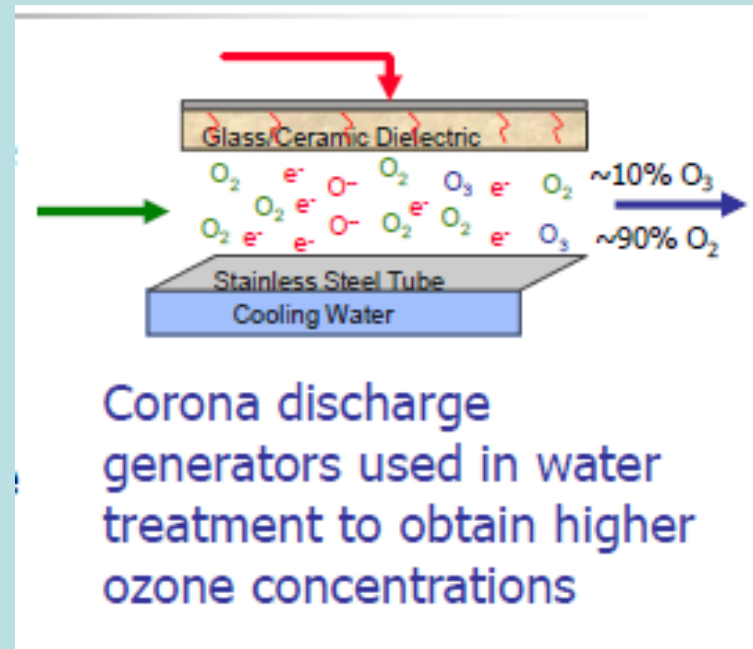


**Ozono: O<sub>3</sub>**

$O_2 + \text{energía} = O_3$

How is ozone formed and how is it both good and bad?

- Natural
- Man made
  - Uncontrolled
  - Controlled
- Commercial applications



## Why is ozone used?



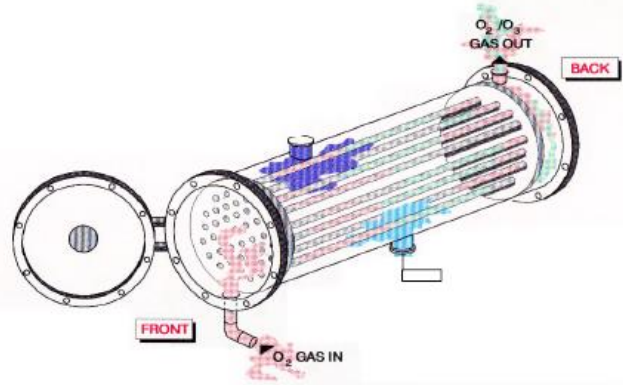
- Oxidize inorganic compounds, such as iron, manganese and hydrogen sulfide
- Oxidize organics with double bonds that cause color
- Inactivate pathogens, such as virus, *Giardia* and *Cryptosporidium*
- Create Hydroxyl Radicals (OH\*) that react with complex organics, such as MIB, Geosmin, pesticides,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

Fuente: Kerwin Rakness – Taller OSE 2105

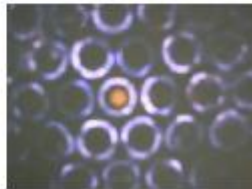
## Where is ozone applied?

- 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

## An Ozone Generator is Constructed Like a Shell-and-Tube Heat Exchanger



## Ozone Generator Vessel

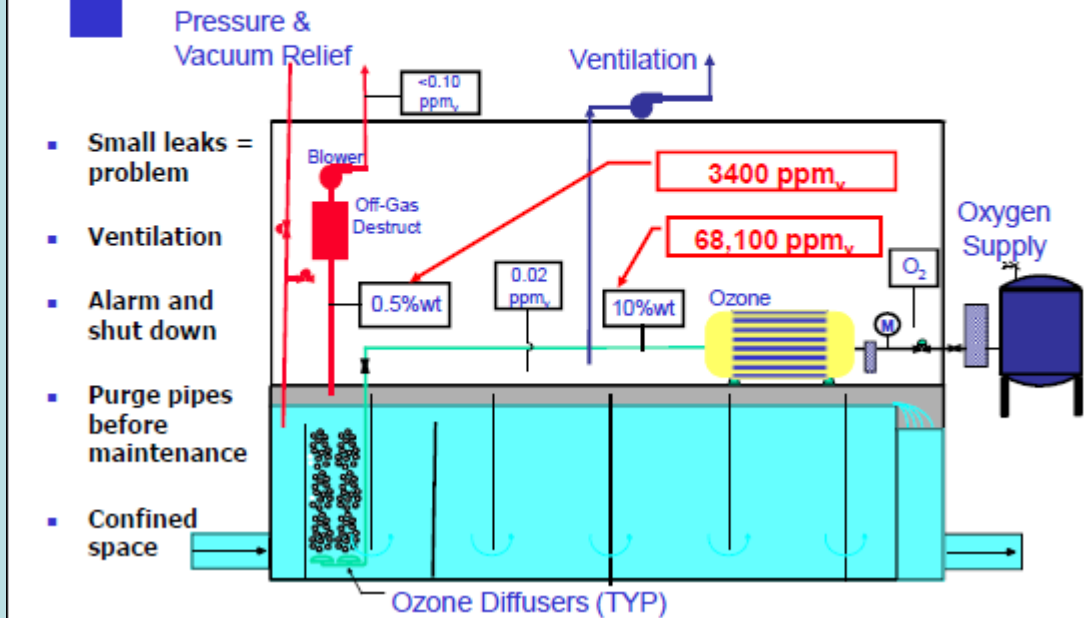


The generator is a shell and tube vessel that has dielectrics inserted into the tube



Aguas Cordobesas- Planta Suquía- Sala generación de ozono

# Relative Ozone Concentrations at a Water Plant



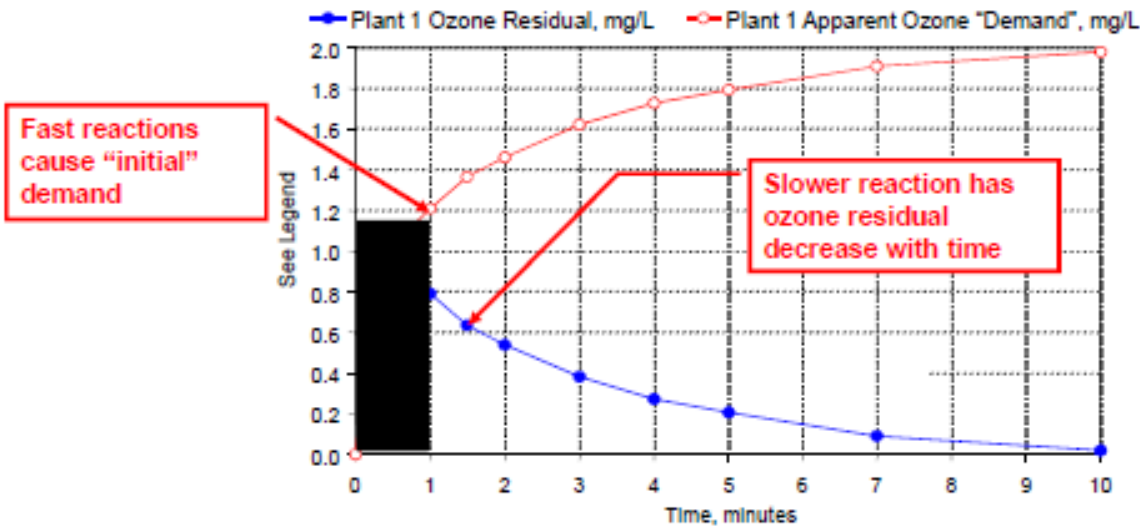
Fuente: Kerwin Rakness – Taller OSE 2105



Aguas Cordobesas- Planta Suquía- LOX para O<sub>3</sub>

# 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





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

Microorganismo	CT (mg/min/L)			
	pH			
	6-7	8-9	6-7	6-7
	Cloro libre	Cloramina	Dióxido de cloro	Ozono
<i>E. coli</i>	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
<i>Giardia lamblia</i> (quistes)	47-150	2200	26	0.5-0.6
<i>Giardia muris</i> (quistes)	30-630	1400	7.2-18.5	1.8-2.0
<i>Cryptosporidium parvum</i>	7200	7200*	78*	5-10*
<i>Cryptosporidium parvum</i> (1 °C)			200	10
<i>Cryptosporidium parvum</i> (22 °C)			120**	7**

Nota: temperatura: 25 °C; \* 1 log; \*\* 3.5 log

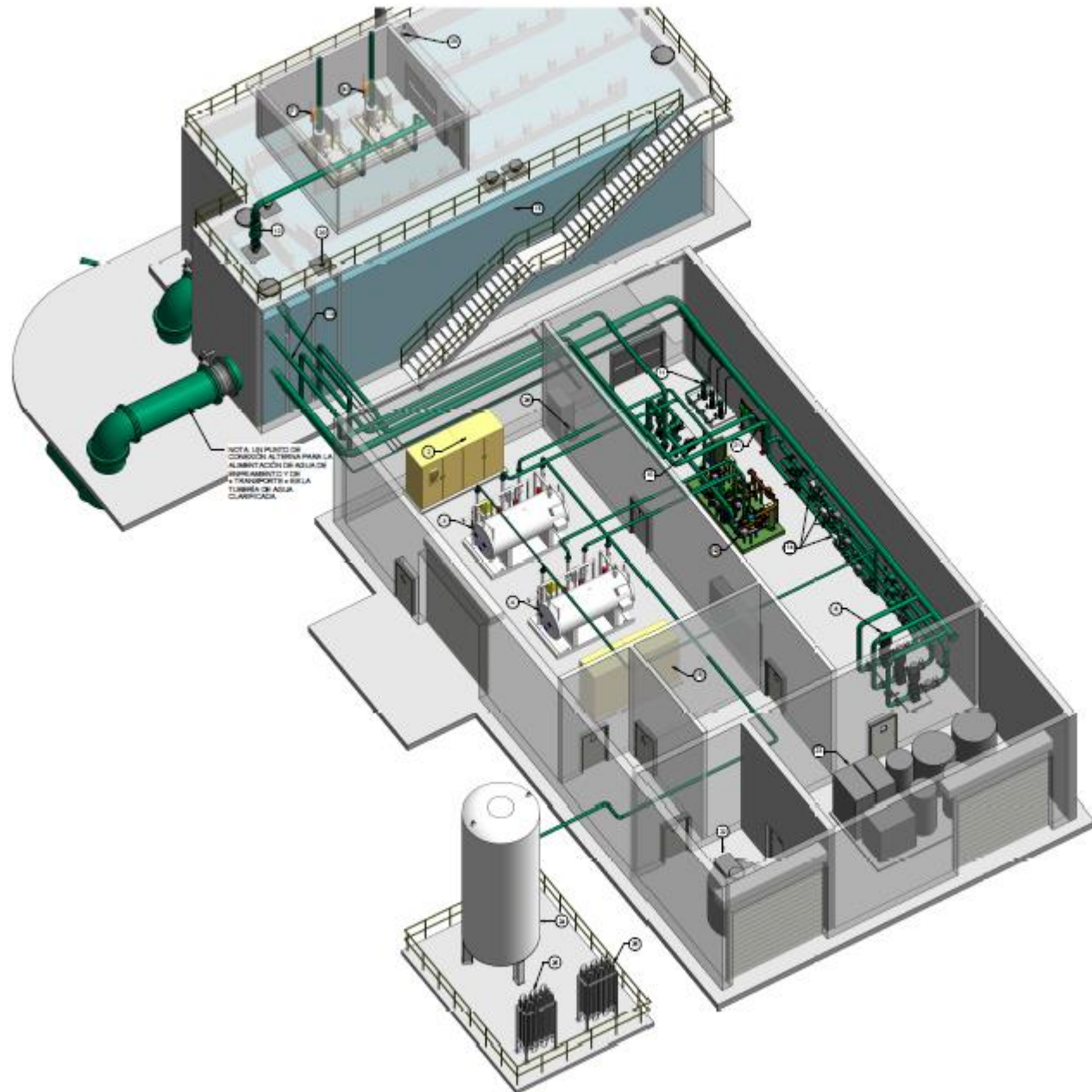
Fuente: EFICIENCIA Y SOSTENIBILIDAD DEL EMPLEO DEL OZONO EN LA GESTIÓN DE LOS RECURSOS HÍDRICOS, Mayra O. BATALLER, Lidia A. FERNÁNDEZ y Eliet VÉLIZ, mayo 2009

**Table 5 Common cyanotoxin treatment practices and their relative effectiveness**

Treatment Process	Relative Effectiveness
<b>Intracellular Cyanotoxins Removal (intact cells)</b>	
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.
<b>Extracellular Cyanotoxins Removal/Inactivation</b>	
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 © 2015 American Water Works Association





**LEYENDA**

- ① PANELES DE CONTROL PRINCIPAL
- ② UNIDAD DE ALIMENTACIÓN #1
- ③ SEPARADOR DE GASEO #1
- ④ SEPARADOR DE GASEO #2
- ⑤ UNIDAD DE ALIMENTACIÓN #2
- ⑥ DESTRUCTOR DE GASEO #1
- ⑦ DESTRUCTOR DE GASEO #2
- ⑧ BOMBAS DE INYECCIÓN
- ⑨ SISTEMA DE REFRIGERACIÓN DE AGUA
- ⑩ BOMBAS DE AGUA DE REFRIGERACIÓN
- ⑪ BOMBAS DE MUESTREO
- ⑫ ALUMINACIÓN DE TUBERÍA
- ⑬ ALUMINACIÓN DE AGUA DE REFRIGERACIÓN
- ⑭ FLECTORES VENTILAS
- ⑮ CÁMERA DE CONTACTO DE GASEO
- ⑯ TUBERÍA DE AGUA CLASIFICADA
- ⑰ TUBERÍA DE AGUA OZONIZADA
- ⑱ DIFUSORES DE AGUA OZONIZADA
- ⑲ CÁMARA DE ALTO
- ⑳ BANCOS DE NEBLA ULTRASONICO
- ㉑ PANELES INALZADOR
- ㉒ TANQUE DE RESERVA DE HONORARIO
- ㉓ SISTEMA VVA (FUTURO)
- ㉔ DEPÓSITO DE COLECCIÓN LÍQUIDO
- ㉕ VAPORIZADORES
- ㉖ LAVABO
- ㉗ ARMARIO

N° DE PLANO		82284024			
PLANDS DE REFERENCIA					
MAYO 20	D	PARA DIMENSIÓN FINAL	A.M	M.H	C.D.
MAR 12	A	PARA INFORMACIÓN	A.M	M.B	C.D.
FECHA	REV.	DESCRIPCIÓN	DB	REV	APROB.
			SIGLAS FECHA - FINES - REVISADO POR EL CLIENTE		
			APROBADO POR EL CLIENTE		
<b>INGENIERÍA BÁSICA</b>					
OBRAS SANITARIAS DEL ESTADO					
SISTEMA DE OZONIZACIÓN					
PLAN DE DISTRIBUCIÓN					
INYECCIÓN DE OZONO					
 OGLAS/FECHA FINES DESARROLLO A.M MAY 30 DISEÑADO M.B MAY 30 REVISADO C.D. MAY 30 APROBADO ESCALA		PLANO N°	REVISIÓN		
N° DE ESCALAS: 1:2		730632D-402	0		
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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 <sub>3</sub>	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,

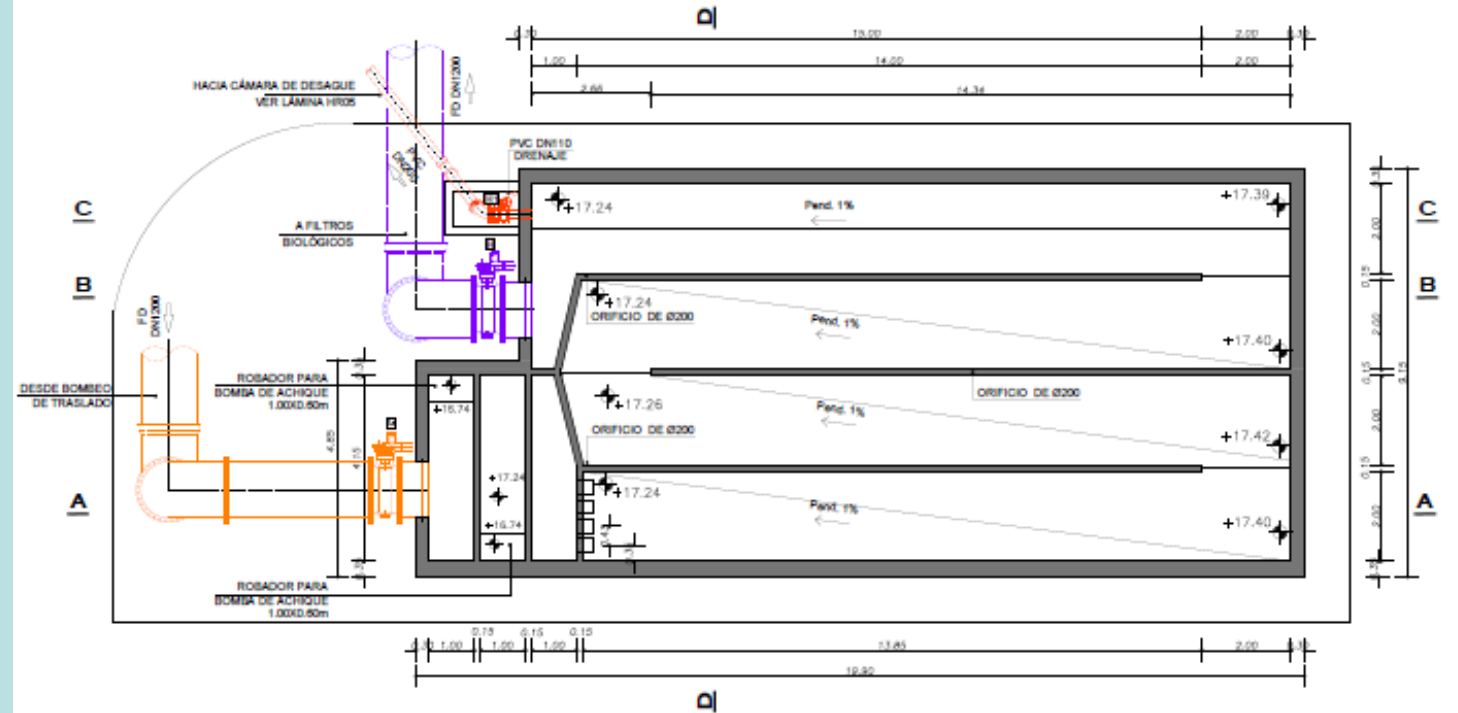
Para caudales medios en la planta, dosis medias de ozono y energías específicas típicas para las distintas concentraciones.

Mayores concentraciones implican equipamientos para enfriamiento con costos más elevados.

Fuente : Suministro Oxígeno para Ozono

Consultora STANTEC para OSE

**PLANTA**  
**ESC. 1:100**

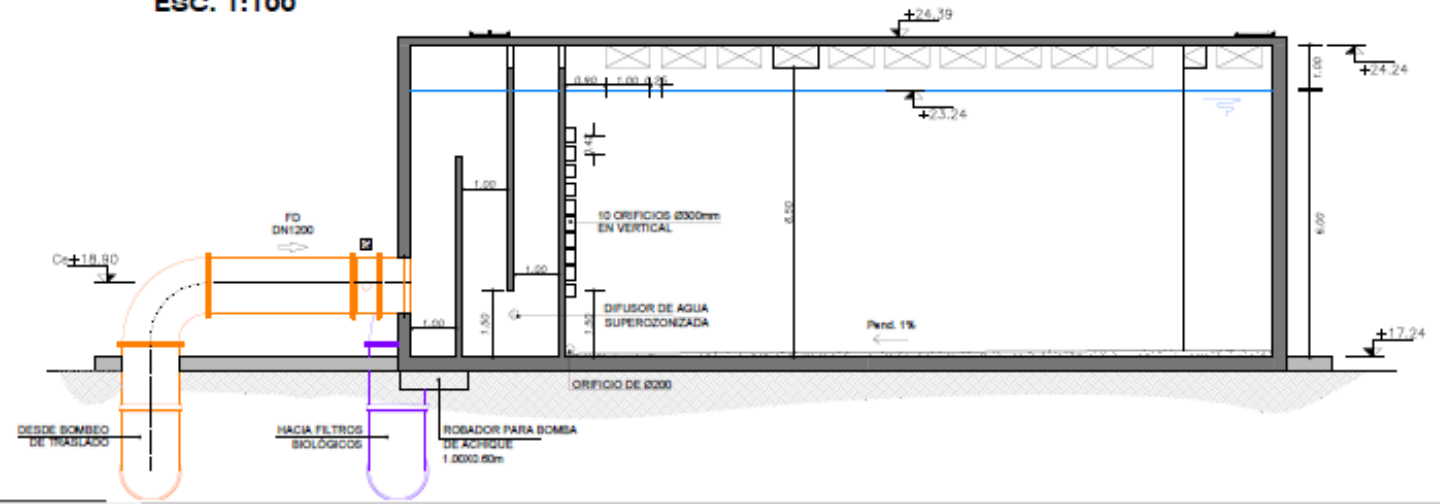


Fuente :  
Planos Proyecto cámara de contacto de ozono,  
Usina Laguna del Sauce – OSE-UGD

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

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

**CORTE A-A**  
**ESC. 1:100**



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