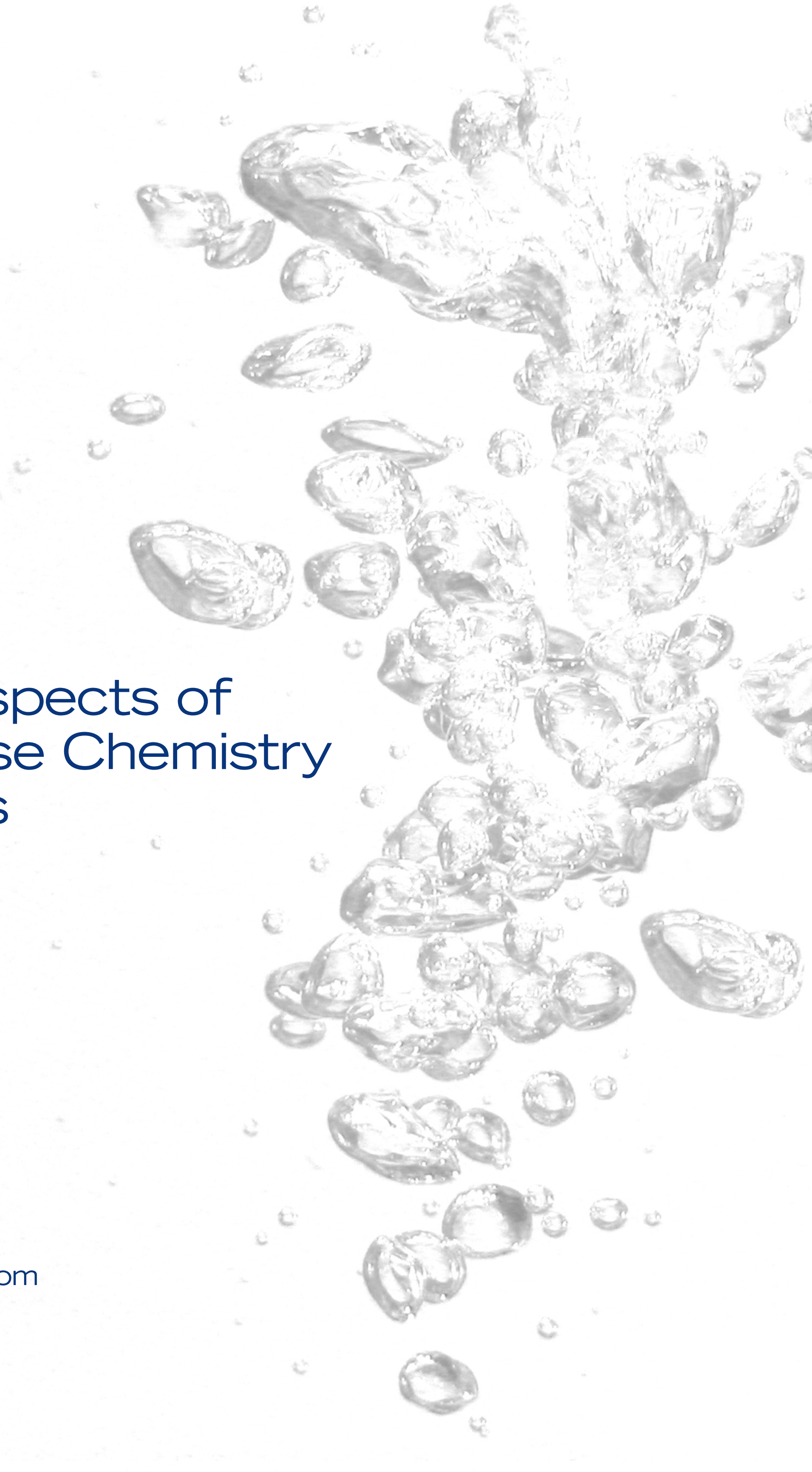
Environmental Aspects of Controlled-Release Chemistry in Cooling Towers



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Abstract
The importance of green chemistry to reduce environmental impact has been growing year by year. Because of this trend many companies, communities, and local or state governments now have "Green" or "Sustainability" targets that they are required or strongly urged to meet. To address this growing demand, many AWT companies are evaluating the need to integrate new technologies into their portfolio that focus on safer, lower carbon foot print water treatment solutions. Controlled Release Technologies provides AWT companies an option to offer their customer base to help them reduce carbon footprint, hazardous liquid chemical inventory, and energy usage. The focal point of this abstract will be to offer an approach for Green comparison based on carbon footprint and other environmental and safety factors. As shown, the predominant objective of any cooling treatment program is maintaining clean heat exchange transfer surfaces and water conservation. This abstract demonstrates the favorable environmental impact of Controlled Release Technology in comparison to traditional liquid cooling water treatment solutions.

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Controlled Release Technology – How It Works
Controlled release chemistry in general refers to a branch of science that allows chemistry to be released at a desired time, place or under specific circumstances. It is done by many methods. For example a medicine might be coated to survive the acidity of the stomach, and then the coating is broken down in the intestines to release the actives. Some coatings slowly dissolve to delay release. Some coatings are abraded off. Controlled Release Cooling Water Treatment is a subset of a larger area.

Controlled Release Technology is a patented method of controlling the dissolution of solid chemical products by the use of time-release polymer coatings and membranes. The principle of Controlled Release Technology is based on osmotic pressure. A proprietary polymer coating or membrane material is used to separate the raw active chemistry from exterior elements. As water is applied to the membrane or polymer coating, water permeates the barrier in both directions. A high concentration of liquid or slurry

chemistry is formed inside the polymer coated tablet (or container) which creates osmotic pressure. The osmotic pressure formed forces the chemistry out of the tablet or container. The polymer coating (or membrane) restricts the rate at which the osmotic pressure can force the chemistry out. This produces a linear dissolution of the solid chemical. Only very low flow rates are required to maintain the osmotic pressure and thus controlled chemical dissolution. High flow rates do not measurably impact dissolution as it does not impact osmotic pressure (assuming the excessive flow does not physically damage the membrane or polymer coating). Zero flow (i.e. when a system is not operating) will allow osmotic equilibrium to occur – thus stopping the chemical dissolution. The controlled release of the chemical allows dry products to be consistently applied to treat various water processing applications.
The non-hazardous polymer coating and membrane materials completely isolate the applicator from the raw chemical thus improving safety and reducing environmental hazards.

Section 1: Defining "Green"
How is the term "Green" specifically defined and quantified? There are many explanations and various resources to cite and this abstract will reference multiple sources. The most practical resource is the Environmental Protection Agency. The EPA Green Chemistry Website (www.epa.gov/greenchemistry/) provides some information about sustainable chemicals. Specifically, the EPA states the following:

> **Sustainable Chemistry Hierarchy**
> Chemical products and processes should be designed to the highest level of this hierarchy and be cost-competitive in the market.

1. Green Chemistry: Source Reduction/Prevention of Chemical Hazards
    - Design chemical products to be less hazardous to human health and the environment*
    - Use feedstocks and reagents that are less hazardous to human health and the environment*
    - Design syntheses and other processes to be less energy and materials intensive (high atom economy, low E-factor)
    - Use feedstocks derived from annually renewable resources or from abundant waste
    - Design chemical products for increased, more facile reuse or recycling
2. Reuse or Recycle Chemicals
3. Treat Chemicals to Render Them Less Hazardous
4. Dispose of Chemicals Properly

*chemicals that are less hazardous to human health and environment are:

- Less toxic to organisms and ecosystems
- Not being persistent or bio-accumulative in organisms or the environment
- Inherently safer with respect to handling and use

One can interpret that the EPA's primary intent is to focus on less toxic and hazardous chemicals and their related supply chains in addition to the importance of safe handling, recycling, and proper disposal. The EPA definition of Green chemistry does not specifically reference the term "carbon footprint". Conservation of natural resources is also a keen focus of the EPA and the "Green" movement in general.

Section 2: Chemical Toxicity and Environmental Hazards

The EPA provides a functional roadmap for the environmental aspect definition of "Green". This is one of the ways to define and measure "Green" and it is worthwhile to look at chemicals typically used to treat cooling water systems.

One measure of toxicity is LC50. LC50 is defined as the test for concentration that kills half. A toxicological test in which the concentration dose that kills 50 percent of a group of test animals is calculated. The lower the LC50 value, the higher the toxicity. Some common LC50 values are shown the table 2.1 below:

Table 2.1

Substance	LC50 (mg/kg)
Acetaminophen (analgesic in Tylenol)	**340**
Acetic Acid (component of vinegar)	**33,500**
Arsenic Trioxide	**15**
Aspirin	**1500**
BHA (antioxidant food additive)	**2000**
Nicotine	**230**
Caffeine	**130**

*Adapted from www.cem.msu.edu/~reusch/VirtualText/cem&soc.htm

Some common examples of cooling water active chemical ingredients are phosphonates, polymers, azoles, polyphosphate, zinc, and ortho phosphate. When formulated as a liquid product, these active ingredients are typically blended with water and pH adjusting stabilizers to maintain the actives in solution until the chemistry can be properly injected into the system. When the pH stabilizing agents are removed from the chemical formula by applying a dry chemistry form through the use of completely non-hazardous, controlled release polymer coatings or membranes, the LC50 (toxicity) values are reduced. Table 2.2 shown below provides a comparison between the solid or dry chemical versus the liquid chemical blend and the corresponding LC50 values (Lower LC50 values indicate higher toxicity levels):

Table 2.2 (Mammalian Toxicity Values)

Chemical Substance	LC50 (mg/kg)
SOLID / DRY Ortho Phosphate, phosphonates (PBTC/HEDP), Benzotriazole, and Co-Polymer	**1876**
SOLID / DRY Phosphonates (PBTC/HEDP), Benzotriazole, and Co-Polymer	**1697**
SOLID / DRY Poly phosphate, Ortho Phosphate, phosphonate (HEDP), Benzotriazole, and Co-Polymer	**2429**
LIQUID Phosphonates (PBTC/HEDP), Benzotriazole, and Co-Polymer	**909**

A direct comparison of LC50 values determines that various dry chemical formulations are slightly less toxic than a common pain reliever, aspirin and 5 times less toxic than Tylenol. Additionally, the dry chemical formulations are approximately 2 times LESS toxic as the direct corresponding liquid formulation.

Summary - EPA "Green" Safety and Environmental Aspect

The safety and environmental aspects of controlled release technology reduce LC50 values in addition to complete elimination of potential human exposure to raw chemical materials. This specifically satisfies two of the goals as outlined in section 1 by the EPA Green Chemistry section: "Design chemical products to be less hazardous to human health and the environment as defined by: being less toxic to organisms and ecosystems, not being persistent or bio-accumulative in organisms or the environment, and inherently safer with respect to handling and use".

Section 3: Carbon Footprint Calculation

A very commonly used term associated with "Green" is "Carbon Footprint". Carbon footprint is defined by the amount of carbon dioxide generated in the manufacturing, use, and disposal of a product. Some of the factors influencing carbon footprint are electrical energy consumption, natural gas consumption, product packaging materials, on site service frequency (fuel to travel to and from service visits), and fuel consumed to deliver products.

The following formulas and emission factors are used in determining carbon footprint:

Power Consumption Factors (Source: EPA, eGrid):

Base Load Power Consumption Factor – 1.37 lbs CO2/kWH
(Source: EPA)

Peaking Load Power Consumption Factor – 1.715196 lbs CO2/kWH
(eGrid Non-base load national average emission rate)

Average Load Power Consumption Factor – 1.4707 lbs CO_2/kWH
(Assumes 7 hours peaking power, 17 hours per day base load)

Gas Consumption Factors (Source: EPA):
Natural Gas Emission Factor – 11.7 lbs CO_2 / 1000 cubic ft.
(or 1,030,000 BTU)
Propane Emission Factor – 12.7 lbs CO_2 / gallon

Product Packaging Factors (Source: EPA WARM program and EIA):
5 Gallon Drum (HDPE) Emission Factor – 15.2 lbs CO_2/empty container
15 Gallon Drum (HDPE) Emission Factor – 40.6 lbs CO_2/empty container
30 Gallon Drum (HDPE) Emission Factor – 81.1 lbs CO_2/empty container
55 Gallon Drum (HDPE) Emission Factor – 111.5 lbs CO_2/empty container
1 LB Corrugated Box and 0.2 lb LDPE Liner – 2.12 lbs CO_2/empty container
LDPE Weight Factor – 5.59 lbs CO_2 Per pound of LDPE
Corrugated Box Material – 1 lb CO_2 Per pound of material
HDPE Weight Factor – 5.07 lbs CO_2 Per pound of HDPE
1 LB Corrugated Box and 0.2 lb LDPE Liner – 2.12 lbs CO_2/empty container

Transportation Fuel Consumption Factors (Source: EPA and EIA):
Gasoline – 19.564 lbs CO_2 / 1 gallon of fuel
Diesel – 22.384 lbs CO_2 / 1 gallon of fuel
Average Diesel Truck Fuel Economy - 6 mpg (Average)
US EPA Estimates Diesel Vehicles Lose 0.5% Fuel Efficiency for every 1000 lbs of additional weight carried.

Calculating Carbon Footprint

By utilizing the referenced emission factors, carbon footprint calculations can be determined for manufacturing, handling, shipping, packaging, applying, and disposing of chemical treatment carbon contribution.
The following sections will compare the carbon dioxide calculations for scale and corrosion inhibitor treatment using controlled release technology chemistry fed at an average of 20 ppm as product and 100 ppm as product of traditional (and equivalent) liquid product. This comparison is designed for a system with 500 tons of cooling load, operating 24 hours per day, 365 days per year, 3.75 cycles of concentration, negligible drift, and average ΔT of 10°F.

3.1 Carbon Footprint Calculation for Controlled Release Technology Products

Disclaimer: For the intent of this calculation, an assumption must be made that the raw materials used for controlled release technology solid products are the same amount and type of raw material products used to make the equivalent liquid product. The obtaining and manufacturing carbon dioxide contribution figures for the raw materials were not readily available to include in this document. Since the factors should be moderately similar (liquid raw materials have a slightly higher carbon footprint due to shipping raw material weights and packaging in plastic), this will not be considered in the calculation. Additionally, this calculation will not include one time carbon dioxide contribution for application equipment such as feeders, chemical pumps, or chemical tanks (for either liquid or solid products). This exercise is for ongoing carbon dioxide footprint calculations only.

The manufacturing process for controlled release technology is much more extensive than blending traditional liquid chemicals. There is very little information currently available on the production process of solid chemistry products thus making the specific calculations somewhat of a question mark to most manufacturers and end users. The following is meant to provide specific calculations and provide more in depth detail with respect to the manufacturing process.

The process of making controlled release products is as follows: dehydrating any raw materials not available in dry form, mixing the active materials together, pressing the mixed materials into a tablet, coating the tablets, and finally packaging the materials. This is quite extensive compared to liquid products which are simply blended into drums of products combined with stabilizing agents. The following calculations show the specific carbon footprint calculations involved in manufacturing controlled release technology products:

- **Step 1) Dehydrating Process –** Natural Gas and energy consumed to dehydrate active materials to a dry form for 400 lbs of controlled release chemistry is 260,000 BTU and 3 KWH. This amount of natural gas and energy equates to 7.45 lbs CO2 produced.

- **Step 2) Mixing Process** – A 15 minute mixing step is used to blend the chemistry. The mixer operates at 22 Amps, 240 volts, single-phase power for 15 minutes. This equates to 1.32 KWH which is 1.94 lbs of CO2 produced from the mixing process.

- **Step 3) Pressing Process –** The tablets are pressed which requires a 4 hour process to produced 400 lbs of controlled release product. During this process, the press operates at 240 volts, 19.5 amps, single-phase power. The power consumed is 18.72 KWH which results in 27.5 lbs of CO2 produced from this step.

- **Step 4) Coating Process** – This process uses electrical energy to spray on the coating but the coating pan also uses natural gas to control humidity. The coating process takes 45 minutes to coat 400 lbs of controlled release chemistry. During the 45 minute process, the coating pan uses 12 Amps, 120 Volt, single phase power. This equates to 1.01 KWH which in turn is 1.48 lbs of CO2. The natural gas consumed during the 45 minute coating process is measured to be 153,000 BTU. This is 1.79 lbs of CO2 produced from natural gas in the coating process, thus the total CO2 produced during coating is 3.27 lbs of CO2 for 400 lbs of controlled release product.

- **Miscellaneous Manufacturing Factors For Controlled Release Products**
  During the above manufacturing process, the humidity and temperature must be carefully controlled and thus factored into the carbon footprint calculation. Additionally, one must include carbon contribution from the use of fork lifts used to handle and move materials in the manufacturing process. The approximate fuel use for transportation while producing 400 lbs of controlled release chemical is 0.5 gallons. This is 6.35 lbs of CO2. The amount energy required for cooling capacity required to condition the space and provide lighting is 20 KWH for the entire manufacturing process. Additionally, the natural gas consumed to provide reheat (humidity and temperature control) is 180,000 BTU. This equates to 37.86 lbs CO2 from lighting, air conditioning the environment, and providing humidity control.

- **Packaging Carbon Dioxide Contribution**
  Packaging – The packaging step for Controlled Release products involves the use of LDPE liner and corrugated box. As indicated previously, the CO2 for one 25 lbs package container of controlled release product is 2.12 lbs CO2 per container. There are 16 containers needed for 400 lbs of product, thus the CO2 for 400 lbs of product is 33.92 lbs of CO2.

- **Shipping Carbon Dioxide Contribution**
  The weight of a product being shipped has an impact on fuel to deliver products. The EPA states that diesel engines lose approximately 0.5% fuel efficiency for every 1000 lbs of additional weight to be shipped. Additionally, the average fuel economy for diesel trucks is 6 mpg. If the shipping distance is 500 miles, the fuel for transportation is 83.3 gallons. The 400 lbs of product shipped would reduce fuel economy by 0.2%. The reduction is 0.167 gallons of diesel fuel. This is 3.73 lbs of CO2 for transportation due to the extra weight of the chemical on the transportation vehicle. A base load factor for shipping (not factoring in weight calculation) covers the vehicle driving to the destination – assumption 5% of the fuel is used to deliver the product to the destination with the other fuel used for other deliveries on the truck. The 5% of 83.3 gallons of fuel used is 4.165 gallons of diesel fuel. This is 93.23 lbs of CO2 for base load calculation. Thus the total fuel impact for shipping 400 lbs of controlled release product 500 miles is 96.96 lbs of CO2 per year.

- **Application (Pumping) of Product In Cooling System**
  There is negligible carbon contribution from the application of the product. Little to no detectable electrical or fuel requirements are needed to apply, pump, or transfer the controlled release technology product. Water is simply circulated through the feed equipment to slowly apply the chemical into the system. This water can be supplied from the water treatment controls flow piping thus eliminating the need for additional piping, water flow (pumping energy), and pressure losses. The carbon dioxide contribution is 0 lbs per year.

Total Controlled Release Technology Carbon Dioxide Contribution
The total carbon dioxide contribution due to manufacturing, shipping, handling, and applying 400 lbs of controlled release product and shipping it 500 miles to a destination is 208.9 lbs of CO2. This does not factor in the energy and fuel required to obtain and manufacture the raw materials for the chemicals. This information was not readily available and for the purpose of the report is not required as both liquid and solid chemicals use the same amount of active ingredients.

3.2 Carbon Footprint Calculation for Traditional Liquid Products

Disclaimer: For the intent of this calculation, an assumption must be made that the raw materials used for controlled release technology solid products are the same amount and type of raw material products used to make the equivalent liquid product. The obtaining and manufacturing carbon dioxide contribution figures for the raw materials were not readily available to include in this document. Since the factors should be moderately similar (liquid raw materials have a slightly higher carbon footprint due to shipping raw material weights and packaging in plastic), this will not be considered in the calculation. Additionally, this calculation will not include one time carbon dioxide contribution for application equipment such as feeders, chemical pumps, or chemical tanks (for either liquid or solid products). This exercise is for ongoing carbon dioxide footprint calculations only.

The process of making an equivalent traditional liquid product is as follows: adjust the temperature of the liquid to the design mixing temperature (some facilities do not perform this step while others do), add ingredients one at a time while mixing and not adding additional ingredients until each one is properly dissolved, once blended continue mixing for an additional hour. The comprehensive process to blend approximately 2000 lbs of product takes approximately 2 hours depending on the facility, manufacturer, and equipment available. The following calculations show the specific carbon footprint calculations involved in producing and applying liquid chemical treatment (liquid blending processes will vary per manufacturer, this process is one example):

- **Chemical Blending Process** – A 2 hour mixing step is used to blend the active ingredients. The mixer operates at 24 Amps, 240 volts, single-phase power for 2 hours. This equates to 11.52 KWH which is 16.9 lbs of CO_2 produced from the mixing process.

- **Miscellaneous Manufacturing Factors For Liquid Products**
  Carbon contribution from the use of fork lifts used to handle and move materials in the manufacturing process. The approximate fuel use for transportation while producing 2000 lbs of Controlled Release Chemical is 1.0 gallons. This is 12.7 lbs of CO_2. Some facilities maintain climate control for the manufacturing of liquid products while others do not. For the sake of this study it is assumed this facility does not control the climate using air conditioning or humidity control. A factor for lighting is 640 watts or 1.0 lbs of CO_2. This results in 13.7 lbs CO_2 from handling and lighting the space during the manufacturing process.

- **Packaging Carbon Dioxide Contribution**
  Packaging – The packaging step for liquid products involves the use of HDPE chemical drums. As indicated previously, the CO_2 for one 5 gallon HDPE drum container is 15.2 lbs CO_2 per container. There are 40 containers needed for 2000 lbs of product, thus the CO_2 for 2000 lbs of product is 608 lbs of CO_2. The impact of using 55 gallon drums is less of an impact by producing 446 lbs of CO_2 per year compared to 608 lbs per year of CO_2. Most Controlled Release Technology applications generally replace 5 gallon drum applications so for the purpose of this document, the 5 gallon drum factor was utilized. It is acknowledged that some chemical companies, albeit a fairly small percentage, reuse existing drums. Note the use of the term "reuse" as opposed to "recycling". Recycling is a very energy intensive process with a high carbon footprint – most companies that recycle plastic drums do so to prevent the plastic material from going to the landfill, not reducing carbon footprint. The process of reusing existing drums also has a carbon footprint since the process involves additional fuel transportation to return the drums as well as the cleaning and preparation protocol for proper reuse. Calculating this specific carbon footprint would require extensive speculation and due to the relatively low percentage of companies that typically reuse drums was thus disregarded for the intent of this paper.

- **Shipping Carbon Dioxide Contribution**
  The weight of a product being shipped has an impact on fuel to deliver products. The EPA states that diesel engines lose approximately 0.5% fuel efficiency for every 1000 lbs of additional weight to be shipped. Additionally, the average fuel economy for diesel trucks is 6 mpg. If the shipping distance is 500 miles, the fuel for transportation is 83.3 gallons. The 2000 lbs of product shipped would reduce fuel economy by 1.0%. The reduction is 0.833 gallons of diesel fuel. This is 18.64 lbs of CO_2 for transportation due to the extra weight of the chemical on the transportation vehicle. A base load factor for shipping (not factoring in weight calculation) covers the vehicle driving

to the destination – assumption 5% of the fuel is used to deliver the product to the destination with the other fuel used for other deliveries on the truck. The 5% of 83.3 gallons of fuel used is 4.165 gallons of diesel fuel. This is 93.23 lbs of CO2 for base load calculation. Thus the total fuel impact for shipping 2000 lbs of controlled release product 500 miles is 111.88 lbs of CO2 per year. *Disclaimer: It is acknowledged that there are wide ranges of concentration in liquid chemical formulations. Most water treatment cooling inhibitor liquid formulations are applied somewhere in the range of 75 ppm to 500 ppm with 150-200 ppm being a reasonable average with 100 ppm used for the purpose of this calculation.*

- **Application (Pumping) of Product In cooling System**
  The chemical injection pumps used to apply the chemical treatment use energy. The average LMI A Series chemical pump uses 22 Watts, 120 volts, single phase power. The approximate average pumping time is 15% of the time – variable with cooling loads (estimated run time based on trending data). This results in 28.9 KWH per year. The carbon dioxide contribution due to operating chemical pumps is 42.4 lbs per year.

Total Carbon Dioxide Contribution - Liquid Products

The total carbon dioxide contribution due to manufacturing, shipping, handling, and applying 2000 lbs of the equivalent liquid chemistry product and shipping it 500 miles to a destination is 792.98 lbs of CO2. This does not factor in the energy and fuel required to obtain and manufacture the raw materials for the chemicals. This information was not readily available and for the purpose of the report is not required as both liquid and solid chemicals use the same amount of active ingredients.

Chart 3.1

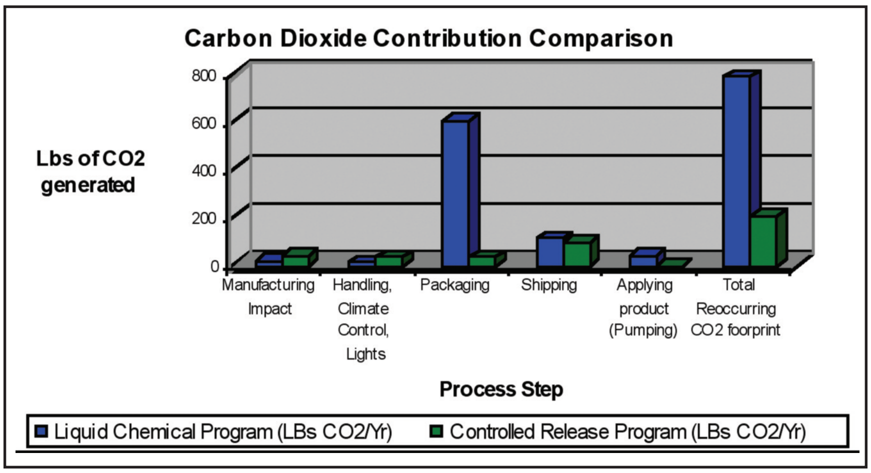

Table 3.1

Reoccurring CO2 Footprint	Liquid Chemical Program (LBs CO2/Yr)	Controlled Release Program (LBs CO2/Yr)
Manufacturing Impact	16.9	40.16
Handling, Climate Control, Lights	13.7	37.86
Packaging	608	33.92
Shipping	111.88	96.96
Applying product (Pumping)	42.4	0
Total Reoccurring CO2 footprint	**792.88**	**208.9**

Summary - Calculating Carbon Dioxide Contribution
As shown above, there are many factors that go into accurately calculating carbon dioxide contribution for various water treatment products. This document did not include the raw material production factor which is currently being researched. The location of where the products are manufactured versus applied can impact the specific carbon dioxide calculation. Specifically, if liquid product is made in one plant 1000 miles away from the end user destination versus controlled release product made 200 miles away from the end user destination the fuel impact will be different than indicated above. Some manufacturers of liquid products do operate in climate controlled environments (i.e heating in winter months) which was not included in the above comparison.
The biggest factors impacting carbon dioxide contribution for liquid products are packaging, shipping, and applying. The biggest factors impacting controlled release technology carbon dioxide contribution are shipping and manufacturing.

Based on an equivalent product comparison of liquid versus controlled release technology (with the same shipping distance and dosage factors included), the controlled release technology carbon dioxide contribution was 3.8 times LESS than the traditional liquid program (just 26% of the carbon dioxide contribution). Again, this assumes a dosage of 20 ppm of solid controlled release product versus 100 ppm of liquid product in addition to not factoring the reuse of liquid drums due to the wide range of variables difficult to generalize such a carbon footprint calculation. This exercise also provides more insight as to the real carbon footprint impacts of manufacturing controlled release product technology.

Section 4.0 Other Factors to Consider for Water Treatment Carbon Footprint

- **Energy Efficiency of HVAC Equipment**
  Energy consumption has the biggest potential impact on carbon footprint. The loss of 10% efficiency in HVAC equipment greatly outweighs the potential gains by focusing on reducing carbon footprint by various water treatment solutions. In the previous example of 500 tons of cooling load that was used to determine water treatment carbon footprint, a 10% loss in energy efficiency would yield approximately an increase of 175,200 KWH per year in increased energy. This decrease in energy efficiency would yield an additional 257,544 lbs per year of CO_2 contribution to the atmosphere. The scale and corrosion inhibitor chemical carbon footprint ranged from 793 lbs per year of CO_2 down to 209 lbs per year of CO_2. This illustrates that if focusing on reducing carbon footprint that energy efficiency is always paramount. The water treatment carbon footprint impact is less than 0.5% of the total potential loss of losing 10% energy efficiency due to a failed water treatment program.

- **On Site Service Frequency**
  How often a service technician visits a customer site also impacts carbon footprint. A technician driving 40 miles round trip to a facility once per week adds over 1500 lbs per year of CO_2 to the treatment carbon footprint when compared to monthly service. If seriously considering carbon footprint impact, the end user must consider the service frequency of the support personnel and implement a strategic service schedule. (Calculations: Scenario #1: 40 mile round trip, 20 miles per gallon fuel efficiency, 2 gallons of fuel per service visit, 52 weeks per year, 104 gallons of fuel per year, 19.6 lbs of CO_2/gallon results in 2038 lbs per year of CO_2. Scenario #2: Same distance and fuel economy, 12 trips per year, 24 gallons of fuel, 19.6 lbs CO_2/gallon, 470 lbs per year of CO_2. Scenario #2 saves 1568 lbs per year of CO_2 which is more than either chemical treatment solution).

- **Non-Chemical Devices, Controls Equipment, Solenoid Valves**
  As indicated several times in this document, all energy consuming devices greatly impact carbon footprint calculations. Mechanical equipment such as Non-Chemical Devices, Controls Equipment, and Solenoid valves all add to carbon footprint. As an example, a non-chemical water treatment device using 5 amps of continuous power demand, 120 volts, single-phase power operating 24 hours per day, 365 days per year. This equates to 5256 KWH per year. This power demand results in 7726 lbs per year of CO_2. This is about 10 times the amount of carbon footprint of traditional liquid chemical products (not factoring in raw material CO_2 impacts or biocide, just scale and corrosion inhibitor only). The intent of this is to emphasize the importance of actual energy and carbon dioxide calculations to determine whether one technology is truly more "Green" than another.

Controls equipment can have a similar impact as non-chemical devices. It is vitally important that actual technical data be provided to determine specific carbon footprint and avoid getting caught in attractive sales presentations.

Abstract Conclusion

The information provided in this document is meant to elevate awareness and stress the importance of understanding Green principles and how to calculate carbon footprint. Controlled Release Technology is one option to offer end users interested in reducing carbon foot print and improving safety relative to traditional liquid chemical delivery methods. As defined by the US EPA, reducing toxicity and lowering impacts to the environment is one way to define Green. Controlled Release Technology accomplishes this and is one choice for companies to consider. Many factors and calculations go into determining carbon footprint. Generally, Controlled Release Technology will lower carbon footprint when compared to many other treatment strategies with the specific figures requiring to be calculated on a case by case basis.