

VCM

Misc. Ideas & Explanations.

12-79

Since I had only explained my 1980 Capital Budget Ideas for the VCM Plant to JOG - I thought it best to explain them to the rest of you. 1980 Ideas attached.

#1 was to run a test - taking a slip stream from the oxy air compressor and run it through a good air filter or ionizing air cleaner - in order to check the amount of dirt coming through the present filters and possibly causing increased fouling & catalyst degradation. If dirty - we should consider a better filtering system.

#6 I've been looking into this. Attached is some miscellaneous information. It "may" be possible that UV light would enhance the formation of HOCl which is the slow reaction in oxy. Enhancing this formation would give better conversion, increased capabilities & capacities.

I haven't checked out using UV in the vent. or Cl₂ feed to R-304.

Additional explanations have been put on the original where needed.

* UV light might break down tars &/or P.E.s. producing something more usable?

Mike MCF

sent
5-3-79

VCM 1980 Capital Budget

1. High Efficiency Air Cleaner for Oxy.

Recommend running side stream of Air through good filter or ionizer cleaner. Could help Oxy run life and performance considerably if there is a little dust carry-over. A little dirt/dust adds up over 1 yr.

2. Split Feed to HCl Colm.

As per attached drawing - Saves Refrigeration & may increase product quality

3. Increase HCl Vapor Overhead Drawoff

The major portion of VCM run to Oxy in the HCl comes in with the liquid HCl. By increasing liquid recycle and vapor drawoff the amount of VCM can be reduced. Also a interchanger here can further lower VCM fed to Oxy. Drawing attached

4. R-101 Packed Bed Reactor. - developmt req'd

Using Activated Carbon, Alumina, et.al to absorb excess chlorine the amount of heavies "may" be reduced also $FeCl_2$ would be absorbed and used - lengthening the R-101 shell life.

5. O_2 to R-304 should be increased to allow more conversion of HCl. Also check HCl addition to R-304 again

6. UV light reacts O_2 AND Hydrocarbons - possible use in Oxy Vent for flammability control. ↑ or elsewhere

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- 7. Ethyl chloride Dehydrohalogenation Reactor.
No idea what this is. (WAS mention in PAST R³D studies)
- 8. Elevate S-307 and Recycle to S306
Save Refrigeration - less lights recovery - higher EDC recovery
- 9. Lower Tars temperature to condense out NaCl
Separate by settler &/or cyclone.
- 10. By pass Refrigerant stream through ^{new} coils in the
compressor suction drum. (eliminates steam coils)
↑ thru manway?
- 11. Check solubility of L.E. overhead deposits in tars.
w/ caution.
- 12. R-305 FeCl₂ Catalyst impregnation. use R-101 EDC
I feel if we run R-305 Catalyst totally FeCl₂
impregnated that there will be a performance
benefit. Feed R-101 EDC to R-305 until sufficient FeCl₂
Absorbed.
- 13. R-101 Off-gas use.
Higher pressure C₂H₄ can be run to the VCM Plant
if Requested - some engineering required. also compressor could
be used on C₂H₄ prior to
ejector.
- 14. TA HCl Condensing.
using an interchanger, K.O. Pot and Pressure control
much of the HCl/VCM mixture from the HCl Column
can be condensed (during shutdown)
Refer to Drawing.
- 15. Oxy N₂ production for plant uses.

treat w/ UV light, carbon Absorption & scrubbing Bal. Comp. Loads

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CALCULATION SHEET

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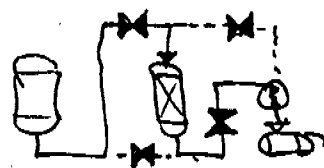
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VCM Debottle neck / Expansion

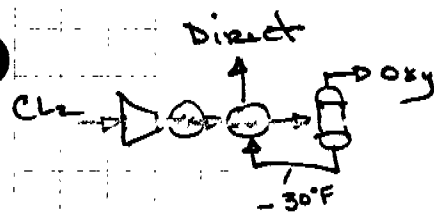
5/79

I Oxy

- 1) Piping Air to elbows for ejector effect - use static mixers down stream if necessary
- 2) Higher horse air compressor for Oxy
- 3) More Catalyst - all reactors 100% for R-303
- 4) R-304 Preheater also steam ejector
- 5) R-303 Backflow piping system for on-line Δp reduction
4 valves - some piping



II Direct



- 1) EDC By Pass Project ($FeCl_2$ absorption)
- 2) bigger Cl_2 compressor - to ease suction problems - maybe to condense most Cl_2 for feed to direct (O_2 & N_2 & H_2 free) Non-condensables to Oxy.
- 3) Davel or Cyclone Solids separators on Acid & caustic washes.
- 4) Iron Traps

III Purification EDC

- 1) Preheat by H.E. Colm condensers, w/ feed EDC on L.E. colm.
- 2) Steam Stripper - ?

IV Secondary - pre-solids removal (prior to ponds).

V Cracking

- 1) Quench or prequench w/ EDC - not tars!
- 2) HCl colm revisions

exchge revisions: H-303⁺, H-304/302, H-305/310

CCl₄ tars → UV HCl + lighter CHCl₃ EDC or VCM? Cl₂?

Ozone/UV process effective wastewater treatment

Toxic wastes made harmless with commercially developed process

H. W. Prengle, Jr., C. E. Mauk, R. W. Legan and C. Hewes, III, Houston Research, Inc., Houston

CHEMICAL OXIDATION of difficult-to-handle impurities in waste-water is practical and economical using an ozone ultraviolet radiation process. The process is particularly effective with toxic and highly refractory compounds such as alcohols, acids, amino acids, fatty acids and polyhydroxy alcohols. Many compounds may be economically oxidized whose reaction rates would otherwise be too low to be processed in other systems.

The process can be used in a number of configurations depending on application. Typically, it is used to handle toxic and/or potentially toxic (when chlorinated) impurities as a combination secondary and/or tertiary process. Performance unequaled by other systems is achievable because of efficient staging of the ozone reactor system with ultraviolet light and results in low capital and operating cost. Ultraviolet radiation enhances the reaction with ozone 10^3 to 10^4 fold and drives the reaction to completion to harmless materials such as CO₂, H₂O, etc.

Much attention has been given to tertiary treatment processes (carbon adsorption, ion exchange, reverse osmosis, chlorination, etc.), which can be added to conventional wastewater treatment processes to remove difficult to oxidize refractory compounds and toxic species and provide effluents which will meet tighter projected discharge standards. However, a number of tertiary processes do not remove all undesirable species some of which produce highly undesirable species¹ when chlorinated in final treatment before discharge or in municipal water treatment.

Now chemical oxidation with ozone is commercially feasible for industrial municipal wastewater treatment for high rate oxidation with improved mass transfer, developed through high interfacial area in a continuous stirred reactor and an optimized reactor system to achieve total utilization of the ozone through use of a multistage reactor. UV radiation provides a critical key to enhance reaction rates dramatically.

Experimental work prove the process' ability to oxidize a wide variety of both inorganic and organic species and

certain composite wastes including: glycine, NH₂CH₂-COOH, the smallest amino acid; ethanol, CH₃CH₂OH; acetic acid, CH₃COOH; glycerol, CH₂OHCHOHCH₂OH; palmitic acid, CH₃(CH₂)₁₄COOH; nitrogen compounds; potassium cyanide; complexed cyanides, cadmium, copper, nickel, iron; photographic wastes, bleach, fixer; medical wastes; secondary effluent, and others. The most difficult to oxidize species are potassium ferricyanide, ethanol and acetic acid; the latter, a product of partial bio and chemical-oxidation of numerous organic materials. In the absence of UV radiation, acetic acid is essentially unoxidized by ozone; however, with UV radiation oxidation proceeds rapidly at room temperature.

REFRACTORIES AND TOXICS CHARACTERIZATION

For purposes of comparison of different refractory and toxic species, a "Refractory Index (RFI)" is defined which is a measure of the difficulty of oxidation of a given molecular species; i.e., the larger RFI, the more difficult the species is to oxidize. A set of standard run conditions are used as follows.

Ozone is used as the oxidant in a run conducted at room temperature (25-27° C). Initial concentration of reactant is 50-100 mg/l. Reactor is operated in the good to excellent mixing regime. No ultraviolet radiation is used.

RFI is calculated by the equations,

$$RFI \text{ (hrs.)} = \frac{B_c^o \text{ (mg/l)} t_{1/2} \text{ (hrs.)}}{A^o \text{ (mg/l)}} \quad (1a)$$

$$B_c^o \text{ (mg/l)} = \frac{\dot{m}_B \text{ (mg/min.) } t_{1/2} \text{ (min.)}}{V \text{ (l)}} \quad (1b)$$

where B_c^o is the cumulative O₃ pumped into the liquid

TABLE 1—RFI values for various compounds

Compound	RFI-value	Qualitative scale
KCN.....	0.41	Slightly refractory (RFI < 1)
Color (α-units).....	0.68	
Complexed Cd-cyanide.....	0.96	
Phenol.....	4.4	Refractory (RFI 1 → 100)
Ammonium ion.....	8	
Simulated medical waste.....	13	
Glycine.....	19.7	Highly refractory (RFI 100 → 1,000)
Palmitic acid (as NH ₄ -salt).....	27.3	
Glycerol.....	112	
Ethanol.....	245	Very highly refractory (RFI > 1,000)
Complexed ferricyanide.....	270	
Acetic acid.....	>1,000	

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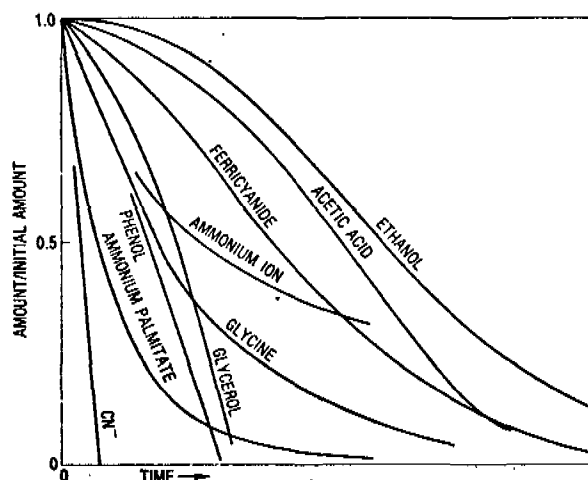


Fig. 1—Typical removal curves for refractory compounds by ozone with UV near 30° C.

- phase from $t = 0$ to $t = t_{1/2}$, per liter of liquid
- $t_{1/2}$ is the time required for 50 percent complete conversion of the reactant component, as measured by TOC for organic species and an appropriate method for inorganic species
- A_0 is the initial amount of reactant component
- m_B is the O_3 mass feed rate to the reactor
- V is the liquid volume in the reactor.

Values of RFI of various compounds studied are shown in Table 1. Potassium cyanide (free cyanide) is least refractory of all compounds studied; acetic acid is most refractory, with complexed ferricyanide, ethanol and glycerol in the highly refractory category.

OZONE OXIDATION WITH UV

Although the Ozone-UV process was initially developed for treatment of complexed cyanides,² it is successfully

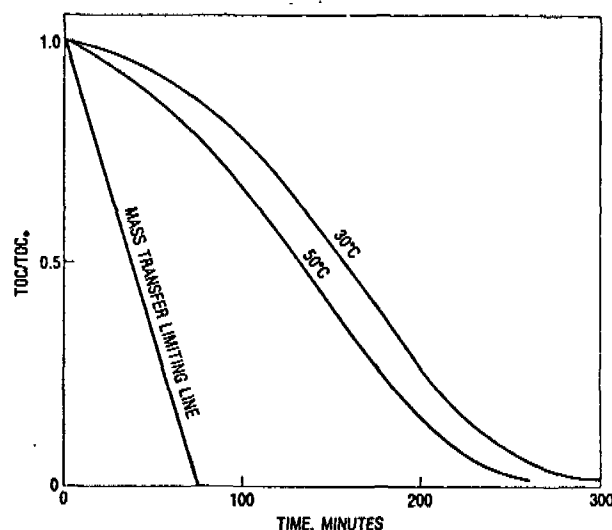


Fig. 2—Ozone oxidation of acetic acid, effect of temperature at low UV intensity.

applied to treatment of many other wastewater species some of which are represented in Fig. 1. Curves of Figs. 1, 2 and 3 result from experimental studies in a batch, continuously sparged and stirred mix reactor. Reactor design permits direct size scaleup without difficulty.^{3,4}

Acetic acid, which is an important intermediate oxidation product of most organic materials, is also one of the more difficult to oxidize species (Fig. 1). However, a slight elevation in temperature has a marked effect on acetic acid destruction (Fig. 2). The mass transfer limiting line is the theoretical stoichiometric limit based on the rate at which ozone is added to the liquid. Improvement up to this limiting line by elevating temperatures alone is impractical.

Ultraviolet light can be used to further improve ozone oxidation of acetic acid (Fig. 3). No reduction of TOC

TABLE 2—Photochemical data on refractory compounds

Compound/(RFI)	Structure	UV absorption range (nm)	Primary photochemical processes	Reference
Acetic acid (>1,000)	$\text{H}_3\text{C}-\text{C}(=\text{O})\text{OH}$	Peak: 205 180-230	1) $\text{R} + \text{CO}_2\text{H}^{++}$ (or $\text{CO}_2 + \text{H}$) 2) RCO_2^{++} (or $\text{R} + \text{CO}_2$) + H 3) RCO^{++} (or $\text{R} + \text{CO}$) + OH 4) $\text{RH} + \text{CO}_2$	⁵ (p. 428 and 431)
Ferricyanide (270)	$[\text{Fe}(\text{CN})_6]^{-3}$	230	Electron transfer to water of hydration	⁵ (p. 270)
Ethanol (245)	$\text{H}_3\text{C}-\text{CH}_2\text{OH}$	Peak: 182, 152 150-200	1) $\text{C}_2\text{H}_5^{++}$ (or $\text{C}_2\text{H}_4 + \text{H}$) + OH 2) $\text{CH}_3\text{CH}_2\text{O}^{++}$ (or $\text{CH}_3 + \text{CH}_2\text{O}$) + H 3) $\text{C}_2\text{H}_4 + \text{H}_2\text{O}$ 4) $\text{CH}_3\text{CHO} + \text{H}_2$ 5) $\text{CH}_4 + \text{CH}_2\text{O}$	⁵ (p. 442, 444)
Glycerol (112)	$\text{H}_3\text{C}-\text{CH}_2-\text{CH}_2\text{OH}$	Peak: 210, 260 190-280	Free radical and intramolecular photodissociative processes	⁶
Glycine (20)	$\text{H}_2\text{N}-\text{CH}_2-\text{COOH}$	Peak: 240, 210 190-240	1) Acid type processes, and 2) Amine type, $\text{RNH} + \text{H}$	⁵ (p. 455 ff) ⁷
Chloroform	$\text{H}-\text{C}(\text{Cl})_3$	Peak: 285, 180 250, 240	1) Free radicals (similarly for CCl_4)	⁸ (p. 526, 527)
Ozone	O_3	Peak: 260 150-300	1) $\text{O}_3(\text{S}_0) \rightarrow \text{O}_3(\text{S}_1)$ 2) $\text{O}_3(\text{S}_1) \rightarrow \text{O}_2(^1\Delta_g) + \text{O}(^1\text{D})$ 3) $\text{O}_3(\text{S}_1) \rightarrow \text{O}_2(^1\Sigma_g^-) + \text{O}(^1\text{D})$ 4) $\text{O}_3(\text{S}_0) \rightarrow \text{O}_3(\text{T}_1) \rightarrow \text{O}_2(^3\Sigma_g^-) + \text{O}(^3\text{P})$	⁹ (p. 207-209)

PRIMARY
PHOTOCHEMICAL
PROCESSES

INITIAL OXIDATION

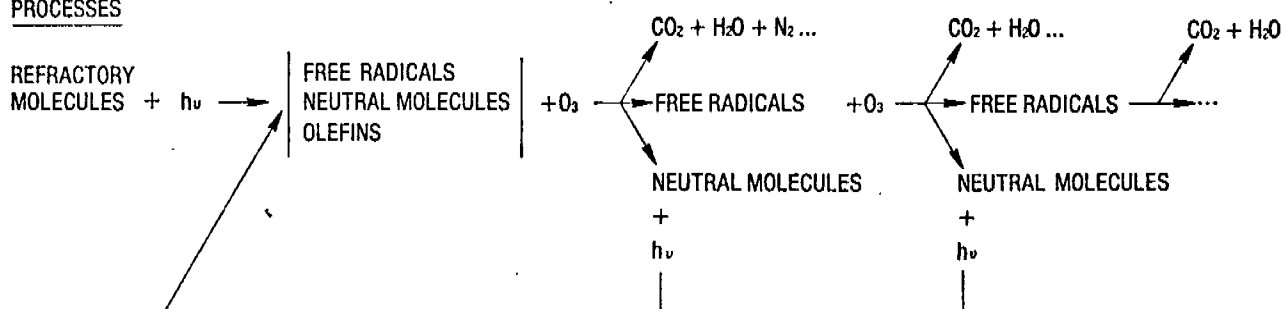


Fig. 5—Over-all photochemical/oxidation process to produce CO₂, H₂O, etc.

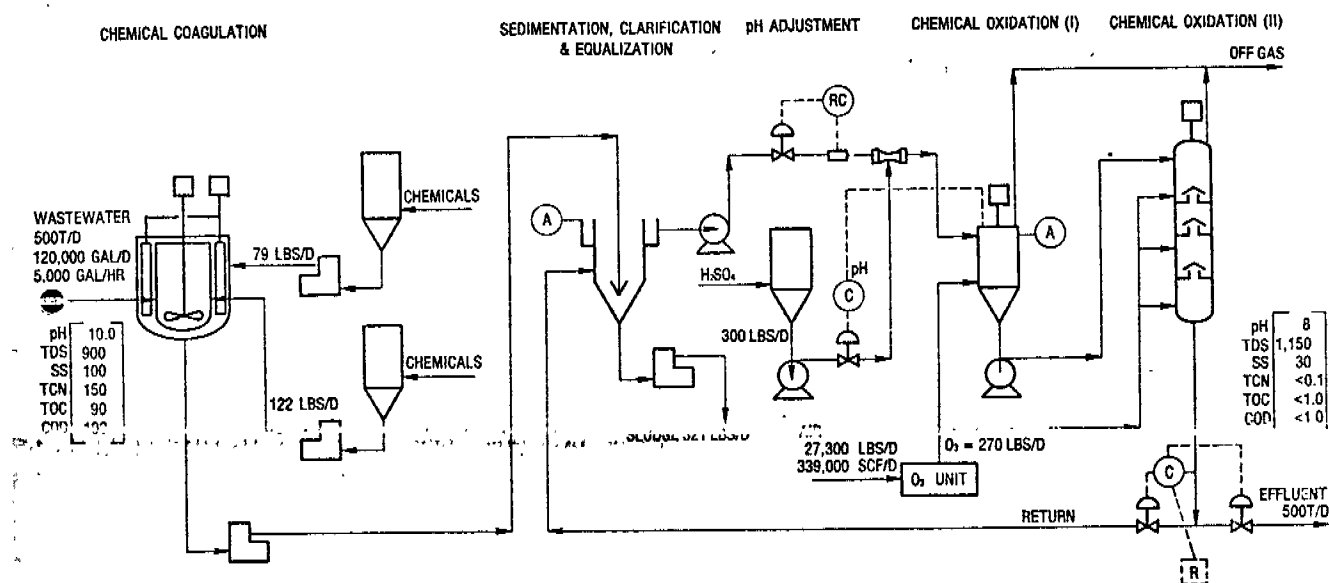
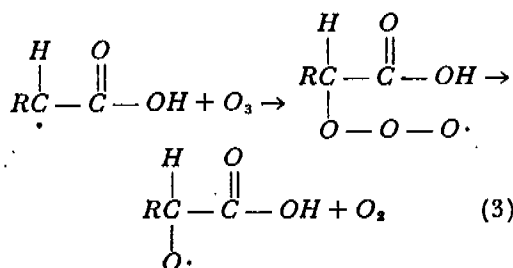
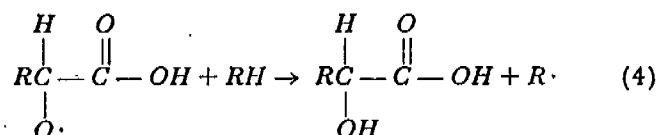


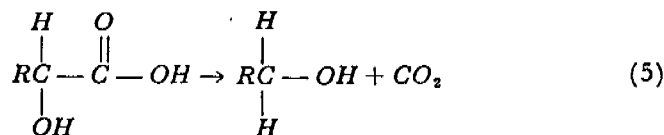
Fig. 6—Process flow for mixed cyanides plus organic refractories oxidation.



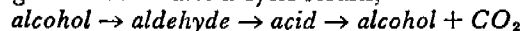
The cycle of the chain propagation is then closed by the free radical removing a hydrogen from a neutral molecule



with the unstable molecule immediately rearranging to release CO₂



In a similar manner, alcohol formed is oxidized to an aldehyde, which is in turn oxidized to an acid. Therefore, for long chain molecules a cycle results,



and in the limiting case of a one-carbon-chain, water (not alcohol) is formed on oxidation of the acid.

UV radiation produces substantially more free radicals than ozone alone; the radicals initiate many more propagation chains and cause the over-all reaction to proceed much, much faster. The over-all photochemical process to produce CO₂, H₂O, N₂, etc., can be represented schematically (Fig. 5). The two-step initiation process (primary photomechanical process and initial O₃ oxidation) is fol-

alum, activated silica and polyelectrolyte, followed by sedimentation, clarification and equalization. The pH is adjusted to 7-8 by acid addition for best results in the chemical oxidation reactors. A single-stage reactor (I) to oxidize front end RFI compounds is followed by a multi-stage reactor for final oxidation of high RFI compounds. Multistaging permits more effective oxidation, reduces total reactor volume and thereby capital cost. Ozone is supplied by a commercially available ozonator. The unit operates on air.

Installed plant cost is \$590,000 and operating cost, including amortization, is approximately \$500/day.

► **Removal of ammonia, cyanide and organic nitrogen compounds (Fig. 7).**

Wastewater treatment processing 700 tons/day (117.4 gpm) containing ammonia, cyanide and organic nitrogen compounds with a total nitrogen content of 1,000 mg/l. The objective of the plant is to reduce the ammonia, cyanide and organic materials to a dischargeable level. The first step is to adjust pH to basic and strip out ammonia with steam. Afterward, pH is further adjusted to near neutral for best results in two chemical oxidation reactors. Ozone is provided by generators using recycled oxygen. Installed facility cost is \$334,000 and operating cost (including amortization) is approximately \$225/day.

► **Tertiary treatment to specifically oxidize refractory organics which would produce toxic compounds if chlorinated (Fig. 8).**

Potentially toxic refractory organic compounds remaining after secondary treatment and carbon adsorption are removed in this facility. A stream of 1 million gallons/day contains 10 mg/l of TOC which must be reduced to a concentration of less than 0.1 mg/l. The influent stream from the previous units is flow controlled to the multistage reaction unit where compounds undergo complete oxidation to carbon dioxide and water. Ozone is supplied by commercially available ozonation unit operating on air. Ozone concentration is adjusted automatically by an effluent monitor. Installed cost of the entire facility is \$505,000.

PROCESS ECONOMICS

Effective reactor staging results in lower total amortized capital and operating costs (Table 3) where the optimum cost is less than a third of the single-stage treating cost. A similar cost analysis can be prepared for any wastewater species for which reaction rate data are available. Indication of the cost contribution for a reactor with mixer and ultraviolet lights is given in Fig. 9. Costs of ozone generated from air and from oxygen (Fig. 10) include the cost of oxygen.

ACKNOWLEDGMENT

Houston Research, Inc., wishes to acknowledge the U.S. Air Force Contract (AFSC/AFWL), F29601-73-C-0065, and U.S. Army Contract (MERDC), DAAK02-74-C-0239, under which substantial development of this process was carried out.

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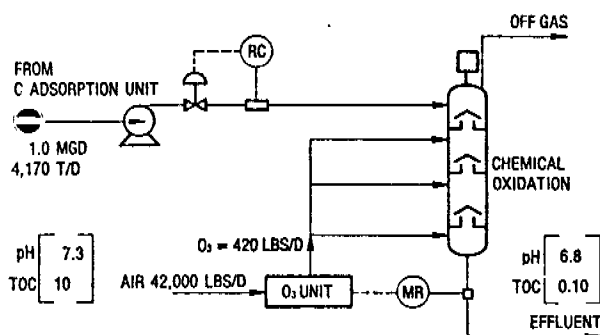


Fig. 8—Process flow for oxidation of refractory organics.

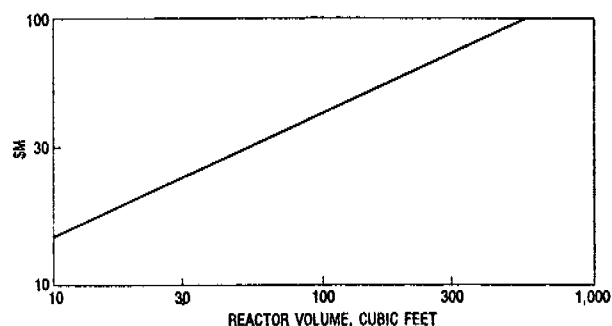


Fig. 9—Installed cost of stainless steel reactor, mixer and UV lights.

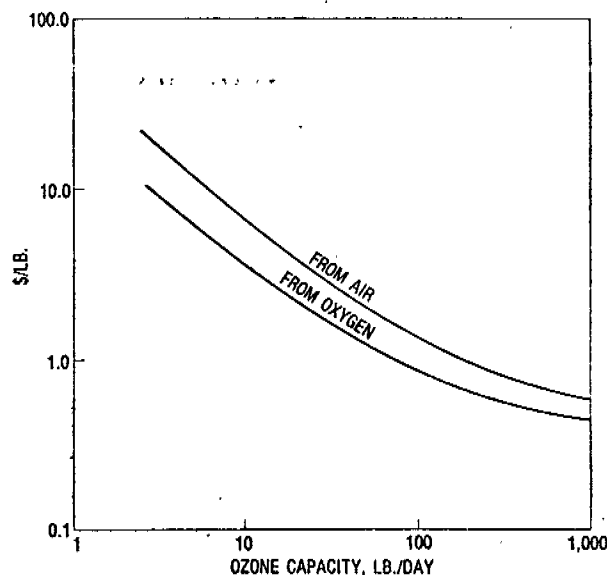
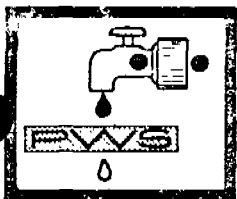


Fig. 10—Cost of producing ozone, including 10-year amortization.

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PURE WATER SYSTEMS, INC

4 EDISON PLACE • FAIRFIELD, NEW JERSEY 07006 • TEL: (201) 575-8750

November 14, 1979

M. McCaulley
Conoco
P.O. Box 727
Westlake, LA 70669

Mr. McCaulley:

In response to your recent request, I am forwarding information about the ultraviolet purification equipment that we produce.

Our research has recently resulted in our being able to expand the use of our "thin-film, high-energy" ultraviolet equipment into the arena of destruction of toxic compounds.

Our process encompasses the injection of an oxidizing compound (H_2O_2) into the flow stream of the compound being treated followed by exposure to our high intensity ultraviolet plasma for approximately 200 seconds. This ultraviolet exposure has a multiple reaction in the decomposition of the toxic compound. The H_2O_2 is dissociated photochemically to H, OH, and O_2 . Additionally, the 184 nanometer ultraviolet will ionize the O_2 to O_3 . The combination of OH and O_3 with the ultraviolet environment supply sufficient energy potential for the destruction of not only a very wide range of toxic compounds, but very high concentrations of these compounds. Compounds which we have successfully treated to are: cyanides (ferro, sodium, potassium, and complexed cyanides), phenols, PCB's, THM's, DDT, acetic acid, organic contamination of tungsten, and others. Total process time required for the most difficult compounds is two hours. Destruction is to levels beyond detectability (less than 10 ppb).

We have laboratory equipment for treating small quantity samples to demonstrate the efficiency of the process and to afford data which is required to scale-up to required volumes. We currently have full-scale toxic destruct equipment with flow capability to 100 GPM.

Thank you for your inquiry, and we look forward to serving you further.

Very truly yours,

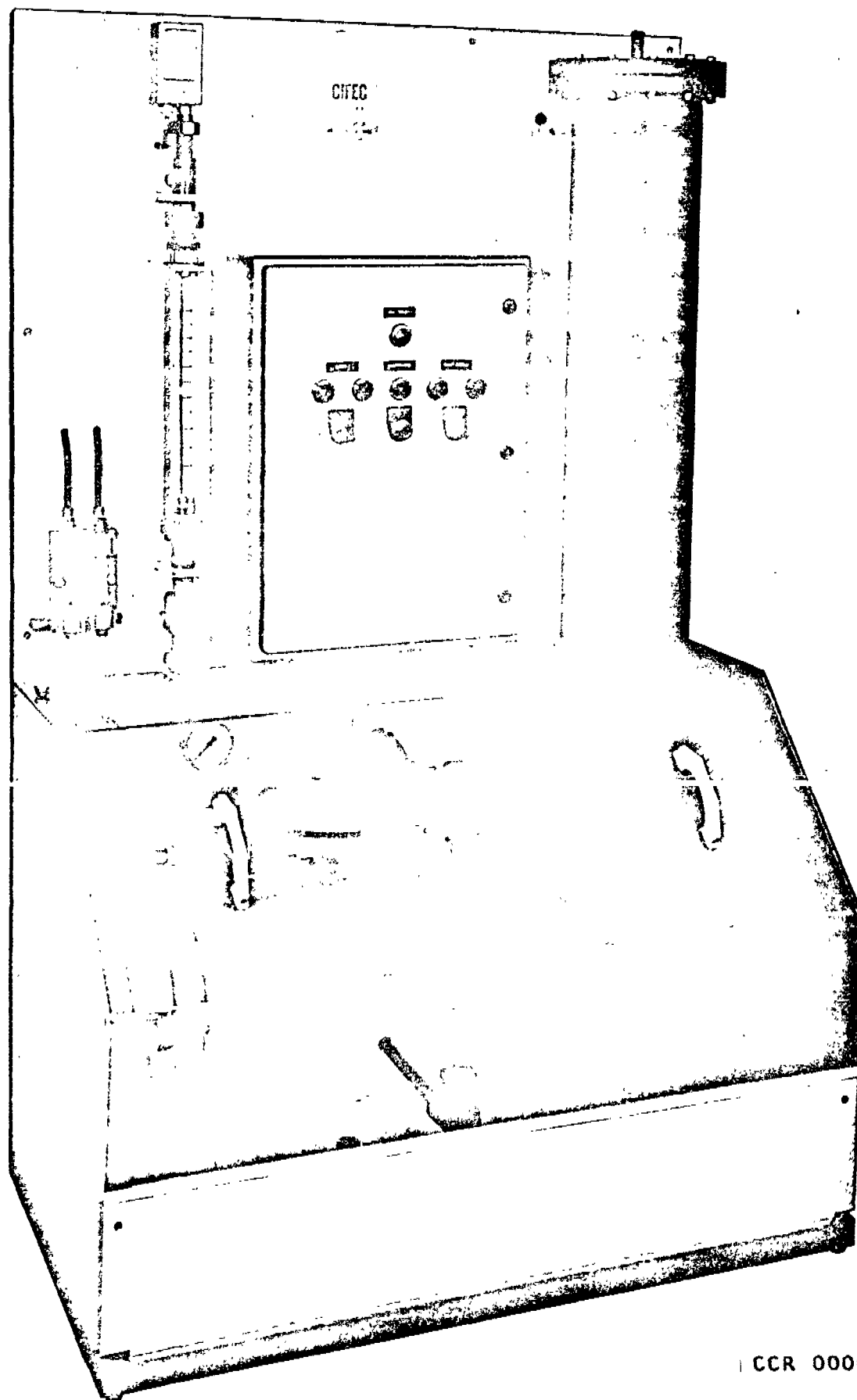
PURE WATER SYSTEMS, INC.

M. Dale Wood
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Please refer further requests to Wayne Wren.



CCR 000038843

CHLORINE DIOXIDE GENERATOR
the french method with enrichment loop

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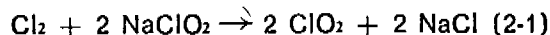
Na chlorite + UV light → EDC stripper (bottom of) scrubber

CIFEC[®] CHLORINE DIOXIDE GENERATOR

United States Patent 3,975,284

THEORY OF OPERATION

Because chlorine dioxide is an extremely unstable gas, it cannot be packaged in containers as is chlorine or sulfur dioxide. Therefore it must be generated at the point of use. The most practical method is to react an aqueous chlorine solution with a sodium chlorite solution producing the following stoichiometric reaction:



Therefore, 1.34 lbs of pure sodium chlorite (NaClO_2) will react with 0.5 lb chlorine to produce 1.0 lb chlorine dioxide. Most technical grades of sodium chlorite are only about 80 percent pure, so that in practice it requires 1.7 lb of chlorite for the above reaction to be complete. The other important factor in the above reaction is that it must be at a controlled low pH, less than 4.0.

This is the secret of the success of the CIFEC "enrichment loop" concept. It insures optimum conditions for the reaction of equation 2-1. Therefore the CIFEC system is capable of producing continuously and reliably a chlorine dioxide solution that is 95 to 98 percent pure. This is the only on-site generation system that can make this claim. The current USA methods use an excess of chlorine to insure maximum yield of chlorite to chlorine dioxide. The result is a solution mixture of approximately 70 percent chlorine and 30 percent chlorine dioxide. This confuses and complicates the measurement of chlorine dioxide residuals in the treated process water. Therefore the French method can be controlled by chlorine dioxide residuals, but the USA methods must be controlled by the sodium chlorite dosage.

SYSTEM DESCRIPTION (see figure 1)

The installation consists of a recirculation loop of aqueous chlorine solution under pressure in a plug-flow regime which prevents negative hydraulic gradient conditions which are detrimental to the process.

Recirculation is accomplished by a special corrosion-resistant positive displacement pump (A)

which also provides the hydraulic power to operate the chlorinator injector (B). A rotameter assembly and diaphragm valve (C) allow the control and regulation of the make-up water.

A sodium chlorite metering pump (E) injects a specified concentration of solution from the sodium chlorite tank (F) into the ClO_2 reactor (D).

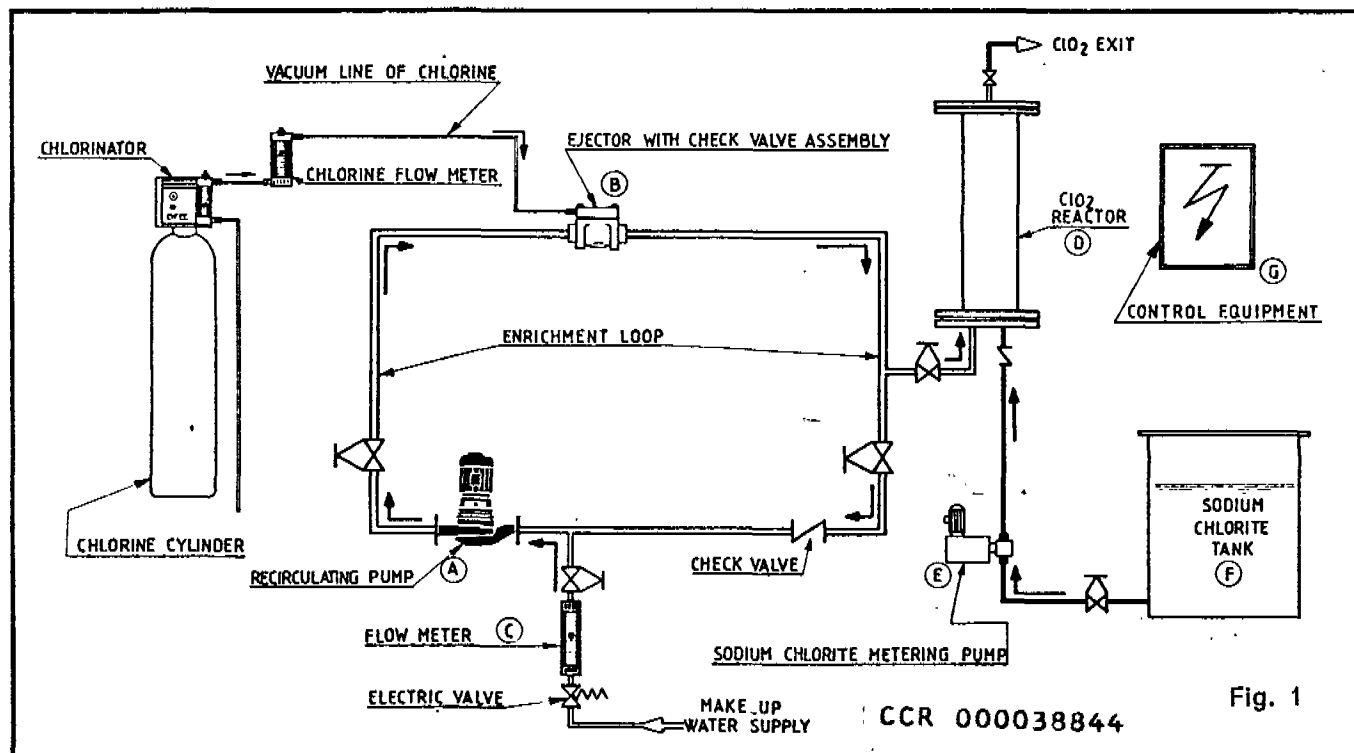


Fig. 1

CCR 000038844

Here the reaction between HOCl and NaClO₂ produces ClO₂.

Control equipment (G) contains the controls for the operation of the two pumps and switchgear necessary to automatically stop the system in the

event of failure of water supply or chlorine supply. The entire assembly is mounted in a high rigidity PVC chassis reinforced with plastic coated steel for maximum corrosion resistance.

SPACE REQUIREMENTS

The CIFEC generator can be located in a small area. The equipment is mounted on a chassis ready to operate with all necessary wiring and piping connections. The sodium chlorite tank and chlorinator and chlorine supply cylinder are usually located outside of, but adjacent to, the generator chassis. The chlorinator can be cylinder mounted,

wall mounted or mounted in a separate module. In addition to a clean water supply and electric power, a proper drain must be provided for the usual accumulation of waste overflow which occurs during normal maintenance procedures. Specific dimensions of the generator and chlorite tanks are listed in the technical data section.

AUTOMATIC CONTROL

Flow proportional control of the CIFEC system can be achieved by the use of a 4-20 ma electric

analog signal. This can be expanded to include residual control if desired.

TECHNICAL DATA

QIN Cl₂O generator

Accuracy	4 % of indicated flow rate.
Capacities	10, 25, 50, 100, 200, 500 and 1000 lb/day chlorine dioxide.
Feed range	10:1 for any combination of chlorine and sodium chlorite.
Injector operating water supply	Must be reasonably clean, operating limits 25-150 psi at 35-70 F.
Pressure at point of application	Maximum allowable is 6-8 psi depending on maximum flow rate of ClO ₂ .
Water supply	For ClO ₂ capacities of 10, 25 and 50 lb/day is 1-3 gpm, 100 lb/day is 5 gpm, 200 lb/day is 10 gpm, 500 lb/day is 20 gpm, and 1000 lb/day is 40 gpm.
Electrical requirements	220-480 volts A.C. 3 phase 60 Hz current for recirculating pump and 110-V-AC single phase current for controls and alarms.
Power requirements	This varies from 1-5 HP depending upon size of unit.
Sodium chlorite metering pumps	Pumps are furnished in accordance with capacity of the generator; this varies from 30 gpd for the smaller unit up to 1200 gpd for the largest unit.
Sodium chlorite tank capacity	105 gal, 130 gal, 265 gal and 500 gal depending on size of metering pump.
Generator dimensions	Up to and including the 200 lb/day unit : width : 3 ft 7 in, depth : 2 ft 1.5 in, and height : 5 ft 9 in ; the 500 lb/day unit is : width : 4 ft 1 in, depth : 2 ft 7.5 in, and height : 6 ft 5 in ; the 1000 lb/day unit is : width : 5 ft 5 in, depth : 3 ft 1 in, and height : 7 ft 5 in.
Sodium chlorite tank dimensions	105 gal = 32 × 33 inches - 130 gal = 34 × 36 inches and 265 gal = 47 × 50 inches.

CCR 000038845

ADVANTAGES OF CHLORINE DIOXIDE

The most significant chemical properties of chlorine dioxide as they relate to potable water and waste water treatment are as follows :

- 1/ ClO_2 does not react with any natural or man-made precursors to form chloroform, which is a known carcinogen - as does chlorine compounds.
- 2/ ClO_2 does not react with ammonia nitrogen to form germicidal compounds of inferior efficiency ;

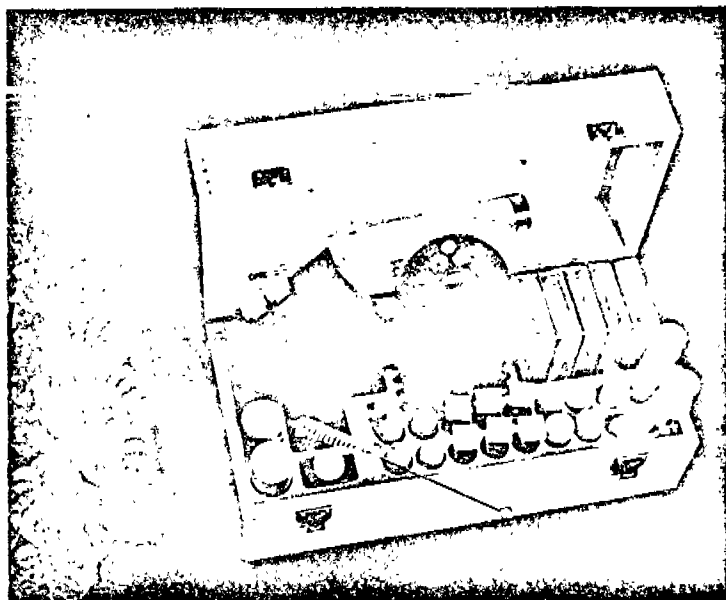
- 3/ ClO_2 unlike chlorine keeps its germicidal efficiency in the pH range of 7 to 10.
- 4/ ClO_2 does not give a chlorine taste to water.
- 5/ ClO_2 destroys phenols.
- 6/ ClO_2 has a continuing disinfecting power twice than of chlorine.
- 7/ ClO_2 has a virucidal, bactericidal and algicidal power higher than chlorine.

PRACTICAL CONSIDERATIONS

The most important attribute of chlorine dioxide is that its bactericidal efficiency is equal to that of free chlorine regardless of the presence of ammonia nitrogen. Therefore on a cost-effective basis the use of chlorine dioxide as a disinfectant for high quality secondary effluents and tertiary effluents is of considerable interest. It could easily be the chemical of choice for disinfection requirements of 2.2/100 ml total coliforms particularly where virus kill is required.

In other situations of potable water and waste water treatment, chlorine dioxide is very effective in removing color and taste and odors resulting from organic compounds. It is specific in its destruction of phenolic compounds. It also is one of the most effective oxidants for the removal of complex organic iron and manganese compounds.

In food processing plants where the ammonia nitrogen content of the recycled water is greater than 2 mg/l, chlorine dioxide kills bacteria on the same order as free chlorine.



the new method CIFEC-PALIN for chlorine dioxide analysis

With this colorimetric method it is possible to measure separately chlorine dioxide, free chlorine, mono-, di- and trichloramine, sodium chlorite and ozone in the same sample.

CCR 000038846

CIFEC

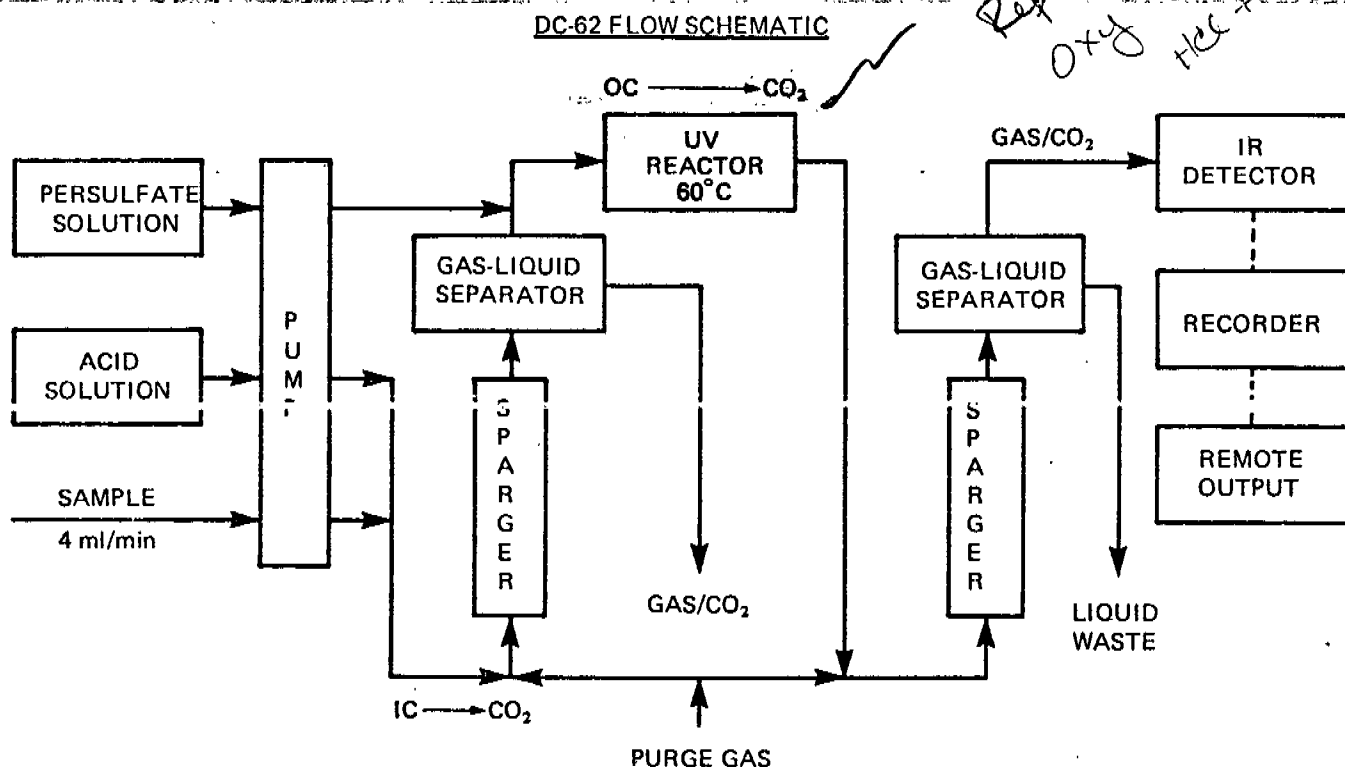
Cie INDUSTRIELLE DE FILTRATION ET D'ÉQUIPEMENT CHIMIQUE S. A.
10, av. de la Porte Molitor, F 75016 PARIS - Tél. 651.52.04 - Tél. 611 627 F

principle of operation

The DC-62 TOC Monitor utilizes ultraviolet promoted chemical oxidation followed by infrared detection to analyze for total organic carbon in water. Inorganic carbon interference is removed by acidification and sparging.

The sample is continuously pumped into the instrument, joined by a phosphoric acid flow, and passes through an inorganic carbon removal sparger and gas-liquid separator. This carbonate free sample then joins a persulfate solution flow and the mixture passes

through the quartz reaction coil where organic carbon is oxidized to CO_2 in the presence of ultraviolet light. This oxidized sample then passes through another sparger and gas-liquid separator where CO_2 from the oxidation process is transferred to the gas phase. This gas then flows to a CO_2 specific infrared detector. An integral recorder continuously displays the linearized detector signal which is the TOC level of the sample. An optional diluter can be used to handle high carbon levels and salt brines.



high salt streams

Salt solutions have typically been a problem with conventional TOC monitors utilizing direct injection into a high temperature furnace. The DC-62 overcomes this problem. In the low temperature oxidation process, the salts all remain in solution and are simply discharged through the analyzer waste line. Streams containing salt up to 3% can be handled directly, without a reduction in oxidation efficiency. Higher salt content streams can be handled after automatic dilution to the 3% or lower level.

high suspended solids streams

The DC-62 is designed to handle particles up to 0.75mm (0.03 in) in diameter. Streams with larger particles having little organic content should be screened. Streams which have larger particles whose organic content must be measured should be analyzed using the Dohrmann DC-60 TOC monitor. The DC-60 can handle particles up to 2.5mm (0.1 in) and is the preferred instrument for on-line monitoring of high suspended solids streams such as found in municipal waste treatment plants.

specifications

operational

Method	Ultraviolet promoted chemical oxidation, infrared detection.
Mode Options	Total Organic Carbon (TOC) Total Carbon (TC)
Inorganic Carbon Removal	>99.5% for low salt* streams >98.0% for high salt* streams
Carbon Range (full scale, continuously adjustable)	0-5 mg/l to 0-100 mg/l for low salt* streams 0-10 mg/l to 0-100 mg/l for high salt* streams 0-100 mg/l to 0-1000 mg/l for low and high salt streams, as well as brines* using optional diluter. Higher ranges available upon request.
	* Low salt, < 0.1% High salt, > 0.1%, < 3% Brines, > 3%, < 30%

performance

Linearity	±2% of full scale
Drift	±5% of full scale per week, maximum

data display

Local Readout	Built-in strip chart recorder
Remote Output	Isolated voltage or current. Variable through either 0 to 10V or 0 to 50 mA with variable zero offset. Typical: 4 - 20 mA (1000 Ω max load)

alarms

TOC Overrange	Selected as a percent of full scale
Temp. Overrange	Reactor region overtemperature
Pressure Overrange	Flow system restriction
Liquid Spill	Reactor region leak
	All alarms feature front panel indicator lamps and contact closures for remote indication.

sample requirements

Flow Rate	Monitor consumes 4 ml/min
Suspended Solids	Accepts particles up to 0.75 mm (0.03 in) diameter. Oxidation efficiency depends on size and chemical nature of particles.

utility and supplies requirements

Power	115 VAC, 60 Hz 700 VA
Spurge Gas	160 ml/min. of CO ₂ free nitrogen, oxygen or air, high salt. 240 ml/min. low salt.
Reagents	
Low salt application	Persulfate Solution, 5% 7.5 litre/wk (1.65 gal/wk) Phosphoric Acid Solution, 10% 3.2 litre/wk (0.7 gal/wk)
High salt application	Persulfate Solution, 5% 10.8 litre/wk (2.4 gal/wk) Phosphoric Acid Solution, 10% 3.2 litre/wk (0.7 gal/wk) Hydrazine Sulfate Solution, 3% 3.2 litre/wk (0.7 gal/wk)

dimensions

Detector Electronics and Readout Module	28cm high, 61cm wide, 61cm deep (11" h x 24" w x 24" d)
Reaction Module	46cm high, 61cm wide, 61cm deep (18" h x 24" w x 24" d)
Reagent Module	43cm high, 61cm wide, 61cm deep (17" h x 24" w x 24" d)
Weight Without Reagents	Net: 124kg (272 lb) Shipping: 146kg (322 lb)

Specifications subject to change without notice.

for more information, contact

ENVIROTECH



DOHRMANN

3240 Scott Boulevard
Santa Clara, California 95050
Telex 346 395

call TOLL-FREE
(800) 538-7708

CCR 000038848

From Alaska, California, Hawaii, Puerto Rico
Call Collect (408) 249-6000

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SM-772-088760 Printed in U.S.A.

Improve total organic carbon monitor reliability with ultraviolet converter

Top Honors

Top Honors distinction was accorded to a continuously operating process total organic carbon monitor that incorporates a high-intensity, ultraviolet-promoted chemical oxidation system instead of a high-temperature pyrolysis system.

"We judge the TOC analyzer to be a significant entry," one of the judges remarks. "The ultraviolet converter is a definite advantage in the right direction rather than the previously used high-temperature furnaces."

In developing the award-winning entry, the firm incorporated its highly successful, low-temperature (50°C), high-intensity UV-promoted chemical oxidation technology used in an ultra-low-level (part-per-billion) laboratory TOC into a process monitor. Reliability was maximized and routine maintenance minimized by careful design. The firm was also able to achieve minimum operating cost and purchase price consistent with operational and design parameters.

The replacement of the traditional red-hot reaction furnace changer with a system

that operates at 60°C is said to eliminate a possible explosion hazard. If service is required, there is reported to be less hazard presented to maintenance personnel. The low-temperature system eliminates the time-consuming shutdown and exchange problems associated with frequent high-temperature reactor failure due to either flow stoppage from crystalline salt deposition or the "corroded-through" failure due to strong oxidant attack.

The low-temperature oxidation system and mechanical features of the monitor minimize the time required to maintain continuous operation. Routine preventative maintenance by semi-skilled personnel is said to run typically about four hours per month. This includes the time needed to check calibration and return the instrument to on-line operation.

On-line TOC monitors need protection from both their external and internal environments. The instrument's packaging concept provides complete isolation of the electronic module from the chemical oxidation module. Both modules are isolated from the external environment by the use of sealed enclosures. Access to the interior of each module is obtained by

opening the gasketed front door. All components are readily accessible. The monitor can be wall-mounted if desired.

The principle of operation of the instrument requires using ultraviolet-promoted chemical oxidation followed by infrared detection to analyze for total organic carbon in water (see flow schematic). Inorganic carbon interface is removed by acidification and sparging.

The sample is continuously pumped into the instrument, joined by a phosphoric acid flow, and passes through an inorganic carbon removal sparger and gas-liquid separator. This carbonate-free sample then joins a persulfate solution flow and the mixture passes through the quartz reaction coil in which organic carbon is oxidized to CO₂ in the presence of ultraviolet light.

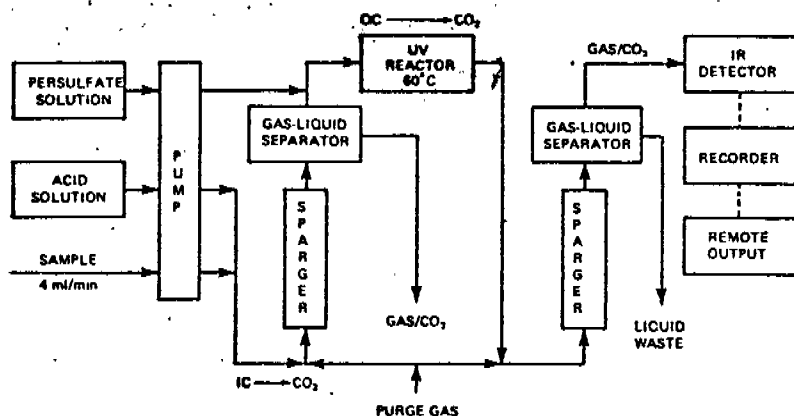
This oxidized sample then passes through another sparger and gas-liquid separator in which CO₂ from the oxidation process is transferred to the gas phase. This gas then flows to a CO₂ specific infrared detector. An integral recorder continuously displays the linearized detector signal which is the TOC level of the sample.

An optional diluter can be used to handle carbon levels to 1000 mg/litre and salt brines to 30%.

Salt solutions have typically been a problem with conventional TOC monitors utilizing direct injection into a high-temperature furnace. The award-winning monitor is said to overcome this problem. In the low-temperature oxidation process, the salts all remain in solution and are simply discharged through the analyzer waste line. Streams containing salt up to 3% can be handled directly, without a reduction in oxidation efficiency. Higher salt content streams can be handled after automatic dilution to the 3% or lower level.

Analyzer is designed to handle particles up to 1 mm (0.04") in diameter. Streams with larger particles having little organic content should be screened.

(Model DC-62 total organic carbon monitor — Envirotech Corporation, Dohrmann Division, 3240 Scott Blvd., Santa Clara, CA 95050.)



Flow schematic illustrates principle of operation of TOC monitor (see text)

Circle 224 opposite last page.

*Tests may be
inexpensive*

ULTRA-VIOLET PRODUCTS, INC. 

PEN-RAY®/SOG DATA

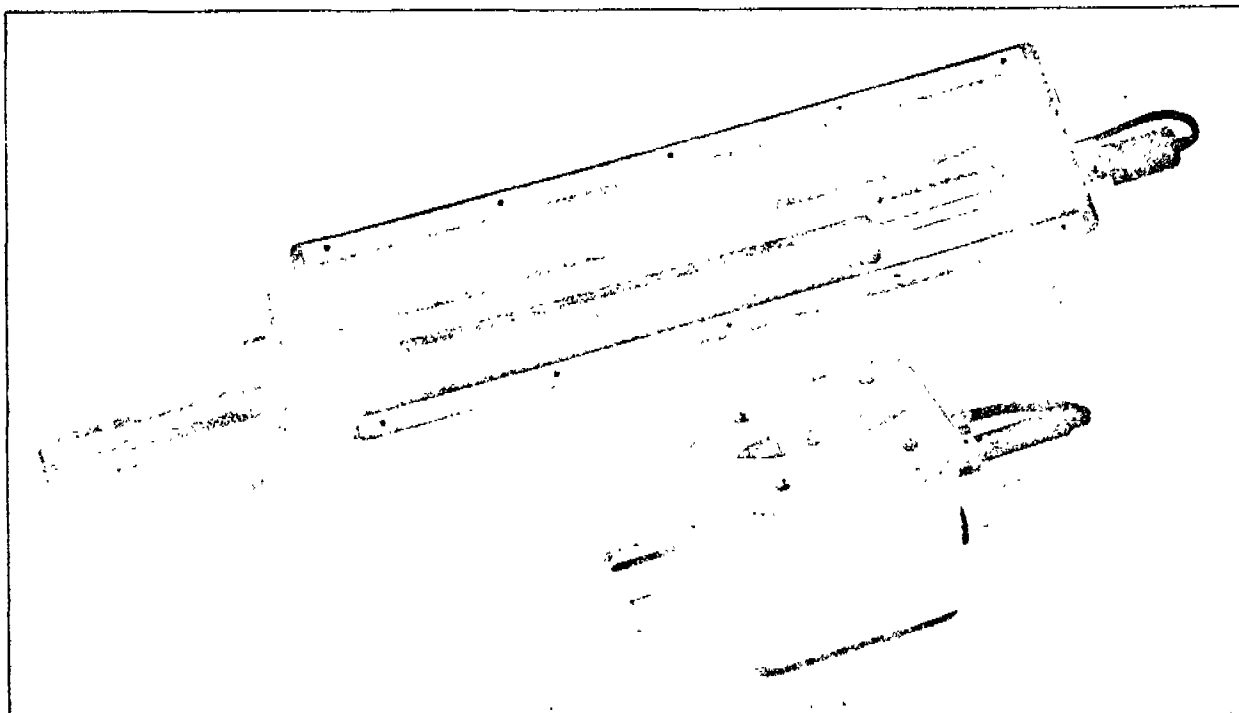
Stable Ozone Generators

FEATURES:

- Long term Stability of Light Source
- Reproducible Ozone Output
- No Electrical Adjustment Required
- Simple Sleeving Technique for Varying Ozone Output
- Light Source of PEN-RAY Lamp Quality
- Low & High Output Units Available
- No Heating of Gas Stream by Light Source
- Quartz Flowtube and Light Source for High 184.9 nm Transmission

MAIN APPLICATIONS:

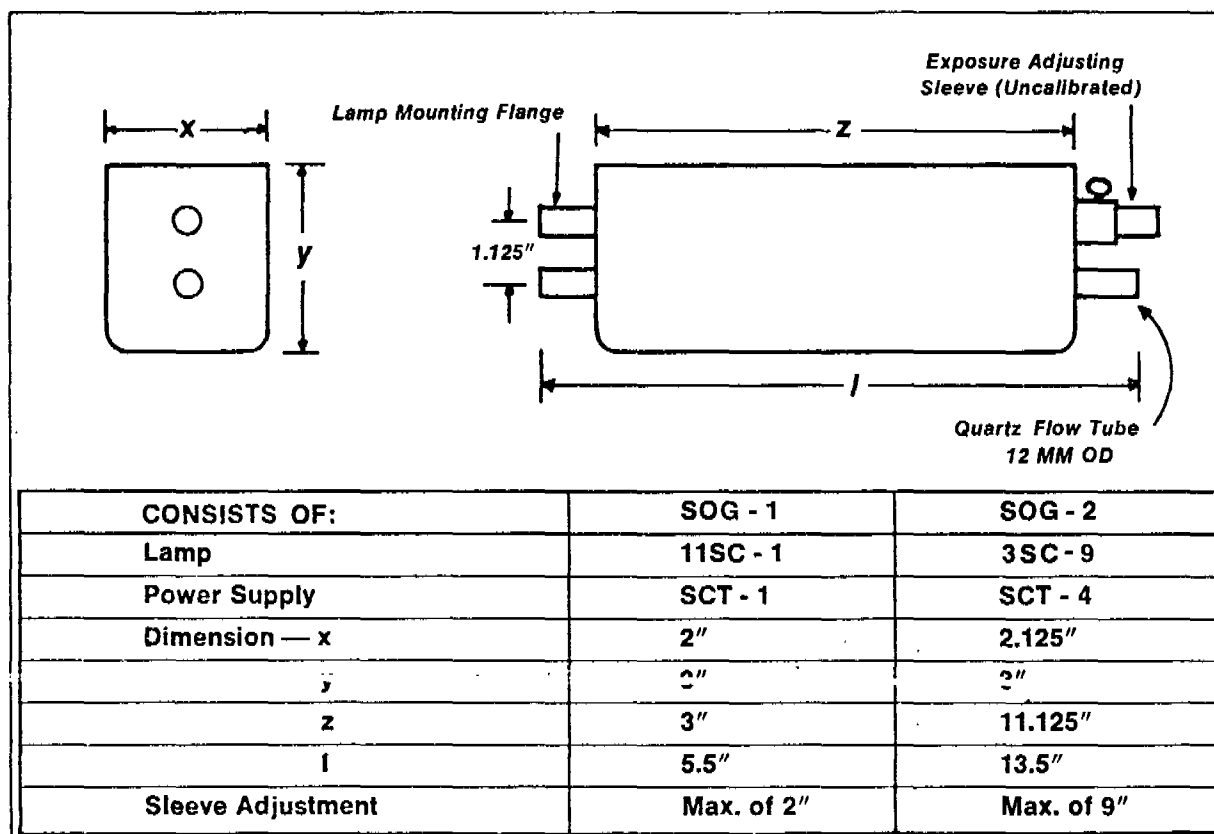
- Calibration of Field and Laboratory Ozone Analyzers
- Source of Oxidant for Aging and Oxidation Testing of Materials, Such as Rubber, Polymers, etc.
- Ozone Source for Instrumentation Development
- Water Purification Studies
- Air Pollution Studies



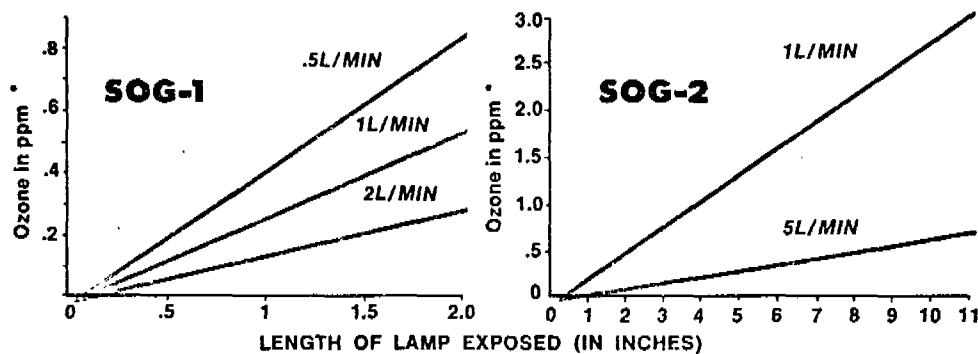
CCR 000038850

PEN-RAY®/SOG DATA

Stable Ozone Generators



The Following Graphs Show Typical Ozone Levels Produced By SOG - 1 And SOG - 2



* Above curves are representative of ozone levels produced by the SOG-1, SOG-2
A Wet Chemistry Technique (KI) was used to determine ozone produced.

Your
Authorized
Dealer

CCR 000038851

LABORATORY
PRODUCTS List Price Schedule

Effective December 31, 1978

ITEM	DESCRIPTION	SHPG. WT.	LIST
B-100A	BLAK-RAY® Lamp 115V, LW	17#	\$199.00
B-100A	BLAK-RAY Lamp 220V, LW	17#	259.00
B-100A/R	BLAK-RAY Lamp 115V, LW	17#	259.00
B-100A/R	BLAK-RAY Lamp 220V, LW	17#	309.00
B-100A/X	BLAK-RAY Lamp 115V, LW	17#	219.00
B-100A/X	BLAK-RAY Lamp 220V, LW	17#	279.00
C-61	MINERALIGHT® Transilluminator 115V, SW	24#	490.00
C-61	MINERALIGHT Transilluminator 220V, SW	24#	510.00
C-61	MINERALIGHT Transilluminator 250V, SW	24#	525.00
C-62	BLAK-RAY Transilluminator 115V, LW	24#	360.00
C-62	BLAK-RAY Transilluminator 220V, LW	24#	398.00
C-62	BLAK-RAY Transilluminator 250V, LW	24#	398.00
C-70	CHROMATO-VUE® Cabinet 115V, SW & LW	29#	650.00
C-70	CHROMATO-VUE Cabinet 220V, SW & LW	29#	675.00
C-70	CHROMATO-VUE Cabinet 250V, SW & LW	29#	675.00
C-71	CHROMATO-VUE Cabinet 115V, LW	29#	598.00
C-71	CHROMATO-VUE Cabinet 220V, LW	29#	675.00
C-71	CHROMATO-VUE Cabinet 250V, LW	29#	675.00
CC-10	CHROMATO-VUE Cabinet	9#	59.95
CC-15	CHROMATO-VUE Cabinet 115V UL, SW & LW	15#	174.00
CC-15	CHROMATO-VUE Cabinet 115V CSA, SW & LW	15#	179.00
CC-15	CHROMATO-VUE Cabinet 220V, SW & LW	15#	185.00
CC-20	CHROMATO-VUE Cabinet 115V, SW & LW	14#	359.00
CC-20	CHROMATO-VUE Cabinet 115V CSA, SW & LW	14#	379.00
CC-20	CHROMATO-VUE Cabinet 220V, SE & LW	14#	379.00
G-203	Adapter	5#	49.95
G-275	Filter Assembly	1#	22.95
G-276	Filter Assembly	1#	74.95
G-277	Filter Assembly	1#	74.95
G-278	Filter Assembly	1#	33.95
J-124	Stand	4#	17.95
J-126	Bracket	1#	5.95
J-129	Stand	3#	29.95
J-221	BLAK-RAY Meter, LW	4#	210.00
J-225	BLAK-RAY Meter, SW	4#	225.00
J-236	Certification System 115V, LW	19#	598.00
J-236	Certification System 220V, LW	19#	620.00

BLAK-RAY®, MINERALIGHT®, GEM-TEMP®,
PEN-RAY®, and CHROMATO-VUE®, are regis-
tered trademarks of ULTRA-VIOLET PRODUCTS,
INC. LW=Long wave ultraviolet (365 nm)
SW=short wave ultraviolet (254 nm)

All prices are F.O.B. San Gabriel, California.
Minimum billing \$50.00 net.
Terms: Net 30 days.

CCR 000038852

ITEM	DESCRIPTION	SHPG. WT.	LIST
J-237	Certification System 115V, SW	19#	\$620.00
J-237	Certification System 220V, SW	19#	690.00
J-260	Radiometer 115V	4#	785.00
J-260	Radiometer 220V	4#	785.00
J-2601A	Sensor (254nm)	2#	225.00
J-2602A	Sensor (365nm)	2#	225.00
J-2603A	Sensor (297nm)	2#	225.00
J-330	Recharger 115V	2#	26.95
J-331	Recharger 12V	2#	26.95
J-332	Recharger 220V	2#	54.95
M-14	MINERALIGHT® Lamp 115V, SW	3#	185.00
M-14	MINERALIGHT Lamp 12V, SW	3#	185.00
M-14	MINERALIGHT Lamp 220V, SW	3#	205.00
M-15	MINERALIGHT Lamp 115V, SW & LW	3#	185.00
M-15	MINERALIGHT Lamp 12V, SW & LW	3#	185.00
M-15	MINERALIGHT Lamp 220V, SW & LW	3#	205.00
M-16	BLAK-RAY® Lamp 115V, LW	3#	165.00
M-16	BLAK-RAY Lamp 12V, LW	3#	165.00
M-16	BLAK-RAY Lamp 220V, LW	3#	189.00
ML-49	BLAK-RAY Lamp, LW	4#	89.95
MS-47	MINERALIGHT Lamp, SW	4#	110.00
MSL-48	MINERALIGHT Lamp, SW & LW	4#	105.00
PCQ-008L	Photochemical Lamp	7#	379.00
PCQ-008PS	Power Supply	11#	175.00
PCQ-008S	Photochemical Lamp	7#	339.00
PCQ-023	Photochemical Lamp	9#	599.00
PCQ-023L	Photochemical Lamp	9#	775.00
PCQ-023PS	Power Supply	11#	175.00
PCQ-024L	Photochemical Lamp	9#	495.00
PCQ-024PS	Power Supply	11#	175.00
PCQ-024S	Photochemical Lamp	9#	790.00
PCQ9G-1	Photochemical Lamp, 2½"	4#	230.00
PCQ9G-1	Photochemical Lamp, 4"	4#	235.00
PCQ9G-1	Photochemical Lamp, 6"	4#	240.00
PCQ9G-1	Photochemical Lamp, 7" or 8"	4#	245.00
PCQ9G-1	Photochemical Lamp, 10" or 11"	4#	249.00
R-52	MINERALIGHT Lamp 115V, SW	12#	339.00
R-52	MINERALIGHT Lamp 220V, SW	12#	375.00
S-68	MINERALIGHT Lamp 115V, SW	15#	549.00
S-68	MINERALIGHT Lamp 220V, SW	15#	549.00
S-68A	MINERALIGHT Lamp 115V, SW	16#	729.00
S-68A	MINERALIGHT Lamp 220V, SW	16#	819.00
S-69	BLAK-RAY Lamp 115V, LW	15#	510.00
S-69	BLAK-RAY Lamp 220V, LW	15#	525.00
SCT-1	Power Supply 115V	4#	79.95
SCT-1	Power Supply 220V	4#	89.95
SCT-2	Power Supply 115V	4#	89.95
SCT-2	Power Supply 220V	4#	99.95
SCT-3	Power Supply 115V	4#	84.95
SCT-3	Power Supply 220V	4#	89.95
SCT-4	Power Supply 115V	6#	84.95
SCT-4	Power Supply 220V	6#	99.95
SOG-1	Ozone Generator 115V	7#	303.00
SOG-1	Ozone Generator 220V	7#	325.00

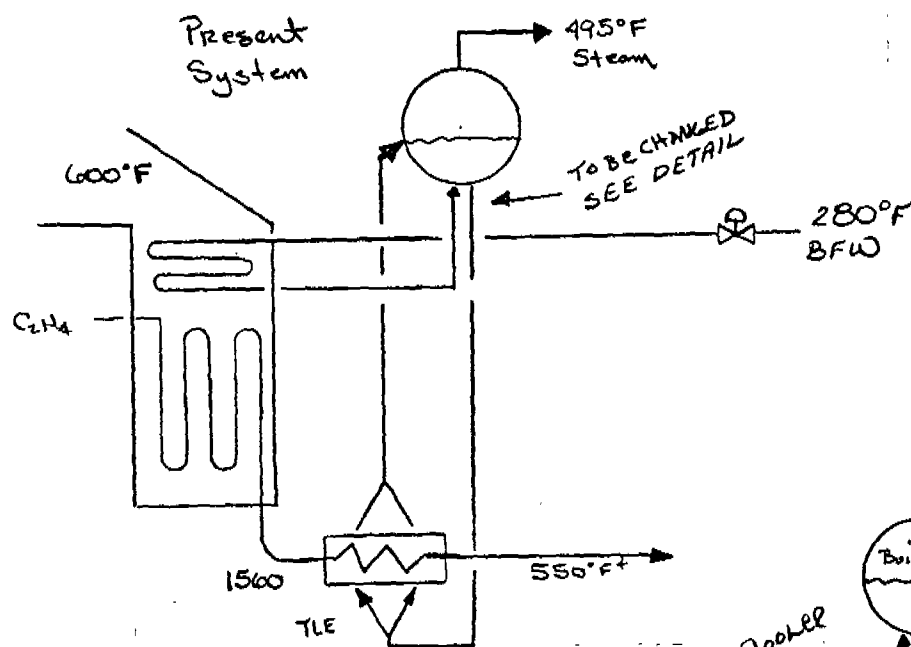
ITEM	DESCRIPTION	SHPG. WT.	LIST
SOG-2	Ozone Generator 115V	13#	\$415.00
SOG-2	Ozone Generator 220V	13#	435.00
SPR-33	Stable PEN-RAY® Lamp 115V	46#	3,475.00
UVC-303	BLAK-RAY® Spectacles	1#	6.00
UVC-503	BLAK-RAY Safety Goggles	1#	7.50
UVL-21	BLAK-RAY Lamp 115V UL, LW	3#	44.95
UVL-21	BLAK-RAY Lamp 115V CSA, LW	3#	49.95
UVL-21	BLAK-RAY Lamp 220V, LW	3#	54.95
UVL-56	BLAK-RAY Lamp 115V, LW	4#	64.95
UVL-56	BLAK-RAY Lamp 115V CSA, LW	4#	69.95
UVL-56	BLAK-RAY Lamp 220V, LW	4#	74.95
UVS-11	MINERALIGHT® Lamp 115V, SW	1#	64.95
USV-11	MINERALIGHT Lamp 115V CSA, SW	3#	74.95
UVS-11	MINERALIGHT Lamp 220V, SW	3#	79.95
UVS-54	MINERALIGHT Lamp 115V, SW	4#	109.95
UVS-54	MINERALIGHT Lamp 115V CSA, SW	4#	114.95
UVS-54	MINERALIGHT Lamp 220V, SW	4#	119.95
UVSL-15	MINERALIGHT Lamp 115V, SW & LW	3#	64.95
UVSL-15	MINERALIGHT Lamp 115V CSA, SW & LW	3#	69.95
UVSL-15	MINERALIGHT Lamp 220V, SW & LW	3#	79.95
UVSL-25	MINERALIGHT Lamp 115V, SW & LW	3#	79.95
UVSL-25	MINERALIGHT Lamp 115V CSA, SW & LW	3#	94.95
UVSL-25	MINERALIGHT Lamp 220V, SW & LW	3#	94.95
UVSL-55	MINERALIGHT Lamp 115V, SW & LW	4#	99.95
UVSL-55	MINERALIGHT Lamp 115V CSA, SW & LW	4#	99.95
UVSL-55	MINERALIGHT Lamp 220V, SW & LW	4#	109.95
UVSL-58	MINERALIGHT Lamp 115V, SW & LW	4#	114.95
UVSL-58	MINERALIGHT Lamp 115V CSA, SW & LW	4#	119.95
UVSL-58	MINERALIGHT Lamp 220V, SW & LW	4#	124.95
X15-B	BLAK-RAY Lamp 115V, LW	7#	84.95
X15-B	BLAK-RAY Lamp 115V CSA, LW	7#	94.95
X15-B	BLAK-RAY Lamp 220V, LW	7#	99.95
X-15H	BLAK-RAY Lamp 115V, LW	7#	99.95
X-15H	BLAK-RAY Lamp 220V, LW	7#	114.95
XX-15	BLAK-RAY Lamp 115V, LW	8#	99.95
XX-15	BLAK-RAY Lamp 115V CSA, LW	8#	99.95
XX-15	BLAK-RAY Lamp 220V, LW	8#	114.95
XX-15H	BLAK-RAY Lamp 115V, LW	8#	99.95
XX-40A	BLAK-RAY Lamp 115V, LW	20#	124.95
XX-40A	BLAK-RAY Lamp 220V	20#	149.95
11SC-1	PEN-RAY Lamp, SW	1#	52.95
11SC-1L	PEN-RAY Lamp, LW	1#	78.95
11SC-2	PEN-RAY Lamp, SW	1#	52.95
22SC-3L	PEN-RAY Lamp, LW	1#	190.00
22SC-3S	PEN-RAY Lamp, SW	1#	119.00
3SC-9	PEN-RAY Lamp, 9" SW	1#	109.95
90-0013-01	PEN-RAY Lamp — Argon Fill	1#	77.95
90-0014-01	PEN-RAY Lamp — Krypton Fill	1#	77.95
90-0015-01	PEN-RAY Lamp — Neon Fill	1#	77.95
90-0016-01	PEN-RAY Lamp — Neon-Mercury Fill	1#	77.95
90-0017-01	PEN-RAY Lamp — Xenon Fill	1#	77.95
98-0008-01	"A" Lamp Shield	1#	7.95
98-0008-02	"B" Lamp Shield	1#	7.95
90-0008-03	"C" Lamp Shield	1#	7.95

CCR 000038854

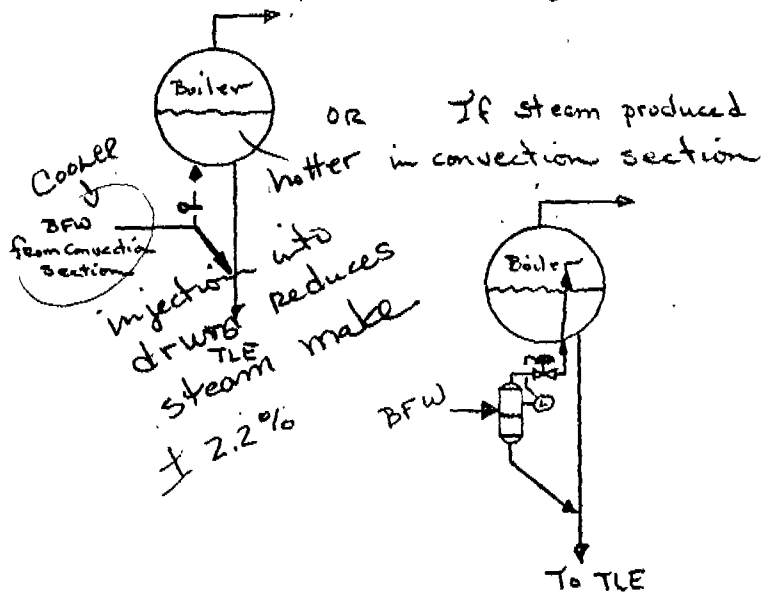
REPLACEMENT PARTS

ITEM	PART NO.	SHPG. WT.	LIST
BATTERIES			
J-333 6V Rechargeable	45-0002-01	2#	\$ 52.75
J-144 6V Super	45-0005-01	6#	7.75
J-145 45V	45-0006-01	6#	35.25
12V Rechargeable	45-0009-01	1#	8.25
BULBS			
100-watt Spot, LW	34-0011-01	2#	40.00
White, for battery lamps	34-0014-01	1#	1.25
100-watt Flood, LW	34-0022-01	2#	50.00
FILTERS (254nm) for:			
S-68, S-68A	38-0006-01	1#	97.95
CC-20	38-0004-01	1#	93.95
R-52	38-0008-01	2#	57.95
C-61	38-0011-01	4#	197.00
UVS-11, UVSL-25	38-0012-01	2#	32.95
MS-47, MSL-48, UVS -54, UVSL-55, UVSL-58	38-0015-01	2#	38.95
M-14, M-15	38-0018-01	1#	18.95
C-70	38-0031-01	2#	198.00
UVSL-15	38-0035-01	2#	21.95
FILTERS (365nm) for:			
C-70, C-71	38-0001-01	2#	36.95
UVL-21	38-0002-01	2#	5.95
CC-20	38-0005-01	1#	30.95
B-100A	38-0009-01	2#	10.95
C-62	38-0010-01	4#	65.95
M-16	38-0019-01	1#	5.95
S-69	38-0032-01	1#	8.95
FILTERS (365nm) for:			
UVSL-15	38-0034-01	1#	5.95
UVL-56, UVSL-55, MSL-48	38-0037-01	2#	5.95
	38-0050-01	2#	5.95
FILTERS, Contrast Control for:			
CC-10, CC-20, C-70, C-71	38-0013-01	1#	20.95
TUBES, Germicidal (254nm)			
4-watt	34-0003-01	1#	13.25
6-watt	34-0013-01	1#	13.25
8-watt	34-0007-01	1#	13.75
15-watt	34-0008-01	2#	13.75
30-watt	34-0025-01	5#	27.50
TUBES, Black Light Blue (365nm)			
4-watt	34-0010-01	1#	11.00
6-watt	34-0016-01	1#	11.00
8-watt	34-0031-01	1#	16.50
15-watt	34-0017-01	2#	16.50
30-watt	34-0018-01	5#	33.00
40-watt	34-0032-01	8#	33.00
TUBES, Black Light (365nm)			
4-watt	34-0005-01	1#	5.50
6-watt	34-0034-01	1#	5.50
8-watt	34-0006-01	1#	13.75
15-watt	34-0009-01	2#	13.75
40-watt	34-0024-01	8#	33.00
TUBES, Multiband (254 & 365nm)			
4-watt	34-0004-01	1#	13.75
6-watt	34-0015-01	1#	13.75
15-watt	34-0033-01	2#	22.00
TUBES, White Light			
8-watt	34-0001-01	1#	4.25
For C-70, C-71	34-0002-01	1#	3.50
TUBES, Quartz			
For S-68, S-68A	32-0009-01	2#	249.00
For R-52	77-0003-01	1#	169.00

Augmented Boiler LMDTs and Circulation Rates



If Stm Gen Project is put in may possibly paid to use convection section to Superheat steam & run BFW directly into Boilers downcomer, or if other preheating of BFW is done.



By injecting BFW into the downcomers to the TLEs the Steam make is increased, because the LMDT increases (provided BFW doesn't exit the convection section at 495°F - No temp gauge there), and the circulation rate increases.

Present LMDT is:

$$\Delta T_1 = 1560 - 495 \quad \Delta T_2 = 550 - 495$$

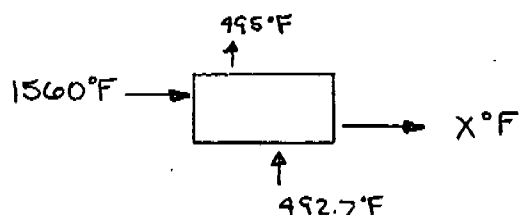
$$LMDT = \frac{1065 - 550}{\ln \frac{1065}{550}} = 340.8^\circ F$$

NXT

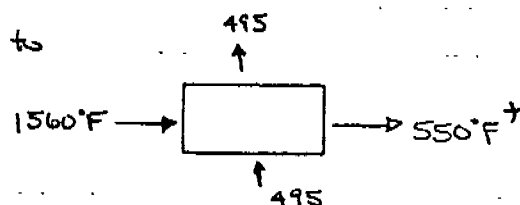
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Assuming a circulation ratio of 10 and BFW entering at 470°F.

$$[(10) 495 + 1(470)] / 11 = 492.7^\circ\text{F} \quad \text{Down come temp.}$$



Compared to



$$\lambda = 717$$

trial & error for X°F

Assume 545°F

$$\Delta T_{Lm} = \frac{1065 - 53.3}{\ln \frac{1015}{53.3}} = 343.3$$

$$Q = U A \Delta T_{Lm}$$

↑
const
↓
increases negligibly

$$\frac{343.3}{340.8} = 0.75\% \text{ increase}$$

$$28.1 \text{ mm BTU/hr} = (X^\circ\text{F}) (1.8424) (34.5)$$

$$\Delta T_{Lm} = 967^\circ\text{F}$$

17°F change

$$X^\circ\text{F} 534^\circ\text{F} \quad 1\text{st Est}$$

$$(1) (717) \Delta T = 28.1$$

$$\Delta T_x = 3562.8$$

$$(11) (717) (3891) = 30.7 \text{ mm BTU}$$

Actual increase about

$$30.7 - 27.9 = 2.8 \text{ mm BTU/hr}$$

$$2.8 \text{ mm BTU/hr} \pm \text{ per heater}$$

$$(30.7) = X^\circ\text{F} (1.8424) (34.5)$$

$$= 1056^\circ\text{F}$$

$$1560 - 1056^\circ\text{F} = 504^\circ\text{F} \text{ outlet too good}$$

from 55°F Approach

to About 48°F Approach

$$(1560 - 543) (1.8424) (34.5 \text{ m}) = 29.56$$

$$- 27.9$$

$$\$210,000/\text{year}$$

WAG

$$1.66 \text{ mm BTU/hr}$$

Mike McCutley *DL-D* **CONOCO**
To *GAIR Fiches* Date *5/80*

Maybe RFD should check up on
the status of this. Could be
useful for removing water
from feed to Light Ends column.
or EDC from effluent, etc.

Mike

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MAGNETICALLY INDUCED SEPARATION OF - STABLE EMULSIONS

Robert Kaiser
Clark K. Colton
Gabor Miskolczy
and
Leon Mir

Experiments were carried out to demonstrate the feasibility of recovering oil from fine, stable oil-in-water emulsions by magnetic means. Emulsions in which the oil phase was rendered magnetically responsive by the addition of a ferrofluid were passed through packed beds (containing magnetic particles and/or screens) placed in a magnetic field. The oil content of the effluent stream was typically two to three orders of magnitude lower than the oil content of the feed emulsion. The influence of various operating parameters including bed height, flow rate, oil magnetization, and magnetic field strength were systematically evaluated. The results demonstrated that it is possible to attain virtually complete removal of particles of the order of one micron in diameter with a static separation device (magnetic demulsifier) using residence times of the order of a fraction of a minute.

The removal of oil from fine oil-in-water emulsions is a common problem which has no universally applicable solution. Such emulsions are found in waste water effluent streams from many sources, including chemical processing and manufacturing plants, petroleum refineries, and rolling mills (1). A major source of oil pollution on the seas occurs from the results of deballasting of vessels, cleaning of oil tanks, and the pumping of bilge water which becomes mixed with waste oils. The oil is usually discharged as a dilute emulsion of fine oil droplets in water (2). Many major tanker fleets are now applying improved operation methods, such as the load-on-top procedure, and installing mechanical shipboard oil-water separators which function by gravitational settling. These methods, however, are not capable of removing the finest particles (2), and the ultimate effluents are generally in excess of present international standards.

All existing methods for breaking oil-in-water emulsions (including chemical, mechanical, electrical, and thermal treatments) suffer from disadvantages such as high cost and technical and practical limitations in deployment (1,3,4). There is need for a more efficient and economical emulsion breaking system, particularly for fine, stable emulsions with oil-phase densities close to that

of water and droplet diameters of 10 microns or less.

A novel method of oil-water separation has been developed which utilizes magnetism to separate the two phases. The basic principle is as follows: An oil-soluble, water-insoluble ferrofluid is added to the oil phase, rendering it magnetically responsive. When the emulsion is passed through a suitable device in which a magnetic field is generated, a selective magnetic body force is exerted on the oil droplets. This force may be used to 1) physically separate oil droplets from the water, and/or 2) retain the oil droplets within the device while the water passes through. The retained oil may then be easily recovered in concentrated form by shutting off the magnetic field. The application of this technique to the problem of removing oil from the surface of the ocean has been previously described (5). This paper presents the results of bench-scale experimental studies to evaluate the use of magnetic separation techniques for removing and recovering oil from fine, stable oil-in-water emulsions. The objectives of these studies were to demonstrate the capabilities of the separation technique and to characterize the parameters affecting process operation.

CCR 000038859

FERROFLUID PROPERTIES

Amec Corporation, Lowell, Massachusetts. Clark K. Colton is with the Massachusetts Institute of Technology, Cambridge, Massachusetts.

Ferrofluids are stable colloidal dis-

retain their liquid characteristics in the presence of a magnetic field and do not settle under gravity or in the presence of a strong magnetic field. The magnetic response of a ferrofluid results from the coupling of individual magnetic particles with a substantial volume of the carrier liquid. Coupling is facilitated by a stabilizing agent which adsorbs on the particle surface and is also solvated by the surrounding liquid. Magnetic properties can be selectively conferred on a variety of liquids, including water, hydrocarbons, and fluorocarbons, by proper choice of the stabilizing agent. The properties and general applications of ferrofluids, as well as the required physical and chemical characteristics for oil-water separation processes, have been described elsewhere (5 - 7).

PRINCIPLES OF MAGNETIC SEPARATION

Magnitude of Forces Involved

When a magnetically responsive fluid droplet is placed in a magnetic field (H) there results an induced magnetization within the droplet (M_f). If, in addition, there is a gradient of the magnetic field, then there is also a magnetic body force (F_m) exerted on the droplet. The magnitude of the force is proportional to the induced magnetization, the magnetic field gradient, and the volume of the droplet (8):

$$F_m = \frac{1}{4\pi} M_f \nabla H \left(\frac{4}{3} \pi R^3 \right) \quad (1)$$

∇H is the local field gradient and R is the droplet radius. The ferrofluid droplet, like all magnetizable objects, is driven toward regions of highest magnetic field intensity.

Assuming that a ferrofluid droplet behaves like a solid sphere (i.e., no internal circulation effects), the drag on the droplet at sufficiently low Reynolds numbers is given by Stokes Law:

$$F_d = 6\pi\mu uR \quad (2)$$

where μ is the viscosity of the surrounding fluids and u is the droplet velocity relative to the surrounding fluid. By equating the magnetic body force with the fluid dynamic drag on the particle, one obtains the equilibrium, steady-state, magnetically-induced velocity of the ferrofluid droplet.

$$u_m = \frac{1}{18\pi} \frac{M_f \nabla H R^2}{\mu} \quad (3)$$

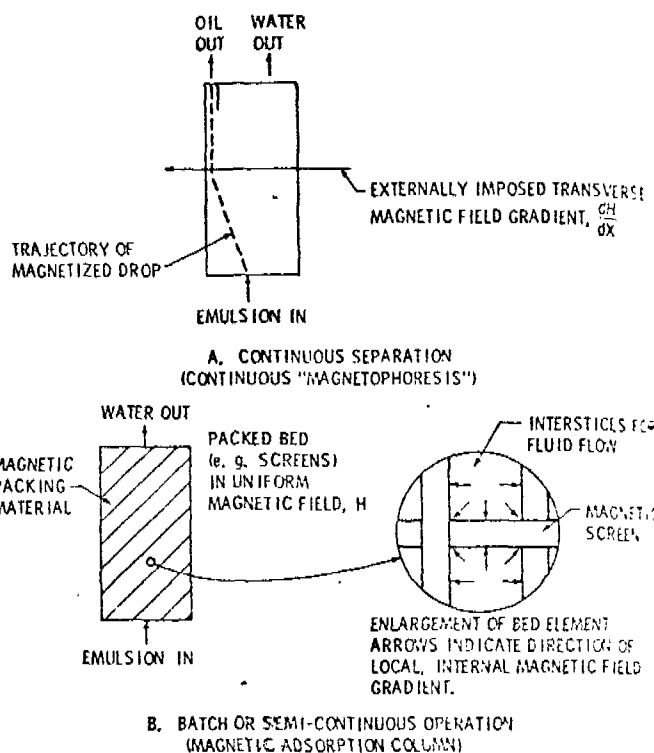


Figure 1 ALTERNATE ARRANGEMENTS FOR MAGNETIC DEMULSIFICATION

Equation (3) is the magnetic analogue of the terminal settling velocity of a particle in a gravitational field resulting from a density difference:

$$u_g = \frac{2 \Delta \rho g R^2}{9 \mu} \quad (4)$$

where u_g is the terminal settling velocity, $\Delta \rho$ is the difference in density between the droplet and the external phase, and g is the acceleration of gravity.

A semi-quantitative feel for the magnitude of forces operative in a magnetic separator may be obtained by comparing the equilibrium velocities associated with a magnetic field gradient and with a gravitational field:

$$\frac{u_m}{u_g} = \frac{1}{4\pi} \frac{M_f \nabla H}{\Delta \rho g} \quad (5)$$

For the experiments carried out in this study, typical order of magnitude estimates of these parameters are $M_f = 10$ gauss, $H = 10^6$ oe/cm, $\Delta \rho = 10^{-1}$ g/cm³, and $g \approx 10^3$ cm/sec². Substitution into Equation 5 gives $u_m/u_g \approx 10^4$. This shows that a magnetic

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VCM

Misc. Ideas & Explanations.

12-79

Since I had only explained my 1980 Capital Budget Ideas for the VCM Plant to JOG - I thought it best to explain them to the rest of you. 1980 Ideas attached.

#1 was to run a test - taking a slip stream from the oxy air compressor and run it through a good air filter or ionizing air cleaner - in order to check the amount of dirt coming through the present filters and possibly causing increased fouling & catalyst degradation. If dirty - we should consider a better filtering system.

#6 I've been looking into this. Attached is some miscellaneous information. It "may" be possible that UV light would enhance the formation of HOCH which is the slow reaction in oxy. Enhancing this formation would give better conversion, increased capabilities & capacities.

I haven't checked out using UV in the vent. or Cl_2 feed to R-304.

Additional explanations have been put on the original where needed.

* UV light might break down tars &/or P.E.s. producing something more usable?

Mike McC.

sent
5-3-79

VCM 1980 Capital Budget

1. High Efficiency Air Cleaner for Oxy.

Recommend running side stream of air through good filter or ionizer cleaner. Could help Oxy run life and performance considerably if there is a little dust carry-over. A little dirt/dust adds up over .1 gyo

2. Split Feed to HCl Colm.

As per attached drawing - Saves Refrigeration & may increase product quality

3. Increase HCl Vapor Overhead Drawoff

The major portion of VCM run to Oxy in the HCl comes in with the liquid HCl. By increasing liquid recycle and vapor drawoff the amount of VCM can be reduced. Also a interchanger here can further lower VCM fed to Oxy. Drawing attached

4. R-101 Packed Bed Reactor. - developmt req'd

Using Activated Carbon, Alumina, et.al to absorb excess chlorine the amount of heavies "may" be reduced also $FeCl_2$ would be absorbed and used - lengthing the R-101 shell life.

5. O_2 to R-304 should be increased to allow more conversion of HCl. Also check HCl addition to R-304 again

6. UV light reacts O_2 AND Hydrocarbons - possible use in Oxy Vent for flammability control.

↑
or elsewhere

CCR 000038862

MADE BY

CENT VENTRAL OIL COMPANY

JOB NO.

CREATED BY

CALCULATION SHEET

DATE

TITLE

FIELD

DATE

7. Ethyl chloride Dehydrohalogenation Reactor.
No idea what this is. (Was mention in PAST R & D studies)
8. Elevate S-307 and Recycle to S306
Save Refrigeration - less lights recovery - higher EDC recovery
9. Lower Tars temperature to condense out NaCl
Separate by settler &/or cyclone.
10. By pass refrigerant stream through ^{new} coils in the compressor suction drum. (eliminates steam coils)
↑ thru manway?
11. Check solubility of L.E. overhead deposits in tars.
w/ caution.
12. R-305 FeCl_2 Catalyst impregnation. use R-101 EDC
I feel if we run R-305 Catalyst totally FeCl_2 impregnated that there will be a performance benefit. Feed R-101 EDC to R-305 until sufficient FeCl_2 Absorbed.
13. R-101 Off-gas use.
Higher pressure C_2H_4 can be run to the VCM Plant if Requested - some engineering required. also compressor could be used on C_2H_4 prior to ejector.
14. TA HCl Condensing.
using an interchanger, K.O. P.O. and Pressure control much of the HCl/VCM mixture from the HCl Column can be condensed (during shutdown)
Refer to Drawing.
15. O_2 N_2 production for plant uses.

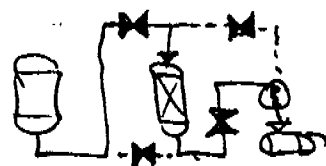
treat w/ UV Light, carbon Absorption & scrubbing Bal. Comp. Loads

VCM Debottle neck / Expansion

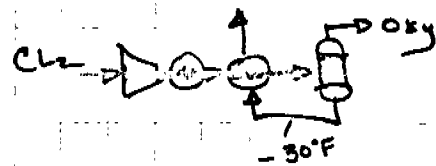
5/79

I Oxy

- 1) Piping Air to elbows for ejector effect - use static mixers - down stream if necessary
- 2) Higher horse air compressor for Oxy
- 3) More Catalyst - all reactors 100% for R-303
- 4) R-304 Preheater also steam ejector
- 5) R-303 Backflow piping system for on-line ΔP reduction
4 valves - some piping



II Direct



- 1) EDC By Pass Project (FeCl_2 absorption)
- 2) bigger Cl_2 compressor - to ease suction problems - maybe to condense most Cl_2 for feed to direct (O_2 & H_2 & H_2 free)
Non-condensables to Oxy.
- 3) Laval or Cyclone Solids separators on Acid & caustic washes.
- 4) Iron Traps

III Purification EDC

- 1) Preheat by H.E. Colm condensers. w/ feed EDC on L.E. colm.
- 2) Steam Stripper - ?

IV Secondary - pre-solids removal (prior to ponds).

V Cracking

- 1) Quench or prequench w/ EDC - not tars!
- 2) HCC colm revisions

exchange revisions: H-303⁺, H-304/302, H-305/310

CCl₄ tars → HCl + lighter CHCl₃ EDC via VCM? CL₂?

Ozone/UV process effective wastewater treatment

Toxic wastes made harmless with commercially developed process

H. W. Prengle, Jr., C. E. Mauk, R. W. Legan and C. G. Hewes, III, Houston Research, Inc., Houston

CHEMICAL OXIDATION of difficult-to-handle impurities in waste-water is practical and economical using an ozone ultraviolet radiation process. The process is particularly effective with toxic and highly refractory compounds such as alcohols, acids, amino acids, fatty acids and polyhydroxy alcohols. Many compounds may be economically oxidized whose reaction rates would otherwise be too low to be processed in other systems.

The process can be used in a number of configurations depending on application. Typically, it is used to handle toxic and/or potentially toxic (when chlorinated) impurities as a combination secondary and/or tertiary process. Performance unequaled by other systems is achievable because of efficient staging of the ozone reactor system with ultraviolet light and results in low capital and operating cost. Ultraviolet radiation enhances the reaction with ozone 10^2 to 10^4 fold and drives the reaction to completion to harmless materials such as CO₂, H₂O, etc.

Much attention has been given to tertiary treatment processes (carbon adsorption, ion exchange, reverse osmosis, chlorination, etc.), which can be added to conventional wastewater treatment processes to remove difficult to oxidize refractory compounds and toxic species and provide effluents which will meet tighter projected discharge standards. However, a number of tertiary processes do not remove all undesirable species some of which produce highly undesirable species¹ when chlorinated in final treatment before discharge or in municipal water treatment.

Now chemical oxidation with ozone is commercially feasible for industrial municipal wastewater treatment for high rate oxidation with improved mass transfer, developed through high interfacial area in a continuous stirred reactor and an optimized reactor system to achieve total utilization of the ozone through use of a multistage reactor. UV radiation provides a critical key to enhance reaction rates dramatically.

Experimental work prove the process' ability to oxidize a wide variety of both inorganic and organic species and

certain composite wastes including: glycine, NH₂CH₂COOH, the smallest amino acid; ethanol, CH₃CH₂OH; acetic acid, CH₃COOH; glycerol, CH₂OHCHOHCH₂OH; palmitic acid, CH₃(CH₂)₁₄COOH; nitrogen compounds; potassium cyanide; complexed cyanides, cadmium, copper, nickel, iron; photographic wastes, bleach, fixer; medical wastes; secondary effluent, and others. The most difficult to oxidize species are potassium ferricyanide, ethanol and acetic acid; the latter, a product of partial bio and chemical-oxidation of numerous organic materials. In the absence of UV radiation, acetic acid is essentially unoxidized by ozone; however, with UV radiation oxidation proceeds rapidly at room temperature.

REFRACTORIES AND TOXICS CHARACTERIZATION

For purposes of comparison of different refractory and toxic species, a "Refractory Index (RFI)" is defined which is a measure of the difficulty of oxidation of a given molecular species; i.e., the larger RFI, the more difficult the species is to oxidize. A set of standard run conditions are used as follows.

Ozone is used as the oxidant in a run conducted at room temperature (25-27° C). Initial concentration of reactant is 50-100 mg/l. Reactor is operated in the good to excellent mixing regime. No ultraviolet radiation is used.

RFI is calculated by the equations,

$$RFI \text{ (hrs.)} = \frac{B_c^o \text{ (mg/l)} t_{1/2} \text{ (hrs.)}}{A^o \text{ (mg/l)}} \quad (1a)$$

$$B_c^o \text{ (mg/l)} = \frac{\dot{m}_B \text{ (mg/min.) } t_{1/2} \text{ (min.)}}{V \text{ (l)}} \quad (1b)$$

where B_c^o is the cumulative O₃ pumped into the liquid

TABLE 1—RFI values for various compounds

Compound	RFI-value	Qualitative scale
KCN.....	0.41	Slightly refractory (RFI < 1)
Color (a-units).....	0.66	
Complexed Cd-cyanide.....	0.96	Refractory (RFI 1 → 100)
Phenol.....	4.4	
Ammonium ion.....	8	
Simulated medical waste.....	13	Highly refractory (RFI 100 → 1,000)
Glycine.....	19.7	
Palmitic acid (as NH ₄ -salt).....	27.3	
Glycerol.....	112	
Ethanol.....	245	Very highly refractory (RFI > 1,000)
Complexed ferricyanide.....	270	
Acetic acid.....	>1,000	

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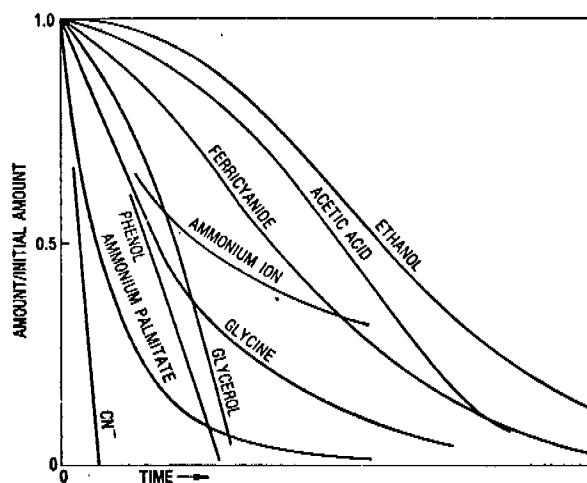


Fig. 1—Typical removal curves for refractory compounds by ozone with UV near 30° C.

phase from $t = 0$ to $t = t_{1/2}$, per liter of liquid
 $t_{1/2}$ is the time required for 50 percent complete conversion of the reactant component, as measured by TOC for organic species and an appropriate method for inorganic species
 A_0 is the initial amount of reactant component
 $\dot{m}_B$ is the O_3 mass feed rate to the reactor
 V is the liquid volume in the reactor.

Values of RFI of various compounds studied are shown in Table 1. Potassium cyanide (free cyanide) is least refractory of all compounds studied; acetic acid is most refractory, with complexed ferricyanide, ethanol and glycerol in the highly refractory category.

OZONE OXIDATION WITH UV

Although the Ozone-UV process was initially developed for treatment of complexed cyanides,² it is successfully

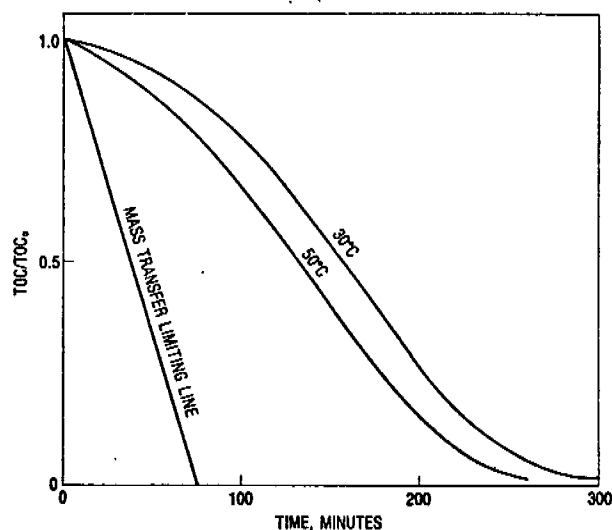


Fig. 2—Ozone oxidation of acetic acid, effect of temperature at low UV intensity.

applied to treatment of many other wastewater species some of which are represented in Fig. 1. Curves of Figs. 1, 2 and 3 result from experimental studies in a batch, continuously sparged and stirred mix reactor. Reactor design permits direct size scaleup without difficulty.^{3,4}

Acetic acid, which is an important intermediate oxidation product of most organic materials, is also one of the more difficult to oxidize species (Fig. 1). However, a slight elevation in temperature has a marked effect on acetic acid destruction (Fig. 2). The mass transfer limiting line is the theoretical stoichiometric limit based on the rate at which ozone is added to the liquid. Improvement up to this limiting line by elevating temperatures alone is impractical.

Ultraviolet light can be used to further improve ozone oxidation of acetic acid (Fig. 3). No reduction of TOC

TABLE 2—Photochemical data on refractory compounds

Compound/(RFI)	Structure	UV absorption range (nm)	Primary photochemical processes	Reference
Acetic acid (>1,000)	<chem>CC(=O)O</chem>	Peak: 205 180-230	1) $R + CO_2H^{++}$ (or $CO_2 + H$) 2) RCO_2^{++} (or $R + CO_2$) + H 3) RCO^{++} (or $R + CO$) + OH 4) $RH + CO_2$	⁵ (p. 428 and 431)
Ferricyanide (270)	$[Fe(CN)_6]^{3-}$	230	Electron transfer to water of hydration	⁵ (p. 270)
Ethanol (245)	<chem>CCO</chem>	Peak: 182, 152 150-200	1) $C_2H_5^{++}$ (or $C_2H_4 + H$) + OH 2) $CH_3CH_2O^{++}$ (or $CH_3 + CH_2O$) + H 3) $C_2H_4 + H_2O$ 4) $CH_3CHO + H_2$ 5) $CH_4 + CH_2O$	⁵ (p. 442, 444)
Glycerol (112)	<chem>CC(O)CO</chem>	Peak: 210, 260 190-280	Free radical and intramolecular photodissociative processes	⁶
Glycine (20)	<chem>NCC(=O)O</chem>	Peak: 240, 210 190-240	1) Acid type processes, and 2) Amine type, $RNH + H$	⁵ (p. 455 ff) ⁷
Chloroform	<chem>CCl3</chem>	Peak: 285, 180 250, 240	1) Free radicals 2) CCl_2 (or CCl)	⁵ (p. 526, 527)
Ozone	<chem>O3</chem>	Peak: 260 150-300	1) $O_3(S_0) \rightarrow O_3(S_1)$ 2) $O_3(S_1) \rightarrow O_2(^1D_g) + O(^1D)$ 3) $O_3(S_1) \rightarrow O_2(^1D_g) + O(^1D)$ 4) $O_3(S_0) \rightarrow O_3(T_1) \rightarrow O_2(^3\Sigma_g^-) + O(^3P)$	⁵ (p. 207-209)

OZONE/UV PROCESS

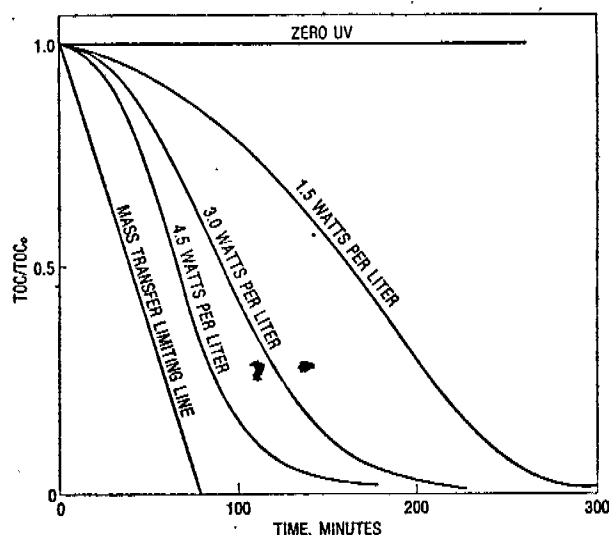


Fig. 3—Ozone oxidation of acetic acid, effect of UV near 30° C.

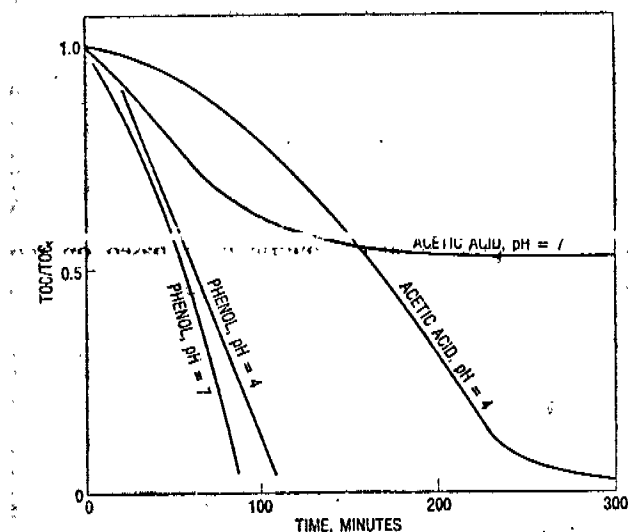


Fig. 4—Effect of initial pH on oxidation of ozone with UV near 30° C.

is realized in the absence of UV but a low UV intensity starts the reaction going very well. Improvement in reaction continues with increased UV. Extrapolation suggests use of UV of 6 watts/liter would raise the reaction to the mass transfer limiting line. Increasing reaction rate by increasing UV is much more effective than elevating temperature and requires less energy.

Although elevated temperature and UV light accelerate ozone reaction rate with all wastewater species, both also accelerate rate of autodecomposition of ozone so that using UV or elevated temperature excessively results in less favorable economics. No generalization of requirements can be made because of the wide variation in reactivities of species; for example, free cyanide needs neither UV nor elevated temperature, but iron complexed cyanides need maximum practical temperature and UV.

TABLE 3—Total treatment cost, including amortization for a specific application

Number of reaction stages	Total cost \$/lb. COD
1.....	0.535
2.....	0.234
3.....	0.185
4.....	0.175
5.....	0.162
6.....	0.151
7.....	0.152
8.....	0.164

Favorable economics usually result when sufficient UV and elevated temperature are employed to move the reaction line close to the limiting line. However, this is not necessarily the economic optimum, which must be determined individually for each wastewater being treated.

Another controlling variable is pH (Fig. 4). For acetic acid, it is better to treat at naturally occurring pH rather than neutralize, while phenol is not strongly pH dependent. Since acid is an important intermediate oxidation product from almost all inorganic material, it is concluded that pH control during ozonation with UV is generally not desirable, although this must be determined for each wastewater species.

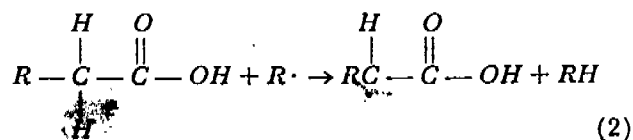
Two distinct aspects of chemistry are involved in the process:

- Photochemical excitation of molecules by UV radiation
- Oxidation by ozone.

Since the over-all process is reaction rate controlled and oxidation by ozone alone is relatively slow for refractory type species, the ozone is not fully utilized. On the other hand, photochemical processes without ozone do not achieve appreciable reaction. Combination of UV and ozone overcome these limits. Excitation of molecules occurs and free radicals are produced which are highly reactive in the presence of ozone. The excited state and free radical species provide more thermodynamically favorable reaction paths as well as increased driving forces for enhancement of reaction rates.

Calvert and Pitts⁵ provide background on primary photochemical processes involved (Table 2). Generally, primary photochemical processes lead to production of free radicals and other smaller neutral molecules including CO and CO₂. CO is the primary step leading to more rapid subsequent oxidation reactions with ozone. Some smaller neutral molecules are more readily oxidizable (e.g., olefins), and all can in turn absorb UV for further activation.

Ozone oxidation reactions have been studied by numerous investigators: Criegee,¹⁰ Bailey and co-workers¹¹—olefins; Shubert and co-workers^{12, 13}—saturated hydrocarbons, and Bailey^{14, 15} and co-workers—free radical formation. Classical chain propagation mechanism of free radical reactions starts with abstraction of a hydrogen atom from a molecule by a second radical, as illustrated for a carboxylic acid.



Ozone additions typically result in the addition of all three oxygen atoms to the radical, followed by rapid release of an oxygen molecule

PRIMARY
PHOTOCHEMICAL
PROCESSES

INITIAL OXIDATION

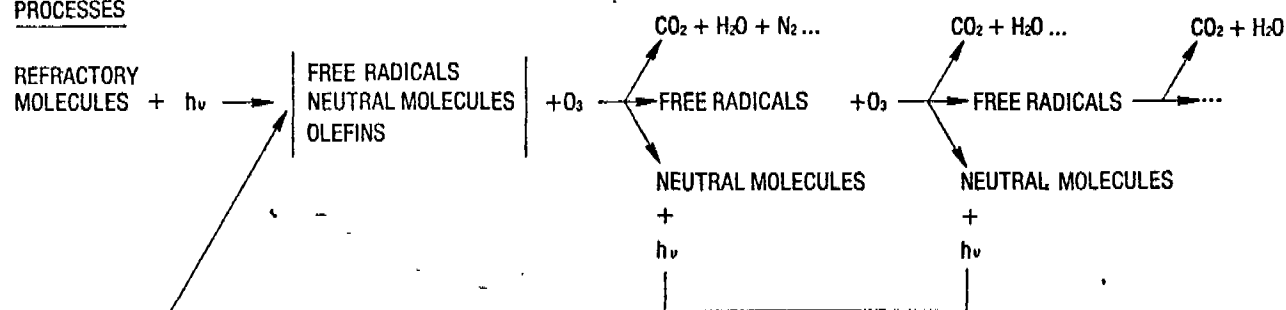


Fig. 5—Over-all photochemical/oxidation process to produce CO₂, H₂O, etc.

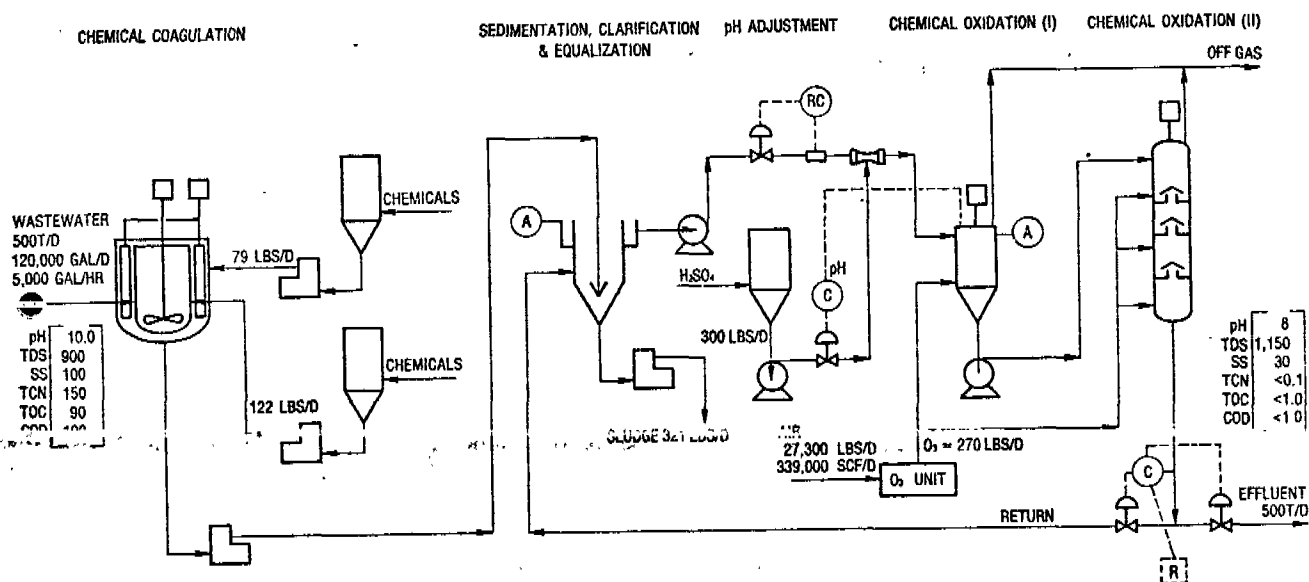
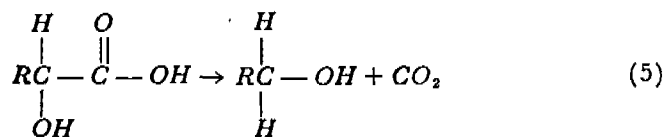
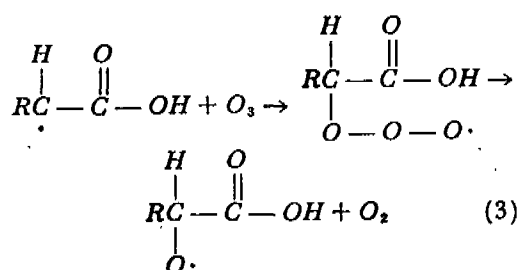
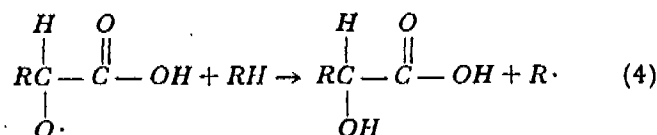


Fig. 6—Process flow for mixed cyanides plus organic refractories oxidation.



In a similar manner, alcohol formed is oxidized to an aldehyde, which is in turn oxidized to an acid. Therefore, for long chain molecules a cycle results,
alcohol → aldehyde → acid → alcohol + CO₂

The cycle of the chain propagation is then closed by the free radical removing a hydrogen from a neutral molecule



with the unstable molecule immediately rearranging to release CO₂

and in the limiting case of a one-carbon-chain, water (not alcohol) is formed on oxidation of the acid.

UV radiation produces substantially more free radicals than ozone alone; the radicals initiate many more propagation chains and cause the over-all reaction to proceed much, much faster. The over-all photochemical process to produce CO₂, H₂O, N₂, etc., can be represented schematically (Fig. 5). The two-step initiation process (primary photomechanical process and initial O₃ oxidation) is fol-

OZONE/UV PROCESS

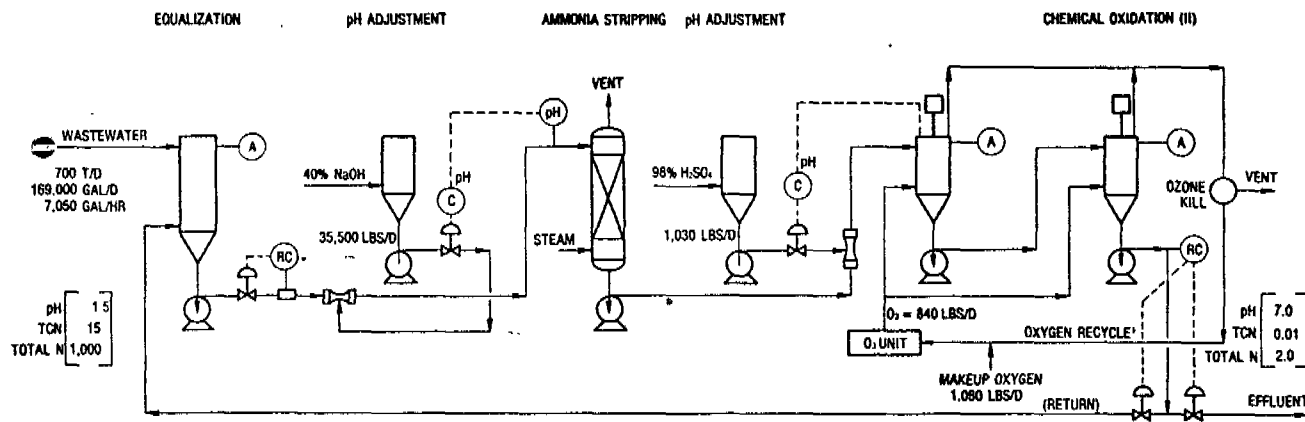
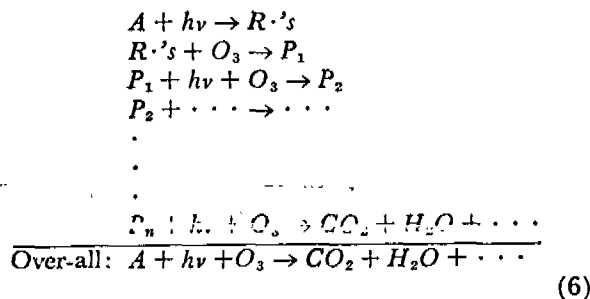


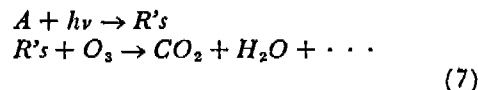
Fig. 7—Process flow for ammonia, cyanide and organic nitrogen compound oxidation.

lowed by propagation chains which produce additional free radicals, neutral molecules and some CO_2 , H_2O . . . by a termination step.

The reaction sequence, when the reaction is rate controlling, may be visualized as follows:



where $R \cdot$'s are the free radicals and $P_1, P_2, \dots$ are intermediate species. When the UV input is larger, the reaction becomes mass transferred controlled, and many more smaller free radicals are produced, which go directly to CO_2 , H_2O , etc., i.e.,



PROCESS CONFIGURATIONS

Several different applications are presented to illustrate how the process can be used.

► Removal of mixed cyanides and certain organic refractory molecules which produce very undesirable organic halides (Fig. 6).

A wastewater treatment facility designed to process 500 tons/day (83.3 gpm) of wastewater containing 900 mg/l of total dissolved solids including cyanides and organic components is shown in fig. 6. Mixed cyanides include free and complexed cyanide compounds (RFI less than 1 to 300) and refractory organic compounds (RFI approximately 1 to 1,000). Influent water quality vector is shown on the diagram. Objective of the plant is to reduce total cyanide (TCN) to below detectable limit, less than 0.1 mg/l, and total organic carbon (TOC) to less than 1 mg/l. The first step involves chemical coagulation with



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CCR 000038869

alum, activated silica and polyelectrolyte, followed by sedimentation, clarification and equalization. The pH is adjusted to 7-8 by acid addition for best results in the chemical oxidation reactors. A single-stage reactor (I) to oxidize front end RFI compounds is followed by a multistage reactor for final oxidation of high RFI compounds. Multistaging permits more effective oxidation, reduces total reactor volume and thereby capital cost. Ozone is supplied by a commercially available ozonator. The unit operates on air.

Installed plant cost is \$590,000 and operating cost, including amortization, is approximately \$500/day.

► Removal of ammonia, cyanide and organic nitrogen compounds (Fig. 7).

Wastewater treatment processing 700 tons/day (117.4 gpm) containing ammonia, cyanide and organic nitrogen compounds with a total nitrogen content of 1,000 mg/l. The objective of the plant is to reduce the ammonia, cyanide and organic materials to a dischargeable level. The first step is to adjust pH to basic and strip out ammonia with steam. Afterward, pH is further adjusted to near neutral for best results in two chemical oxidation reactors. Ozone is provided by generators using recycled oxygen. Installed facility cost is \$334,000 and operating cost (including amortization) is approximately \$225/day.

► Tertiary treatment to specifically oxidize refractory organics which would produce toxic compounds if chlorinated (Fig. 8).

Potentially toxic refractory organic compounds remaining after secondary treatment and carbon adsorption are removed in this facility. A stream of 1 million gallons/day contains 10 mg/l of TOC which must be reduced to a concentration of less than 0.1 mg/l. The influent stream from the previous units is flow controlled to the multistage reaction unit where compounds undergo complete oxidation to carbon dioxide and water. Ozone is supplied by commercially available ozonation unit operating on air. Ozone concentration is adjusted automatically by an effluent monitor. Installed cost of the entire facility is \$505,000.

PROCESS ECONOMICS

Effective reactor staging results in lower total amortized capital and operating costs (Table 3) where the optimum cost is less than a third of the single-stage treating cost. A similar cost analysis can be prepared for any wastewater species for which reaction rate data are available. Indication of the cost contribution for a reactor with mixer and ultraviolet lights is given in Fig. 9. Costs of ozone generated from air and from oxygen (Fig. 10) include the cost of oxygen.

ACKNOWLEDGMENT

Houston Research, Inc., wishes to acknowledge the U.S. Air Force Contract (AFSC/AFWL), F29601-73-C-0065, and U.S. Army Contract (MERDC), DAAK02-74-C-0239, under which substantial development of this process was carried out.

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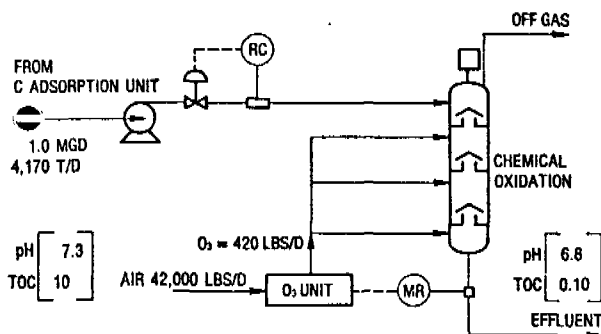


Fig. 8—Process flow for oxidation of refractory organics.

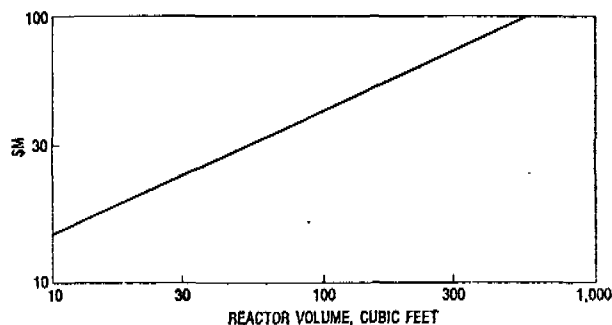


Fig. 9—Installed cost of stainless steel reactor, mixer and UV lights.

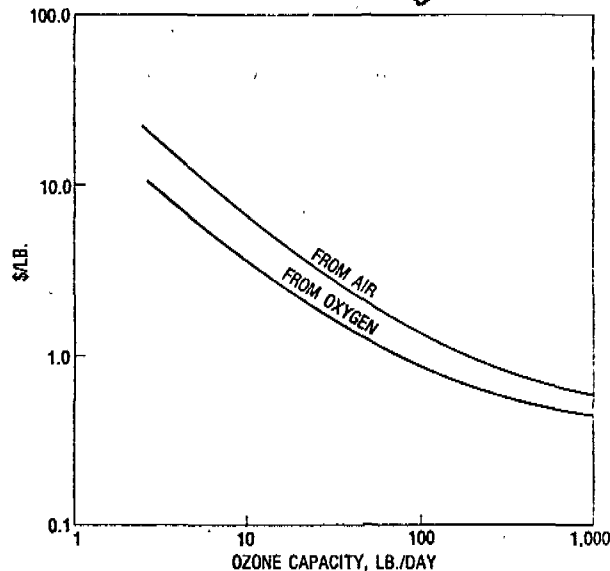
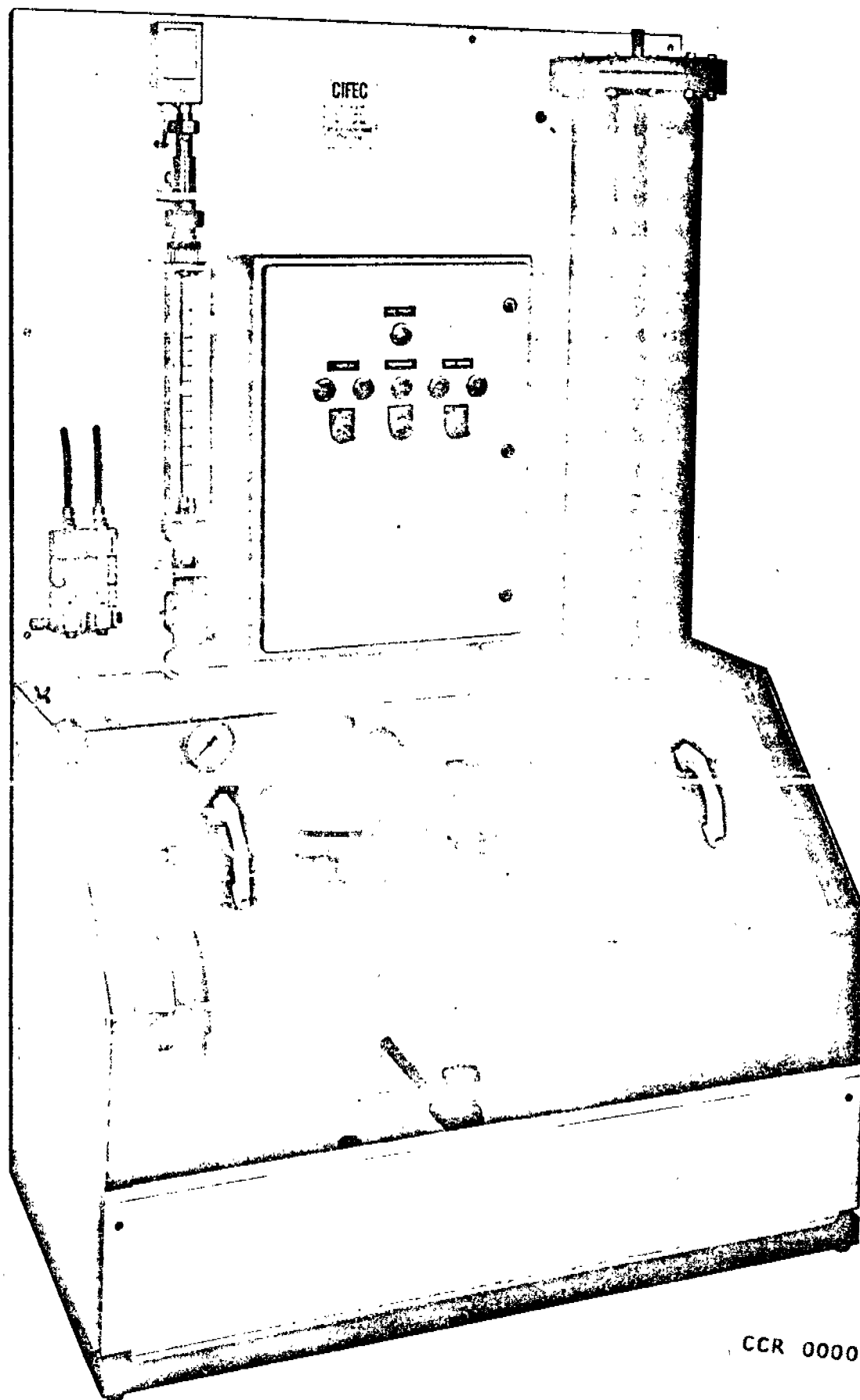


Fig. 10—Cost of producing ozone, including 10-year amortization.



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CHLORINE DIOXIDE GENERATOR
the french method with enrichment loop

CIFEC
BLOXY

Na Chlorite + UV → to bottom of EDC stripper
Scrubbers

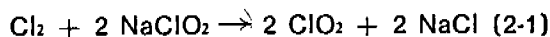
CIFEC®

CHLORINE DIOXIDE GENERATOR

United States Patent 3,975,284

THEORY OF OPERATION

Because chlorine dioxide is an extremely unstable gas, it cannot be packaged in containers as is chlorine or sulfur dioxide. Therefore it must be generated at the point of use. The most practical method is to react an aqueous chlorine solution with a sodium chlorite solution producing the following stoichiometric reaction:



Therefore, 1.34 lbs of pure sodium chlorite (NaClO_2) will react with 0.5 lb chlorine to produce 1.0 lb chlorine dioxide. Most technical grades of sodium chlorite are only about 80 percent pure, so that in practice it requires 1.7 lb of chlorite for the above reaction to be complete. The other important factor in the above reaction is that it must be at a controlled low pH, less than 4.0.

This is the secret of the success of the CIFEC "enrichment loop" concept. It insures optimum conditions for the reaction of equation 2-1. Therefore the CIFEC system is capable of producing continuously and reliably a chlorine dioxide solution that is 95 to 98 percent pure. This is the only on-site generation system that can make this claim. The current USA methods use an excess of chlorine to insure maximum yield of chlorite to chlorine dioxide. The result is a solution mixture of approximately 70 percent chlorine and 30 percent chlorine dioxide. This confuses and complicates the measurement of chlorine dioxide residuals in the treated process water. Therefore the French method can be controlled by chlorine dioxide residuals, but the USA methods must be controlled by the sodium chlorite dosage.

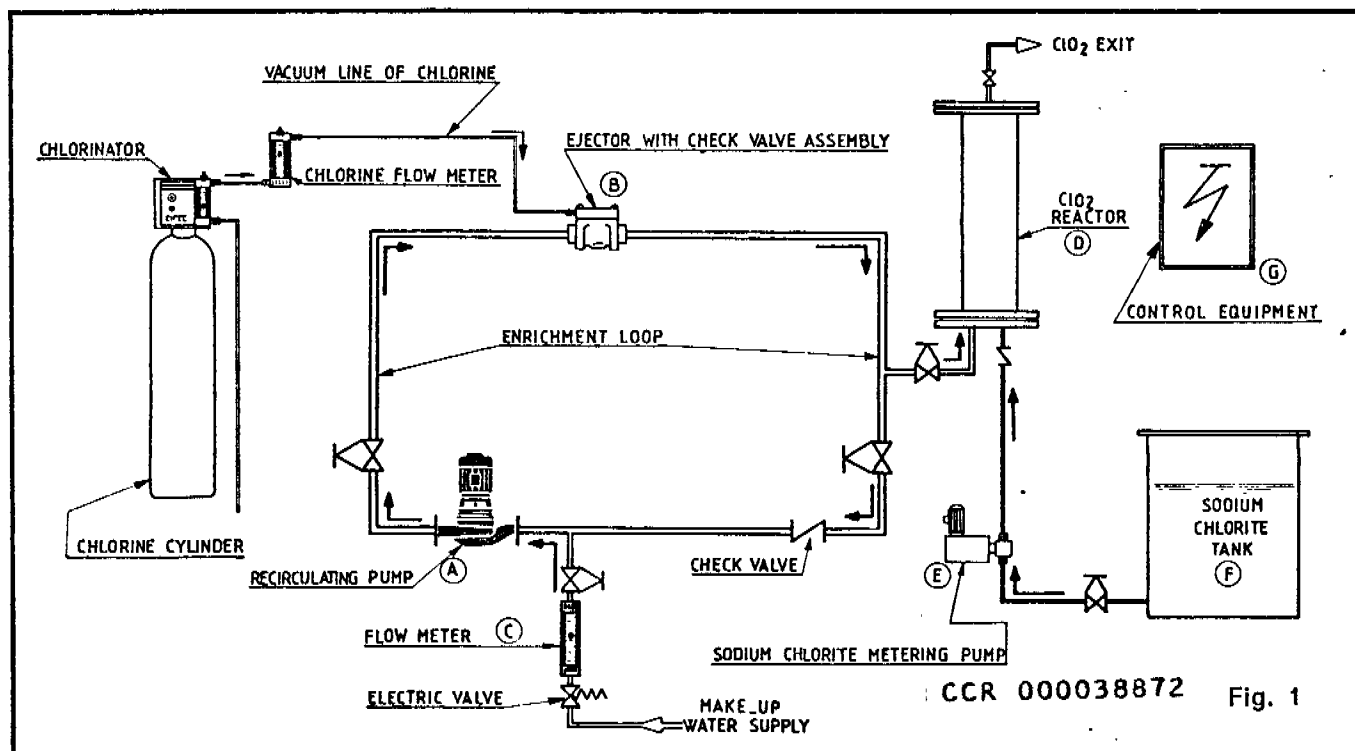
SYSTEM DESCRIPTION (see figure 1)

The installation consists of a recirculation loop of aqueous chlorine solution under pressure in a plug-flow regime which prevents negative hydraulic gradient conditions which are detrimental to the process.

Recirculation is accomplished by a special corrosion-resistant positive displacement pump (A)

which also provides the hydraulic power to operate the chlorinator injector (B). A rotameter assembly and diaphragm valve (C) allow the control and regulation of the make-up water.

A sodium chlorite metering pump (E) injects a specified concentration of solution from the sodium chlorite tank (F) into the ClO_2 reactor (D).



Here the reaction between HOCl and NaClO₂ produces ClO₂.

Control equipment (G) contains the controls for the operation of the two pumps and switchgear necessary to automatically stop the system in the

event of failure of water supply or chlorine supply. The entire assembly is mounted in a high rigidity PVC chassis reinforced with plastic coated steel for maximum corrosion resistance.

SPACE REQUIREMENTS

The CIFEC generator can be located in a small area. The equipment is mounted on a chassis ready to operate with all necessary wiring and piping connections. The sodium chlorite tank and chlorinator and chlorine supply cylinder are usually located outside of, but adjacent to, the generator chassis. The chlorinator can be cylinder mounted,

wall mounted or mounted in a separate module. In addition to a clean water supply and electric power, a proper drain must be provided for the usual accumulation of waste overflow which occurs during normal maintenance procedures. Specific dimensions of the generator and chlorite tanks are listed in the technical data section.

AUTOMATIC CONTROL

Flow proportional control of the CIFEC system can be achieved by the use of a 4-20 ma electric

analog signal. This can be expanded to include residual control if desired.

TECHNICAL DATA

*CLIN Cl₂O
Generator*

Accuracy	4 % of indicated flow rate.
Capacities	10, 25, 50, 100, 200, 500 and 1000 lb/day chlorine dioxide.
Feed range	10:1 for any combination of chlorine and sodium chlorite.
Injector operating water supply	Must be reasonably clean, operating limits 25-150 psi at 35-70 F.
Pressure at point of application	Maximum allowable is 6-8 psi depending on maximum flow rate of ClO ₂ .
Water supply	For ClO ₂ capacities of 10, 25 and 50 lb/day is 1-3 gpm, 100 lb/day is 5 gpm, 200 lb/day is 10 gpm, 500 lb/day is 20 gpm, and 1000 lb/day is 40 gpm.
Electrical requirements	220-480 volts A.C. 3 phase 60 Hz current for recirculating pump and 110-V-AC single phase current for controls and alarms.
Power requirements	This varies from 1-5 HP depending upon size of unit.
Sodium chlorite metering pumps	Pumps are furnished in accordance with capacity of the generator ; this varies from 30 gpd for the smaller unit up to 1200 gpd for the largest unit.
Sodium chlorite tank capacity	105 gal, 130 gal, 265 gal and 500 gal depending on size of metering pump.
Generator dimensions	Up to and including the 200 lb/day unit : width : 3 ft 7 in, depth : 2 ft 1.5 in, and height : 5 ft 9 in ; the 500 lb/day unit is : width : 4 ft 1 in, depth : 2 ft 7.5 in, and height : 6 ft 5 in ; the 1000 lb/day unit is : width : 5 ft 5 in, depth : 3 ft 1 in, and height : 7 ft 5 in.
Sodium chlorite tank dimensions	105 gal = 32 × 33 inches - 130 gal = 34 × 36 inches and 265 gal = 47 × 50 inches.

ADVANTAGES OF CHLORINE DIOXIDE

The most significant chemical properties of chlorine dioxide as they relate to potable water and waste water treatment are as follows :

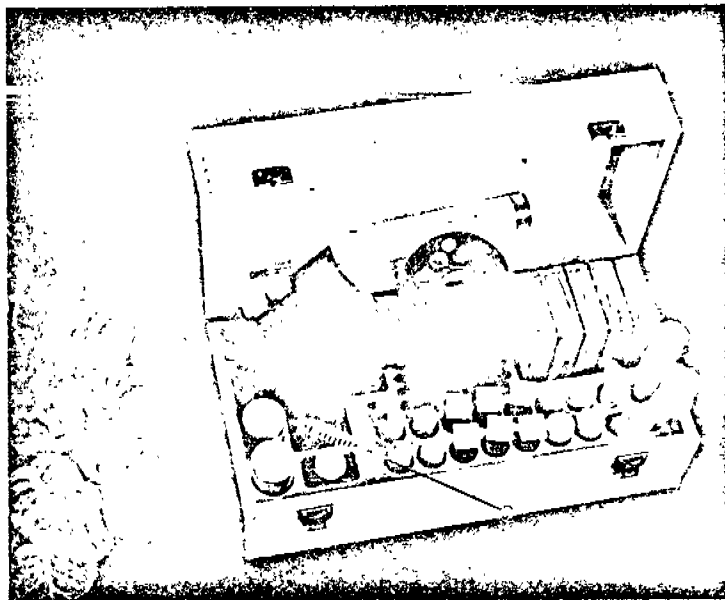
- 1/ ClO_2 does not react with any natural or man-made precursors to form chloroform, which is a known carcinogen - as does chlorine compounds.
- 2/ ClO_2 does not react with ammonia nitrogen to form germicidal compounds of inferior efficiency ;
- 3/ ClO_2 unlike chlorine keeps its germicidal efficiency in the pH range of 7 to 10.
- 4/ ClO_2 does not give a chlorine taste to water.
- 5/ ClO_2 destroys phenols.
- 6/ ClO_2 has a continuing disinfecting power twice than of chlorine.
- 7/ ClO_2 has a virucidal, bactericidal and algicidal power higher than chlorine.

PRACTICAL CONSIDERATIONS

The most important attribute of chlorine dioxide is that its bactericidal efficiency is equal to that of free chlorine regardless of the presence of ammonia nitrogen. Therefore on a cost-effective basis the use of chlorine dioxide as a disinfectant for high quality secondary effluents and tertiary effluents is of considerable interest. It could easily be the chemical of choice for disinfection requirements of 2.2/100 ml total coliforms particularly where virus kill is required.

In other situations of potable water and waste water treatment, chlorine dioxide is very effective in removing color and taste and odors resulting from organic compounds. It is specific in its destruction of phenolic compounds. It also is one of the most effective oxidants for the removal of complex organic iron and manganese compounds.

In food processing plants where the ammonia nitrogen content of the recycled water is greater than 2 mg/l, chlorine dioxide kills bacteria on the same order as free chlorine.



the new method CIFEC-PALIN for chlorine dioxide analysis

With this colorimetric method it is possible to measure separately chlorine dioxide, free chlorine, mono-, di- and trichloramine, sodium chlorite and ozone in the same sample.

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CIFEC

Cie INDUSTRIELLE DE FILTRATION ET D'ÉQUIPEMENT CHIMIQUE S. A.
10, av. de la Porte Molitor, F 75016 PARIS - Tél. 651.52.04 - Télex 611627 F

principle of operation

The DC-62 TOC Monitor utilizes ultraviolet promoted chemical oxidation followed by infrared detection to analyze for total organic carbon in water. Inorganic carbon interference is removed by acidification and sparging.

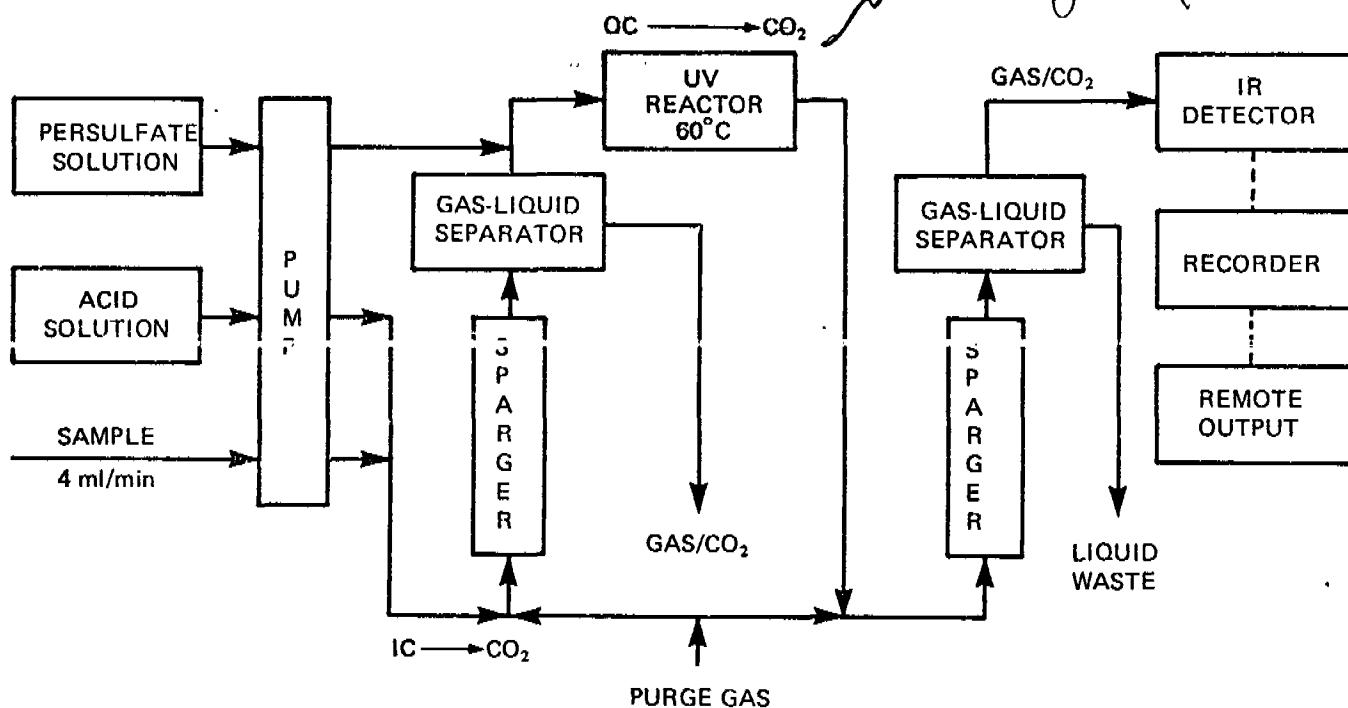
The sample is continuously pumped into the instrument, joined by a phosphoric acid flow, and passes through an inorganic carbon removal sparger and gas-liquid separator. This carbonate free sample then joins a persulfate solution flow and the mixture passes

through the quartz reaction coil where organic carbon is oxidized to CO_2 in the presence of ultraviolet light.

This oxidized sample then passes through another sparger and gas-liquid separator where CO_2 from the oxidation process is transferred to the gas phase. This gas then flows to a CO_2 specific infrared detector. An integral recorder continuously displays the linearized detector signal which is the TOC level of the sample.

An optional diluter can be used to handle high carbon levels and salt brines.

DC-62 FLOW SCHEMATIC



high salt streams

Salt solutions have typically been a problem with conventional TOC monitors utilizing direct injection into a high temperature furnace. The DC-62 overcomes this problem. In the low temperature oxidation process, the salts all remain in solution and are simply discharged through the analyzer waste line. Streams containing salt up to 3% can be handled directly, without a reduction in oxidation efficiency. Higher salt content streams can be handled after automatic dilution to the 3% or lower level.

high suspended solids streams

The DC-62 is designed to handle particles up to 0.75mm (0.03 in) in diameter. Streams with larger particles having little organic content should be screened. Streams which have larger particles whose organic content must be measured should be analyzed using the Dohrmann DC-60 TOC monitor. The DC-60 can handle particles up to 2.5mm (0.1 in) and is the preferred instrument for on-line monitoring of high suspended solids streams such as found in municipal waste treatment plants.

specifications

operational

Method	Ultraviolet promoted chemical oxidation, infrared detection.
Mode Options	Total Organic Carbon (TOC) Total Carbon (TC)
Inorganic Carbon Removal	>99.5% for low salt* streams >98.0% for high salt* streams
Carbon Range (full scale, continuously adjustable)	0-5 mg/l to 0-100 mg/l for low salt* streams 0-10 mg/l to 0-100 mg/l for high salt* streams 0-100 mg/l to 0-1000 mg/l for low and high salt streams, as well as brines* using optional diluter. Higher ranges available upon request. * Low salt, < 0.1% High salt, > 0.1%, < 3% Brines, > 3%, < 30%

performance

Linearity	±2% of full scale
Drift	±5% of full scale per week, maximum

data display

Local Readout	Built-in strip chart recorder
Remote Output	Isolated voltage or current, Variable through either 0 to 10V or 0 to 50 mA with variable zero offset. Typical; 4 - 20 mA (1000 Ω max load)

alarms

TOC Overrange	Selected as a percent of full scale
Temp. Overrange	Reactor region overtemperature
Pressure Overrange	Flow system restriction
Liquid Spill	Reactor region leak
All alarms feature front panel indicator lamps and contact closures for remote indication.	

sample requirements

Flow Rate	Monitor consumes 4 ml/min
Suspended Solids	Accepts particles up to 0.75 mm (0.03 in) diameter. Oxidation efficiency depends on size and chemical nature of particles.

utility and supplies requirements

Power	115 VAC, 60 Hz 700 VA
Sparge Gas	160 ml/min. of CO ₂ free nitrogen, oxygen or air, high salt. 240 ml/min. low salt.
Reagents	
Low salt application	Persulfate Solution, 5% 7.5 litre/wk (1.65 gal/wk) Phosphoric Acid Solution, 10% 3.2 litre/wk (0.7 gal/wk)
High salt application	Persulfate Solution, 5% 10.8 litre/wk (2.4 gal/wk) Phosphoric Acid Solution, 10% 3.2 litre/wk (0.7 gal/wk) Hydrazine Sulfate Solution, 3% 3.2 litre/wk (0.7 gal/wk)

dimensions

Detector Electronics and Readout Module	28cm high, 61cm wide, 61cm deep (11" h x 24" w x 24" d)
Reaction Module	46cm high, 61cm wide, 61cm deep (18" h x 24" w x 24" d)
Reagent Module	43cm high, 61cm wide, 61cm deep (17" h x 24" w x 24" d)
Weight Without Reagents	Net: 124kg (272 lb) Shipping: 146kg (322 lb)

Specifications subject to change without notice.

for more information, contact

ENVIROTECH



DOHRMANN

3240 Scott Boulevard
Santa Clara, California 95050
Telex 346 395

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Improve total organic carbon monitor reliability with ultraviolet converter

Top Honors

Top Honors distinction was accorded to a continuously operating process total organic carbon monitor that incorporates a high-intensity, ultraviolet-promoted chemical oxidation system instead of a high-temperature pyrolysis system.

"We judge the TOC analyzer to be a significant entry," one of the judges remarks. "The ultraviolet converter is a definite advantage in the right direction rather than the previously used high-temperature furnaces."

In developing the award-winning entry, the firm incorporated its highly successful, low-temperature (50°C), high-intensity UV-promoted chemical oxidation technology used in an ultra-low-level (part-per-billion) laboratory TOC into a process monitor. Reliability was maximized and routine maintenance minimized by careful design. The firm was also able to achieve minimum operating cost and purchase price consistent with operational and design parameters.

The replacement of the traditional red-hot reaction furnace changer with a system

that operates at 60°C is said to eliminate a possible explosion hazard. If service is required, there is reported to be less hazard presented to maintenance personnel. The low-temperature system eliminates the time-consuming shutdown and exchange problems associated with frequent high-temperature reactor failure due to either flow stoppage from crystalline salt deposition or the "corroded-through" failure due to strong oxidant attack.

The low-temperature oxidation system and mechanical features of the monitor minimize the time required to maintain continuous operation. Routine preventative maintenance by semi-skilled personnel is said to run typically about four hours per month. This includes the time needed to check calibration and return the instrument to on-line operation.

On-line TOC monitors need protection from both their external and internal environments. The instrument's packaging concept provides complete isolation of the electronic module from the chemical oxidation module. Both modules are isolated from the external environment by the use of sealed enclosures. Access to the interior of each module is obtained by

opening the gasketed front door. All components are readily accessible. The monitor can be wall-mounted if desired.

The principle of operation of the instrument requires using ultraviolet-promoted chemical oxidation followed by infrared detection to analyze for total organic carbon in water (see flow schematic). Inorganic carbon interface is removed by acidification and sparging.

The sample is continuously pumped into the instrument, joined by a phosphoric acid flow, and passes through an inorganic carbon removal sparger and gas-liquid separator. This carbonate-free sample then joins a persulfate solution flow and the mixture passes through the quartz reaction coil in which organic carbon is oxidized to CO₂ in the presence of ultraviolet light.

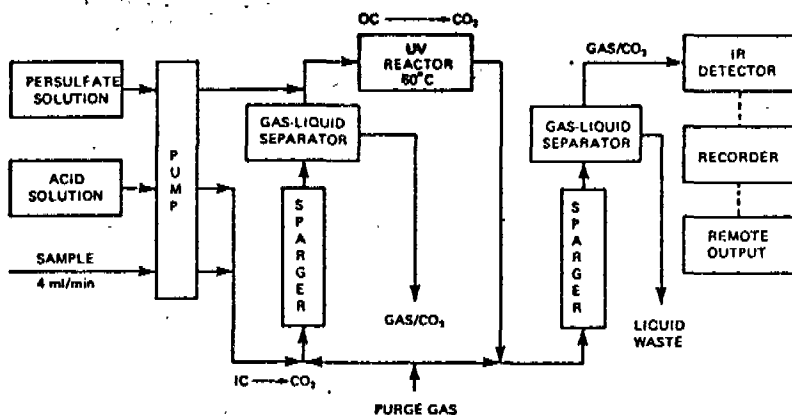
This oxidized sample then passes through another sparger and gas-liquid separator in which CO₂ from the oxidation process is transferred to the gas phase. This gas then flows to a CO₂ specific infrared detector. An integral recorder continuously displays the linearized detector signal which is the TOC level of the sample.

An optional diluter can be used to handle carbon levels to 1000 mg/litre and salt brines to 30%.

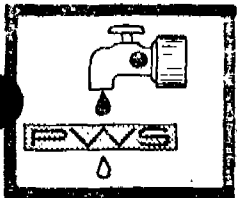
Salt solutions have typically been a problem with conventional TOC monitors utilizing direct injection into a high-temperature furnace. The award-winning monitor is said to overcome this problem. In the low-temperature oxidation process, the salts all remain in solution and are simply discharged through the analyzer waste line. Streams containing salt up to 3% can be handled directly, without a reduction in oxidation efficiency. Higher salt content streams can be handled after automatic dilution to the 3% or lower level.

Analyzer is designed to handle particles up to 1 mm (0.04") in diameter. Streams with larger particles having little organic content should be screened.

(Model DC-62 total organic carbon monitor — Envirotech Corporation, Dohrmann Division, 3240 Scott Blvd., Santa Clara, CA 95050.)



Flow schematic illustrates principle of operation of TOC monitor (see text)



PURE WATER SYSTEMS, INC.

4 EDISON PLACE • FAIRFIELD, NEW JERSEY 07006 • TEL: (201) 575-8750

November 14, 1979

M. McCaulley
Conoco
P.O. Box 727
Westlake, LA 70669

Mr. McCaulley:

In response to your recent request, I am forwarding information about the ultraviolet purification equipment that we produce.

Our research has recently resulted in our being able to expand the use of our "thin-film, high-energy" ultraviolet equipment into the arena of destruction of toxic compounds.

Our process encompasses the injection of an oxidizing compound (H_2O_2) into the flow stream of the compound being treated followed by exposure to our high intensity ultraviolet plasma for approximately 200 seconds. This ultraviolet exposure has a multiple reaction in the decomposition of the toxic compound. The H_2O_2 is dissociated photochemically to H, OH, and O_2 . Additionally, the 184 nanometer ultraviolet will ionize the O_2 to O_3 . The combination of OH and O_3 with the ultraviolet environment supply sufficient energy potential for the destruction of not only a very wide range of toxic compounds, but very high concentrations of these compounds. Compounds which we have successfully treated to are: cyanides (ferro, sodium, potassium, and complexed cyanides), phenols, PCB's, THM's, DDT, acetic acid, organic contamination of tungsten, and others. Total process time required for the most difficult compounds is two hours. Destruction is to levels beyond detectability (less than 10 ppb).

We have laboratory equipment for treating small quantity samples to demonstrate the efficiency of the process and to afford data which is required to scale-up to required volumes. We currently have full-scale toxic destruct equipment with flow capability to 100 GPM.

Thank you for your inquiry, and we look forward to serving you further.

Very truly yours,

PURE WATER SYSTEMS, INC.

M. Dale Wood
M. Dale Wood
President

MDW:lv
Encls.

Please refer further requests to Wayne Wren.

CCR 000038878

*Tests may be
inexpensive*

ULTRA-VIOLET PRODUCTS, INC. 

PEN-RAY®/SOG DATA

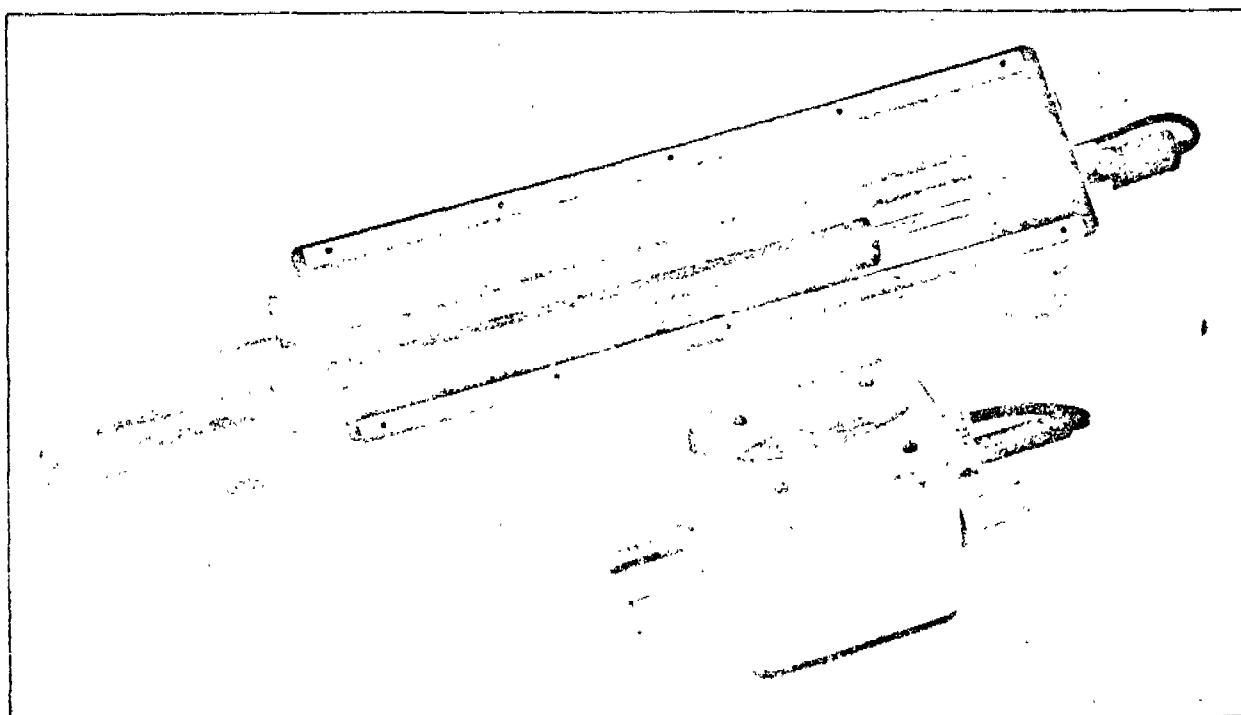
Stable Ozone Generators

FEATURES:

- Long term Stability of Light Source
- Reproducible Ozone Output
- No Electrical Adjustment Required
- Simple Sleeving Technique for Varying Ozone Output
- Light Source of PEN-RAY Lamp Quality
- Low & High Output Units Available
- No Heating of Gas Stream by Light Source
- Quartz Flowtube and Light Source for High 184.9 nm Transmission

MAIN APPLICATIONS:

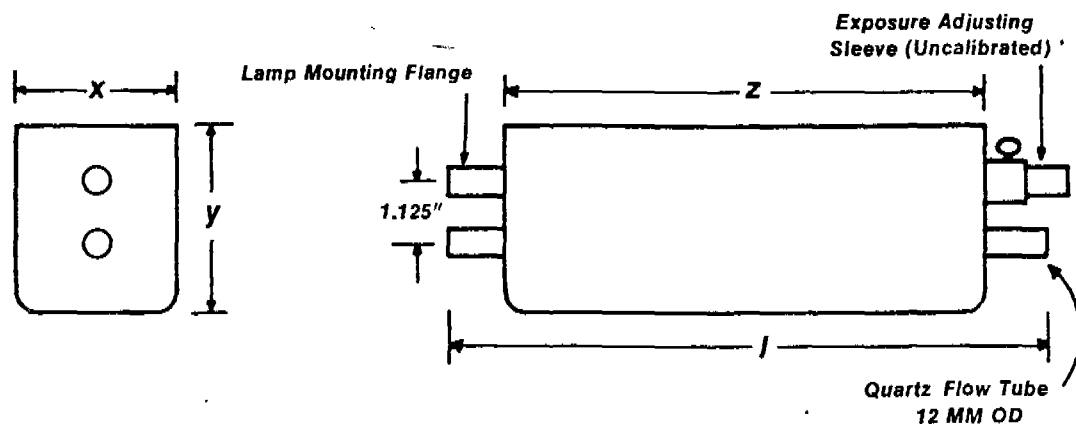
- Calibration of Field and Laboratory Ozone Analyzers
- Source of Oxidant for Aging and Oxidation Testing of Materials, Such as Rubber, Polymers, etc.
- Ozone Source for Instrumentation Development
- Water Purification Studies
- Air Pollution Studies



CCR 000038879

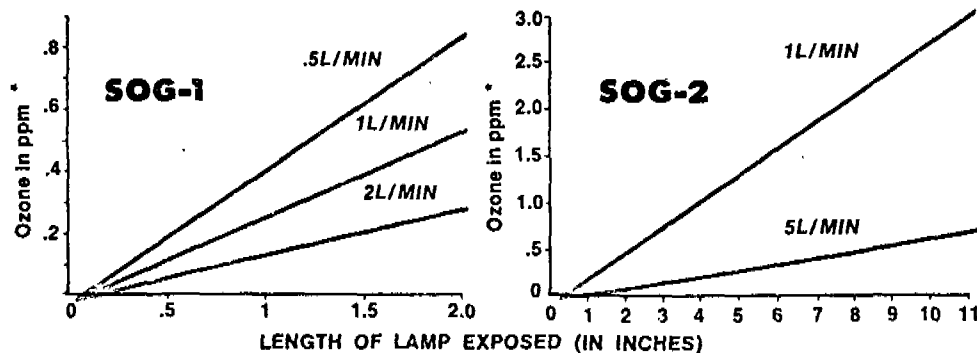
PEN-RAY®/SOG DATA

Stable Ozone Generators



CONSISTS OF:	SOG - 1	SOG - 2
Lamp	11SC - 1	3SC - 9
Power Supply	SCT - 1	SCT - 4
Dimension — x	2"	2.125"
y	2"	2"
z	3"	11.125"
I	5.5"	13.5"
Sleeve Adjustment	Max. of 2"	Max. of 9"

The Following Graphs Show Typical Ozone Levels Produced By SOG - 1 And SOG - 2



* Above curves are representative of ozone levels produced by the SOG-1, SOG-2. A Wet Chemistry Technique (KI) was used to determine ozone produced.

Your
Authorized
Dealer

CCR 000038880

LABORATORY
PRODUCTS List Price Schedule

Effective December 31, 1978

ITEM	DESCRIPTION	SHPG. WT.	LIST
B-100A	BLAK-RAY® Lamp 115V, LW	17#	\$199.00
B-100A	BLAK-RAY Lamp 220V, LW	17#	259.00
B-100A/R	BLAK-RAY Lamp 115V, LW	17#	259.00
B-100A/R	BLAK-RAY Lamp 220V, LW	17#	309.00
B-100A/X	BLAK-RAY Lamp 115V, LW	17#	219.00
B-100A/X	BLAK-RAY Lamp 220V, LW	17#	279.00
C-61	MINERALIGHT® Transilluminator 115V, SW	24#	490.00
C-61	MINERALIGHT Transilluminator 220V, SW	24#	510.00
C-61	MINERALIGHT Transilluminator 250V, SW	24#	525.00
C-62	BLAK-RAY Transilluminator 115V, LW	24#	360.00
C-62	BLAK-RAY Transilluminator 220V, LW	24#	398.00
C-62	BLAK-RAY Transilluminator 250V, LW	24#	398.00
C-70	CHROMATO-VUE® Cabinet 115V, SW & LW	29#	650.00
C-70	CHROMATO-VUE Cabinet 220V, SW & LW	29#	675.00
C-70	CHROMATO-VUE Cabinet 250V, SW & LW	29#	675.00
C-71	CHROMATO-VUE Cabinet 115V, LW	29#	598.00
C-71	CHROMATO-VUE Cabinet 220V, LW	29#	675.00
C-71	CHROMATO-VUE Cabinet 250V, LW	29#	675.00
CC-10	CHROMATO-VUE Cabinet	9#	59.95
CC-15	CHROMATO-VUE Cabinet 115V UL, SW & LW	15#	174.00
CC-15	CHROMATO-VUE Cabinet 115V CSA, SW & LW	15#	179.00
CC-15	CHROMATO-VUE Cabinet 220V, SW & LW	15#	185.00
CC-20	CHROMATO-VUE Cabinet 115V, SW & LW	14#	359.00
CC-20	CHROMATO-VUE Cabinet 115V CSA, SW & LW	14#	379.00
CC-20	CHROMATO-VUE Cabinet 220V, SE & LW	14#	379.00
G-203	Adapter	5#	49.95
G-275	Filter Assembly	1#	22.95
G-276	Filter Assembly	1#	74.95
G-277	Filter Assembly	1#	74.95
G-278	Filter Assembly	1#	33.95
J-124	Stand	4#	17.95
J-126	Bracket	1#	5.95
J-129	Stand	3#	29.95
J-221	BLAK-RAY Meter, LW	4#	210.00
J-225	BLAK-RAY Meter, SW	4#	225.00
J-236	Certification System 115V, LW	19#	598.00
J-236	Certification System 220V, LW	19#	620.00

BLAK-RAY®, MINERALIGHT®, GEM-TEMP®,
PEN-RAY®, and CHROMATO-VUE®, are regis-
tered trademarks of ULTRA-VIOLET PRODUCTS,
INC. LW=Long wave ultraviolet (365 nm)
SW=short wave ultraviolet (254 nm)

All prices are F.O.B. San Gabriel, California.
Minimum billing \$50.00 net.
Terms: Net 30 days.

CCR 000038881

ITEM	DESCRIPTION	SHPG. WT.	LIST
J-237	Certification System 115V, SW	19#	\$620.00
J-237	Certification System 220V, SW	19#	690.00
J-260	Radiometer 115V	4#	785.00
J-260	Radiometer 220V	4#	785.00
J-2601A	Sensor (254nm)	2#	225.00
J-2602A	Sensor (365nm)	2#	225.00
J-2603A	Sensor (297nm)	2#	225.00
J-330	Recharger 115V	2#	26.95
J-331	Recharger 12V	2#	26.95
J-332	Recharger 220V	2#	54.95
M-14	MINERALIGHT® Lamp 115V, SW	3#	185.00
M-14	MINERALIGHT Lamp 12V, SW	3#	185.00
M-14	MINERALIGHT Lamp 220V, SW	3#	205.00
M-15	MINERALIGHT Lamp 115V, SW & LW	3#	185.00
M-15	MINERALIGHT Lamp 12V, SW & LW	3#	185.00
M-15	MINERALIGHT Lamp 220V, SW & LW	3#	205.00
M-16	BLAK-RAY® Lamp 115V, LW	3#	165.00
M-16	BLAK-RAY Lamp 12V, LW	3#	165.00
M-16	BLAK-RAY Lamp 220V, LW	3#	189.00
ML-49	BLAK-RAY Lamp, LW	4#	89.95
MS-47	MINERALIGHT Lamp, SW	4#	110.00
MSL-48	MINERALIGHT Lamp, SW & LW	4#	105.00
PCQ-008L	Photochemical Lamp	7#	379.00
PCQ-008PS	Power Supply	11#	175.00
PCQ-008S	Photochemical Lamp	7#	339.00
PCQ-023	Photochemical Lamp	9#	599.00
PCQ-023L	Photochemical Lamp	9#	775.00
PCQ-023PS	Power Supply	11#	175.00
PCQ-024L	Photochemical Lamp	9#	495.00
PCQ-024PS	Power Supply	11#	175.00
PCQ-024S	Photochemical Lamp	9#	790.00
PCQ9G-1	Photochemical Lamp, 2½"	4#	230.00
PCQ9G-1	Photochemical Lamp, 4"	4#	235.00
PCQ9G-1	Photochemical Lamp, 6"	4#	240.00
PCQ9G-1	Photochemical Lamp, 7" or 8"	4#	245.00
PCQ9G-1	Photochemical Lamp, 10" or 11"	4#	249.00
R-52	MINERALIGHT Lamp 115V, SW	12#	339.00
R-52	MINERALIGHT Lamp 220V, SW	12#	375.00
S-68	MINERALIGHT Lamp 115V, SW	15#	549.00
S-68	MINERALIGHT Lamp 220V, SW	15#	549.00
S-68A	MINERALIGHT Lamp 115V, SW	16#	729.00
S-68A	MINERALIGHT Lamp 220V, SW	16#	819.00
S-69	BLAK-RAY Lamp 115V, LW	15#	510.00
S-69	BLAK-RAY Lamp 220V, LW	15#	525.00
SCT-1	Power Supply 115V	4#	79.95
SCT-1	Power Supply 220V	4#	89.95
SCT-2	Power Supply 115V	4#	89.95
SCT-2	Power Supply 220V	4#	99.95
SCT-3	Power Supply 115V	4#	84.95
SCT-3	Power Supply 220V	4#	89.95
SCT-4	Power Supply 115V	6#	84.95
SCT-4	Power Supply 220V	6#	99.95
SOG-1	Ozone Generator 115V	7#	303.00
SOG-1	Ozone Generator 220V	7#	325.00

CCR 000038882

ITEM	DESCRIPTION	SHPG. WT.	LIST
SOG-2	Ozone Generator 115V	13#	\$415.00
SOG-2	Ozone Generator 220V	13#	435.00
SPR-33	Stable PEN-RAY® Lamp 115V	46#	3,475.00
UVC-303	BLAK-RAY® Spectacles	1#	6.00
UVC-503	BLAK-RAY Safety Goggles	1#	7.50
UVL-21	BLAK-RAY Lamp 115V UL, LW	3#	44.95
UVL-21	BLAK-RAY Lamp 115V CSA, LW	3#	49.95
UVL-21	BLAK-RAY Lamp 220V, LW	3#	54.95
UVL-56	BLAK-RAY Lamp 115V, LW	4#	64.95
UVL-56	BLAK-RAY Lamp 115V CSA, LW	4#	69.95
UVL-56	BLAK-RAY Lamp 220V, LW	4#	74.95
UVS-11	MINERALIGHT® Lamp 115V, SW	1#	64.95
USV-11	MINERALIGHT Lamp 115V CSA, SW	3#	74.95
UVS-11	MINERALIGHT Lamp 220V, SW	3#	79.95
UVS-54	MINERALIGHT Lamp 115V, SW	4#	109.95
UVS-54	MINERALIGHT Lamp 115V CSA, SW	4#	114.95
UVS-54	MINERALIGHT Lamp 220V, SW	4#	119.95
UVSL-15	MINERALIGHT Lamp 115V, SW & LW	3#	64.95
UVSL-15	MINERALIGHT Lamp 115V CSA, SW & LW	3#	69.95
UVSL-15	MINERALIGHT Lamp 220V, SW & LW	3#	79.95
UVSL-25	MINERALIGHT Lamp 115V, SW & LW	3#	79.95
UVSL-25	MINERALIGHT Lamp 115V CSA, SW & LW	3#	94.95
UVSL-25	MINERALIGHT Lamp 220V, SW & LW	3#	94.95
UVSL-55	MINERALIGHT Lamp 115V, SW & LW	4#	99.95
UVSL-55	MINERALIGHT Lamp 115V CSA, SW & LW	4#	99.95
UVSL-55	MINERALIGHT Lamp 220V, SW & LW	4#	109.95
UVSL-58	MINERALIGHT Lamp 115V, SW & LW	4#	114.95
UVSL-58	MINERALIGHT Lamp 115V CSA, SW & LW	4#	119.95
UVSL-58	MINERALIGHT Lamp 220V, SW & LW	4#	124.95
X15-B	BLAK-RAY Lamp 115V, LW	7#	84.95
X15-B	BLAK-RAY Lamp 115V CSA, LW	7#	94.95
X15-B	BLAK-RAY Lamp 220V, LW	7#	99.95
X-15H	BLAK-RAY Lamp 115V, LW	7#	99.95
X-15H	BLAK-RAY Lamp 220V, LW	7#	114.95
XX-15	BLAK-RAY Lamp 115V, LW	8#	99.95
XX-15	BLAK-RAY Lamp 115V CSA, LW	8#	99.95
XX-15	BLAK-RAY Lamp 220V, LW	8#	114.95
XX-15H	BLAK-RAY Lamp 115V, LW	8#	99.95
XX-40A	BLAK-RAY Lamp 115V, LW	20#	124.95
XX-40A	BLAK-RAY Lamp 220V	20#	149.95
11SC-1	PEN-RAY Lamp, SW	1#	52.95
11SC-1L	PEN-RAY Lamp, LW	1#	78.95
11SC-2	PEN-RAY Lamp, SW	1#	52.95
22SC-3L	PEN-RAY Lamp, LW	1#	190.00
22SC-3S	PEN-RAY Lamp, SW	1#	119.00
3SC-9	PEN-RAY Lamp, 9" SW	1#	109.95
90-0013-01	PEN-RAY Lamp — Argon Fill	1#	77.95
90-0014-01	PEN-RAY Lamp — Krypton Fill	1#	77.95
90-0015-01	PEN-RAY Lamp — Neon Fill	1#	77.95
90-0016-01	PEN-RAY Lamp — Neon-Mercury Fill	1#	77.95
90-0017-01	PEN-RAY Lamp — Xenon Fill	1#	77.95
98-0008-01	"A" Lamp Shield	1#	7.95
98-0008-02	"B" Lamp Shield	1#	7.95
90-0008-03	"C" Lamp Shield	1#	7.95

CCR 000038883

REPLACEMENT PARTS

ITEM	PART NO.	SHPG. WT.	LIST
BATTERIES			
J-333 6V Rechargeable	45-0002-01	2#	\$ 52.75
J-144 6V Super	45-0005-01	6#	7.75
J-145 45V	45-0006-01	6#	35.25
12V Rechargeable	45-0009-01	1#	8.25
BULBS			
100-watt Spot, LW	34-0011-01	2#	40.00
White, for battery lamps	34-0014-01	1#	1.25
100-watt Flood, LW	34-0022-01	2#	50.00
FILTERS (254nm) for:			
S-68, S-68A	38-0006-01	1#	97.95
CC-20	38-0004-01	1#	93.95
R-52	38-0008-01	2#	57.95
C-61	38-0011-01	4#	197.00
UVS-11, UVSL-25	38-0012-01	2#	32.95
MS-47, MSL-48, UVS -54, UVSL-55, UVSL-58	38-0015-01	2#	38.95
M-14, M-15	38-0018-01	1#	18.95
C-70	38-0031-01	2#	198.00
UVSL-15	38-0035-01	2#	21.95
FILTERS (365nm) for:			
C-70, C-71	38-0001-01	2#	36.95
UVL-21	38-0002-01	2#	5.95
CC-20	38-0005-01	1#	30.95
B-100A	38-0009-01	2#	10.95
C-62	38-0010-01	4#	65.95
M-16	38-0019-01	1#	5.95
S-69	38-0032-01	1#	8.95
FILTERS (365nm) for:			
UVSL-15	38-0034-01	1#	5.95
UVL-56, UVSL-55, MSL-48	38-0037-01	2#	5.95
	38-0050-01	2#	5.95
FILTERS, Contrast Control for:			
CC-10, CC-20, C-70, C-71	38-0013-01	1#	20.95
TUBES, Germicidal (254nm)			
4-watt	34-0003-01	1#	13.25
6-watt	34-0013-01	1#	13.25
8-watt	34-0007-01	1#	13.75
15-watt	34-0008-01	2#	13.75
30-watt	34-0025-01	5#	27.50
TUBES, Black Light Blue (365nm)			
4-watt	34-0010-01	1#	11.00
6-watt	34-0016-01	1#	11.00
8-watt	34-0031-01	1#	16.50
15-watt	34-0017-01	2#	16.50
30-watt	34-0018-01	5#	33.00
40-watt	34-0032-01	8#	33.00
TUBES, Black Light (365nm)			
4-watt	34-0005-01	1#	5.50
6-watt	34-0034-01	1#	5.50
8-watt	34-0006-01	1#	13.75
15-watt	34-0009-01	2#	13.75
40-watt	34-0024-01	8#	33.00
TUBES, Multiband (254 & 365nm)			
4-watt	34-0004-01	1#	13.75
6-watt	34-0015-01	1#	13.75
15-watt	34-0033-01	2#	22.00
TUBES, White Light			
8-watt	34-0001-01	1#	4.25
For C-70, C-71	34-0002-01	1#	3.50
TUBES, Quartz			
For S-68, S-68A	32-0009-01	2#	249.00
For R-52	77-0003-01	1#	169.00