United States
Environmental Protection
Agency

Chlorine and Chlorinated Hydrocarbon Data Collection and Analysis Summary

February 2012

U.S. Environmental Protection Agency
Office of Water (4303T)
Washington, DC 20460

This document summarizes the data EPA collected in support of its effluent guidelines rulemaking for the Chlorine and Chlorinated Hydrocarbon (CCH) industry. EPA collected data to identify which CCH manufacturing processes generate dioxin and other toxic chemicals and how the resulting wastewater is treated prior to discharge. CCH comprises the following three manufacturing segments:

- Chlorine manufacturing;
- Chlorinated hydrocarbon manufacturing; and
- Polyvinyl chloride manufacturing.

All of the facilities where EPA collected data requested that their data be considered confidential business information (CBI). To protect facility confidentiality, EPA cannot provide site visit or sampling reports in the public docket. In an effort to share findings without compromising CBI, EPA is summarizing its data collection in this document:

- Section 1 describes the scope of the CCH industry;
- Section 2 describes the site visit program;
- Section 3 describes the EPA sampling program;
- Section 4 describes the voluntary sampling program (VSP) implemented by some facilities;
- Section 5 describes the dioxin analysis; and
- Section 6 provides a summary.

Appendix A provides a list of the site visits and sampling episodes conducted during the CCH data collection. Appendix B presents a list of CCH facilities as of 2006, the start of the rulemaking project.

1. Scope of the CCH Manufacturing Segments

In the 2004 Effluent Guidelines Plan (69 FR 53712), EPA found that, despite existing regulations, significant amounts of dioxin and other toxic pollutants are discharged from facilities manufacturing chlorine (by the chlor-alkali process), ethylene dichloride (EDC), vinyl chloride monomer (VCM), and polyvinyl chloride (PVC). EDC is produced by direct chlorination or oxychlorination, VCM is produced by dehydrochlorination, and PVC by the polymerization of VCM. EPA identified chlor-alkali, EDC, VCM, and PVC manufacturing operations as possible candidates for effluent limitations guidelines and standards (ELG) revision.

During 2005, EPA identified other manufacturing processes that operate under similar conditions to the chlor-alkali, EDC, and VCM processes, and therefore have the potential to generate and discharge dioxin. EPA identified this facility group based on common practices – chlorine manufacture and use of chlorine in certain chemical manufacturing. EPA decided to expand the manufacturing operations considered for revised ELGs to include all chlorine manufacturing including manufacturing by other processes such as Downs Sodium and Uhde-HCl. EPA also identified additional chlorinated hydrocarbons manufactured by direct chlorination, oxychlorination, dehydrochlorination, or hydrochlorination. Therefore, EPA expanded the scope of the potential ELG revisions to the manufacture of chlorine and chlorinated hydrocarbons and refers to this industry group as the Chlorine and Chlorinated Hydrocarbon (CCH) manufacturing segments. CCH comprises the following three manufacturing segments:

- Chlorine manufacturing;
- Chlorinated hydrocarbon manufacturing; and
- Polyvinyl chloride manufacturing.

Chlorinated hydrocarbons that are regulated under the Pesticide Chemicals Point Source Category (40 CFR Part 455) or under the Pharmaceuticals Manufacturing Point Source Category (40 CFR 439) are not included in the CCH manufacturing segments.

2. SITE VISIT PROGRAM

During 2005 and 2006, EPA visited 13 CCH facilities covering a range of manufacturing and treatment processes. The purpose of the site visit program was to gather:

1. General information about the site and manufacturing operations.
2. Process-specific information including wastestreams generated.
3. Information on pollution prevention and wastewater treatment.
4. Information for potential wastewater sampling including facility-specific health and safety requirements and location of potential sampling points.

EPA selected facilities for site visits from information in National Pollutant Discharge Elimination System (NPDES) permits, discharge monitoring reports (DMRs), Clean Water Act Section 308 survey responses conducted during the development of the 2004 Effluent Guidelines Plan, location, and type of manufacturing process. EPA visited sites with a variety of facility characteristics including:

- Production technology (e.g., chlor-alkali cell type);
- Dioxin-control technology (e.g., tertiary solids removal treatment);
- Discharge practices;
- Geographic location;
- Manufacturing processes onsite (i.e., facilities solely operating CCH process lines vs. integrated facilities manufacturing multiple chemicals); and
- Treatment processes (i.e., facilities using current state-of-the-art practice).

EPA documented each of the 13 site visits in a site visit report which provided general background information on the facility, descriptions of all CCH manufacturing processes including diagrams showing all wastestreams generated, a description of wastewater treatment processes with supporting diagrams, and a list of potential sampling points. EPA delivered drafts of the site visit reports to each facility for review and incorporated any changes requested by the facility to accurately capture the information collected.

3. EPA SAMPLING PROGRAM

EPA conducted sampling at four different facilities as part of the EPA sampling program. The purpose of the EPA sampling program was to:

1. Characterize process wastewater streams to determine where dioxin is formed in the process.
2. Determine the concentration and quantity of dioxin generated and discharged.
3. Evaluate treatment technologies that may represent best available technology (BAT) treatment for dioxin.

The majority of CCH facilities employ biological treatment to remove organics generated in the manufacturing process. Because dioxin is hydrophobic and adheres to solids, removing solids or sludges will likely be effective in removing dioxin from wastewater. CCH facilities may reduce dioxin in wastewater by removing solids in segregated streams.

EPA selected the sites for sampling based on the manufacturing processes performed at the site and the treatment technology employed. EPA selected four facilities that would cover the majority of CCH manufacturing processes. Because many CCH facilities also manufacture non-CCH chemicals, EPA selected sample locations to capture CCH wastewater prior to commingling with other facility wastewater.

Prior to conducting the sampling episode, EPA developed Sampling Plans for each facility with the following information:

- Detailed description of the facility's operations including diagrams with the sampling points;

- Proposed sampling approach including the rationale for selecting the sampling point locations, the analytes included, the number of samples to be collected, the sampling methodology including the quality assurance samples to be collected, and the field and process operating data to be collected;

- Description of the sampling activities including the organization of the team of EPA and contractor staff conducting the sampling episodes, a list of sampling preparation and field sampling activities, and contact information for all facility, EPA, and contractor staff.

- List of the sampling shipping procedures; and

- Site-specific health and safety requirements.

Although EPA's focus was on collecting data to characterize the generation and treatment of dioxin, EPA also included the following analytes in the first two sampling episodes. EPA reviewed the results from the initial sampling episodes to reduce the list of analytes for the remaining three episodes based on the pollutants detected in CCH wastewater. The analytes flagged with an (*) were not collected during the remaining three sampling episodes.

- Classicals:
  - Biochemical oxygen demand, 5-day (BOD_5),
  - Chemical oxygen demand (COD),
  - Total organic carbon (TOC),
  - Total suspended solids (TSS),
  - Total dissolved solids (TDS),
  - Total Kjeldahl nitrogen (TKN)*,
  - Ammonia as nitrogen*,
  - Nitrate/nitrite as nitrogen*,
  - Total phosphorus*,
  - Sulfate,
  - Chloride,
  - Alkalinity,
  - Hexane extractable material (HEM)*,
  - Silica-Gel Treated Hexane Extractable Material (SGT-HEM)*.

- Metals;

- Organics:
  - Volatile organics, and
  - Semivolatile organics; and

- Chlorinated biphenyls congeners (PCBs); and

- Dioxin and furan congeners (dioxin).

EPA conducted the sampling episodes in 2006 and 2007. Each episode collected 24-hour composite samples over either a two-day or four-day period. EPA developed two summary reports for each sampling episode to document the results:

1. Sampling Episode Report (SER) – The SER documented the sampling procedures and any deviations from the sampling plan. It includes the operational data collected during the episode and presents the analytical results.

2. Engineering Review – The engineering review presents additional information on the analytical data including a discussion of any data quality issues, a comparison of results to the analytical method minimum level, a discussion of data variability, if applicable, and the calculation of pollutant loadings using concentration and flow data.

4. VOLUNTARY SAMPLING PROGRAM

In February 2007, U.S. VCM manufacturers (referred to as the vinyl chloride producers or VCP) proposed a voluntary sampling program to provide EPA with dioxin data from all VCM manufacturing facilities. The proposed voluntary program included all 13 (consisting of 12 existing and 1 future) U.S. EDC/VCM manufacturing sites. The proposed program focused on vinyl chloride manufacturing sites because of industry knowledge, based primarily on the Vinyl Institute Dioxin Characterization study, that the oxychlorination process and the thermal oxidation of chlorinated hydrocarbons are potential dioxin sources in the CCH manufacturing segments.[1]

Under the voluntary program, the VCP proposed to first analytically calculate a quantitative baseline of dioxin surface wastewater discharges from participating VCP sites through a voluntary sampling program (VSP). The VCP then proposed to achieve, as an initial target, maximum dioxin mass discharges equivalent to process wastewater flow multiplied by 0.1 ng/L I-TEQ, on a collective, 12-facility basis. For the sum of discharges from the 12 EDC/VCM facilities, the maximum daily discharge was thus proposed to be no more than 42 milligrams of dioxin per day (I-TEQ).[2]

EPA developed a generic sampling plan and site-specific sampling plans for the VSP which described the locations to be sampled and the sampling methodology. The purpose of the VSP was to characterize process wastewater from CCH manufacturing operations prior to commingling with non-CCH wastewater. The facilities analyzed samples for dioxin and total suspended solids (TSS) for each sampling point selected. For stand-alone CCH facilities that do not operate non-CCH manufacturing processes, facilities collected samples from the wastewater treatment effluent. For integrated facilities where CCH process wastewater is significantly diluted with other non-CCH wastewater before treatment, facilities sampled streams representing all CCH processes prior to entering the combined wastewater treatment system. Facilities also collected a sample at their final outfall.

Each facility conducted at least four 24-hour sample composite collections spaced at least one month apart, or as needed to capture all relevant site operating modes. Facilities were to consider various operating modes in selecting the number and frequency of sampling episodes to capture representative operations. In addition to the dioxin and TSS analytical results, facilities also provided operational data and sampling log sheets for the sample collection period.

Facilities collected the samples in 2008 and 2009 and provided data to EPA in 2009 and early 2010. EPA developed site-specific SERs for each facility similar to the SERs developed for the

[1] Vinyl Institute. 2002. *The Vinyl Institute Dioxin Characterization Program Final Report.* (July 1).

[2] Because it directly addressed dioxin in wastewater from EDC/VCM facilities, the VCP selected the European Commission Integrated Pollution Prevention and Control (IPPC) *Reference Document on Best Available Techniques (BAT) in the Large Volume Organic Chemical Industry*[2] as the basis for the voluntary program. The IPPC document identifies a BAT maximum concentration of 0.1 nanogram per liter, international toxic equivalent basis (ng I-TEQ/L) for dioxin congeners in treated EDC/VCM wastewater.

EPA sampling program. All facilities claimed their data as CBI; therefore, these reports are not included in the public docket.

5. DIOXIN ANALYSIS

EPA identified the CCH manufacturing segments as potential wastewater sources of dioxin. Because dioxin is the toxic pollutant of concern in the CCH manufacturing segments, EPA focused the analysis of the EPA and voluntary sampling data on dioxin. This section provides background on dioxin and describes EPA's dioxin calculation methodology.

5.1 Dioxin Background

The term "dioxins" refers to a group of compounds that have similar chemical and physical properties and are associated with a common group of toxic responses. Table 1 lists the 17 dioxin and furan congeners that exhibit dioxin-like toxicity and that are referred to as dioxin. The most widely studied of the congeners listed in Tables 1 is 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) which serves as the reference chemical for other compounds that exhibit dioxin-like toxicity. Table 1 also provides the toxic equivalency factors (TEFs) and toxic weighting factor (TWFs), which are explained below. Section 5.2 provides information on EPA's dioxin calculation methodology.

Table 1. Dioxin-Like CDD and CDF Congeners

CAS Number	Chemical Name	Abbreviated Name	WHO 1998 Toxic Equivalency Factor (TEF)	Toxic Weighting Factors
CDDs				
1746-01-6	2,3,7,8-tetrachlorodibenzo-p-dioxin	2,3,7,8-TCDD	1	703,584,000
40321-76-4	1,2,3,7,8-pentachlorodibenzo-p-dioxin	1,2,3,7,8-PeCDD	1	692,928,000
39227-28-6	1,2,3,4,7,8-hexachlorodibenzo-p-dioxin	1,2,3,4,7,8-HxCDD	0.1	23,498,240
57653-85-7	1,2,3,6,7,8-hexachlorodibenzo-p-dioxin	1,2,3,6,7,8-HxCDD	0.1	9,556,480
19408-74-3	1,2,3,7,8,9-hexachlorodibenzo-p-dioxin	1,2,3,7,8,9-HxCDD	0.1	10,595,840
35822-46-9	1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin	1,2,3,4,6,7,8-HpCDD	0.01	411,136
3268-87-9	1,2,3,4,6,7,8,9-octachlorodibenzo-p-dioxin	1,2,3,4,6,7,8,9-OCDD	0.0001	6,586
CDFs				
51207-31-9	2,3,7,8-tetrachlorodibenzofuran	2,3,7,8-TCDF	0.1	43,819,554
57117-41-6	1,2,3,7,8-pentachlorodibenzofuran	1,2,3,7,8-PeCDF	0.05	7,632,640
57117-31-4	2,3,4,7,8-pentachlorodibenzofuran	2,3,4,7,8-PeCDF	0.5	557,312,000

Table 1. Dioxin-Like CDD and CDF Congeners

CAS Number	Chemical Name	Abbreviated Name	WHO 1998 Toxic Equivalency Factor (TEF)	Toxic Weighting Factors
70648-26-9	1,2,3,4,7,8-hexachlorodibenzofuran	1,2,3,4,7,8-HxCDF	0.1	5,760,000
57117-44-9	1,2,3,6,7,8-hexachlorodibenzofuran	1,2,3,6,7,8-HxCDF	0.1	14,109,440
72918-21-9	1,2,3,7,8,9-hexachlorodibenzofuran	1,2,3,7,8,9-HxCDF	0.1	47,308,800
60851-34-5	2,3,4,6,7,8-hexachlorodibenzofuran	2,3,4,6,7,8-HxCDF	0.1	51,204,160
67562-39-4	1,2,3,4,6,7,8-heptachlorodibenzofuran	1,2,3,4,6,7,8-HpCDF	0.01	85,760
55673-89-7	1,2,3,4,7,8,9-heptachlorodibenzofuran	1,2,3,4,7,8,9-HpCDF	0.01	3,033,984
39001-02-0	1,2,3,4,6,7,8,9-octachlorodibenzofuran	1,2,3,4,6,7,8,9-OCDF	0.0001	2,021

Source: Van den Berg, et.al. 1998. *Toxic Equivalency Factors (TEFs) for PCBs, PCDDs, PCDFs for Humans and Wildlife*. Environmental Health Perspectives. Volume 106, Number 12, December 1998.
U.S. EPA. 2006. *Toxic Weighting Factor Development in Support of CWA 304(m) Planning Process,* Washington, DC. (June). EPA-HQ-OW-2004-0032-1634.

Since 1987, EPA has assigned TEFs to dioxin congeners to calculate a toxic equivalency (TEQ) for mixtures of the congeners. TEFs provide a method for evaluating the toxicity of dioxin congeners compared to the toxicity of TCDD. TEF values are not calculated, but are assigned values determined by a panel of experts that evaluates the available scientific data, taking into account chemical structure, persistence, resistance to metabolism, and uncertainties inherent in scientific literature. TEF values range from 1.0 to 0.0001 with 1.0 representing the toxicity of 2,3,7,8-TCDD, which is considered the most toxic dioxin congener. TEF values are constantly under review as new toxicity information becomes available. Since EPA's initial review in 1987, the North Atlantic Treaty Organization (NATO) in 1989 and the World Health Organization (WHO) in 1994 and in 1998 have released TEF values based on different weighting factors and the most recent scientific data available at the time. Table 1 presents the commonly accepted 1998 WHO TEF values.

TWFs are another approach for measuring the relative toxicity of dioxin to other chemicals. EPA's Engineering and Analysis Division (EAD) developed TWFs to use in ELG development programs. The purposes of TWFs are to account for differences in toxicity among pollutants of concern in a given ELG and to provide a means for comparing mass loadings of different pollutants on the basis of their toxic potential. According to EPA's *t Toxic Weighting Factor Development in Support of the Clean Water Act 304(m) Planning Process*[3], TWFs are derived from chronic aquatic life criteria or toxic effect levels and human health criteria or toxic effect levels established for the consumption of fish. In the TWF method for assessing water-based

[3] U.S. EPA. 2006. *Toxic Weighting Factor Development in Support of CWA 304(m) Planning Process,* Washington, DC. (June). EPA-HQ-OW-2004-0032-1634.

effects, the toxicity levels of pollutants are compared to a benchmark value that represents the toxicity level of a specified pollutant. EPA selected copper, a metal commonly detected and removed from industrial effluent, as the benchmark pollutant. To assign TWF values, EPA/EAD maintains a database of aquatic life and human health toxicity data, as well as physical/chemical property data for more than 1,900 pollutants compiled from over 100 references. TWF values are determined based on the toxic aquatic life effects and human health effects values stored in the database. Table 1 also lists the dioxin TWFs.

EPA's National Center for Environmental Assessment is currently working on a comprehensive reassessment of dioxin exposure and human health effects. EPA published the *Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds* in December 2003. This document is undergoing revisions after review by the National Academy of Sciences. In May 2010, EPA released its draft *Reanalysis of Key Issues Related to Toxicity and Response to NAS Comments (Reanalysis)* for public comment and peer review. On August 29, 2011, EPA announced a plan for moving forward with the dioxin *Reanalysis* and will release Volume 1 of the *Reanalysis* in early 2012.

5.2 Dioxin Calculation Methodology

To compare the dioxin concentrations obtained through the EPA and voluntary sampling programs to the VCP's proposed limit of 0.1 ng/L TEQ, EPA converted the dioxin concentrations from units of ng/L or pg/L to units of ng TEQ/L. Many of the dioxin concentrations from both sampling programs were below levels of detection or at levels less than the minimum calibration level but greater than the estimated detection limit ('J' flag). EPA followed the methodology below in calculating average dioxin concentrations and total toxic equivalencies (TEQs) for non-detects.

1. Non-detect (U-flag) –For each congener, identify the number of detected samples and non-detect samples in the data set[4]:

   a. If at least one sample in the data set is detected, then:

      i. If any of the detected samples has a 'J' flag, then calculate the concentrations for the non-detects as follows:

         $Conc_{congener} = 0$

      ii. If none of the detected samples has a 'J' flag, then calculate the concentrations for the non-detects as follows:

         $Conc_{congener} = ½ \text{ detection limit}$

[4] A Data Set is either the full set of results from the VSP which consists of four days of sampling at least one month apart or the results from the EPA Sampling episode which consists of either two or four consecutive days of sampling.

iii. Calculate the concentrations for the detected samples, regardless of flags, as follows:

$Conc_{congener}$ = reported concentration

b. If all samples in the sampling episode are non-detect, then:

$Conc_{congener} = 0$

2. Calculate average concentration of individual congener for the data set:

$Avg_{congener} = \sum Conc_{congener}$ / # sampling periods

3. Calculate individual congener TEQ using the WHO-1998 toxic equivalency factors (TEFs) shown in Table 3:

$TEQ_{congener} = TEF_{congener} \times Avg_{congener}$

4. Total TEQ concentration = $\sum TEQ_{congener}$ (for all congeners)

EPA used a similar methodology to calculate the toxic-weighted pound equivalent (TWPE) of dioxin using the TWFs reported in Table 1, the average concentration by congener, and the sampling point stream flowrate.

5. Calculate individual congener TWPE using the TWFs shown in Table 1:

$TWPE_{congener}$ (lb/year) = $TWF_{congener} \times Avg_{congener}$ (pg/L) x Flowrate (gal/day) x conversion factors

6. Total TWPE = $\sum TWPE_{congener}$ (for all congeners)

6. SUMMARY

EPA used the CBI sampling data to compute total dioxin concentrations and loads for all congeners for the streams included in the EPA and voluntary sampling programs. EPA used the results of the dioxin analysis to answer the following questions:

- What are the sources of dioxin in CCH wastewater?
- Is dioxin being discharged to receiving streams from CCH facilities?
- Is dioxin removed by CCH wastewater treatment?

EPA found that the vinyl chloride manufacturing process is the source of dioxin in the CCH manufacturing segment. EPA found very low levels of dioxin in the PVC manufacturing segment. Similarly, EPA calculated very low dioxin levels at all but one facility manufacturing chlorine. Although vinyl chloride manufacturers discharge the majority of dioxin for the CCH manufacturing segments, one facility accounts for the vast majority of dioxin being discharged. In addition, the majority of chlorinated hydrocarbon manufacturing facilities have wastewater treatment technology that would potentially match "best available technology" for the industry. Therefore, EPA will work with the few facilities with significant dioxin discharges through permitting and will not move forward with the development of effluent guidelines for the CCH manufacturing segments.

Appendix A. Summary of CBI Reports Generated During CCH Data Collection[a]

		Reports Generated					
Facility	Location	Site Visit Report	EPA Sampling Plan	EPA Sampling Episode Report	EPA Sampling Engineering Report	VSP Sampling Plan	VSP Sampling Episode Report
Dow Chemical Co.	Freeport, TX	X	X	X	X	X	X
Dow Chemical Co.	Plaquemine, LA	X				X	X
Formosa Plastics Corp.	Baton Rouge, LA	X				X	X
Formosa Plastics Corp.	Delaware City, DE	X					
Formosa Plastics Corp.	Point Comfort, TX	X				X	X
Georgia Gulf Corp.	Lake Charles, LA					X	X
Georgia Gulf Corp.	Plaquemine, LA	X				X	X
OxyVinyls	Deer Park, TX					X	X
OxyVinyls	Ingleside, TX	X	X	X	X	X	X
OxyVinyls La Porte VCM	La Porte, TX	X	X	X	X	X	X
OxyVinyls Battleground Chlor-Alkali	La Porte, TX	X					
OxyVinyls Pasadena PVC	Pasadena, TX	X					
Pioneer (now Olin)	St. Gabriel, LA	X					
PPG Industries, Inc.	Lake Charles, LA	X				X	X
Shintech, Inc.	Addis, LA	X	X	X	X		
Westlake	Calvert City, KY					X	X
Westlake	Geismar, LA					X	X

[a]All reports are considered Confidential Business Information and are not included in the public docket.

Appendix B. CCH Facility List (2006)

Facility Name	Location
Chlorine Only	
ASHTA Chemicals, Inc.	Ashtabula, OH
Bayer Corp.	Baytown, TX
DuPont	Niagara Falls, NY
ERCO Worldwide	Port Edwards, WI
General Electric Co.	Burkville, AL
General Electric Co.	Mt. Vernon, IN
Georgia Pacific Corp.	Green Bay, WI
Georgia Pacific Corp.	Muskogee, OK
Georgia Pacific Corp.	Rincon, GA
Kuehne Chemical Co., Inc.	Delaware City, DE
Kuehne Chemical Co., Inc.	South Kearny, NJ
Olin Corp.	Augusta, GA
Olin Corp.	Charleston, TN
Olin Corp.	McIntosh, AL
Olin Corp.	Niagara Falls, NY
Olin (formerly Pioneer)	Henderson, NV
Olin (formerly Pioneer)	St. Gabriel, LA
OxyChem	Convent, LA
OxyChem	Hahnville, LA
OxyChem	Mobile, AL
OxyChem	Muscle Shoals, AL
OxyChem	Niagara Falls, NY
OxyVinyls Battleground	La Porte, TX
Titanium Metals Corporation of America (TIMET)	Henderson, NV
US Magnesium	Salt Lake City, UT
Chlorinated Hydrocarbon Only	
Dover Chemical Corp.	Dover, OH
Dover Chemical Corp.	Hammond, IN
Dow Corning	Carrollton, KY
DuPont Performance Elastomers	La Place, LA
DuPont Performance Elastomers	Louisville, KY
Ferro Corp.	Bridgeport, NJ
Hexion Specialty Chemicals, Inc.	Norco, LA
OxyVinyls Deer Park	Deer Park, TX
OxyVinyls La Porte	La Porte, TX
Velsicol Chemical Corp.	Memphis, TN
Westlake Monomers	Geismar, LA
PVC Only	
Certainteed Corp.	Westlake, LA

Facility Name	Location
Colorite Specialty Resins	Burlington, NJ
Dow Chemical Co.	Texas City, TX
Formosa Plastics Corp.	Delaware City, DE
Georgia Gulf Corp.	Aberdeen, MS
Georgia Gulf Corp.	Oklahoma City, OK
OxyVinyls	Louisville, KY
OxyVinyls	Pedricktown, NJ
OxyVinyls Deer Park PVC	Deer Park, TX
OxyVinyls Pasadena PVC	Pasadena, TX
Polyone Corp.	Henry, IL
Polyone Corp.	Louisville, KY
Polyone Corp.	Pedricktown, NJ
Shintech, Inc.	Addis, LA
Shintech, Inc.	Freeport, TX
Westlake PVC Corp	Calvert City, KY
Westlake Monomers	Geismar, LA
Integrated Facilities – Facilities manufacture chemicals in more than one CCH segment	
Dow Chemical Co.	Freeport, TX
Dow Chemical Co.	Plaquemine, LA
Formosa Baton Rouge	Baton Rouge, LA
Formosa Plastics Corp.	Point Comfort, TX
Georgia Gulf Corp.	Plaquemine, LA
OxyChem	Geismar, LA
OxyChem	Wichita, KS
OxyVinyls	Ingleside, TX
PPG Industries, Inc.	Lake Charles, LA
PPG Industries, Inc.	Natrium, WV
Shintech, Inc.	Plaquemine, LA
Westlake Monomers	Calvert City, KY