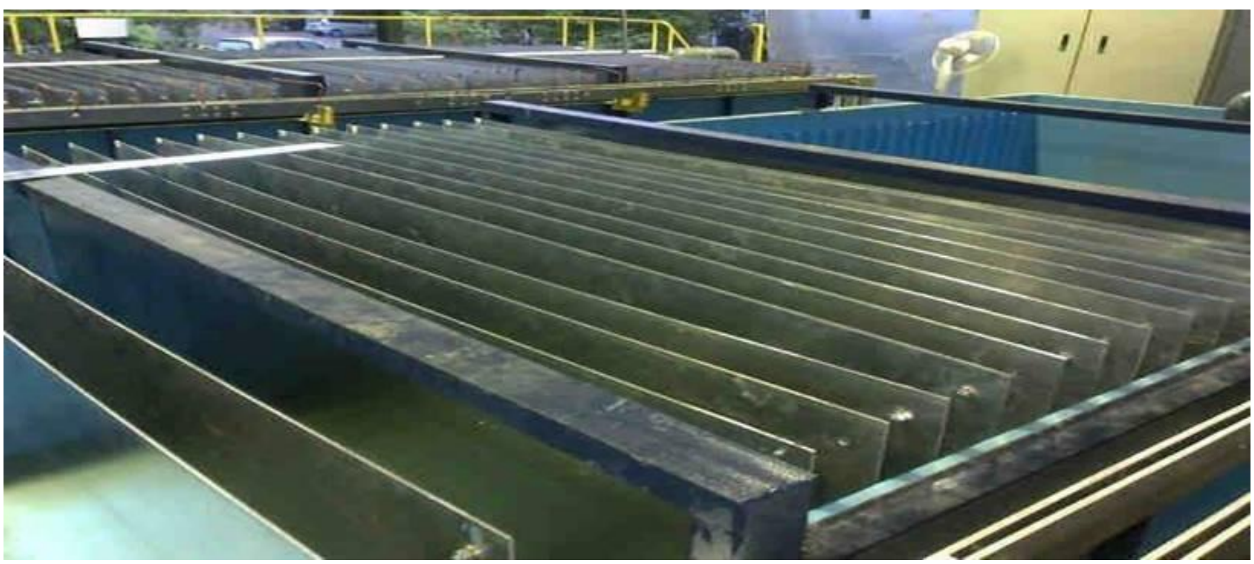
# PELLET FLOW CIRCUIT REACTOR (ELECTROCOAGULATION)

## INTRODUCTION

It has been long recognized that Electrocoagulation, when used in treating waste waters from operations such as steam cleaning, refineries, rendering plants, food processors, mining, produced water, etc., the contaminants are generally reduced 95 to 99%; Dissolved silica, clays, carbon black, and other suspended materials in water are generally reduced by 98%; Heavy metals in water such as arsenic, cadmium, chromium, lead, nickel, and zinc are generally reduced by 95 to 99%.

The most significant limiting factor that has previously kept electrocoagulation from overtaking other wastewater treatments is passivation. Passivation is a constantly increasing buildup of corrosion during reaction that eventually degrades and renders the electrocoagulation reactor ineffective. For the past 100 + years, countless hours of research and development has yielded little progress to slow the effects of passivation and, up to now, nothing has been developed to stop it. To date, the project reaction must be stopped, and the electrode plates must be cleaned of the corrosion buildup or replaced before the process can resume. In addition, the electrode plates are subject to a finite life after which they must be discarded. Most EC systems today utilize many rows of metal plates (see example picture below).



The prior concept and design of Electrocoagulation (EC) technology has now been perfected into a unique, disruptive technology, which has already proven to be the solution to the many disparate waste streams that have become a serious detriment to not just operations, but water scarcity as well. Carden Water Systems LLC has developed the Pellet Flow Circuit Reactor (EC

Reactor) which will substantially increase contaminate removal rates without system fouling and will lower capital and operating costs appreciably compared to conventional EC. The EC Reactor provides all the extraordinary benefits of EC without any of the traditional, limiting features of conventional EC that has prevented its dominance as an effective wastewater processing technology.

With the new EC Reactor, the electrodes are not operating as "expense consumables". The metal consumables are no longer plates, but instead are pellets that are set in a cyclonic motion by the flow stream being treated. The physical interaction of the pellets with one another prevents the scaling effect and removes the scale as it forms. The non-consumable electrodes define the upper and lower boundaries of the reaction chamber and are directly tied to the power source. The pellets react via the electrical conductivity of the stream being treated.

The EC Reactor design footprint is significantly smaller and lighter than conventional plate-electrocoagulation systems. A comparable EC (plate) system would need two reactors, each with 72 plates and each be 5 ft. X 5 ft. The new EC Reactor is 30-inch diameter @ 100 GPM) (see picture below).

As passivation (fouling) is no longer a limiting factor, the electrical current potentials can be increased to greatly enhance the separation of contaminates in solution and improve project productivity. The pellets are consumed entirely during the process and replenished automatically, which allows for continuous operation. Without any scaling or fouling of the consumable pellets, flow streams previously determined untreatable in conventional electrocoagulation are now beneficially and profitably treatable.

The EC Reactor technology offers an alternative to the use of metal salts or polymers and poly-electrolyte addition for breaking stable emulsions and suspensions. The technology removes metals, colloidal solids and particles and soluble inorganic pollutants from aqueous media by introducing highly charged polymeric metal hydroxide species. These species neutralize the electrostatic charges on suspended solids and oil droplets to facilitate agglomeration or coagulation and resultant separation from the aqueous phase. The treatment prompts the precipitation of metals and salts.

The EC Reactor also creates an electro advanced oxidation process (EAOP), produced in the same reactor (in situ). In this instance, the EC Reactor creates the coagulation at the same time the EAOP is producing the hydroxyl radicals and the subsequent oxidation. Oxidation by itself occurs slowly in contrast to oxidation with hydroxyl radicals, which occurs very rapidly. Hydroxyl radical exposure is significantly higher (100 times greater) than during conventional oxidation. EAOP also relies upon non-consumable electrodes, as are found in this EC Reactor.

**Carden's New EC Reactor Advantages**

- As opposed to traditional EC, the metal consumables are no longer plates, but instead pellets that are set in a cyclonic motion by the flow stream being treated.
- The physical interaction of the pellets with one another prevents the scaling effect and removes the scale as it forms. With limited scaling or fouling of the consumable pellets, flow streams previously determined untreatable in conventional electrocoagulation are now beneficially and profitably treatable.
- The EC Reactor has non-consumable upper and lower flow directing plates, which also introduces electrical current to the reaction chamber.
- As passivation (fouling/scaling) is no longer a limiting factor, the electrical current potentials can be greatly increased to significantly enhance the separation of contaminates in solution and improve project productivity.
- The EC Reactor will perform exceptionally well with either acid or caustic streams, well beyond the capabilities of conventional EC.
- EC Reactor is easy to operate with enough operational latitude to handle most problems encountered on running.
- Sludge formed by the EC Reactor tends to be readily settable and easy to de-water, because it is composed of mainly metallic oxides/hydroxides. Above all, it is a low sludge producing technique.
- Flocs formed by the EC Reactor are similar to chemical floc, except that floc tends to be much larger, contains less bound water, is acid-resistant and more stable, and therefore, can be separated faster by filtration.
- The EC Reactor produces effluent with less total dissolved solids (TDS) content as compared with chemical treatments. If this water is reused, the low TDS level contributes to a lower water recovery cost.
- The EC Reactor process has the advantage of removing the smallest colloidal particles, because the applied electric field sets them in faster motion, thereby facilitating the coagulation.
- The EC Reactor process avoids the use of chemicals, so there is no problem of neutralizing excess chemicals and no possibility of secondary pollution caused by chemical substances added at high concentration as when chemical coagulation of wastewater is used.
- The gas bubbles produced in the EC Reactor during electrolysis can carry the pollutant to the top of the solution, where it can be more easily concentrated, collected and

removed.

- The electrolytic processes in the EC Reactor cell are controlled electrically with no moving parts, thus requiring less maintenance.
- The EC Reactor design footprint is significantly smaller and considerably lighter than conventional plate-electrocoagulation systems.

System Capabilities • Removes heavy metals as oxides that pass TCLP. • Removes suspended and colloidal solids • Breaks oil emulsions in water • Removes fats, oil, and grease • Removes complex organics • Destroys & removes bacteria, viruses, and cysts • Processes multiple contaminants

Benefits • Low capital costs • Low operating costs • Low power requirements • No chemical additions • Low maintenance • Minimal operator attention • Handles a wide variation in the waste stream • Consistent and reliable results • Sludge minimization • Treats multiple contaminants

This new EC Reactor is the distinct economic and environmental choice for meeting water treatment discharge standards and compliance requirements. It can recover capital and operating costs by eliminating discharge fees and fines, harvesting resources, and significantly reducing water replacement costs. With the advent of the EC Reactor, electrocoagulation has now reached profitable commercialization and has already proven to extensively eliminate the disadvantages of the classical treatment techniques.

## **CASE STUDIES:**

### **BEVERAGE COMPANY:**

Located in the Central Valley, CA. Results below per HACH DR 900.

*Carden Customer GW-GP Well Water as received - based on independent lab.*

| *Source Well Water* | | *Results After Carden CES-* | |
|---|---|---|---|
| *pH ..............................* | *8.171* | *pH................................* | *7.70* |
| *Calcium (Ca)...............* | *174.70 mg/l* | *Ca as $CaCO_3$...................* | *6.20 mg/L* |
| *Magnesium (mg)........* | *70.294 mg/l* | *Mg as $CaCO_3$ ...................* | *6.80 mg/L* |
| *Silica .........................* | *40.274 mg/l* | *$SiO_2$................................* | *0.0 mg/L* |
| *Turbidity (NTU) ............* | *0.3900* | *Turbidity (NTU).............* | *0.0000* |

*The EC also removed to ND the iron and zinc and would have removed arsenic should it be present. Note: Not only did the EC System remove all the Silica, the Calcium went from 174.70 down to 6.2 and the Magnesium from 70.3 to 6.8.*

### **FOOD COMPANY**:

Company (HC-CV) well water, with the primary focus being on Silica.in the RO reject from the well water. The reject tested to be 122 PPM. That reject water was run thru the EC System and reduced the Silica to 4 PPM. Results based on independent lab. The additional permeate then went back to another RO. The hardness ($CaCO_3$ and Arsenic was also reduced to acceptable levels.

**LEACHATE from LANDFILLS**

The EC Reactor successfully treated leachate from a landfill in the southeast and met the discharge permit levels. The Company had negotiated a contract to treat the equalization pond, which holds approximately 3.5 million gallons of highly toxic material, with approximately 15,000 GPD entering the pond. This area has heavy rains and the pond overflows into the aquifer resulting in large fines. No company has successfully/economically treated this waste stream.

The below pictures are of the results of successfully treating the above referenced leachate and meeting discharge permit levels.

1)Landfill Leachate 2) Leachate thru EC Reactor 3) Water thru UF 4) Water/ RO

**Leachate water just thru EC Reactor (3rd bottle after pH adjustments), no UF or RO**

**TURBIDITY:** One of the issues faced in certain situations is turbidity (FAU) in the final permeate. See analysis and picture below using Carden's EC System. These samples were drawn after sedimentation and without filtering.

Hach Colorimeter, Program
745 Turbidity, Results;

| | |
|---|---|
| D/I Water | 0 FAU |
| Raw Leachate | 344 FAU |
| Leachate Post CES | 45 FAU |
| Leachate Post pH/Adj, CES, pH/Adj | 7 FAU |