

The RBC process was first marketed commercially by J.C. Stengelin Ltd., of Tuttlingen, W. Germany. They now have licences in several countries including:

T.E.B.A.	Strasbourg, France
Sabla	Lyons, France (Package plants)
Mecana S.A.	Schmerikon, Switzerland
Autotrol Corp.	Milwaukee, Wisconsin (US & Canada)
P. Reinisch	Graz, Austria
C.J.B. Developments	Southampton, England

The above companies have supplied virtually all the RBC units presently in operation.

In addition the following companies supply RBC equipment:

Ames Crosta Mills	Toronto, Ontario
Ames Crosta Mills	Heywood, England.
Environmental Control Inc.	Oconomowoc, Wisconsin

4 SUMMARY OF TREATMENT PLANTS VISITS

Six operating RBC plants were visited to review the operation and performance of the equipment under normal conditions. Four of these plants had been in operation for several years and the waste being treated included domestic, brewery, distillery, and dairy effluents. It has originally been intended to visit privately-owned plants but this proved impossible since virtually all the plants of the RBC type are publicly owned.

In the detailed plant visit reports, Appendix II, the RBC construction is described as "Standard Stengelin". This refers to the form used by the J.C. Stengelin Co. and their licensees. It employs 1.5 cm (5/8") thick expanded polystyrene discs 3 meter (9 ft.10 in.) diameter with 30 discs per meter mounted on a common shaft. The discs are immersed 40% in the waste and driven by an electric motor through a gear reducer or chain drive.

The data available at the plant was limited since none were equipped to perform BOD, COD or suspended solids analyses (except by volume). The data normally recorded was limited to flow, pH and various visual observations. In all cases the local regulatory authority performed a limited number of analyses and whatever records were available are reproduced in this report. In some cases the analyses were not adequately correlated with flow so their value is limited. Detailed plant inspection reports are appended.

4.1 Spalt, Bavaria, W. Germany

The town of Spalt, Bavaria owns a brewery which is the major local industry. The brewery and domestic wastes are treated in the oldest Stengelin supplied RBC plant. The operator reported that the normal ratio of brewery waste flow to that of the domestic waste was about 80%:20% but this of course varies with the season.

The RBC was originally installed in the open but storm damage to the equipment and also the biomass necessitated the addition of a building to house the units.

The BOD removal was generally above 80% and appeared to be dependent on the influent load, BOD removal efficiency increased when the raw waste strength was high.

The RBC units are arranged in two parallel groups of four each. Due to poor hydraulic design, the flow is not equally divided between the two groups. This results in the 3rd & 4th shafts in the group receiving the lesser flow carrying only a light biological growth, presumably due to being underloaded. It would appear therefore that the actual specific loading on the RBC in this plant is greater than apparent from simple calculation.

4.2 Amberieu en Bugey, Ain, France

Located in the Department of Ain the town of Amberieu en Bugey has a medium sized slaughter house and a railway marshalling yard as the main industries. The RBC was reported to be treating the slaughter waste but on arrival it was learned that this waste had been routed directly to the river until shortly before the visit. There was no BOD removal data available for the combined abattoir/domestic treatment so all the data reported herein represents domestic waste only.

This was the only one of the plants visited where a serious effort was made to minimize the operating labour. In this case the city has a contract with the supplier (a Stengelin licensee) to operate and maintain the plant and accept responsibility for its performance for about $7,000 per year (at French costs). The normal operating requirement was reported to be about 2 man hours/day.

4.3 Kappelroedeck, Baden Wurtt, West Germany

The waste in this case consists of domestic and schnapps distillery in unknown proportions. All the distillery wastes except the still bottoms are treated in the RBC system. The only analysis for copper reported was on the digested primary and secondary sludge and this was 410 mg /l, dry basis. This would indicate a concentration of about 5 mg/l in the raw waste and if this is normal then it would significantly reduce the

measured BOD of the raw waste. Since the copper content of the treated waste is probably lower, the BOD analyses on it are possibly more accurate, suggesting that the actual plant efficiency may be higher than reported.

4.4 Bad Durrheim, Baden Wurtt, W. Germany

This plant had been in operation for a few days at the time of the visit and was inspected only because of its proximity to the manufacturers plant and the opportunity offered to have the chief engineer explain the design of one of his latest plants.

4.5 Urloffen, Baden Wurtt, W. Germany

The waste treated in the RBC plant consists of domestic, distillery, dairy and winery. The three industries are all small units run by individual farmers and are believed to discharge their total wastes to the treatment plant. The BOD_5 concentrations in the influent to the plant were the highest noted in all the inspections. The manufacturer had described the plant as a poor one to visit due to its being overloaded. This clearly caused a high effluent BOD_5 typically about 70 mg/l but the removal efficiency was almost 90% during these periods.

The operator reported that the only problem associated with the overloading was that the channel carrying the RBC effluent to the secondary clarifier had to be cleaned daily to avoid plugging with biomass. There was no data available on the suspended solids content of the secondary clarifier overflow but a photograph of it after half hour settling is included in Appendix II. The operator had recently been provided with a microscope for sludge examination.

4.6 Leidersdorf AG, Zealand, Denmark

This was reported to be a full scale plant prior to the visit but it was in fact only a pilot operation with a short history. It incorporated a completely different form of construction from the "Standard Stengelin" employed in all the full scale systems studied.

The media employed for support of the biomass consists of a cylindrical "cage" packed with $1\frac{1}{2}$" diameter plastic balls but the principle of operation is the same as for the disc type construction. A similar construction is employed successfully at the Water Pollution Research Laboratory at Stevenage, England.

The waste being treated is from a fur cleaning plant and contains 18 mg/l chromium. The BOD reduction obtained was about 50% at a specific BOD_5 loading of 1.3 lbs/sq ft/day but in view of the short operating history and the toxic nature of the waste this data is of limited value in assessing the potential of this form of construction.

5 REPORT ON VISITS TO RESEARCH AND RELATED ESTABLISHMENTS

Since several of the plants visited had no records of the laboratory analyses performed on their effluents, it was necessary to meet with local regulatory authorities. The data collected in these visits is included with the appropriate detailed report on the plant visit in Appendix II. The following more general information on the RBC from the regulatory authorities point of view was received.

5.1 Wasserwirtschaftsamt Offenburg, Baden Wurtt, West Germany

At the Wasserwirtschaftsamt (i.e. Water Control Board) in Offenburg the opinion of the chief engineer Mr. Marsch was that the RBC was economically attractive for populations up to 50,000. This represents 6000 lb BOD_5/day at the standard German loadings.

He felt that the RBC was capable of treating the normal fluctuations in domestic sewer loadings but that extreme variations such as pH below 3 would cause a biomass kill. He was of the opinion that a well run activated sludge system could withstand shock loads and could recover from a biomass kill faster than an RBC treatment system.

In general he prefers the activated sludge process for treatment of domestic and mixed effluents. He advised that, to the best of his knowledge, J. C. Stengelin Ltd. had supplied all the full scale RBC plants in operation in Southern Germany.

5.2 Wasserwirtschaftsamt, Ansbach, Bavaria, W. Germany

Dr. Boie, the director of the laboratory and Technical Services for the regional water control board, was interviewed. His comments were similar to those above except that he considers that in practice, the RBC is more reliable, can treat greater fluctuations in loading and will recover more quickly from a biomass kill than an activated sludge system. He felt that while the activated sludge process may be theoretically

superior to the RBC, the practical difficulties and costs associated with achieving optimum conditions in activated sludge render the RBC superior in actual operating results. Dr. Boie advised that his work indicates that RBC systems could remove heavy metals and toxic high molecular weight organics to some extent. He explained this is due to wider variety of ages and types in the microbial population than is normal in otherwaste treatment processes. This results in a biomass which is capable of absorbing the non-biodegradable contaminants and then precipitating as secondary sludge. Dr. Boie stated that he considered that the development of RBC construction methods which incor orate higher surface area to volume ratios than those current would be advantageous.

5.3 Dr. Hartmann (Sewage Treatment Plant, Nurnberg), Bavaria W. Germany

Dr. Hartmann was one of the principal research workers on the development of the RBC as it currently exists (23). He is now technical director of the municipal sewage treatment plant at Nurnberg, a large modern activated sludge system.

Dr. Hartmann's comments agreed closely with those of Dr. Boie except that he advised that trials conducted by his department at the University of Stuttgart had indicated that the slightly textured surface of expanded polystyrene discs such as used by J.C. Stengelin and licensees was capable of supporting a heavier biological growth than a smooth plastic or metal surface. He felt that this would outweigh any advantages gained by the use of alternative media with higher specific surface area RBC for construction. He said that he would prefer to have an RBC system presently under his supervision since its operation would be simpler than the activated sludge but that the economics would be very unfavourable for such a large plant. The population of Nurnberg is about 800,000.

Dr. Hartmann advised that he did not believe that the use of oxygen enriched atmospheres around the RBC would be advantageous since he considered that oxygen transfer to the biomass is not a limiting factor.

5.4 Water Pollution Research Laboratory, Stevenage, England

This installation is British Government owned and operated, and conducts a variety of fundamental and applied research in the field of waste treatment. The work includes the operation and study of pilot plants,

including several RBC installations.

Their general conclusions to date are that, for wastes under 800 mg/l BOD_5, the principal design criteria is the BOD loading per unit area, per unit time, regardless of whether the media consists of polystyrene discs, smooth plastic mass transfer media or various other format which have been investigated. They did not consider retention time to be significant within the range of retention time to surface loading ratios studied.

6 DISCUSSION OF DATA

6.1 Process Data

Table 1 on the following pages summarizes the numerical data collected on the operating RBC plants of most interest to Canada. All detail data which formed the basis for this Table is included in Appendix II.

Five of the plants inspected were operating as routine waste treatment facilities and the monitoring of the performance was generally limited to that required by the regulatory authorities. The other, a pilot plant had too short a history to generate useful data.

It is apparent that the BOD removal efficiency generally rises with higher loads (5). Since the efficiency of most interest for design and equipment selection is that at high loads, Table 1 is based on the data representing the highest 20% of the daily BOD loads for each plant. The various limitations and assumptions involved in the preparation of this Table are defined in the footnotes.

In view of the restricted amount of data available for the compilation of Table 1, it is patently undesirable to employ these loadings for design of an RBC treatment plant. There is extensive data in the literature which would be of assistance in this matter but in view of the variations involved there are obvious advantages in running pilot plants for unusual wastes or when large capital investments are required.

The BOD loading and the power requirements are quoted on the basis of raw waste BOD since most of the available data were in that form. It is more conventional and also more logical to employ these loadings based on settled BOD for design and comparison purposes.

TABLE 1

SUMMARY OF DATA ON OPERATING RBC PLANTS

PLANT CHARACTERISTIC / TYPE OF WASTE	KAPPELROEDECK	URLOFFEN	SPALT	AMBERIEU EN BUGEY
	DOMESTIC DISTILLERY	DOMESTIC DISTILLERY WINE DAIRY	DOMESTIC 20% BREWERY 80%	DOMESTIC 100% (AT TIME DATA COLLECTED)
Raw Influent (MUSGPD)(3)	0.6	0.34 (1)	0.34	1.27 (5)
No.of stages in series	8	6	4	3
BOD_5 (mg/l)		620	370	270
(lbs/day) (3)	875	1,753	1,047	2,856
INFLUENT TO RBC AFTER PRIMARY SEDIMENTATION				
Phosphate (mg/l)	4.5	11.4	-	-
Ammonia (mg/l)	Total (N) 19.3	29.5	23.8 (4)	-
Nitrite (mg/l)	-	0.14	0.47 (4)	0.01 (7)
Nitrate (mg/l)	-	3.0	12.8 (4)	0.5 (7)
Permanganate (mg/l)	-	193	200 (4)	-
pH	-	7.2	7.1	-
Temperature (^oF)	58	58	55	-
SECONDARY TREATED WASTE				
BOD_5 (mg/l)	25	70	46	38
(lbs/day) (3)	125	198	130	402
removal (%) (3)	85	89	88	86
Phosphate (mg/l)	4.3	8.8	-	-
Ammonia (mg/l)	Total (N) 13.4	30.8	14.4	-
Nitrite (mg/l)	-	0.8	0.2	0.5 (7)
Nitrate (mg/l)	-	30 (2)	3.4	0.5 (7)
Permanganate (mg/l)	-	88	85	-
LOADING CRITERIA				
Area Discs (sq.ft)	196,000	117,000	220,000	302,000
Total installed HP	6	8	12	12
GPD/sq.ft (3)	3.1	2.9	1.6	4.2
Lbs BOD_5/day/1000 sq.ft(3)(6)	4.5	15.0	4.3	9.5
Lbs BOD_5/HP day (6) (8)				200

Ref. following page for footnotes

TABLE 1 (cont.)

The data above is the average of all data collected on the plants herein described. As figures come from different sources a number of changes and assumptions have had to be made to permit comparison.

(1) Urloffen flow relates only to one set of test data.
(2) Urloffen Nitrate data is based on only one test. The other figure shown in the tables appears too high to be realistic.
(3) Highest loads only (i.e. top 20% of data) based on raw waste and final effluent.
(4) As only raw sewage data was quoted on Spalt this has been reduced by 33% equivalent to the normal reduction on primary sedimentation.
(5) The flow quoted is the average for the plant and is not associated directly with the test data.
(6) Based on raw waste. Most of the literature data is based on settled waste but this was not available here.
(7) All only one figure reported.
(8) The figures used for lbs BOD_5/HP day are based on lbs of BOD_5 removed per installed HP and not electrical load. The latter was approximately 40% of installed HP on the only installation where data was available and this is believed to be representative.

The low BOD_5 concentration at both Kappelroedeck and Amberieu could be caused by presence of cooling waters. The presence of 410 mg/l of copper in the Kappelroedeck sludge indicates possible interference with both BOD determination and plant removal efficiency.

The power requirements represent the connected horsepower since this was the only data available. The actual power required for normal operation is estimated to be about 30 to 50% of the connected HP (1), (14) but the larger motors are required to start the discs or other media turning after a shutdown (due to power failure for example), since the load is severely unbalanced in that condition.

Figures 1 and 2 following were compiled by the University of Stuttgart and are commonly used for RBC plant design in Europe. The corresponding data from Table 1 is plotted on Figure 2 for comparison, making an arbitrary allowance of 1/3 for BOD removal by primary treatment.

The data for Kappelroedick and Amberieu en Bugey fit the curves reasonably but that for Spalt and Urloffen indicate that the plant efficiencies are lower than the curves would predict.

It was not possible to arrive at any conclusions with respect to toxicity removal by RBC systems. None of the plants had any toxicity removal requirements imposed upon them and therefore did not perform relevant analyses.

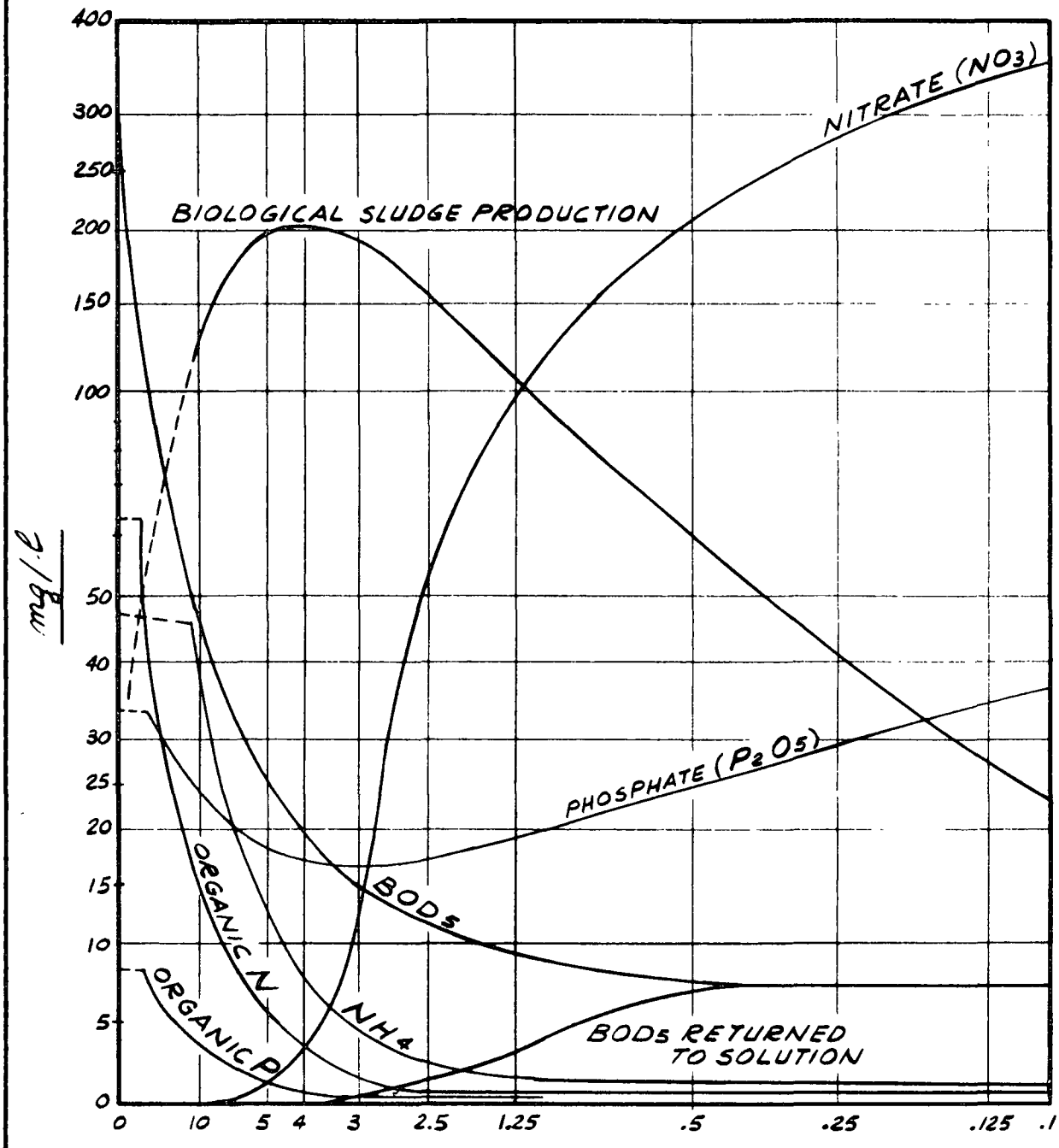
Operation of the RBC is simple and was being performed in all cases by one man, dayshift only, with little training. The process is inherently stable and short circuiting does not occur since the plants are multi-stage.

The biomass is always visible and operators develop the ability to recognize the incidence of toxicity or extreme pH variations in the waste waters, facilitating corrective action.

6.2 Application of RBC in Combination with other Waste Treatment Processes

There were no installations visited where the RBC was being applied in combination with other waste treatment systems. However, Mr. V. Stengelin advised that there was an RBC system under construction at Donnaueschingen (South West Germany) which would serve as a roughing pretreatment for a conventional activated sludge system. The waste involved is very strong and includes abattoir and brewery waste.

In view of the relationship observed and also reported in the literature between efficiency and specific loading it would appear that the RBC would be applicable as a pretreatment for strong wastes but not



(DATA DEVELOPED BY UNIVERSITY OF STUTTGART)

GRAPH OF LOADING VS. PERFORMANCE

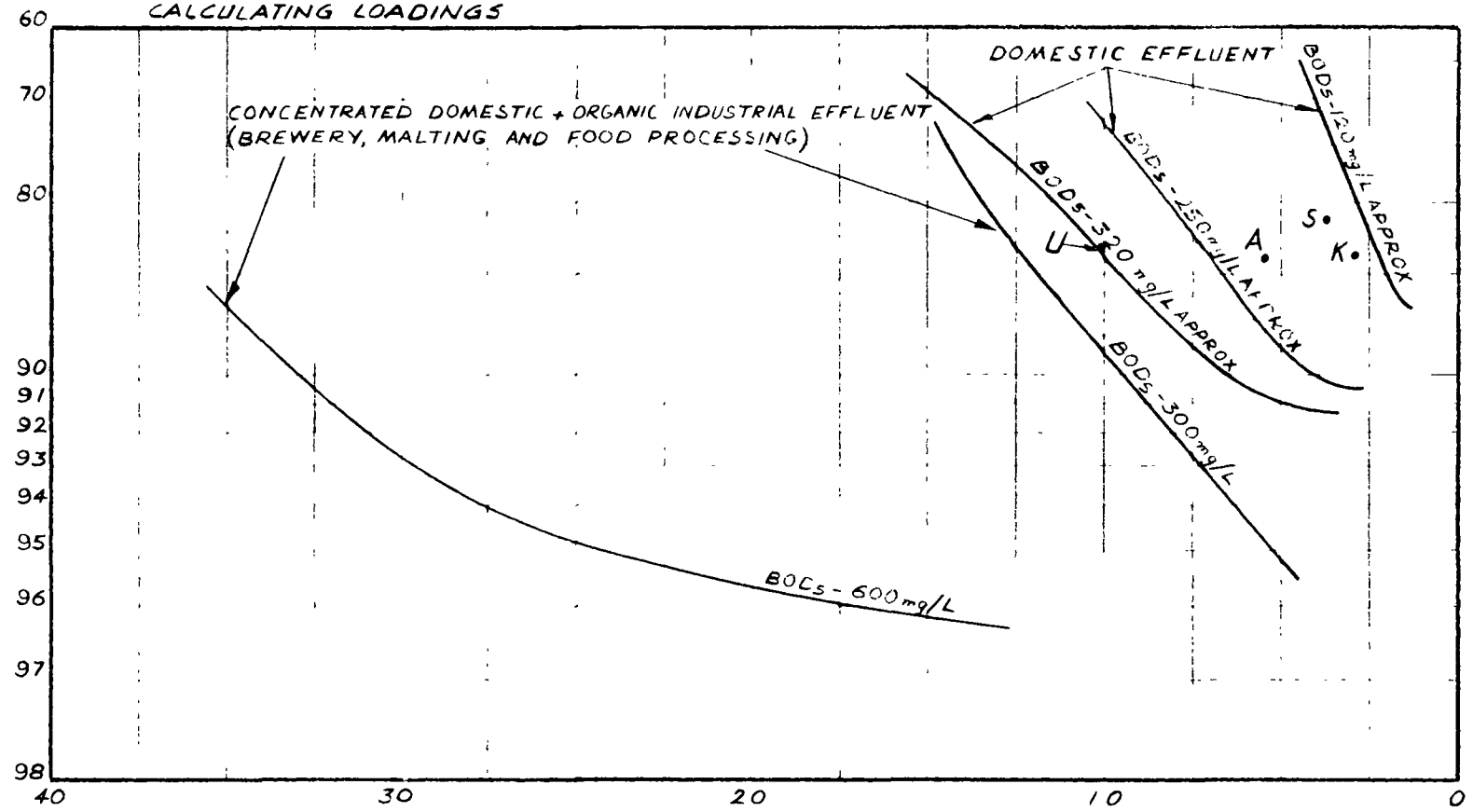
NOTE:
ABOVE CURVES WERE DEVELOPED AT THE UNIVERSITY OF STUTTGART FOR POLYSTYRENE DISCS BUT ARE BELIEVED TO BE REPRESENTATIVE FOR OTHER MEDIA.

NOTE:
BASED ON TYPICAL DOMESTIC WASTE 320 mg/l BOD_5 AFTER SETTLING

ENVIRONMENT CANADA OTTAWA — ONTARIO	BEAK	BY S.R. DATE 10-1-72 DWG NO A1158-7	FIG. 1

RAW BOD REDUCED BY 33% TO ALLOW FOR SETTLING DATA DURING PERIODS OF VERY LOW LOADING WAS NEGLECTED IN CALCULATING LOADINGS

K = KAPPELROEDECK 115 mg/L BOD.
U = URLOFFEN 405 " "
S = SPALT 250 " "
A = AMBERIEU 150 " "



NOTE ABOVE CURVES WERE DEVELOPED AT THE UNIVERSITY OF STUTTGART FOR POLYSTYRENE DISCS BUT ARE BELIEVED TO BE REPRESENTATIVE FOR OTHER MEDIA

BOD REDUCTION vs SPECIFIC LOADING

ENVIRONMENT CANADA
OTTAWA – ONTARIO

BEAK

BY D C S DATE 11-1-73
DWG NO A1158-3

FIG 2

normally as a tertiary treatment for BOD removal (4), (6), (8).

6.3 Shock Loading

It is apparent from the inspection of Tables 3, 4, 8 and 9, Appendix II, that the RBC is capable of absorbing shock loads quite well. There is not enough data to perform a statistical analysis but it is BEAK's opinion that the above data indicates a greater capacity for treatment of shock and variable loads than a conventional activated sludge system (8), (13). A low rate system such as an aerated lagoon would probably be more resilient than the RBC for such short shock loading periods.

6.4 Short Circuiting

As would be expected from the design of the vats containing the RBC there was no evidence of short circuiting at any of the full scale plants visited (2). There are references in the literature to difficulties which have occurred when the vat contour was more than several inches away from the periphery of the RBC disc or other biomass supporting media (4), (20).

6.5 Media Spacing

All full scale plants inspected had the same disc spacing of 1.3" between centres and since occasional plugging did occur but did not cause any apparent problems this spacing would appear to be close to the practical limit for this type of construction.

At Leidersdorf and at the Water Pollution Research Laboratory in England where mass transfer media were employed to support the biomass there were no difficulties with plugging despite spaces being much smaller than those between discs.

6.6 Solids Disposal

As reported in the individual plant inspection reports the secondary sludge was in all cases returned to the primary clarifier and the combined sludge from there was digested anaerobically and then dried and used as fertilizer. In all cases the local farmers were permitted to remove the solids at no charge and at no cost to the waste treatment plant owners.

6.7 Disinfection

In no case was the final waste or the sludge treated with chlorine or other disinfectant prior to disposal.

6.8 Maintenance

There were no records available of actual maintenance costs but it was clear from discussions with the operators, all of whom had been at their respective plants since start-up, that maintenance was minimal. There had been no major overhauls or replacement of equipment. The greatest problem was the damaged section in the RBC unit at Spalt and that could have been avoided by better operating attention.

6.9 Nutrient Removal

The primary requirement of a biological system processing sewage, with regard to nitrogen nutrients, is to convert ammoniacal nitrogen to nitrates. This has three beneficial effects. It removes ammonia which is toxic to fish, especially in alkaline conditions; eliminates the oxygen demand of nitrification; and can form a valuable reservoir of oxygen, preventing anerobic conditions when the dissolved oxgyen is depleted in highly polluted industrial rivers. If the water in the river is used for drinking on the other hand, high nitrates are undesirable because levels above 10 mg/l as nitrogen in drinking water are reported to increase the risk of methemoglobinemia in young children. The data collected on RBC's in Europe does not show any significant increase in nitrification in comparison with conventional systems.

It has been stated in the literature that the RBC is more effective in removing phosphates from wastes than conventional systems (9), (5). However, there was no evidence of this in the data collected on the plants discussed herein, possibly due to their low biological loading.

6.10 Economics of Scale

In its present form the largest RBC unit on the market is a 95,000 sq ft shaft available from Autotrol Corporation. This will have a capacity in the order of 500 lbs/day of BOD so that larger plants would have to use a number of these or similar equipment. The major part of the capital cost of a primary and secondary treatment system incorporating an RBC is the RBC equipment and its associated civil and electrical works. Typically this would account for about 70% of the total so that the increase of capital cost with increasing capacity is more nearly linear with RBC systems than with conven-

tional systems (2). Recent cost estimates by BEAK confirm this. There would appear to be considerable scope for development of larger equipment to reduce the unitcost of larger plants but the opinion in Europe is that the practical limit has been reached. It is probable that North American requirements will lead to the development of larger units than used in Europe as has occurred with much industrial equipment.

7 DESIGN OF RBC WASTE TREATMENT PLANTS

The design of an RBC waste treatment plant follows the same principles as the design of any process plant. The input (loads) and desired output (treated effluent quality) must be established, a preliminary equipment selection performed and the economic feasability of the alternative equipment, plant sites, materials of construction etc. be studied to select the optimum. Such work is the responsibility of the project engineer and the following notes are intended to assist in this. It is of course impossible and undesirable to write absolute rules for plant design since each requirement is different. A well engineered plant will always be more economic than on designed to a fixed set of rules. It is assumed that any engineer designing an RBC plant has reasonable knowledge and experience of conventional waste treatment plant design.

7.1 RBC Process Design

The key parameter in RBC plant design is the specific surface loading of the biological media. This can be determined by pilot tests or by reference to the literature (4), (5), (16), (19).

In case of domestic, dairy, brewery, distillery and some meat packing wastes there is probably enough data available provided that the waste to be treated has characteristics similar to those reported in the literature.

In most cases in Canada the criteria will be a maximum permissible discharge of BOD_5 and suspended solids so that selection of RBC area can be performed quite simply by using curves similar to Figures 1 and 2, pages 12 and 13, or from the literature or pilot investigations. If nutrient, heavy metal or toxicity removal is required then there may be a minimum as well as a maximum loading which will provide the desired result for each para-

meter, and each optimum loading may not be compatible. While it is theoretically possible to remove N, P, heavy metals and toxicants by operating the plant for maximum sludge production, this may be difficult to achieve in practice unless the load variations are exceptionally small. The curves were generated at the University of Stuttgart and the data collected by BEAK is plotted for comparison. The curves were prepared for polystyrene discs but are believed to be representative for other materials of construction.

7.2 Clarifiers

The primary clarifier size is a function of the raw waste quality and would be similar for the RBC as for other systems. There were no indications at any of the plants inspected of operating problems with RBC systems due to poor SS removal in the primary clarifier. Some RBC's operate at high SS loadings so that relatively high upflow rates could probably be employed in the primary clarifier with some economic advantage. In cases where the waste contains little settleable matter it is possible to omit primary clarifiers.

The secondary clarifier upflow rate can be quite high in relation to the values conventionally employed in activated sludge plants. European experience suggests that an upflow rate of up to 1,300 USG/ft^2/day at maximum design flow rates can be safely employed. Reference 29 contains further information on this subject.

7.3 Foam

BEAK have no evidence of reports of significant foaming in RBC plants (2). Thus it would appear that no special precautions would be required unless the effluent is known to foam very severely. In such cases a pilot study would be required.

7.4 Flies and Odour

Similar remarks apply as to foam (19).

7.5 Weather Protection

The full scale plants visited were similar to each other in the degree of weather protection incorporated. Clarifiers were unprotected, the RBC units were in unheated and uninsulated buildings (2). The controls,

pumps, etc. were in heated and insulated buildings. In all cases the operators reported fog and ice formation inside the buildings in cold weather but there were no difficulties associated with this except that maintenance work was uncomfortable (15).

The plants at Amberieu en Bugey and Spalt experience winters at least as severe as the Montreal-Ottawa area so that there was no experience available to predict performance of the RBC in unheated buildings in the colder parts of Canada. However, in view of the short detention time of the RBC process and the lack of cold weather problems in Spalt and Amberieu en Bugey it appears probable that there would be little or no additional weather protection required for RBC installations in most parts of Canada. This is as yet unconfirmed but there are a number of new installations in the U.S. which are now available for inspection.

In view of the high humidity and frequent condensation in RBC buildings structural corrosion could be a problem. Concrete, wood and asbestos cement seemed to give good service in the plants visited but steel required frequent painting. One plant was originally built with the RBC units in the open but wind and rain damaged both the discs and the biomass and necessitated the construction of a building. All RBC buildings in the plants visited had generous provision for natural ventilation by adjustable windows or shutters. Typically these occupied about 15% of the total wall area but the operators advised that these were mostly closed in cold weather.

The lowest temperature normally occurring at the plants visited was $-22^{o}F$.

7.6 RBC Vat Design

The bottoms of the RBC vats in all plants visited in Germany were semicircular concrete with about 2" clearance between the vat bottom and the outside dia. Herr Stengelin of J.C. Stengelin advised that if the vat contour did not approximate the disc contour then solids would settle and decompose anaerobically causing emission of malodorous gases. The plant in France employed trapezoidal bottom vats and there have been no difficulties reported to date. This would be more economical to construct than the semi-circular design.

7.7 Materials of Construction

All full scale plants employed concrete vats, tanks and channels, and ungalvanized steel and expanded polystyrene discs. There was no evidence or report of significant corrosion. In general it seems reasonable to employ conventional biological waste treatment plant materials in RBC systems (19).

7.8 Head Loss Through System (16)

The head loss through the RBC units was very low in all plants visited. Accurate measurement was impractical but it was estimated at $\frac{1}{4}$" per stage.

7.9 Sludge Recycle

In all plants visited the secondary clarifier underflow was recycled continuously to the primary clarifier infeed. All primary clarifier underflow was wasted. This wasting method appears desirable to provide a seed to the effluent and should improve the systems ability to withstand short shock loads. There was no information available on operation without recycling sludge to the primary clarifier at any of the plants visited. The plants at Spalt and Amberieu en Bugey had provision for recycling the sludge to the RBC infeed but there had been no need to use this up to the time of the inspection.

7.10 Sludge Disposal

European practice is to anaerobically digest all sludge and then dispose of it as fertilizer locally with or without drying in beds. As a result there is a paucity of data on the dewatering characteristics of secondary sludge produced by RBC plants but some current work will be reported shortly (29).

8 CONCLUSIONS

The following conclusions have been made as a result of this study:

1. The Rotating Biological Contactor is a simple and reliable process to provide secondary treatment for a variety of industrial and municipal wastes. It has demonstrated this capability for a period of at least 5 years in the installations inspected, all of which appeared to have many additional years of effective life remaining.

2. The BOD_5 removal capacity of the operating installations inspected was slightly lower than the literature would suggest. All installations demonstrated the capability of achieving 80-90% removal with loading of 4-15 lb BOD_5 per day per 1000 ft^2 of discs.
3. The data available indicates that the RBC probably has a greater capacity to resist operating instability from shock loads than an activated sludge system but perhaps less then long detention time systems such as aerated lagoons. As an example one installation indicated that an occasional pH of 4.0 did not upset the operations.
4. The RBC offers a means of removing BOD with a much lower power consumption than activated sludge, aerated lagoons and other conventional biological treatment systems.
5. The maintenance of RBC equipment is generally simple as would be expected from low speed, low power rotating machinery. There were no significant special problems encountered with equipment main enance at the plants inspected.
6. From discussion with German government officials, suppliers and plant operators there appeared to be no technical factors which would limit the size of an RBC waste treatment plant. The relationship between capacity and capital cost for RBC waste treatment plant is approximately linear, so that the economics appear to favour smaller RBC plants rather than large scale installations.
7. Alternative construction of the biological contact media are presently under development and may significantly reduce the cost of RBC installations.
8. The RBC process is as applicable in Canadian climates as activated sludge systems. The short retention time of the process will prevent freezing in the RBC and assist in avoiding icing in the clarifier.
9. The limited data available did not demonstrate any advantage of the RBC process over other treatment methods in the removal of nutrients. However, none of the plants inspected were

attempting to remove nutrients with the RBC.

10. The solids produced in the RBC treatment systems were all digested anaerobically and disposed of as fertilizer. As a result no data was available on the dewatering of biological solids from the RBC.

APPENDIX 1

REVIEW OF EUROPEAN AND NORTH AMERICAN RBC LITERATURE

APPENDIX 1 REVIEW OF EUROPEAN AND NORTH AMERICAN RBC LITERATURE

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(1)

"Cannery Waste Treatment with RBC and Extended Aeration Pilot Plants" - Burn R.J. , Cochrane M.W. and Dostal K.W. - Good Waste Research Branch, National Waste Treatment Research Program, Pacific Northwest Water Laboratory, Environmental Protection Agency, 200 S.W. 35th Street, Corvallis, Oregon.

This paper summarizes the observations made during the operation of two waste treatment pilot plants, namely an aeration tank and a rotating biological contactor, on a cannery waste. Similar amounts of COD were removed by each unit but the RBC required only about 1 to 5% of the detention time of the aeration tank and about 50% of the horsepower. The aeration tank effluent passed through a tube settler whilst the RBC effluent was passed through a clarifier. The suspended solids in the final effluent of both units was considered too high for discharge into receiving waters, but acceptable for discharge into a municipal sewer. With the aeration tank, as sludge was removed from the tube settler, it was proposed to allow this to decompose by endogenous respiration at the close of the canning season. The RBC, however, produced a sludge which on a larger scale plant would have to be disposed of by digestion or incineration. The RBC was affected by short term overloading because of the small detention time, however, when longer shock loads occurred, the RBC recovered much faster than the aeration tank.

(2)

"Biological Waste Treatment Using Rotating Discs" - J.A. Borchardt, Department of Civil Engineering, The University of Michigan, Ann Arbor, Michigan.

This paper describes recent pilot plant experience with the rotating biological disc waste treatment device for municipal sewage. Some operational and economic aspects of the process are discussed, these being the high BOD removal rate for low detention times, the lower power requirements, the ability to recover rapidly from shockloads and the simplicity of operating the system. The disadvantages of the system are the need for cover over the discs to protect them from hail, the lack of adequate data at this point to permit a sufficiently wide latitude in industrial waste design and the high costs of a large plant. At present, the RBC is very economical in small to medium sized treatment plants.

(3)

"Effects of Exposing Slimes on Rotating Discs to Atmospheres Encriched with Oxygen" -
Torpey W, Heukelekian H. Kaplovsky and Epstein L. Department of Environmental Sciences, Rutger's University, New Brunswick, N.J. Presented 6th International Water Pollution Research, June 18-23, 1972 - Published by Pergamon Press.

The results of operating a 41,635 liter per day staged rotating disc pilot plant on primary effluent at a New York City Sewage Plant have been presented for three modes of operation, namely,
(1) the slimes in all stages exposed to ambient atmospheres,
(2) the slimes in stage 1 exposed to oxygen enrichment, and (3) the slimes in stages 1 and 3 of a 3-stage operation exposed to oxygen enrichment. In the first mode of operation about 30 minutes of contact with the slimes was sufficient to remove 90% of the BOD_5; in the second mode of operation 18 minutes accomplished the same rate of removal of BOD_5. In the third mode, not only was 90% of the BOD_5 removed during 18 minutes of contact with the slimes but a substantial portion of the nitrogenous demand was satisfied.

Nitrification normally proceeded at a rate of 2.2 mg/l per stage or 22 mg/l per hour of contact with the slimes. Under the specific operating condition prevalent in the third mode described above, nitrification proceeded at a rate of 76 mg/l per hour of contact.

A portion of the effluents from all the above modes was subjected to treatment using partially submerged, illuminated disks for the purpose of extracting nutrients from the stream by synthesis into attached algal cells. The effluent from the algal unit was subjected to adsorption of residual organics on packed beds of granular activated carbon. The total leakage of organics through the system was 1.4 mg/l, all soluble, for all three modes of operation, while the practical carbon exhaustion rate was in the range of 15 to 20 mg/l.

(4)

"Rotating Biological Contactor" - Federal Water Pollution Control Administration Department of Interior, Washington, D.C. 20036, Phase I Report, Contract 14-12-24.

Results of a testing program have shown that the RBC can operate efficiently during dry weather flows at 80-90% COD and BOD_5 reduction, on settled effluents with loadings up to 500 lbs COD/day/1000 cu. ft. (300 lb BOD_5 Day/1000 cu.ft.).

An in-line RBC can substantially reduce the organic loading on the main treatment plant during dry weather flows by providing treatment within the RBC unit itself and through seeding the downstream portion of the sewer following the RBC unit. During simulated wet weather flows of up to 20 times the dry weather flow rate, the efficiency of the RBC fell to 15% COD and BOD_5 reduction for a residence time of 3 minutes, but the COD removal capacity more than tripled to 1800 lbs COD/Day/1000 cu. ft. (1190 lbs BOD_5/Day/1000 cu. ft.). These tests demonstrate that the RBC can make a significant contribution to reducing the total organic load on the main treatment plant and the receiving waterway even during the high flows experienced during heavy rainfall. From the data obtained during the laboratory testing program the proposed RBC demonstration plant can reduce the BOD_5 discharged by a combined sewer overflow during the frequent low intensity rainfalls by up to 60%. It also demonstrated rapid recovery to dry weather efficiency following a heavy rainfall simulation test. Depending on the residence time of the wastewater in the RBC unit, full efficiency can be restored in some instances in less than 30 minutes.

(5)

"Municipal Sewage Treatment with a Rotating Biological Contactor", - Federal Water Pollution Control Administration, Department of Interior - Contract 14-12-24, Modification 2.

A Rotating Biological Contactor (RBC) was installed at the Milwaukee Metropolitan Sewerage Commission treatment plant at Jones Island to demonstrate the feasibility of treating municipal waste with an RBC system.

The RBC system effectively treated domestic sewage at high loading rates. Ninety percent COD removal was attained at a loading of 350 to 400 pounds of COD per day per thousand cubic feet of disc volume. Pounds of COD removed increased with pounds of COD applied. Efficiency of treatment

improved with increased retention time. Percent BOD removal was approximately five percent greater than percent COD removal. Lower disc speed resulted in a slightly lower efficiency. Lower strength wastes are not as efficiently treated as higher strength wastes at the same organic loading. Recovery from high hydraulic loading is rapid.

(6)

"Application of the BIO-DISC* Process to Treatment of Domestic Wastewater" - Antonie R.L., Autotrol Corporation, Milwaukee, Wisconsin 53209.

A secondary treatment package plant incorporating the rotating disc treatment process has been tested on domestic wastewater over a wide range of operating conditions. Effective removal of BOD and suspended solids is achieved for a residence time of 20 minutes in the disc system and 30 minutes in a secondary clarifier. This demonstrates the suitability of the disc process for roughing treatment and for upgrading the treatment of existing primary treatment plants. Effluent BOD and suspended solids concentrations of 20 mg/l and 80% oxidation of ammonia and Kjeldahl nitrogen were obtained for a disc system residence time of 50 minutes. This demonstrates the suitability of the process to provide complete secondary treatment for any domestic wastewater application. Under both of these sets of conditions 6 lb. BOD were removed per Hp-hr. of power consumed. For a 90 minute residence time 95% ammonia nitrogen and 90% Kjeldahl nitrogen removal were obtained. This shows the unique capability of the rotating disc process to effectively oxidize both carbonaceous and nitrogenous BOD in very short retention times.

* "BIO-DISC" is now a registered trade mark of Ames Crosta Mills. Autotrol Corporation have registered and now use the name "BIO-SURF".

The effective treatment, low power consumption, and low maintenance requirements shown by the rotating disc process during these tests establish its suitability to domestic wastewater treatment and expecially to package plant applications.

(7)

"Rotating Discs Fulfill Dual Wastewater Role", Antonie, R., Van Aacken, K. - Water and Wastes Engineering, January 1971.

This paper is a general description of the rotating biological contactor. It lists the advantages of low power requirements, short retention times, ability to handle widely varying loading rates. It is suggested to be of greatest use in package plants for domestic sewage, in upgrading existing treatment plants and in treating industrial wastes where a large fluctuation of waste concentration is likely to occur. This would also be advantageous to seasonal industries where a short startup time is required.

(8)
"Reported Capabilities of the Rotating Biological Surface as a Secondary Treatment System" - N.C.A.S.I., 260 Madison Ave., New York, N.Y. 10016.

Typical RBS operating parameters are summarized and compared to activated sludge. The applicability of the RBS to wastewater treatment in the pulp and paper industry is considered. It is not felt that RBS represents an all inclusive substitute for such established systems of biological treatment as the aerated basin. It would appear to offer potential as a pre-treatment device where existing operations are overloaded or where economic advantages are to be gained with joint treatment ventures. In such applications, the diminishing degradeability of the remaining wastewater constituents would have to be considered. The suitability of the system for high strength wastes could render it advantageous for the treatment of high strength segments of the total mill effluent.

As an alternative to conventional high rate treatment systems, laboratory and field studies suggest that RBS might be advantageous from a perspective of greater shock load capabilities, lower capital and operating costs, and ease of sludge separation and disposal.

However, to conclusively define the potential for the RBS system of waste treatment in the paper industry would require a comprehensive pilot study of sfficient magnitude and duration to determine if the successful performance of RBS can be extended to pulp and paper mill effluents, to assess the generation rate and subsequent disposal characteristics of secondary sludge originating with the RBS system and to evaluate equipment performance and maintenance requirements after extended exposure to the chemical stress imposed by the effluents.

(9)

"Rotating Discs with Biological Growths Prepare Wastewater for Disposal or Reuse".
Torpey W.N., Heukelekian H., Kaplovsky A.J., Epstein, R. - JWPCF Volume 43, No. 11, p. 2181

A method of treatment of primary effluent by a series of rotating discs with attached growths has been developed capable of producing removals of carbonaceous BOD up to 95 percent and the oxidation of ammonia to nitrates. The removal of N and P from the effluent of these units is being attempted by promoting the growth of attached filamentous algae on illuminated rotating discs that are readily harvestable in contract with the removal of planktonic algae grown in oxidation ponds. The effluent thus prepared is highly amenable to adsorption on activated carbon such that the leakage of organics was held between the limits of 1 to 2 mg/1.

(10)

"Reduces BOD 99% at Low Cost" - Ziemba J.V. - Food Engineering, June 1971.

This paper describes the use of a BIO-DISC system for treating wastewater from a small cheese factory. The secondary treatment plant consisted of 4 BIO-DISC units each containing 22 polystyrene discs $\frac{1}{2}$ inch thick and 10 feet in diameter. 95% BOD removal was attained for a 5 hour retention time. Experience with the system after six months operation showed no clogging of media, low operating and maintenance costs, rapid recovery from toxic materials and a short start-up time of 1 to 2 weeks. Primary treatment of the effluent was done in a three compartment septic tank and tertiary treatment followed the BIO-DISCS to give a final BOD removal of 99%.

(11)

"Treatment of Cheese Processing Eastes by the *"BIO-DISC Process", Birks, C.W., Hynek, R.J. - Autotrol Corporation, Milwaukee, Wisconsin

This paper describes the use of a BIO-DISC system used on the wastewater from a cheese factory. The BIO-DISC was operating on the effluent from a septic tank. Despite poor biodegradation efficiencies of the anaerobic pretreatment system, overall organic reduction of 95% and/or effluent BOD levels of less than 100 mg/l were obtained by the BIO-DISC. Performance data indicated that the unit could operate effi-

(11) Cont'd
ciently under high hydraulic and organic loads and under severe climatic conditions. Maintenance and operating costs are given.

* "BIO-DISC" is now a registered trade mark of Ames Crosta Mills. Autotrol Corporation have registered and now use the name "BIO-SURF.

(12)
"Response of the BIO - DISC* Process to Fluctuating Wastewater Flows" - Antonie R.L. - Allis-Chalmers, Milwaukee, Wisconsin.
This paper describes the effects of fluctuating flows through a BIO-DISC. The BIO-DISC process is well suited to treatment of industrial wastes. Its large microbial population which if effectively contacted with waste water and efficiently aerated gives it a high capacity for BOD removal. BOD reuction of 90% and more can be achieved on many industrial wastes for residence times of 60 min. or less. This is accomplishged with a power consumption of about five KWh per 1000 lbs of BOD removed.

The information from theinvestigations reported in this paper and several investigations in Europe, demonstrate very stable operation by the BIO-DISC process. Its treatment effectiveness during and following various flow patterns, including intermittent, cyclic and surging flows, further enhances its applicability to treatment of industrial wastewater.

* "BIO-DISC" is now a registered trade mark of Ames Crosta Mills. Autotrol (successor to Allis Chalmers) have registered and now use "BIO-SURF" to replace "BIO-DISC".

(13)
"Preliminary Results of a New Approach in the Aerobic Biological Treatment of Highly Concentrated Wastes," Welch F.M, Research Division, Allis Chalmers Manufacturing Company, Milwaukee Wisconsin.

The results of a preliminary testing program demonstrate the potential of the RBC in treating wastes of various concentrations. The RBC which in some respects can be considered a combination of the trickling-filter and the activated -sludge processes exhibits a degree of flexibility and control over the biological process which may prove to be beneficial to the Engineer and plant operator.

The Rotating Biological Contactor has a great many operating parameters that allow process variation which makes the RBC suitable for treating a wide range of biodegradable wastes. The basis of the RBC is the microbial mass which consists of a filamentous organism on which the predominating bacteria acclimatize to operating conditions, grow and metabolize the waste material. The microbial film is not subject to the upsets that are experienced in an activated sludge process due to hydraulic surges or organic overloads. By varying the disc rpm it is possible to not only control the agitation of the biomass but also control the DO content of the mixed liquor.

Staging, which is beneficial in treating concentrated wastes is readily accomplished by RBC units which allow for individual completely mixed units to be constructed which are capable of developing the optimum conditions for the biological degradation of the waste material. The large captive biomass that is retained on the discs of an RBC allows for optimum contact and assimilation of the waste by the bacteria.

(14)

"Systemation in using the Rotating Biological Surface (RBS) Waste Treatment Process"- Joost R.H., Environmental Pollution Control, Inc., Oconomowoc, Wisconsin.

This paper gives a general description of the RBC and its advantage of low retention time, ability to recover fast from shockloads, low poer costs and low maintenance costs. A further advantage is that the units may be placed in any configuration or stacked according to the space available. When using the RBC with existing treatment facilities, it is advantageous to place the unit ahead of the existing secondary treatment plant as it has the ability to dampen shock loads on the system.

(15)

"Preliminary Results of a Novel Biological Process for Treating Dairy Wastes" - Antonie R.L., Welch F.M., Research Division, Allis-Chalmers Manufacturing Co., Milwaukee, Wisconsin.

A pilot plant RBC system was first tested under controlled conditions using a synthetic dairy waste. The unit was then installed at a dairy and further testing carried out. 100 to 200 gph of waste was treated, containing from 1200 to 4000 mg/1 COD. The pilot plant consisted of two

(15) Cont'd

RBC units in series, each with a settling tank.

The field tests showed that the RBC could treat the combined and whey wastes of a dairy plant under field conditions as effectively as synthetic dairy waste under controlled conditions. Varying weather conditions had no apparent effect on RBC effectiveness; however, moderate insulation of the tankage and covering the discs were necessary for operation in sub-freezing temperatures.

RBC characteristics of a large microbial population, flexible aeration capacity, little maintenance, low power requirements and predictable performance make the RBC an attractive process for biological treatment of dairy waste.

(16)

"The BIO-DISC Process: New Technology for the Treatment of Biodegradeable Industrial Wastewater " - Antonie R.L., Chemical Engineering Symposium Series, Water - 1970, Volume 67, Number 107.

This paper describes the RBC and its effectiveness in treating industrial and municipal waste. The system is very effective in providing roughing treatment for discharge of industrial wastes to municipal sewers, because of the very low residence time required. Loadings for roughing treatment were in the range of 300 to 1300 lbs BOD/day/1000 cubic feet of disc volume and for complete treatment 100-400 lbs BOD/day/1000 cubic feet of disc volume. Power consumption varies according to the degree of treatment desired but ranges from 10 - 150 HP - hr/1000 lbs of BOD removed. The system has the advantage of having a low head loss between units. It is possible to place the units either above or below ground, depending on the space available and the units allow treatment plants to be expanded easily as the treatment requirements increase.

(17)

"Rotating Biological Contactors Following Anaerobic Lagoons", - Chittenden J.A., Wells W.J. University of Sheffield.

This paper presents the results of a pilot plant study using a rotating biological contactor to stabilize and reduce the BOD of the effluent from an anaerobic lagoon treating meat packing wastes.

The initial test run for the rotating disc pilot plant was for a flow rate of 10.000 GPD or 8.0 GPD/sq ft of disc area with all three stages rotating at 3 rpm. Under these conditions there was no DO in the effluent from any of the stages. The BOD reduction through the first stage was 42.5 percent, and the overall BOD reduction for the three stages was 50.2 percent based on settled BOD values.

The second test run modified only the rotating speed of the first stage which was increased from 3 to 6 rpm. Only an occasional trace of DO was detected throughout the system. The BOD reduction through the first stage was 52.5 percent, and the overall BOD reduction was 64.5 percent.

For the third test run, the rate offlow was reduced to 5,000 GPD or 4.0 GPD/sq ft of disc area per stage. There was a DO concentration of 0.9 to 1.5 mg/l in the effluent from the first stage which persisted through the unit. The BOD reduction for the first stage was 79.5 percent and the overall BOD reduction was 83.2 percent.
The pilot-plant study indicated that the system would be an efficient, economical, and easily operated method for treating the effluent from an anaerobic lagoon with the additional advantage of reduced odours. Furthermore, because the disc would be housed, an odour control system could be provided easily.

(18)

"Feasibility of Rotating Disc Treatment Process for Hardboard and Insulation Board Wastewater" - Willard H.K.,Eckerle W.F., Scott R.H. Product Research Association, Dallas, Texas, June 21, 1972.

This paper describes the use of an RBC pilot plant operating on effluent from a hardboard mill for a period of 6 months. Flow rate ranges of 100, 200 and 700 GPD were pumped to the system for a period of about 2 months each. Loading rates up to 1 gallon /sq ft/day gave a BOD removal of 60% and at 0.5 gals/sq ft /day a BOD removal of 90%.

The pilot plant operated favorably with few operating difficulties and overcame shock loadings in a short period of time. During process operation the biofilm mass were measured at 6.5 mg/sq cm, but this peaked prior to equilibrium to 19.4 mg/sq cm with resultant sloughing. This was much greater than other reports had suggested with different wastes.

Costs of such a plant to treat a 100 TPD hardboard mill to 85% BOD removed were estimated at $150,000.

(19)

"Some Developments in the Treatment of Sewage from Small Communities". - Bruce A.M., Brown, B.L., Mann H.T., - Department of the Environment, Water Pollution Research Laboratory, Stevenage, England.

A report is included of a pilot operation run for about 9 months on about 700 USGPD of strong domestic sewage.

The RBC consisted of galvanized expanded metal discs and it was concluded that there were no inherent disadvantages or advantages of these over other media. It was also concluded that the maximum loading should be 1.2 lb BOD/day/1000 sq ft based on settled waste if the common British effluent standard of 30 mg/1 SS and 20 mg/1 BOD is to be consistently maintained.

The total BOD of the raw effluent ranged from 470 to 670 mg/1 and treated effluent from 14 to 37 mg/1. Ammonia removal ranged from 10% to 75% and suspended solid concentrations were generally close to the above mentioned BOD values.

The equipment was reported to be trouble free and required virtually no operating supervision.

(20)

"Application of Rotating Disc Process to Municipal Wastewater Treatment". Autotrol Corporation for Environmental Protection Agency. Contract No. 14-12-810, Project 17050 DAM.

A prototype package plant incorporating the rotating disc wastewater treatment process was tested on municipal wastewater to evaluate its treatment capabilities and establish guidelines for operation and testing of a sull-scale rotating disc demonstration plant. The package plant included a rotating bucket feed mechanism, ninety-one 1.75-meter diameter discs divided into two stages, and a secondary clarifier with a sludge-removal mechanism. Variables tested included hydraulic loading, rotational disc speed, sludge recycle, and wastewater temperature as it varied with climatic conditions.

At a hydraulic loading of 1.5 GPD/ft^2 of disc surface, the package plant achieved 87% removal of BOD and 80% removal of suspended solids to

yield an effluent of 20 mg/l BOD and suspended solids when treating effluent from the existing primary clarifier. At the same hydraulic loading, 85 % removal of ammonia nitorgen was obtained to yield an effluent of 3.5 mg/l.

Low maintencnce requirements and low power consumption were demonstrated by the rotating disc process during the test program.

(21)

"Results of operation of experimental contact filter with partially submerged rotating plates". Doman, J. Sewage Wks J., 1929, 1, (5), 555.

This paper describes the use of rotating partially submerged discs for biological waste treatment at a small plant in the U.S. in 1925. The experimental unit consisted of a $4\frac{1}{2}$ gallon tak with 14 galvanized discs of 14 inches diameter rotating at between $\frac{1}{2}$ - 1 rpm. Moderate treatment was achieved even though it is suspected that the BOD loading per unit area of disc was excessively high.

(22)

"The Biologic Wheel". Anon. Sewage Wks J., 1929 1, 560.

A report of the same time as that of DOMAN of a similar type of installation tested in the U.S. The unit was called a "biologic wheel".

(23)

"Entwicklung und Betrieb von Tauchtropfkorperanlagen". Hartmann, H. - Gas u. WassFach, 1960, 101, 281.

Hartmann describes the operation of two experimental "dipping contact" disc plants and outlines their performance characteristics and the economics of the process for sewage treatment.

(24)

"Aufbau, Abbauleistung und Bemessung von Tauchtropfkorpern". Popel, F. Schweiz Z. Hydrol, 1964, 26, 394.

Popel describes the use of the rotating biological contactor in Europe. The paper includes design formulae for BOD loading, disc area and rotational speed.

(25)

"Der Tauchtropfkorper". Hartmann, H. Ost. Wasserw., 1965, 17, 264.

This paper describes the established use of the rotating biological contactor in Europe with information on design BOD loadings and rotational speed.

(26)

"Scheibentauchkorper in Kombination mit konventioneller Vorund Nachklärung und Schlammbehandlung als Kläranlage fur kleine Gemeinden". Lohr, M., Gas-u. WassFach, 1967, 108, 1029.

Lohr describes the use of a rotating biological contactor which was driven hydraulically by the sewage.

(27)

"New approach to aerobic treatment processes", Welch, F.M. Wastes Engng, 1969, 6. D.12.

This paper describes the use of RBC's on sewages for small municipalities and on industrial wastes. They are used with primary sedimentation on septic tanks.

(28)

"A Flexible Effluent Treatment Package". National Research Development Corporation. Inventions for Industry, 1972. No. 39. (U.K.)

This paper describes the BIO DISC package treatment plant where primary settling, biological treatment using rotating discs and secondary clarification are included in a single unit suitable for small communities.

(29)

"Development of the Rotating Biological Contactor Process Parameters for the Pulp and Paper Industry" - A report in preparation by T.W. Beak Consultants Limited, for the Canadian Committee on Pollution Abatement Research, to be published 1973.

Pilot scale studies of the effectiveness of treating several pulp and paper mill effluents with rotating biological contactors were conducted at three locations. A two foot diameter unit was applied to a structural board mill effluent while six feet diameter units were applied to a sulphite mill effluent and an integrated full bleached kraft pulp and paper mill effluent.

The program was under the direction of the National Council of the Pulp and Paper Industry for Air and Stream Improvement (NCASI) with Boise Cascade Corporation and T.W. Beak Consultants Limited, who were under contract to the Canadian Committee on Pollution Abatement (CPAR), as active participants.

The treatment units were operated by Boise Cascade who analyzed the influent and effluent for BOD, COD, toxicity, colour, phosphate, suspended solids, volatile suspended solids, temperature and pH. As well, sludge volume indices and total sludge produced were determined.

The NCASI limited their studies to an analysis of the data generated by Boise under varying flows, BOD loadings, and unit rotational speeds and to a thorough evaluation of the settling and dewatering characteristics of the secondary sludge produced. These latter studies included vacuum filtration and centrifugation with an without chemical conditioners.

Beak participated in the program by executing continuous bioassay toxicity tests in the influent and treated effluent as required by Canadian Federal Government regulations. Beak also conducted phosphate balances and limited colour tests around each unit.

A final report for CPAR summarizes and analyses all data and determines its applicability to the Canadian pulp and paper industry in terms of cost and effectiveness. This report will be completed in 1973.

(30)

"The biological decomposition of mineral oil products in a process using disc-contact aerators".
Bringmann G., and Xuhn, R. The Bundesgesundheitsamt, Institut fur Wasser-Boden-und Lufthygiene, Berlin-Dahlem.
Gesundheitsingenieur, 1968, 89 179-186. (Translated by D. Darling, Aug. 1968)

A model RBC loaded with 65 litres per hour of synthetic waste water was observed during continuous operations.

The synthetic waste water contained various known quantities of mineral oil products as well as sufficient ammonium phosphate to ensure that reactions would not be N or P limited. To maintain a maximum mineral oil content of 1 mg per litre in effluent this RBC demonstrated the fol-

lowing renewal capabilities per unit surface area of the discs:

18-20 g per m^2 per 24 hours for ordinary gasoline and aircraft fuel.

11 g per m^2 per 24 hrs for high-grade gasoline.

4 g per m^2 per 24 hrs. for diesel-fuel and

2 g per m^2 per 24 hrs for light fuel oil;

1 g per m^2 per 24 hrs crude oil and light lubricating oil;

0.5 g per m^2 per 24 hrs for medium lubricating oil and drilling oil.

The hydrocarbon-organisms isolated from the discs of the contact aerator were cultivated in a mineral medium with the various mineral oil products as the only source of carbon. In further tests pure cultures of the isolated hydrocarbon organisms were re-plated and microscipically differentiated and the genera found were classified and recorded. The genus Pseudomonas showed the widest substrate spectrum; pseudomonas strains were isolated from the disks of the contact-aerator during feeding. with normal petrol, aircraft fuel, "petroleum", diesel fuel, crude oil of the "Es-Siler" and Kirkuk origin, light lubricating and drilling oil. The substrate spectrum of theisolated strains of the genus Achromobacterium extended to the hydrocarbons: "Petroleum", light fuel oil, crude oil from "Kirkuk", light and medium lubricating oil as well as drilling oil. The substrate spectrum of Achromobacterium compared with that of Pseudomonas which includes also the light, volatile hydrocarbons, was more strongly marked towards the high boiling hydrocarbons. The genus Chromobacterium was isolated only during the feeding of the discs with high-grade petrol and crude oil from "Kuwait"; the genus Brevibacterium when fed with medium grade machine oil and the genus Mycobacterium during feeding with "petroleum".

APPENDIX II

DETAILED PLANT VISIT REPORTS

APPENDIX II DETAILED PLANT VISIT REPORTS

TABLE OF CONTENTS

LIST OF PHOTOGRAPHS

PLANT VISIT REPORT FORM

1. IDENTIFICATION

Location	: SPALT, BAVARIA
Plant Name	: KLAERANLAGE BRAUEREI SPALT

PERSONNEL CONTACTED

Operator	: Bruno Hohmulle
Distance to adjacent property and associated precautions or problems	: 100 yds (School) No odour or flies reported or evident

EQUIPMENT SUPPLIER

Name	: J.C. STENGELIN
Address	: Tuttlingen, W. Germany

2. GENERAL TECHNICAL BACKGROUND

Type of Waste	: 20% Domestic 80% Brewery
Characteristics of Fluctuations	: Peak in Summer Brewery rises to 4000 lbs/day BOD Domestic Sewers Unsegregated
Date of Start-up	: 1965
Design Capacity	: 1.7 MUSGD (Wet weather flow)
Actual Load	: 0.34 MUSGD (Normal dry weather)

Former or alternative existing treatment	: None
Protection from the elements	: Unheated and uninsulated building. RBC was originally installed in open but storm damage occurred to polystyrene discs. Difficulties were encountered in maintaining biological growth due to rain and hail.
Disc dia.	: 9'10"
Number	: 8 shafts, 170 discs each
Thickness	: 5/8"
Spacing	: 1.31"
Total area	: 220,000 sq.ft
Capacity of RBC Vats	: 18,500 USG
Head Loss Through RBC Units	: Approximately 2"
Disc Rotational Speed	: 1 rpm
Power	: 1.5 HP motor on each shaft. In event of power failure causing the upper half of the disc to dry out, some difficulties are experienced in re-starting.
Number of Stages	: 4
Number of Units in Parallel	: Two. Due to layout of the waste piping immediately before the RBC section, the loads on the two parallel sections were unbalanced. All four stages in one section had a thick biomass whereas only the first two stages of the other section were thickly coated and the latter two carried only light growth. There was no data available on the performance of the separate sections although this condition was described as being normal by the operator

Vat Construction	: Concrete
Is order of stages alternated?	: Not possible without structural alterations
Disc Construction	: STD. STENGELIN Have broken some due to poor assembly. Occurred due to a bolt failure (clearly visible) working loose in the disc frame and fouling concrete vat. This could have been avoided by better operating attention.

4. OPERATION

	Man Hrs/day
Operation	: 9 Hrs/Day Mon. - Fri. 3 Hrs/Day Sat. & Sun.
Supervision	: 1 Hr/week
	(Above labour includes almost all maintenance plus work unrelated to waste treatment. Latter estimated at 25%).
Chemicals used (Incl. Nutrients)	: None

Operating problems:

- Maintenance of growth	: Normally no difficulty. On one occasion all growth detached and flushed out of the RBC to the secondary clarifier due to accidental spill of fungicide in town. Growth was re-established in 5 days. No relevant BOD removal data was available.
- Plugging of discs	: Has not occurred
- Plugging of vats	: Some solids settle in vats as evidenced by outer diameter of discs being wiped clean. This is now prevented by opening vat drains once every 6 weeks for a few minutes and returning the underflow to the primary clarifier.

- Foam : None
- Odour : None evident or reported except when primary clarifier sludge pumps are down.
- Corrosion : No difficulties reported.
- Equipment reliability : Chain sprockets (cast iron) life limited to a few years. Disc breakage has occurred as noted under "Disc Construction".
- Bearing and Drive Life : No replacements in 7 years except as noted above.

5. SOLIDS HANDLING

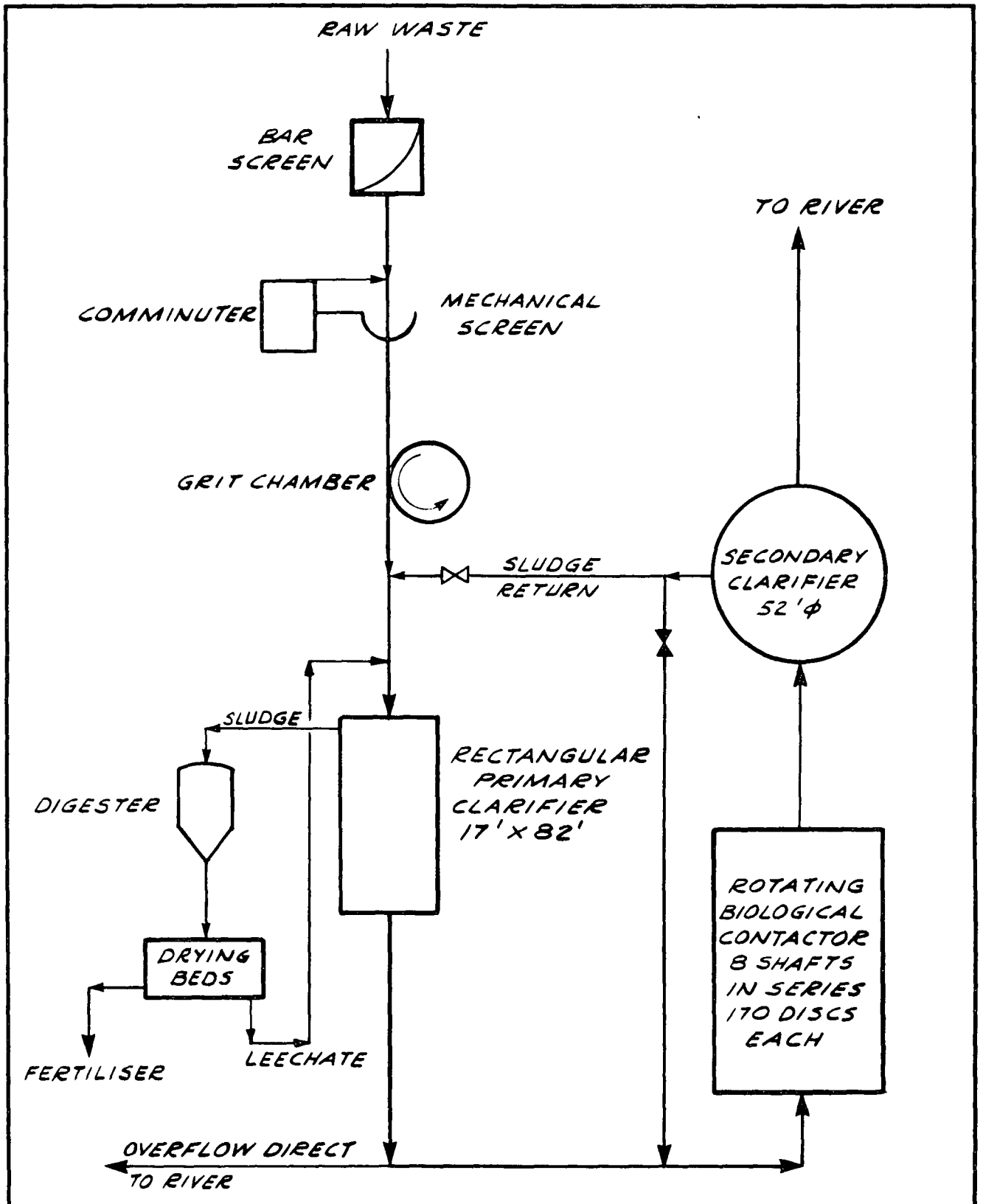
Clarifier

- Rate : 160 USg/ft^2/day dry weather
  800 USG/ft^2/day wet weather
- Diameter : 52 ft.
- Depth : 12' (estimated)
- Chemical consumption : Nil

Sludge Disposal

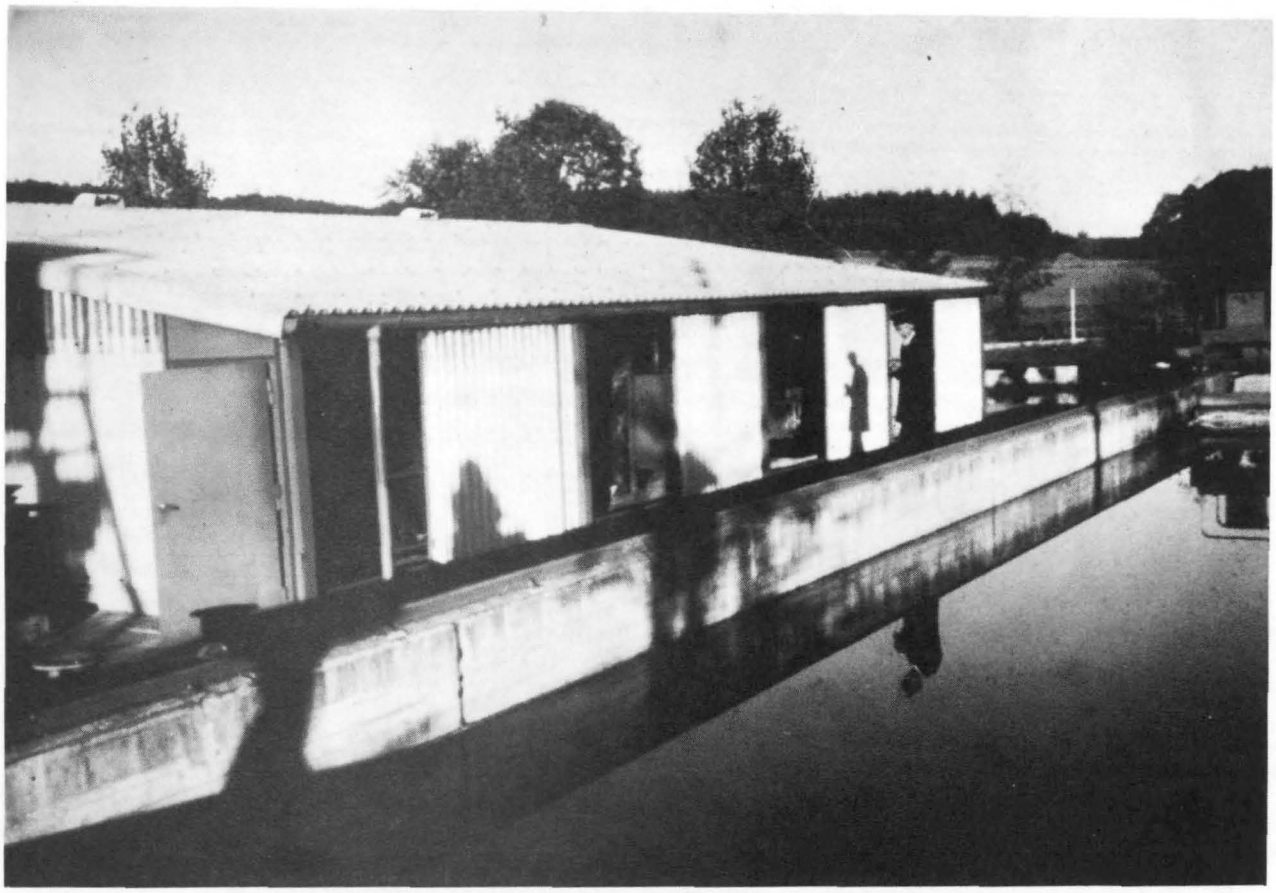
Digested (primary and secondary together) then dewatered in drying beds. All sludge used as fertilizer.

- Odour : No difficulties reported or evident.



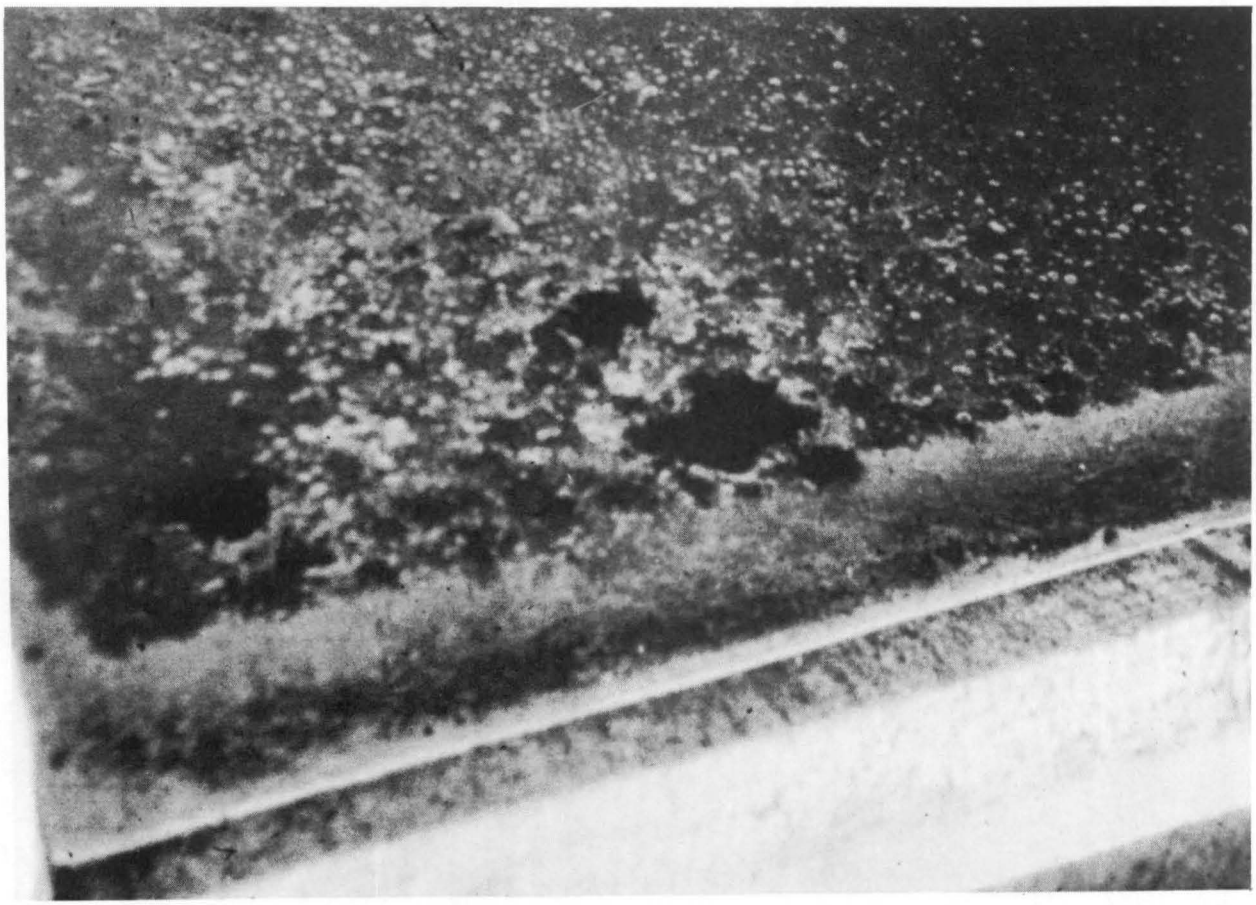
R.B.C. FLOWSHEET - SPALT BREWERY & DOMESTIC

ENVIRONMENT CANADA OTTAWA - ONTARIO	BEAK	BY S.R. DATE 8-1-73 DWG NO A1158-1	FIG. 3

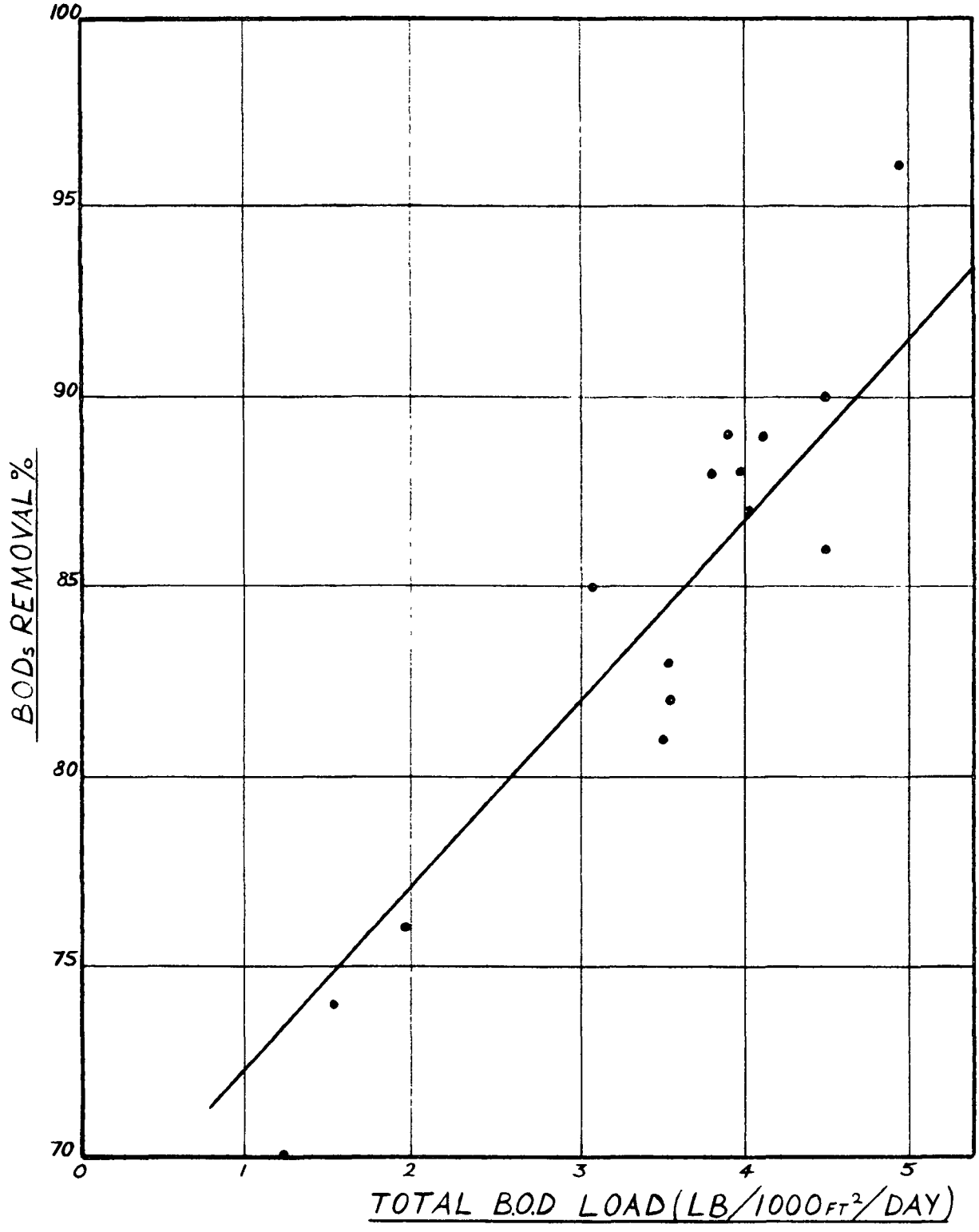


Primary Clarifier - SPALT

Damaged RBC discs - SPALT



Primary Clarifier Emitting Gas Due to Failure
to Withdraw Sludge - SPALT



BOD REMOVAL EFFICIENCY vs SPECIFIC LOAD

R.B.C. PERFORMANCE — SPALT

ENVIRONMENT CANADA OTTAWA — ONTARIO	BEAK	BY D.C.S DATE 12-1-73 DWG NO A 1158-9	FIG 4

TABLE 2

R.B.C. PERFORMANCE DATA

WATER QUALITY CONTROL BOARD - MITTELFRANKEN (WEST GERMANY)

TREATMENT PLANT SPALT : DISTRICT WEISSENEURG/BAVARIA

SAMPLE DATE - 24 APRIL 1968

WEATHER:

SAMPLING DAY - DRY

PREVIOUS DAY - DRY

			Primary Treated	R.B.C. Outflow	Secondary Treated
1.	BOD_5	mg/l	210	35	14
2.	BOD_5 removal	%	-	83.3	93.3
3.	Permanganate demand	$KMnO_4$ mg/l		80	56
4.	Oxygen dissolved	O_2 mg/l		3.3	4.0
5.	Settleable solids	mg/l	0.8		0.1
6.	Temperature	^oF			54
7.	pH		7.3	7.2	7.1
8.	Ammonia	NH_4 mg/l	26.4	9.9	2.1
9.	Nitrates	NO_3 mg/l	19	20	23
10.	Chlorides	Cl mg/l	49	46	43
11.	Flow	MUSGPD			0.435
12.	BOD lb/day		760 (Est.1100 Raw)		

(A1158) SPALT

TABLE 3

RBC PERFORMANCE DATA

WATER QUALITY CONTROL BOARD - MITTELFRANKEN (WEST GERMANY)
TREATMENT PLANT - SPALT DISTRICT - WEISSENBURG/BAVARIA
SAMPLE DATES - 26 & 27 JULY 1967. WEATHER
R - Raw Waste Sampling Day - Dry
T - Treated Waste Previous Day - Dry

	SAMPLE TIME			0600 - 0800		0800 - 1000		1000 - 1200		1200 - 1400		1400 - 1600		1600 - 1800		1800 - 2000		2000 - 2200		2200 - 2400		0.00 - 200	
	WASTE TYPE			R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T
1	BOD 5		mg/l	87	46	305	45	375	40	-	45	250	60	315	-	410	-	320	-	170	-	145	-
2	BOD_5 REMOVAL		%	-	47	-	85.3	-	89.3	-	-	-	76	-	-	-	-	-	-	-	-	-	-
3	PERMANGANATE DEMAND	KMnO4	mg/l	120	67	440	68	440	63	810	66	400	71	460	81	82.0	88	450	74	250	74	140	66
4	DISSOLVED OXYGEN	O_2	mg/l		0.3		0.4		0.1		0.2	-	0	-	0	-	0	-	0	-	0	-	0
5	SETTLEABLE SOLIDS (by Volume)		ml/l	0.2	0.01	1.0	0.01	0.2	0.01	0.5	0.01	0.1	0.01	2.5	0.01	5.3	0.01	6.5	0.01	1.5	0.01	0.2	0.01
6	WASTE TEMPERATURE		°F	64.0	63.3	64.4	65.5	65.7	66.7	63.9	66.7	64.8	67.5	66.0	66.2	63.3	65.1	62.2	63.1	61.0	63.7	61.0	62.2
7	PH			7.7	7.3	7.4	7.2	7.6	7.3	6.6	7.4	7.1	7.3	7.2	8.3	7.3	7.1	7.2	7.1	7.0	6.9	7.2	7.1
8	AMMONIA	NH_4	mg/l	12.4	6.6	14.8	6.6	14.8	6.0	1.6	9.8	9.1	5.4	9.1	7.0	17.3	7.4	29.7	8.2	18.1	8.2	23.8	7.4
9	NITRATES	NO_3	mg/l	21	1.9	22	1.7	18	1.7	22	1.7	18	1.0	21	0.7	-	0.7	-	0.8	20	0.8	18	0.6
10	CHLORIDES	Cl	mg/l	54	50	39	51	34	53	75	51	61	49	56	49	87	53	72	52	66	52	56	54
11	NITRITES	NO_2	mg/l	0.55	0.01	0.35	0.01	0.02	0.30	0.02	0.30	0.02	0.01	0.80	0.01	0.3	0.01	0.4	0.01	0.55	0.01	2.0	0.01
12	DETERGENTS		mg/l			0.8 - 20h				3.0	1.4							20h - 0.8					
13	FLOW		MUS GPD	0.274		0.274		0.274		0.252		0.343		0.228		0.085		0.080		0.057		0.060	
14	BOD TOTAL LBS/DAY			199		695		855				715		600									

(A1158) SPALT

TABLE 4

RBC PERFORMANCE DATA

WATER QUALITY CONTROL BOARD - MITTELFRANKEN (WEST GERMANY)
TREATMENT PLANT - SPALT; DISTRICT - WEISSENBURG/BAVARIA
SAMPLE DATES - 10 & 11 DECEMBER, 1969.
WEATHER:
R - Raw Waste — Sampling Day - Dry & Frost
T - Treated Waste — Previous Day - Dry & Frost

	0800 - 1000		1000 - 1200		1200 - 1400		1400 - 1600		1600 - 1800		1800 - 2000		2000 - 2200		2200 - 2400		0.00 - 0200		0200 - 0400		0400 - 0600		0600 - 0800		0800 - 1000	
	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T
BOD_5 mg/l	335	32	350	43	400	54	410	57	410	77	480	< 81	620	< 74	415	< 76	305	< 73	275	< 73	195	59	365	50	370	41
BOD_5 % REMOVAL	-	90	-	88	-	87	-	86	-	> 81	-	> 83	-	> 88	-	> 82	-	> 76	-	> 74	-	70	-	86	-	89
PERMANGANATE DEMAND $KMnO_4$ mg/l	420	75	470	80	520	91	540	100	590	110	590	110	580	110	500	110	430	110	420	110	360	92	270	87	330	85
DISSOLVED OXYGEN O_2 mg/l	-	1.3	-	1.3	-	0.6	-	0.6	-	0.6	- *	0.4	-	0.4	-	0.5	-	0.4	-	0.1	-	0.4	-	0.3	-	1.9
SETTLEABLE SOLIDS (By Volume) mg/l	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
WASTE TEMPERATURE °F	46.4	43.2	48.0	44.8	50.0	45.0	50.0	45.9	49.6	46.6	49.6	46.0	48.9	46.4	49.5	46.2	48.6	46.4	48.0	44.8	48.0	45.0	47.1	46.4	48.2	46.8
PH	7.1	7.2	7.0	7.3	7.0	7.1	7.0	7.0	7.1	7.0	7.1	7.2	7.0	7.1	7.1	7.2	7.0	7.1	7.1	7.3	7.2	7.3	7.1	7.1	6.9	7.1
AMMONIA NH_4 mg/l	16.1	21.4	33.0	18.1	41.2	23.9	44.5	23.1	40.4	21.4	34.6	27.2	33.0	26.4	33.0	23.9	34.6	21.4	25.5	20.6	19.8	19.0	16.5	16.1	21.4	13.2
NITRATES NO_3 mg/l	16	11	7.6	10	7.2	7.2	5.6	6.6	3.0	5.6	10	4.2	7.2	1.2	3.9	0.6	6.9	0.6	10	0.4	10	0.3	10	0.4	9.5	0.7
CHLORIDES Cl mg/l	57	67	61	65	67	68	68	65	69	67	72	69	75	68	76	69	74	69	67	69	58	69	58	68	61	66
NITRITES NO_2 mg/l	0.25	0.40	0.30	0.25	0.19	0.50	0.15	0.40	0.60	0.40	0.20	0.35	0.45	0.70	0.80	0.40	1.0	0.05	0.65	0.01	0.50	0.02	0.60	0.01	0.95	0.01
FLOW MUSCPD	0.365	-	0.297	-	0.274	-	0.347	-	0.228	-	0.194	-	0.171	-	0.228	-	0.171	-	0.148	-	0.159	-	0.319	-	0.297	-
TOTAL BOD lb/day	1016	97	868	106	912	124	1185	165		146	778	132	887	106	789	144	436	104	338	90	260	78	270	139	918	102

* Data reported obviously questionable.

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TABLE 5

Weather:
Dry - 1; Frost - 2;
Rain - 3; Thunderstorm - 4;
Spring Run Off - 5.

TREATMENT PLANT OPERATING REPORT FOR THE MONTH: MAY 1971
IN SPALT (WEST GERMANY)

			RAW WASTE				SETTLEABLE SOLIDS (by volume, after 2 hours)													POWER CONSUMPTION	
Date	Time	Weather	Air Temp.	Temp.	pH	Flow Indicator	Previous day's Total	Infl. 1st Clar.	Effl. 1st Clar.	Effl. RBC	Effl. Sec. Clar.	Clarity of Effl.	Relative Stability	Debris at Screen	Sand	Total Raw Sludge	Digest. sludge to drying beds	Temp. of digest. sludge	pH of digest. sludge	Gas production	Period of additional heat supply	Total Plant	Biological Section
			°F	°F		MUSGPD	MUSG	ml/l	ml/l	ml/l	ml/l	ft	Days	ft³	ft³	ft³	ft³	°F		ft³	h	KWh	KWh
1	7.00	3	37.4	44.6	6.2	0.278	0.276	1	0.1	11	0	0.99	3	3.53	3.53	530	-	82.4	7.5	4740	-	140	75
2	8.00	1	37.4	44.6	6.2	0.278	0.297	1.5	0.1	10	0	0.95	3	3.53	3.53	530	-	80.6	7.5	3500	-	140	75
3	6.30	1	37.4	45.5	6.2	0.278	0.265	2	0.1	11	0	0.85	3	3.53	3.53	1765	1765	78.8	7.5	2720	8	80	75
4	6.30	1	39.2	45.5	6.2	0.228	0.246	1.5	0.1	10	0	0.85	3	3.53	3.53	530	-	78.8	7.5	4120	8	120	75
5	6.30	1	39.2	45.5	6.2	0.251	0.295	2	0.2	10	0	0.88	3	3.53	3.53	530	-	80.6	7.5	4140	-	140	75
6	6.30	1	41.0	56.3	6.7	0.274	0.440	4	0.2	14	0	0.82	3	3.53	3.53	530	-	80.6	7.5	3460	-	120	75
7	6.30	1	35.6	54.5	6.7	0.274	0.430	9	0.5	22	0	0.74	3	3.53	3.53	530	-	80.6	7.5	4380	12	140	75
8	7.00	1	39.2	53.6	6.7	0.274	0.444	4	0.2	24	0	0.97	3	3.53	3.53	530	-	80.6	7.5	4350	-	120	75
9	8.00	1	57.2	53.6	6.7	0.440	0.583	4	0.2	30	0	0.99	3	3.53	3.53	530	-	80.6	7.5	3110	-	180	75
10	6.30	1	53.6	53.6	6.7	0.342	0.293	5.5	0.2	9	0	0.99	3	3.53	3.53	1765	1765	80.6	7.5	3570	-	120	75
11	6.30	1	41.0	53.6	6.4	0.342	0.330	2.5	0.1	2.5	0	0.99	3	3.53	3.53	530	-	80.6	7.5	3960	-	120	75
12	6.30	1	50.0	53.6	6.2	0.388	0.335	0.5	0.1	15	0	1.15	3	3.53	3.53	530	-	80.6	7.5	4200	9	140	75
13	6.30	1	50.0	54.5	6.2	0.251	0.241	2	0.2	19	0	0.72	3	3.53	3.53	530	-	80.6	7.5	3180	-	120	75
14	6.30	1	50.0	56.3	6.2	0.274	0.260	2	0.3	20	0	1.25	3	3.53	3.53	530	-	80.6	7.5	3640	8	120	75
15	6.30	1	51.8	57.2	6.4	0.274	0.154	1,5	0.2	20	0	1.28	3	3.53	3.53	530	-	82.4	7.5	4100	-	120	75
16	7.00	4	59.0	57.2	6.4	0.296	0.364	2.5	0.5	24	1	-	-	7.06	7.06	530	-	84.2	7.5	5100	-	140	75
17	6.30	1	66.2	57.2	6.4	0.440	0.411	1.8	0.1	15	0	1.21	3	7.06	7.06	530	-	84.2	7.5	3920	-	80	75
18	6.00	1	46.4	53.6	6.4	0.412	0.370	1	0.1	7	0	1.28	3	7.06	7.06	1765	1765	82.4	7.5	4310	-	120	75
19	7.30	1	48.2	57.2	6.4	0.388	0.338	0.6	0.2	20	0	1.15	3	7.06	3.53	530	-	80.6	7.5	2900	-	120	75
20	6.30	1	59.0	56.3	6.4	0.412	0.381	1	0.1	18	0	1.21	3	7.06	3.53	530	-	80.6	7.5	5020	-	140	75
21	6.00	1	55.4	59.0	6.2	0.365	0.308	4	3	7	0.5	0.53	3	3.53	3.53	530	-	82.4	7.5	4000	-	100	75
22	6.30	4	51.8	55.4	6.2	0.388	0.451	2.5	0.1	11	0	1.25	3	3.53	3.53	530	-	84.2	7.5	4740	11	140	75
23	7.00	4	48.2	53.6	6.2	0.412	0.477	3	1	20	0	-	3	7.06	3.53	530	-	82.4	7.5	3960	-	100	75
24	6.30	4	50.0	56.3	6.2	0.616	0.738	2.8	0.1	17	0	-	-	7.06	7.06	530	-	82.4	7.5	4840	-	100	75
25	6.30	4	50.0	56.3	6.2	0.594	0.638	0.8	0.01	4	0	-	3	7.06	7.06	530	-	82.4	7.5	4520	-	140	75
26	6.00	1	48.2	57.2	6.4	0.456	0.464	1	0.4	10.2	0	1.35	3	3.53	3.53	530	-	82.4	7.5	4840	-	140	75
27	6.30	1	50.0	56.3	6.7	0.440	0.301	1.5	0.2	10	0	1.08	3	3.53	3.53	530	-	82.4	7.5	3960	-	140	75
28	6.30	1	48.2	56.3	6.7	0.456	0.535	1	0.2	9	0	1.05	3	3.53	3.53	530	-	82.4	7.5	4060	-	140	75
29	6.30	1	44.6	53.6	6.2	0.440	0.460	2	0.1	8	0	0.99	3	3.53	3.53	530	-	82.4	7.5	2760	-	120	75
30	8.00	1	55.4	57.2	6.2	0.383	0.418	1.5	0.2	6	0	0.99	3	3.53	3.53	530	-	82.4	7.5	3070	-	140	75
31	8.00	1	59.0	53.6	6.2	0.388	0.421	1.5	0.1	10	0	1.35	3	3.53	3.53	530	-	80.6	7.5	2620	-	120	75
							11.904									20.135	5295			120330		3999	2325

(A1158)

TABLE 6

TREATMENT PLANT OPERATING REPORT FOR THE MONTH: OCTOBER 1972
IN SPALT (WEST GERMANY)

Weather
Dry - 1; Frost - 2;
Rain - 3, Thunderstorm - 4,
Spring Run Off - 5.

				RAW WASTE				SETTLEABLE SOLIDS (by volume, after 2 hours)														POWER CONSUMPTION	
Date	Time	Weather	Air Temp.	Temp.	pH	Flow Indicator	Previous day's Total	Infl 1st Clar.	Effl. 1st Clar.	Effl. RBC	Effl. Sec. Clar.	Clarity of Effl.	Relative Stability	Debris at Screen	Sand	Total Raw Sludge	Digest. Sludge to drying beds	Temp. of digest. sludge	pH of digest. sludge	Gas production	Period of additional heat supply	Total Plant	Biological Section
			°F	°F		MUSGPD	MUSG	ml/l	ml/l	ml/l	ml/l	ft	Days	ft³	ft³	ft³	ft³	°F		ft³	h	KWh	KWh
1	8.00	1	24.8	57.2	6.2	0.365		1.5	0.1	6	0	1.57	5	3.53	3.53	530	-	80.6	7.5	1910	13	100	75
2	6.30	1	19.4	57.2	6.2	0 319	0.160	2	0.1	9	0	1.35	5	3.53	3.53	530	-	80.6	7.5	1450	5	100	75
3	6.30	1	19.4	56 3	6 2	0 342	0.205	3	0.1	11	0	1.28	5	3.53	3.53	530	-	82.4	7.5	3180	11	140	75
4	6 30	1	15.8	56 3	6 2	0 342	0.180	2.5	0.1	10	0	1.28	5	3.53	3.53	530	-	81.5	7.5	3531	-	140	75
5	6.30	1	17 6	57.2	6.2	0.342	0 175	1.5	0.1	9	0	1.28	5	3.53	3.53	530	-	80.6	7.5	3180	4	120	75
6	6 30	1	19.4	57 2	6 2	0.342	0 181	2	0.1	11	0	1.28	5	3.53	3.53	530	-	80.6	7.5	2820	5	140	75
7	6 30	1	28.4	56 3	6.7	0.365	0.188	3	0.1	10	0	1.28	5	3.53	3.53	530	-	80.6	7.5	2820	-	100	75
8	6.30	1	32.0	57 2	6.7	0.365	0.196	1.5	0.1	10	0	1.38	5	3.53	3.53	530	-	80 6	7.5	2400	11	140	75
9	6 30	1	28 4	57.2	6 2	0 296	0.148	2	0.1	12	0	1.38	5	3.53	3.53	530	-	80.6	7.5	1560	3	100	75
10	6.30	1	32.0	57.2	6.2	0.319	0.194	3	0.2	14	0	1.25	5	3.53	3.53	530	-	80.6	7.5	-	-	140	75
11	6.30	1	24.8	57 2	6.2	0.342	0.174	1	0.2	14	0	1.31	5	3.53	3.53	530	-	80.6	7.5	3000	11	120	75
12	6.30	1	23.0	57 2	6.2	0 342	0.179	2	0 1	10	0	1.25	5	3.53	3.53	530	-	78.8	7.5	2650	-	120	75
13	6.30	1	32.0	57.2	6 2	0 365	0.197	1 5	0.1	10	0	1.28	5	3.53	3.53	530	-	78.8	7.5	3531	12	140	75
14	6.30	1	19.4	59 0	6.2	0 342	0.174	1.2	0.1	14	0	1.25	5	3.53	3.53	530	-	80.6	7.5	2820	7	120	75
15	8 00	1	21.2	57.2	6 2	0 365	0.206	2	0.1	12	0	1.25	5	3.53	3.53	530	-	80 6	7.5	2540	3	140	75
16	6.30	1	21.2	57 2	6.2	0 296	0 136	2	0.1	10	0	1.38	5	3.53	3.53	530	-	80.6	7.5	2370	7	80	37.5
17	6.30	1	23.0	59 0	6.2	0 342	0.160	2	0.1	7	0	1.32	5	3.53	3.53	530	-	80.6	7.5	2190	10	120	67.5
18	6.30	1	32.0	59 0	6.2	0.365	0.178	1	0.1	8	0	1 35	5	3.53	3.53	530	-	82 4	7.5	2820	6	100	56.4
19	6.30	1	14 7	-	-	0 365	0.160	-	-	-	0	-	5	3.53	3.53	530	-	84.2	7.5	2800	7	100	80.4

(A1158)

PLANT VISIT REPORT FORM

1. IDENTIFICATION

Location	: AMBERIEU EN BUGEY
Plant Name	: STATION D'EPURATION D'AMBERIEU EN BUGEY
Address	: HOTEL DE VILLE DEPARTMENT DES EAUX

PERSONNEL CONTACTED

City Engineer	: M. Milleot
Distance to adjacent property and associated precautions or problems	: 500 ft fence for safety. No precautions against odour or bacterial contamination. No associated problems reported.

EQUIPMENT SUPPLIER

Name	: TEBA (licensed by Stengelin)
Address	: Rue Marechal Foch, Strasbourg, France.

2. GENERAL TECHNICAL BACKGROUND

Type of Waste	: Abattoir and City
Flow (Average, maximum, minimum)	: 1.27 1.85 0.78 MUSGD
Characteristics of Fluctuations	: Normal combined sewers
Plant started up	: July 1970
Abattoir connected	: 1 August 1972
Design Capacity	: 4.56 MUSGD 2980 lbs BOD/day
Protection from the Elements	: Unheated and uninsulated building.

Outdoor ambient temperature	: Low -22°F High 90°F At visit 60°F
Ambient temperature in RBC	: As ambient outdoors
Pre RBC treatment	: Coarse screen, aerated grit chamber, primary clarifier
Post RBC treatment	: Secondary clarifier, sludge digester
Disc diameter	: 9'10"
Number of discs	: 12 shafts , 180 discs each
Disc thickness	: 5/8", spacing 1.31" o/c
Total area	: 302,000 sq. ft.
Retention of RBC Vats	: at max. design flow 14 minutes at average flow 36 minutes
RBC Vat Capacity	: Approx. 43,000 USG
Head losses through RBC units	: under 2" total
Normal disc speed	: 1.5 rpm
Disc drive	: - one motor 1 HP each shaft - considered adequate
No. of stages in series	: 3
No. of parallel units	: 4
Alternative Sequences of flow through RBC sections	: None
RBC Vat Contour	: Trapezoidal

4. OPERATION

	Man Hrs/day
Operation and maintenance	: 2
Analysis	: once/2 months by laboratory
Supervision	: Included above (Operation and Maintenance are by contract)
Chemicals used (Incl. nutrients)	: None

Operating problems

- Maintenance of growth	: None reported or evident
- Plugging of discs	: None reported or evident
- Plugging of vats	: None reported or evident
- Short Circuiting	: None reported or evident
- Foam	: None reported or evident
- Odour	: None reported or evident
- Corrosion	: None reported or evident
- Equipment reliability	: No breakdowns reported. Considered "Trouble free".
- Bearing and drive life	: No failures to date.

5. SOLIDS DISPOSAL

General description of solids disposal	: Anaerobic digestion followed by drying beds.
Secondary clarifier	: 1.1 hr retention at design flow 4 hrs retention at average flow
Chemical consumption	: Nil
Sludge bed area	: 5000 sq. ft., apparently adequate. No odour
Sludge used	: as fertilizer
Frequency of solids removal from RBC vats	: Never.

TABLE 7

PERFORMANCE DATA ON AMBERIEU-EN-BUGEY PLANT

	BOD_5			COD			NO_3			NO_2			SS	
	In mg/l	Out mg/l	% Removal	In mg/l	Out mg/l	% Removal	In mg/l	Out mg/l	% Removal	In mg/l	Out mg/l	% Removal	In mg/l	Out mg/l
26 Oct. 71	196	8	96	500	-		-	-	-	-	-		152	-
6 Jan. 72	110	20	82	225	45	80	-	-	-	-	-		65	22
4 May 72	196	29	93	668	-	-	-	-	-	-	-		282	100
22 Aug. 72	270	38	86	920	97	90	0.5	0.5		0.01	0.5	-	406	22

NOTES: 1) Corresponding flow data not available

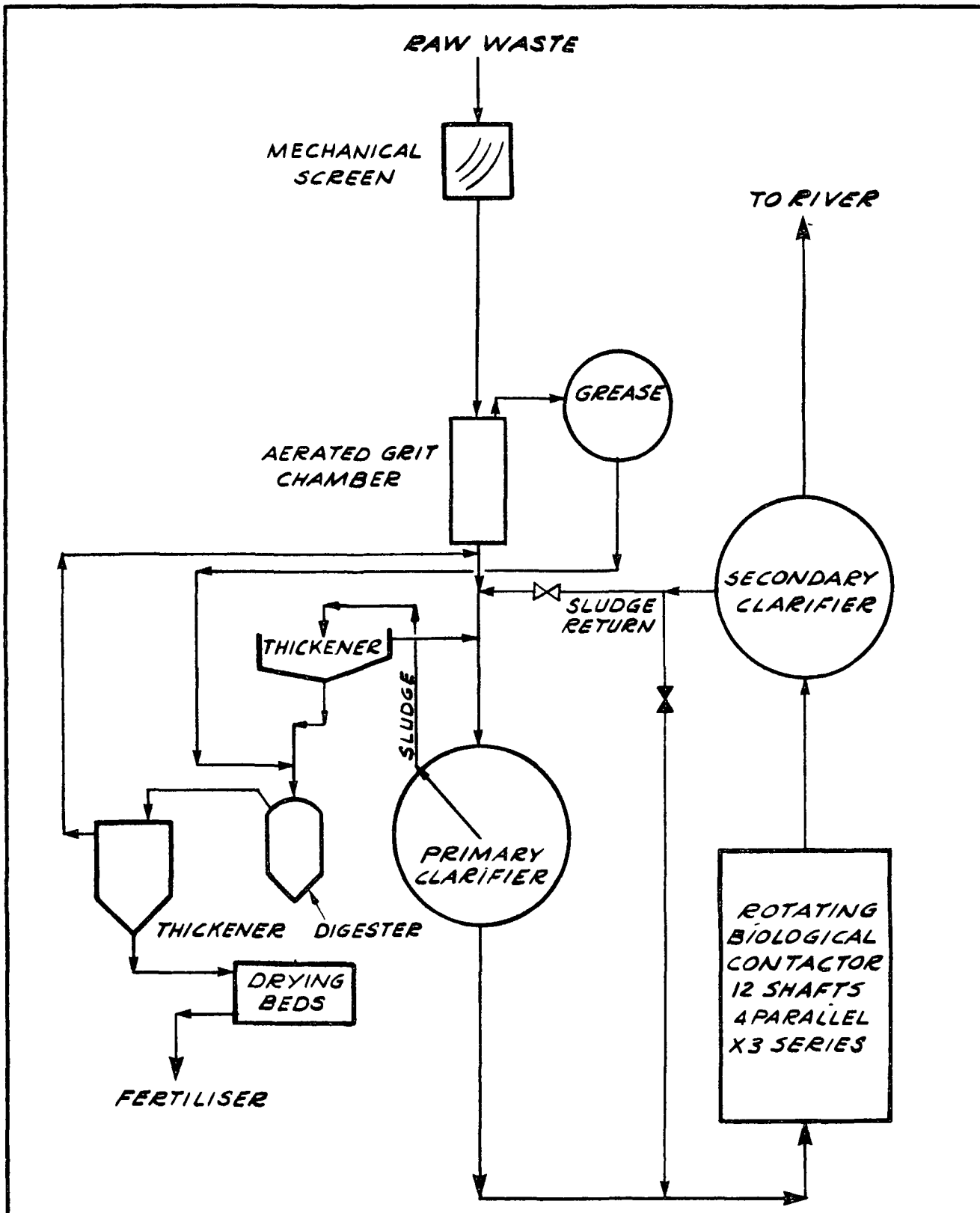
2) "In" refers to Raw Waste

3) All above data collected for domestic waste discharge only prior to connection of slaughter-house waste.

4) All data in mg/l

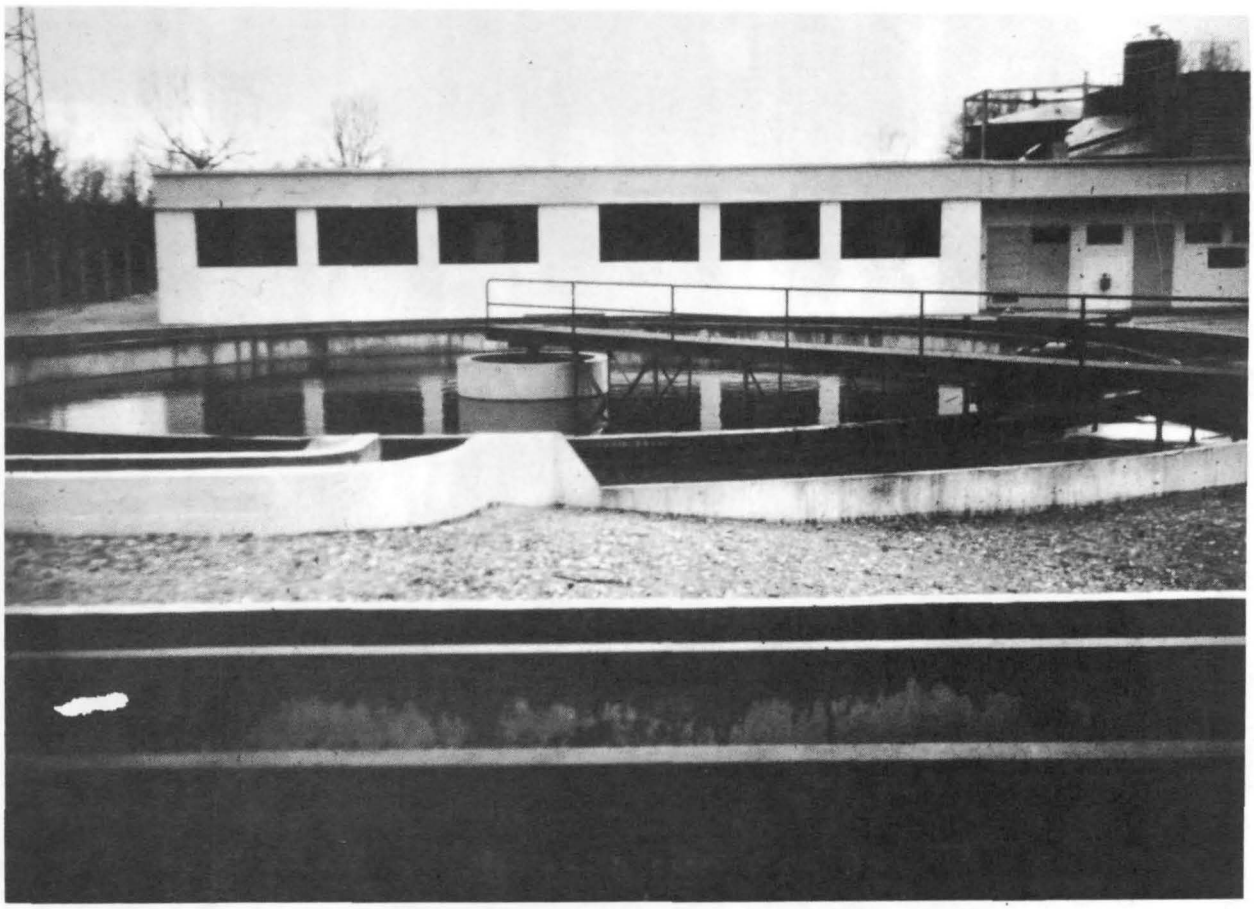
5 Plant underloaded

(A1158) AMBERIEU



R.B.C. FLOWSHEET - AMBERIEU EN BUGEY
DOMESTIC & ABBATOIR

ENVIRONMENT CANADA OTTAWA - ONTARIO	BEAK	BY S.R. DATE 8-1-73 DWG NO A1158-6	FIG. 5



Clarifier & RBC Building - AMBERIEU-EN-BUGEY

Cost

The total cost for the system was $350,000. (40% Civil Engineering, 60% mechanical and electrical).

Operation

The Town of Amberieu-en-Bugey have signed a Contract with T.E.B.A. for the maintenance and operation of the system as follows:

- Manpower	$1,100.00
- Power	3,300.00
- Miscellaneous	150.00
TOTAL	$4,550.00
- Overhead, escalation and profit - 30%	$1,400.00
- Insurance	400.00
TOTAL	$6,350.00 yr

For this annual fee, T.E.B.A. has contracted to maintain and operate the installation for a period of 10 years.

The Contractor guarantees to the town "in any circumstances" the discharge to the river of an effluent which will meet the criteria of the "Conseil Superieur d'Hygiène Publique de France".

PLANT VISIT REPORT FORM

1. IDENTIFICATION

Location	: KAPPELROEDICK
Plant Name	: KLARENANLAGEN VON KAPPELROEDICK
Address	: KAPPELROEDICK BADEN WURT, WEST GERMANY

PERSONNEL CONTACTED

Supervisor	: ERNST HILLBRECHT
Distance to adjacent property and associated precautions or problems:	½ mile No difficulties reported and no specific precautions.

EQUIPMENT SUPPLIER

Name	: J.C. STENGELIN
Address	: Tuttlingen, West Germany

2. GENERAL TECHNICAL BACKGROUND

Type of Waste	: Domestic/Schnapps Distillery
Flow	: .23 MUSGD (except Distillation slop) Dry weather flow
Characteristics of Fluctuations	: Combined Sewers Due to City sewer design, 1st day of wet weather washes large quantities of solids into the plant.
Start-up	: December, 1967
Design Capacity	: .91 MUSGD (Wet weather) 1400 lb/day BOD .23 MUSGD (Dry weather)

Actual Loads	: Flows as above, BOD 400 lbs/day reported.
Parallel or Former System	: None
Protection from the Elements	: Unheated and uninsulated building
Outdoor Ambient Temperature	: low 15°F, high 100°F, at visit 60°F
Ambient Temperature in RBC	: Same
Pre and Post RBC Treatment	: Screening and primary clarifier
Post RBC Treatment	: Secondary clarifier and sludge digester
Disc Diameter	: 9'10"
Number of Discs	: 8 shafts, 180 discs each
Disc Thickness	: 5/8", spacing 1.31" o/c
Capacity of RBC Section	: 196,000 USG
Retention of RBC Section	: .51 hours (Wet weather) 2 hours (Dry weather)
Head Losses	: 4" in RBC
Normal Disc Speed	: 1 rpm
Drive	: Four 1½ HP motors driving, 2 shafts each
No. of Stages in Series	: 8
No. of Parallel Units	: One
Vat Contour	: Semi-circular. 2" clearance from disc to Vat
Vat Construction	: Concrete
Is Order of Stages Alternated?	: Not at present Plant initially operated as two parallel lines of 4 stages but the regulatory authority tested outfall in both the 2 x 4 and 1 x 8 modes and expressed a preference for the latter.

4. OPERATION

Man Hrs/day

Operating and Maintenance Labour : 8 hrs/day, 5 days, 3 hrs Sat. 2 hrs Sun.

Analysis : By Water Control Board

Chemicals Used (Incl. Nutrients) : None

Operating Problems

- Maintenance of growth : Has been lost several times due to total waste pH being depressed below 3 by Schnapps distillery. Recovered in about 1 week.

- Plugging of Discs : When flow is high (i.e. 0.9 MUSGD) due to rain and then drops to DWF (0.25 MUSGD) 1st and second stage discs plug full of Biomass about 8 days later. This does not noticeably affect BOD_5 reduction according to the operator. The discs clear themselves within a few days.

- Plugging of valves, screws, etc.: Never

- Foam : None evident or reported

- Odour : None reported, even when discs are plugged with Biomass

- Corrosion : None evident

- Equipment reliability : Occasional drive chain failure

- Bearing and drive life : 5 years service to date without major repairs

- Recovery after loss of growth : 1 week until discs have visually recovered

- Biological growth

	1st Stage	2nd Stage	5th Stage	8th Stage
Thickness	1/8"	1/8"	1/16"	0 - 1/16"
Colour	gray	gray-brown	brown	patchy brown

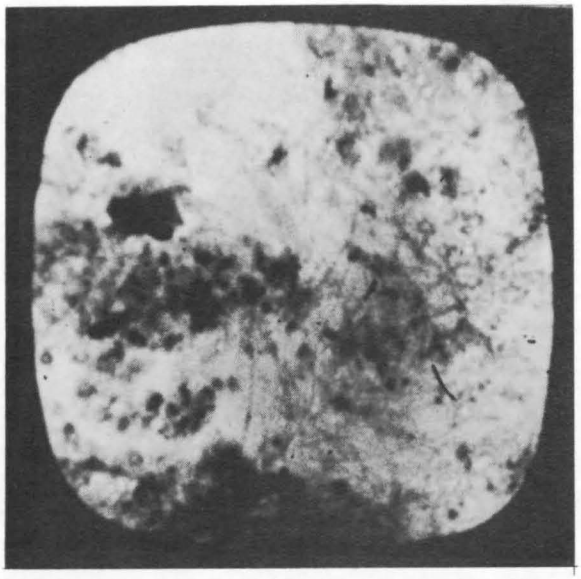
- Short circuiting : None evident

5. SOLIDS DISPOSAL

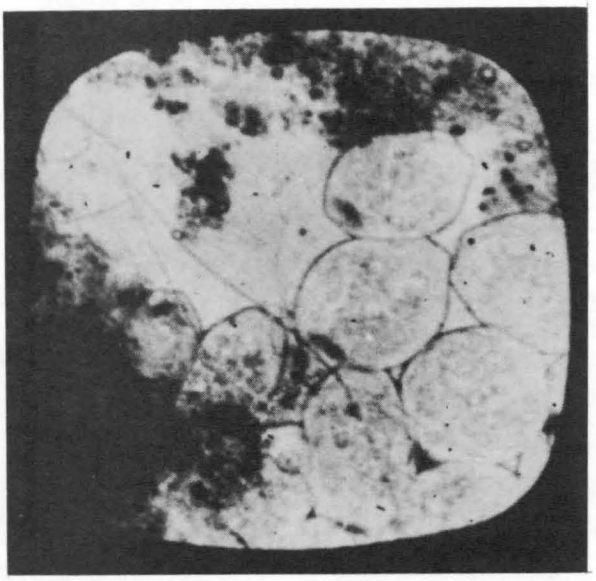
Clarifier	Primary	Secondary
- Area	3400 sq.ft.	680 sq.ft.
- Depth	10 ft.	31 ft.
- Rate	680 USG/ft^2/ day	340 USG/ft^2/day (dry weather) 1,340 USG/ft^2/day (wet weather)
- Chemical consumption	Nil	Nil
	The secondary clarifier had a heavy green floating algae growth at the time of the visit. The operator advised that this was abnormal.	

Solids Dewatering

- Equipment : Drying beds after digester
- Drying beds' odour : None at visit. None normally
- Drying beds' leechate : Returned to plant input
- Disposal : Either wet or dry as fertilizer always digested
- Method of solids removal from drum vats : None
- Frequency of solids removal from drum vats : Never



STAGE 1



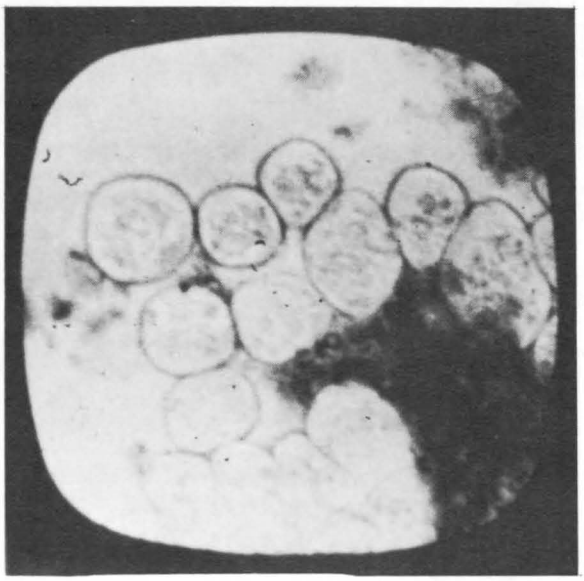
STAGE 2

Stage 1 has no protozoa present and has a quantity of filamentous bacteria possibly sphaerotilus.

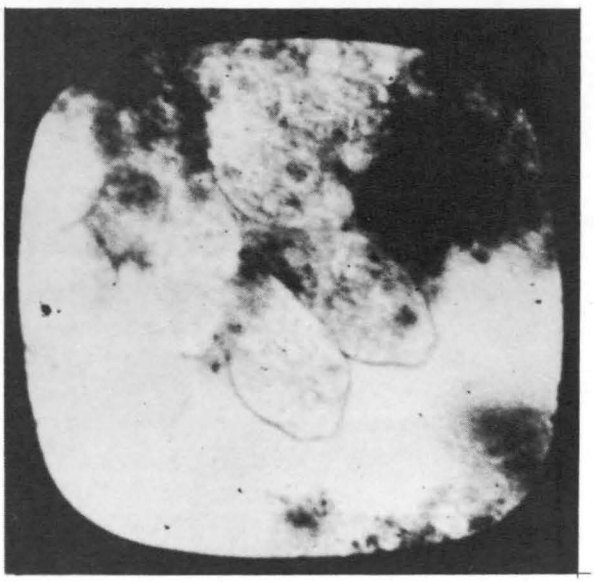
Stages 2-3-4 have stalked ciliate protozoa present indicating a stable population with good removals and low organic loading.

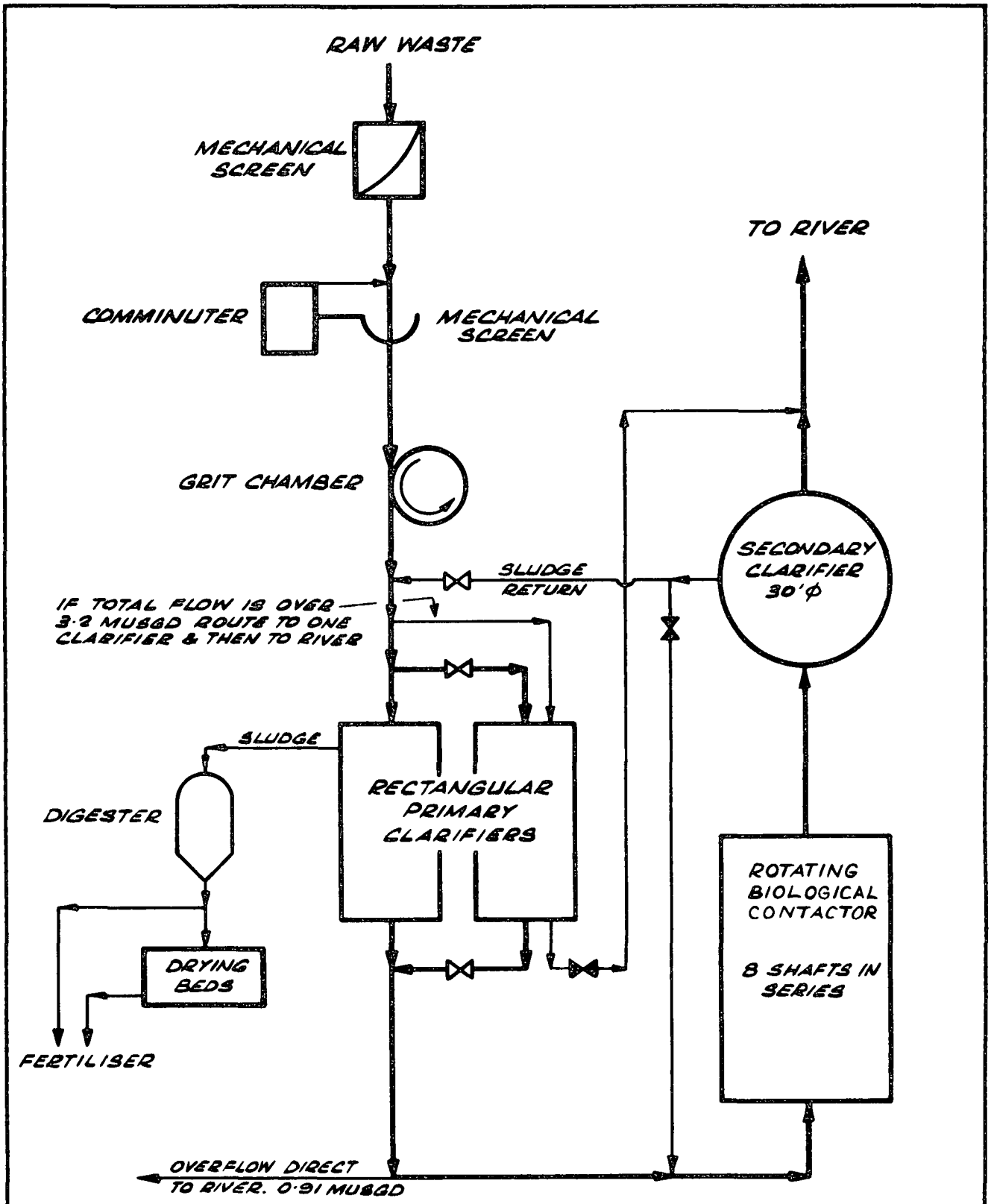
Note: Plant was operating as two parallel sections of 4 stages in series when photographs were taken.

STAGE 3



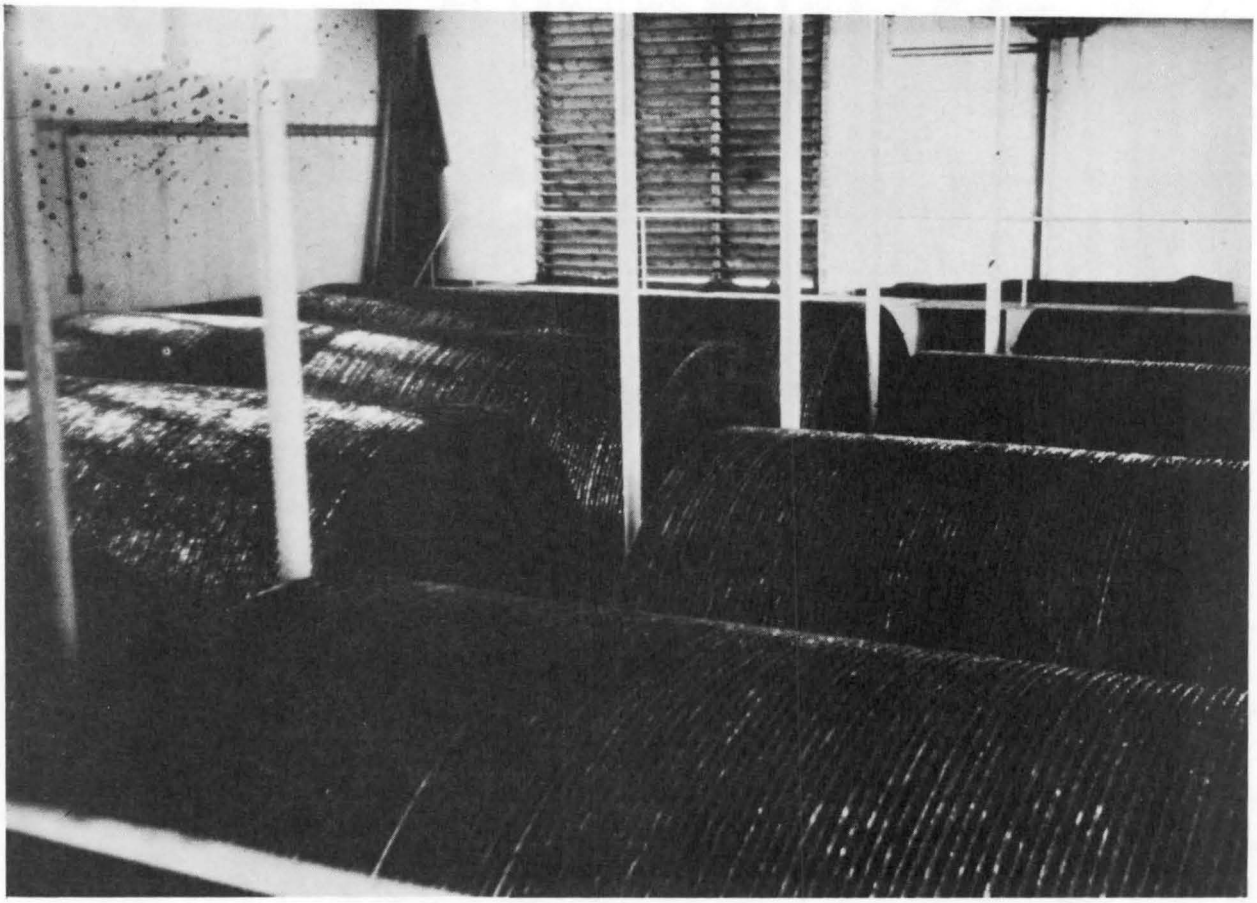
STAGE 4



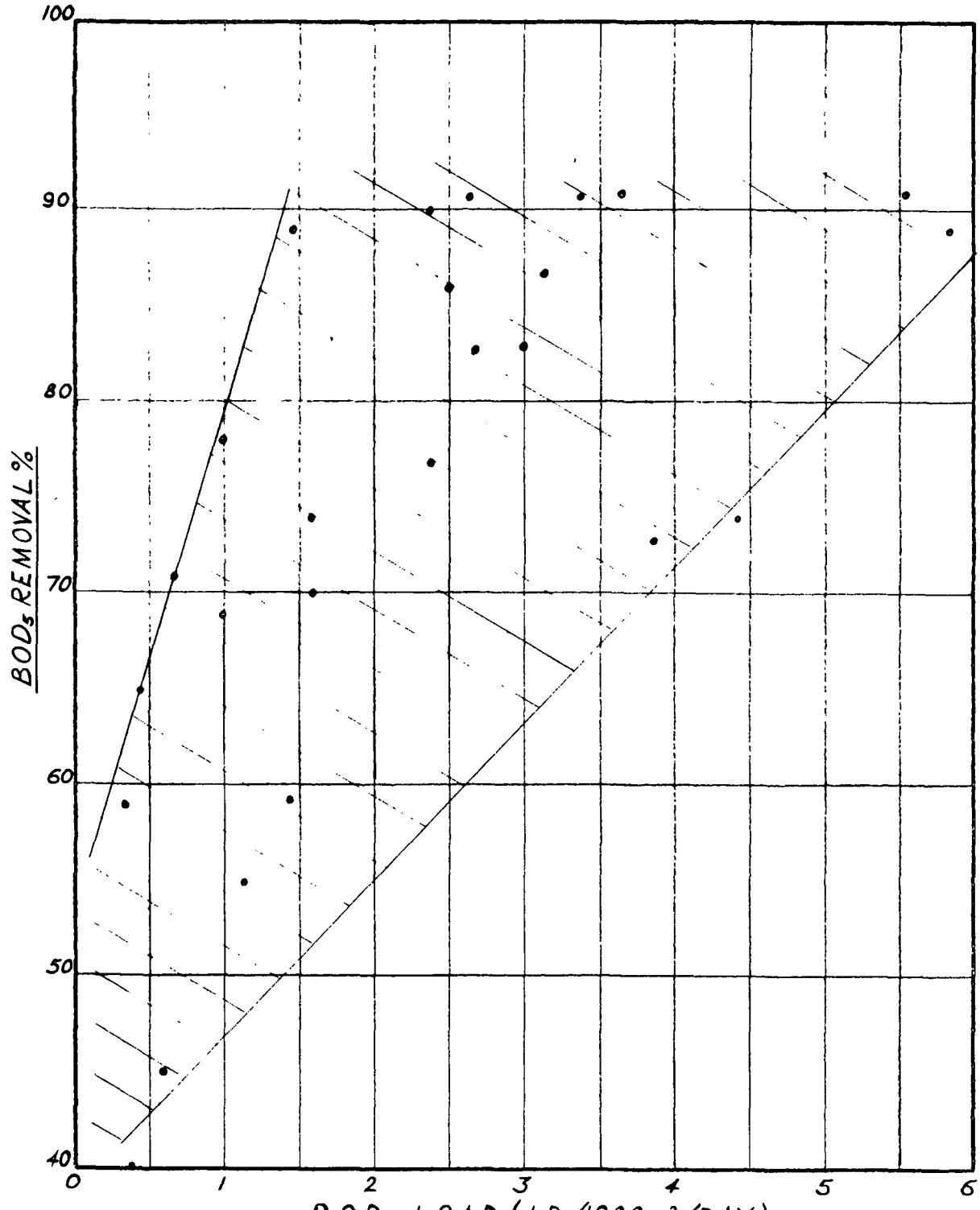


R.B.C. FLOWSHEET—KAPPELROEDICK DOMESTIC & DISTILLERY

ENVIRONMENT CANADA OTTAWA - ONT.	BEAK	BY RCD DATE 5-1-73 DWG NO A1158-4	FIG. 6



RBC Installation - KAPPELROEDICK



BOD REMOVAL EFFICIENCY vs SPECIFIC LOAD

R.B.C. PERFORMANCE - KAPPEL ROE DECK

ENVIRONMENT CANADA OTTAWA — ONTARIO	BEAK	BY DCS DATE 12-1-73 DWG NO A1158-10	FIG 7

TABLE 8

STUDY OF R.B.C. WASTE TREATMENT PLANT AT KAPPELROE DECK W. GERMANY - INFLUENT DATA

	Time of Sample		Inflow		BOD_5		Total Phosphate		Total Nitrogen		Temp.
Date	From	To	Net (MUSG/D)	Including Returned (MUSG/D)	PPM	lb/day	PPM	lb/day	PPM	lb/day	°F
15-6-69	6.00	6.00	0.24	0.27	209	471	5.05	11.64	19.85	44.97	59
16-6-69	6.00	10.00	0.34	0.37	96	296	3.55	11.11	14.75	45.50	
	10.00	14.00	0.33	0.36	244	740	13.96	42.33	46.07	139.68	
	14.00	18.00	0.27	0.30	212	542	14.57	37.04	37.64	96.30	59
	18.00	22.00	0.28	0.30	244	632	11.68	30.16	31.12	80.42	
	22.00	6.00	0.42	0.45	96	359	4.07	15.34	15.42	57.67	
16-6-69	6 00	6.00	0.34*	0.37	156*	487*	8.07*	24.87*	25.47*	79.37*	
17-6-69	6.00	10.00	0.30	0.33	21	58	1.95	5.29	10.05	28.04	
	10.00	14.00	0.34	0.37	64	199	3.91	12.17	30.27	94.18	57
	14.00	18.00	0 28	0.31	204	536	7.31	19.05	29.53	77.78	
	18.00	22.00	0.27	0.30	80	203	3.84	9.52	22.22	56.08	
	22.00	6.00	0.22	0.25	43	90	5.94	12.70	19.13	40.21	
17-6-69	6 00	6.00	0.27*	0.30	77*	196*	4.69*	11.64*	22.06*	55.56*	
18-6-69	6.00	10.00	0.30	0.33	27	71	2.54	9.52	15.47	42.33	
	10.00	14.00	0.50	0.53	152	675	6.21	27.51	27.85	123.81	57
	14.00	18.00	0.65	0.68	137	786	3.64	20.63	14.51	83.07	
	18.00	22.00	0.73	0.76	36	229	1.18	7.41	8.79	55.56	
	22.00	6.0	0.49	0.52	18	79	1.12	4.76	10.60	46.03	
18-6-69	6.00	6.00	0.53*	0 56	69	320	2.59*	11.64*	14.19*	66.14*	
19-6-69	6.00	10.00	0.84	0.87	37	270	1.19	8.47	10.32	75.13	
	10.00	14.00	0.84	0.87	121	882	3.27	23.81	18.00	131.22	57
	14.00	18.00	0.78	0.81	171	1160	4.48	30.69	15.33	105.29	
	18.00	22.00	0.60	0.63	61	323	4.23	22.22	12.99	68.78	
	22.00	6.00	0.49	0.52	29	126	2.40	10.58	12.71	55.56	
19-6-69	6.00	6.00	0.67*	0.70	82	481	2.99*	17.46*	13.89*	82.01*	
20-6-69	6.00	10.00	0.52	0.55	30	139	2.59	12.17	15.39	71.43	
	10.00	14.00	0.55	0.58	131	634	6.02	29.10	23.86	115.34	
	14.00	18.00	0.55	0.58	229	1110	4.59	22.22	30.36	147.62	59
	18.00	23.30	0.44	0.47	154	606	4.83	19.05	19.18	75.66	
	23.30	6.00	0.36	0.39	61	202	3.21	10.58	15.48	51.32	
20-6-69	6.00	6 00	0.47*	0.50	121	508	4.25*	17.46*	20.75*	87.30*	
Average for the 5 days	-	-	0.46	-	100	400	4.52	16.61	19.27	74.08	

* Calculated daily average

(A1158)

NOTES: (1) All samples were composites collected over periods noted

(2) BOD_5 data is probably low due to probable high Cu content of waste.

TABLE 9

STUDY OF R.B C. WASTE TREATMENT PLANT AT KAPPELRODDICK W. GERMANY - EFFLUENT DATA

Date	Time of Sample From	Time of Sample To	Outflow (MUSGPD)	BOD_5 (PPM)	BOD_5 (lbs/day)	BOD_5 % Removal	Total Phosphate (PPM)	Total Phosphate (lbs/day)	Total Phosphate % Removal	Total Nitrogen (PPM)	Total Nitrogen (lbs/day)	Total Nitrogen % Removal
15-6-69	7.00	7.00	0 24	24	48	90	4 65	9 52	18	10 35	20 65	54
16-6-69	7.00	11 00	0 34	12	34	89	3.02	8.47	24	6.23	17 46	62
	11.00	15 00	0 33	23	64	91	4.40	12 17	71	13.04	36 51	74
	15 00	19 00	0 27	39	90	83	11 28	25 93	30	26 03	60 32	37
	19 00	23 00	0 28	35	82	87	11 90	28.04	7	24 19	56 61	30
	23 00	7 00	0 42	63	220	39	8 56	30 16	-	21 79	76 19	-
16-6-69	7.00	7 00	0 34*	41*	118*	76	7.80*	22 22*	11	18 71*	53.44*	33
17-6-69	7 00	11 00	0 30	26	66	-	3 08	7 94	-	11.32	28.57	-
	11 00	15 00	0 34	15	43	78	3 89	11.11	9	12 45	35 45	62
	15 00	19 00	0 28	21	50	91	4 82	11.64	39	23 35	55 56	29
	19 00	23 00	0 27	27	62	69	5 25	12.17	-	21 10	48.15	14
	23 00	7 00	0 22	17	32	65	5.76	10 58	17	12 52	23 28	42
17-6-69	7 00	7 00	0 27*	21*	47*	76	4 64*	10 58*	8	15 59	35 45*	36
18-6-69	7 00	11 00	0 30	12	30	59	3 44	8.47*	11	15.05	37 57	11
	11 00	15 00	0 50	14	59	91	3.41	14.29	48	12.80	53.44	57
	15 00	19 00	0 65	38	208	73	4.14	22 75	-	13.39	73 54	11
	19 00	23 00	0 73	17	103	55	1.90	11.64	-	5 37	32 80	41
	23 00	7 00	0 49	12	49	38	1 01	4 23	11	6.42	26 46	43
18-6-69	7 00	7 00	0 53*	19*	83*	74	2 47*	10 58*	9	9 44*	41 27*	38
19-6-69	7.00	11 00	0 84	12	85	69	1.08	7 41	13	6.36	44 97	40
	11.00	15 00	0 84	33	233	74	2 15	15 34	36	12.15	85 71	35
	15 00	19 00	0 78	19	124	89	3.28	21 69	29	11 30	74 07	30
	19 00	23 00	0 60	19	96	70	3 32	16 93	24	9.32	47 09	32
	23 00	7 00	0 49	17	70	45	2.73	11 11	-	8 90	36 51	34
19-6-69	7 00	7 00	0 67*	20*	113*	77	2 46*	13.76*	21	9 57*	53.97*	34
20-6-69	7 00	11 00	0 52	9	40	71	3 02	13 23	-	9 89	43 39	39
	11 00	15 00	0 55	18	83	87	3 99	18 52	36	18.63	85 71	25
	15 00	19 00	0 55	22	101	91	5 36	24.87	-	18.78	86 77	41
	19 00	23 30	0 44	28	103	83	5.76	21.16	-	13.35	49 21	35
	23 30	7 00	0 36	14	44	78	3 83	12 17	-	8.87	28 04	45
20-6-69	7 00	7.00	0 47*	18*	70*	86	4.35	16.93*	3	13.68*	53 44*	39
Average for the 5 day			0 46	23	86	78	4 34	14.81	11	13.40	58.20	21

* Calculated daily average

(A1158)

PLANT VISIT REPORT FORM

1. IDENTIFICATION

Location	: BAD DURRHEIM
Plant Name	: MUNICIPAL SEWAGE PLANT
Address	: BAD DURRHEIM, BADEN WURT, WEST GERMANY

PERSONNEL CONTACTED

Designer	: V. STENGELIN
Supervisor	: -
Distance to adjacent property and associated precautions or problems	: ½ mile. No precautions against odour or bacterial contamination

EQUIPMENT SUPPLIER

Name	: J.C. STENGELIN
Address	: Tuttlingen, West Germany

2. GENERAL TECHNICAL BACKGROUND

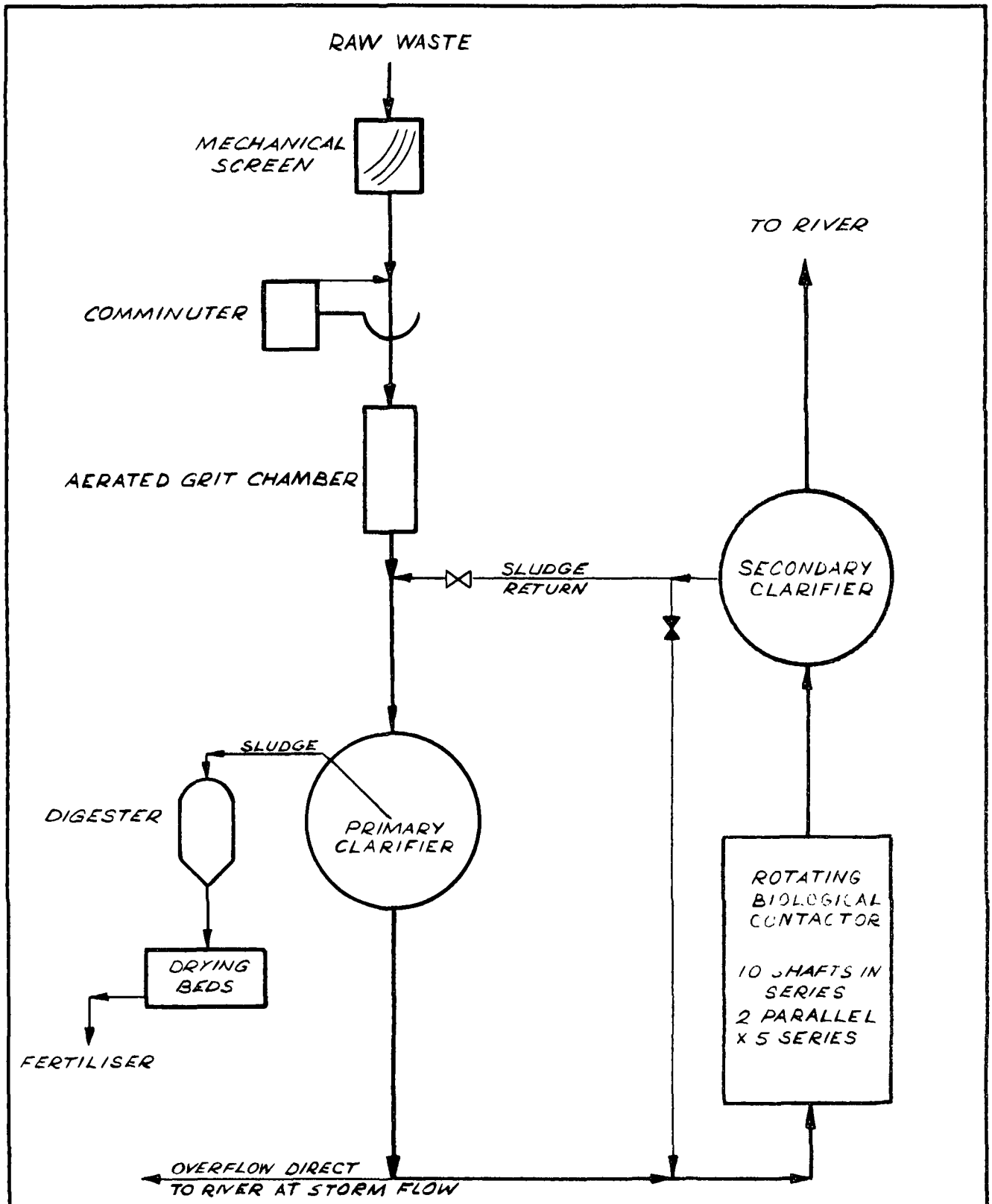
Type of Waste	: Domestic 60%, Abbatoir 20%, Dairy 20%
Flow (Average, maximum)	: 0.91 MUSGD, 9.1 MUSGD
Characteristics of Fluctuations	: Combined sewers
Start-up:	: 3 days before visit
Total Capital Cost	: $400,000
Design Capacity	: 2450 lbs/day BOD
	Regulatory authority requires 20 ppm BOD in treated effluent

Summary of Parallel or Former Systems	: None
Protection from the Elements	: Unheated and uninsulated building
Outdoor Ambient Temperature	: low -5°F, high 100°F, at visit 50°F
Pre RBC Treatment	: Screen, grit chamber and primary clarifier
Post RBC Treatment	: Seconday clarifier
Disc Diameter	: 9'10"
Disc Number	: 10 shafts, 200 discs each
Disc Thickness	: 5/8", spacing 1.31"
RBC Section Capacity	: 27,200 USG
Total Area of RBC	: 27,800 sq.ft.
Head Losses	: Appx. 2' total plant, 3" through RBC section
Normal Disc Speed	: 1 rpm
Drive	: 1.4 HP motor each shaft normal load .5 HP
No. of Stages	: 5
No. of Parallel Units	: 2
Vat Contour	: Semi-circular
Vat Construction	: Concrete
Is Order of Stages Alternated?	: No
Disc Construction	: STD "Stengelin"

4. OPERATION

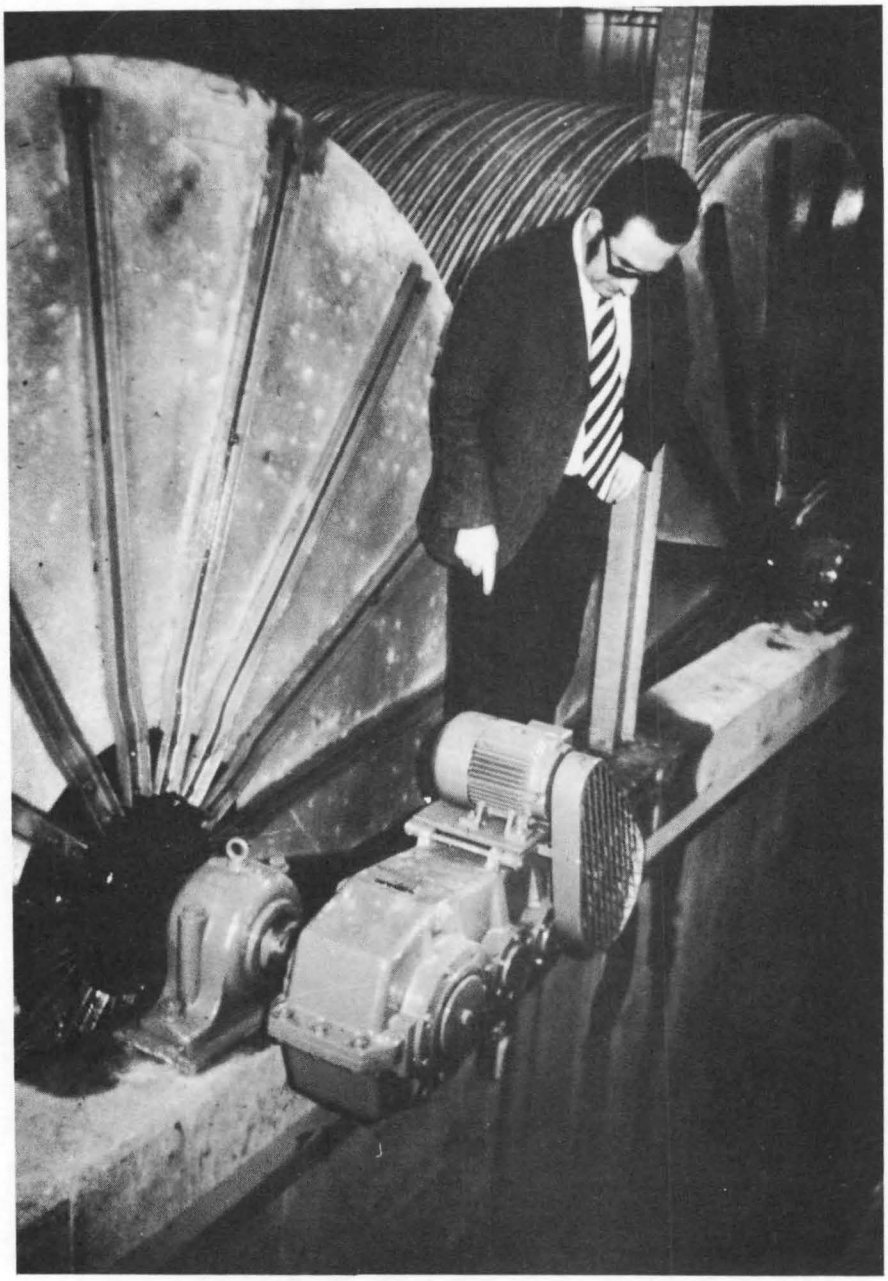
Operation and Analysis (Including most Maintenance)	: 1 man 28 hrs/week
Chemicals Used (Incl. Nutrients)	: None

Performance Data	: None available due to the short history of operation
Start-up History	: No difficulties evident



R.B.C. FLOWSHEET — BAD DURRHEIM
DOMESTIC ABBATOIR & DAIRY

ENVIRONMENT CANADA OTTAWA - ONT	BEAK	BY D.C.S DATE 5-1-73 DWG NO A1158-2	FIG. 8



RBC after 3 days operation - BAD DURRHEIM

PLANT VISIT REPORT FORM

1. IDENTIFICATION

Location	: URLOFFEN
Plant name	: CITY PLANT
Address	: URLOFFEN, (RHEIN)
PERSONNEL CONTACTED	: Operator
Distance to adjacent property and associated precautions or problems	: ¼ Mile. No difficulties reported or evident

EQUIPMENT SUPPLIER

Name	: J.C. STENGELIN
Address	: Tuttlingen, W. Germany

2. GENERAL TECHNICAL BACKGROUND

Type of waste	: 40% Domestic, 30% Distillery 10% Dairy, 10% Winery
Flow	: 0.34 MUSGD
Characteristics of Fluctuations	: Plant normally treats 0.34 MUSGD since this was the designed overflow level. The originally estimated flows are now greatly exceeded.
Start-up	: 1965
Design Capacity	: 0.34 MUSGD (Peak) 1030 lbs/day BOD
Actual loads	: 0.34 MUSGD 1720 lbs/day BOD
Summary of Parallel or Former Systems	: None
Protection from the elements	: Unheated and uninsulated building.
Outdoor ambient temperature	: low 15°F; high 100°F, at visit 60°F

Pre-RBC treatment	: Screen and clarifier
Post RBC Treatment	: Clarifier
Disc diameter	: 9'10"
Number of discs	: 6 shafts, 140 discs each
Disc thickness	: 5/8" spacing 1.31" o/c
Total RBC area	: 116,900 sq. ft.
Capacity of RBC Section	: 11,400 USG
Retention at .34 MUSGD	: 48 minutes
Head losses	: Under 4" through RBC section
Normal disc speed	: 1.25 rpm
Drive	: 4 Motors of 2 HP each: - 2 Drive 2 shafts each - 2 Drive 1 shaft each
No. of stages	: 6 in series
No. of parallel units	: 1
Vat contour	: Half round 2" clearance from disc outside diameter
Vat construction	: Concrete
Is order of stages alternated?	: Have tried 3 series x 2 parallel. However, local regulatory authority prefer all 6 shafts to be in series and this was the mode of operation at the time of the visit.

3. OPERATION

	Man Hrs/day
Labour	: 50/week One man does all maintenance and operation analysis.
Chemicals used (Incl. nutrients)	: None

Performance	: At time of visit the loading had been .34 MUSGD (i.e. overflowing before RBC section) for several weeks despite continuous dry weather. The influent and effluent BOD were 600 and 70 mg/1 respectively in the only two tests performed in this period. The operator advised this was "normal" but no other records were available.

Operating problems

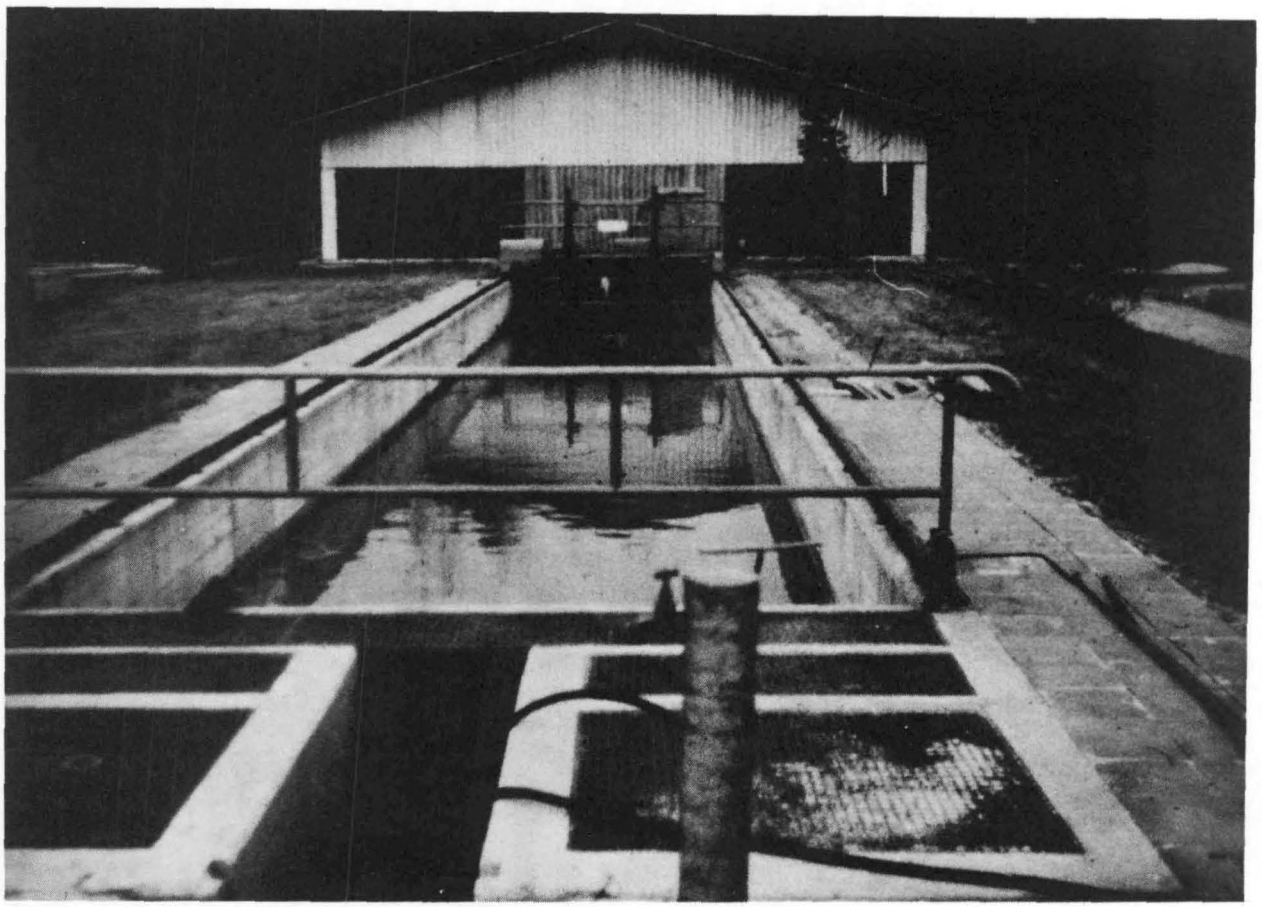
- Maintenance of growth	: Loss of biomass when waste pH drops below 3.5.
- Plugging of discs	: has never occurred.
- Plugging of vats	: Vats are flushed out monthly.
- Plugging of valves, screws, etc.	: Does not occur but channels carrying effluent from RBC to the secondary clarifier are cleared daily.
- Foam	: None evident or reported.
- Odour	: None evident or reported.
- Corrosion	: None evident or reported.
- Equipment reliability	: Considered satisfactory. Breakdown described as "rare".
- Bearing and drive life	: No problem with single drive. Some problem with chains on double drive.
- In cold weather	: Ice forms inside building walls. This does not create difficulties.
- Biomass	: Recently the operator has been observing biomass specimens with a microscope. He reported that sphaerotilus are in the majority when the loadings are high (approx. 600 mg/1 BOD) and rotifers predominate when the load is under 400 mg/1. Growth thickness ranged from 1/8" on first stage to 3/16" on last stage at time of visit.
- Recovery after loss of growth	: About 1 week if BOD under 400 mg/1. Up to 3 weeks at normal dry weather loading at 600 mg/1.

SOLIDS DISPOSAL

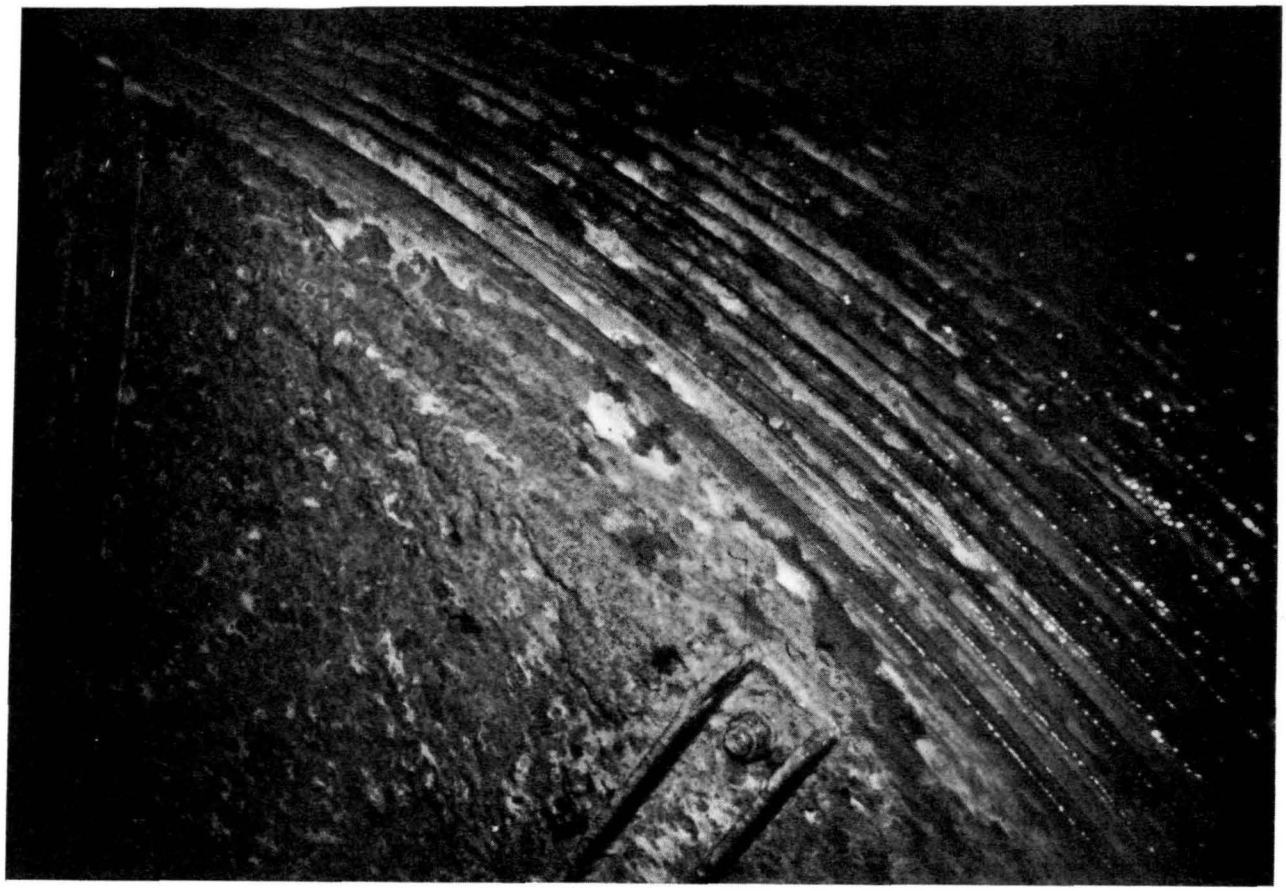
Secondary sludge retained to primary. All primary sludge digested and dewatered in drying beds and used for fertilizer .

Secondary clarifier

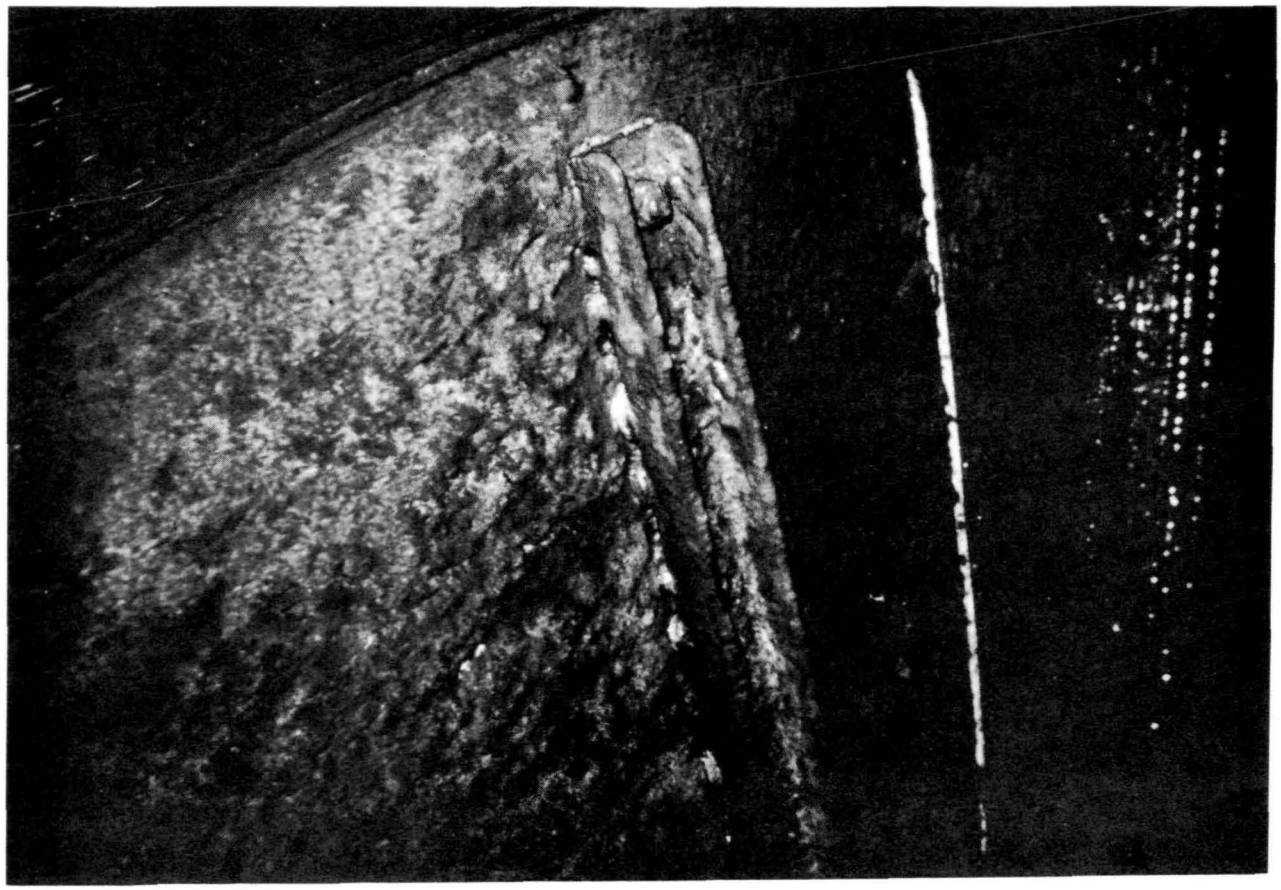
Diameter	: 25 feet
Upflow rate	: 715 USG/ft^2/day



Primary Clarifier & RBC Building - URLOFFEN



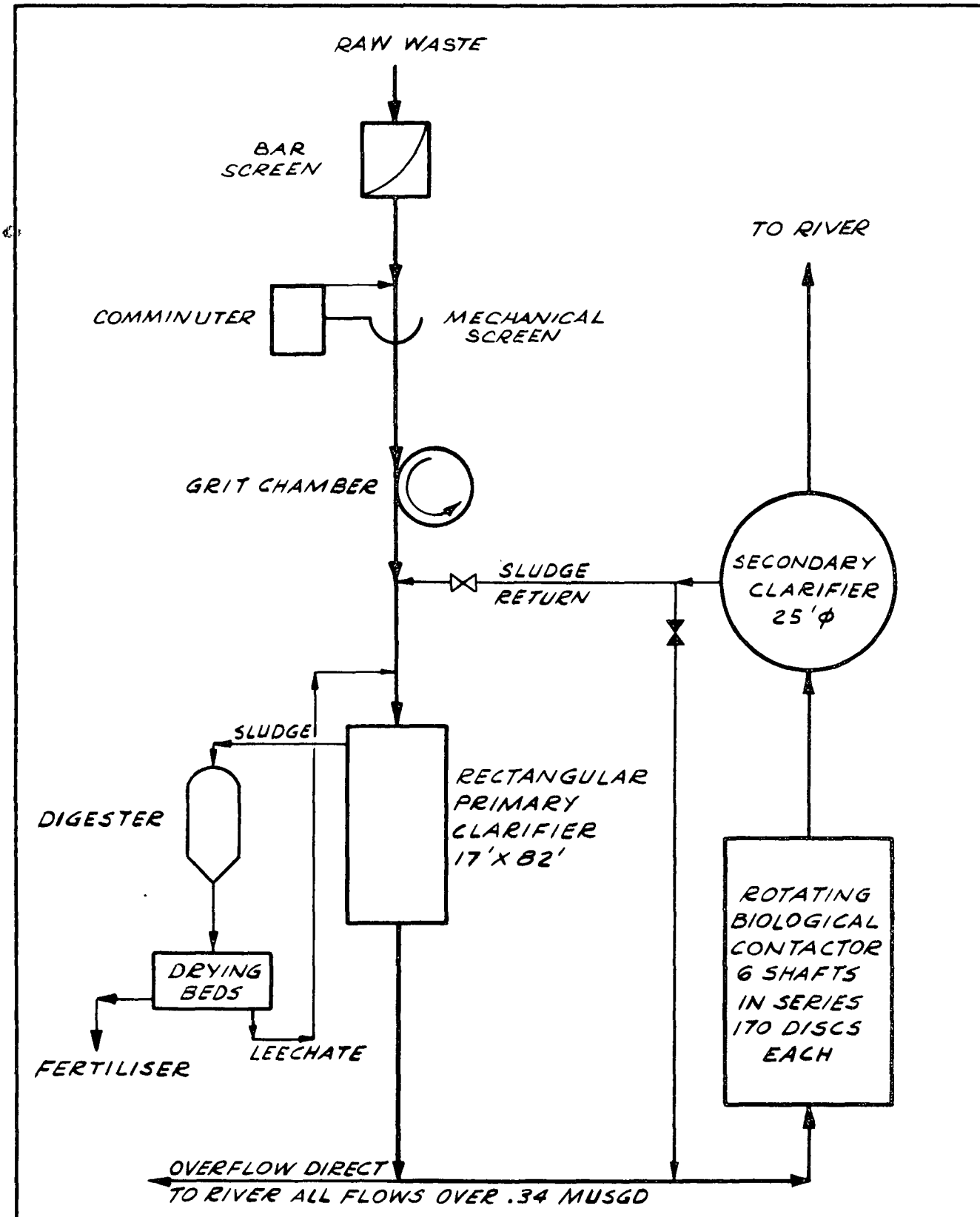
Biomass - 1st stage - URLOFFEN



Biomass - 5th stage - URLOFFEN

RBC effluent after 30 min. settling - ,URLOFFEN

Secondary Clarifier Effluent after 30 min. settling - URLOFFEN



R.B.C. FLOWSHEET – URLOFFEN DOMESTIC & DISTILLERY

ENVIRONMENT CANADA OTTAWA - ONTARIO	BEAK	BY S.R. DATE 8.1-73 DWG NO A1158-3	FIG. 9

TABLE 10

DEPARTMENT VB WATERWORKS
WEST GERMANY

PERFORMANCE OF THE RBC TREATMENT PLANT
IN URLOFFEN

TUESDAY - 20 JUNE 1967
SAMPLING TIME - 4.50 PM
WEATHER - DRY

		Raw Waste	Primary Treated Waste	Secondary Treated Waste
Suspended solids	mg/l	212	105	34.4
Ignition losses	%	41.6	46.6	20.7
Settleable solids (by volume)	mg/l	0.3	-	-
pH		6.6	7.2	7.4
$KMnO_4$	mg/l	322	246	100
BOD_5	mg/l	1,367	732	70
BOD_5 removal	%	-	47	95
NH_4	mg/l	28.8	36.0	34.6
NO_2	mg/l	0.12	0.14	0.81
NO_3	mg/l	1.37	2.05	1,587*
PO_4	mg/l	44.53	11.4	8.79

NOTE: Table 14 was used for preparation of Table 1 in preference to this one due to lack of flow data.

* Value reported. This was disregarded for calculation since it is highly improbable.

TABLE 11

Investigated by	:	V. STENGELIN
Town or City	:	URLOFFEN/RHEIN
State	:	BADEN-WURTT.
Pop. Conn.	:	3000
Designed for	:	8000
Flow Ave	:	.25 MUSGD
No. of Discs	:	840 Dia. 3 Stage 2 x 3
Power Req. RBC (KWH	:	2,0
Sample	:	12.30 - 13.10
Coll.	:	22 October 1965

Parameters Investigated	Influent Primary Clarifier	Effluent Primary Clarifier	Effluent RBC Stage 1	2	Effluent Secondary Clarifier
ODOUR	Fecal	Fecal	Musty	-	-
TURBIDITY	Turbid	-	Clear	Clear	Clear
pH	7.3	7.3	7.5	7.5	7.5
SETTLEABLE SOLIDS	0.8	0.2	1.7	1.9	0.2
BOD_5 (aft.Settling)	83	80	14.7	6.1	6.0
NH_4^+	118	122	78	18	17
NITRITE (NO_2^-)		0.2			0.8
NITRATE (NO_3^-)	Trace	2.0	38	120	150

NOTE: Plant underloaded

TABLE 12

Investigated by	:	V. STENGELIN
Date	:	30.12.65
Town or City	:	URLOFFEN/RHEIN
State	:	BADEN WURTT.
Pop. Conn.	:	3000
Designed for	:	8000
No. of Disc	:	840 - Dia. 3, Stage 2 x 3
Power Req.RBC (KWH)	:	ca. 2 KW
Sample Coll.	:	Grab 14.15.
Flow (L/Sec) Ave.	:	.34 MUSGD
Air Temp. outside	:	35°F
" " RBC Room	:	40°F
Weather Cond.	:	Rain and Snow

Parameters Investigated	Influent Primary Clarifier	Effluent Primary Clarifier	Effluent RBC Stage 3	Effluent RBC Stage 6	Effluent Secondary Clarifier
TEMPERATURE °C		7.5			
pH	6.4	6.4	6.5	6.5	6.4
SETTLEABLE SOLIDS	4	1.5	4	4	Trace
BOD_5 AFT. SETTLING	56	37	15.5	13.0	10.0
$KMND_4$ AFT.SETTLING	148	123	57	51	51
METHYLENE-BLUE TEST h.	24	4 Days	Unchanged after 5 days		
NH_4^+ CONTENT	22	22	15	10.5	8.5
NITRATE (NO_3^-)	30	27	60	65	80
CHLORIDES (Cl^-)	52	59	56	57	49

NOTE: Plant underloaded

TABLE 13

TREATMENT PLANT OPERATING REPORT FOR THE MONTH· SEPTEMBER 1972
IN URLOFFEN (WEST GERMANY)

Weather
Dry - 1, Frost - 2,
Rain - 3, Thunderstorm - 4;
Spring Run Off - 5.

Date	Time	Weather	Air Temp.	INFLOW Temp.	pH	Amount of Sewage Flow Indicator	Amount of Sewage Previous days Total	SETTLEABLE SOLIDS (by volume) Influent to primary clarifier after 2 hr	SETTLEABLE SOLIDS (by volume) Effluent from Rot. Biol.Cont. (2 hr.)	Clarity of Effluent	Total raw sludge	Digested sludge to drying beds	Temp. of digesting sludge	pH of digesting sludge	Gas production	Period of additional heat supply	POWER CONSUMPTION Total plant	POWER CONSUMPTION Biological part
			°F	°F		MUSGPD	MUSG	ml/l	ml/l	ft	ft³	ft³	°F		ft³	h	KWh	KWh
1	15.00	1	71.6	59.0	7.1	0 455	0 264	2	2	0.66	283	283	86.0	7.1	3000	12	150	100
2	16.00	1	68.0	59.9	7.1	0.455	0.291	2	2	0.66	212	-	86.0	7.1	2470	6	150	100
3	8.00	1	64.4	57.2	7.1	0.342	0 291	2	2	1.64	283	283	86.0	7.1	2370	7	150	50
4	9.00	1	57.2	58.1	7	0.228	0.220	2	2	1.64	283	283	86.0	7.1	4240	1	200	50
5	10.00	1	59 0	58 1	7	0.342	0 278	2	2	1.31	283	-	86.0	7.1	3420	12	150	150
6	11.00	1	55 4	60.8	7	0.342	0.207	2	2	1.31	283	283	86.0	7.1	3220	7	150	-
7	12 00	1	71 6	60.8	7	0.455	0.228	2	2	1.15	283	-	86.0	7.1	3140	-	150	100
8	13.00	1	71.6	59.9	7.1	0 455	0 193	2	2	1.15	283	283	82.4	7.1	2650	5	150	100
9	14 00	1	78.8	59.9	7	0.455	0 278	2	2	0.98	283	-	82.4	7.1	3530	6	150	50
10	15 00	1/3	68 0	58 1	7	3.420	0 505	2	2	0.66	283	283	80.6	7.1	3070	-	200	100
11	16.00	1	68.0	59 0	7	0.455	0.294	2	2	0.66	424	424	80.6	7.1	2920	7	150	100
12	8.00	1	46 4	59.0	7	0.228	0.236	2	2	1.31	353	353	78.8	7.1	3530	6	150	50
13	9.00	1	50.0	59.0	7	0 342	0.220	2	2	1.44	283	-	78.8	7.1	2540	9	150	100
14	10 00	1	53.6	59.0	7	0.228	0.215	2	2	1.05	283	283	78.8	7.1	4020	9	150	100
15	11.00	1	53.6	59 0	7	0.570	0.193	2	2	0.98	283	-	77.0	7.1	3000	8	150	100
16	12.00	1	57.2	57 2	7	0.455	0.392	2	2	0.98	283	283	77.0	7.1	3630	3	200	100
17	13.00	3/1	60.8	57.2	7.1	0.455	0.390	2	2	0.98	283	-	77.0	7.1	2820	4	200	150
18	14.00	1	57.2	57 2	7	0.455	0.202	2	2	1.12	283	283	77.0	7.1	3040	-	150	50
19	15 00	1	53.6	57 9	7	0.455	0 254	2	2	0.98	283	-	77.0	7.1	4020	1	150	100
20	16.00	1	57 2	57.9	7.1	0.455	0.209	2	2	0.82	283	283	77.0	7.1	3530	2	150	100
21	8.00	1	50.0	57.9	7.1	0 342	0.236	2	2	1.64	283	283	77.0	7.1	3240	9	150	-
22	9.00	1	50.0	57 9	7	0.228	0.273	2	2	1.80	283	-	77.0	7.1	3040	7	150	100
23	10.00	1	50.0	60.8	7	0.228	0.239	2	2	1.64	283	283	77.0	7.1	2820	-	150	100
24	11.00	1	57.2	58.6	7	0.228	0.233	2	2	1.48	283	-	77.0	7.1	2970	-	150	100
25	12.00	3/1	55.4	57.2	7	0.455	0 520	2	2	0.85	283	283	77.0	7.1	2820	3	100	150
26	13 00	1	53 6	57.9	7	0.455	0.415	2	2	0.95	283	-	77.0	7.1	3240	12	150	50
27	14 00	1	53.6	57.9	7	0.570	0.264	2	2	0.92	283	283	77.0	7.1	1765	4	150	100
28	15 00	1	55.4	57.6	7	0 570	0.204	2	2	0.79	283	-	77.0	7.1	3180	2	150	100
29	16.00	1	57.2	58 3	7	0 570	0.264	2	2	0.72	283	283	77.0	7.1	3750	2	150	100
30	8.00	1	46.4	56 3	7	0.228	0.286	2	2	1.71	283	-	77.0	7.1	3000	-	150	100
							8.294				8630	5022			93925			

(A1158)

TABLE 14

URLOFFEN RBC WASTE TREATMENT PLANT

Average Performance (of 2 Tests) by Regulatory Authority

FLOW	BOD_5 IN		BOD_5 OUT		% REMOVAL
	mg/l	lbs/dy	mg/l	lb/dy	
.34	620	1755	70	198	89 %

NOTE: Plant overloaded

TABLE 15

R.B.C. EFFLUENT TEST REPORT

LOCATION: TREATMENT PLANT - URLOFFEN

DATE OF TEST: 13 January, 1969

NAME OF SAMPLE	RAW WASTE	PRIMARY TREATED WASTE	ROT. BIO. CONT. OUTFLOW 1st stage	ROT. BIO. CONT. OUTFLOW 2nd stage	Treated Waste
Sample No.	1	2	3	4	5
Sampling Time	9^{30} - 10^{15}	9^{30} - 10^{15}	10^{00} - 11^{00}	10^{00} - 11^{00}	10^{00} - 11^{00}
Appearance Smell	Yellowish turbid without smell	Yellowish turbid without smell	Yellowish turbid without smell	Yelllow turbid without smell	Yellow Turbid without smell
Settleable solids After (2 h) mg/l	1.9	0.7	0.7	0.7	0.4
pH	7.1	7.2	7.25	7.35	7.3
$KMnO_4$ - demand mg/l	221	139	120	98	76
Ammonia (NH_4) mg/l	27	23	27	27	27
Nitrates (NO_3) mg/l	12	4	10	20	30
BOD_5 mg/l	120	83	67	32	20
BOD_5 removal %	-	29	44	73.4	83.3
Dissolved oxygen mg/l	-	-	4.35	3.5	-

(A1158) URLOFFEN

PLANT VISIT REPORT FORM

1. IDENTIFICATION

Location	: Near Copenhagen, Denmark
Plant Name	: LEIDERSDORF AG
Address	: Ølstykke, Zealand, Denmark

PERSONNEL CONTACTED

Operating	: None
Supplier	: LIEF HOLMBERG
Distance to adjacent property and associated precaution or problems	: ½ mile

EQUIPMENT SUPPLIER

Name	: EUROPEAN PLASTIC MACHINERY
Address	: 23 Krimsvej, Copenhagen

2. GENERAL TECHNICAL BACKGROUND

Type of Waste	: Fur Plant 15-30 ppm Cr (Pilot Plant)
Flow	: 2280 USGPD
Characteristics of Fluctuations	: Constant flow. Plant uses Cr salts to work sheepskins and kill bacteria
Design Capacity	: 2280 USGPD, 20 lb/day BOD
Actual Loads	: 2280 USGPD
Summary of Parallel or Former Systems	: Have 4 stage aerated lagoon system of about 20 days retention which does not provide adequate BOD reduction. Typical experience has shown 25% reduction.

Protection from the Elements	: None (Has not yet operated in Winter)
Ambient Temperature	: low $0^{o}F$, high $80^{o}F$, at visit $40^{o}F$
Pre RBC Treatment	: Agitated stabilization ponds of about 24 hour rotation
Post RBC Treatment	: Secondary clarifier
Detention Time	: 16 hours
Head Losses	: N/A. Would be under 1" in full scale
Normal Rotational Speed	: $2\frac{1}{2}$ rpm
Drum Ø	: 4 feet
Ball Ø	: 38 mm.
Total Surface	: 2680 sq.ft.
Drive	: 0.7 HP motor (Actual load o.4 HP)
No. of Stages	: 1
No. of Parallel Units	: 2
Possible Use of O_2 enriched Atmosphere	: Under consideration
Vat Contour	: Rectangular
Vat Construction	: Steel
RBC Construction	: Wire mesh and steel cylindrical cage packed with 38 mm ϕ plastic balls

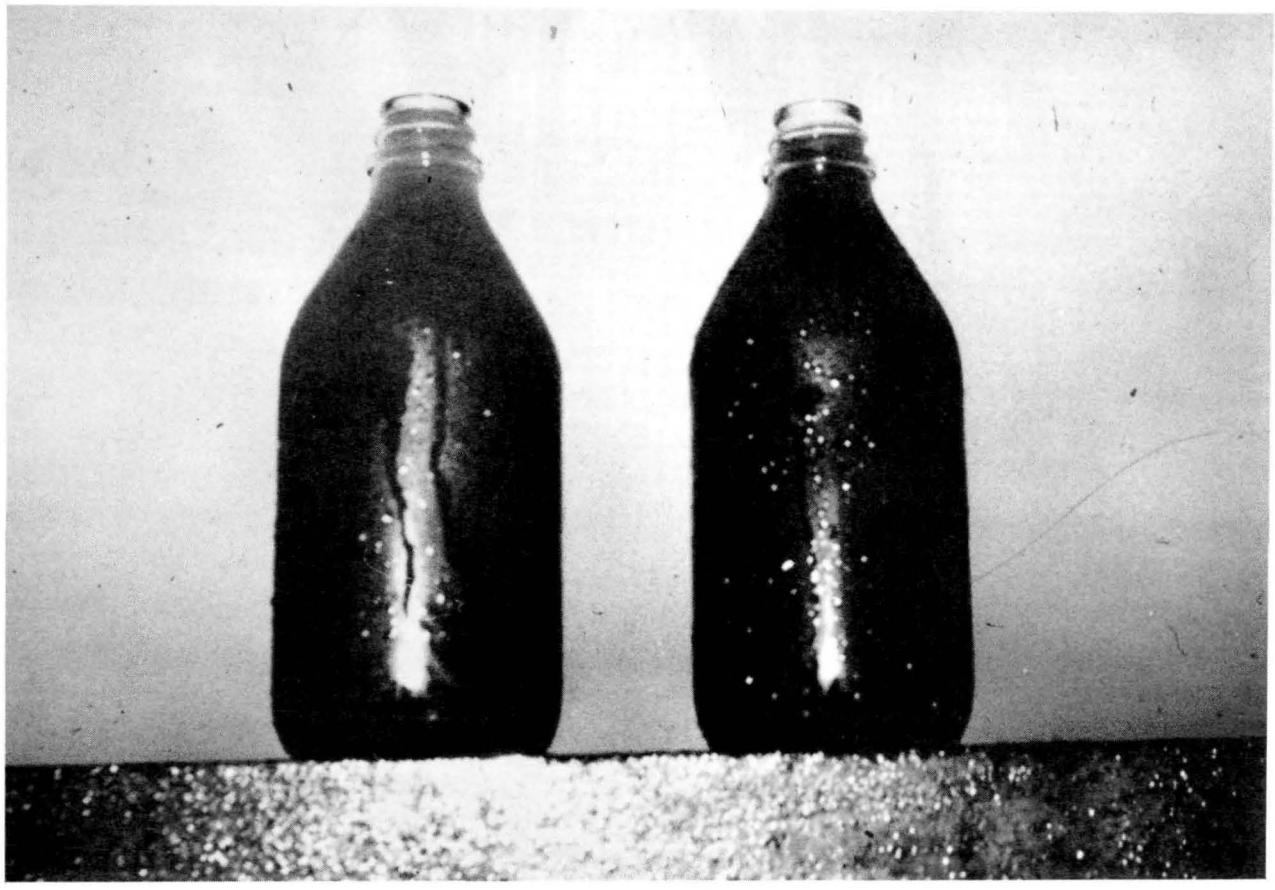
4. OPERATION

Operating Problems	: Note - short history - pilot plant
- Maintenance of growth	: Without settling/stabilization system prior to RBC it was not possible to maintain a viable biomass. Otherwise, no difficulties reported.
- Plugging of discs	: None reported or evident

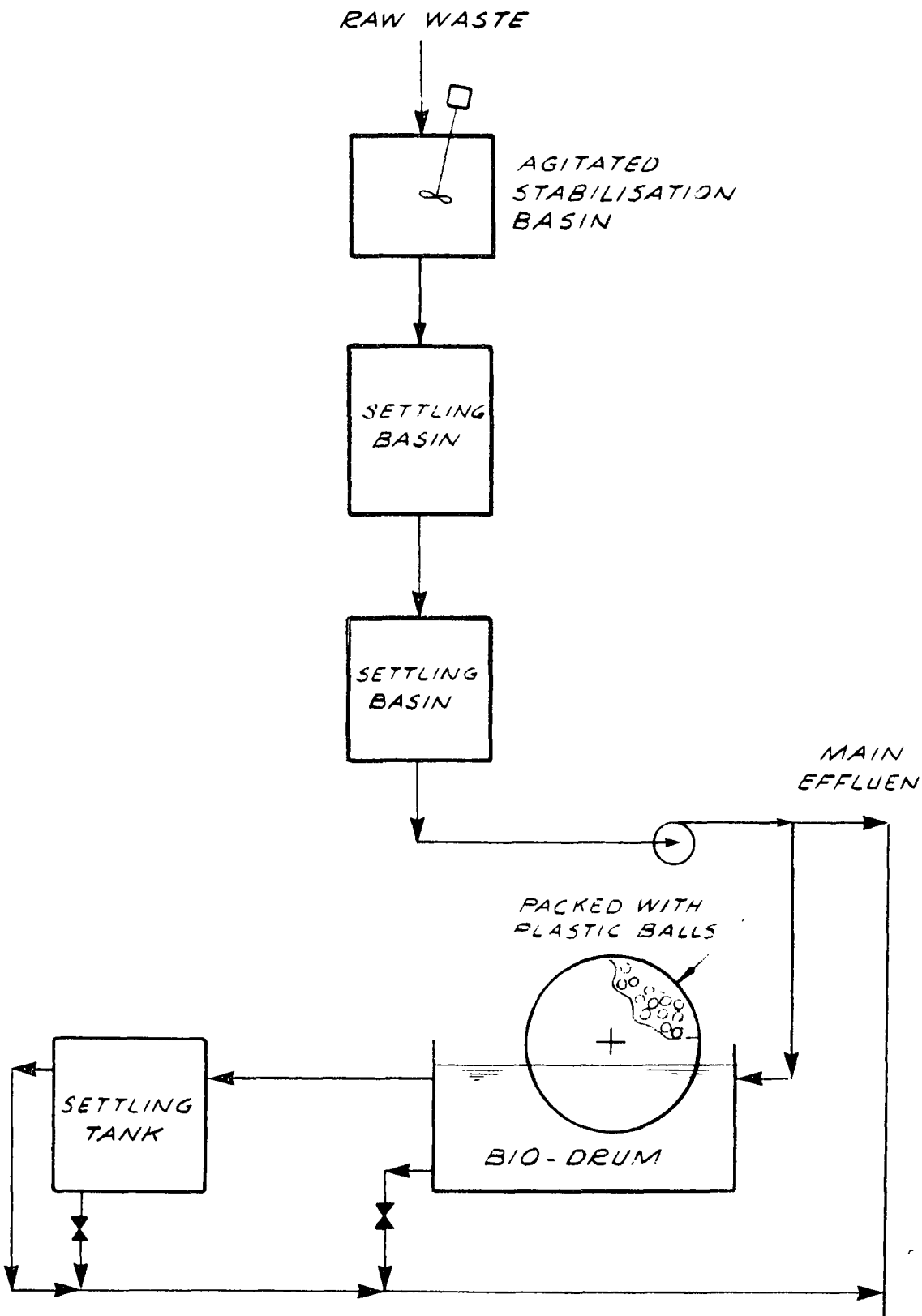
- Plugging of Vats : None reported or evident
- Foam : Several inches of light unstable foam on equipment
- Odour : Cannot be evaluated due to ambient odour
- Corrosion : None evident
- Start-up history : Stabilization ponds required (fur plant is 5 day/week operation)

5. SOLIDS DISPOSAL

General Description of Solids Disposal : Waste was routed to a secondary clarifier but no data was available on settling characteristics or quantity of sludge removed. A sample taken at the time of the visit did not exhibit any visible precipitation after a half hour in contrast to other RBC treated wastes which settled rapidly in similar circumstances



Treated & Untreated Waste - BIO-DRUM



R.B.C. WASTE TREATMENT PLANT
BIO-DRUM - COPENHAGEN

ENVIRONMENT CANADA OTTAWA – ONTARIO	# BEAK	BY S. R DATE 9-1-73 DWG NO A1158-5	FIG. 10