AltelaRain™ – State of the Art Produced Water Treatment Technology

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Abstract

Altela, Inc. provides products and services to customers in need of creating pure water from highly brackish and contaminated water sources. Altela has developed a fundamentally new water desalination product, the AltelaRain™ System, that inexpensively removes 100% of the dissolved salts and other contaminants from industrial waste waters and undrinkable brackish waters found throughout the world – representing the first new low-cost water desalination technology in the last 50 years. Altela has initially targeted the multi-billion dollar market for disposal of salt water co-produced with oil and natural gas production. By removing all contaminants from this dirty oilfield produced water, Altela converts these contaminated water liabilities into clean water assets, thereby removing our customer's high disposal costs and environmental liability by the present oilfield methods of reinjecting the water back into the ground or storage in large 'pits'. The AltelaRain™ System has successfully completed real-world oilfield beta testing. The beta water quality test results received from an independent water quality lab demonstrate the very high quality of treated water obtained from this simple, elegant technology for the treatment of highly challenged produced water. Total dissolved solids were reduced from 41,700 mg/L to 106 mg/L. Chloride was reduced from 25,300 mg/L to 59 mg/L. Similarly, benzene levels were reduced from 450 ug/L to non-detectable following AltelaRain™ treatment.

The Problem

Produced water is water trapped in underground formations which comes to the surface during oil and gas exploration and production. It occurs naturally in formations where oil and gas are found and, along with the oil and gas, is millions of years old. When oil or gas is produced, they are brought to the surface along with this produced water as a combined produced fluid. The composition of this produced fluid includes a mixture of either liquid or gaseous hydrocarbons, produced water, dissolved or suspended solids, produced solids such as sand or silt, and recently injected fluids and additives that may have been placed in the formation as a result of exploration and production activities.

Produced water indicators vary across (and even within) formation basins, depending on the depth of the well, geology, and environment of the deposit. In addition, formation hydrology often causes the quality of the produced water to change intermittently as the production well ages. The volume of produced water from oil and gas wells also does not remain constant with time. Traditionally, the water-to-oil ratio is the lowest when the well is new. As the well ages, the water-to-oil ratio increases, while the percentage of oil and gas similarly declines. For both oil and gas, the well's economic life is usually dictated by the amount of water produced – and its cost of disposal – rather than by the true end of oil or gas underground at the well. That is, by reducing the cost of produced water disposal, the economic reserves of oil and gas are increased in the U.S. Produced water is by far the largest volume of waste generated in oil and gas extraction operations. An average of over 7 barrels of produced water is co-produced with each barrel of oil produced in the United States, and, as oil wells age, the proportion of produced water co-produced continues to increase beyond that figure, sometimes to as much as 98% of the material brought to the surface. Oil wells in the U.S. may therefore be more realistically viewed as "dirty water wells", with the byproduct of oil representing only about 2% to 12% of the actual fluids lifted to the surface. Wells elsewhere in the world average about 3 barrels of produced water per barrel of oil, but still illustrate the point that, at most, only about 25% of an oil well's output is oil. Similar high ratios of gas to produced water production exist for production of natural gas. Overall, it is estimated that the United States oil and gas industry generates 15 to 20 billion barrels of produced water every year. To help put this in perspective, this is equivalent to about one-quarter-million acre-feet of water.

Produced water handling and treatment represents an $18 billion cost to the oil and gas industry in the U.S. alone. The cost of disposing of oil and gas produced water ranges from a low of $0.002 per gallon ($0.10/barrel) to a high of $0.24 a gallon ($10.00/barrel). By contrast, water for agricultural irrigation costs in the range of $0.0001 per gallon ($0.004/barrel) and municipal drinking water costs in the range of $0.003 per gallon ($0.13/barrel). The price of cleaning produced water is therefore as much as 80 times greater than municipal water, and as much as 2,600 times greater than agricultural irrigation water. The separation, handling, and disposal of produced water represent the single largest waste stream challenge facing the oil and gas production industry.

The Solution

Altela's patented AltelaRain™ technology uniquely cleans oil and gas industry produced water by removing its salts, residual oils and other contaminants - allowing it to be used on-site rather than requiring disposal in costly reinjection wells or evaporation ponds. In the arid western United States, purified produced water represents a new water supply and very desirable asset. Altela-cleaned water is attractive to ranch and farm landowners leasing their mineral rights to oilfield producers. In addition, drilling operators need clean water for fractionation and tertiary recovery operations. Presently, many producers are paying for dirty produced water to be trucked out and, at the same time, paying for clean water to be trucked in – the AltelaRain™ technology can eliminate both.

The Technology

The basic Altela technology is a simple and elegant process based on thermal distillation, which desalinates and decontaminates salty and polluted water in a fundamentally different way than the more familiar reverse osmosis and other membrane-based desalination technologies. In simple terms, the technology mimics nature's process of making pure rain water from seawater. What positions it as the first, truly new and disruptive water desalination/decontamination technology in over 50 years, however, is a scientifically complex, but inexpensively implemented, internal heat transfer process that allows the re-use of the latent heat of condensation over and over again to greatly offset the total latent heat of evaporation required in conventional thermal distillation. This internal heat transfer technology recaptures the energy used to evaporate water, thus yielding approximately 4 times the amount of distilled water per energy input as traditional distillation/evaporation techniques. Consequently, the AltelaRain™ technology yields energy costs that are approximately only 25% of comparable distillation/evaporation processes.

The water vapor from the evaporation chamber is transferred to the condensation chamber by a carrier gas, with the ability to absorb and desorb pure water from the produced water several times over, resulting in extremely high energy efficiencies, Figure 1. Ambient air is brought into the bottom of the tower on the evaporation side of a heat transfer wall. The wall is wetted by saline feed water, which is fed into the evaporation side at the top of the tower. As the air moves from the bottom to the top of the tower, low-temperature heat is transferred into the evaporation side through the heat transfer wall, allowing the air to rise in temperature and evaporate water from the wet saline liquid which coats the heat transfer wall. Water concentrated in contaminates leaves from the bottom of the tower and warm saturated air rises to the top of the tower. Heat is added to this hot air by an external heat source (low grade, atmospheric pressure steam). This hotter saturated air is then sent back down through the tower on the condensation side of the heat transfer wall. The evaporation side of the tower, being slightly cooler than the condensation side, allows the air to cool and transfer the latent heat condensation from the condensation side to the evaporation side. Pure distilled water condensate leaves the condensation side of the tower at the bottom of the tower.

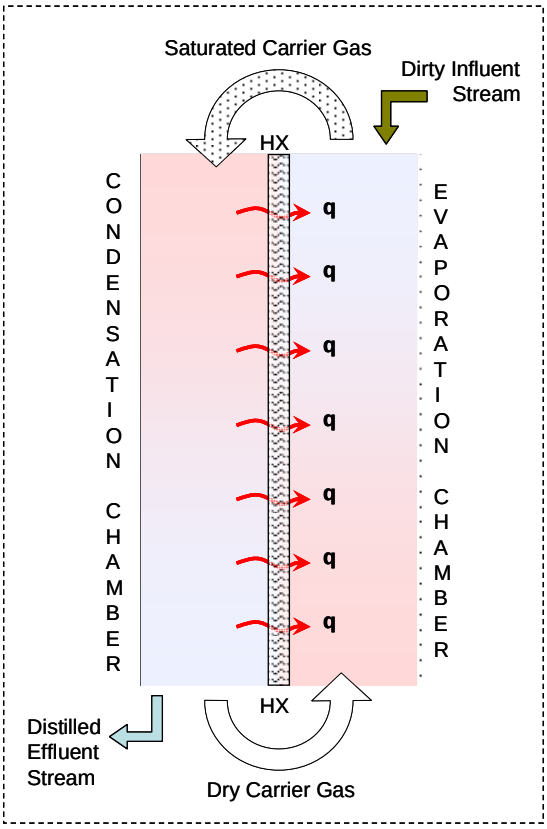

Figure 1: AltelaRain™ Process

Individual AltelaRain™ towers are approximately the size of a residential water heater and are capable of processing approximately 330 gallons per day (8 BPD) of water with salt concentration in excess of 150,000 ppm. The AltelaRain™ System can reduce effluent disposal volumes by as much as 90%. Since the treated water stream is distilled water, the quality of water from the AltelaRain™ System is extremely high. In summary, the key advantages of the AltelaRain™ technology include:

- Extremely high quality of treated water
- Relatively low cost

- High thermal efficiency
- Unattended operation
- No fouling
- No scaling
- No membranes to replace
- Near ambient temperature operation
- Operates at ambient pressure
- Uses waste heat to operate
- No pre-treatment
- No post-treatment

The AltelaRain™ System is highly scalable in size and can be produced in a variety of configurations to fit individual on-site needs. A smaller capacity system can be built and installed in a single 8 by 40 foot container. For higher volume applications, larger 180 to 250 BPD systems can be joined together to double or triple production capacity. Scaling up the volume of the system in this manner yields some cost savings on a per-barrel cost basis. The AltelaRain™ System is designed to minimize maintenance and operation costs. The use of plastics minimizes or eliminates many of the maintenance issues related to scaling, fouling or corrosion of metal systems. The moving parts in the system are few, and consist of proven, robust, off-the-shelf components, such as low pressure water pumps and air blowers. The system operates at ambient pressures and modest temperatures, and as such, has few mechanical failures in plumbing and related systems. The ability to remotely monitor the system allows field operators to detect system problems early and take remedial action before major failures take place.

Summary of Field Results

A beta pilot test using real oil-field produced water was conducted by Altela, Inc. employing the AltelaRain™ System for a conventional oil well located in southeastern New Mexico in early 2006. Coincident with this, Altela received from the New Mexico environmental regulatory authorities the first-ever permit issued for the surface discharge, on site, of clean water extracted from the highly brackish and contaminated produced water pumped from an oil or gas wellhead. The water quality test results received from an independent water quality lab demonstrate the very high quality of treated water obtained from this simple technology for the treatment of highly challenged produced water. Total dissolved solids were reduced from 41,700 mg/L to 106 mg/L. Chloride was reduced from 25,300 mg/L to 59 mg/L. Similarly, benzene levels were reduced from 450 ug/L to non-detectable following AltelaRain™ treatment. Detailed water quality data following AltelaRain™ treatment is outlined below in Table 1.

Table 1: AltelaRain™ Produced Water Pilot Test

	Water Contaminant (Analyte)	Symbol	Before Altela (mg/L) *except for Radium 226 and 228 which is in pCi/L	After Altela (mg/L) *except for Radium 226 and 228 which is in pCi/L
	Salts:			
1	Total Dissolved Solids	TDS	41,700	106
2	Chloride	Cl	25,300	59
3	Sulfate	SO4	81	0
	Metals:			
4	Arsenic	As	0.036	0
5	Barium	Ba	19.1	0
6	Cadmium	Cd	0	0
7	Chromium	Cr	0	0
8	Cyanide	CN	0	0
9	Fluoride	F	0.6	0
10	Lead	Pb	0	0
11	Total Mercury	Hg	0	0
12	Nitrate	NO3 as N	0	0
13	Selenium	Se	0.096	0.001
14	Silver	Ag	0	0
15	Uranium	U	0	0
16	Copper	Cu	0.02	0
17	Iron	Fe	38.1	0
18	Manganese	Mn	0.72	0
19	Zinc	Zn	0.01	0.03
20	Aluminum	A	0	0.3
21	Boron	Ba	44.8	0.2
22	Cobalt	Co	0	0
23	Molybdenum	Mo	0	0
24	Nickel	Ni	0	0
25	**BTEX:**			
26	Benzene		0.45	0
27	Toluene		0.45	0.0078
28	Ethylbenzene		0	0
29	Total Xylenes		0.76	0
	Radialogical:			
30	Radium 226		423	1.1
31	Radium 228		587	1.1

	Other:			
32	pH	pH	7.17	8.74

Conclusion

Oil and gas companies need lower cost methods for handling and disposing of produced water. Produced water handling and disposal is generally very expensive due to the large volumes of water that must be lifted to the surface, separated from the petroleum product, treated, and then injected into the ground or disposed of in surface evaporation ponds. In addition, environmental concerns are making it increasingly difficult to permit new surface ponds or injection wells. Historically, the produced water generated at an oil or gas site is stored on-site in large tanks. Oil and gas companies must pay for disposal trucking companies to visit the site multiple times per week, pump the produced water out of the storage tanks and transport the waste to commercial underground reinjection sites. These disposal trucks must often travel great distances to the reinjection sites. When these trucks are unavailable or during periods of poor weather, many well sites must be shut down due to the inability to store and/or dispose of the produced water on-site.

In addition, many oil and gas wells are simply "pinching back" production due to the inability of the on-site infrastructure to handle produced water volumes. Trucking costs alone can be in excess of $3.00 per barrel (bbl) and a disposal reinjection well can cost upwards of $4,000,000 to drill (assuming the ever increasing and costly regulatory compliance and environmental protests can be satisfied). In many locations, total produced water disposal costs are greater than $5.00 per barrel. Stated differently, the oil and gas industry spends as much as 80 times as much, per gallon, to get rid of dirty produced water as individuals pay for clean municipal water. Unfortunately, based on the high degree of complexity of produced water chemistry, produced water treatment technologies are presently not in wide use. Those that are have historically been applied only to mildly saline waters (almost drinkable before treatment, such as some coal bed methane produced water), and they have largely been developed by oil and gas operators on a case-by-case basis. Recent field tests of the AltelaRain™ System, conversely, demonstrate the technology's unique ability to successfully treat and purify a myriad of complex produced water chemistries while delivering the following inherent advantages to the produced water treatment industry:

Removal of Contaminants: AltelaRain™ represents a simple solution to removing all produced water contaminants, even in highly-challenged and extremely high-TDS conditions. Like all distillation based processes, the liquid water generated on the condensation side of the heat exchanger is pure and contains virtually no dissolved or suspended solids. The vapor phase water formed during evaporation is free of chemical compounds which have boiling points greater than or equal to that of water (at atmospheric conditions). As a closed-loop thermal process, the clean water vapor then condenses in the form of a very high-purity water stream. Like most thermal processes, water chemistry has only mild effects on system performance. Real world testing of the technology has revealed that highly volatile BTEX compounds typically found in produced waters do not condense in the distillate stream.

Flexibility: The low cost, scale-resistant materials used to fabricate AltelaRain™ towers enable AltelaRain™ Systems to be built that are modular and mobile, easily maintained, and capable of processing water with highly variable influent compositions. The modular design of an AltelaRain™ based system enables customization of each treatment system with little or no additional cost to oil and gas customers. For example, a system can be installed to minimize the effluent brine reject stream simply by re-configuring the physical layout of the primary system towers into differing series/parallel configurations.

Cost Effectiveness: Like other thermal processes, AltelaRain™ is simple, easy to maintain, and can operate unattended for long periods of time. However, unlike other desalination methods like RO, MSF, or MED, the primary treatment components are fabricated entirely from polymer (plastic) materials. This eliminates the need for costly influent pre-treatment components (such as filters, flocculants, and anti-scalant chemical additives). No metal is present on which corrosion and scaling can occur. Also, similar to other thermal processes, the major operating expense is the energy required to evaporate the influent water. Since the system operates at low temperatures, typically 180°F or less, it is possible to employ low grade sources of waste heat. Such operating scenarios dramatically increase the operating efficiency by further reducing the operating costs by virtue of the technology's unique ability to repeatedly 're-use' this low-grade heat multiple times by applying the exothermic heat of condensation to the endothermic heat of evaporation in a continual loop process.

Equity Considerations: AltelaRain™ based treatment systems typically require more physical space to treat a given volume of water than comparable reverse osmosis systems. This is a function of the low thermal conductivity of plastics relative to that of metal. This is generally a minor consideration in oil and gas locations, since well sites are located remotely with ample land available for the system's installation. Furthermore, many low cost construction techniques can be employed to erect temporary or permanent structures. Operation noise is minimal. A system that treats 90 BPD requires an area of 40' by 8'.

Environmental: The AltelaRain™ technology mimics nature's rain cycle and is inherently environmentally friendly. There are no pre- or post-treatment chemicals requiring handling or disposal. The pure distilled water stream that is generated can be reused for numerous beneficial uses.