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Demonstration of the "CABOS" Wastewater Treatment System for Vessels (1975 -77)

Technology Development
Report EPS 4-WP-77-6

Water Pollution Control Directorate
October 1977

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DEMONSTRATION OF THE "CABOS" WASTEWATER TREATMENT SYSTEM FOR VESSELS (1975-77)

A development and demonstration project
conducted under contract
for Task 7
Canada/United States Agreement on
Great Lakes Water Quality

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ABSTRACT

"CABOS" is a new, modified biological sewage treatment system developed as part of the Government of Canada's vessel waste program under the 1972 Canada-U.S. Agreement on Great Lakes Water Quality. This report describes evaluation of the first prototype system during the 1975 shipping season aboard the SS John A. France, a bulk carrier owned and operated by Scott Misener Steamships Limited.

The system included sewage flow equalization, carbon adsorption, bio-oxidation, clarification, filtration and ozone disinfection. The average effluent quality during the various testing periods under different loading conditions ranged from 6 to 25 mg/l BOD_5 and from 5 to 13 mg/l SS. This was well within the prescribed limits of the new Great Lakes Sewage Pollution Prevention Regulations, which specify 50 mg/l BOD_5 and 50 mg/l SS.

This intense testing program, carried out by the Ontario Research Foundation (ORF), was followed in 1976 by routine operation by the ship's crew with minimum ORF supervision and sampling. During 1976, ORF investigated a suitable, automatic effluent quality monitoring system as required by the Regulations under the Canada Shipping Act. The efforts of ORF to select, procure and laboratory test suitable effluent monitoring equipment are also described in this report.

Finally, some information is presented on the second prototype which will be further modified in the first production model for official land testing and approval as required under the Regulations.

RÉSUMÉ

En vertu de l'accord canada-américain de 1972 sur la qualité de l'eau des Grands lacs, le gouvernement canadian gère un programme d'assainissement visant les déchets de navigation. Ce programme a permis de mettre au point un nouveau mode d'épuration biologique modifié, le système "CABOS" (Carbon Adsorption Bio-oxidation System)*. Au cours de la saison de navigation de 1975, l'Ontario Research Foundation (ORF) a fait l'évaluation du premier prototype installé sur le John A. France, un "vraquier" appartenant à la Scott Misener Steamships Limited et exploité par elle.

Le système effectue la régularisation des débits, l'adsorption sur charbon actif, l'oxydation biologique, la clarification, la filtration et l'ozonation. La qualité moyenne des eaux traitées a varié, suivant les périodes d'essai et les conditions de charge. La $D.B.O._5$ se situait entre 6 et 25 mg/l et les matières en suspension entre 5 et 13 mg/l, nettement sous la limite de 50 mg/l prescrite pour ces deux paramètres dans le nouveau Règlement de prévention de la pollution des Grands lacs par les eaux d'égout.

Suite à cette période d'essai intensive de l'ORF, l'équipage du navire a pu se servir normalement du système en 1976. Au cours de cette même année, l'ORF n'a effectué qu'une supervision et des échantillonnages minimaux. Concurremment, l'ORF a étudié un système automatique pour surveiller la qualité des effluents tel que l'exigent les Règlements découlant de la Loi sur la marine marchande du Canada.

Outre l'évaluation du premier prototype, le rapport decrit les efforts de l'ORF pour choisir, acquérir et essayer l'équipement approprié en laboratoire. On y donne aussi des renseignements sur le deuxième prototype. Le premier modèle de série aura d'ailleurs subi de nouvelles modifications en vue des essais officiels a terre et de l'approbation, conformément au règlement.

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* Système d'oxydation biologique par adsorption su charbon.

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1. Demonstration of the first CABOS prototype aboard the SS John A. France - The first prototype was capable of processing toilet and shower wastes to give a high quality effluent in keeping with the new Great Lakes Sewage Pollution Prevention Regulations. The effluent standards could be met without the polishing filter. The marine engineers satisfactorily performed all operational and maintenance tasks.

It was concluded that the start-up procedure required simplification and that the inclusion of an automatic, excess sludge wasting device would greatly enhance the system. Further, the production prototype should incorporate the best available marine grade materials and protection of electrical and electronic equipment from voltage fluctuations to assure the mechanical and electrical reliability of the CABOS system.

Finally, under the new Regulations, there is a need to include an instrumented effluent quality monitoring package in the present CABOS system.

2. Effluent quality monitoring equipment - A Delta Scientific Ozone Monitor and an HF Instruments Turbidimeter were tested for ozone residual detection and for the indirect measurement of suspended solids, respectively.

This effluent monitoring equipment, evaluated at ORF for three months under indoor pilot plant conditions, appeared to meet requirements and to require a minimal amount of routine maintenance. The turbidity cells of the turbidimeter should be cleaned daily and the calibration checked weekly. Occasional (one to two months) calibration checks and cleaning of the ozone appeared to assure satisfactory operation.

3. The second shipboard CABOS prototype - The second prototype was designed as a number of separate components or modules so that it could be installed on an existing ship without alteration of the ship. An effluent quality monitoring module based on the ORF recommendations was incorporated, as well as a semi-automatic sludge level and wastage control system, but the effluent filter of CABOS I, was omitted.

4. Commercialization - By August, 1977, sufficient experience and confidence had been gained from the systems aboard the SS John A. France and the SS Silver Isle for Scott Misener Steamships Limited (SMSL) to apply to the Crown for a nonexclusive licence to manufacture and market the CABOS system for marine vessel application.

At the time of completing this report, SMSL was also preparing to build the first production model for official testing and approval as required by the Regulations.

1. INTRODUCTION

1.1 Background

The Canada-U.S. Agreement on Great Lakes Water Quality of 1972 embodies the principle that every vessel operating in these waters with an installed toilet facility shall be equipped with a device or devices to contain vessel sewage, or to incinerate it, or to treat it to an adequate degree. Funds made available to the Department of Fisheries and Environment under the terms of the Agreement were consequently directed to several projects designed to resolve the outstanding problem of wastes and pollutant substances generated aboard commercial vessels of all kinds. One of these was with the Ontario Research Foundation as the prime contractor for the development and demonstration of its proposed CABOS waste treatment system for commercial vessels.

The objective of the project has been the development of a viable waste treatment system for commerical vessels which performs successfully in accordance with the demanding requirements of the Great Lakes Sewage Pollution Prevention Regulations under the Canada Shipping Act, as administered by the federal Ministry of Transport. The Regulations require the approval of marine sanitation devices by the Department of Fisheries and Environment (DFE). To be approved, effluent systems must undergo rigorous land testing in an approved testing establishment and, among other criteria, meet the following limits, based on average results:

Suspended Solids (SS) - 50 mg/l or less,
Biochemical Oxygen Demand (BOD) - 50 mg/l or less,
Chlorine residual - not less than 0.5 mg/l nor more than 1.0 mg/l after 30 minutes contact time, or alternately,
Total coliforms - 200/100 ml or less.

The Regulations in their entirety are included in Appendix I, as published in Canada Gazette Part II, Vol III, No. 4 (February 2, 1977).

The first of a series of contracts to ORF was awarded in mid-1973 for Phase I, which included laboratory studies and pilot plant testing; ship selection; preliminary waste survey; and design, fabrication and installation of the prototype aboard ship. Descriptions of the various

units and the findings of these studies under Phase I have been published previously as Technology Development Report EPS 4-WP-76-2, "CABOS - A New Wastewater Treatment System Vessels".

In mid-April, 1975, field evaluation of the CABOS unit aboard the SS John A. France, operating on the Great Lakes, commenced. The intense testing program carried out by ORF during the 1975 season was followed in 1976 by routine, day-to-day operation by the ship's marine engineers with minimum supervision.

The main thrust during 1976 by ORF was to investigate suitable effluent quality monitoring equipment to measure suspended matter and residual disinfectant content as required by Section 6 (7) of the Regulations.

During the 1976-77 winter lay-up SMSL installed a second generation prototype aboard the SS Silver Isle, being operated for Mohawk Navigation Limited. By August, 1977, sufficient experience had been gained from both prototypes to begin construction of the first production model to be land tested at an approved establishment as required under the Regulations.

1.2 Scope

This report describes the 1975 season testing program aboard the SS John A. France, including start-up, daily operational procedures, biological performance, intensive sampling (July, August, October), operational problems, treatment of galley wastes and assessment. With the first prototype operational, 1976 saw a reduction of research and development activity on this project. The report briefly describes conditions aboard ship during 1976 and the efforts of ORF to select, procure and laboratory test suitable effluent turbidity and ozone residual equipment for installation in the CABOS system aboard the SS John A. France. Finally, some additional information is presented on the second unit installed during the 1976 winter layover aboard the SS Silver Isle which, modified further in the first production prototype, is to be land tested for official approval under the Regulations.

2. DEMONSTRATION OF THE CABOS SYSTEM ABOARD THE SS JOHN A. FRANCE

Based on the encouraging results of both the laboratory and pilot plant studies, approval was given for a shipboard prototype. Through the cooperation of the Dominion Marine Association an agreement was signed with Scott Misener Steamships Limited for the construction and installation of a CABOS prototype system aboard the SS John A. France, incorporating certain equipment pre-purchased by DFE.

The first prototype was designed by ORF based on its previous work and a preliminary survey of wastewater aboard the SS John A. France. Scott Misener Steamships Limited built and installed the system prior to the 1975 shipping season.

2.1 Description of First Shipboard Prototype

A flow sheet of the first prototype CABOS unit as originally installed is shown in Figure 1 and a functional diagram in Figure 2. It combined the processes of adsorption on carbon and bio-oxidization for degradation of pollutants, followed by sludge separation, filtration and disinfection. Equipment consisted of a grinder pump, surge tank, multizone aerated reactor, clarifier, multimedia filter, ozone generator, ozone contactor, sludge holding tank, and auxiliary equipment.

Incoming wastewater entered the surge tank via a grinder pump which disintegrated coarse solids and fibres. The surge tank accommodated peak flows and also provided the first step in the bio-oxidization and activated carbon adsorption process.

Mixed liquor from the surge tank was pumped to the horizontal multizone reactor (aeration tank) at a constant flow rate by one of two progressive cavity pumps, and was aerated. The aeration tank was charged with activated carbon. Zone growth of microorganisms and disintegration of bioflocs and suspended solids increased the decomposition rate, leading to a high treatment efficiency.

Mixed liquor from the aeration tank flowed to the clarifier, (Figure 3) which had an arrangement for foam removal by an airlift. Activated sludge, separated in the clarifier (Figure 4), was returned to the surge tank or multizone aeration tank by an airlift or a pump, respectively, excess sludge being stored in an aerated holding tank.

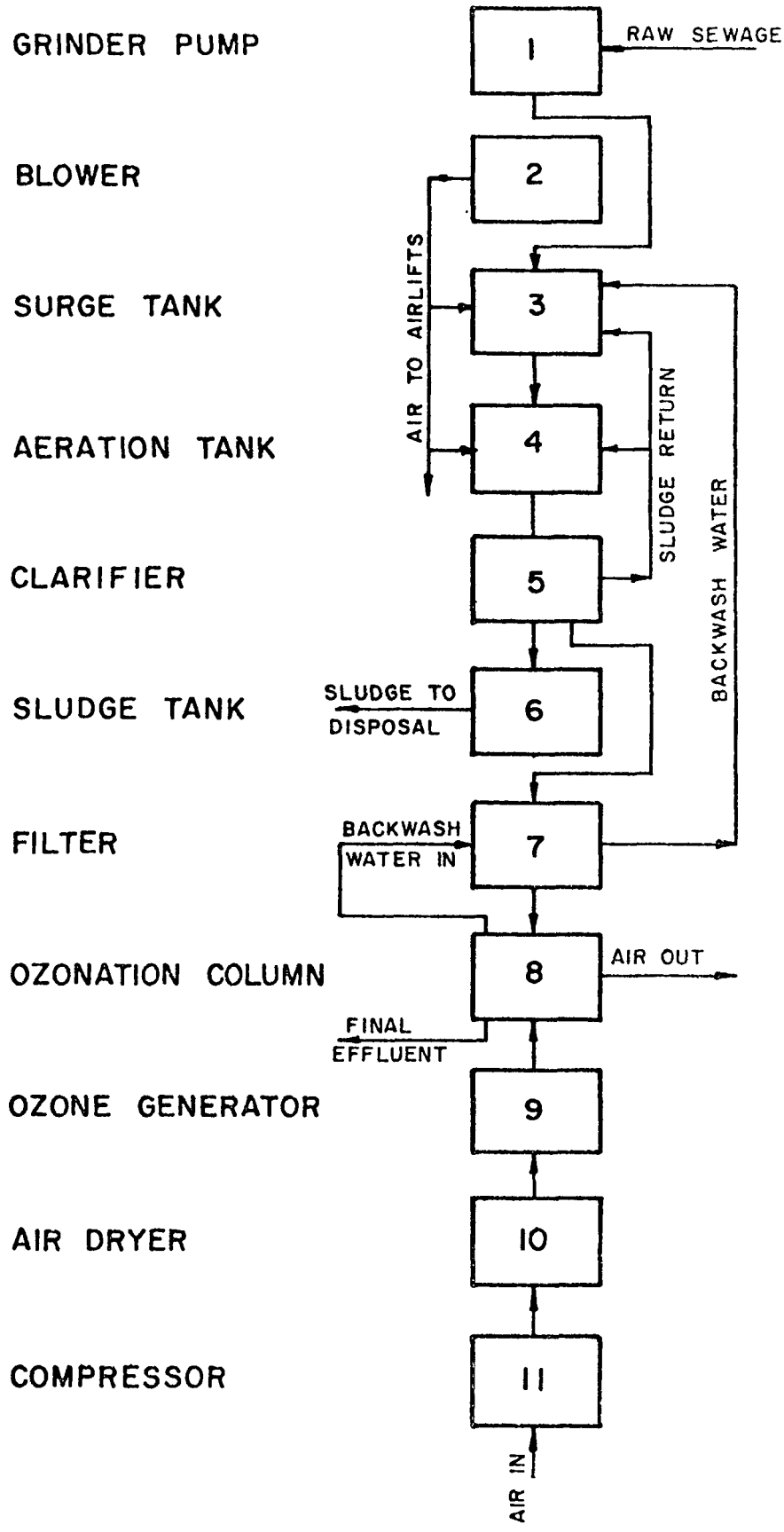

FIGURE 1. FLOW SHEET OF FIRST PROTOTYPE CABOS UNIT

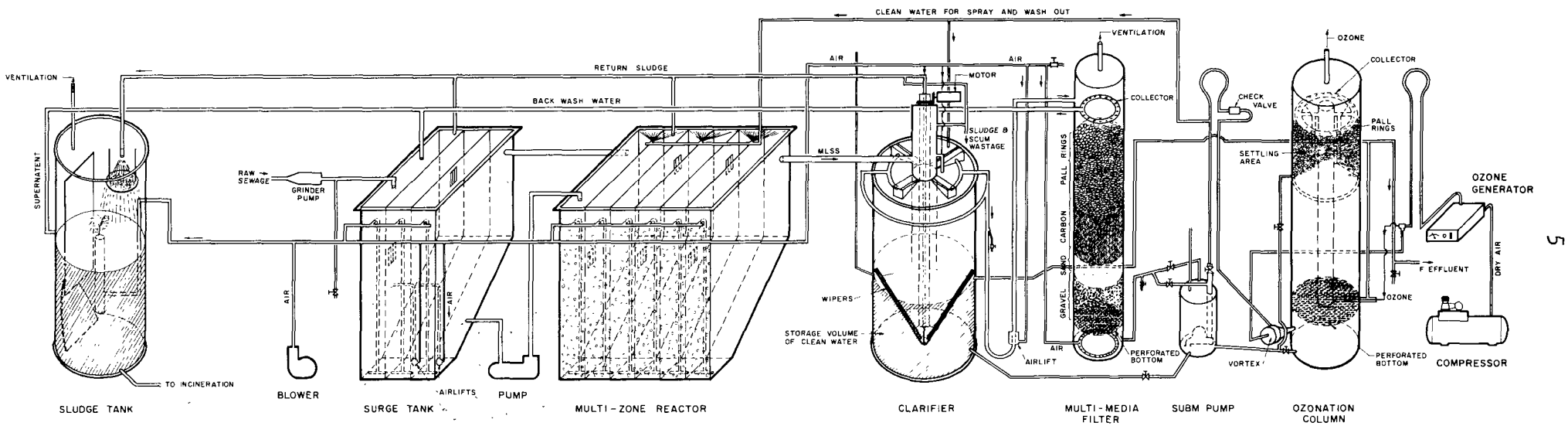

FIGURE 2. CABOS - SHIPBOARD WASTEWATER TREATMENT UNIT (FUNCTIONAL DIAGRAM)

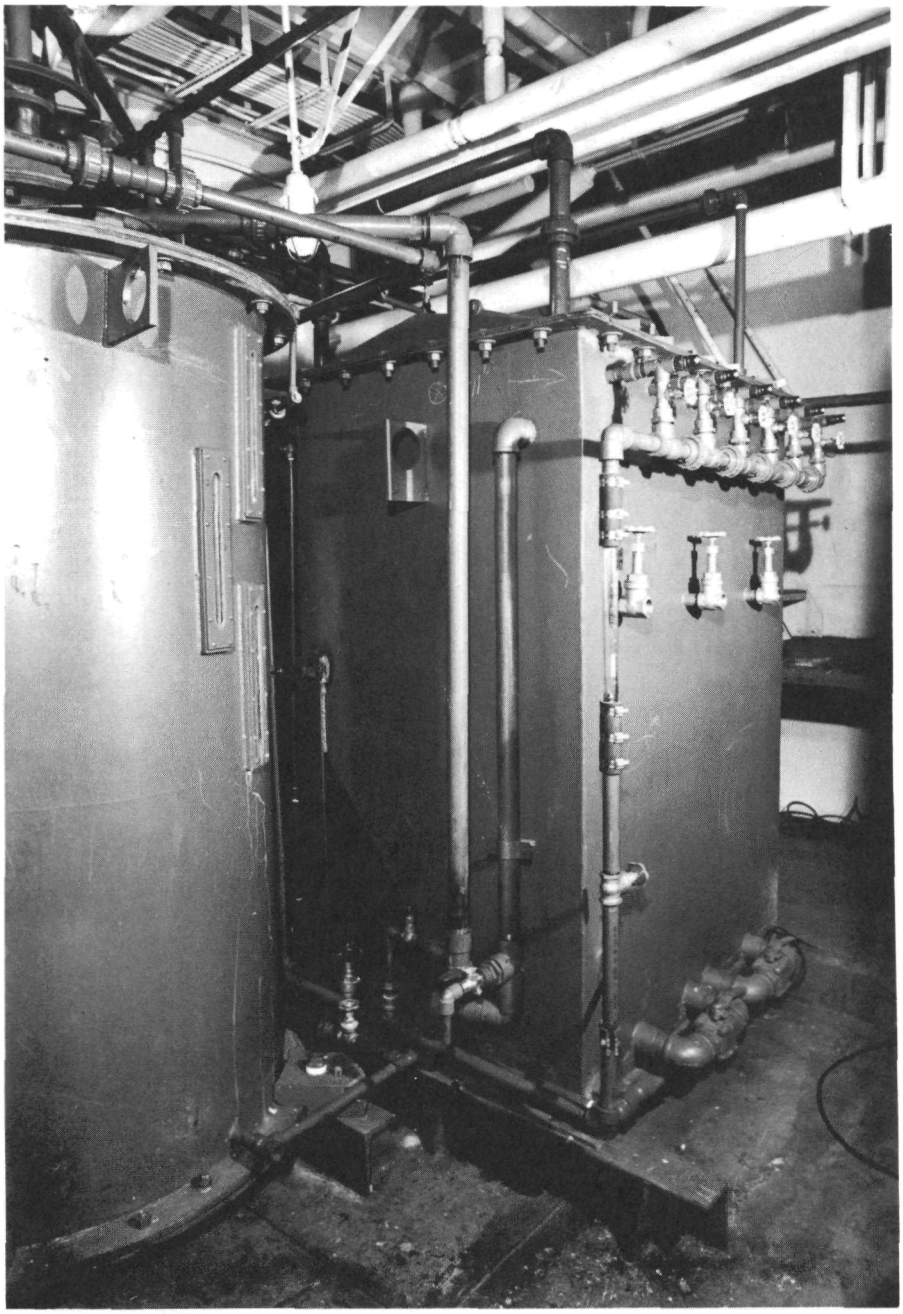

FIGURE 3. AERATION TANK (RIGHT)

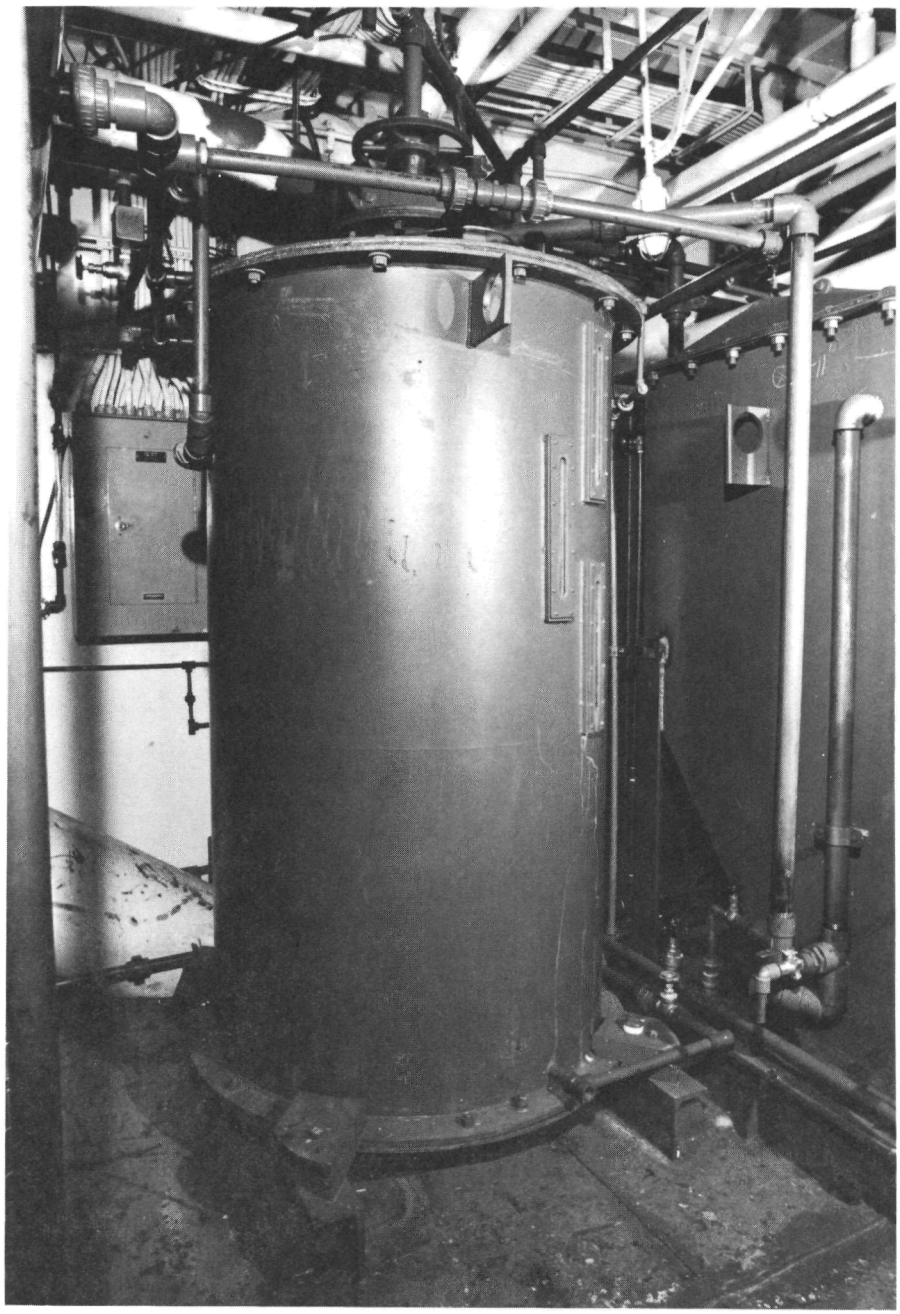

FIGURE 4. CLARIFIER

Effluent from the clarifier was polished in a downflow multimedia filter (right Figure 5) which was periodically backwashed with water from the ozone tank (left Figure 5) and from a storage space under the settling zone of the clarifier. Used backwash water was returned to the surge tank. Piping was provided for by-passing of the filter.

The polished effluent was disinfected by ozone in a specially designed contactor in which ozone distribution was provided by a vortex system. The mixture of polished effluent and ozone flowed up through the packed peripheral part of the contactor and then down through the central part.

Air for the ozone generator was supplied by a compressor and air dryer, while air for the surge tank, aeration tank, sludge holding tank, and air lifts was provided by one of two blowers, or by the ship.

2.2 Ship's Characteristics

The SS John A. France is a bulk carrier, 723 feet long, powered by steam turbines, with a cargo capacity of 26,000 tons. Crew may vary up to 39 men with crew quarters fore and aft. A space of approximately 12' x 9' x 12' was available for the CABOS unit.

The ship's piping was modified to allow the hook-up of several sources of wastewater to the CABOS unit, independently and in any combination. Wastewater not being processed was pumped to the existing stand-by sewage disposal units.

2.3 1975 Season Program

The period from mid-April, 1975, to June, 1975, was used to set up an analytical laboratory aboard and to check out all analytical procedures. The 1975 shipping season was then divided into several experimental periods for testing the unit under different wastewater loads, including operating the unit with a reduced reaction volume in the aeration tank, and with and without the filter.

2.3.1 Start-up

The CABOS unit installed aboard the SS John A. France was started on May 9, 1975. By the fifth day, an appreciable amount of sludge had developed and chemical addition was stopped. The turbidity of the effluent declined and the unit was considered to be in operation.

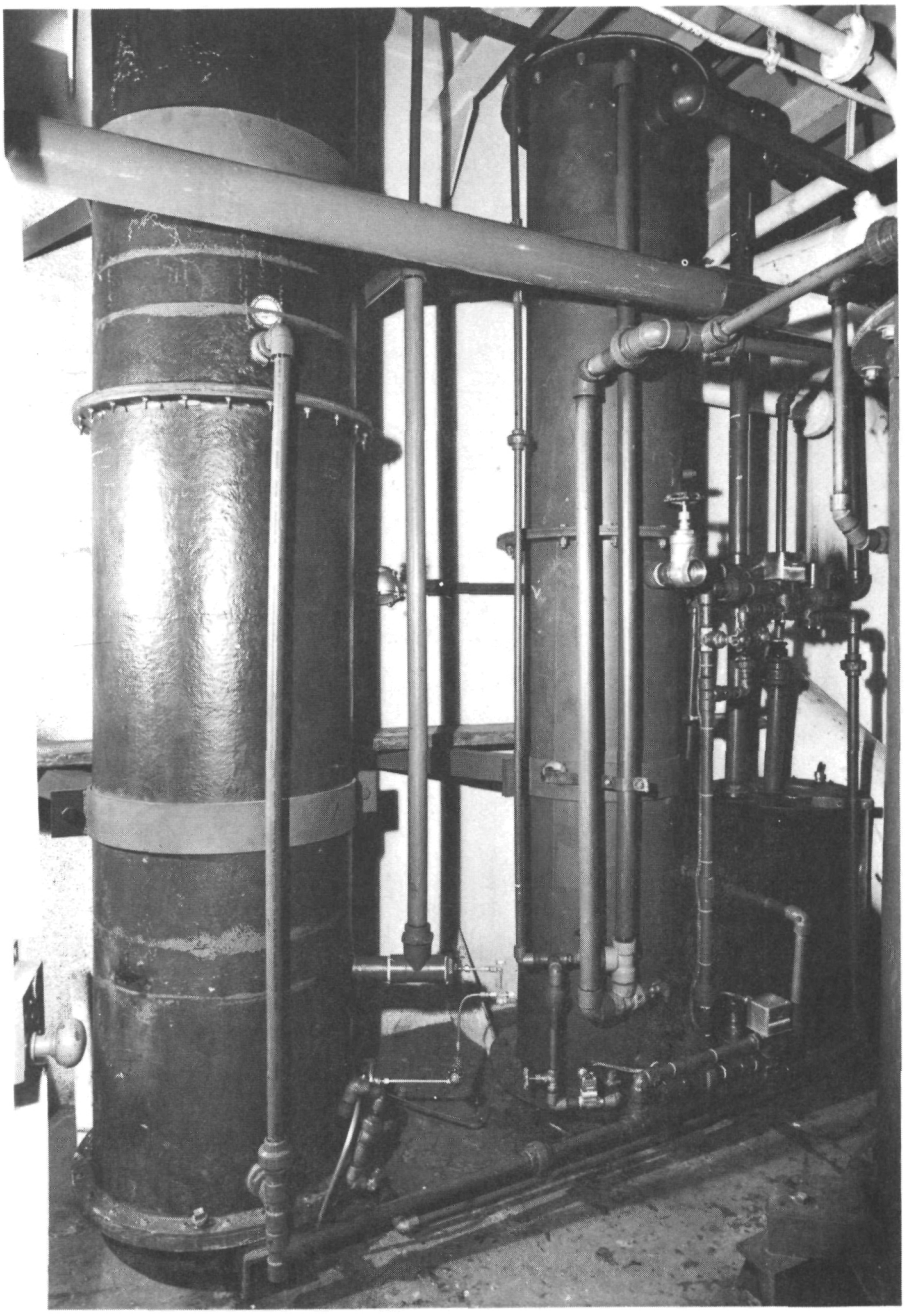

FIGURE 5. OZONE COLUMN AND FILTER

The disinfection subsystem was started on June 3, using the ship's air supply as a feed to the ozone generator. For protection of the air dryer, a prefilter was installed to remove moisture and oil mist.

2.3.2 Daily operational procedures

The daily operational procedures included checks of all mechanical equipment and instruments, backwashing the filter, physical and chemical analyses, recording in log sheets and corrective action as necessary. The specific items are given in Appendix II and Appendix III.

2.3.3 Biological treatment performance

June 7 was chosen as the beginning of the process evaluation period because the unit had passed start-up difficulties by that date, including replacement of granular activated carbon by powdered activated carbon, replacement of piping from the clarifier, and relocation of piping from the surge tank. The unit was in proper functioning order with the concentration of suspended solids in the mixed liquor at 7000 mg/l.

October 22 was chosen for the end of the evaluation period because on that date loading conditions were significantly altered by the addition of galley wastes. The suspended solids concentration in the mixed liquor was also 7000 mg/l at that time.

The intervening months were divided into three experimental periods, each of which contained a time for stabilization and a time for intensive testing. The following samples were collected in the course of the work:

1) raw sewage,
2) mixed liquor,
3) clarifier effluent,
4) filter effluent,
5) disinfected effluent.

Samples were analysed on-board throughout the stabilization periods for temperature, turbidity, pH, conductivity, ammonia (NH_3), total organic carbon (TOC), suspended solids (SS), and settling characteristics. Mixed liquor from each chamber of the aeration tank was analysed for dissolved oxygen (DO).

During intensive testing, additional analyses were done at ORF. These included volatile suspended solids (VSS), soluble organic carbon (SOC), biochemical oxygen demand (BOD_5), total Kjeldahl nitrogen (TKN), nitrates (NO_3), phosphates (PO_4), and coliform count.

A summary of operational conditions and analytical results during the whole evaluation program from June 7, 1975, to October 22, 1975, is given in Table 1.

The average effluent quality during the three testing periods ranged from 6 to 25 mg/l BOD_5 and from 5 to 13 mg/l SS.

2.3.4 Test period 1 - June 7 to July 13, 1975

The treatment flow was: grinder pump - surge tank - full volume of aeration tank - clarifier - filter - ozonation column. Wastewater processed consisted of toilet waste from 33 to 39 persons, and shower and sink waste from 12 to 18 persons. The daily volume varied from 2315 to 3654 litres, with an average of 2801 litres.

During this testing period, and immediately prior to it, no major operational difficulties occurred. It is considered that the results obtained during this period fairly represented the unit's capability under the conditions listed. Analytical results obtained during the intensive testing period from July 6 to July 13, 1975, are presented in Table 2.

The final, disinfected effluent was of excellent quality. Average values were: 5 mg/l SS, 13 mg/l BOD_5 and coliform count 95 organisms/100 ml.

2.3.5 Test period 2 - July 14 to August 23, 1975

The treatment flow was: grinder pump - surge tank - 2/3 of the volume of the aeration tank - clarifier - filter - ozonation column. Wastewater processed consisted of toilet waste from 37 to 39 persons, and shower and sink waste from 19 persons. The daily volume varied from 2334 to 2506 litres, with an average of 2406 litres.

After the first intensive testing period, 1/3 of the reaction volume of the aeration tank was withdrawn from use by blocking passages between the first and second reaction chambers. Feed into the aeration tank was redirected into the second reaction chamber.

TABLE 1. SUMMARY OF OPERATIONAL CONDITIONS AND ANALYTICAL RESULTS, 1975

Testing Period	Dates 1975	Reaction Volume Litres	Food/ Micro-Organisms Ratio	Filter in use	Daily Volume Processed litres	Raw Sewage		Clarifier Effluent		Final Effluent	
						BOD mg/l	SS mg/l	BOD mg/l	SS mg/l	BOD mg/l	SS mg/l
1	July 6-13	1630	0.185	Yes	2801	690	621	31	31	13	5
2	August 17-23	1153	0.407	Yes	2406	1160	827	226	121	25	13
3	October 10-13	1630	0.168	No	3210	201*	228*	20	42	6	10

* Believed not representative.

TABLE 2. INTENSIVE TESTING ANALYTICAL RESULTS - PERIOD 1 (JULY 6 - 13, 1975)

Sample	Data Summary	Suspended Solids ppm	Volatile Suspended Solids ppm	TOC ppm	BOD ppm	NH_3 - N ppm	Turbidity JTU	Total Coliforms / 100 ml
# 1 Raw Sewage	Min.	400	360	264	460	83	67	1.2×10^8
	Max.	786	767	446	780	118	170	8.6×10^8
	Av.	621	587	365	690	105	110	4.1×10^8
# 3 Clarifier Effluent	Min	23	22	23.4	26	26	7.6	4.8×10^5
	Max.	41	38	36.8	34	46	14.0	5.2×10^6
	Av.	31	29	29.6	31	37	11.0	2.7×10^6
	Rem %	95.0	95.1	91.9	95.5	64.8	90.0	99.3
# 4 Clarifier Effluent	Min.	5	4	9.5	6	25	3.5	4.0×10^4
	Max.	7	7	19.8	11	44	7.4	1.8×10^6
	Av.	6	5	16.1	9	35	5.3	7.3×10^5
	Rem %	99.0	99.1	95.6	98.7	66.7	95.2	99.8
# 5 Disinfected Effluent	Min.	4	3	6.8	12	34	2.8	< 10
	Max.	6	5	22.5	14	66	6.0	240
	Av.	5	4	14.0	13	43	4.2	95
	Rem %	99.2	99.3	96.2	98.1	59	96.2	99.99998

Operation of the CABOS unit during the stabilization period and during intensive testing was erratic due to wide variations of pressure in the air supply, which caused many stoppages of sludge return and inadequate filter backwash. This resulted in overcharging of the clarifier, spillage of clarifier effluent, deterioration of clarifier effluent quality, and plugging of the filter by the mechanism described above.

Due to the above mechanical difficulties, the analytical results obtained during this period did not represent the real capability of the CABOS unit under the conditions listed.

Analytical results for the intensive testing period from August 17 to August 23, 1975 are presented in Table 3. The final disinfected effluent was still of good quality. Average values were: 13 mg/l SS, 25 mg/l BOD_5, and coliform count 230 organisms/100 ml.

2.3.6 Test period 3 - August 23 to October 13, 1975

The treatment flow was: grinder pump - surge tank - full volume of the aeration tank - clarifier - ozonation column. Wastewater processed consisted of toilet, shower and sink waste from 31 to 33 persons. The daily volume varied from 3051 to 3496 litres, with an average of 3210 litres.

During this testing period, and immediately prior to it, no major operational difficulties occurred. It is considered that the results obtained represented fairly the unit's capability under the conditions listed. Analytical results for the third intensive testing period are presented in Table 4.

The final, disinfected effluent was of excellent quality with respect to suspended solids and biochemical oxygen demand. However, it did not meet the objective for coliform count. Average values were: 10 mg/l SS, 6 mg/l BOD_5, and coliform count 5300 organisms/100 ml.

2.3.7 Biological load applied

The biological load applied to the unit as mass of BOD_5 per month was calculated for June through October. The volume of wastewater processed was calculated as the difference between the water meter readings at the beginning and the end of each month plus the volume of sludge wasted (including spills). A figure for the average concentration of incoming wastewater was derived from the analytical results obtained during intensive testing and during an assessment conducted on grey water.

TABLE 3. INTENSIVE TESTING ANALYTICAL RESULTS - PERIOD 2 (AUGUST 17 - 23, 1975)

Sample	Data Summary	Suspended Solids ppm	Volatile Suspended Solids ppm	TOC ppm	BOD ppm	NH_3 - N ppm	Turbidity JTU	Total Coliforms / 100 ml
# 1 Raw Sewage	Min.	491	203	497	840	49.1	110	-
	Max.	1320	580	167	1890	127.4	170	-
	Av.	827	358	322	1160	80.8	136	-
# 3 Clarifier Effluent	Min	78	29	40	87	10.9	12	-
	Max.	270	103	184	330	30.3	35	-
	Av.	121	47	71	226	22.5	21	-
	Rem %	85.4	86.9	77.9	80.5	71.2	84.6	-
# 4 Filter Effluent	Min.	11	2	8	19	12.5	3.3	2.8×10^5
	Max.	35	15	43	33	32.3	9.8	3.5×10^6
	Av.	22	8	20	28	20.6	6.8	1.5×10^5
	Rem %	97.3	97.8	93.8	97.6	74.5	95	-
# 5 Disinfected Effluent	Min	11	2	11	12	13.7	3.3	1×10^2
	Max.	16	6	20	40	25.5	9.2	1.3×10^5
	Av.	13	3	14.5	25	18.8	5.5	2.3×10^2
	Rem %	98.4	99.2	99.5	97.8	76.7	95.9	99.98

TABLE 4. INTENSIVE TESTING ANALYTICAL RESULTS - PERIOD 3 (October 10 - 13, 1975)

Sample	Data Summary	Suspended Solids ppm	Volatile Suspended Solids ppm	TOC ppm	BOD ppm	NH_3 - N ppm	Turbidity JTU	Total Coliforms / 100 ml
# 1 Raw Sewage	Min.	117	85	79.5	60	33.4	80	-
	Max.	444	383	365	398	135	130	-
	Av.	228	186	193	201	84.5	103	-
# 3 Clarifier Effluent	Min.	28	25	30.7	15	26.8	9	2.6×10^6
	Max.	70	66	54.9	31	55.1	13	2.4×10^7
	Av.	42	37.1	38.2	20.3	41.4	10.1	6.6×10^6
	Rem. %	81.6	80.0	80.2	89.9	51.0	90.2	-
# 5 Disinfected Effluent	Min.	6	6	16.1	2	29.4	3.0	4.2×10^2
	Max.	17	14	27.4	11	49.8	7.4	1.5×10^4
	Av.	10.1	9.1	20.3	6	38.8	4.7	5.3×10^3
	Rem %	95.6	95.1	89.5	97.0	54.1	95.4	99.92

The biomass loading parameters are summarized in Table 5.

The BOD_5 loads applied to the unit during the evaluation period were as follows:

June	-	22,839 g BOD_5,
July	-	45,761 g BOD_5,
August	-	28,267 g BOD_5,
September	-	25,412 g BOD_5,
October	-	32,115 g BOD_5,

Total biological load applied - 154,394 g BOD_5.

2.3.7.1 Sludge wastage, conversion and age. During the period from June 7 to October 22, 1975, sludge withdrawn was as follows:

Total sludge withdrawn	24,195 g sludge SS,
Assuming 15% activated carbon	3,629 g activated carbon,
Biomass withdrawn	20,566 g biomass SS.

Conversion of food expressed as BOD_5 applied into biomass was 29.6% assuming the concentration of suspended solids in the clarifier effluent to be 45 mg/l. Conversion of food to biomass without counting loss of suspended solids through the clarifier effluent was 13.3%.

The mean cell residence time during the testing program, accounting for 15% activated carbon and sludge wastage, was 32 days.

2.3.7.2 Activated carbon use. During the period from June 7 to October 22, 1975, the material balance for activated carbon was as follows:

Carbon in system on June 7	5,424 g,
Carbon added during testing period	11,123 g,
Carbon in system on October 22, 1975	1,808 g.

Therefore, activated carbon expended during the period was 14,639 g. With an applied biological load of 154,394 g BOD_5, carbon used was approximately 0.1 g of activated carbon for each gram of applied BOD_5.

TABLE 5. BIOMASS LOADING PARAMETERS

ITEM	Period 1	Period 2	Period 3
Volume (l)			
Surge tank	189	189	189
Aeration tank	1430	953	1430
Total	1619	1142	1619
MLSS concentration (g/l)	7.5	7.0	6.2
Less 15% activated carbon	1.125	1.05	0.93
Biomass concentration (g/l)	6.375	5.95	5.27
Biomass in system (g)	10,321	6795	8532
Daily BOD_5 load (g)	1915	2767	1431
F/M	0.19	0.41	0.17

3. ASSESSMENT OF THE FIRST CABOS PROTOTYPE

Operation under real conditions aboard ship during the 1975 season was viewed as a series of experiments under different conditions. Initial difficulties (smell, pipe plugging, etc.), which reflected limited information about on-board conditions, were overcome by modifications to the unit and by provision of extra man-hours for operation. From about June 5th on, most of the difficulties encountered were caused by pressure fluctuation of the air supply. Understandably, a reliable air supply is a prerequisite for successful operation of the CABOS unit.

The following is a summary of experience gained during the 1975 shipping season with the unit installed aboard the SS John A. France.

3.1 Hardware Modifications

After start-up of the CABOS unit, a number of operational difficulties developed. These difficulties fell into three categories: odour, air supply and piping problems.

3.1.1 Odour

Odour was generated in the CABOS and adjacent area through leaks in the lids of the surge tank and the aeration tank, and in the laundry room from the open grinder.

The open grinder was exchanged for a closed grinder pump unit. The new unit had better grinding characteristics and also gave a better opportunity for sampling of raw sewage. The unit eliminated the source of odour in the laundry room.

Also, the 2" Ø air vent system was exchanged for 3" Ø, and problems caused by backpressure were eliminated. Finally, additional bolts were put in the lids of the surge tank, aeration tank and clarifier.

3.1.2 Air supply

The blowers and motors could not withstand the voltage and frequency variations which were encountered aboard ship, and this resulted in damage to one blower and two burnt-out motors. As an immediate solution provision was made for supply of ship's air to the CABOS unit through a pressure regulator.

3.1.3 Piping problems

The pipes between the clarifier and the airlift pump, and the surge tank and the airlift pump, became plugged several times, causing erratic operation of the whole unit. Also, the development of back pressure in the air vent system caused hydraulic imbalance in the airlifts and occasional spillage of clarifier effluent.

Corrective action was taken by modifying the piping as follows:

(a) The 3/4" Ø pipe from the bottom of the clarifier was exchanged for a 1-1/2" Ø pipe and the appropriate valve and unions were installed.

(b) The outflow pipe from the surge tank was relocated. A new coupling was welded on the inclined side of the surge tank about five inches higher than the original. This modification solved the problem.

(c) A hand operated valve was installed in the clarifier overflow pipe.

(d) An air filter was installed on the air supply line to the ozone generator.

(e) A filter by-pass was installed.

3.2 Process Design Considerations

The basic process design of CABOS stood up well to testing aboard ship. The surge tank capacity was adequate for treatment of black water with about 1/3 of the shower and sink waste. However, it had inadequate capacity for surges of the remaining shower and sink waste, and galley waste.

The aeration tank volume was adequate for the required treatment efficiency. The blowers provided with the unit proved to be unacceptable for on-board operation. In the future, the CABOS unit will rely on the ship's air supply.

The cross section, height and hydraulic arrangement of the clarifier fulfilled requirements during most of the 1975 season. When the clarifier effluent did not meet the desired level, the cause was a deficiency elsewhere. The multimedia filter performed as expected. However, the complexity of piping and operation made it an undesirable treatment stage.

The sludge holding tank met the needs of the experimental period. The ozone contact tank was adequate for storage of water for filter backwash. Occasional failure to disinfect treated waste to the required level was probably caused by an unacceptably high load of suspended solids to the tank.

The automatic controls functioned without any problem.

3.3 Galley Waste Treatment

Several attempts were made to process galley waste. However, excessive foaming caused plugging of the air vent, with consequent unreliable operation of the sludge return air lift. Also, foam spilled from the clarifier. Use of a defoamer (Dow Corning DB-31) did not cure the problem.

Since acclimatization of the activated sludge is important, an experiment was conducted in which galley waste was gradually reintroduced into the unit. In this test, it was found possible to increase the load until about half the galley waste was being processed, without significant foaming. However, the work was done at the very end of the season and there was insufficient time to carry out conclusive tests.

4. SELECTION, PROCUREMENT AND LABORATORY TESTING OF EFFLUENT QUALITY MONITORING EQUIPMENT

To meet the requirements of the Great Lakes Sewage Pollution Prevention Regulations, treatment systems must have some form of monitoring for the effluent suspended matter and residual disinfection content prior to discharge.

The effluent monitoring equipment must measure, directly or indirectly, concentrations in the range of 50 mg/l suspended solids and 200/100 ml fecal coliforms.

A contract to the Ontario Research Foundation to select, purchase and laboratory test monitoring equipment for use aboard the SS John A. France was funded by DFE in mid-1976. In this phase of the project, instrument selection and purchase was carried out by ORF on behalf of the Crown. Also, upon receipt, electrical checks were made to ensure all instruments were received in working order.

4.1 Selection

4.1.1 Ozone monitor

The CABOS sewage treatment system uses ozone as a disinfectant. A number of instruments are available which will measure "total oxidants", such as chlorine in water or wastewater, based on amperometric or colourimetric measurements. Modified chlorine residual measuring instruments have also been used for the measurement of ozone in water.

A Delta Scientific Model 8340, employing polarographic membrane electrodes, which are less subject to interferences, was selected because (a) an early model of this type had given satisfactory performance in monitoring ozone residuals from another experimental sewage treatment plant at ORF (CANWEL), and (b) chlorine monitors are also available operating on similar principles but with a different constant voltage potential applied to the electrode.

In the case of ozone and chlorine disinfection, since it is possible to measure for "free residual", this would give a measure not only of disinfection but, indirectly, of the biological oxygen demand of the effluent. For example, a "free" ozone residual will not appear until

the carbonaceous material oxidizable by ozone in aqueous solution has disappeared. Similarly, a free chlorine residual (in the form of HOCl) after 30 minutes would indicate a stabilized effluent. Thus, monitoring for free residuals would also give an indirect indication of the BOD_5 of the effluent.

4.1.2 Suspended solids monitor

It is not possible to continuously measure suspended solids directly, but a satisfactory approach is to record turbidity of the effluent, which is related to the suspended solids content. For a given waste stream of fairly constant composition, a relationship between turbidity readings and suspended solids can be made with reasonable confidence.

An HF Instruments turbidimeter model DRT-200 was selected from a number of similar instruments. Final choice of the HF Instruments turbidimeter was made on the basis of: (a) it is Canadian made and serviced, (b) it has an easily changed and cleaned thread-in type measuring cuvet (glass cell for reading), (c) satisfactory performance was obtained from an earlier HF Instruments model, DRT 1000, at ORF, and (d) it has a claimed voltage stability over a range of 85 to 135 V AC line output.

4.2 Instrument Performance

Laboratory trials of the ozone and turbidity measuring instruments were carried out, with continuous operation during November and December, 1976, and part of January, 1977, on the ozone disinfected effluent from the sewage treatment pilot plant at ORF. The monitoring equipment is shown in Figure 6.

4.2.1 Ozone monitor

4.2.1.1 Calibration. The procedure for calibration of the Delta Scientific Model 8340 given in the manufacturer's manual, while easily accomplished under laboratory conditions, was found to be too complex for shipboard use where the instruments will be on line. A simplified procedure which appeared to entail little or no loss of accuracy when operating on-line on the ozonated effluent at ORF was adopted.

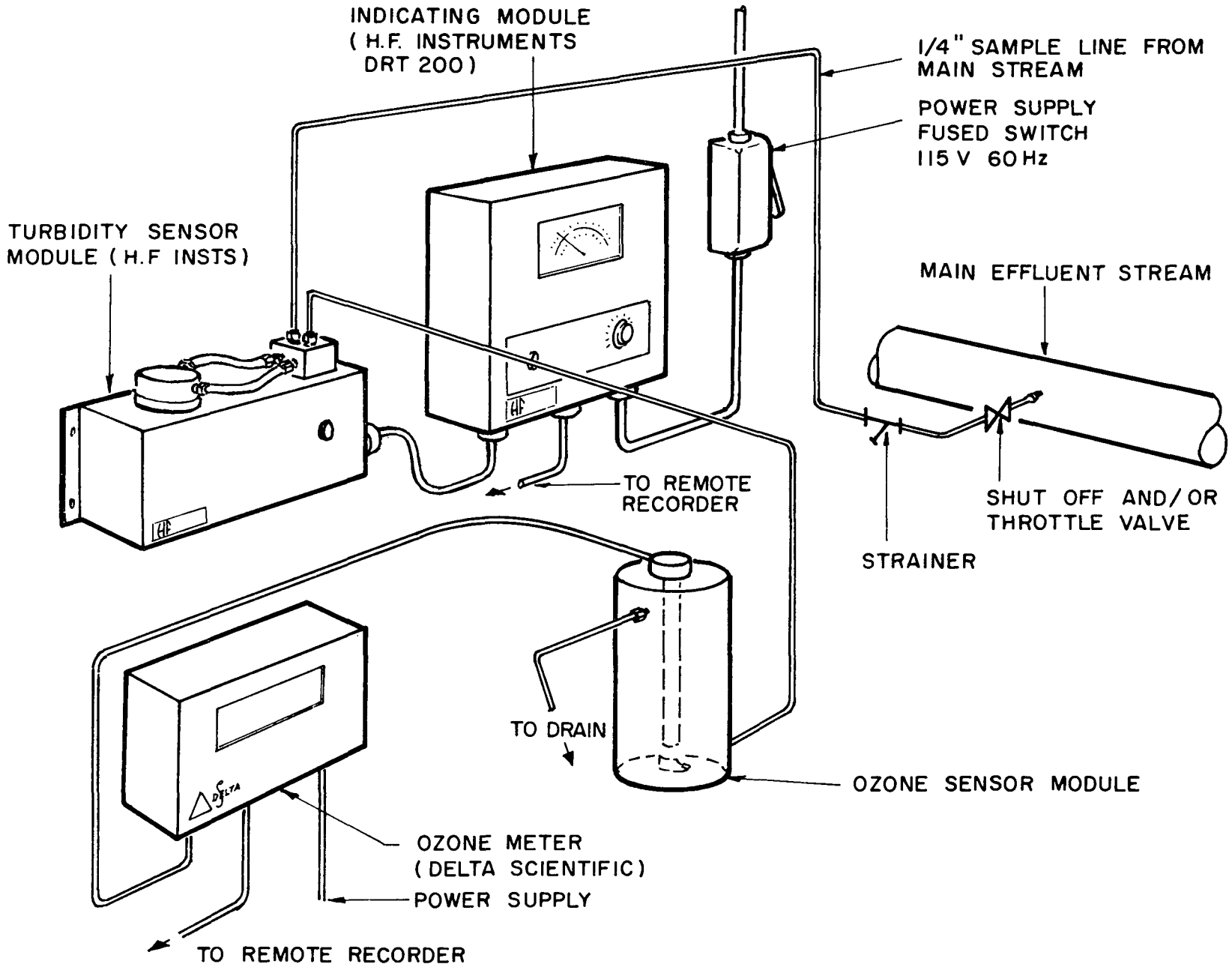

FIGURE 6. MONITORING EQUIPMENT INSTALLATION DETAILS

A sample of the effluent from the exit port of the cell containing the sensor was placed directly into a flask containing neutral potassium iodide. The sample was then acidified, starch indicator added, and the solution titrated to a colourless end point with 0.005N thiosulphate.

The manual warns against this method for calibration because any peroxides present will liberate iodine from potassium iodide and thus give an erroneously high titration and residual ozone value. The rapidity and ease with which this method can be used, with only a flask, reagents and one ml graduated pipette, more than offset any loss in accuracy (<10% under the conditions at ORF).

The zero check of the instrument can be determined by clamping off the flow and allowing the ozone residual to decay. No differences were noted in the zero check with the distilled water method recommended in the manual and two other methods which were tried.

4.2.1.2 With recorder. A Rustrak recorder with a 4-20 ma range was used for most of the trial period. A short trial with a Rustrak recorder operating in the 0-10 mv range was also carried out in January.

Satisfactory recordings of ozone residuals were obtained although it was noted that noise levels, as evidenced by recorder pen fluctuations, were increased over recordings made in the 4-20 ma position. For this reason, it is recommended that future instruments and recorders be ordered and operated in the 4-20 ma current mode because of the reduced sensitivity to external electrical fields. For operation aboard ship, it is also recommended that twin screened wire for connecting the instrument to the recorder with the outer screen connected to instrument and recorder ground be used, particularly if a millivolt output circuit and recorder are used.

4.2.1.3 Routine maintenance. The most sensitive range (0-1 mg/l O_3) of the instrument was used during the trial, with measured ozone residuals generally between 0.2 and 0.3 mg/l. Coliforms in the ozonated effluent under these conditions were not detectable in 500 ml samples and total plate counts were in the order of 20-50 per 100 ml. No real problems were encountered with the instrument in almost three months of continuous operation.

The electrode and cell assembly were cleaned once at the end of two months of operation to remove a fine film of aluminum hydroxide (from alum treatment of the ORF effluent) which had deposited on the cell walls and on the sensor. This had not noticeably affected the response of the instrument. Cleaning was carried out in situ without interrupting power to the instrument by merely opening the cell assembly and cleaning the sensor and cell with a soft moist paper towel.

Although the manual states that no special precautions were necessary to store the probe, it is advisable to keep the probe moist at all times after commissioning since otherwise there is a tendency for the electrolyte to evaporate or leak slowly, resulting in salt deposits in the fine capillaries leading from the electrolyte reservoir to the membrane.

The ozone meter was found to be sensitive to switching transients from other nearby electrical equipment, causing spikes in the AC line which caused the meter to fluctuate briefly. Incorporation of a transient suppressor (GE varistor) across the input AC line to the instrument reduced these effects to a small flicker of the meter needle.

The instrument was sensitive to power outages even if the outage lasted only a minute. The electrodes are of the "passive" type and have an impressed voltage on them which takes time to reach equilibrium. As a result, if power is lost, at least 30 minutes is required for the instrument to come back to its original setting.

4.2.2 Suspended solids monitor

4.2.2.1 Calibration. The HF Instruments DRT-200 turbidimeter is provided with a primary reference standard which has a value of 0.12 Formazin Turbidity Units. Linearity of the instrument was checked in other ranges using Formazin standards prepared in the ORF laboratory according to Standard Methods for the Examination of Water and Wastewater, 13th ed., p. 351. Very good linearity was noted throughout the switched ranges of the instrument. Once calibrated in this range, response in other ranges in a linear manner is obtained. Calibration checks can be carried out without shut-down of the on-line flow to the unit.

4.2.2.2 With recorder. The 0-10 mv output available from terminals 3 and 4 was connected to the Rustrak recorder during the on-line trials. A milliamp output circuit is also available and again it is recommended that for shipboard use a 4-20 ma span recorder output be used to minimize interference from external electrical fields.

4.2.2.3 Routine maintenance. When first tested on-line, the turbidimeter was found to be extremely sensitive to switching transients from electrical equipment. The problem was eventually diagnosed as a fault or faults in the power supply and the instrument was returned for servicing. This delayed testing of the monitoring package by about one month.

On reinstallation the instrument was found to be much less susceptible to voltage transients. Reinstallation of a varistor in the AC line input further reduced this effect. (The electrical problems experienced with this instrument are not likely to be fundamental instrument design problems but rather a fault of this particular instrument since other versions of the HF Instruments turbidimeters employing similar electronic circuitry in the CANWEL program have performed satisfactorily.)

Continuous operation on the ORF biological sewage treatment plant effluent was carried out initially on ozonated effluent and later on an unozonated effluent from the clarifier. The turbidity of the final ozonated effluent from the system at ORF was very low (<1 Nephelometric Turbidity Units) so that there was no need for frequent cleaning of the cell.

It was noticed, however, that a gradual permanent yellowing of the inside of the glass cuvet occurred during operation on ozonated effluent. This was probably due to a coloured oxidation product from ozone attack of the Tygon tubing used to connect the effluent to the cell. Daily cleaning of the cell might have prevented this but it is estimated that a glass cuvet would last at least two to three months without significantly affecting readings when turbidity readings equivalent to 50 ppm suspended solids or less are being measured.

The turbidimeter was also used for a period of three weeks on an unozonated biological effluent with turbidities in the 5-20 NTU range to assess conditions more likely to be encountered aboard ship. Daily cleaning of the cell was carried out. This procedure, which takes less than

a minute when using a spare, clean cell as a replacement, is recommended.

Cleaning of the cuvet is best carried out by rinsing the cell in clear water and, if necessary, using a piece of soft moistened paper towel to remove any adhering deposits on the cell wall. A turbidity reading of 20-22 NTU corresponded to a suspended solids concentration, as determined by the standard gravimetric method, of 50 ppm in the biological clarifier effluent from the plant at ORF.

4.3 Shipboard Testing

It had been intended to conduct shipboard tests of the monitoring package before the end of the 1976 shipping season, but circumstances beyond the control of the ORF prevented this from being carried out.

5. THE SECOND SHIPBOARD CABOS PROTOTYPE - SS SILVER ISLE

The first prototype was thoroughly tested "at sea" for two sailing seasons by marine engineers. During the 1976-77 winter layup, the second prototype was born, founded on the basic sanitary engineering design of the first ORF unit, but modified from experience to be more in tune with the requirements of the then available draft Great Lakes Sewage Pollution Prevention Regulations, and to be operated by marine engineers with a minimum of maintenance and little supervision.

The second version, built entirely by Scott Misener Steamships Limited was designed to be installed on existing ships with a minimum of alteration, for example, the SS Silver Isle. It is made up of a number of components or modules, including:

1) raw sewage pumping, flow measurement and control system for connection to existing holding tank or new tank where required;
2) air requirements for aeration and air lift pumping supplied from the ship's system;
3) clarifier with concentric overflow weir, scum and foam skimming, and mechanical scraper facilities;
4) ozonation equipment self-contained in one cabinet with air compressor, cooling water system and high voltage equipment;
5) ozone chamber now in four consecutive sections to assure intimate contact and to reduce the headroom required;
6) effluent quality monitoring system to continuously measure and record ozone residual and turbidity;
7) settled sludge recirculation by air lift to the aeration tank and a separate sludge collection tank (existing or supplied) by semi-automatic controls;
8) alarm panel using failsafe circuits, readily available components, independent lamp test circuit and low voltage lamps for long life.

An effluent polishing filter was not included in the second prototype flow sheet. Based on the SS John A. France experience, an acceptable effluent of not more than 50 mg/l BOD_5 and 50 mg/l suspended solids based on average results can be achieved without the filter.

ACKNOWLEDGEMENT

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APPENDIX I

GREAT LAKES SEWAGE POLLUTION PREVENTION REGULATIONS

Registration
SOR/77-130 4 February, 1977

CANADA SHIPPING ACT

Great Lakes Sewage Pollution Prevention Regulations

P.C. 1977-229 3 February, 1977

His Excellency the Governor General in Council, on the recommendation of the Minister of Transport, pursuant to subsection 730(1) of the Canada Shipping Act, is pleased hereby to make the annexed Regulations respecting prevention of pollution of the Great Lakes Waters by sewage from ships.

REGULATIONS RESPECTING PREVENTION OF POLLUTION OF THE GREAT LAKES WATERS BY SEWAGE FROM SHIPS

Short Title

1. These Regulations may be cited as the *Great Lakes Sewage Pollution Prevention Regulations*.

Interpretation

2. In these Regulations,

"approved device" means a marine sanitation device approved by the Director, in accordance with these Regulations; (*appareil approuvé*)

"B.O.D." (biochemical oxygen demand) means the quantity of oxygen utilized in the biochemical oxidation of organic matter during a five day period when tested in accordance with the method described in section 507 of Standard Methods; (*demande biochimique en oxygène (D.B.O.)*)

"Director" means the Director, Abatement and Compliance Branch, Water Pollution Control Directorate, Environmental Protection Service, Department of the Environment, Ottawa; (*directeur*)

"discharge" includes, but not so as to limit its meaning, any spilling, leaking, pumping, pouring, emitting, emptying, throwing or dumping; (*déversement*)

"holding tank" means a tank used for the collection and storage of sewage for eventual disposal; (*citerne de retenue*)

"marine sanitation device" means any equipment installed on board a ship that is designed to receive, retain, store, treat or discharge sewage and any process to treat such sewage; (*appareil d'épuration marine*)

"person" includes a partnership or association; (*personne*)

"recognized" means recognized in writing by the Director; (*reconnu*)

"residual chlorine content" means the quantity of free available chlorine when tested in accordance with the amperom-

Enregistrement
DORS/77-130 4 février 1977

LOI SUR LA MARINE MARCHANDE DU CANADA

Règlement sur la prévention de la pollution des Grands lacs par les eaux d'égout

C.P. 1977-229 3 février 1977

Sur avis conforme du ministre des Transports et en vertu du paragraphe 730(1) de la Loi sur la marine marchande du Canada, il plaît à Son Excellence le Gouverneur général en conseil d'établir le Règlement sur la prévention de la pollution des eaux des Grands lacs par les eaux d'égout des navires, ci-après.

RÈGLEMENT SUR LA PRÉVENTION DE LA POLLUTION DES EAUX DES GRANDS LACS PAR LES EAUX D'ÉGOUT DES NAVIRES

Titre abrégé

1. Ce règlement peut s'intituler: *Règlement sur la prévention de la pollution des Grands lacs par les eaux d'égout.*

Interprétation

2. Il faut entendre par

«appareil approuvé» un appareil d'épuration marine approuvé par le Directeur selon ce règlement; (*approved device*)

«appareil d'épuration marine» tout équipement installé à bord d'un navire et conçu pour recevoir, retenir, entreposer, traiter ou déverser les eaux d'égout et tout procédé d'épuration de ces eaux; (*marine satination device*)

«chlore résiduel» le chlore libre dont la quantité restante est déterminée par une épreuve faite selon la méthode de dosage ampérométrique décrite à l'article 409C de Standard Methods; (*residual chlorine content*)

«citerne de retenue» une citerne utilisée pour recueillir et emmagasiner les eaux d'égout avant leur évacuation éventuelle; (*holding tank*)

«demande biochimique en oxygène (D.B.O.)» la quantité d'oxygène consommée durant cinq jours d'oxydation biochimique des matières organiques et déterminée par une épreuve faite selon la méthode décrite à l'article 507 de Standard Methods; (*B.O.D.*)

«déversement» un déversement comprenant, sans en limiter la signification, toute opération de culbutage, expulsion, pompage, évacuation, émission, vidage, jet ou basculage; (*discharge*)

«directeur» le directeur de la Direction de la dépollution et du contrôle, Direction générale de la lutte contre la pollution

etric titration method described in section 409C of Standard Methods; (*chlore résiduel*)

"sewage" means human body wastes and wastes from toilets and other receptacles intended to receive or retain body wastes and includes any sludge or residues from a marine sanitation device but does not include effluent from an approved device that treats sewage to a standard whereby the effluent contains

(*a*) not more than 50 mg/l of suspended solids,

(*b*) not more than 50 mg/l of B.O.D., and

(*c*) a residual chlorine content of not less than 0.5 mg/l or more than 1.0 mg/l after the chlorine has been in contact with the sewage for not less than thirty minutes,

except where, to meet those standards, the sewage has been intentionally diluted, unless the dilution is only that reasonably required to add appropriate chemicals; (*eaux d'égout*)

"Standard Methods" means the Standard Methods for the Examination of Water and Wastewater, fourteenth edition, 1976, published by the American Public Health Association; (*Standard Methods*)

"suspended solids" means the total suspended matter in or on a liquid when tested in accordance with procedures specified in section 208D of Standard Methods. (*matières solides en suspension*)

Prescription of a Pollutant

3. For the purposes of Part XX of the *Canada Shipping Act*, sewage is hereby prescribed to be a pollutant.

Application

4. (1) Subject to subsection (2), these Regulations apply to

(*a*) every ship in the Canadian waters of

(i) the Great Lakes, and

(ii) the St. Lawrence River as far east as the lower exit of the St. Lambert Lock at Montreal; and

(*b*) every Canadian ship in the non-Canadian waters of

(i) the Great Lakes, and

(ii) the St. Lawrence River.

(2) These Regulations do not apply to

(*a*) a naval ship or a ship for the time being used as a naval auxiliary;

(*b*) a ship that is used solely for pleasure and is not carrying persons or goods for hire or reward, whether or not the ship is chartered or hired by or on behalf of the persons carried thereon;

(*c*) a ship the keel of which is laid, or, if no keel is laid, is at a similar stage of construction, on or after the date of the coming into force of these Regulations, until two years after the date of the coming into force of these Regulations; or

des eaux, Service de la protection de l'environnement, ministère de l'Environnement, Ottawa; (*Director*)

«eaux d'égout» les excréments humains et les ordures des toilettes et des autres récipients destinés à recevoir ou à retenir ces ordures et comprend les boues ou les résidus de tout appareil d'épuration marine, mais ne comprend pas l'effluent d'un appareil approuvé si cet effluent contient

a) au plus 50 mg/l de matières solides en suspension,

b) au plus 50 mg/l de D.B.O.,

c) au moins 0,5 mg/l et au plus 1,0 mg/l de chlore résiduel après contact du chlore avec les eaux d'égout durant au moins trente minutes,

sauf si, pour répondre aux normes, les eaux d'égout ont été intentionnellement diluées, la dilution ne dépassant pas toutefois la quantité raisonnablement nécessaire pour ajouter les produits chimiques appropriés; (*sewage*)

«matières solides en suspension» toutes les matières solides présentes dans ou à la surface d'un liquide lors d'un essai conforme à l'article 208D de Standard Methods; (*suspended solids*)

«personne» une personne physique, une société ou une association; (*person*)

«reconnu» reconnu par écrit par le directeur; (*recognized*)

«Standard Methods» la quatorzième édition (1976) des *Standard Methods for the Examination of Water and Wastewater* publiée par l'American Public Health Association. (*Standard Methods*)

Polluant

3. Aux fins de la Partie XX de la *Loi sur la marine marchande du Canada*, les eaux d'égout sont réputées être des polluants.

Application

4. (1) Sous réserve du paragraphe (2), ce règlement s'applique

a) à tout navire dans les eaux canadiennes

(i) des Grands lacs, et

(ii) du fleuve Saint-Laurent jusqu'à la sortie aval de l'écluse de Saint-Lambert à Montréal, à l'est; et

b) à tout navire canadien dans les eaux non canadiennes

(i) des Grands lacs, et

(ii) du fleuve Saint-Laurent.

(2) Ce règlement ne s'applique pas

a) aux navires de guerre ni aux navires pour lors utilisés comme auxiliaires;

b) aux navires servant uniquement à des fins de plaisance et qui ne transportent ni personnes ni marchandises pour un prix de louage ou une rémunération, que le navire soit ou non affrété ou loué par les personnes qu'il transporte ou au nom de celles-ci;

c) aux navires dont la quille est posée ou sinon, aux navires qui en sont à une étape semblable de construction, à la date de l'entrée en vigueur de ce règlement ou ultérieurement jusqu'à deux ans plus tard; ou

(*d*) a ship other than one described in paragraph (*c*), until five years after the date of the coming into force of these Regulations.

Sewage Disposal

5. (1) Subject to subsection (2), no ship shall discharge sewage into any waters described in subsection 4(1) and no person shall discharge or permit the discharge of sewage from a ship into any such waters.

(2) Sewage may be discharged from a ship

(*a*) to secure the safety of the ship or persons on board; or

(*b*) as the result of damage to the ship or its equipment if all reasonable precautions have been taken before and after the occurrence of the damage for the purpose of preventing or minimizing the discharge.

Approved Devices

6. (1) Every ship that is fitted with toilet facilities shall be fitted with an approved device.

(2) Where

(*a*) an application, in writing, has been made to the Director for approval of a marine sanitation device in accordance with Part I of the schedule, and

(*b*) the device meets the applicable requirements of Parts II and III of the schedule,

the Director shall approve the device and issue an approval number in respect thereof.

(3) Subject to subsection (5), where a prototype marine sanitation device has been approved in accordance with subsection (2), all devices that conform in all respects to the prototype shall be deemed to be approved and shall carry the same approval number as the prototype.

(4) Every approved device shall be marked with the approval number in the same place and in the same manner as the information described in subsection 3(1) of the schedule.

(5) The Director may withdraw the approval of a marine sanitation device if he has reason to believe that any part of the device ceases to meet the applicable provisions of these Regulations.

(6) An approved device that is designed to treat sewage shall be so positioned or located as to allow a sample of the effluent to be obtained from inside the ship at a point where there is to be no further treatment.

(7) An approved device that is designed to produce an effluent meeting the standards referred to in paragraphs (*a*) to (*c*) of the definition "sewage" in section 2 shall include instrumentation to indicate the performance of the device by providing an automatic continuous record while the device is in operation, of measurements of the

(*a*) suspended matter, and

(*b*) residual disinfectant content,

present in the effluent and by indicating the time at which the measurements are made.

d) aux navires autres que ceux qui sont décrits à l'alinéa *c*), jusqu'à cinq ans après la date de l'entrée en vigueur de ce règlement.

Évacuation des eaux d'égout

5. (1) Sous réserve du paragraphe (2), aucun navire ne peut déverser des eaux d'égout dans les eaux décrites au paragraphe 4(1) et il est interdit de déverser ou de permettre de déverser les eaux d'égout d'un navire dans ces eaux.

(2) Les eaux d'égout peuvent être déversées d'un navire

a) pour assurer sa sécurité ou celle des personnes à bord; ou

b) en conséquence d'une avarie au navire ou à son équipage, si toutes les précautions raisonnables avant et après l'avarie ont été prises pour prévenir le déversement ou l'amoindrir.

Appareils approuvés

6. (1) Tout navire muni d'installations de toilette est équipé d'un appareil approuvé.

(2) Lorsque

a) le directeur reçoit une demande écrite d'approbation d'un appareil d'épuration marine selon la partie I de l'annexe, et

b) que l'appareil répond aux prescriptions applicables des parties II et III de l'annexe,

le directeur approuve l'appareil et lui assigne un numéro d'approbation.

(3) Sous réserve du paragraphe (5), lorsqu'un prototype d'appareil d'épuration marine a été approuvé selon le paragraphe (2), tous les appareils se conformant en tous points au prototype sont censés être approuvés et portent le même numéro d'approbation que celui du prototype.

(4) Tout appareil approuvé porte son numéro d'approbation au même endroit et de la même façon décrits au paragraphe 3(1) de l'annexe.

(5) Le directeur peut révoquer l'approbation donnée à un appareil d'épuration marine s'il a des raisons de croire qu'une partie quelconque de l'appareil ne répond plus aux dispositions applicables de ce règlement.

(6) Un appareil approuvé conçu pour épurer les eaux d'égout est placé ou situé de façon qu'il soit possible de prélever des échantillons de l'effluent à l'intérieur du navire en un point où l'épuration ne se produit plus.

(7) Un appareil approuvé conçu pour produire un effluent répondant aux normes visées aux alinéas *a*) à *c*) de la définition de l'expression «eaux d'égout» à l'article 2 est muni d'instruments qui indiquent son rendement en mesurant et en enregistrant automatiquement et continuellement pendant qu'il est en marche, la présente dans l'effluent

a) de matières solides en suspension, et

b) du désinfectant résiduel,

ainsi que l'heure où les mesures sont faites.

(8) The record referred to in subsection (7) shall be dated and retained on board the ship for a period of at least twelve months.

(9) When an approved device is fitted in a ship to which these Regulations apply, the owner of the ship shall, within a reasonable time thereafter, notify the Director in writing of

(*a*) the name of the ship;

(*b*) the official number of the ship;

(*c*) the Director's approval number for the device; and

(*d*) the manufacturer's serial number for the device.

(10) Every ship that is fitted with an approved device shall have on board at least two copies of the approved documents described in subsection 3(2) of the schedule.

Equivalents

7. Notwithstanding anything contained in these Regulations, where these Regulations require a marine sanitation device to have a particular fitting, material, appliance or other provision or to undergo a particular test, the Director may allow any other fitting, material, appliance, provision or test, if he is satisfied that the other fitting, material, appliance, provision or test is at least equivalent to that required by these Regulations.

(8) L'enregistrement visé au paragraphe (7) est daté et gardé à bord du navire durant au moins douze mois.

(9) Dans un délai raisonnable après l'installation d'un appareil approuvé à bord d'un navire auquel ce règlement s'applique, le propriétaire du navire communique par écrit au directeur

a) le nom du navire;

b) le numéro matricule du navire;

c) le numéro d'approbation assigné par le directeur à l'appareil; et

d) le numéro de série donné par le fabricant à l'appareil.

(10) Tout navire muni d'un appareil approuvé conserve à son bord au moins deux exemplaires des documents approuvés décrits au paragraphe 3(2) de l'annexe.

Équivalents

7. Par dérogation à ce règlement exigeant de munir un appareil d'épuration marine d'une garniture, d'un matériau, d'un dispositif ou d'un accessoire particulier ou de lui faire subir une épreuve particulière, le directeur peut permettre d'utiliser toute autre garniture, matériau, dispositif, accessoire ou épreuve, s'il est convaincu qu'ils sont au moins l'équivalent de ce qu'exige ce règlement.

SCHEDULE

APPROVAL OF MARINE SANITATION DEVICES

PART I

Approval Procedure

1. (1) Subject to subsection (2), an application for the approval of a marine sanitation device shall identify the device by type or model and shall include in triplicate the following information where applicable:

(*a*) complete construction plans, fully dimensioned, showing the physical and chemical properties of the materials;

(*b*) design parameters and calculations showing

(i) operating principles,

(ii) anticipated performance results under average and extreme conditions of loading, ambient temperatures and ship motion,

(iii) retention time under maximum loading conditions,

(iv) maximum user capacity in terms of flow rate or number of persons the device is capable of serving,

(v) electrical power requirements and circuit diagrams,

(vi) instrumentation, control feature diagrams and specifications,

(vii) means of venting, and

(viii) safety features;

(*c*) installation instructions;

(*d*) operating and maintenance instructions;

(*e*) schedule of production quality control and inspection and test procedures;

ANNEXE

APPROBATION D'APPAREILS D'ÉPURATION MARINE

PARTIE I

Règles d'approbation

1. (1) Sous réserve du paragraphe (2), une demande d'approbation d'un appareil d'épuration marine indique le type ou le modèle de l'appareil et contient, en triple exemplaire, les renseignements suivants, selon le cas:

a) les plans de construction complets, entièrement cotés, montrant les propriétés physiques et chimiques des matériaux;

b) les paramètres et les calculs de l'étude, indiquant

(i) les principes de fonctionnement,

(ii) le fonctionnement prévu dans les conditions moyennes ou extrêmes de charge, de températures ambiantes et de mouvements du navire,

(iii) la durée de retenue dans les conditions maximales de charge,

(iv) la capacité maximale d'utilisation exprimée en débits ou en nombre de personnes que l'appareil est capable de desservir,

(v) l'énergie électrique nécessaire et les schémas des circuits,

(vi) les instruments utilisés, les schémas et les indications se rapportant aux commandes,

(vii) les dispositifs de ventilation, et

(viii) les dispositifs de sécurité;

c) les instructions pour l'installation;

(*f*) the name of the recognized test establishment that performed the tests required by Part III; and

(*g*) all test results obtained and certified by the recognized test establishment referred to in paragraph (*f*).

(2) The information required by paragraphs (1)(*a*) to (*f*) may be submitted prior to obtaining the test results referred to in paragraph (1)(*g*), in which case the Director may issue a partial approval with respect to those items covered by paragraphs (1)(*a*) to (*f*).

PART II

Design and Construction

2. (1) Every marine sanitation device shall be built of materials that are corrosion resistant under the conditions of use and designed

(*a*) so as to prevent the escape of dangerous gases or obnoxious odours into the interior of the ship;

(*b*) so that the device is not an integral part of the ship's structure; and

(*c*) so that the potable water systems or other systems cannot be contaminated by sewage or treated effluent.

(2) Every marine sanitation device shall

(*a*) have all components made of non-flammable materials or of materials that do not support combustion;

(*b*) where possible, have piping and components made of steel or equivalent material;

(*c*) have each part of the device that is required by the manufacturer's instructions to be routinely serviced readily accessible;

(*d*) have, as an integral part of the device, suitable containers for chemicals that are specified or provided by the manufacturer for use in the operation of the device and the containers shall have a means of indicating the remaining supply of such chemicals;

(*e*) have all heavy components of the device securely bolted to seatings and not dependent on connected piping for support;

(*f*) have sampling valves fitted on the device at every location where the design of the device requires periodic sampling; and

(*g*) be designed so that the device operates efficiently when inclined 15° in any direction from the horizontal.

(3) Every holding tank shall

(*a*) be made of steel;

(*b*) be of welded construction;

(*c*) where stiffeners are required, be stiffened on the external side of the plating;

(*d*) be coated internally with an epoxy lining;

(*e*) be fitted with at least one level indicator that

d) les instructions relatives au fonctionnement et à l'entretien;

e) le programme de contrôle de la qualité, les méthodes d'inspection et d'essai;

f) le nom du bureau d'épreuve reconnu qui fait épreuves exigées par la partie III; et

g) tous les résultats des épreuves et attestés par le bureau d'épreuve reconnu visé à l'alinéa *f*).

(2) Lorsque les renseignements exigés aux alinéas (1)*a*) à *f*) peuvent être présentés avant l'obtention des résultats des épreuves visés à l'alinéa (1)*g*), le directeur peut délivrer une approbation partielle quant aux éléments prévus par les alinéas (1)*a*) à *f*).

PARTIE II

Conception et construction

2. (1) Tout appareil d'épuration marine est construit de matériaux qui résistent à la corrosion dans les conditions d'utilisation et est conçu de façon

a) à empêcher la diffusion de gaz dangereux ou d'odeurs nauséabondes à l'intérieur du navire;

b) à ne pas faire partie intégrante de la structure du navire; et

c) que les systèmes d'eau potable ou les autres systèmes ne puissent être contaminés ni par les eaux d'égout ni par l'effluent épuré.

(2) En ce qui concerne les appareils d'épuration marine

a) toutes leurs parties constituantes sont construites de matériaux ininflammables ou de matériaux qui n'entretiennent pas la combustion;

b) si possible, leurs tuyaux et pièces composantes sont construits en acier ou en un matériau équivalent;

c) toute pièce qui, selon les instructions du fabricant, doit faire l'objet d'un entretien courant, doit être facilement accessible;

d) ils doivent avoir des récipients intégrés destinés à contenir les produits chimiques que le fabricant recommande ou fournit pour utilisation dans le fonctionnement de l'appareil et être munis d'un dispositif indiquant le contenu en produits chimiques;

e) toutes leurs pièces composantes lourdes sont solidement boulonnées sur une embase et ne prennent appui sur aucun tuyau raccordé;

f) des robinets de prélèvement d'échantillon sont installés là où il y a lieu de surveiller périodiquement les appareils; et

g) ils doivent pouvoir fonctionner efficacement à un angle de 15° avec l'horizontale.

(3) Toute citerne de retenue

a) est construite en acier;

b) est faite de pièces soudées;

c) a des cornières de raidissement sur la face extérieure des tôles;

d) est enduite à l'intérieur d'un époxyde ou d'un autre enduit approuvé;

e) a au moins un indicateur de niveau

(i) does not require the operator to come into contact with the sewage, and

(ii) indicates when the tank is seventy-five per cent full by volume;

(*f*) not be fitted with baffles;

(*g*) be provided with hand holes or manholes for cleaning purposes;

(*h*) be fitted with a vent made of steel pipe of a diameter and scantlings sufficiently large to avoid excessive pressure buildup and terminating at a safe location not less than 3 m above the uppermost accommodation level; and

(*i*) have a flame screen made of non-corrosive material fitted to the vent outlet.

(4) A holding tank having a maximum capacity set out in column I of an item of the following table shall have

(*a*) the minimum thickness of tank plating set out in column II of that item; and

(*b*) the maximum unsupported flat surface panel area set out in column III of that item:

TABLE

Item	Column I Maximum capacity of tank in l	Column II Minimum thickness of tank plating in mm	Column III Maximum unsupported flat surface of panel areas in m^2
1.	Less than 1300	3.0	0.25
2.	1300 and over but less than 4500	4.5	0.5
3.	4500 and over	6.0	0.8

(5) Every marine sanitation device designed to discharge an effluent into water shall be designed to treat sewage to the standard referred to in paragraphs (*a*) to (*c*) of the definition "sewage" in section 2 of these Regulations.

Documentation and Operation

3. (1) Every marine sanitation device shall be permanently and legibly marked with lettering of at least 3 mm in height, stamped on the device or on a suitable plate fastened to the device, showing where applicable

(*a*) the name of the manufacturer;

(*b*) the name and model number of the device;

(*c*) the date of completion of manufacture (month and year);

(*d*) the manufacturer's serial number;

(*e*) the average and peak capacity (flow rate, volume or number of persons served) of the device and the period of time for which it is rated to operate at peak capacity;

(*f*) the power requirements (voltage and current);

(*g*) the type and quantity of fuel required;

(*h*) the type and quantity of chemicals required;

(i) qui n'oblige pas l'opérateur à venir en contact avec les eaux d'égout, et

(ii) qui indique quand la citerne est remplie à soixante-quinze pour cent;

f) n'est pas munie de chicanes;

g) a des trous de main ou des trous d'homme pour permettre le nettoyage;

h) est munie d'un évent fait d'un tuyau d'acier de diamètre suffisant débouchant à trois mètres au moins au-dessus des emménagements les plus élevés; et

i) est munie à la sortie de l'évent d'une toile pare-flamme faite d'un matériau inoxydable.

(4) Une citerne de retenue dont la capacité maximale est indiquée à la colonne I du tableau ci-après est faite de tôles

a) dont l'épaisseur minimale est indiquée dans la colonne II; et

b) dont la surface plane maximale sans appui est indiquée dans la colonne III:

TABLEAU

N°	Colonne I Capacité maximale de la citerne en l	Colonne II Épaisseur minimale des tôles de la citerne en mm	Colonne III Surface maximale de tôles plane sans appui en m^2
1.	Moins de 1 300	3,0	0,25
2.	1 300 ou plus, mais moins de 4500	4,5	0,5
3.	4 500 ou plus	6,0	0,8

(5) Tout appareil d'épuration marine destiné à déverser son effluent dans les eaux doit être conçu pour épurer les eaux d'égout selon les normes visées aux alinéas *a*) à *c*) de la définition de l'expression «eaux d'égout» à l'article 2 de ce règlement.

Documentation et fonctionnement

3. (1) Tout appareil d'épuration marine porte en lettres permanentes et lisibles d'au moins 3 mm de hauteur, poinçonnées soit sur l'appareil soit sur une plaque assujettie à l'appareil, s'il y a lieu,

a) le nom du fabricant;

b) le nom et le numéro de modèle de l'appareil;

c) la date où la fabrication s'est terminée (mois et année);

d) le numéro de série donné par le fabricant;

e) les capacités moyenne et de pointe (débit, volume ou nombre de personnes desservies) de l'appareil et le temps de fonctionnement à pleine capacité;

f) les besoins en électricité (tension et courant);

g) le type et la quantité de combustible nécessaire;

h) le type et la quantité de produits chimiques nécessaires;

i) la durée du cyble dans le cas d'un incinérateur intégré;

(*i*) the cycle time for an unitized incinerating device;
(*j*) the maximum angles of pitch and roll to which the device is designed to operate satisfactorily;
(*k*) water (salt, fresh or brackish) in which the device is designed to operate;
(*l*) the maximum safe working pressure at which the device is designed to operate; and
(*m*) the maximum operating level of liquid retention components.

(2) The following documentation relating to every marine sanitation device shall be submitted to the Director for approval:

(*a*) directions for
(i) installing the device so that all parts that require servicing are readily accessible and any required flue clearance is provided,
(ii) the safe operation and servicing of the device,
(iii) cleaning, winter lay up and ash or sludge removal,
(iv) installing vent piping and flue piping,
(v) handling, storage and the use of any chemicals necessary for operating the device, and
(vi) recommended methods of making fuel, plumbing and electrical connections, with electrical supply circuit overcurrent protection;
(*b*) a complete parts list;
(*c*) a schematic diagram showing the relative location of each part;
(*d*) a wiring diagram;
(*e*) a description of the servicing that may be performed without coming into contact with sewage or chemicals; and
(*f*) operating directions, safety precautions and warnings, if any, printed in lettering of at least 3 mm in height on a placard suitable for posting on or near the device.

Automatic Operation

4. Every marine sanitation device referred to in subsection 2(5) shall

(*a*) be capable of automatic operation for a period of at least twenty-four hours without supervision; and
(*b*) be fitted with visible and audible alarms to indicate malfunctions.

PART III

Testing

5. Every marine sanitation device shall be tested by a recognized test establishment in accordance with the procedures set out in this Part.

j) les angles maximaux de tangage et de roulis jusqu'où l'appareil est capable de fonctionner de façon satisfaisante;
k) les eaux (salées, douces ou saumâtres) où l'appareil est capable de fonctionner;
l) la pression limite maximale de fonctionnement sans danger; et
m) le niveau maximal de fonctionnement des appareils de retenue des liquides.

(2) Les documents ci-après relatifs à tout appareil d'épuration marine doivent être présentés au directeur pour approbation:

a) les instructions
(i) pour installer l'appareil de façon que toutes les pièces dont il faut assurer le service soient facilement accessibles et que soit prévu tout espace requis pour une conduite de fumée,
(ii) pour faire fonctionner et entretenir sans danger l'appareil,
(iii) pour le nettoyage, la mise au repos durant l'hiver et la vidange des cendres ou des boues,
(iv) pour installer des tuyaux d'aération ou des tuyaux de fumée,
(v) pour manutentionner, emmagasiner et utiliser les produits chimiques nécessaires au fonctionnement de l'appareil, et
(vi) au sujet des méthodes recommandées pour raccorder les conduits de combustibles et les tuyaux, pour connecter les dispositifs de protection contre les surintensités aux circuits d'alimentation en électricité;
b) une liste complète des pièces;
c) un diagramme montrant l'emplacement relatif de chaque pièce;
d) un schéma de câblage;
e) une description des travaux d'entretien qu'il est possible d'effectuer sans venir en contact avec les eaux d'égout ou les produits chimiques; et
f) les instructions relatives au fonctionnement, les précautions relatives à la sécurité et les avertissements, s'il en est, imprimés en lettres d'au moins 3 mm de hauteur sur une affiche à fixer sur ou près de l'appareil.

Fonctionnement automatique

4. Tout appareil d'épuration marine visé au paragraphe 2(5) doit

a) pouvoir fonctionner automatiquement durant une période d'au moins vingt-quatre heures sans surveillance; et
b) être muni d'avertisseurs optiques et sonores qui en indiquent les défauts de fonctionnement.

PARTIE III

Épreuves

5. Tout appareil d'épuration marine est éprouvé par un bureau d'épreuve reconnu selon les règles visées dans cette partie.

Hydrostatic Test

6. (1) Every liquid retention tank or holding tank shall be subject, for one hour, to

(*a*) a hydrostatic pressure of not less than 2.5 m head of water, or

(*b*) a hydrostatic pressure of not less than one and one-half times the maximum to which it could be subjected in service,

whichever is the greater, and shall show no evidence of leakage.

(2) Where a liquid retention tank or holding tank is to be lined with a protective coating, the hydrostatic test referred to in subsection (1) shall be carried out prior to the protective coating being applied.

Materials Suitability Tests

7. In any case where doubt exists as to the ability of a material to withstand exposure and contact with substances normally found in marine sanitation devices, samples of the material shall

(*a*) be partially submerged for one hundred hours at an ambient temperature of 22°C in each of the following substances, namely,

(i) sewage,

(ii) any disinfectant that is required in the operation of the device,

(iii) any chemical compound produced in the operation of the device,

(iv) fresh water,

(v) salt water containing not less than 3.5 per cent sodium chloride, by weight,

(vi) toilet bowl cleansers,

(vii) engine oil (S.A.E. No. 30),

(viii) ethylene glycol,

(ix) household detergents,

(x) bilge cleaning detergents, and

(xi) a mixture of the substances mentioned in subparagraphs (i) to (x) if it appears, in the opinion of the Director, that the deleterious effects of those substances are additive, and

(*b*) be doused twenty times, allowing a one hour drying period between dousing, in each of the following substances:

(i) gasoline,

(ii) diesel fuel,

(iii) mineral spirits,

(iv) turpentine, and

(v) methyl alcohol,

and shall show no significant deterioration in the chemical composition and physical characteristics of the material after such treatment.

Prototype Operational Tests—Discharging Systems

8. (1) A prototype of every marine sanitation device referred to in subsection 2(5) shall satisfactorily undergo the operational test referred to in subsection (3).

Épreuve hydrostatique

6. (1) Toute citerne de retenue ou d'emmagasinage des liquides est soumise durant une heure

a) à la pression hydrostatique d'une colonne d'eau de 2,5 m au moins,

b) à une pression hydrostatique non inférieure à une fois et demie la pression maximale à laquelle elle pourrait être soumise en service,

la plus grande pression étant à retenir, et il ne doit se produire aucune fuite.

(2) Lorsqu'une citerne de retenue ou d'emmagasinage des liquides doit être doublée d'un enduit de protection, il faut faire l'épreuve hydrostatique visée au paragraphe (1) avant d'appliquer l'enduit.

Épreuves des matériaux

7. S'il existe un doute quant à l'aptitude d'un matériau à résister aux substances auxquelles il est exposé ou avec lesquelles il est mis en contact et qui normalement se trouvent dans les appareils d'épuration marine, il faut

a) immerger partiellement des échantillons du matériau durant cent heures à la température ambiante de 22°C dans

(i) les eaux d'égout,

(ii) tout désinfectant nécessaire au fonctionnement de l'appareil,

(iii) tout composé chimique produit durant le fonctionnement de l'appareil,

(iv) de l'eau douce,

(v) de l'eau salée contenant au moins 3.5 pour cent de chlorure de sodium en poids,

(vi) les produits à nettoyer les cuvettes de W.C.,

(vii) de l'huile de graissage (SAE n° 30),

(viii) de l'éthylène-glycol,

(ix) les détergents de ménage,

(x) les détergents pour nettoyer les bouchains, et

(xi) un mélange des substances visées aux sous-alinéas (i) à (x) si, de l'avis du directeur, il semble que la nocivité de chaque substance s'ajoute à celle de toutes les autres, et

b) arroser ces échantillons vingt fois et les mettre à sécher une heure durant après chaque arrosage avec

(i) de l'essence de pétrole,

(ii) du mazout diesel,

(iii) de l'essence minérale,

(iv) de la térébenthine, et

(v) de l'alcool méthylique,

et les matériaux ne doivent montrer aucun changement sensible de leur composition chimique ni de leurs propriétés physiques.

Épreuves de fonctionnement d'un prototype—Systèmes à déversement

8. (1) Un prototype d'appareil d'épuration marine visé au paragraphe 2(5) doit subir de façon satisfaisante l'épreuve de fonctionnement visée au paragraphe (3).

(2) The test referred to in subsection (3) shall be performed on the same device and the device shall be

(*a*) set up in a manner simulating installation on a ship in accordance with the manufacturer's instructions with respect to mounting, water supply, discharge fittings and other piping; and

(*b*) operated in accordance with the manufacturer's instructions.

(3) Subject to subsection (4), after an initial start-up time the device shall be subjected to an operational test involving the following procedures and during which it meets the following requirements:

(*a*) it shall treat fresh sewage that consists of fecal matter, urine, toilet paper and flush water and has a minimum concentration of 500 mg/l of suspended solids and to which primary sewage sludge has been added, if necessary to attain that concentration,

(*b*) in the case of an intermittent treatment device, it shall process sewage of the concentration specified in paragraph (*a*) and of a quantity that is twenty-five per cent greater than the average flow capacity specified by the manufacturer, over at least an eight consecutive hour period on at least ten days within a twenty day period,

(*c*) subject to paragraph (*d*), in the case of a continuous treatment device or a large device, as determined by the Director, it shall process sewage of the concentration specified in paragraph (*a*) over at least ten consecutive days at the average daily flow capacity specified by the manufacturer and, during three periods of each day, the device shall process sewage at the peak flow capacity for the time it is rated at such capacity,

(*d*) in the case of a biological system, during the fifth or sixth day of the ten consecutive day test period, in lieu of the tests specified in paragraph (*c*), the device shall process a quantity of sewage that is twenty per cent of the daily flow capacity specified by the manufacturer,

(*e*) there shall be no sewage or treatment chemicals remaining on the surfaces or in crevices that could come in contact with a person servicing the device in accordance with the description of servicing referred to in paragraph 3(2)(*e*),

(*f*) for one hour of each eight hour test period, it shall be tilted about its transverse and longitudinal axes to the maximum angles specified by the manufacturer and shown on the device in accordance with paragraph 3(1)(*j*) or to 15° from the normal operating position whichever is the greater, and at least one tilt shall be in each one of the four directions about those axes,

(*g*) forty effluent samples shall be taken during the ten day period referred to in paragraphs (*b*) and (*c*) of which, during each day,

(i) one sample shall be taken at the beginning, middle and end of an eight consecutive hour period, and

(ii) one sample shall be taken at a peak flow capacity during the period referred to in subparagraph (i),

(*h*) for two of the eight consecutive hour periods referred to in paragraph (*g*), when effluent samples are taken the influent sewage temperature shall be made to vary from 2°C to 32°C between the second and sixth hours, and

(2) L'épreuve visée au paragraphe (3) est toujours faite sur le même appareil qui est

a) monté de façon à simuler une installation à bord d'un navire faite selon les instructions du fabricant au sujet du montage, de l'alimentation en eau, des dispositifs de déversement et des tuyaux; et

b) utilisé selon les instructions du fabricant.

(3) Sous réserve du paragraphe (4), après un certain temps de marche, l'appareil doit être soumis à une épreuve de fonctionnement comportant les opérations ci-après et durant laquelle il devra répondre aux exigences suivantes:

a) il épure des eaux d'égout fraîches composées de matières fécales, d'urine, de papier hygiénique et d'eau de chasse et ayant une concentration minimale de 500 mg/l de matières solides en suspension, auxquelles ont été ajoutées des boues primaires d'égout, si nécessaire pour leur assurer cette concentration,

b) s'il est du type à fonctionnement intermittent, il épure les eaux d'égout visées à l'alinéa *a*), en quantité dépassant de vingt-cinq pour cent le débit moyen spécifié par le fabricant, durant au moins huit heures consécutives pendant au moins dix jours d'une période de vingt jours,

c) sous réserve de l'alinéa *d*), s'il est du type à fonctionnement continu ou un grand appareil d'après le directeur, il épure les eaux d'égout visées à l'alinéa *a*) au moins dix jours consécutifs au débit quotidien moyen spécifié par le fabricant et, trois fois, chaque jour, il épure les eaux d'égout au débit de pointe le temps qu'il est estimé capable de fonctionner à ce débit,

d) dans le cas d'un système d'épuration biologique, il épure une quantité d'eau d'égout égale à vingt pour cent du débit quotidien spécifié par le fabricant durant le cinquième ou le sixième jour d'une période d'épreuve de dix jours consécutifs au lieu d'être soumis aux épreuves spécifiées à l'alinéa *c*),

e) il ne doit rester ni eaux d'égout ni produits chimiques utilisés pour épurer ces eaux à la surface ou dans des crevasses où ils pourraient venir en contact avec une personne assurant le service de l'appareil selon les instructions visées à l'alinéa 3(2)*e*),

f) durant une heure sur huit heures d'épreuve, il est incliné sur son axe transversal et son axe longitudinal des angles maximaux spécifiés par le fabricant et indiqués sur l'appareil, selon l'alinéa 3(1)*j*) ou de l'angle de 15° à partir de sa position normale de fonctionnement, si cet angle est plus grand, au moins une fois à chacun des quatre angles que permettent de prendre ces axes,

g) quarante échantillons d'effluent sont prélevés durant la période de dix jours visée aux alinéas *b*) et *c*), soit chaque jour

(i) un échantillon au début, au milieu et à la fin de chaque période de huit heures consécutives, et

(ii) un échantillon au moment du débit de pointe durant la période visée au sous-alinéa (i),

h) dans le cas de deux des périodes d'épreuve de huit heures consécutives visées à l'alinéa *g*), des échantillons d'effluent sont prélevés lorsque la température des eaux d'égout qui arrivent dans l'appareil varie entre 2°C et 32°C entre la deuxième et la sixième heure, et

(*i*) at the discretion of the Director, an analysis of each sample of the effluent, and of one sample of the influent, per day, shall be conducted to assess any or all of the following parameters:

(i) total solids,
(ii) volatile solids,
(iii) settleable solids,
(iv) suspended solids,
(v) volatile suspended solids,
(vi) B.O.D. and chemical oxygen demand,
(vii) turbidity in jackson turbidity units,
(viii) total phosphorus,
(ix) disinfectant residual,
(x) pH value,
(xi) fecal coliforms,
(xii) total coliforms, and
(xiii) any additional information, as required by the Director,

in accordance with the methods described in Standard Methods.

(4) When performing the applicable tests referred to in subsection (3), the level of disinfection shall be sufficient to ensure that the final effluent has a fecal coliform count not greater than 200/100 ml.

Prototype Operational Tests—Incinerating Systems

9. If incineration is employed in the final disposal of sewage, the incinerator shall

(*a*) incinerate only when the combustion chamber door is closed;

(*b*) purge the combustion chamber of combustible fuel vapours prior to and after incineration;

(*c*) shut down automatically if the burner does not ignite;

(*d*) not allow an excess accumulation of fuel in the combustion chamber;

(*e*) not produce a temperature on surfaces adjacent to the incineration chamber higher than 67°C and not produce a temperature on surfaces exposed to normal body contact higher than 41°C when operating in an ambient temperature of 25°C;

(*f*) completely burn all incoming sewage to a dry inert ash; and

(*g*) not discharge or emit fly ash, malodours or toxic substances.

Prototype Operational Tests—Recirculating Systems

10. In the case of a marine sanitation device that, according to the manufacturer's specifications, processes sewage to a lesser standard than that referred to in paragraphs (*a*) to (*c*) in the definition "sewage" in section 2 of the Regulations and that recirculates the treated fluid, the tests to be carried out on the device shall be determined by the Director, but the level of disinfection of any recirculated fluid shall be such that the fecal coliform count is not greater than 240/100 ml.

i) chaque échantillon de l'effluent et un échantillon des eaux d'égout qui arrivent seront analysés chaque jour, à la discrétion du directeur, pour déterminer tous les paramètres suivants ou l'un ou l'autre de ces paramètres,

(i) le total des matières solides,
(ii) les matières solides volatiles,
(iii) les matières solides qui précipitent,
(iv) les matières solides en suspension,
(v) les matières solides volatiles en suspension,
(vi) la demande biochimique et la demande chimique en oxygène,
(vii) la turbidité en unités de jackson,
(viii) le phosphore total,
(ix) le désinfectant résiduel,
(x) le pH,
(xi) les coliformes fécaux,
(xii) le total des coliformes, et
(xiii) tout renseignement supplémentaire demandé par le directeur,

au moyen des méthodes décrites dans Standard Methods.

(4) Au moment d'effectuer les épreuves applicables visées au paragraphe (3), le niveau de désinfection doit être suffisamment élevé pour que le compte des coliformes fécaux dans l'effluent définitif ne dépasse pas 200/100 ml.

Épreuves de fonctionnement d'un prototype—Systèmes à incinération

9. Si l'épuration se termine par l'incinération, l'incinérateur

a) ne peut fonctionner à moins que la chambre de combustion ne soit fermée;

b) doit débarrasser la chambre de combustion des vapeurs du combustible avant et après l'incinération;

c) doit cesser automatiquement de fonctionner dans le cas où le brûleur refuserait de s'allumer;

d) ne peut permettre au combustible de s'accumuler excessivement dans la chambre de combustion;

e) ne peut élever la température des surfaces adjacentes à la chambre d'incinération à plus de 67°C ni celles des surfaces normalement exposées à entrer en contact avec le corps humain à plus de 41°C quand la température ambiante est de 25°C;

f) doit réduire entièrement en cendres sèches et inertes toutes les matières qui y pénètrent; et

g) ne peut déverser ni émettre des cendres volantes, des odeurs nauséabondes ou des matières toxiques.

Épreuves de fonctionnement du prototype—Systèmes à recyclage

10. Dans le cas d'un appareil d'épuration marine qui selon les informations du fabricant, épure les eaux d'égout selon une norme inférieure à celle qui est visée aux alinéas *a*) à *c*) de la définition de l'expression «eaux d'égout» à l'article 2 du règlement et qui recycle le fluide épuré, le directeur choisit les épreuves auxquelles il faut soumettre l'appareil, mais le degré de désinfection doit réduite le nombre des coliformes fécaux à 240/100 ml au plus dans le fluide recyclé.

QUEEN'S PRINTER FOR CANADA, OTTAWA, 1977 IMPRIMEUR DE LA REINE POUR LE CANADA, OTTAWA, 1977

APPENDIX II

DAILY OPERATIONAL PROCEDURES - 1975 SEASON

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DAILY OPERATIONAL PROCEDURES - 1975 SEASON

(a) Check all mechanical equipment for proper functioning.

(b) Check air flow at all points of consumption.

(c) Read instruments and fill in "Operation Log Sheet".

(d) Check adjustment of pressure switches and timers.

(e) Backwash the filter (using the procedure given in Appendix III).

(f) Fill in "Automatic Control Log Sheet".

(g) Perform physical and chemical analyses.

(h) Fill in "Analysis Log Sheet".

(i) If the sediment volume after 30 min. of settling is more than 700 ml, waste 30 IG of sludge.

(j) The sediment should be a deep black colour. If it is pale, add 5 lb of powdered activated carbon to the aeration tank.

(k) Exchange circular chart in the level indicator.

(l) Check ozone generator for leaks.

(m) Drain water from the air filter bowl.

(n) Drain condensate from the air supply lines.

(o) Take corrective action as necessary.

(p) Collect samples for analyses to be made at the ORF laboratory.

(q) Report any unusual happenings to Project Manager or Chief Engineer, as appropriate.

(r) Perform additional tasks as required by Project Manager or Chief Engineer.

APPENDIX III

FILTER BACKWASH PROCEDURE

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FILTER BACKWASH PROCEDURE

The procedure for filter backwash using the automatic control was as follows:

(a) Select a time for filter backwash when no peak load is expected.

(b) Wait until pump stops. Liquid level in surge tank is 18-22".

(c) Open valve for backwash water from filter to surge tank.

(d) Close valve for backwash water from filter to overboard.

(e) Check that the valve for scouring air is open one revolution.

(f) Check that timers are adjusted as follows:

(i)	T3 - Filter fill-up time	3 min.
(ii)	T4 - Air scouring time	2 min.
(iii)	T5 - Low water wash time	2 min.
(iv)	T6 - High water wash time	16 min.
(v)	T7 - Settling time	20 sec.

(g) Turn on backwash cycle.

(h) Frequently observe the water level in the surge tank. If the water level reads 55" interrupt backwash cycle, continue with item (j).

(i) Wait until backwash cycle is finished - lights on timers T3 - T7 are off.

(j) Open valve for backwash water from filter to overboard.

(k) Close valve for backwash water from filter to surge tank.