廢水處理及回收的臭氧技術

臭氧應用於廢水回收 20111007

- 臭氧在廢水回收的應用
- 應用的方法：臭氧注入、反應槽的設計
- 選擇臭氧機的注意事項：穩定性、耗能
- 設備費用及操作費用

AirTree Ozone Technology CO., Ltd.
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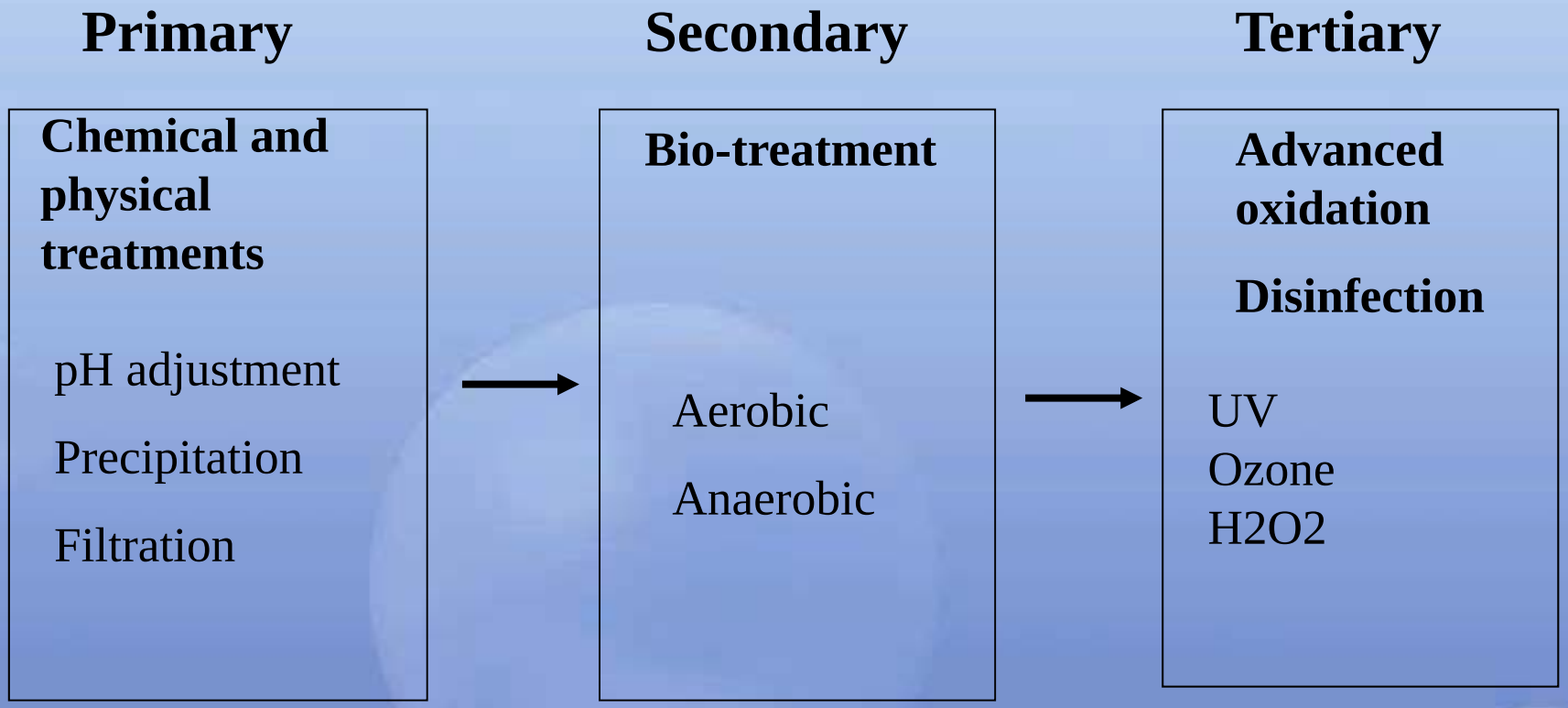
Waste water treatment processes

pH = ???, COD =??? ppm,

Chemicals/formula ??? ppm

CMD = ???



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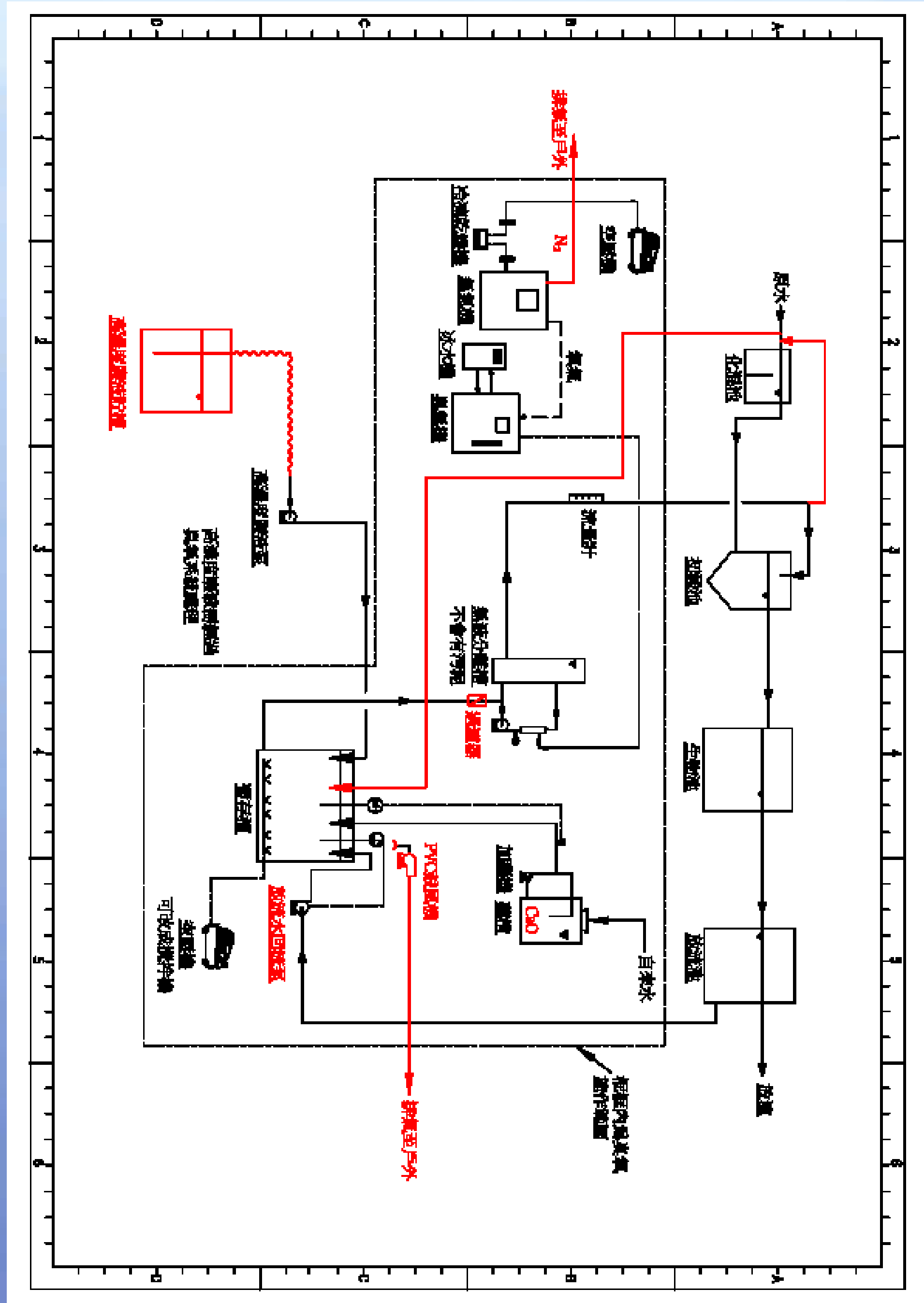
AirTree



What can ozone do ?

Disinfection

bacteria < spore < virus < cysts

Oxidation (eV)

F_2 (3.0) > OH (2.8) > O (2.4) > O_3 (2.09)

> H_2O_2 (1.77) > HOCl (1.5) > Cl_2 (1.3)

Breaking chemicals into small molecules

Reduce COD BOD

Decolor

Deodor

AirTree

In acid solution

pH adjusted

O_2

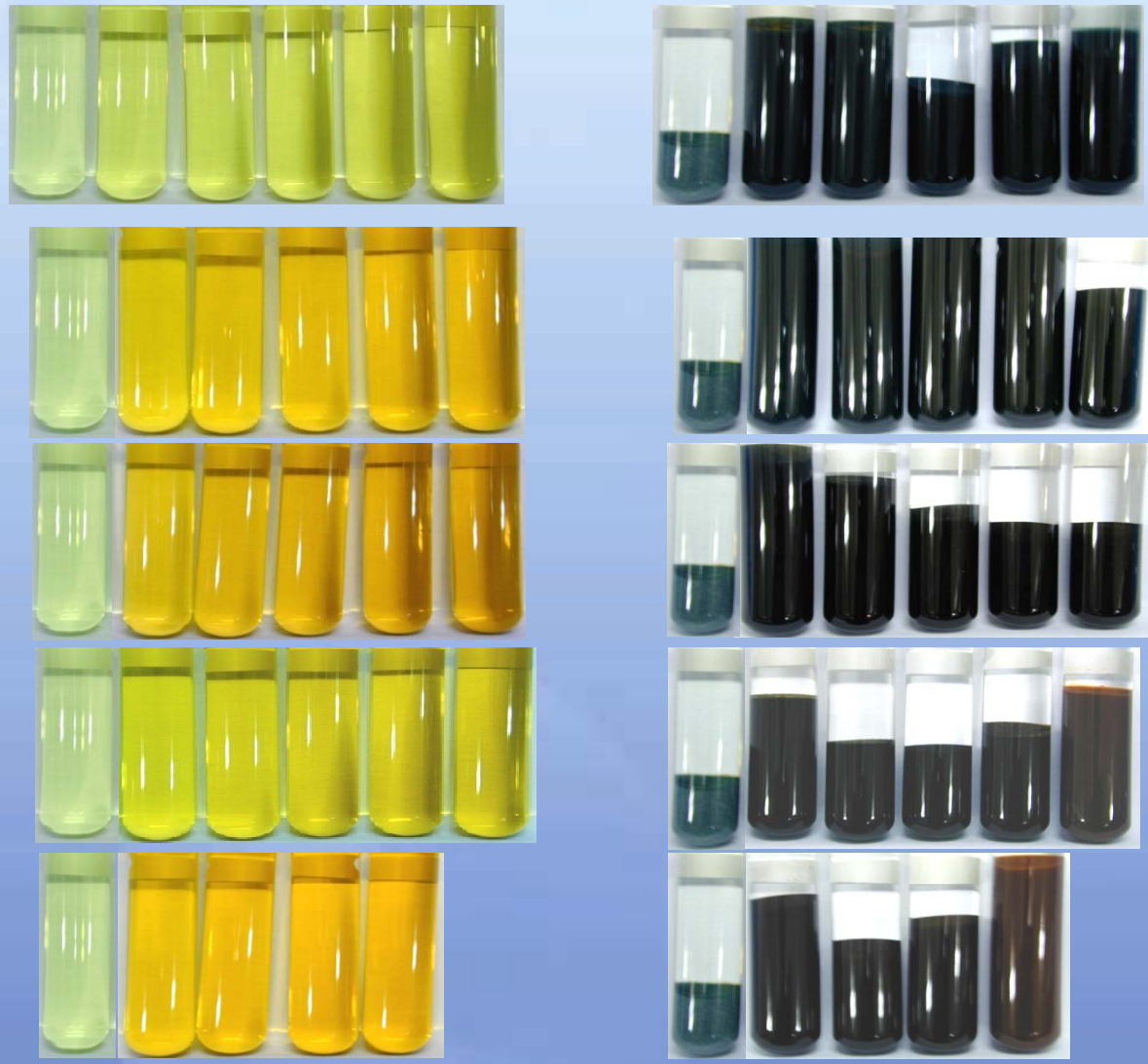
O_3 (wt%)

4.5%

6%

8%

10%



0 4 6 8 10 12 (min)

0 4 6 8 10 12 (min)

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$$Fe^{3+} + e^{-} \rightarrow Fe^{+2} \qquad \Delta E = 0.77eV$$

$$O_3 + 2H^{+} + 2e^{-} \rightarrow O_2 + H_2O \qquad \Delta E = 2.09eV$$

$$O_2 + 4H^{+} + 4e^{-} \rightarrow 2H_2O \qquad \Delta E = 1.229eV$$

$$4Fe^{2+} + O_2 + 4H^{+} \rightarrow 4Fe^{+3} + 2H_2O$$

$$2Fe^{2+} + O_3 + 2H^{+} \rightarrow 2Fe^{+3} + H_2O + O_2$$

$$nF\Delta E = RTLn(K)$$

F=96500, R = 8.314, T = temperature in K

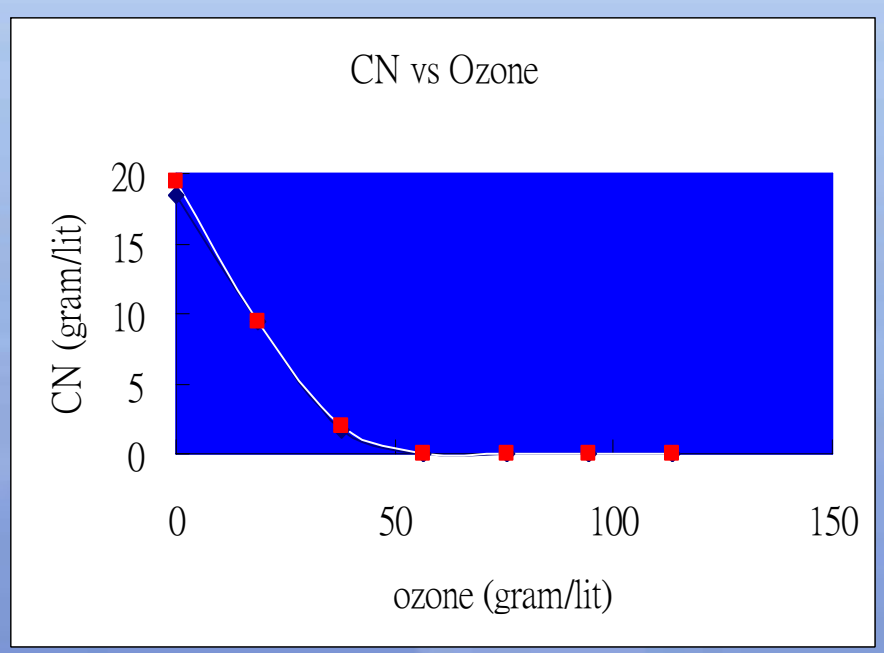
for O_2, n = 4 K = 1.14×10^{31}

for O_3, n = 2 K = 4.54×10^{44}

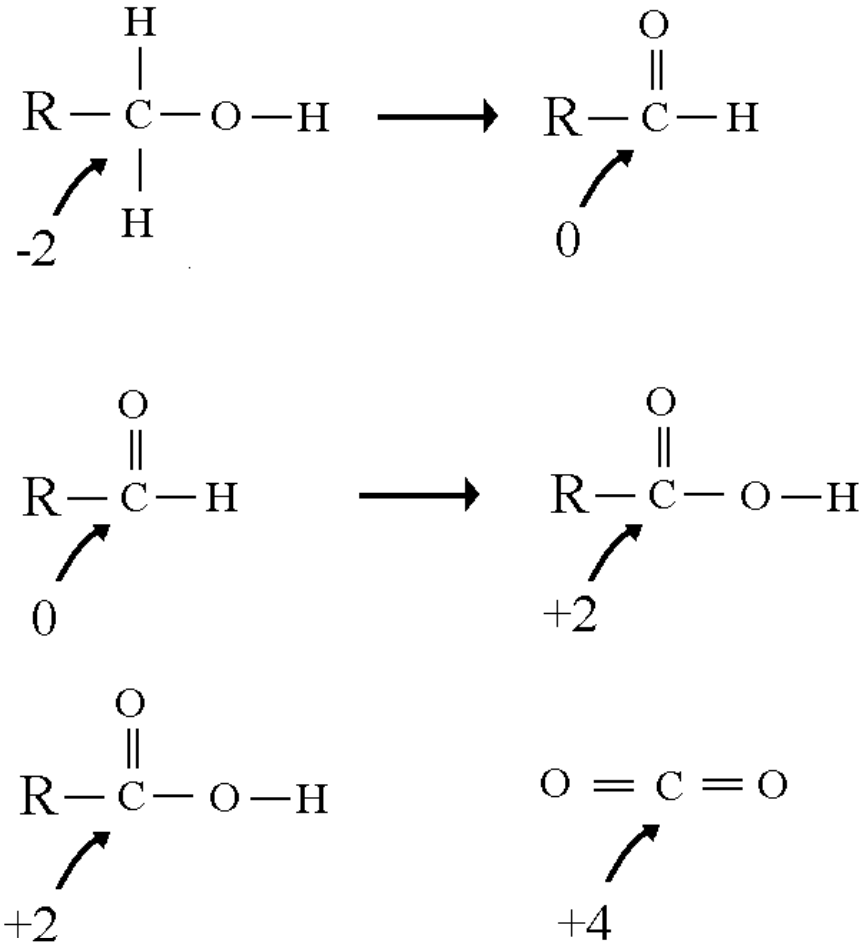
$$CN^- + O_3 \rightarrow CNO^- + O_2 (1.846\,O_3 / 1.0\,CN^-)$$

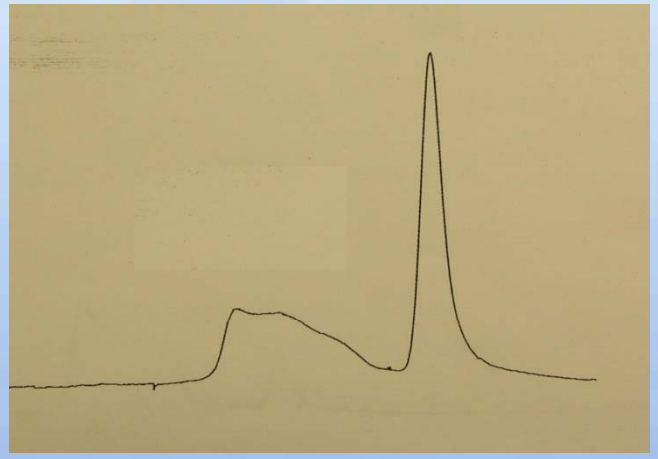
$$2CNO^- + 3O_3 + H_2O \rightarrow N_2 + 2HCO_3^- + 3O_2$$

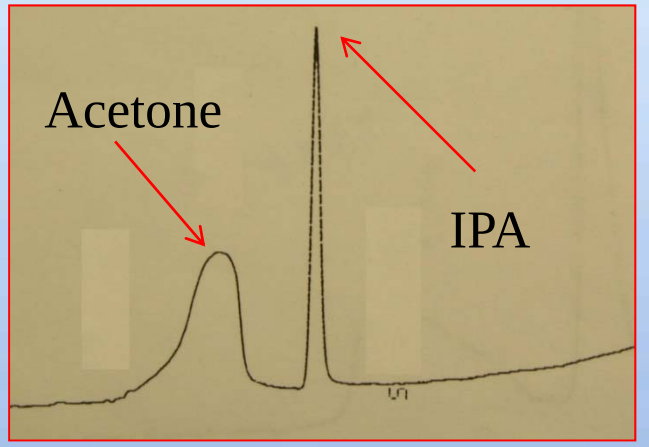
$$2CN^- + 5O_3 + H_2O \rightarrow 2HCO_3^- + N_2 + 5O_2 (4.64\,O_3 / 1.0\,CN^-)$$

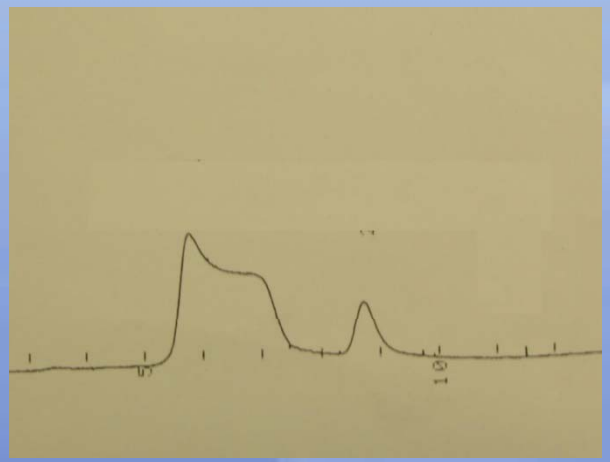


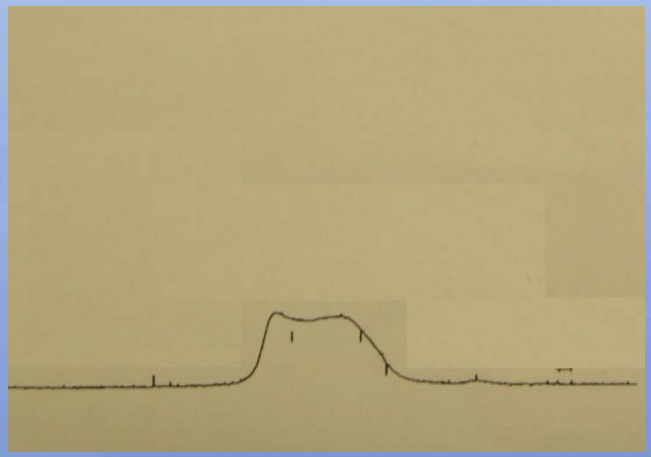
Oxidation of alcohol and ketone groups

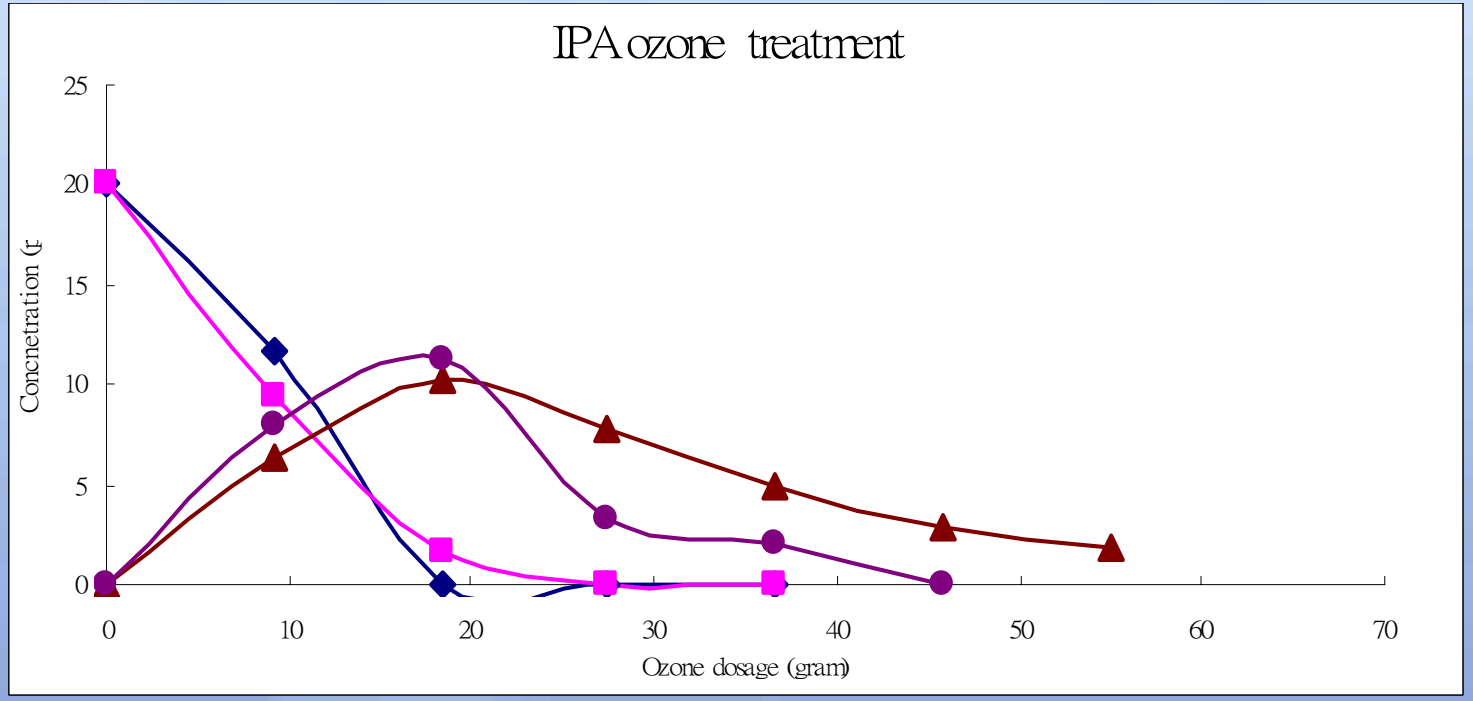


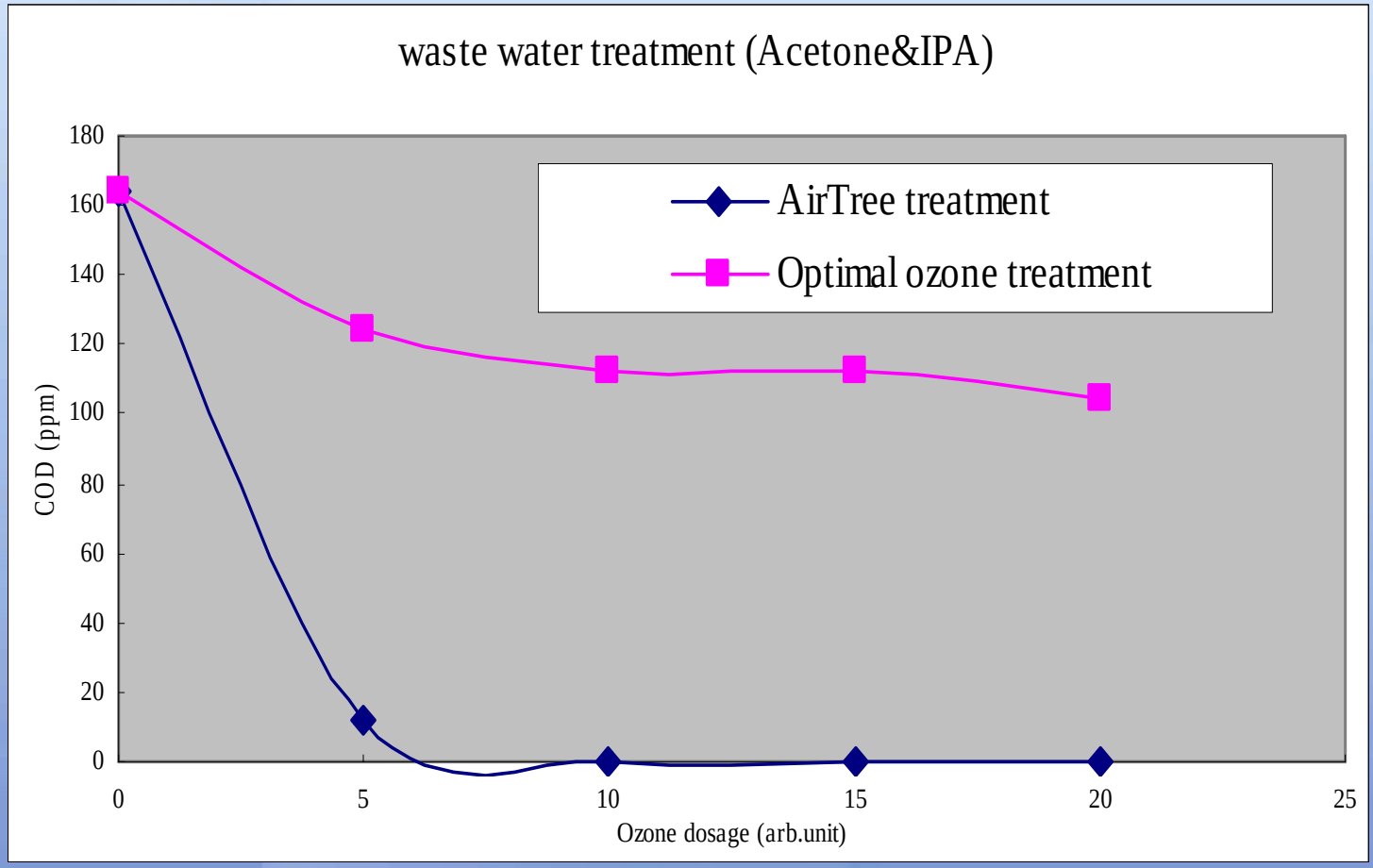


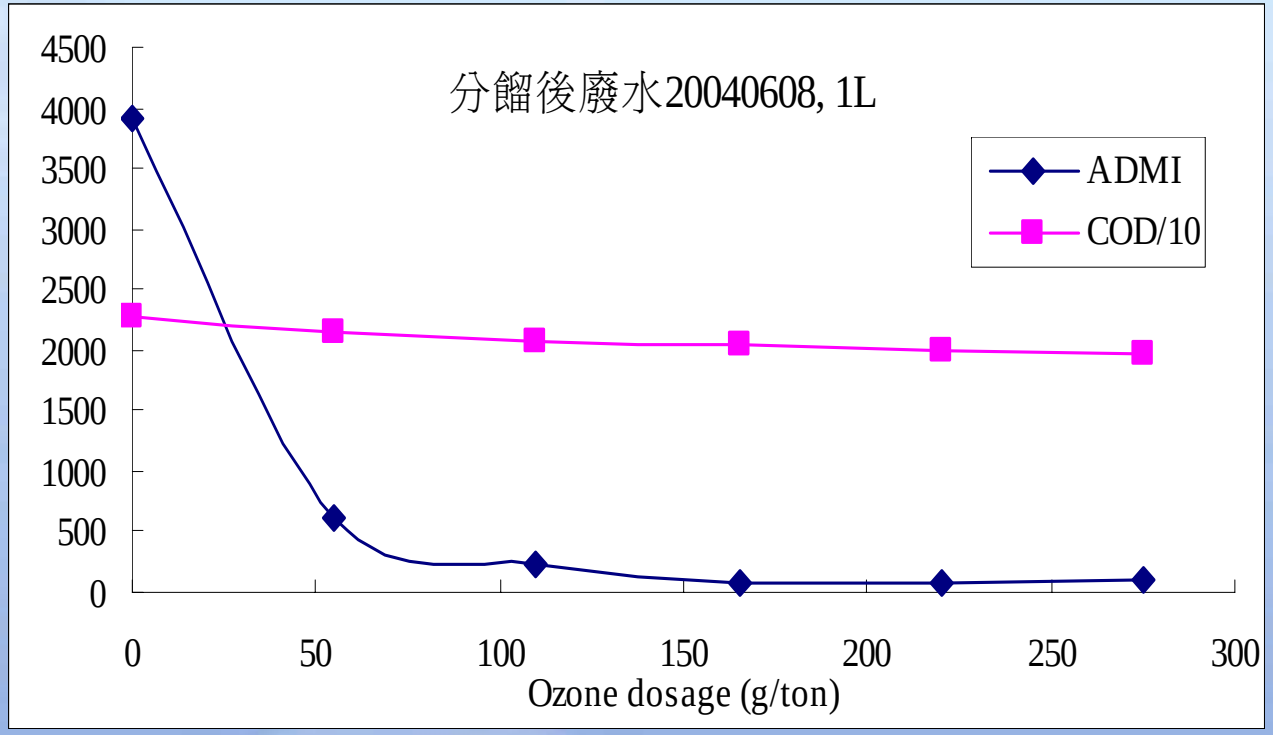

Acetone
IPA

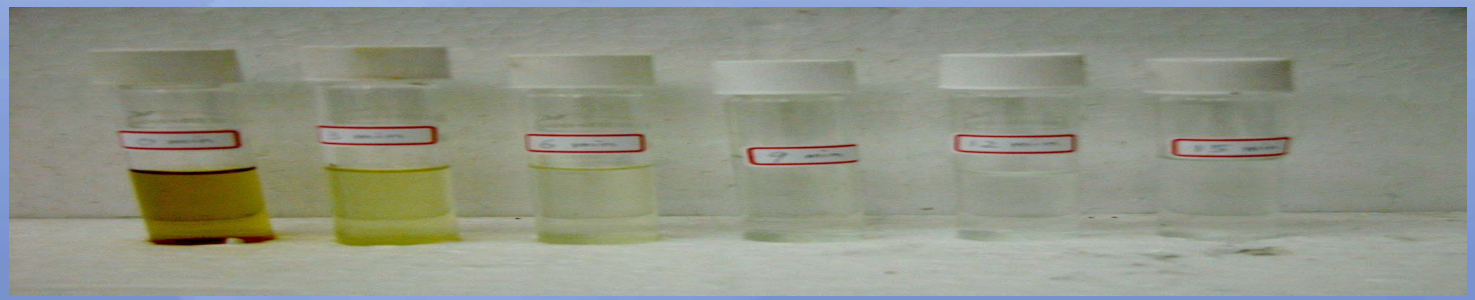





IPA ozone treatment
25
20
15
10
5
0
Concnetration (p
0
10
20
30
40
50
60
70
Ozone dosage (gram)


waste water treatment (Acetone&IPA)
180
160
140
120
100
80
60
40
20
0
COD (ppm)
0
5
10
15
20
25
Ozone dosage (arb.unit)
AirTree treatment
Optimal ozone treatment





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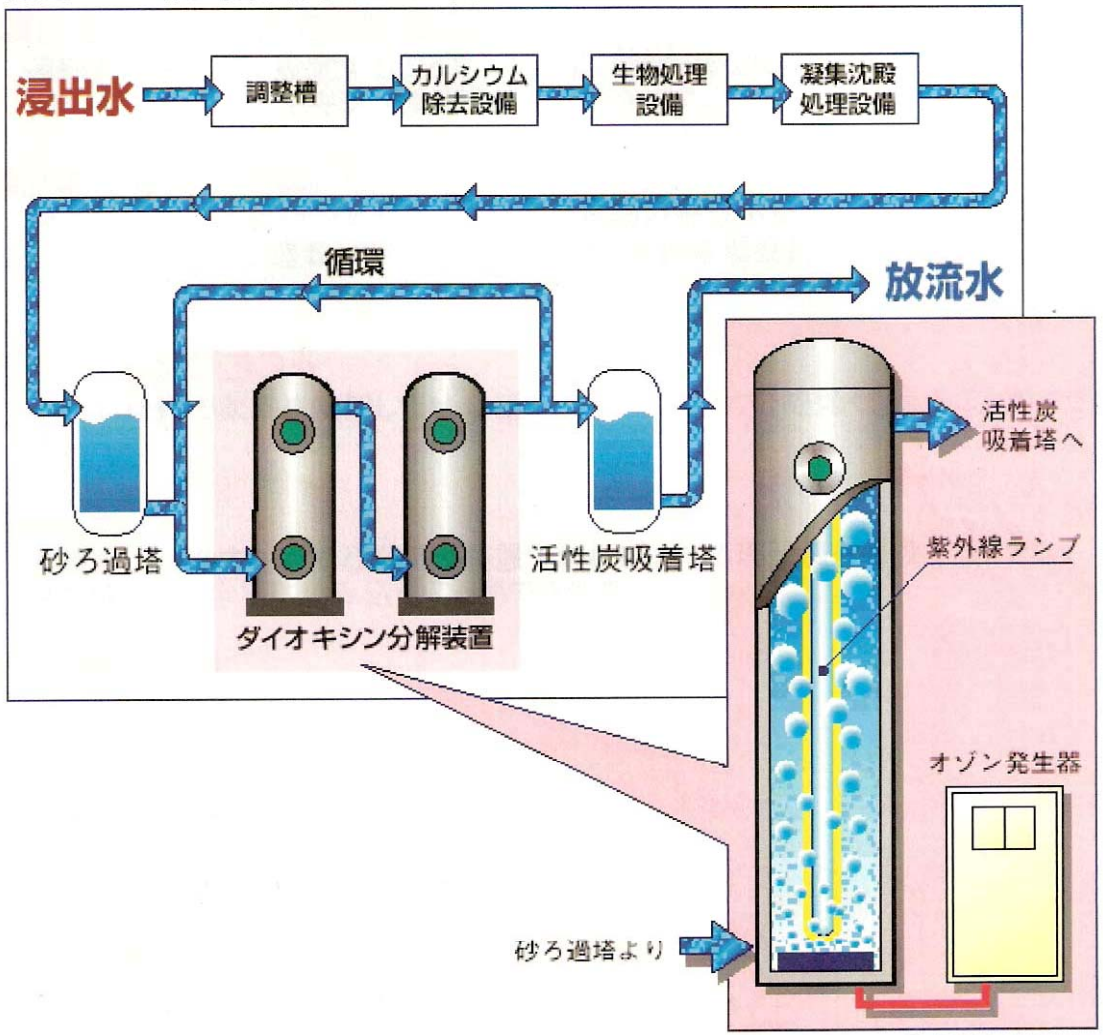
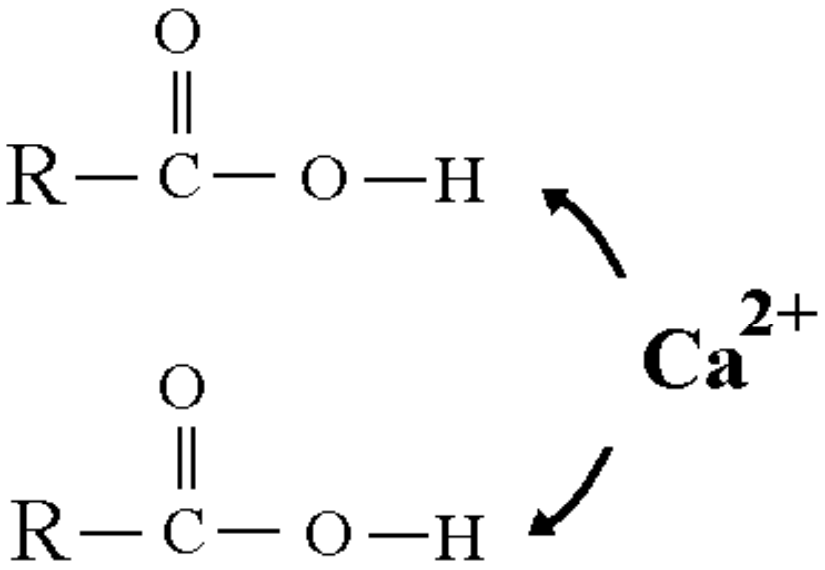
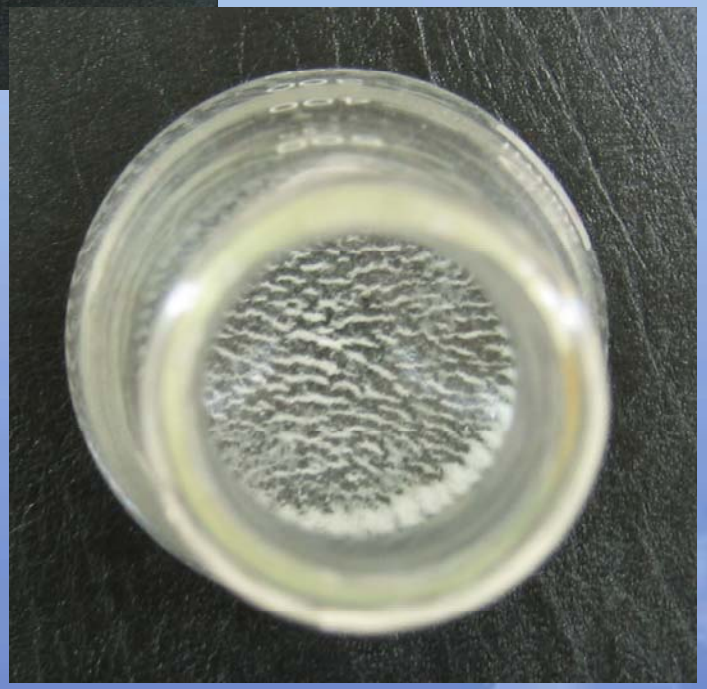
処理フロー（例：廃棄物最終処分場浸出水処理）



ダイオキシン分解装置概略図
（紫外線ーオゾン反応塔）

Chelation





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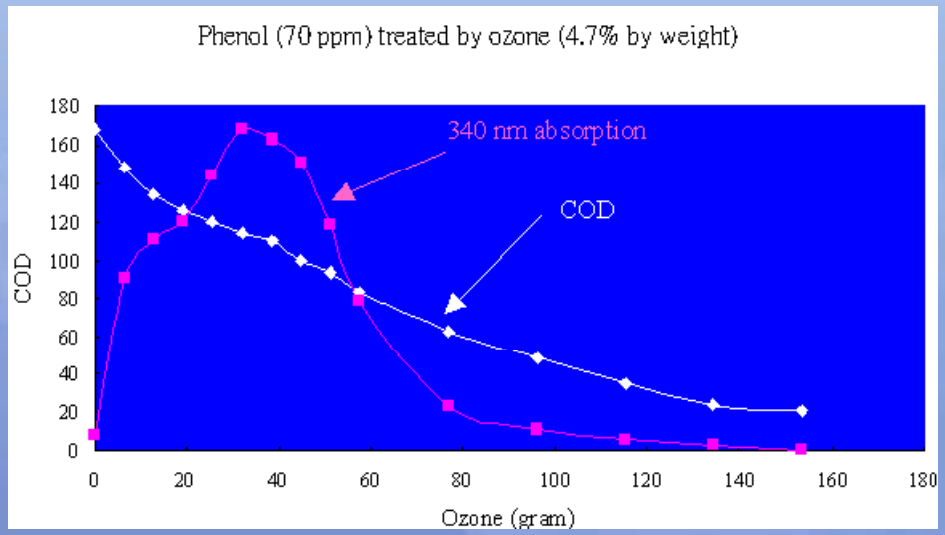
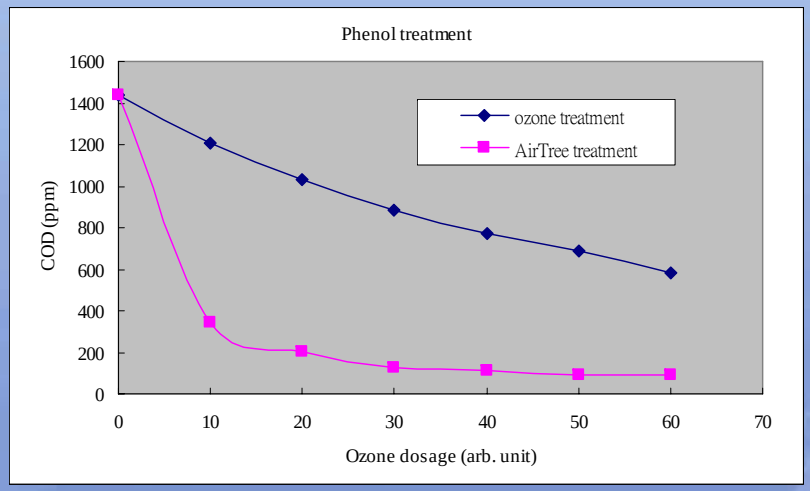
Phenol treated by ozone





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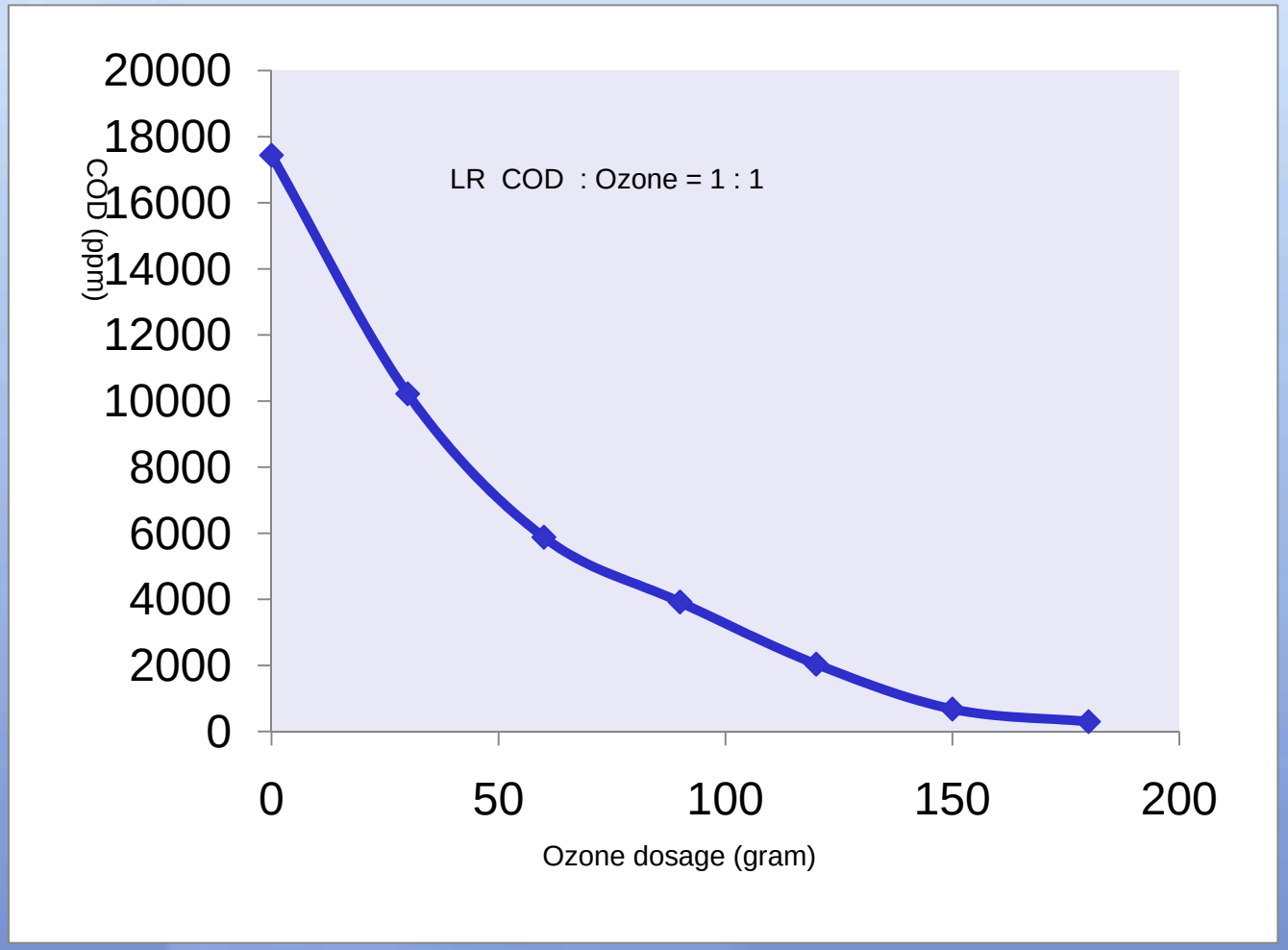
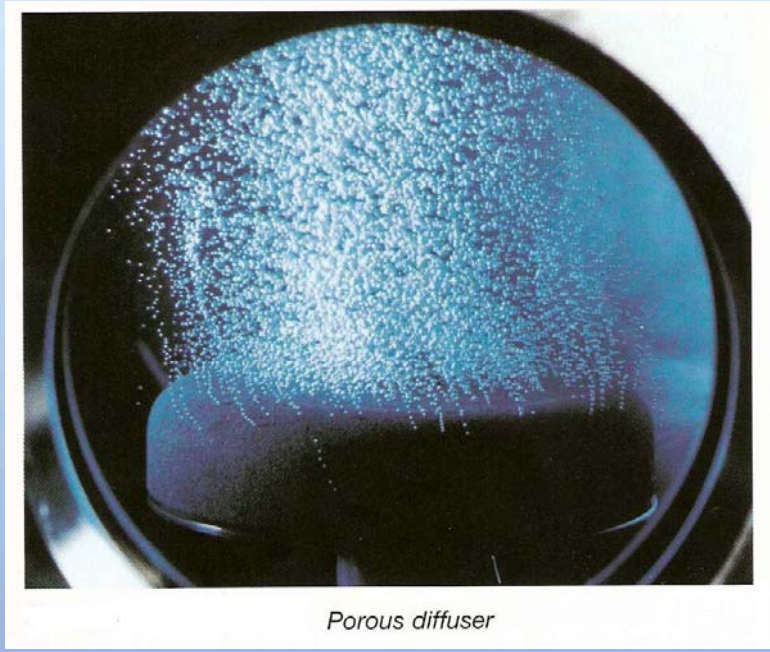
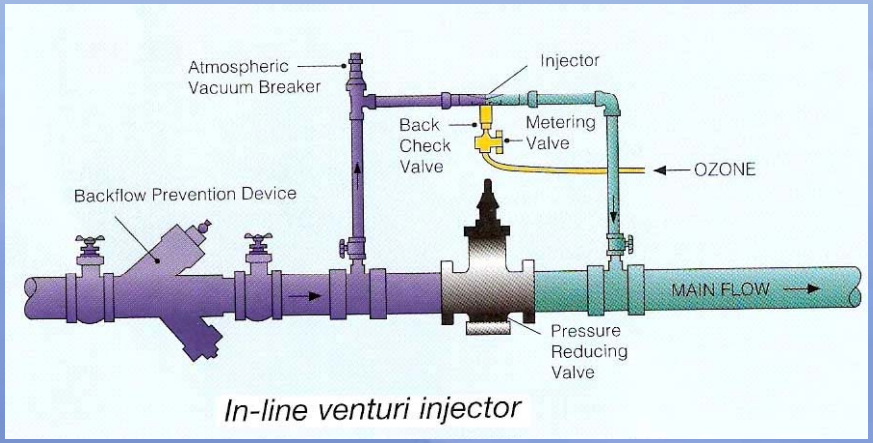

LR COD : Ozone = 1 : 1
COD (ppm)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
50
100
150
200
Ozone dosage (gram)

AMDI = 426



Porous diffuser



In-line venturi injector

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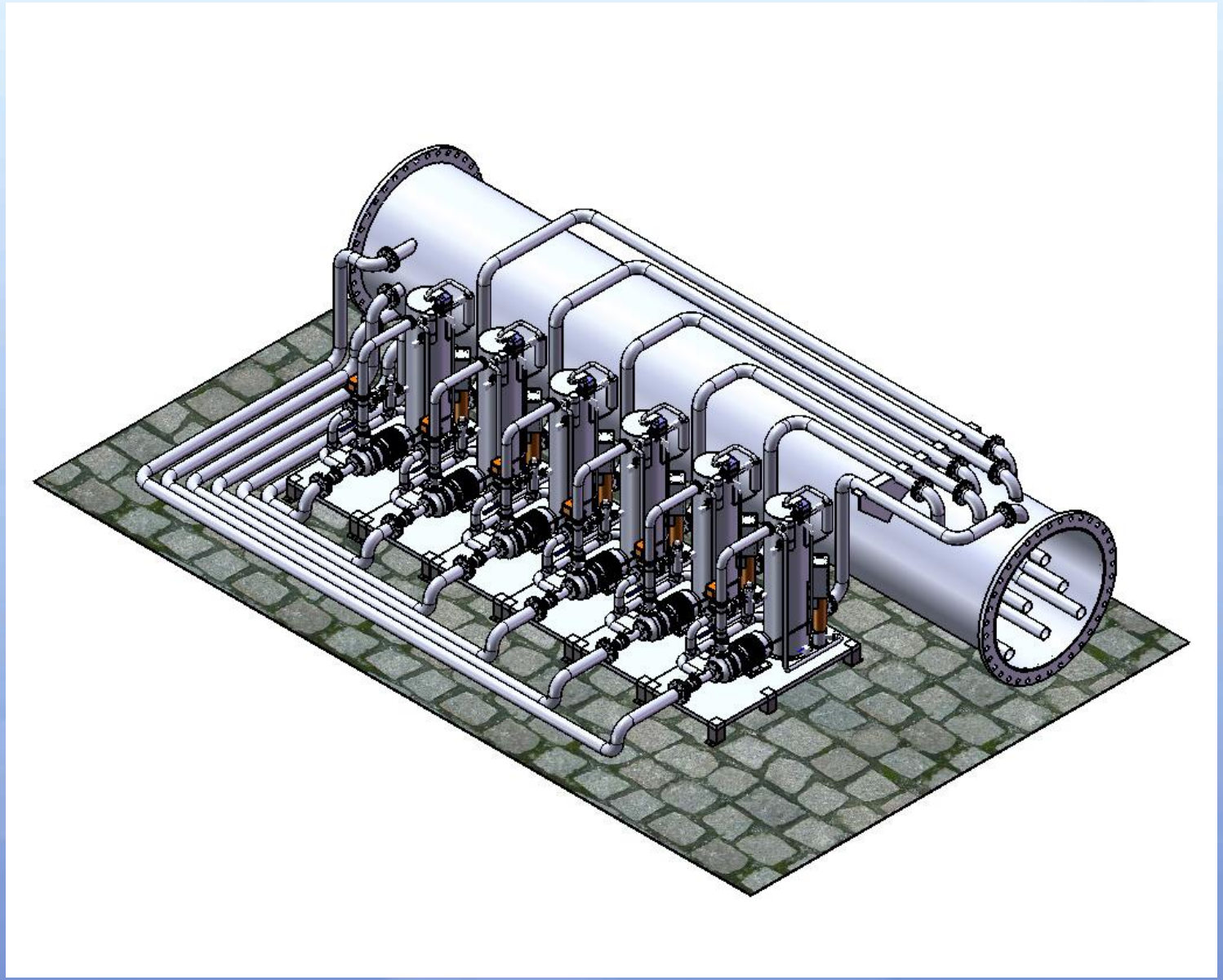
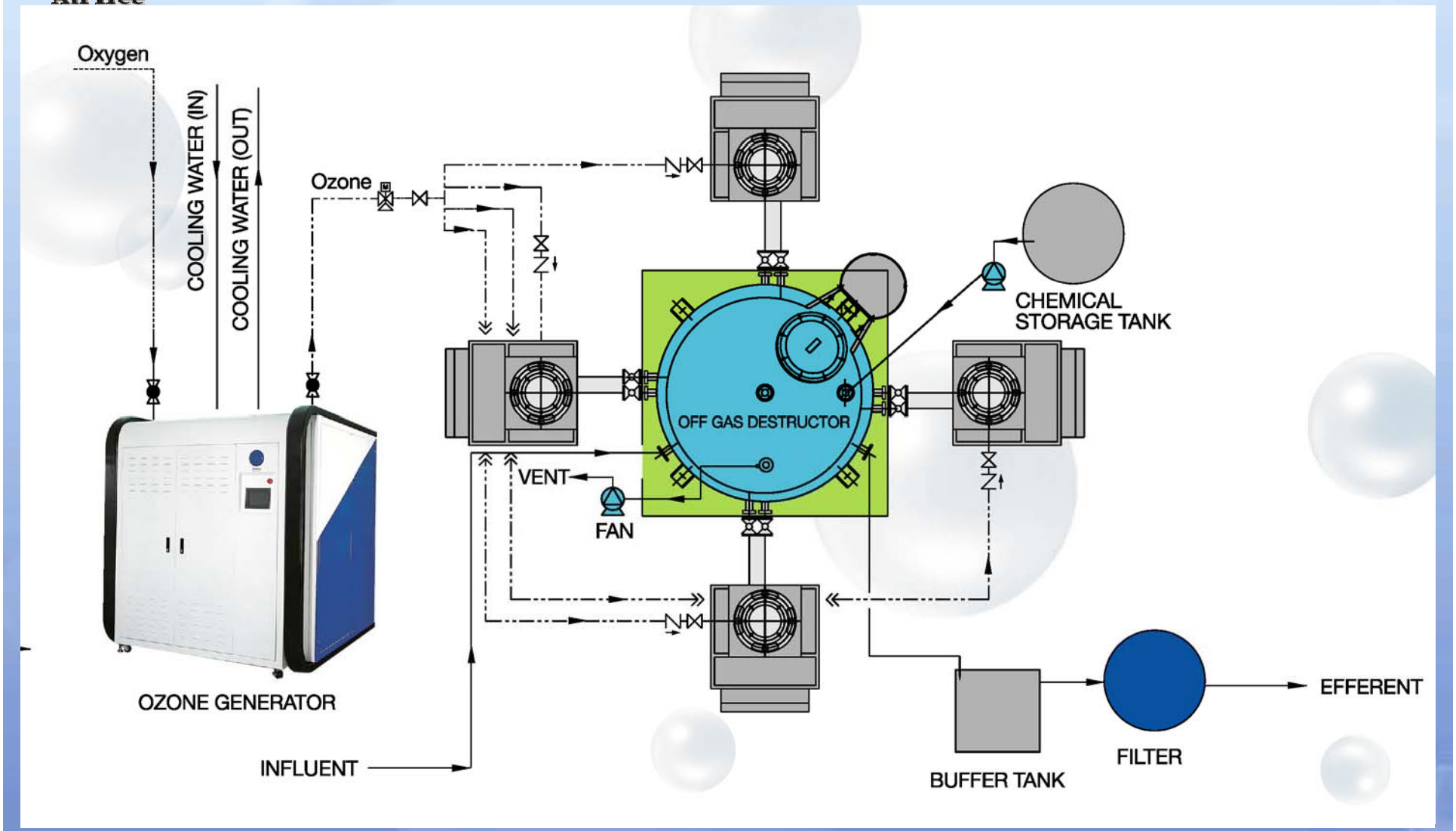
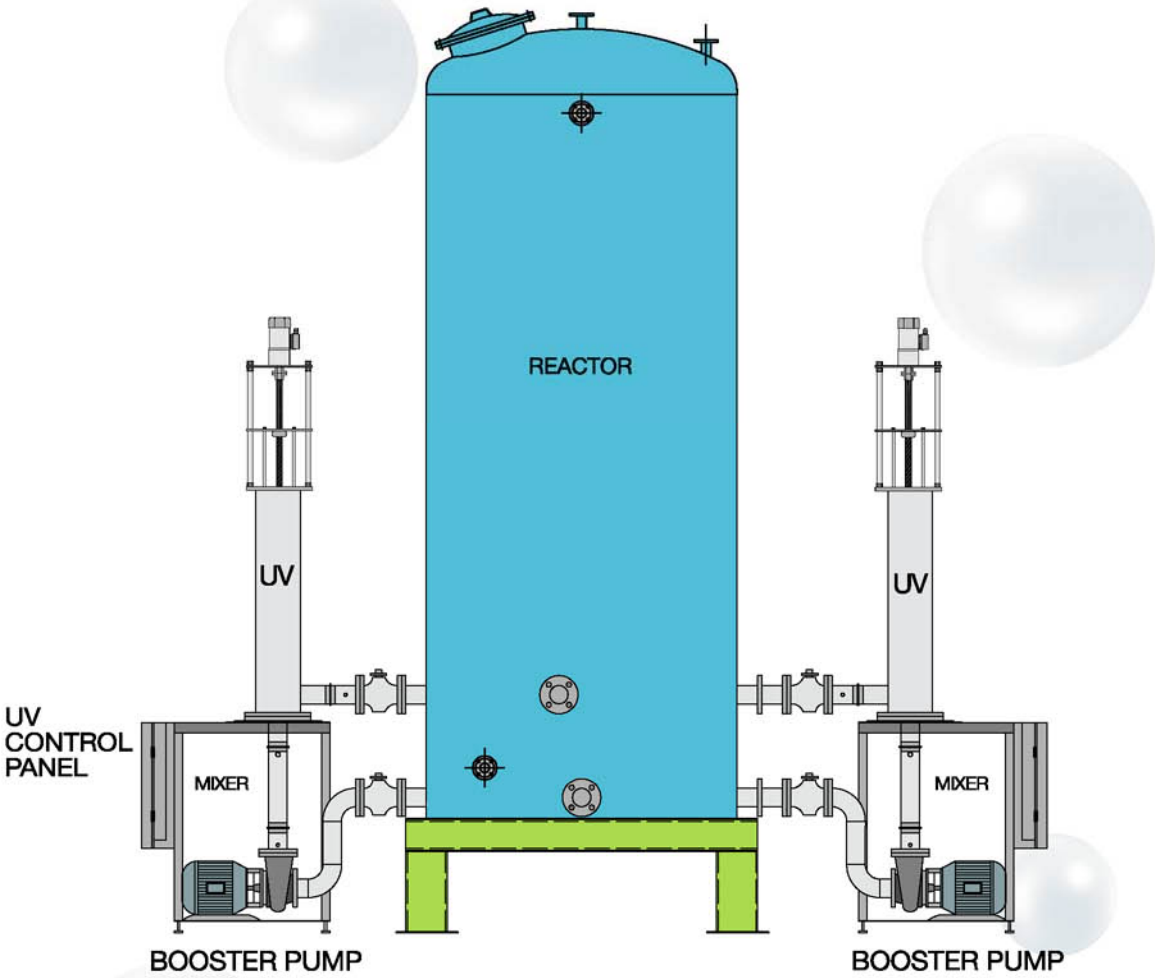
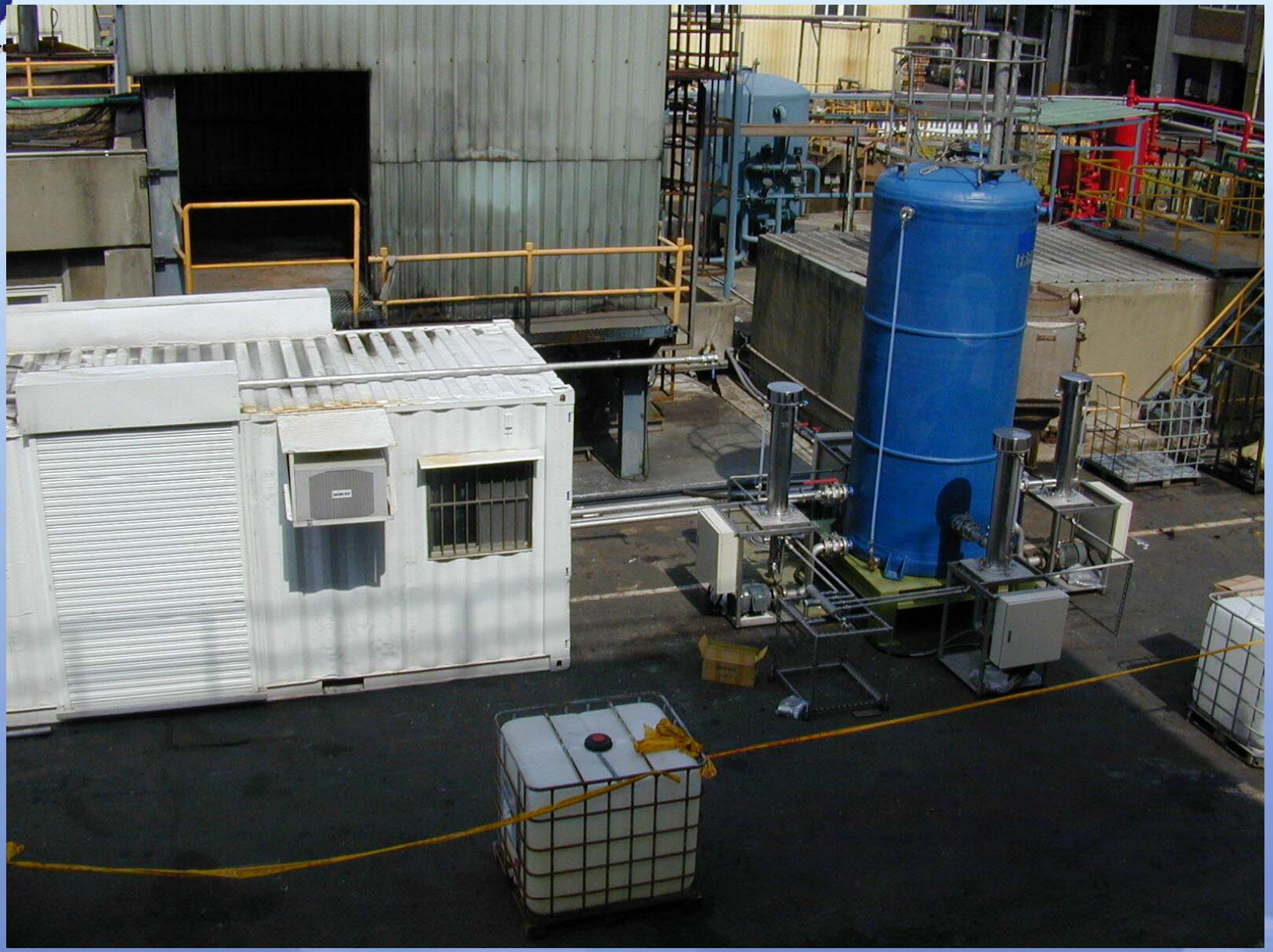


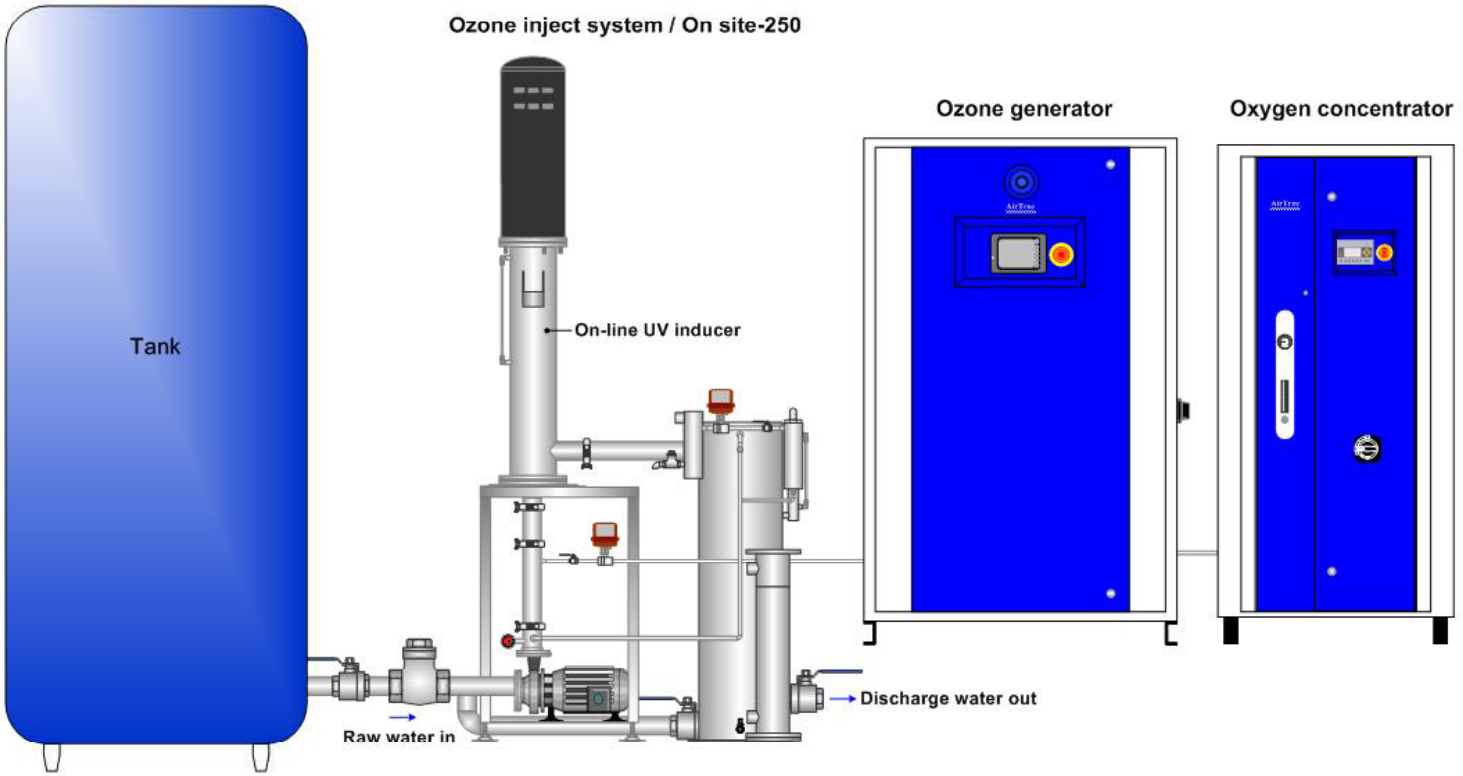

Oxygen
COOLING WATER (IN)
COOLING WATER (OUT)
Ozone
CHEMICAL
STORAGE TANK
OFF GAS DESTRUCTOR
VENT
FAN
OZONE GENERATOR
INFLUENT
BUFFER TANK
FILTER
EFFERENT



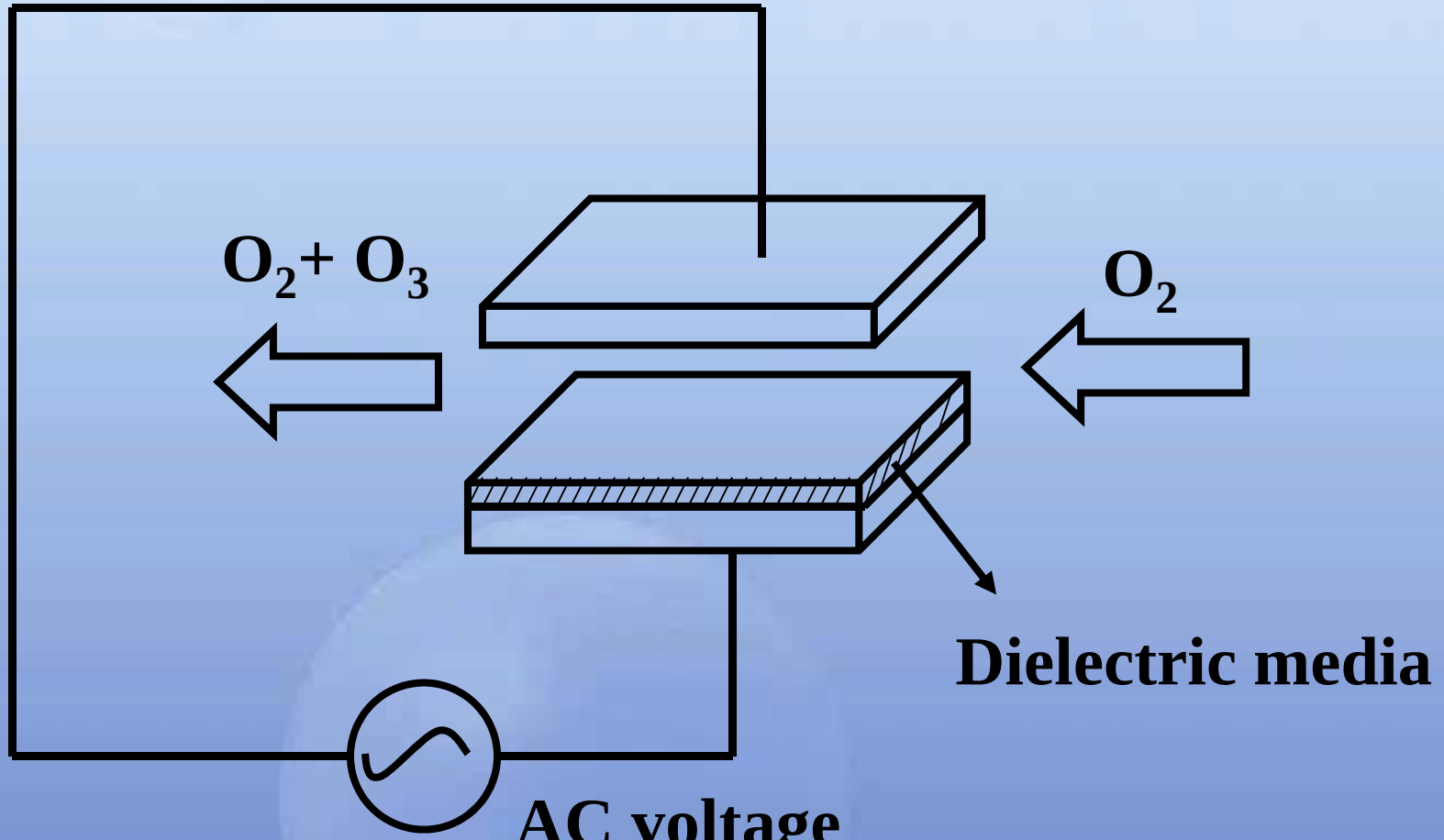
Ozone Injection and UV System



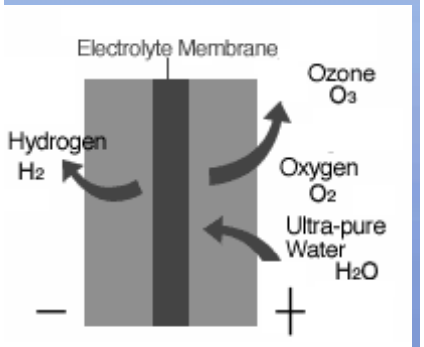
http://www.airtreetech.com


Ozone inject system / On site-250
Ozone generator
Oxygen concentrator
Tank
On-line UV inducer
Discharge water out
Raw water in

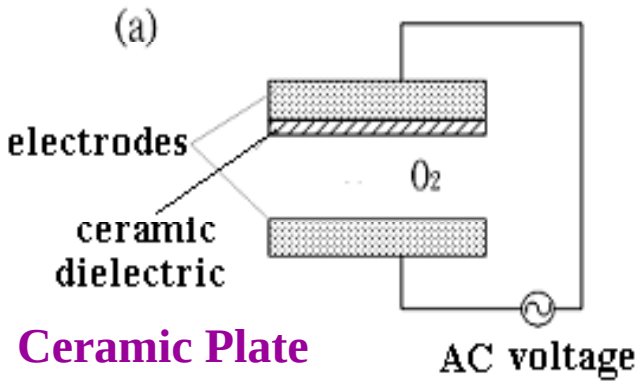
Ozone Formation by Micro-discharge



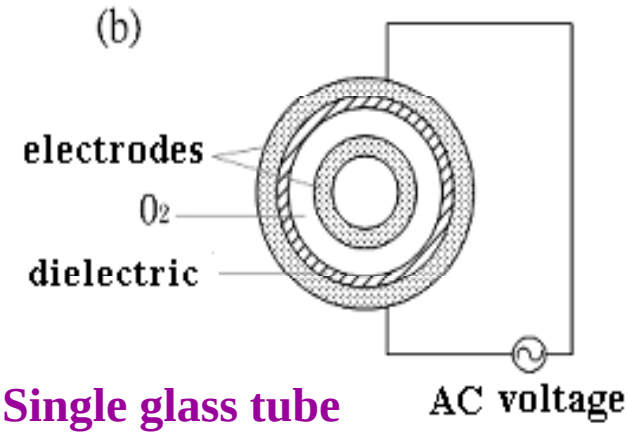
The Design Structure of Ozone Generation



Electrolysis Cell

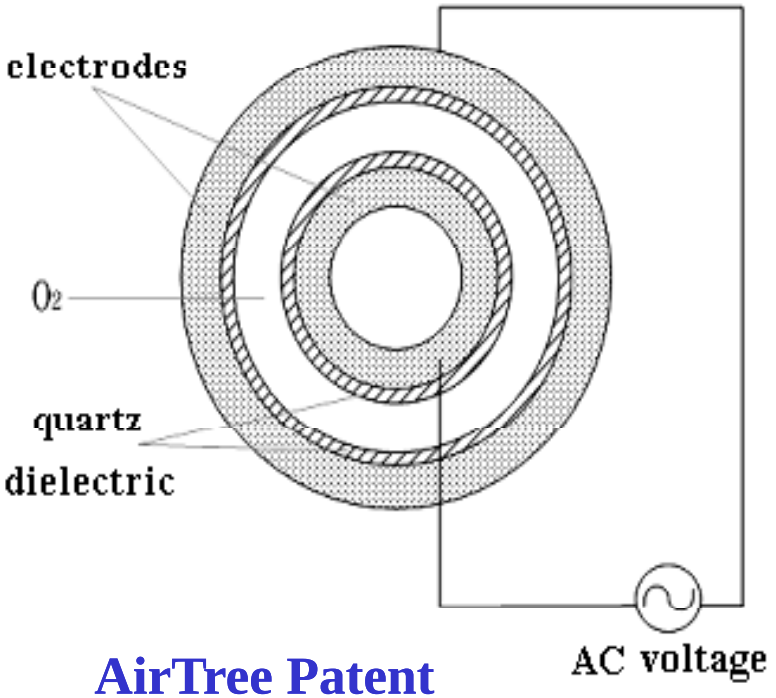


Ceramic Plate



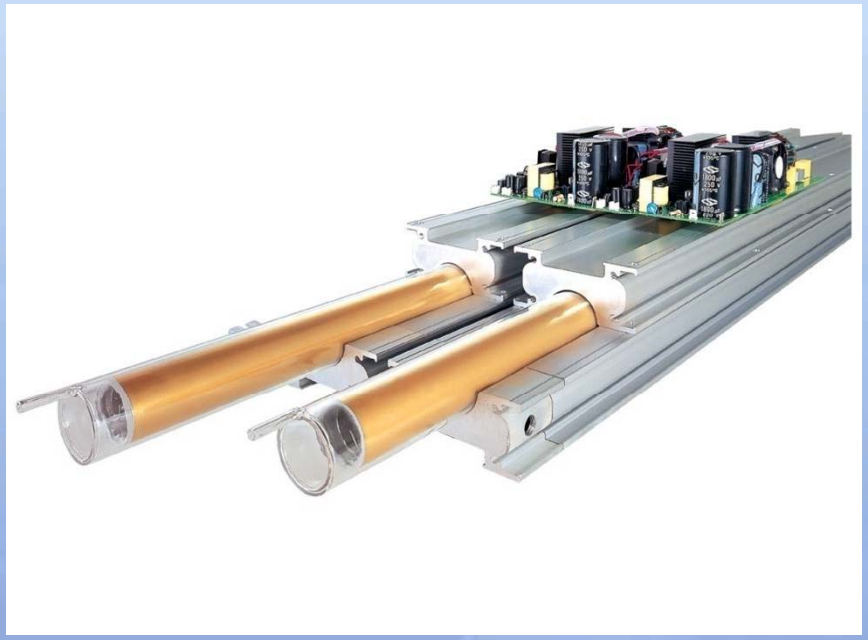
Single glass tube

(c) Double quartz tube



AirTree Patent

OZAT® AT dielectric and CFS generator module



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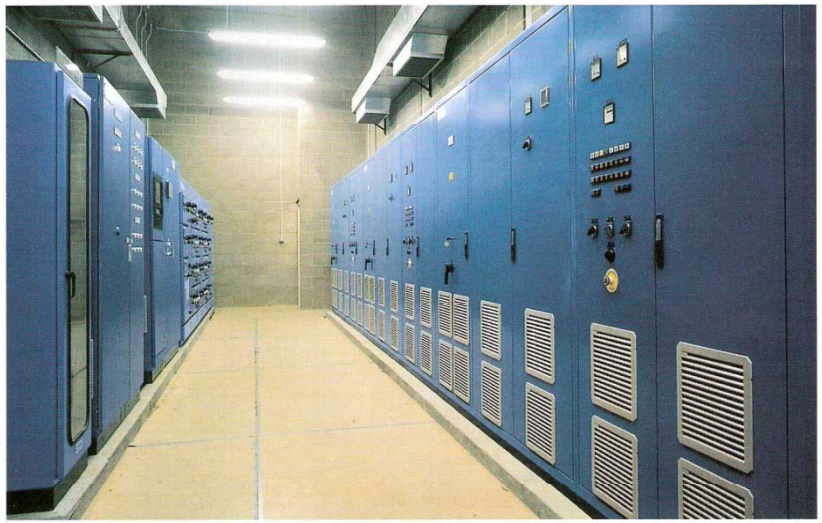
Rostock Water Works. Advanced Technology ozone generators (3 x 8.7 kg/h at 10 wt%)



The control room of the Coppermills Advanced Water Treatment Works (GB) with the medium frequency power supply unit on the right

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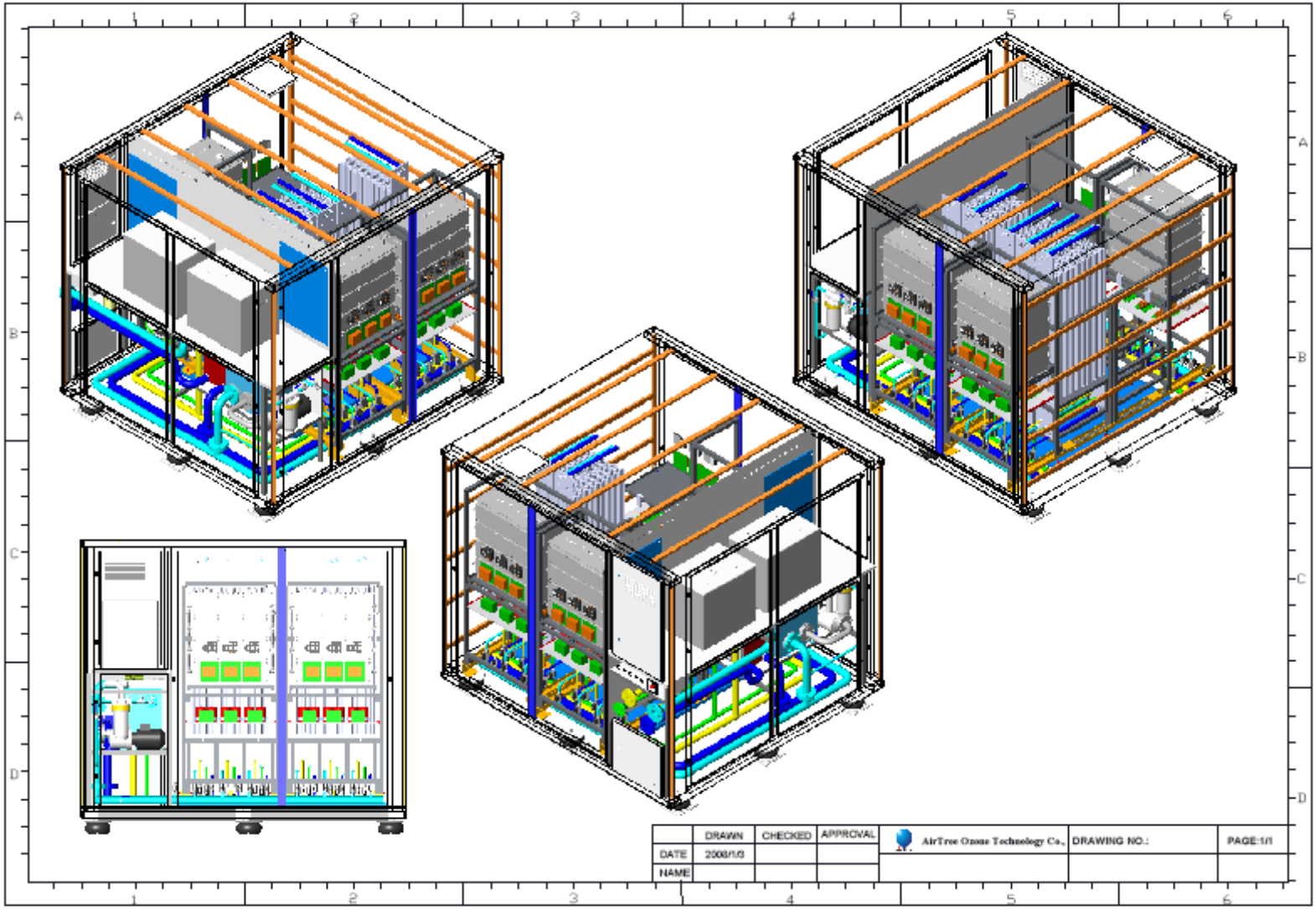

DRAWN
CHECKED
APPROVAL
DATE
2008/1/3
NAME
AirTree Ozone Technology Co.,
DRAWING NO.:
PAGE:1/1

Structure of Ozone Generator

Production (gram/hr)

100 g/h → 2kg/h → 60 kg/h

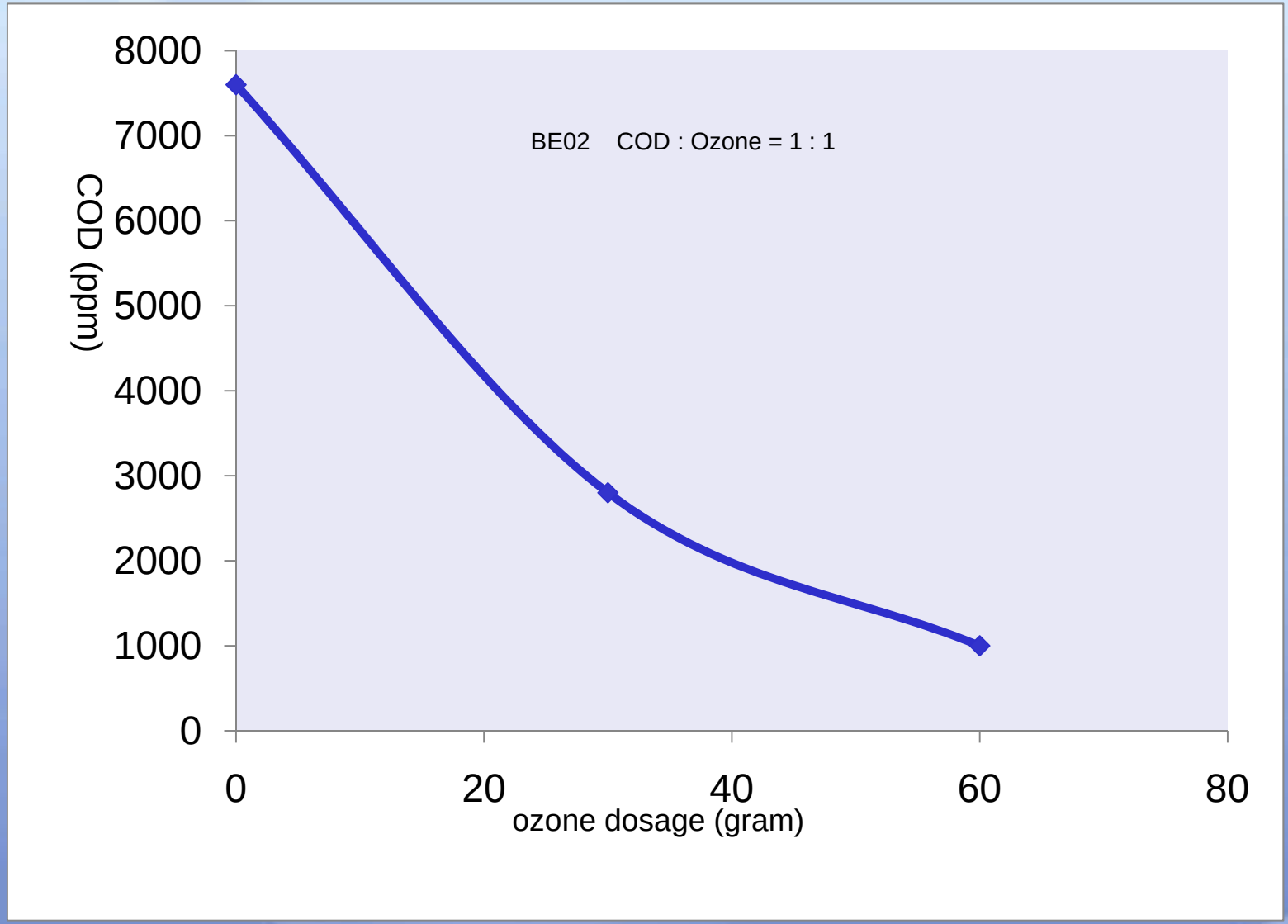
Parameters of Ozone Generator

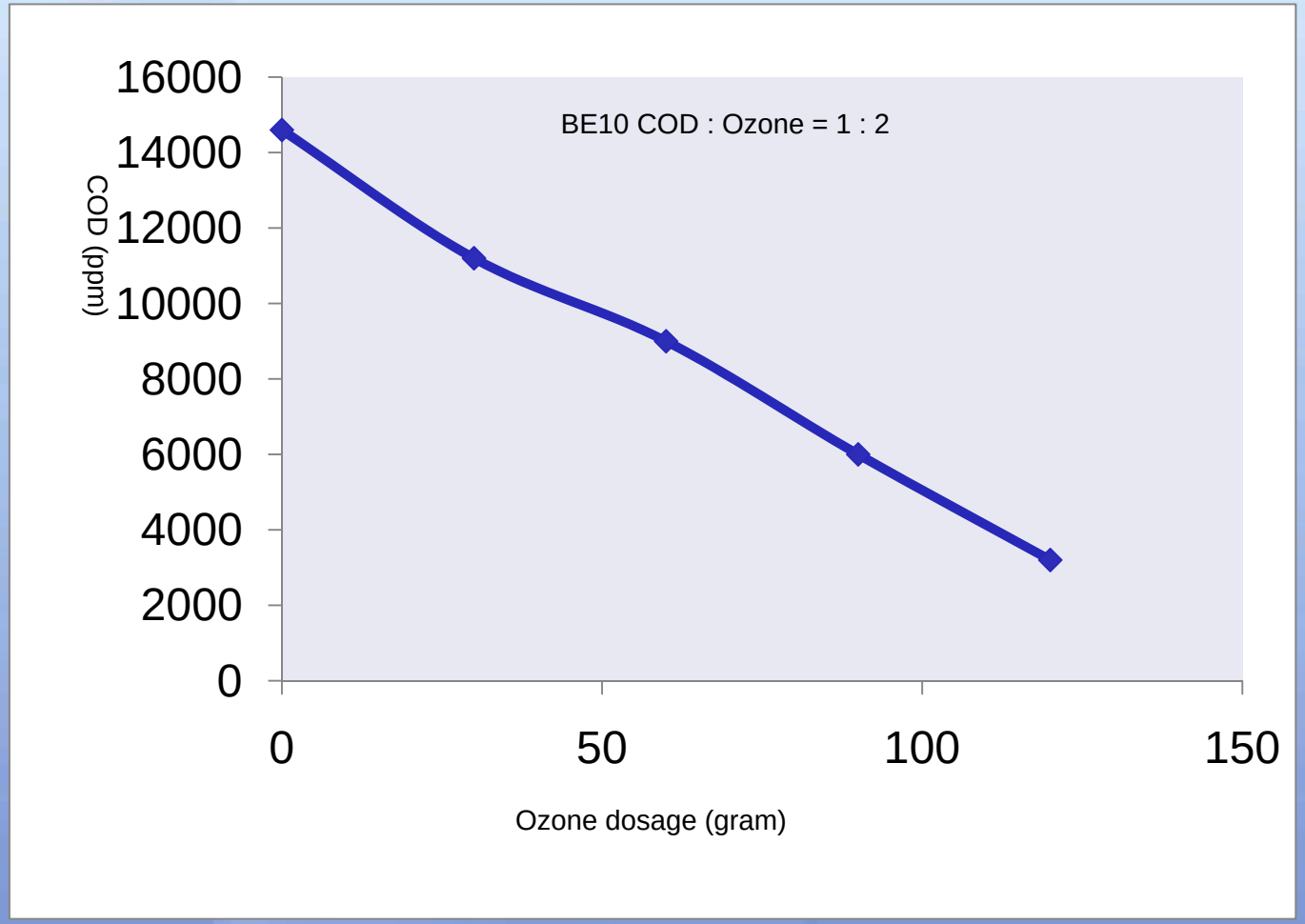
Concentration (mg/l)

Power consumption (kw/kg ozone)

Cooling water – quality, flow rate , temperature
energy consumption (kw/kg ozone)

Pressure – inlet, outlet


BE02 COD : Ozone = 1 : 1
COD (ppm)
8000
7000
6000
5000
4000
3000
2000
1000
0
0
20
40
60
80
ozone dosage (gram)


BE10 COD : Ozone = 1 : 2
COD (ppm)
16000
14000
12000
10000
8000
6000
4000
2000
0
0
50
100
150
Ozone dosage (gram)

Energy cost for ozone treating one kg of COD

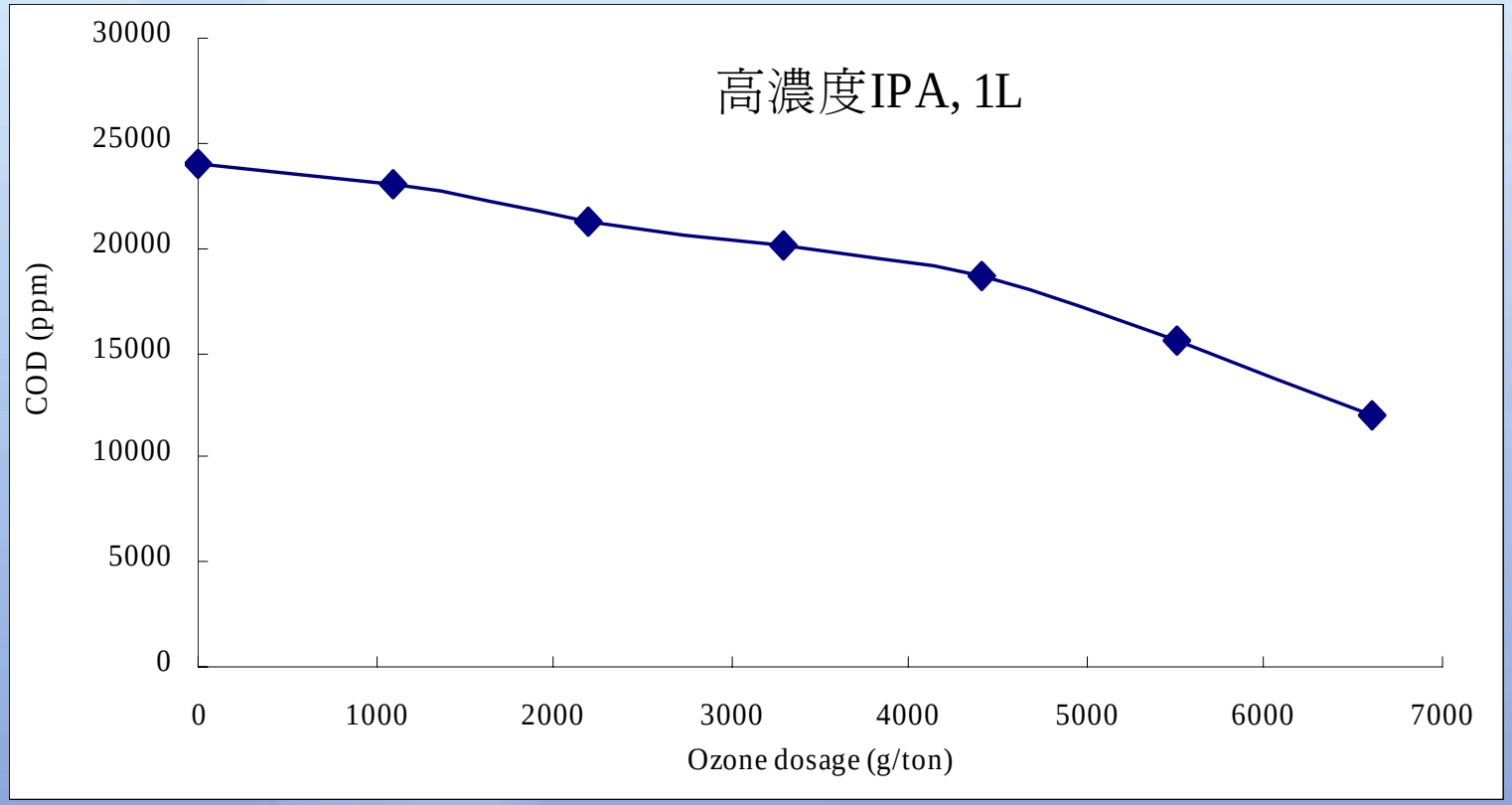
Taking ozone : COD = 1 : 1 (in weight)

10 kw/kg ozone generation

4 kw reacting tank

2 kw cooling water circulation
close loop chiller cooling water
10 x 0.6/0.4 = 15 kw

29 kw /kg (10% by weight, PSA oxygen)



COD : Ozone = 1 : 0.54

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AirTree

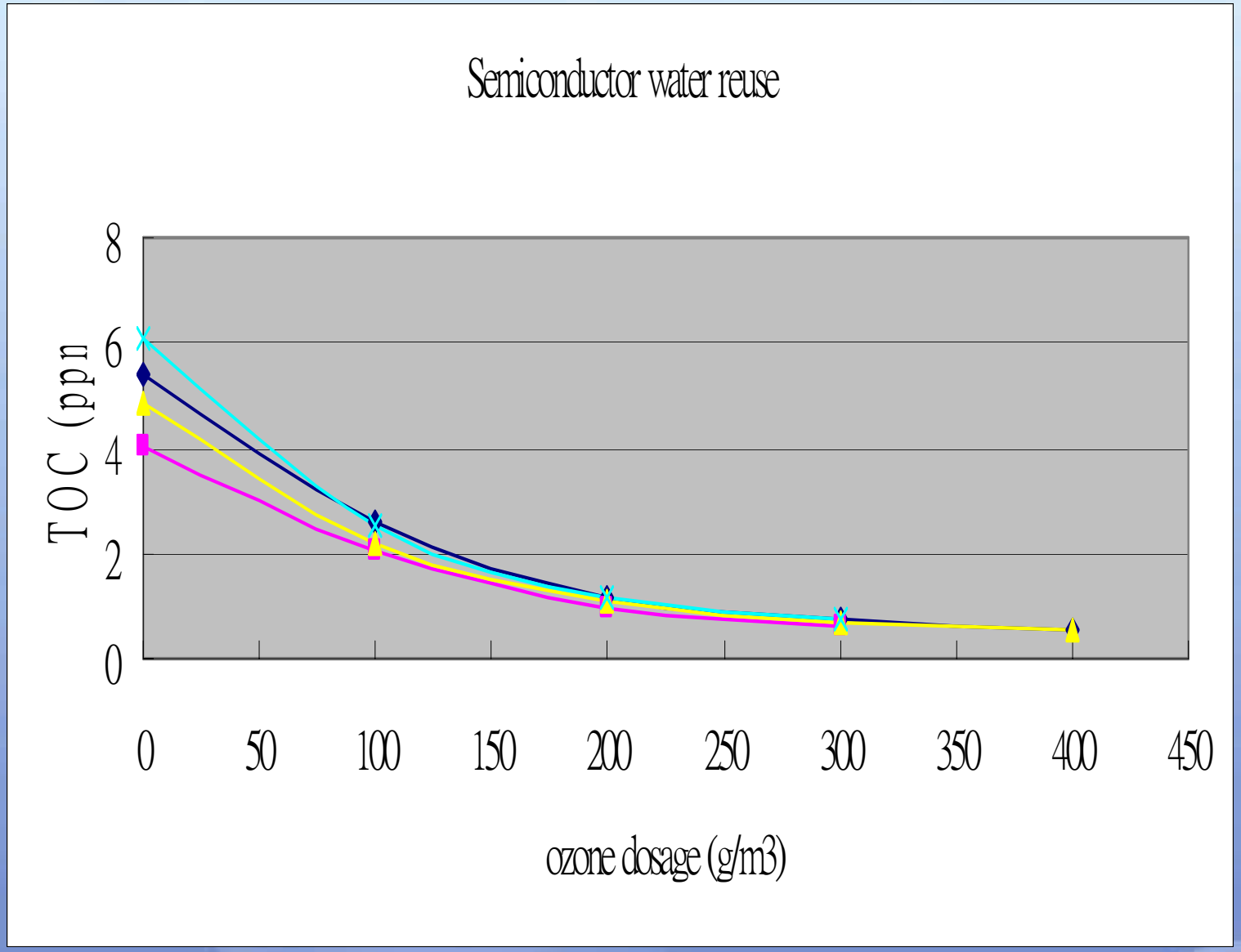
AirTree
Ozone Technology

Water Reuse

Ozone Treatment

AirTree Ozone Technology Co., Ltd.

http://www.airtree.com E-mail: market@airtree.com


Semiconductor water reuse
TOC (ppm)
8
6
4
2
0
0
50
100
150
200
250
300
350
400
450
ozone dosage (g/m3)

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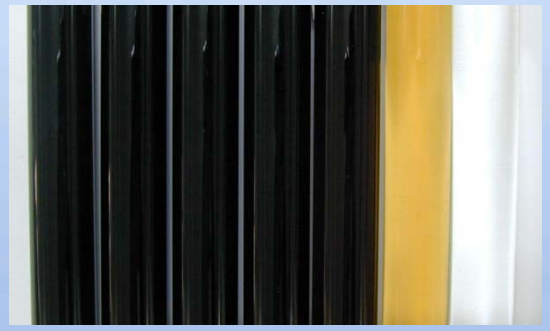
Dye waste water



Original processes

Ozone treatment in the original process

Ozone treatment starting from

un-treated waste water

Ozone treatment starting from the second chemical treatment

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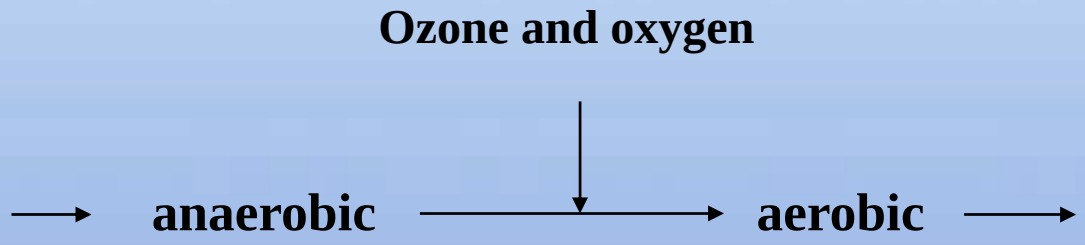
Pre-ozone treatment (before aerobic treatment)

1. Fragment big molecule and poisonous molecule

2. Supply oxygen



Purpose：

Increase the ability of aerobic treatment by

1. **Break down big molecule into small molecule**
2. **Oxide molecule to for bacteria favor acid molecule**

Improvement proposal : pre-ozone treatment to increase the ability of aerobic treatment

1. Ozone dosage (50 ppm ~ 100 ppm) up to decolor achieved

The ability is expected to be increased 30% ~ 50%

2. Ozone dosage (10 ppm ~ 20ppm) up to break down molecule

The ability is expected to be increased 10% ~ 30%.

The barrier for waste water ozone treatment

RUNNING COST

COD : Ozone = 1 : X

O3 (kg) x power consumption (kw/kg) x 3

3 = 1 + 2 (1 /electricity + 2/oxygen)

臭氧機的氧氣回收

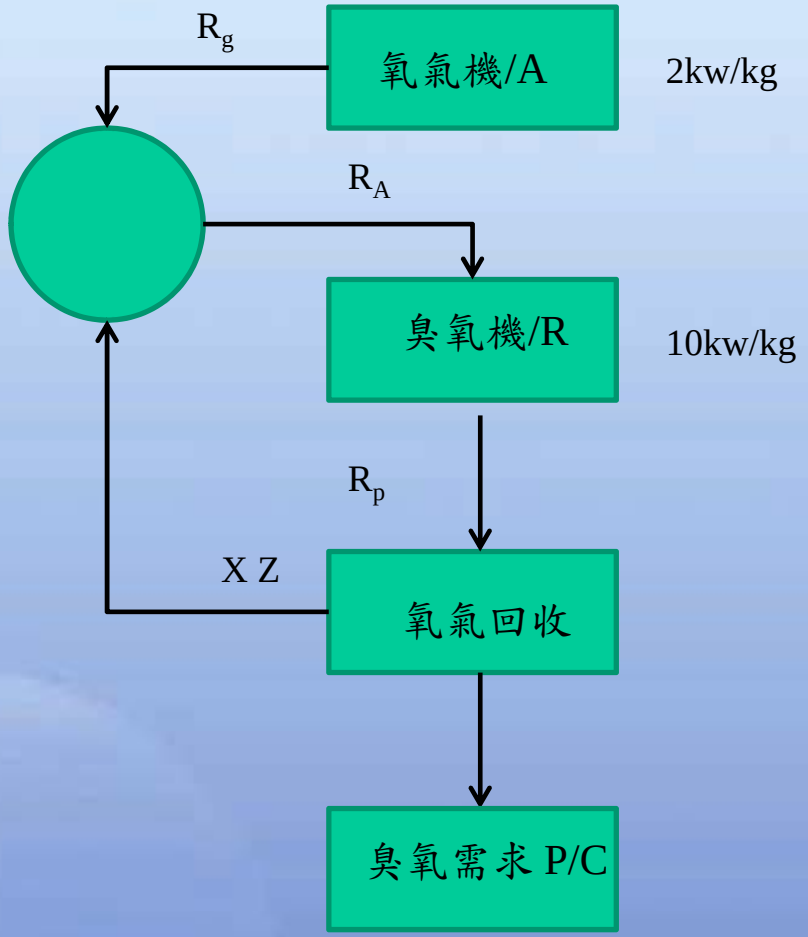
需求規格:
C 臭氧輸出濃度 (% by weight)
P 臭氧產量 (g/h)
G 原始氧氣需求量 (m^3/h)
A 氧氣機濃度 (per cent assuming 90%, 0.9)

氧氣回收效能
R 臭氧機濃度 (% by weight)
X 氧氣回收率
Y 臭氧機的損耗率
Z 氧的回收濃度 (per cent)

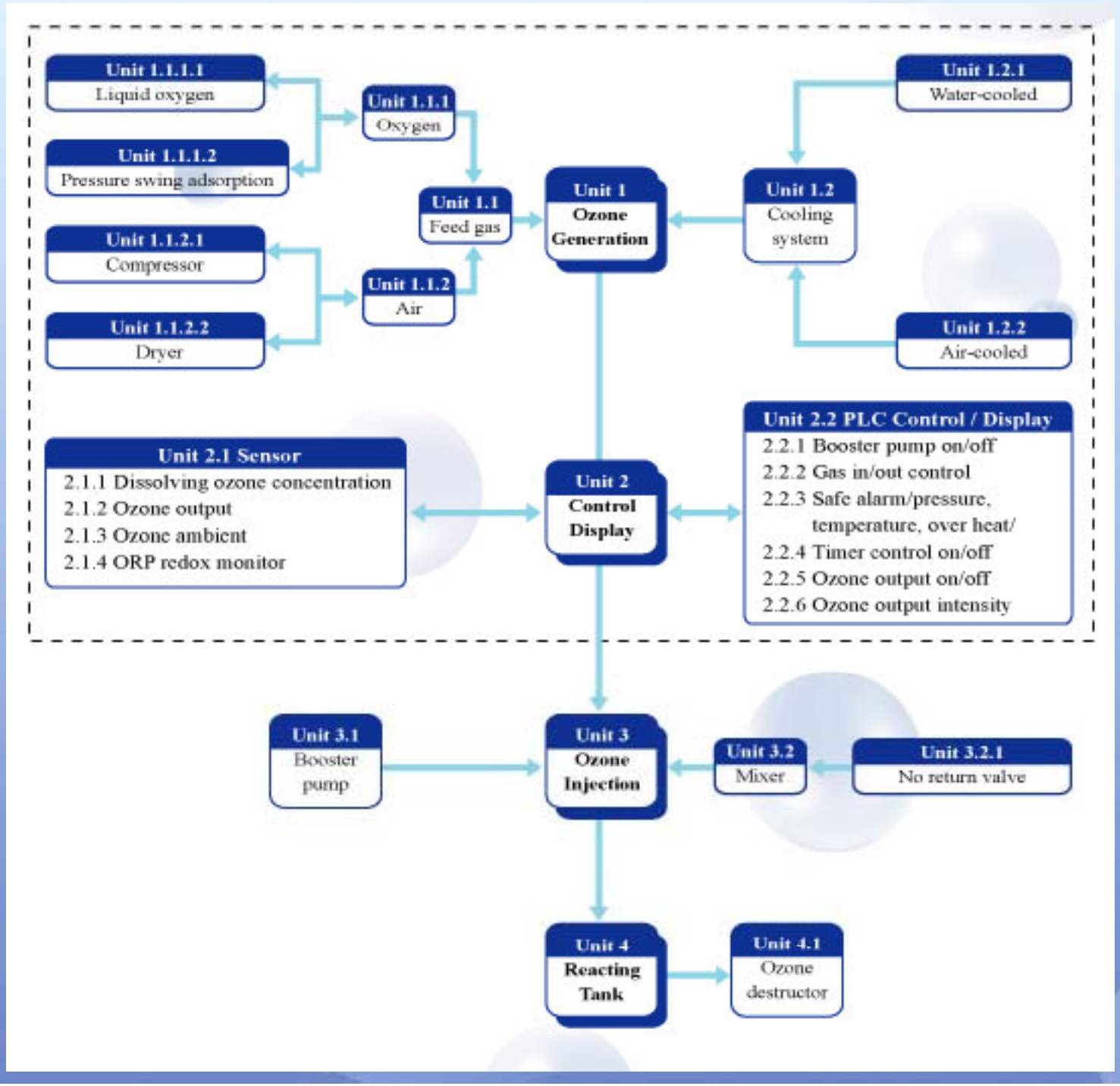
氧氣機及臭氧機的實際操作值

臭氧機的規格
臭氧機的氧氣濃度
$R_A = X Z + (1-X) A$
臭氧機的產量
$R_p = P (1 + Y)$

氧氣機的規格
氧氣機的需求量
$R_g = (1-X) G + G P Y C/R$



Thank You!


Unit 1.1.1.1
Liquid oxygen
Unit 1.1.1.2
Pressure swing adsorption
Unit 1.1.1
Oxygen
Unit 1.1
Feed gas
Unit 1.1.2.1
Compressor
Unit 1.1.2.2
Dryer
Unit 1.1.2
Air
Unit 1
Ozone Generation
Unit 1.2.1
Water-cooled
Unit 1.2
Cooling system
Unit 1.2.2
Air-cooled
Unit 2.1 Sensor
2.1.1 Dissolving ozone concentration
2.1.2 Ozone output
2.1.3 Ozone ambient
2.1.4 ORP redox monitor
Unit 2
Control Display
Unit 2.2 PLC Control / Display
2.2.1 Booster pump on/off
2.2.2 Gas in/out control
2.2.3 Safe alarm/pressure, temperature, over heat/
2.2.4 Timer control on/off
2.2.5 Ozone output on/off
2.2.6 Ozone output intensity
Unit 3.1
Booster pump
Unit 3
Ozone Injection
Unit 3.2
Mixer
Unit 3.2.1
No return valve
Unit 4
Reacting Tank
Unit 4.1
Ozone destructor

http://www.airtreetech.com

CaO is used to adjust pH and forms calcium ion

The amount of organic calcium created

One phenol molecule contributes two CODs

COD 50 ppm formed by phenol contains 25 phenol molecules

Each calcium ion can chelate two phenol molecules

Adding CO2 to remove calcium and adjust pH

Legionnaires' Disease Bacterium, LDB

Oak Ridge National Laboratory, :The Effect of Three Oxidizing Biocides on Legionella Pneumophils Serogroup I":

Ozone concentration 0.24ppm，contact time 5min， 99.9% inactivity (pH7.2, 25℃)

99.9% inactivity of O_3, Cl_2 and H_2O_2

L. Pneumophils Serogroup I

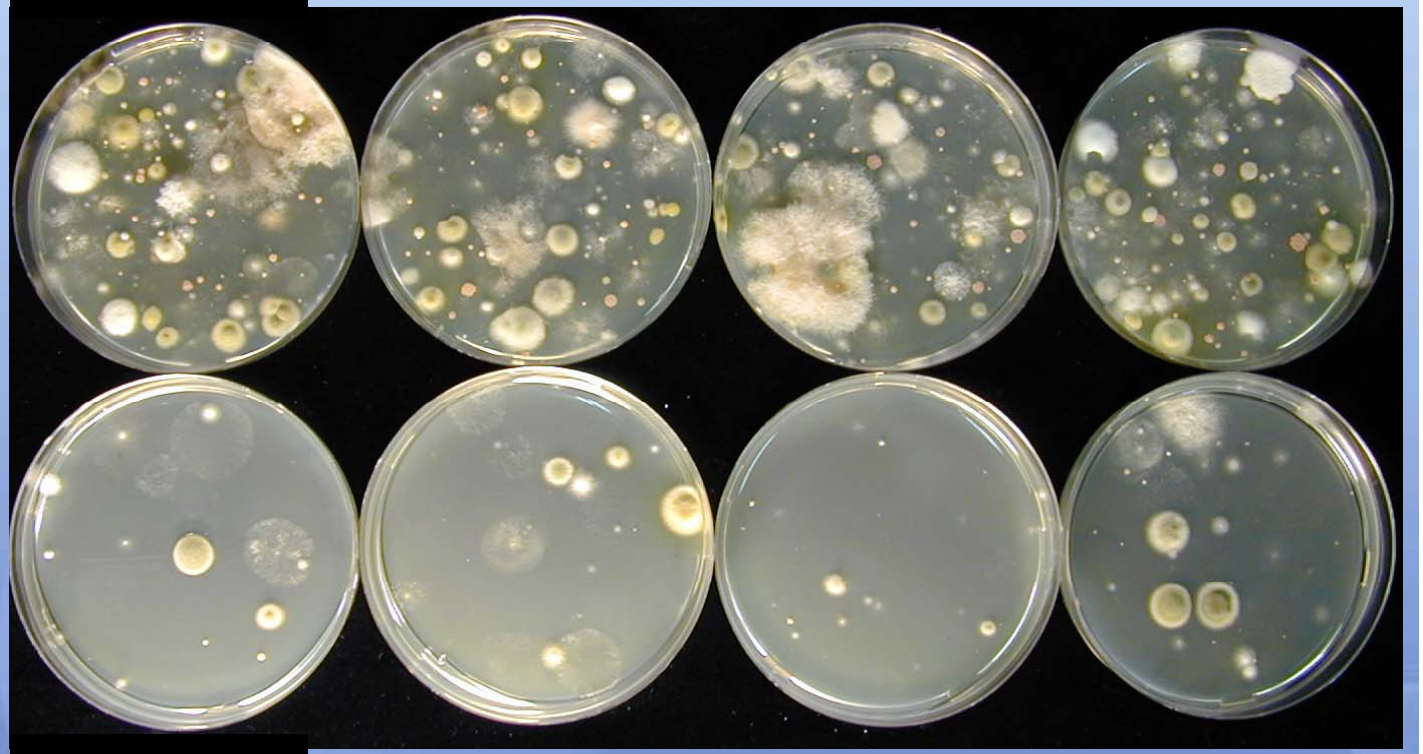
chemicals	pH	Temp. (℃)	Contact time (min)	Concent. (ppm)
O_3	7.2	25	<5	0.24
	7.2	35	<5	0.13
	7.2	45	<5	0.13
	8.0	25	<5	0.20
	8.9	25	<5	0.14
Cl_2	7.2	25	30-45	0.30
H_2O_2	7.2	25	30	1,000

Application of Air Sterilization

in Dr. S.N.Fu Library at Academia Sinica

After 5 days treatment

Untreated



Treated

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