1. DESCRIPTION OF THE DRINTEC™ LIMESTONE CONTACTOR

Traditional downflow or upflow $CaCO_3$ contactors have been used for quite some time for recarbonation of desalinated waters. However, traditional contactors need frequent reloading as well as back-washing on every reload to avoid turbidity problems at the outlet.

Turbid waters from the backwashes need to be diverged to a separate stream, loosing some production and continuity of the remineralization process.

In the patented DrinTec™ process, upflow contactors of constant height are created by means of feeding the granulated limestone continuously, under water, and directly onto the limestone bed by a limestone feeding system.

Fig. 1.1: Some aspects of different DrinTec™ contactors remineralization facilities.

This patented process provides the advantage that quality after contactors is always constant. In addition, a series of operational and maintenance advantages improve considerably operational costs over the traditional down-flow or up-flow design.

The operation of these tanks is as follows: carbon dioxide rich water enters the tank through the lower part and is distributed across a filtering floor. It then flows upwards from the lower part of the crushed limestone bed and, as it moves upwards, its chemical composition is corrected.

While moving upwards within the limestone bed, the carbon dioxide rich water reacts with the limestone in the bed forming soluble calcium bicarbonates. This causes dissolution of the limestone and an increase in pH and alkalinity. Once it has flowed through the bed, the now remineralized water moves further up into no-limestone zone and then leaves the tank at the outlet.

The tanks have an in-built silo in their upper part and the limestone feeding system guides the product from the silo to the surface of the bed. This way, the product is dosed directly onto the bed by gravity, maintaining a constant bed height while the limestone is consumed.

Dosing occurs very slowly and without creating turbulence. The limestone granules fall by gravity through the feeding system and without obstruction. The system feeds itself constantly depending solely on the natural demand of the water.

The silo allows the contactors to operate autonomously for three to four weeks.

The system operates at 0,6-0,7 bars.

DrinTec™ tanks do not require frequent backwashing but just during start-up. Backwashing with water can be done during normal operations by isolating one tank but it is only recommended when using poor quality limestone or when beds get contaminated with organics or biofouling. In any case it is recommended to do air sponging every 6 months to a year to avoid bed compaction and preferential consumption routes inside the limestone bed.

Fig. 1.2: Some aspects of different DrinTec™ contactors remineralization facilities.

Turbid water is discharged by diverting it before entering the clean water manifold pipe.

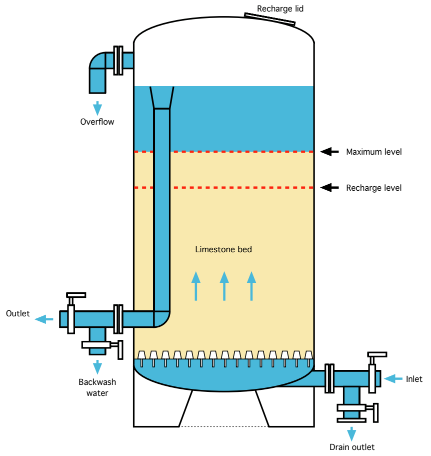
The recharging process is performed manually by means of a gantry crane that moves over the cells loading openings and allows for dosing with big-bags depending on the demand.

Because the recharging process is carried out in the silo and independent of the contactor bed, loading does not create turbidity and can be carried out while maintaining normal operational conditions.

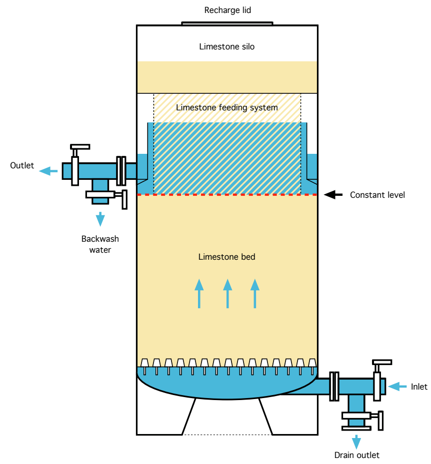
Fig. 1.3: General overview of ten DrinTec™ limestone contactors installation with CO_2 low pressure dissolver.

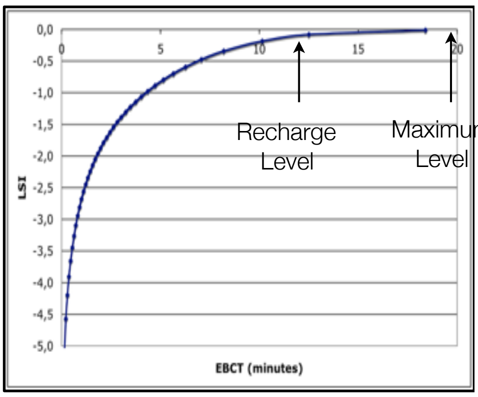
2. Advantages of the DrinTec™ process

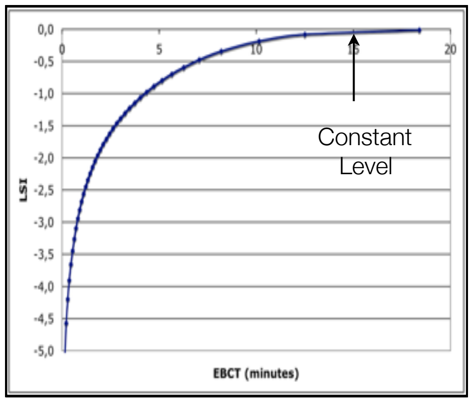
Traditional
Limestone Contactor

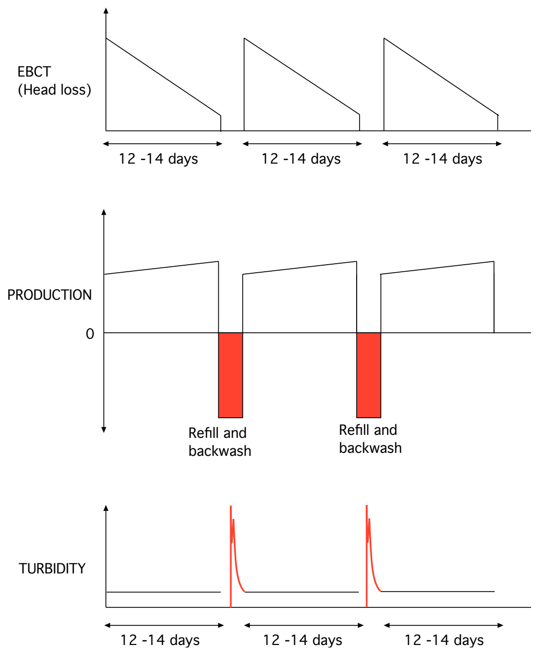


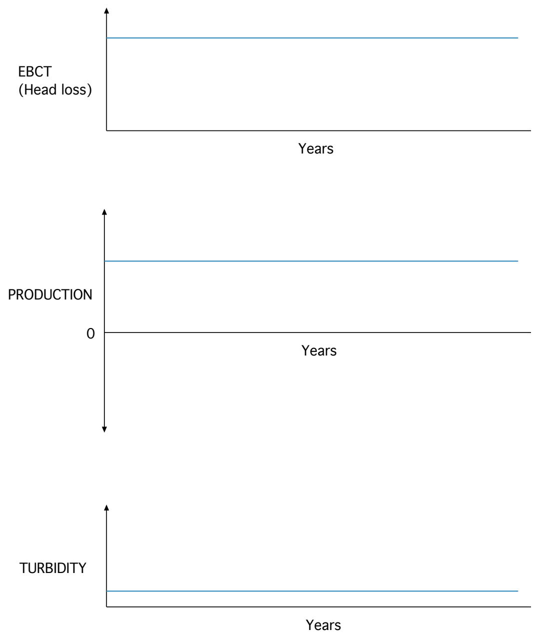
Drintec™
Limestone Contactor











Advantages of DrinTec™ option against contactor without constant feeding.

3. MAIN ADVANTAGES OF THE DRINTEC™ TECHNOLOGY

CONTACTOR TYPE	ADVANTAGES	DISADVANTAGES
Traditional Downflow Contactors	- Backwash cycle cleans limestone media and prevents iron oxide particles and other sediments from fouling or coating the media. - Large particle limestones are prevented from leaving the filter tank due to the bottom underdrain.	– Requires frequent automatic or manual backwash cycles to clean limestone media during replenishment and to avoid media compaction. – Requires spare units to operate during replenishment and backwashing. – Potentially higher headloss due to limestone media compaction. – Longer downtime during media replenishment. – Variation in tank head loss due to changes in bed height. – Lost in CO_2 application efficiency due to continuous backwash. – Variation in water quality due to changing bed height CO_2 concentration in the media. – Waste water treatment plant (WWTP) required for treating large amounts of backwash water. This includes settler and sludge removal units as well as water recovery system. – Return of cleaned water from the WWTP to the entrance of the plant causes flow increases and potentially turbidity events. Therefore reuse from backwash water requires sufficient storage for constant feeding . – Sludge from WWTP settler needs to be disposed. – Need for a separate storage area outside the filter area. – Operators with high technical skill required. - Delicate design due to motors and automation. Risk of failure, even under harsh environmental conditions. – Higher energy consumption – Higher capital and O&M costs.

CONTACTOR TYPE	ADVANTAGES	DISADVANTAGES
DrinTec™ Upflow contactors with continuous limestone feeding	- Constant water quality due to continuos bed height. - Refilling is done in the in-built silo and not directly on the bed's surface. No turbid water is generated during refill. No need to backwash and divert turbid water every refill. - No frequent backwash required if good limestone, only sponging every 6 months recommended. - No need for spare units. - A very even consumption among tanks as they have same hydraulic head loss that remains constant during operation and refilling. - Continuous operation. No need to stop the plant during replenishment. - Lower head loss experienced. - Effluent turbidity is typically low and below 0.5 NTU. - No backwash water treatment plant needed. Pumps and blower used in other sections of the desalination plant can be used for initial clean-up of the media and eventual sponging. - No sludge to be disposed off. - Low energy consumption as no frequent for backwashing is needed. - Robust design. No moving parts and low risk of failure, even under harsh environmental conditions. - Higher CO_2 efficiency due to constant operation, no backwashing and long contact times. - No need for separate storage area. In-built silos allow for and autonomy of 30 days or more. - Lower operation health and safety factors due to no moving parts. - Simple to operate. No high technical skills required. - Less expensive on capital costs and O&M.	- Good quality limestone recommended (< 0,3% Fe_2O_3) to prevent iron or other sediments from fouling or coating the media and prevent the need for backwashing. - Percentage of limestone particles less than 0,1 mm to be minimized (< 1%) for prevent limestone been dragged by up-flowing water.

4. Limestone quality

The next table shows the quality of the limestone recommended for limestone contactors. In case of different quality, limestone pilot tests should be carried out to evaluate the material.

The presence of impurities with particle size >100 µm should be avoided to make sure there is no accumulation of impurities inside the reactor. On the other hand, the presence of too much fine dusty material <30 µm should be avoided as this tends to generates a constant turbidity of 1-2 NTU.

To guaranty good water quality, clean washed, air blown material and large particle material Ø 2-5 mm is preferred.

Table 4.1: Recommended limestone quality

Purity	≥ 97%
Size	2 mm - 5 mm
CaO	> 55 %
SiO_2	< 0,5%
Al_2O_3	< 0,5%
MgO	< 1,5%
Fe_2O_3	< 0,12%
Mn_3O_4	< 0,01%
Specific weight (t/m^3)	2,7
Dry granular specific weight (t/m^3)	1,5
Particles Ø < 0.3 mm	< 3%
Particles Ø < 0.1 mm	< 1%
Insolubles > 0.1 mm	< 0,2 %

Fig. 4.1: Typical aspect of granulated limestone

5. DrinTec™ low pressure dissolver

Inappropriate injection of CO_2 would cause an uneven distribution among the different contactors. To avoid this problem a system is proposed that guarantees the dilution of CO_2 prior to injection in the main inlet pipe at low pressure.

CO_2 dosing will be carried out in a by-pass of the main line where the CO_2 is injected at counter-current and at low differential pressure in a special dissolver that guarantees injecting gasified water without free bubbles. The dissolver will be designed for a constant water flow rate. CO_2 dose will be adjusted according to desired pH after treatment.

Injection pressure will be defined by main pipe operational pressure. A booster pump to add 0,2 bar of extra pressure may be required.

Fig. 5.1: Examples of DrinTec™ CO_2 low pressure dissolvers.

6. DrinTec™ installations reference list

Year	Flow rate (m^3/d)	Type of cell	Location
2016	19.000	FRP tanks	Canary Islands, Spain (on-going)
2015	163.800	Steel tanks	Middle East (on-going)
2015	2.400	FRP tanks	Saudi Arabia (on-going)
2015	6.000	FRP tanks	Saudi Arabia (on-going)
2014	30.000	Concrete	Canary Islands, Spain
2014	12.000	Concrete	Canary Islands, Spain
2013	24.000	Concrete	Canary Islands, Spain
2012	400 and 3.000	HDPE	Canary Islands, Spain
2012	384.000	Concrete	Middle East
2012	6.000	FRP tanks	Canary Islands, Spain
2012	11.000	FRP tanks	Chile, South America
2011	24.000	Concrete	Canary Islands, Spain
2011	21.000	Concrete	Canary Islands, Spain
2010	2.000	FRP tanks	Cape Verde Islands
2009	200.000	Concrete	Barcelona, Spain
2009	1.000	FRP tanks	Taiwan
2009	2.000	FRP tanks	Oman
2008	84.000	Concrete	Alicante, Spain
2007	10.000	Concrete	Canary Islands, Spain
2005	10.000	Concrete	Canary Islands, Spain
2004	3.000	FRP tanks	Balearic Islands, Spain
Since 2002	300 to 1.200 per unit	FRP tanks	Various countries, over 60 units