



*From Concept to Reality...
Driving Global CO₂ Solutions*

"When pH Matters"
Harvey Swain



About | Air Water Inc.



- Acquired TOMCO₂ Systems
February 23, 2018
- Headquartered in Osaka, Japan
with - \$6B in Annual Sales (98% in Japan)
- >12,000 Employees
- A Market Leader in Japan Industrial Gas & Cryogenic Equipment
- Focus on International Acquisitions
 - Preference towards US manufacturing companies with engineered industrial gas products
 - Acquire, Invest & Grow



Driving Global CO₂ Solutions

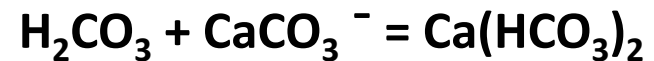
About | Why is CO₂ Important?

Carbon Dioxide reacted with water produces Carbonic Acid.

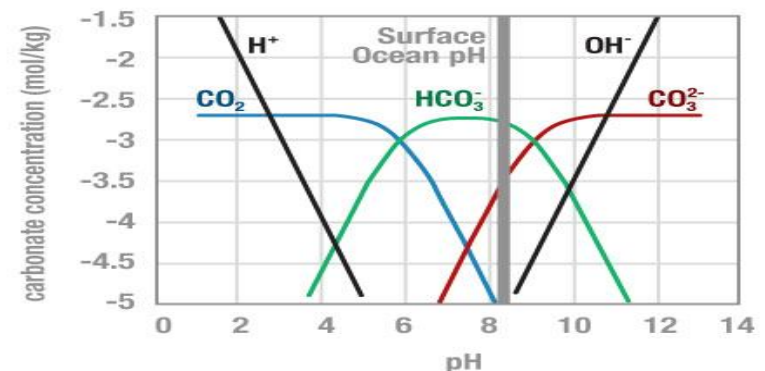
The importance of this reaction will determine your success rate of remineralization. Your goal is to produce drinkable water containing the correct amount calcium bicarbonate (LSI & Alkalinity).

Remineralization

Remineralization is the process replenishing the minerals in the permeate water after the Reverse Osmosis process. This process begins by taking the permeate water, which is aggressive and corrosive in nature and is not suitable for direct use as potable water or introduction into a distribution system and adding the minerals back. By adding back the alkalinity and dissolved minerals in the desalinated water, the water becomes ready for potable use.



carbonic acid + calcium carbonate = calcium bicarbonate



Direct CO₂ Gas Injection

Direct CO₂ Gas Injection System is the traditional method for using Carbon Dioxide for pH control.

- This system is designed to inject CO₂ gas into a water source. Once the gas dissolves, it will produce carbonic acid. The carbonic acid then reacts with the alkalis present in the water, neutralizing them, thus reducing the pH.
- Efficiency of the CO₂ Gas transfer depends on numerous factors like water chemistry, injection point design, and physical condition located at injection point.



Direct CO₂ Gas Injection | Effects of Lime Slurry (Milk)



Injecting CO₂ Gas directly into the permeate stream will cause a slow chemical reaction of Lime and CO₂ leading into Calcium Carbonate Precipitation.

Pressurized Solution Feed (PSF)



TOMCO₂'s Pressurized Solution Feed System™ is the most **Eco-Friendly Carbon Dioxide pH Control** system on the market. Our technology is designed to maximize the conversion of CO₂ gas into carbonic acid, utilizing **more than 95%** of the CO₂ required. By accomplishing this efficiency, our system prevents the off gassing of CO₂ back into the atmosphere.



Equipment | CO2 Storage Tank & Vaporizer System



CO2 Storage Systems



CO2 Ambient Vaporizers

Common to Both Types of Injection Systems

Equipment | Direct CO₂ Gas Injection System



CO₂ Gas Feed System



CO₂ Gas Dissolver



CO₂ Gas Injection
With Lime Milk



Chemical Mixer



Degasser Towers

Equipment | Direct CO₂ Gas Injection System



Motive/ Carrier
Water System



PSF System
"Carbonic Acid"



Carbonic Acid
Solution Diffuser

OPEX | Chemical Usage Efficiency

Cost of CO ₂	\$480.00	Per Metric Ton
CO ₂ Dosage	55	Kg/hr.
Total Used Per Day	1,320	Kilograms
Cost of CO ₂	\$231,264.00	Per Year
Direct Gas CO ₂ Injection (Based on Henry's Law 30°C 1,000 kPa)	54%	Efficiency
Carbonic Acid Solution (Based on Henry's Law 30°C 1,000 kPa)	95%	Efficiency
Difference Between Systems	41%	Efficiency
Savings Using the PSF "Carbonic Acid" System	\$94,818.00	Per Year

CAPEX | CO₂ Gas Injection System

Carbon Dioxide Gas System (55 kg/hr.)		
Carbon Dioxide Storage System (AD-2000 Coded)	\$110,00.00	50 Ton (1 Units)
Ambient Vaporizer (Switching System with Heater & Regulators)	\$52,000.00	100 kg/hr. (2 Units)
CO ₂ Gas Injection System	\$68,000.00	55 kg/hr. (2 Units)
Chemical Mixer	\$40,000.00	450 mm (18")
Subtotal System	\$270,000.00	
CO ₂ Gas Dissolver	Price Unknown	To Increase Solubility of CO ₂ Gas
Degasser Towers	Price Unknown	Per Year
Total System	\$\$\$\$\$\$	

CAPEX | PSF “Carbonic Acid” System

Carbon Acid Solution System (55 kg/hr.)		
Carbon Dioxide Storage System (AD-2000 Coded)	\$115,00.00	50 Ton (1 Units)
Ambient Vaporizer (Switching System with Heater & Regulators)	\$52,000.00	100 kg/hr. (2 Units)
PSF System	\$100,000.00	55 kg/hr. (2 Units)
Motive / Carrier Water	\$50,000.00	Dual Pump
Subtotal System	\$317,000.00	
Chemical Mixer	Not Required	
CO2 Gas Dissolver	Not Required	
Degasser Towers	Not Required	
Total System	\$317,000.00	

1000 x mole fraction of CO₂ in liquid phase

Partial pressure of CO₂ in kPa

t/°C	5	10	20	30	40	50	100
0	0.067	0.135	0.269	0.404	0.538	0.671	1.337
5	0.056	0.113	0.226	0.338	0.451	0.564	1.123
10	0.048	0.096	0.191	0.287	0.382	0.477	0.950
15	0.041	0.082	0.164	0.245	0.327	0.409	0.814
20	0.035	0.071	0.141	0.212	0.283	0.353	0.704
25	0.031	0.062	0.123	0.185	0.247	0.308	0.614
30	0.027	0.054	0.109	0.163	0.218	0.271	0.541
35	0.024	0.048	0.097	0.145	0.193	0.242	0.481
40	0.022	0.043	0.087	0.130	0.173	0.216	0.431
45	0.020	0.039	0.078	0.117	0.156	0.196	0.389
50	0.018	0.036	0.071	0.107	0.142	0.178	0.354
75	0.012	0.025	0.049	0.074	0.099	0.123	0.245
100	0.010	0.020	0.039	0.059	0.079	0.098	0.196

No	Name of Plant/ Client	Plant Information	Start-up Year	Type of CO ₂ injection system
1	Ma'aden / Alcoa Plant, Ras Al Khair Industrial City Saudi Arabia	Plant Capacity 25,000 m ³ /day <u>Type of Treatment</u> Remineralization/Alkalinity Control	2014	Direct Gas Injection Feed System
2	Ras Al Khaimah Desalination Plant, Ghalilah, UAE	Plant Capacity 68,140 m ³ /day <u>Type of post-treatment</u> Remineralization/Alkalinity Control	2014	Pressurized Solution Feed "Carbonic Acid"
3	Sadara Chemical Plant, Al Jubal, Saudi Arabia	Capacity 1 MGD <u>Type of treatment</u> Remineralization/Alkalinity Control	2015	Pressurized Solution Feed "Carbonic Acid"
4	Ma'aden Phosphate Company Ras Al Khair, Saudi Arabia	Capacity 1,368 m ³ /day <u>Type of post-treatment</u> Remineralization/Alkalinity Control	2016	Pressurized Solution Feed "Carbonic Acid"
5	MASDAR Pilot Plant, Ghantoot, United Arab Emirates	Capacity 100 m ³ /day <u>Type of post-treatment</u> Remineralization/Alkalinity Control	2015	Pressurized Solution Feed "Carbonic Acid"
6	Yanbu (10x3000 m ³ /d containerized plants) Plant, Yanbu, Saudi Arabia	Capacity 30,000 m ³ /day <u>Type of post-treatment</u> Remineralization/Alkalinity Control	2017	Direct Gas Injection Feed System
7	200 MLD Independent Water Plant Qurayyat, Oman	Capacity 200,000 m ³ /day <u>Type of post-treatment</u> Remineralization/Alkalinity Control	2017	Pressurized Solution Feed "Carbonic Acid"

No	Name of Plant/ Client	Plant Information	Start-up Year	Type of CO ₂ injection system
8	Rabab Harweel Integrated Project – Water Treatment Plant, Harweel Cluster, Oman	Capacity 100 m ³ /day <u>Type of post-treatment</u> Remineralization/Alkalinity Control	2018	Direct Gas Injection Feed System
9	El Tor Desalination Plant El Tor, Egypt	Capacity 30,000 m ³ /day <u>Type of post-treatment</u> Remineralization/Alkalinity Control	2018	Pressurized Solution Feed "Carbonic Acid"
10	Ras Al Khair Industrial Waste Water Plant Ras Al Khair, Saudi Arabia	Capacity 25,000 m ³ /day <u>Type of Treatment</u> Wastewater - Metal Removal / pH Control	Under Construction	Pressurized Solution Feed "Carbonic Acid"

Complete Carbon Dioxide “pH Control” System

Slide | with Graphics



Taylor-Wharton
Since 1742

- Acquired by Air Water in 2016
- Global Leader in Cryogenic Tank manufacturing
- Vacuum-Insulated Bulk Tanks
- MicroBulk
- Liquid Cylinder
- BevCarb
- LNG
- Vaporizers
- Vacuum Insulated Piping

DOHMEYER
CRYOGENIC • FREEZING • PRECISION

- Industry Manufacturer of Cryogenic Refrigeration Systems for:
 - Food Processing
 - Pharmaceuticals
 - Aeronautic
 - Plastics
 - Steel