WHITE PAPER:
Addressing the Dangers of Lead and Other Toxic Substances in Drinking Water

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ABSTRACT

The crisis in Flint, Michigan, where as many as 8,000 children under age six were exposed to unsafe levels of lead after a budget-cutting decision to switch drinking-water sources, may be the most serious contamination threat facing the country's water supplies. But it is hardly the only one. Lead is a potential concern for homes and businesses whether on a public (municipal) or private (individual well or spring) water supply. Throughout the nation, communities both large and small are facing crises in confronting lead and other dangerous chemical and other contaminants in their drinking water. Increasingly, various methods of water purification and filtration are offered as potential solutions to reducing the toxicity of tap water in many communities. While each provide some effectiveness, most are not without limitations. This white paper identifies the growing scope of the problem, and suggests a solution for addressing elimination of toxicity in tap water that is proven to be 99.9 percent effective.

IDENTIFYING THE PROBLEM

Because the evidence of unhealthy levels of lead in the drinking water of many communities, this paper will focus primarily on the dangers of consuming water with lead content. The solution presented here applies not only to lead, however, but to elimination of hundreds of other real and potentially dangerous contaminants found in potable water.

The Problem with Lead. Lead is a heavy metal with a bluish-gray color. It has a low melting point, is easily molded and shaped, and can be combined with other metals to form alloys. For these reasons, lead has been used by humans for millennia and is widespread today in products as diverse as pipes; storage batteries; pigments and paints; glazes, vinyl products, weights, shot and ammunition; cable covers; and radiation shielding. Lead constitutes 0.002 percent of the Earth's crust, and in nature it exists mainly as lead sulphide. It has become widely-distributed in the biosphere only in the past few thousand years, almost entirely as the result of human activity. Prior to human exploitation, people were not exposed to lead, and once introduced into the environment, it persists.[i] Lead is found in natural deposits as ores, and is rarely found in source water. Lead and mining operations may be sources of contamination. Currently, approximately 70 percent of the lead mined in the U.S. comes from seven mines in the New Lead Belt in southeastern Missouri.[ii]

The chemical symbol for lead, "Pb", comes from the Latin *plumbum,* the root for the word "plumbing". While lead paint and dust are the primary source of lead exposure, especially in older homes, drinking water is also a source of exposure to lead.

<u>How Lead Gets in the Water.</u> The harsh chlorinated water flowing out of urban water treatment facilities will often cause lead to leach into the pipe water. While measures have been taken during the last two decades to reduce exposure to lead in tap water, lead can still be found in some metal water taps, interior water pipes, or pipes connecting a house to the main water pipe in the street. Lead found in tap water usually comes from the corrosion of older fixtures, or from the solder that connects pipes. When water sits in leaded pipes for several hours, lead can leach into the water supply.

Lead is associated with a wide range of toxicity, extending from acute, clinically obvious, symptomatic poisoning at high levels of exposure down to subclinical (but still very damaging) effects at lower levels. Lead poisoning can affect virtually every organ system in the body. Further, the neurobehavioral changes associated with early exposure to lead appear to be persistent and irreversible.[iii]

Drinking Water Contaminants. Among an alarming number of contaminants and toxic materials, lead and copper enter drinking water primarily through plumbing materials. Exposure to lead and copper may cause health problems ranging from stomach distress to brain damage.

Because lead contamination normally occurs from corrosion of lead pipes, it is not directly detected or removed by the water system. To address this, the EPA requires water systems to control the corrosive levels of their water if the level in homes or businesses exceeds an Action Level. For lead, the Action Level is set at 15 parts per billion (ppb), thought to be the lowest level to which water systems can reasonably be required to control this contaminant if it occurs in the water being delivered to a home or establishment.

Safe Water Drinking Act (SWDA). According to EPA estimates, only 91 contaminants are regulated by the SDWA, yet more than 60,000 chemicals are used within the United States. Government and independent scientists have scrutinized thousands of those chemicals in recent decades, and identified hundreds associated with a risk of cancer and other diseases at small concentrations in drinking water, according to an analysis of government records by The New York Times. More than 62 million Americans have been exposed since 2004 to drinking water that did not meet at least one commonly-used government health guideline intended to help protect people from cancer or serious disease. This is according to an analysis by the Times of more than 19 million drinking-water test results from the District of Columbia and the 45 states that made data available. But because such guidelines were never incorporated into the Safe Water Drinking Act, the vast majority of that water never violated the law.[iv]

Chlorine and Fluoride. Moreover, chlorine and fluoride, introduced into drinking water, are increasingly shown to involve hidden and often long-term dangers. Once thought to be safe, research has shown that "Chlorine is the greatest crippler and killer of modern times. It is an insidious poison."[v] According to the EPA, repeated exposure to trace amounts of chlorine in water is linked to bladder, colon, breast, and rectal cancers; heart trouble; premature senility; asthma; eczema; and higher rates of miscarriage and birth defects.[vi]

Fluoride has been added to the public water supply since the early 1940s as a result of studies suggesting that ingesting small amounts of fluoride could prevent tooth decay. As well as being linked to a wide number of health problems, mass medication of the U.S. population with fluoridated drinking water is shown to reduce IQ levels in children in 36 of 43 studies.[vii]

Health Effects of Exposures to Lead in Drinking Water. The Safe Drinking Water Act requires EPA to determine the level of contaminants in drinking water at which no adverse health effects are likely to occur with an adequate margin of safety. These non-enforceable health goals, based solely on possible health risks, are called maximum contaminant level goals (MCLGs). EPA has set the maximum contaminant level goal for lead in drinking water at zero because lead is a toxic metal that can be harmful to human health even at low exposure levels. Lead is persistent, and it can accumulate in the body over time.

Children are Especially Vulnerable. Young children, infants, and fetuses are particularly vulnerable to lead because the physical and behavioral effects of lead occur at lower exposure levels in children than in adults. A dose of lead that would have little effect on an adult can have a significant effect on a child. In children, low levels of exposure have been linked to damage to the central and peripheral nervous system, learning disabilities, shorter stature, impaired hearing, and impaired formation and function of blood cells.

The Centers for Disease Control and Prevention (CDC) recommends that public health actions be initiated when the level of lead in a child's blood is 5 micrograms per deciliter (µg/dL) or more.[viii] In 2010, as estimated 535,000 children aged 1-5 in the U.S. had blood lead levels (BLLs) ≥ 5µg/dL. According to the World Health Organization (WHO), there is no known safe blood level concentration, and even levels as low as 5µg/dL may result in decreased intelligence in children, behavioral difficulties, and learning problems.[ix]

Despite progress in reducing BLLs among children in this age group overall, long-standing disparities persist. The geometric mean BLLs (GM BLLs) among younger children, those belonging to poor families, and those enrolled in Medicaid were significantly higher compared with their older, more affluent counterparts, while GM BLL for non-Hispanic black children was significantly higher compared with either non-Hispanic white or Mexican American children.[x]

It is important to recognize all the ways a child can be exposed to lead. Children are exposed to lead in paint, dust, soil, air, and food, as well as drinking water. If the level of lead in a child's blood is at or above the CDC action level of 5 micrograms per deciliter, it may be due to lead exposures from a combination of sources. EPA estimates that drinking water can make up 20 percent or more of a person's total exposure to lead. Infants who consume mostly mixed formula can receive 40 percent to 60 percent of their exposure to lead from drinking water.

Making the possibility of lead poisoning even worse are the studies that fluoridated water supplies can increase children's absorption of lead, and, when lead is introduced into the body in sufficient quantities, replaces zinc, which can disrupt normal brain cell growth.[xi]

In children, even low levels of lead in the blood can result in behavior and learning problems; lower IQ and hyperactivity; slowed growth; hearing problems; and anemia. In rare cases, ingestion of lead can cause seizures, coma, and even death. Making the possibility of lead poisoning even worse are the studies that fluoridated water supplies can increase children's absorption of lead, and, when lead is introduced into the body in sufficient quantities, replaces zinc, which can disrupt normal brain cell growth.

Pregnant Women. Lead accumulates in our bodies over time and is stored in bones along with calcium. During pregnancy, lead is released from bones as maternal calcium and is used to help form the bones of the fetus. This is particularly true if a woman does not have enough dietary calcium. Lead can also cross the placental barrier exposing the fetus to lead. This can result in serious effects to the mother and her developing fetus, including reduced growth of the fetus and premature birth.

Adults. Lead is also harmful to adults. Adults exposed to lead can suffer from cardiovascular effects, increased blood pressure and incidence of hypertension; decreased kidney function; and reproductive problems in both men and women.[xii] For many adults, results of lead exposure have existed since childhood, exacerbating its toxic effects.

SCOPE OF THE PROBLEM

Throughout the nation, cities like Sebring, Ohio; Washington, D.C.; Durham and Greenville, North Carolina; Jackson, Mississippi; Brick Township, New Jersey; Lansing, Michigan; Columbia, South Carolina; St. Louis, Missouri; Pittsburgh, Pennsylvania; and even small villages such a Hoosick Falls, New York – just to name a few – are facing crises in confronting lead and other dangerous chemical contaminants in their drinking water. These are just a few of the many communities addressing potable water contamination in recent years. Unsafe levels of lead and other contaminants have turned up in tap water in city after city. The national attention given to the water crisis in Flint, Michigan, has drawn public notice to the problem which, prior to 2015, received little coverage or consideration.

Federal officials and many scientists agree that most of the nation's 53,000 community water systems provide safe drinking water.[xiii] However, evidence of the contamination of Flint's water system, and that of other cities, remind experts that there are holes in the safety net of rules and procedures intended to keep water not just lead-free, but free of all poisons.

According to the EPA, streams that are tapped by water utilities serving one-third of the U.S. population are not yet covered by clean-water laws that limit levels of toxic pollutants. Even purified water often travels to homes through pipes that in in considerable disrepair, increasing the problem of water-borne disease and pollutants entering the tap water. Further, while Congress banned lead water pipes 30 years ago, between 3.3 million and 10 million older ones remain. These are primed to leach lead into tap water by forces as simples as jostling the pipes during repairs, replacing older pipes, or a change in water chemistry.[xiv]

Moreover, both researchers and industry officials maintain that the problems extend well beyond lead. There are many other potentially harmful contaminants which have yet to be evaluated, much less regulated. The EPA has compiled a list of 100 potentially risky chemicals and 12 microbes that are known or expected to be found in public water systems, but are not yet regulated. In the last 15 years, it also has required water systems to test for 80 additional contaminants to determine if they should be regulated.[xv] Efforts to address shortcomings often encounter pushback from industries such as mining and agriculture that fear cost increases, and from politicians who may be ideologically opposed to regulation.

In a testimony before the U.S. House Democratic Steering and Policy Committee Hearing, Professor Yanna Lambrinidou of Virginia Tech, addressed Flint's lead problem, and argued that efforts were not going far enough to address the issue. She noted that samplings of water that had been sitting in lead pipes had unacceptable lead levels in as much as 70.5 percent of water systems.[xvi]

ADDRESSING SOLUTIONS

Is Bottled Water the Solution? In response to concerns about tap water quality, bottled water sales have soared over the past couple of decades. In Flint, MI, a typical family of four consumes up to 151 16.9-ounce bottles of water a day for cooking, drinking, doing dishes, hygiene, etc.[xvii] The number of bottles consumed by an entire city – and the added crisis of disposal of millions of plastic bottles - has created an entirely new environmental problem for the region involving collection, recycling, and disposal. It can take up to 450 years for the empty plastic water bottles to break down in a landfill.[xviii]

But is it safer? It is important to know that 25 to 30 percent of bottled water comes straight from municipal tap water systems, despite the pretty nature scenes on the bottles that imply otherwise. According to the Natural Resources Defense Council (NRDC), the Federal Government does not require bottled water to be safer than tap; in fact, just the opposite is true in many cases. Tap water in most big cities must be disinfected, filtered to remove pathogens, and tested for cryptosporidium and giardia viruses. Bottled water does not have to be.[xix] Bottled water is required to be tested less frequently than tap water for bacteria and chemical contaminants, and U.S. Food and Drug Administration (FDA) bottled water rules allow for some contamination by *E. coli* or *fecal coliform*, contrary to EPA tap water rules that prohibit any such contamination. This leaves open the possibility, says NRDC, that some bottled water may present similar health threats to those with weakened immune systems, the elderly, and others they caution about drinking tap water.

The Dangers of Chloramine. More than one in five Americans are drinking tap water that has been treated with a derivative of chlorine known as chloramine. This disinfectant is formed by mixing chlorine with ammonia.[xx] The result is a toxic disinfection byproduct (DBP) which reacts with natural organic matter like decaying vegetation in the source water. DBPs are over 1,000 times more toxic than chlorine, and out of all the other toxins and contaminants present in municipal water, DPTs are the worst. One of the most common DBPs, trihalomethanes (THMs) have been shown to cause cancer in laboratory animals, and are also linked to reproductive problems in both animals and humans, such as spontaneous abortion, stillbirths, and congenital malformations, even at lower levels. These types of DBPs can also weaken the immune system, disrupt the central nervous system, damage the cardiovascular system, disrupt the renal system, and cause respiratory problems. A more thorough analysis of the dangers of chloramine in the water supply is presented by Johnson-Kula and Lieberman (2006).[xxi]

Purified, Reverse Osmosis, Filtered, Distilled, Purified Water. When we understand the uncertainties of tap and bottled water, point-of-entry water filtration clearly becomes the best choice for millions of Americans. Point of entry (POE) systems are installed at the main water line where water first enters the home. Sometimes known as "whole house water filters", POE systems are able to deliver treated water to all plumbing sites (sinks, baths, showers, washing machines, dish washers, ice makers, toilets, and outdoor water sprinklers and hoses). Point-of-use (POU) systems, on the other hand, are installed at a single water connection, usually under a kitchen or bathroom sink. POUs are lower capacity, most applicable to light use applications.

When considering the benefits of water purification products over tap and bottled water, it is important to remember that there are no bad systems; any water purifier is better than no purifier. Determining the best system is a simple matter of comparing the product's performance to other alternatives. The performance of a particular water purification system can be easily verified by reviewing its Performance Data Sheet which lists all the contaminants the system is certified to remove and to what degree. By comparing each products contaminant reduction capabilities, system cost and ongoing cost per gallon, it is easy to determine which product best fits consumer needs.

It is also important to look at the advantages or disadvantages of other products or technologies, even though they are not leading brands. Such is the case with reverse osmosis and distillation systems. Although none of the leading brands employ either of these de-mineralizing techniques, as their popularity has declined in recent years, there is an ongoing debate over the healthfulness of de-mineralized water vs. filtered water, with minerals. While there are studies that argue both sides of this debate, after 15 years of specialized study in water quality and health, the benefits of drinking naturally-balanced water with minerals vs. de-mineralized water, makes more sense. From a non-scientific perspective, the simple fact that nowhere on this planet do we find naturally occurring de-mineralized water, should tell us that we were not meant to have it. In nature, all fresh water contains traces of natural minerals like calcium, magnesium and potassium, which is what our body was designed to run on. There are several very credible research reports and books that stress the more recent opinion that long-term consumption of demineralized water can in fact be dangerous. Researchers and authors report that long-term consumption of distilled water results in multiple mineral deficiencies.[xxii] "[xxiii]

Water stripped of its natural minerals becomes more acidic, which pulls minerals from teeth and bones to produce bicarbonate to neutralize the acid. Many studies suggest that cancer cells only grow in an acidic environment. The theory seems supported by the fact that in areas of the world where people live the longest, most disease-free lives, those areas have the most alkaline water, with the highest mineral content.

Because of the popularity and demand for home and office water treatment products, many companies have marketed these products as "state-of-the-art" drinking water systems, which they simply are not. Often these products are marketed by using a demonstration that measures the TDS (total dissolved solids), and implies that this measurement shows the systems effectiveness at removing contaminants. TDS meters measure the dissolved minerals in water, primarily calcium and magnesium, and have little or nothing to do with contaminant levels.

Distillation and reverse osmosis are not very effective at removing synthetic chemicals. Distillation removes things based on their relative boiling point. Virtually all synthetic chemicals boil at a lower temperature than water and therefore are vaporized and condensed along with the water in a distillation process. Reverse osmosis removes materials based on molecular size. Virtually all synthetic chemicals are molecularly smaller than water and therefore cannot be effectively removed by this process.

While other processes, including point-of-use distillation; reverse osmosis; pitchers and carafe-style filters; and carbon block and granular carbon filters provide alternatives to tap and bottled water, they do not have the quality, convenience, economy, and proven success as point of entry water purification.

Soft Water Systems. While providing a solution to hard water for home and business usage, soft water systems create challenges for water management, water conservation, and the environment. While soft water systems remove calcium and magnesium from hard water, they create potential environmental problems. The salt build-up in soft water can poison the soil, thus killing plants and harming the environment when discharged. Also, water softeners require increase water usage, making it a water-waster. Finally, there is an increased risk of water softener salt in drinking water, and bacterial contamination from plumbing cross-connections at the water softener.[xxiv]

Best Water Filtration Options: Point-of-Entry Water Filtration and Purification System. A proven safe and effective method of eliminating the problems of contaminants in house and building water is to install an energy-efficient point-of-entry (POE) water filtering and purification system. A POE (sometimes referred to as a whole house) water filtration system will do the best job of removing lead, other contaminants, and the harsh chlorine byproducts from the building environment. These toxins are a danger not only in drinking water, but also in showers, toilets, and appliances.

There are several health- and cost-related reasons for considering this as the best alternative to regular tap water and soft water systems. As indicated, point-of-entry systems allow water to emerge from every water source in the building, removing lead, chlorine, fluorides, and other contaminants as soon as they enter the plumbing system, and are no longer released into the air. Using a POE filtration and purification system greatly enhances the overall healthfulness of drinking water, and can alleviate the effects of asthma and allergies for those who already suffer by providing cleaner air to breathe in the house (since chlorine and other toxic vapors are not being released into the air).

POE systems are also the only truly effective shower filter. They filter water at low temperatures to facilitate the removal of lead, chlorine, and other chemicals. Consumption of water through drinking is only one way in which the body absorbs lead and other toxic materials. The skin is the largest organ of the body, and contaminants are absorbed into the body through showering. Further, using a POE system ensures protection from the carcinogenic effects of both consuming and inhaling chlorine, lead, and other dangerous chemicals.

Filtration. Filters are designed to trap various kinds of debris, dirt, and organic particles that will otherwise enter the equipment and/or plumbing system, restrict water flow, and create breeding ground for bacteria. Filtration is the first line of defense for residential, commercial, and industrial facilities, where the source of water may be ponds, wells, or streams that have high exposure to contamination from airborne pollutants, surface run-off, agricultural or industrial waste, or similar dangers. The first step in achieving clean water is to install a filtration device that effectively removes particulate matter and similar debris. Filtration is an important step in water treatment, especially for water intended for human consumption. Filtration systems provide a bacteriostatic environment, and are designed to remove volatile organic chemicals, hydrogen sulfide and sulfur, herbicides, pesticides, chemical fertilizer residues, trihalomethanes, and many other pollutants.

Recommended filtration units are comprised of several filter types and media that remove harmful chemicals, metals, and toxins from the water as it passes through these layers. Filters used in staged filter housings are configured as shown in Attachment I. Other filter mediums and system filters can be determined by a water quality analysis. If fluid conditions require additional micronic particle trapping for enhanced results, filters are available in various micronic sizes providing flexibility and adaptability to meet the needs of all fluid conditions and applications. Attachments II and III reveal test results utilizing recommended filtration.

Ultra-Violent Disinfection/Purification. The best POE systems utilize an ultraviolet (UV) technology, which has proven documented effectiveness both scientifically and commercially for over 50 years. It is nature's own disinfection/purification method, and the preferred solution for both small flow residential applications as well as large flow commercial projects. The UV disinfection technology used in a POE system provides safe process and potable water, free of disease-causing pathogens. As water passes through the UV chamber, UV light will attack and render harmless any bacterial, viral, or spore contamination present in the treated water. High intensity UV light destroys contaminants with a 99.9 percent or greater kill rate based on the multi-process technology provided in the system. The output water is thus disinfected and offers exceptionally high quality for human consumption and use. Once installed, these systems require little or no maintenance, and use only a minimal amount of power.

POE/POU. One caution to the standard point-of-entry systems is that, once the purified water is passed from the main line into the house or business, the risk of contamination from leeched lead and other toxins within the building remains. Water standing in internal pipes for more than a few hours poses a risk of creating biofilms or leaching from any lead pipes. Most POE systems, therefore, recommend additional point-of-use (POU) systems, such as filters which are attached to a faucet. This can drive up the cost of a system, and still only ensure that the water will be 99.9 percent pure only where there are additional faucet filters. There is one system, however, which has resolved that problem through a process called *deposit control*.

Patented Deposit Control System. The basic component in one of the finest point-of-entry systems is the deposit controller. It is comprised of a microprocessor, solenoid coil wrap, and/or a reaction chamber, through which water flows. Water is thus exposed to a triangular wave signal that lies at the heart of the deposit control technology. As the fluid passes through, it is treated and then carries the treatment downstream to condition the rest of the plumbing system, non-chemically and reliably. The signal constantly changes the polarity, frequency, and amplitude of the current entering the water.

There are several benefits to this method. It increases the capability of the water to hydrate scale ions and other colloidal particles. The hydrogen molecules are enhanced, and the water is made, in effect, "wetter". This "hydrated" water can dissolve unwanted particles, suspect them in a solution, and allow them to be easily filtered out and flushed from the system. Accordingly, the mineral and biological particles that cause scale, deposits, and corrosion are dissolved and washed away. The breeding environments for bacteria, such as biofilm and corrosion, are eliminated.

Testing for this process has been completed in Japan by Makoto Nagashima, PhD. The test results of a particular system using this technology are included in the Attachments to this paper, and are available for more thorough review through Threestrand Quality Health Solutions at www.threestrandstl.com.

CONCLUSION

Finally, the use of a point-of-entry filtration and purification system utilizing deposit control technology is the last means of protection from breakdowns in municipal water treatment and sanitation systems. As evidenced in Flint, Michigan, and elsewhere across the nation, these area-wide systems can become dangerously contaminated, despite the many safeguards built into the systems. The "solution" of providing millions of bottles of water to stricken areas has shown to be only a stop-gap solution at best, providing drinking water that may be only slightly better than the tap water in the affected region. Small point-of-use water filters are better, but must be changed frequently, and do not protect consumers and institutions which use water in a multitude of ways beyond the sink. Point-of-entry systems are the best safeguard against contamination of tap water, and provide the comprehensive protection within a home or facility that is necessary to ensure maintenance of greater health standards and water purity. It is important, however, that the system have a built-in deposit control system to eliminate the need for – and additional cost of – point-of-use systems at the faucet site.

Endnotes

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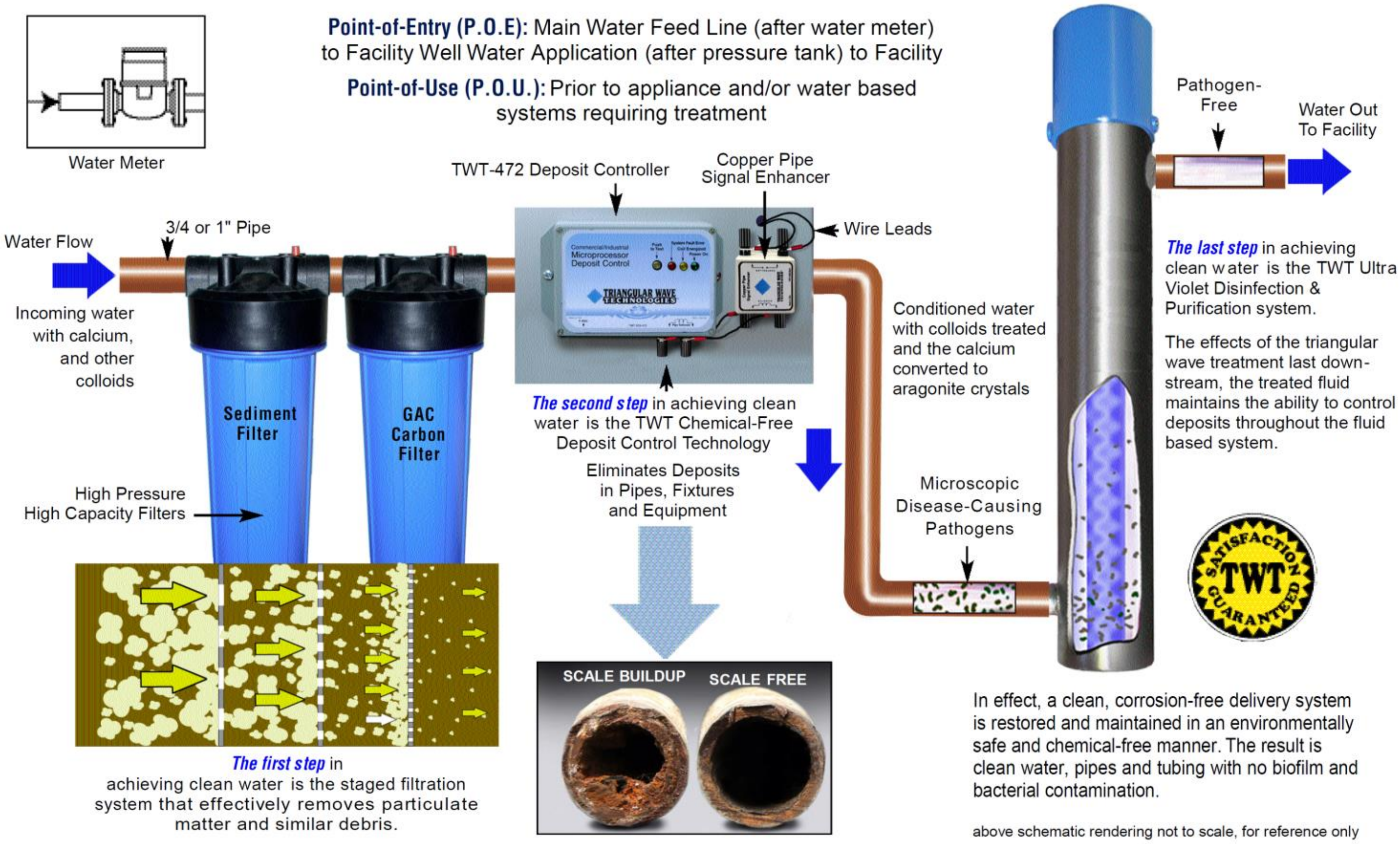
ATTACHMENTS

I. Point-of-Entry Technology with Deposit Control System

The recommended system maintains a corrosion-free delivery system that is maintained in an environmentally-safe and chemically-free manner. The result is clean water, no biofilm in pipes or tubing, and no bacterial contamination. These systems are ideally suited for wells, homes, offices, factories, farms, medical/dental and laboratory environments, hospitals, restaurants, schools, and anywhere the need for cleaner water is required.



* A third Filter Pod can be added for separate KDF & GAC filtration

II. Test Results

Method:

Reagent grade lead chloride was spiked into drinking water and run through the filter per manufacture and NSF specifications. The influent and effluent water were tested per *EPA Methods for Chemical Analysis of Water and Waste* (EPA-600/4-79-020).

Sample Date: 3-23-90 **Report Date**: 5-04-90

Sample ID: 9003-1233B Di-Tech KDC+1.5

Subject: One KDF was received for testing to determine its ability to handle heavy metal removal from water.

Respectfully Submitted, Pat Brueckner, Chemist

Total Flow	Influent Water	Effluent Water	% Removal
1 Gallon	0.17 mg/L	< 0.01 mg/L	99.99%
5 Gallon	0.16 mg/L	< 0.01 mg/L	99.99%
10 Gallon	0.16 mg/L	< 0.01 mg/L	99.99%
50 Gallon	0.17 mg/L	< 0.01 mg/L	99.99%
100 Gallon	0.16 mg/L	< 0.01 mg/L	99.99%
250 Gallon	0.16 mg/L	< 0.01 mg/L	99.99%
500 Gallon	0.16 mg/L	< 0.01 mg/L	99.99%
600 Gallon	0.17 mg/L	< 0.01 mg/L	99.99%
750 Gallon	0.16 mg/L	< 0.01 mg/L	99.99%
1000 Gallon	0.16 mg/L	< 0.01 mg/L	99.99%
1250 Gallon	0.17 mg/L	< 0.01 mg/L	99.99%
1350 Gallon	0.16 mg/L	0.03 mg/L	81.25%
1425 Gallon	0.16 mg/L	0.08 mg/L	50.00%

Initial flow:	0.4 gallon/minute at 60 psi.
Cycle:	10% on and 90% off for a maximum of 16 hours/day.
Comments:	The KDF filter reduced the level of lead pumped through the unit to a non-detectable level (<0.01mg/L) to 1250 gallons.

III. KDF/GAK Test

The laboratories conducting the testing of this technology were commissioned by various companies involved in the original formulation and manufacture of the Copper-Zinc filter media known as KDF. The following results were produced by the Biological Research Solutions, Inc., Detroit, Michigan Laboratory Report:

<u>NSF Standard 53 Test Protocol Performed by Independent Laboratory</u>

20,000 gallons of city water, spiked with high levels of specific contaminants, was run through a KDF/GAC cartridge. The efficiency shown below was measured *after* 20,000 gallons has passed through the cartridge (when new, removal is 99.+ percent) Most other non-standard tests show results after only one pass of contaminated water, which does not indicate how the filter will perform towards the end of its life. To pass the NSF-53 protocol, the effluent must be under the EPA Maximum Contaminant Level (MCL) throughout the test.

All concentrations are measured in milligrams per liter (mg/l). Test Results at 20,000 Gallons

Chemical	Influent	Effluent	Efficiency	EPA MCL
THM (chloroform)	0.57	0.029	95%	0.1
Lead	0.19	0.006	97%	0.025
Fluoride (1)	8.26	0.78	91%	1.4
Nitrate (1)	30.7	8.03	74%	10.0
Barium	10.4	0.56	95%	1.0
Arsenic	0.37	0.007	98%	0.05
Cadmium	0.03	0.004	87%	0.01
Chromium VI	0.15	0.011	93%	0.05
Chromium III	0.163	0.003	98%	0.05
Selenium	0.1	0.006	94%	0.01
Mercury	0.006	0.000*	99+%	0.002
Endrin	0.0008	0.000*	99%+	0.0002
Lindane	0.011	0.0012	89%	0.004
Methoxychlor	0.32	0.0059	98%	0.1
Toxaphene	0.013	0.000*	99%+	0.005
2,4-D	0.3	0.02	93%	0.1
Silvex (2,4,5-TP)	0.029	0.004	86%	0.01

-- Below detectable limit. *

(1) While this test shows a reduction in these contaminants, KDF is inconsistent in their removal of certain water conditions. Special nitrate and fluoride filters, or reverse osmosis, is offered if removal is needed.

A separate test was run on another KDF/GAC cartridge to determine chlorine removal capacity. The challenge solution contained 3 mg/l chlorine (most cities use less than 1 mg/l). 2 mg/l lead was also added. At 20,000 gallons, both were being removed 99.9 percent. The test was terminated at 28,400 gallons when the chlorine removal rate hit 90 percent. The lead removal rate was still 97.6 percent.