

**CBA Environmental Services, Inc.**  
**Statement Of Qualifications**  
***Chlorinated Volatile Organic Compound (CVOC)***  
***Remediation Services***

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## 1.0 INTRODUCTION

### 1.1 Company

Since its inception in 1993, CBA Environmental Services, Inc. has been providing the global marketplace with some of the worlds most effective, state-of-the-art, and cost sensitive remedial technologies. Through the utilization of these technologies, CBA has taken on some of the most environmentally challenging tasks and has achieved great success.

During the past 10-15 years, a new challenge has made its presence known. Chlorinated Volatile Organic Compounds (CVOCs) have been developed as far back as 1821 and have had severe impacts on the environment. The following Statement of Qualifications will give information about 5 distinct CVOCs including history of the product, its environmental impacts, treatment approaches, and remedial projects representative of these contaminants.

CBA's corporate headquarters is located in Hegins, Pennsylvania; affiliated offices are located in Wisconsin, Denmark, and the United Kingdom.

### **CBA Regional and Affiliate Operations**

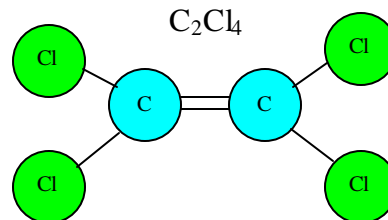


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## 2.0 CHLORINATED VOLATILE ORGANIC COMPOUNDS

### 2.1 Constituents and History

#### 2.1.1 PCE (Tetrachloroethylene)

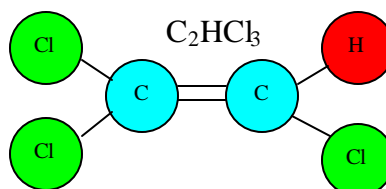


PCE was discovered by Michael Faraday, a physicist and chemist, in 1821. Though PCE is most often thought of in conjunction with the drycleaner industry, only 25% of all PCE production in the United States is used by drycleaners. PCEs other uses include metal cleaning, vapor degreasing, and as an ingredient in automotive aerosols. Commercial consumption of PCE has been on the decline in the U.S. since its peak in the late 1970's when it was determined to be a carcinogen by the United States Consumer Product Safety Commission.

PCE is manufactured through the use of high temperature chlorination of ethylene or 1,2-dichloroethane, which produces Trichloroethene (TCE) as a byproduct. At one time, PCE was produced by the chlorination of acetylene until high prices forced a change in the 1970's.

PCE is the second most commonly found chlorinated solvent at CVOC impacted sites. It has been detected in at least 771 of the 1,430 National Priorities List sites identified by the EPA.

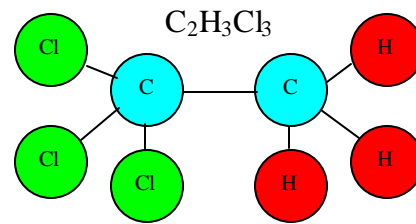
#### 2.1.2 TCE (Trichloroethylene)



TCE was regarded as the dominant cleaning solvent through the 1970's and peaked with its use in the automotive and aerospace industries as a degreaser. Besides being used as a degreaser, TCE has been used as an ingredient in dyes, rubber, glue, insecticide, paint, and water proofing materials. In some instances, TCE was even used to extract caffeine from coffee beans.

In the mid-1970's reports began to surface that, like PCE, TCE was a carcinogen. This caused business and industry to switch from TCE to TCA (1,1,1-Trichloroethane). TCE is the most commonly found chlorinated solvent at CVOC impacted sites. It has been detected in at least 852 of the 1,430 National Priorities List sites identified by the EPA.

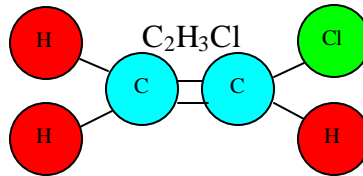
### 2.1.3 TCA (1,1,1-Trichloroethane)



TCA dates back to 1840 when it was synthesized from 1,1-Dichloroethane and chlorine. TCA was originally used in Europe as a rubber solvent. However, it was first used in the United States in the 1940's as a product in cold cleaning and as a corrosion inhibitor. Upon its replacement of TCE in the mid-1970's, TCA was linked to 21 deaths relating to decongestant aerosol sprays and fluorocarbon propellants.

TCA also has a very high rate of detection at CVOC impacted sites. Of the 1,430 sites listed on the EPA's National Priorities List, TCA has been detected at least 696 instances.

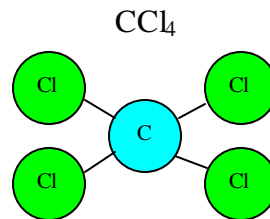
### 2.1.4 Vinyl Chloride



Vinyl Chloride is most widely known for its use in the production of polyvinyl chloride (PVC) pipes. It is also used as an ingredient in adhesives and refrigerants and acts as a copolymer in plastic wraps. The major characteristic that makes vinyl chloride unique compared to other chlorinated solvents is the fact that it is one of only 2 compounds whose liquid density is less than that of water.

Vinyl Chloride has been detected in at least 496 of the 1,430 National Priorities List sites identified by the EPA.

### 2.1.5 Carbon Tetrachloride



Carbon Tetrachloride was a popular solvent from the early 1900's through the 1950's. Commercial use and production ended January 1, 2000. Carbon Tetrachloride was used to treat animals for hookworm in the 1920's and replaced gasoline as a dry cleaning agent in the 1930's. By the 1950's, half of all Carbon Tetrachloride produced was used in Freon 11 among other chlorofluorocarbons. In the 1970's, Carbon Tetrachloride was identified as a carcinogen and its use in any emissions was banned in 1996. Carbon Tetrachloride has been identified in at least 326 of the 1,430 National Priorities List sites identified by the EPA.

### 3.0 THE CHALLENGE

As described in Section 2.0, chlorinated volatile organic compounds can be found at most of the hazardous waste sites across the country. These forms of halogenated organics, once released to the environment, present several unique challenges to the owners of contaminated sites as well as to the environmental remediation industry.

Many of these compounds are listed hazardous wastes, and therefore, are subject to RCRA's Land Disposal Restrictions. Off-Site disposal at a permitted hazardous waste landfill or at an incinerator are options that are often too costly; whereas, many on-site and in-situ remediation technologies have been inconsistent over varying site and subsurface conditions. Many popular conventional in-situ technologies often reach a point of diminishing returns prior to achieving cleanup objectives and end up exceeding preliminary budgets and schedules. The recalcitrant nature of CVOCs along with their variability in partitioning and distribution in the subsurface environment often make it difficult to predict the success of any one remediation technology.

Remedial designers are faced with the task of selecting a treatment approach that will meet the cleanup objectives, while staying within a fixed budget and meeting an aggressive schedule. The treatment approach must account for the characteristics of both the contaminant and site. Contaminated site owners would like nothing more than to eliminate all liability by achieving clean closure with the most cost effective and timely approach possible.

With the large number of chlorinated solvent sites still remaining across the United States, CBA saw a dire need to develop a technology that could provide effective and cost sensitive treatment options for CVOC contaminated soils. In recognition of this, CBA has worked very closely with chemical manufacturers and industrial equipment companies to develop patented treatment technologies that have been instrumental in the clean up of CVOC impacted sites.



Some in-situ technologies require a large initial capital investment and occupy the majority of the site. Additionally, most conventional in-situ technologies are limited by the characteristics of the soils, and although in-situ, may still restrict access and use of the site. Remediation professionals should be realistic when evaluating time vs. cost analysis for in-situ methods and should also consider more aggressive treatment alternatives.

## 4.0 THE CBA SOLUTION

CBA's patented MITU technology, in conjunction with various treatment reagents, has revolutionized the rapid remediation of sites that have been contaminated with chlorinated solvents. The MITU technology is designed to aggressively increase the surface area of soils to optimize treatment conditions that will facilitate maximum removal of contaminants.

CBA has developed and patented a treatment train approach for CVOC contaminated soils that involves thermal desorption followed by chemical oxidation with potassium permanganate. This approach has enabled CBA to achieve substantial mass removal rates, as high as 99% in some instances.

CBA's MITU technology combined with various treatment approaches has proven its effectiveness time and time again. Whether it be thermal treatment of a small site with only one contaminant or thermal and chemical treatment of large sites with multiple contaminants, CBA has the experience and ability to achieve site closures in a very timely, cost efficient manner.

### 4.1 MITU Technology

#### 4.1.1 MITU-LVR

This model consists of a large track trencher outfitted with a specialized rotating drum attachment. This model has the capability of cutting to a depth of 4 feet with a trench width of 11 feet. The unit is fairly compact when the trenching boom is in the ground; it is approximately 20 feet long at this point. The MITU-LVR is typically equipped with a vapor collection hood and auxiliary heat system when performing Thermal treatment.



The MITU-LVR can be utilized for thermal desorption (pictured left) or for admixing various reagents. This model has completed several projects involving thermal, chemical oxidation, and enhanced bioremediation treatment of soils contaminated with organic compounds. The unit is capable of treating soils in-place or ex-situ in a constructed treatment cell.

The MITU Rotating Drum is fairly easy to mobilize to most site locations. The unit is compact enough to allow for excellent maneuverability on projects which have very little operating space. This unit is ideal for soils requiring extensively high heat (up to 800 °F) and aggressive soil breakdown (i.e. hard clay). The unit





CVOC contamination in vadose zone soils is distributed among three phases of the soil matrix. The partitioning and distribution of the contamination depends on the soil characteristics as well as the concentrations and characteristics of the specific contaminants. The movement of contaminants through the soil media is either by advection, movement with bulk air flow, or by diffusion, movement via concentration gradient. Volatile compounds desorb from the soil particle surface, transfer to the soil water, and volatilize to the soil gas. In low to medium permeable soils (sand and gravel), diffusion is the limiting factor in the movement and re-movement of contaminants.



Typically, there is no combustion involved in either the primary or secondary treatment of organics with the MITU; therefore, air quality permitting is of minor significance. However, for contaminants with low adsorption isotherms, secondary catalytic or thermal oxidation of the vapor stream may be required. If necessary, CBA has experience in obtaining the proper air quality permits for utilization of the MITU.

Unlike incineration or even LTDD, thermal treatment with the MITU does not require excavation of contaminated soils; the thermal treatment can be performed in-place or on excavated soils. The underlying feature of successful thermal treatment with the MITU is its ability to break down soil density. The shearing action of the trencher pulverizes the soil into very fine particles, effectively increasing the surface area to volume ratio. In turn, CVOCs are more readily volatilized by virtue of increased contact with air flow and heat. The MITU utilizes an electrically powered heat generation system to heat forced air to temperatures in excess of 800°F (425°C). The forced air is then conveyed into the trench and across the soil particles. The final soil temperature depends on the soil characteristics and on retention time.

The vaporized constituents are captured beneath an enclosed shroud that is subjected to negative pressure, and are treated in a secondary treatment unit prior to discharge to the atmosphere. Secondary treatment of the vaporized constituents may consist of condenser units, catalytic or thermal oxidation, or carbon adsorption units.

The trenching head, heat generation system, and vapor collection system are all operated through an integrated control panel mounted in the equipment's cab. Several of the system's parameters can be monitored during operation to maintain operational control and optimize treatment effectiveness.

SVE and LTTD technologies have been able to achieve an average of 90% and 95% CVOC removal efficiencies respectively. The MITU technology has had very favorable results in the field displaying consistency with the 90% to 95% average removal efficiencies accomplished by the other technologies. Some typical contaminant removal results achieved through thermal treatment with the MITU are displayed in Table 2.1.

**Table 2.1 Typical Thermal Treatment Remediation Results**

Contaminant	Pre-Treatment (mg/kg)	Post Treatment (mg/kg)	% Reduction
Benzene	5.6	0.005	99.9%
Toluene	270	0.05	99.9%
Ethyl Benzene	54.5	0.97	98.2%
Xylene	324	4.5	98.6%
<b>PCE</b>	<b>369</b>	<b>18.1</b>	<b>95%</b>
<b>TCE</b>	<b>25</b>	<b>.5</b>	<b>98%</b>

#### 4.2.2 Chemical Oxidation

In-situ chemical oxidation is a relatively new technology being used to treat CVOCs in soil and groundwater. There are three viable oxidants that are currently commercially available – Permanganate (Potassium and Sodium forms –  $\text{KMnO}_4$ ,  $\text{NaMnO}_4$ ), Hydrogen Peroxide ( $\text{H}_2\text{O}_2$ ), Ozone ( $\text{O}_3$ ), and Persulfate.

The attractiveness of in-situ chemical oxidation is that it is a relatively fast process. Most CVOCs are amenable to oxidation, and treatment can be completed in relatively short order. Generally the oxidation products are  $\text{CO}_2$ , water and chloride ion. The end products for the oxidants are generally innocuous. Ozone and peroxide generate oxygen and water; permanganate generates Manganese Dioxide ( $\text{MnO}_2$ ), an insoluble mineral. The permanganate also will leave the corresponding cation – potassium or sodium.



CBA has had tremendous success using potassium permanganate for oxidation of CVOCs, particularly trichloroethylene (TCE) and tetrachloroethylene (PCE).

Permanganate has been preferred as an oxidant over ozone and peroxide due to its resistance to auto decomposition and its effectiveness over a larger pH range. The stoichiometric reactions for the complete destruction of PCE and TCE utilizing potassium permanganate are as follows:



The stoichiometry indicates that approximately 1.3 pounds of permanganate is required to completely oxidize one pound of PCE. The equation, however, ignores oxygen demand inherent in the site soils due to natural organic material (NOM) and other reductants. Therefore, using a factor of three to ten times the weight ratio noted above is not uncommon.

Although the reaction mechanisms involved with oxidizing organic compounds sorbed to soils are not fully understood, the key to successful application is ensuring the contact between the oxidant and the contaminant. Typically the rate of contaminant degradation in heterogeneous matrices is controlled by the concentration of the oxidant, and any surface or subsurface structures as well as lithological changes can impede the success of in-situ chemical oxidation. However, CBA's patented MITU process is ideal for ensuring contaminant/reagent contact within vadose zone soils equating to appreciable contaminant degradation rates at lower than expected oxidant dosage rates. At a Wisconsin Hazardous Waste Site containing soils contaminated with chlorinated solvents, CBA used a combination of thermal treatment and chemical oxidation with potassium permanganate to achieve the required treatment objectives.

Typically, permanganate is applied to contaminated media as a solution or as a slurry; however, CBA applied potassium permanganate in its dry crystalline form (see photo, right). This method has proven to be successful in vadose zone soils having an adequate moisture content (>17%) and also in saturated soil conditions. In this application, the MITU is utilized to mix the  $\text{KMnO}_4$  directly into the soils. A water spray is typically used for dust control and to aid in the kinetics of the chemical oxidation.



## **5.0 TECHNICAL SUPPORT**

CBA is capable of offering varying degrees of technical support to consultants and site owners throughout the remedial investigation and design phases of environmental remediation projects. This technical support may include performing bench-scale treatability studies; providing details and cost estimates for various treatment approaches; and providing technical specifications for treatment technologies.

CBA has also developed several professional alliances within the scientific communities involving the research and development of innovative treatment technologies and approaches. CBA has solidified these alliances by entering into agreements which allow free exchange of information regarding environmental remediation efforts.

### **5.1 Carus Chemical**

One such strategic alliance that CBA has formed is with Carus Chemical Company, the largest and only producer of permanganate in the United States. CBA has worked very closely with Carus Chemical's Research and Development Division to optimize the effectiveness of applying  $\text{KMnO}_4$  to CVOC impacted soils via the MITU Technology. CBA and Carus often work together closely to provide a variety of services. One such service is a permanganate demand study.

In this type of study, contaminated soils are tested in the laboratory to determine the time incremental permanganate demand. The data obtained through these tests is useful for qualitatively assessing the feasibility of permanganate oxidation.

CBA also has the capability to perform more detailed bench-scale treatability studies that can provide additional information for determining expected permanganate dose rates. This information can be used to develop remediation cost estimates and for implementing field pilot studies.

## 6.0 CONCLUSION

Often times, relying on a single on-site treatment approach will prove to be too costly or the single approach will not be able to meet treatment objectives.

CBA Environmental Services' patented MITU Technology and its ability to deliver multiple reagents in varying subsurface conditions has revolutionized In/Ex-Situ rapid clean up of CVOC impacted soils. The MITU Technology facilitates the optimal soil conditions for reagent-contaminant contact, which equates to a more efficient and aggressive treatment approach. The ability to provide multiple approaches on a single site also allows CBA to offer a very cost effective site remediation and closure.

CBA will strive to remain on the leading edge of soil treatment technologies. As new and more challenging environmental concerns come to light, CBA will take the necessary steps to research the issue and find cutting edge solutions to the worlds most pressing environmental problems.

## **7.0 EXPERIENCE**

CBA has successfully completed numerous remediation projects involving the treatment of chlorinated volatile compounds at various site locations. The type of sites range from active dry-cleaning facilities to abandoned Superfund sites. In most cases, CBA has either served as the general contractor or as a specialty remediation contractor; whichever the case, CBA is comfortable with either role.

CBA has had a significant amount of experience with the handling and application of potassium permanganate for remedial uses. In fact, CBA was directly involved in the grass-roots development of the direct application of crystalline  $\text{KMnO}_4$  to contaminated soils. CBA's experience with thermal treatment is also noteworthy, as the thermal desorption process utilized by the MITU was developed by CBA. Continued developments to both processes are ongoing in order to keep pace with the latest technological advances.

CBA's projects have varied in size and location; the following case studies are representative of large, medium, and small sized projects.

### **7.1 Project Case Study – Milwaukee, Wisconsin**

This large-sized project was completed at a state Superfund site and involves the treatment of mixed waste (*organics & metals*); the primary organic constituents were PCE and TCE. The remedial approach included the thermal / chemical-oxidation treatment train. (*see case study pg. 7-2*)

### **7.2 Project Case Study – Arcade, New York**

This medium-sized project, completed for a Fortune 500 company, involved the thermal treatment of soil with multiple organic contaminants. However, the primary concern was TCE. (*see case study pg. 7-3*)

### **7.3 Project Case Study – Zieglerville, Pennsylvania**

This relatively small project was completed as an interim response action for the Pennsylvania Department of Environmental Protection. CBA's thermal treatment process was used to remediate soils impacted with TCE. (*see case study pg. 7-4*)

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