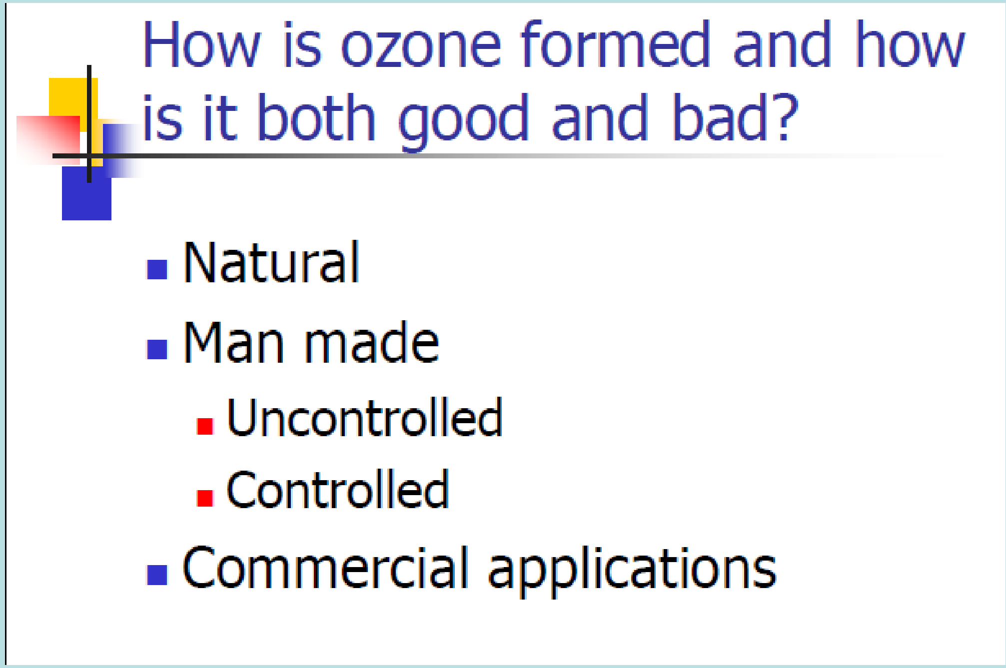
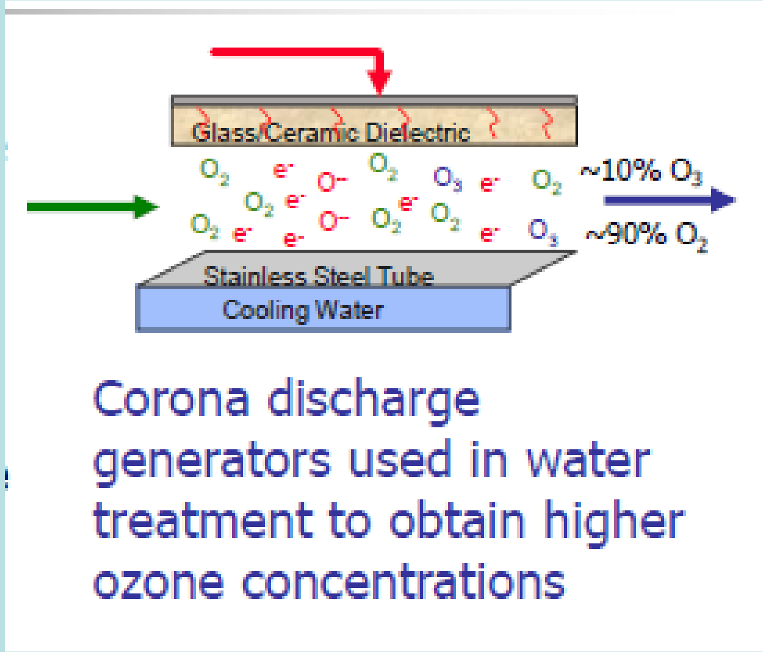
Ozono: O_3

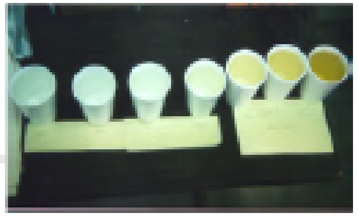
O2 + energía = O3



Fuente: Kerwin Rakness – Taller OSE 2105



Why is ozone used?

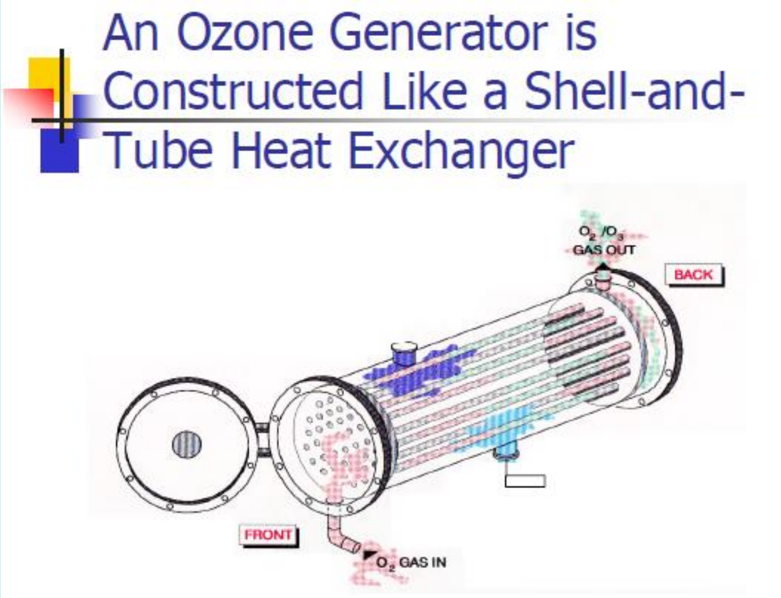


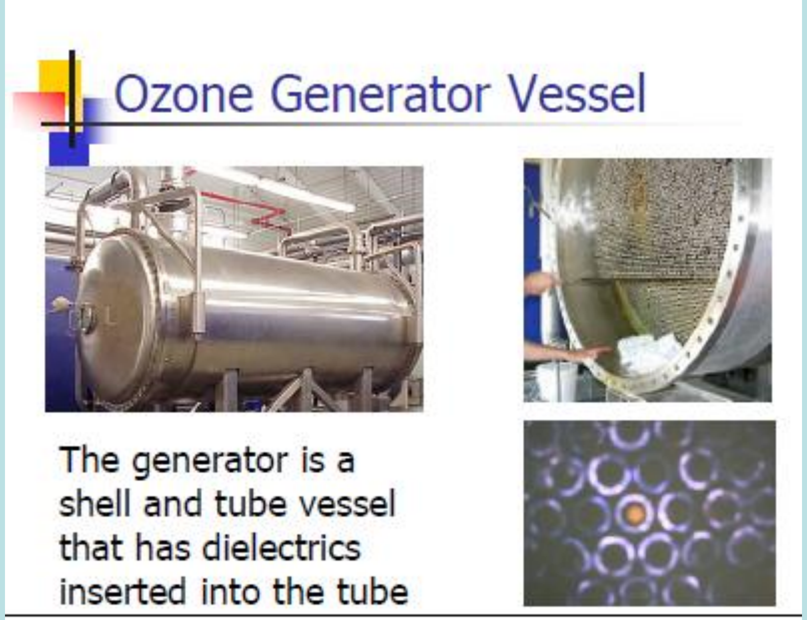
- Oxidize inorganic compounds, such as iron, manganese and hydrogen sulfide
- Oxidize organics with double bonds that cause color
- Inactivate pathogens, such as virus, *Giardia* and *Cryptosporidium*
- Create Hydroxyl Radicals (OH*) that react with complex organics, such as MIB, Geosmin, pesticides, TCE, PCE and other

Fuente: Kerwin Rakness – Taller OSE 2105

Where is ozone applied?

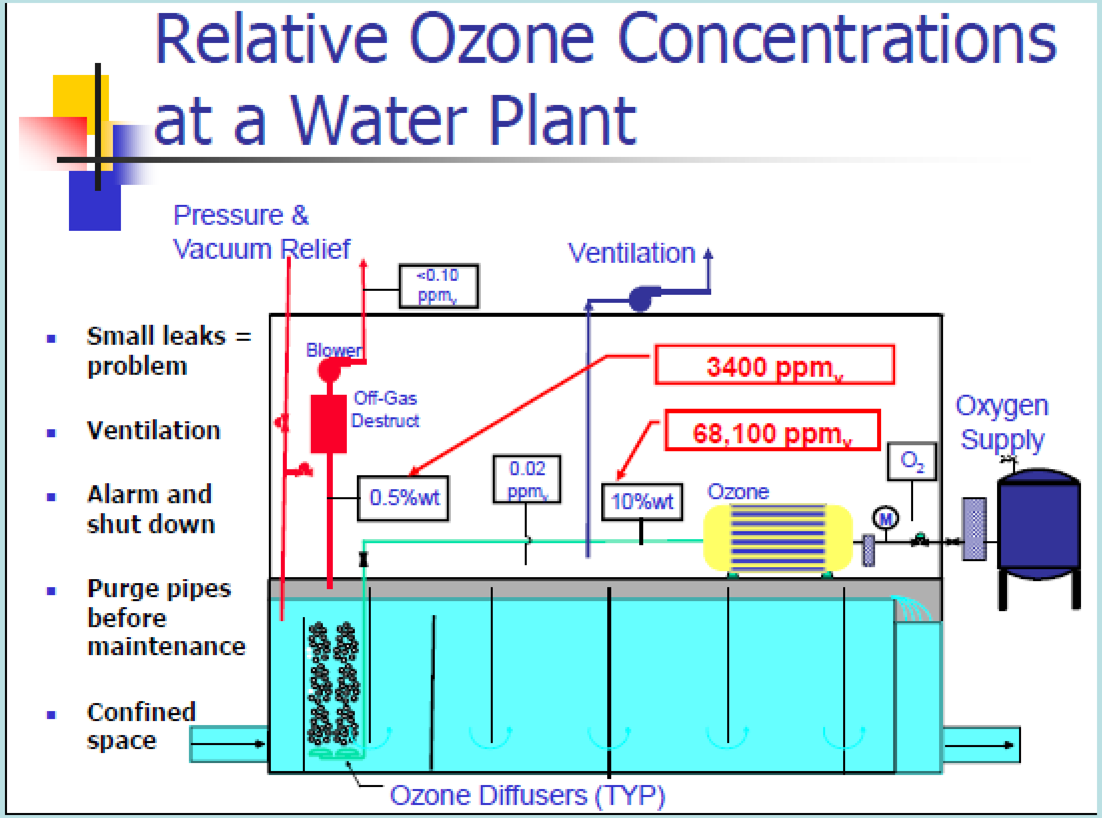
- Pre-ozone (POZ) only
  - Pre-oxidation to assist with particle micro-coagulation and sedimentation
  - Disinfection at some plants, plus less issue with hydraulic profile in the plant
- Settled-water ozone (SOZ) only
  - Ozone dose is lower due to removal of some organics
  - Retrofit can be difficult between sedimentation and filtration
- Both POZ and SOZ to get double benefit





Fuente: Kerwin Rakness – Taller OSE 2105

Aguas Cordobesas- Planta Suquía- Sala generación de ozono

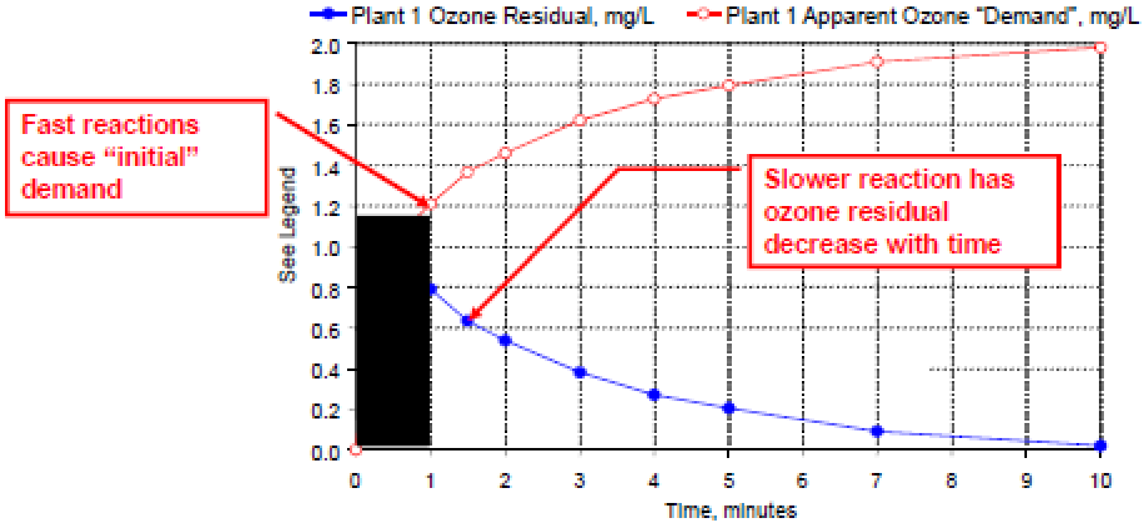


Fuente: Kerwin Rakness – Taller OSE 2105

Aguas Cordobesas- Planta Suquía- LOX para O3

Ozone Demand and Decay

- Ozone gas is generated on site and is dissolved into the water.
- Dissolved ozone creates demand & decay.
- Reported "demand" depends on time (1.2-mg/L @ 1-min)
- Ozone residual decreases (i.e., ozone decay) with time following a mathematical first-order decay curve



Fuente: Kerwin Rakness – Taller OSE 2105

CUADRO IV. VALORES DE CT PARA LA INACTIVACIÓN DE 2 log

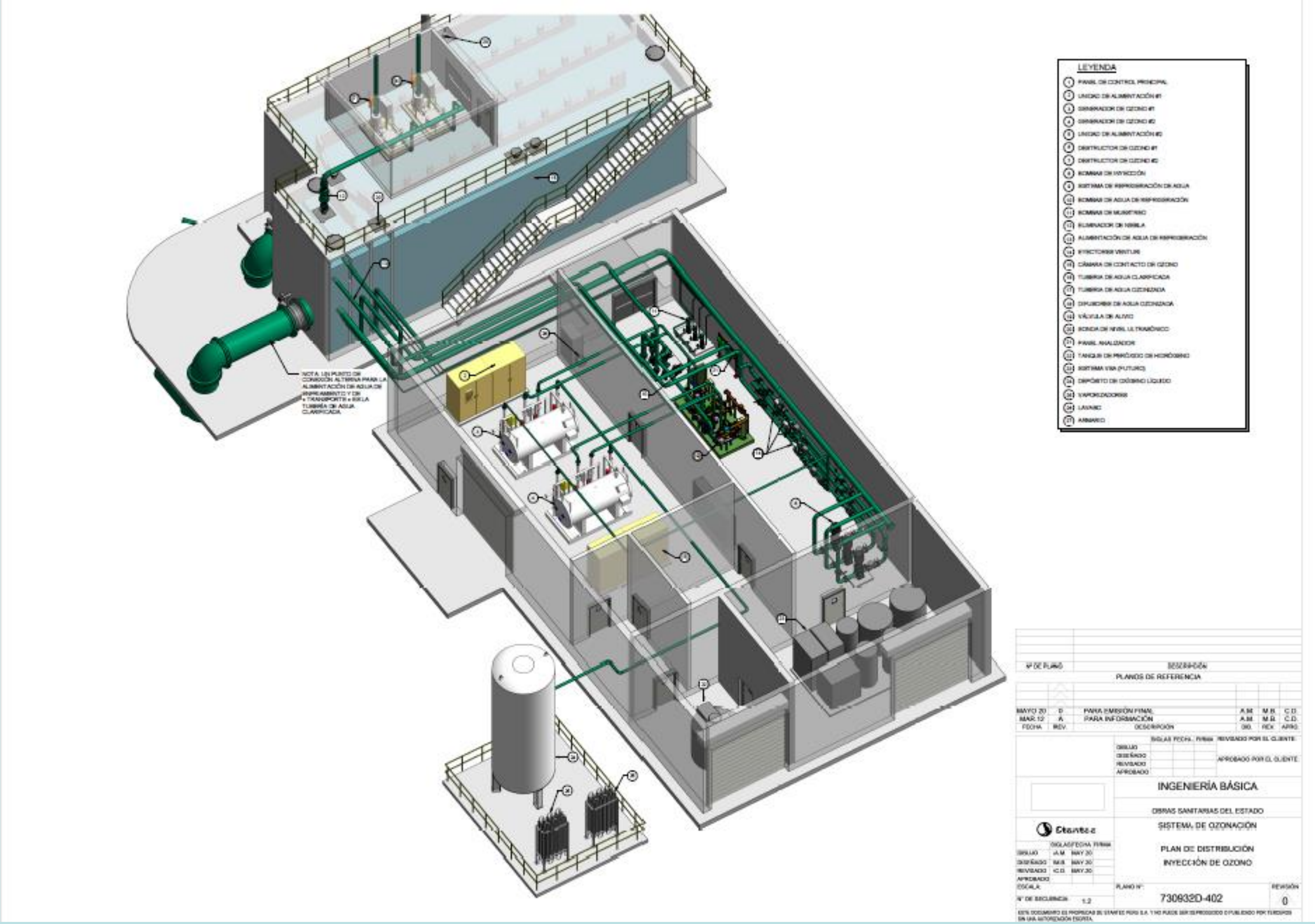
Microorganismo	CT (mg/min/L) pH			
	6-7 Cloro libre	8-9 Cloramina	6-7 Dióxido de cloro	6-7 Ozono
E. coli	0.034-0.05	95-180	0.4-0.75	0.02
Polio virus	1.1-2.5	768-3740	0.2-6.7	0.1-0.2
Rotavirus	0.01-0.05	3800-6500	0.2-2.1	0.006-0.06
Giardia lamblia (quistes)	47-150	2200	26	0.5-0.6
Giardia muris (quistes)	30-630	1400	7.2-18.5	1.8-2.0
Cryptosporidium parvum	7200	7200*	78*	5-10*
Cryptosporidium parvum (1 ºC)			200	10
Cryptosporidium parvum (22 ºC)			120**	7**

Nota: temperatura: 25 ºC; * 1 log; ** 3.5 log

Fuente: EFICIENCIA Y SOSTENIBILIDAD DEL EMPLEO DEL OZONO EN LA GESTIÓN DE LOS RECURSOS HÍDRICOS, Mayra O. BATALLER, Lidia A. FERNÁNDEZ y Eliet VÉLIZ, mayo 2009

Table 5 Common cyanotoxin treatment practices and their relative effectiveness

Treatment Process	Relative Effectiveness
Intracellular Cyanotoxins Removal (intact cells)	
Conventional coagulation, sedimentation, filtration	Effective for the removal of intracellular/particulate toxins by removing intact cells. Generally more cost effective than chemical inactivation/degradation, removes a higher fraction of intracellular taste and odor compounds, and easier to monitor.
Flotation (e.g., dissolved air flotation)	Effective for removal of intracellular cyanotoxins because many toxin-forming cyanobacteria are buoyant.
Pretreatment oxidation (oxidant addition prior to rapid mix)	Overall, can either assist or make treatment more difficult, depending on the situation. Pre-oxidation processes may lyse (cause dissolution or destruction of) cells, causing the cyanotoxins contained within to release the toxins. Ozone may be an exception (see "Ozone" row) because it both lyses cells and oxidizes the cyanotoxins.
Membranes (microfiltration or ultrafiltration)	Effective at removing intracellular/particulate toxins. Typically membranes require pretreatment.
Extracellular Cyanotoxins Removal/Inactivation	
Chlorination	Effective for oxidizing extracellular cyanotoxins (other than anatoxin-a) when the pH is below 8
Chloramines	Not effective
Potassium permanganate	Effective for oxidizing microcystins and anatoxins. Not effective for cylindrospermopsin and saxitoxins.
Chlorine dioxide	Not effective with doses typically used in drinking water treatment
Ozone	Very effective for oxidizing extracellular microcystin, anatoxin-a, and cylindrospermopsin
Activated carbon (powdered activated carbon and granular activated carbon)	Most types generally effective for removal of microcystin, anatoxin-a, saxitoxins, and cylindrospermopsin. Because adsorption varies by carbon type and source water chemistry, each application is unique; activated carbons must be tested to determine effectiveness.
UV radiation	Degrades toxins when used at high doses, but not adequate to destroy cyanotoxins at doses used for disinfection.
Membranes (reverse osmosis [RO] or nanofiltration [NF])	RO effectively removes extracellular cyanotoxins. Typically, NF has a molecular weight cut off of 200 to 2,000 Daltons, which is larger than some cyanotoxins. Individual membranes must be piloted to verify toxin removal.



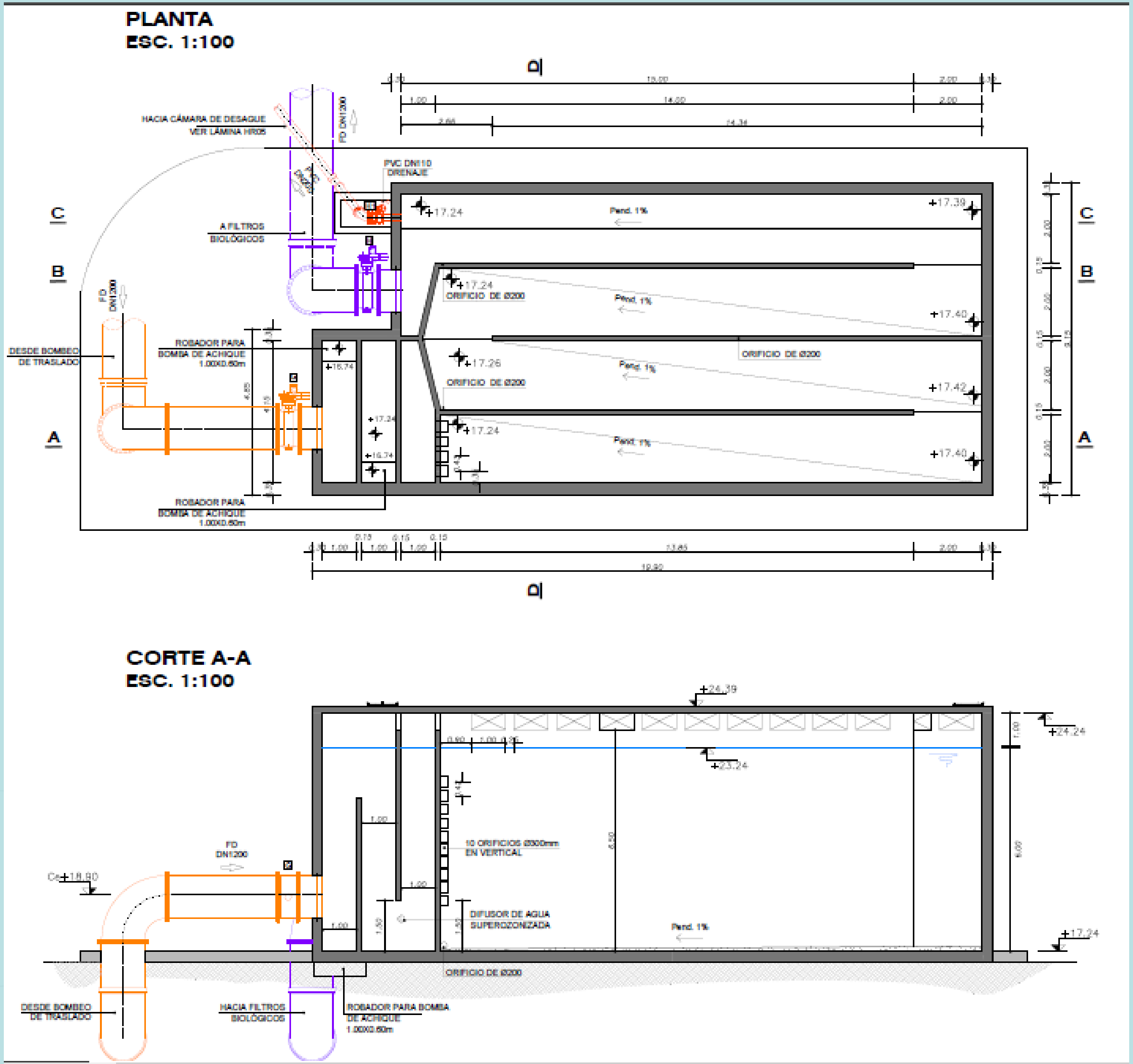
Fuente : Estudios de Preingeniería
Consultora STANTEC para OSE

Tabla 9. Costo de Producción de Ozono

Concentración de Ozono	Costo de LOX	Cost de electricidad	Costo por kg. O_3	Costo por día	Costo por mes
%	*US$/d*	*US$/d*	*US$/kg. Ozono*	*US$/d*	US$/mes
6%	1 482 $	161 $	7,21 $	1 644 $	49 315 $
7%	1 271 $	183 $	6,37 $	1 454 $	43 608 $
8%	1 112 $	204 $	5,77 $	1 316 $	39 489 $
9%	988 $	226 $	5,32 $	1 214 $	36 430 $
10%	889 $	248 $	4,99 $	1 137 $	34 111 $
11%	809 $	269 $	4,73 $	1 078 $	32 332 $
12%	741 $	291 $	4,52 $	1 032 $	30 957 $
13%	684 $	312 $	4,37 $	996 $	29 893 $

Para precios de energía y oxígeno líquido del año 2019,
Para caudales medios en la planta, dosis medias de ozono y energías específicas típicas para las distintas concentraciones.
Mayores concentraciones implican equipamientos para enfriamiento con costos más elevados.

Fuente : Suministro Oxígeno para Ozono
Consultora STANTEC para OSE



Fuente :
Planos Proyecto cámara de contacto de ozono, Usina Laguna del Sauce – OSE-UGD

Largo = 17m
Ancho = 8,45
Altura = 7 m

Tiempo de contacto (factor baffle=1):
7 min para Q máx
11 min para Q diseño

Fuente :
Obra cámara de contacto de ozono,
Usina Laguna del Sauce – OSE-UGD

Fuente :
Obra cámara de contacto de ozono, Usina Laguna del Sauce – OSE-UGD

Fuente :
Obra filtros biológicos,
Usina Laguna del Sauce – OSE-UGD