

Quantum Disinfection™: Applications & Laboratory Testing Recommendations

Document N° 081319



Product name: Quantum Disinfection™ (QD ceramics)
At the service of: Original Equipment Manufactures only (OEM)

Product certifications:

NSF/ANSI 42 Certificate #:	C0292640-01
IAPMO - NSF/ANSI 61 Certificate #:	23033
MOH - China Certificate #:	2015KF2513

Objective

The Document N° 081319 describes in detail:

- the Applications conditions & principals including examples of appropriate devices;
- the Laboratory testing recommendations for the Quantum Disinfection™ ceramics, including protocols, operation parameters and results.

Please read carefully all the Important notes!, both in red and in blue.

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1. QD Ceramics

1.1. General Characterization

The general characteristics of the QD ceramics are grouped in the next table. A picture of the media (in a classical petri dish) is presented here below:

Table 1. Quantum Disinfection™ ceramic - general characterization



Characteristic	Value
Chemical composition	Al ₂ O ₃ - TiO ₂ - AgCl
Shape	Sphere
Mesh size (Minimum)	7 x 14
Mesh size for the average particle to fall (Tyler Mesh)	8 x 10
Particle size repartition (%: ball size)	90 - 95 %: 2 mm < 5%: 1.0 mm < 5%: 3.0 mm
Apparent density (g/cm ³)	0.70
Color*	95%: white < 5 %: blue

* Color changes from white to grey indigo under UV or visible light

Information about the disinfection principals, mode of action, certifications, 3rd party laboratory reports, scientific evidences, scientific publications, patents, physical-chemical description, marketing material, can be found on our website: www.quantumdisinfection.au or under demand at will@quantumdisinfection.au



1.2. Main Applications

The main applications for the QD ceramics are regrouped, by market sector, in the following table:

	Market	Application
1	Residential water disinfection	
	Integration	- Water Purifiers (Counter Top) - Post RO systems - Pitcher type filters - Filtration systems - Activated carbon cores
	Final stage complement (after filters, softeners, etc.)	- Whole house (Point-of Entry) - Inline systems (Point-of-Use, Under-the-sink) - Rain water tanks (Point-of-Exit)
2	Commercial water disinfection	- Ice making machines - Water dispensers - Refrigeration system - Recreative Vehicles and Boats - Fountain drink machines - Water transportation trucks - Water storage tanks (Point of-Exit, Point-of-Use) - Restaurants & Hotels drinking water lines
3	Industrial water disinfection (Point-of-Use manly)	
	- Food and beverages - Cosmetics - Pharmaceutical - Laboratory	- cleaning hoses - process water lines - ultra-pure water lines
	Coolers (small cooling towers)	- hot water line (recirculation circuits)
	Agriculture	- greenhouse irrigation lines
	Poultry	- animal drinking water lines

The QD ceramics can be successful applied in other markets that the ones presented in the above table, like for example, all applications were UV light is applied (water flows under 12 GPM).

In addition, the QD ceramics can be potentially or theoretically adapted to all waters or liquids were disinfection or sanitation is required (all flows).



1.3. Application Principals

The Quantum Disinfection™ ceramics are unique materials, and therefore, do not behave similar with the existent or classical disinfection methods. In order to obtain the maximum efficiencies when applied for water disinfection, all of the 3 following principles have to be respected.

Principle 1. Water quality

The QD ceramics are not a filter. QD can not be applied for water filtration in order to remove suspended solids. Being very porous, the QD ceramics will rapidly clog and quickly lose their germicide capacities. For this reason, **a pre-filtration, of at least 5 micron (1 micron better), is always necessary** to be installed upfront.

The QD ceramics are a disinfection media that eliminate microorganisms due to their ionic surfaces (positive charges). Due to this propriety, the QD media will react will all anions present in the water and some of them (**Cl-, Br-, NaCl and Na₂S₂O₃**) can form a salt crust at the surface of the media inhibiting progressively the germicide capacities.

The list of all important water parameters with the recommended values is presented in Table 4.

Principle 2. Controlled contact

The QD ceramics do not require contact time in order to achieve the germicidal efficiencies. They need contact.

All classical disinfectants disinfect the water following the contact time principle expressed as the period necessary for the activated agent (Chlorine, Bromide, H₂O₂, Ozone, Copper ions or Colloidal Silver, UV light, etc.) to kill or inactivate the microorganisms.

The germicidal performances of the QD ceramics are related to their activated surfaces (Ag+). The microorganisms from the water must touch the QD ceramics in order for them to be killed. In this case, the term contact refers only to the controlled physical - mechanical touch, completely excluding the time notion. Moreover, because no residual chemicals are introduced in the water, no by-pass phenomena are allowed. All water that has to be disinfected must touch the the QD ceramics.

In order to insure the contact, the QD media has to be **well packed in beds**, starting with, at least, 2 cm in depth regardless the water flow and pressure. All devices, systems, cartridges or units have to be provided with an inlet and outlet and the QD media has to be packed in-between these 2 points.

Principle 3. Water Flow vs Quantum Disinfection™ Quantity

A minimum quantity of QD ceramics is required for a certain water flow. For example, at least 500 g of Quantum Disinfection™ activated ceramics are needed for 10 GPM (37 L/min) water flow.

The correspondence in between the Water Flow and QD Quantity is graphically represented in the following graphic.

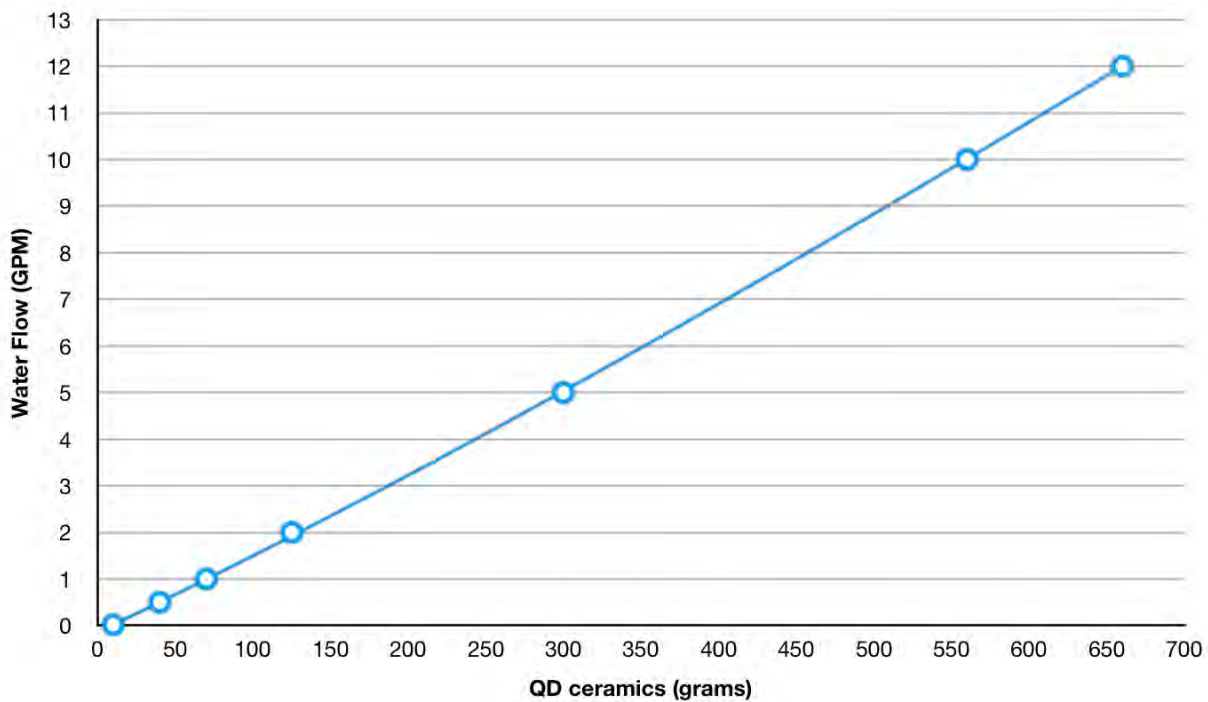


Figure 1. Correspondence in between Quantum Disinfection™ ceramic and water flow

Table 2. Correspondence in between Quantum Disinfection™ ceramic, water flow and warranted disinfected water volume

Water Flow		Quantity of QD (grams)	Water volume	
GPM	L/min		Gallons	Liters
12	45	660	200,000	756,000
10	38	560	180,000	680,400
5	19	300	90,000	340,200
2	8	125	50,000	189,000
1	4	70	15,000	56,700
0.5	2	25	3,000	11,340
0.02	0.07	10	200	756

As it can be seen in table 2, at least 200,000 gallons (756,000 liters) can be disinfected with 660 grams of QD ceramics at all flows up to 12 GPM (44 L/min). Respectively, only 10 are necessary for a pitcher type filter that can disinfect 200 gallons (756 liters) of water.



1.4. Performance Claims

The majority of our test (research, internal laboratory and pilot, 3rd party laboratories and weekly quality control) were and are made with *Escherichia coli* (train 11775, supplier ATCC).

E. coli is the microorganism that we recommend for all laboratory tests. If all 3 application principals are respect or, if you test one of Claire's systems or Claire's Authorized Partner or Distributor systems, *E. coli* should be reduced, at least 99.99 % (Log 4).

Notice that other microorganisms were punctually tested (one time only) by different 3rd Party Laboratories (all reports available under demand). Table 3 regroups all microorganisms that have been tested.

Table 3. Tested Microorganism

Micro-organisme type	Specie	Reduction (Best results - %)
bacteria	<i>Escherichia coli</i>	99.99
	<i>Pseudomonas aeruginosa</i>	99.9999
	<i>Staphylococcus aureus</i>	99.9999
	<i>Enterococcus hirae</i>	99.99999999
	<i>Legionella adelaidensis</i> *	99.9999
	<i>Citrobacter sp</i>	99.999
yeast	<i>Candida albicans</i>	99.999
algae	<i>Anabaena constricta</i>	99.999
protozoa	<i>Cryptosporidium</i>	99.9
virus	<i>Bacteriophage MS2 (RNA)</i>	99.9999

* tests were made in stagnation soaking mode and not in a continues water flow

Other species or microorganism types *may be* reduced by the QD ceramics, testing being the only way to be certain.

Notice that certain species of heterotrophic microorganisms tested as HPC (Heterotrophic Plated Counts) show a deferent behavior if compare with *E. coli* or the other species mentioned in table 3, their reduction was less significant in the same testing conditions.

2. Laboratory Testing Method

2.1. Testing unit and protocole

The germicidal capacities of all devices, systems, cartridges or vessels that contain the Quantum Disinfection™ ceramics (QD) can be evaluated using a test unit like the one presented in Figure 2.



Figure 2. Test unit: general view

The testing unit is composed of a 100 gallon water tank, and a distribution pump (up to 18 GPM) that supply the testing water to the unit presented in Fig. 2. The bacteria are injected in the water line with a peristaltic pump.

The QD system is installed in between 2 flow control valves and 2 pressure gages respectively. Downstream, before the second valve is installed a digital flow-meter, and after the valve is installed a tap as a sampling point. Th unit allows 4 different systems to be tested in the same time, all at different water flows. In addition, a UV system can be also optionally tested in parallel, as a disinfection control.

The testing unit serve for both Prove of Concept (“one pass” 30 min tests) and End-of-Life tests (continues infected waters flowing through the systems).



2.2. Operational Parameters

2.2.1. Bacteria

The majority of our tests are realized using *E. coli* cells (strain 11775, supplier ATCC) that are injected directly in the inlet water line from a bacteria broth (liquid LB + *E. coli* previously incubated for 15 hours at 37°C) at a concentration of approximately 10^5 - 10^6 CFU/100ml.

Note: If you are looking for a log 6 reduction, please add **only** log 6 (10^6 CFU) in the water and not more, hoping for a total elimination. Do not add log 7 hoping to see downstream log 1 and claiming a log 6 reduction, because the logarithmic functions are not linear.

2.2.2. Water Quality

In order to isolate the bacteria presences form all other water parameters we advice to the germicide activity of the Quantum Disinfection™ ceramics with RO water (characteristics presented in table 4).

If you do not use RO water for your laboratory test, please strictly respect, at least, the parameters that have an *Important Note!* in order to obtain the maximum performances. The QD ceramics are less sensitive to rest of the water parameters.

Table 4. Parameters of laboratory testing water

Parameter	Value
pH Important note!	7.2
Total Suspended Solids: TSS (mg/L) Important note!	< 0.001
Total Dissolved Solids: TDS (mg/L)	29.3
Turbidity (NTU)	< 0.1
Temperature (°C) Important note!	25
Sodium Thiosulfate (mg/L) Important note!	< 0.001
Heavy metals (mg/L)	< 0.010
Nitrate (mg/L)	< 0.5
Nitrite (mg/L)	< 0.1
Alkalinity (mg CaCO ₃ /L)	5
Calcium (mg/L)	2.2
Cadmium (mg/L)	< 0.001
Chloride (mg/L)	< 5
Chlorine (mg/L) Important note!	<0.1
Bromine (mg/L) Important note!	< 0.01
Fluoride (mg/L)	< 0.1
Hardness (mg CaCO ₃ /L)	4.5
Magnesium (mg/L)	1.5
Salt (as NaCl mg/L) Important note!	< 0.1



Important note! In many cases but not always, if you inoculate the water with *E. coli* previously grown at 37°C in a classical incubator conditions, there are 2 parameters that can highly influence that results concerning the germicidal performances of the Quantum Disinfection™ ceramics:

1. Temperature: it has to be adjusted to 25 °C;
2. pH: it has to be adjusted at 7.2.

If the water temperature is not adjusted at 25°C or the water pH is not in 7.2, the *E. coli* bacteria that was previously incubated at 37°C, are "shocked" and are going into a "self protective" spore state where the mitochondrial energy of the cells is significantly reduced and there is no exchange with the water environment. This state is not common for the bacteria and, in nature, it can be found only at very low temperatures (0-4°C).

It is very important to differentiate between the laboratory tests where the operators can "shock" the bacteria by changing their normal incubation habitats, with the natural water environments where the existent bacteria are already adapted, alive and perfectly functional.

Important note! DO NOT USE thiosulfate or no other chemicals for the dechlorination of the water. These chemicals react with QD ceramics and destroy or reduce considerably their germicide proprieties.

Important note! Always, 4 chemicals from table 4 will destroy the germicidal properties of the Quantum Disinfection™ ceramics: Thiosulfate, Chlorine, Bromide and salt. The inhibition process is related to a very powerful and immediate reaction of these anions with the positive silver surface (Ag+) of the activated ceramics. Ones exposed to these chemicals, the Quantum Disinfection™ ceramics will crystallize these chemicals on its surface, irreversibly.

Important note! Always, if you have suspend solids (> 1 ppm) in the laboratory testing water be aware that the Quantum Disinfection™ media is very porous and can easily get clogged and lose its germicidal properties. Note also that backwashing or washing processes are not efficient.

Important note! We noticed that, in many cases but not always, significant reduction of Nitrates, Ammonia, Phosphates, Fluoride, PFAS or Arsenic can be seen. More information about these chemicals reduction can be found in CLAIRE Technologies specific reports (on demand).

2.2.3. Sampling

Important Note! Always pre-flash the Quantum Disinfection™ systems for at least 5 minutes before taking any water sample. If not, the water can contain small ceramics fines (white) and alumina or silver chloride traces can be found in the water. After flashing and use, these traces are undetectable.

Important note! DO NOT ADD ANY sodium thiosulfate or any other chemicals for the elimination of the germicide effects in the downstream water samples. These chemicals can influence the cells in a beneficial way and, in some cases, they can help them reconstruct their broken membranes. In addition, the chemical adds do not reflect the real environments in which the QD ceramics will be applied.

Several methods can be followed in order to evaluate the germicide activity of the Qd systems, but in general, we advice to quantify the bacteria concentration, both upstream and downstream, by Total Plate Counts of colony forming units in Petri dishes (LB-agar gels). The germicide activities are expressed in percent and log reduction. The following 2 methods are the most common:

Direct Pleading: 25 ml of water samples have to be taken up-stream (A) and down-stream (B) of the QD systems at different time intervals. From the 25 ml sample, only 50 µl have to be plated on LB-agar in Petri dishes and incubated (37 C, 16-24h) for the bacteria colony growth;

Millipore Filtration - Pleading: 100 ml of water samples have to be taken up-stream (A) and down-stream (B) of the QD systems at different time intervals. All these 100 ml can be filtered on a Millipore Membrane Filter (0.45 µm), then transferred on LB-agar in Petri dishes and incubated (37 C, 16-24h) for the bacteria colony growth.

2.3. Results

A typical result for a Claire inline system that contain 660 g of QD ceramics (test made on Nov 26, 2018) using the Direct Pleading method, is presented in the following figures.



Figure 3. *E. coli* colonies growth in Petri dishes from water samples taken at 5, 10, 15, 20 and 30 min intervals:

A: Upstream samples (left column);
B: Downstream samples (right column)

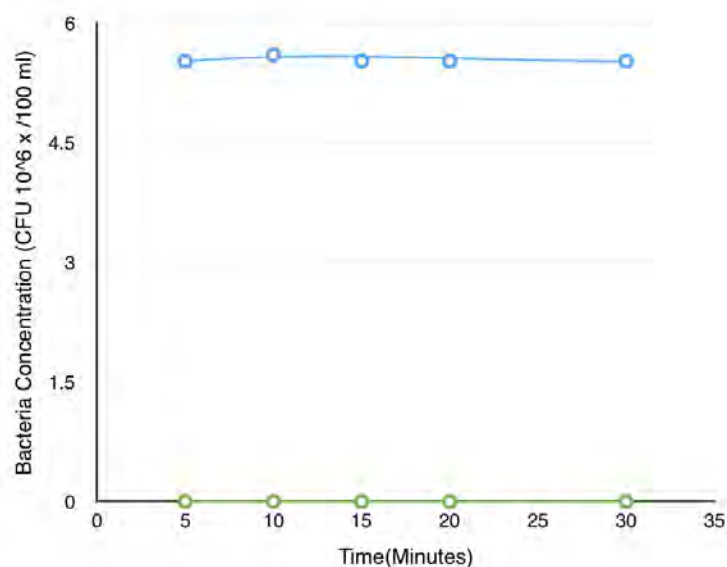


Figure 4: Evolution of *E. coli* concentration in time: downstream water samples (green line); upstream water samples (blue line)

If all 3 application principals are respect or, if you test one of Claire's systems or Claire's Authorized Partner or Distributor systems, *E. coli* should be reduced, at least 99.99 % (Log 4).

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