

EPA/600/R-01/012
March 2001
Final
www.epa.gov/ncea

User's Manual for the Database of Sources of Environmental
Releases of Dioxin-Like Compounds in the United States:
Reference Years 1987 and 1995

Exposure Assessment and Risk Characterization Group
National Center for Environmental Assessment - Washington Office
Office of Research and Development
U.S. Environmental Protection Agency
Washington, DC 20460

DISCLAIMER

This document has been reviewed in accordance with the U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

ACKNOWLEDGMENTS

The National Center for Environmental Assessment (NCEA) within EPA's Office of Research and Development was responsible for the preparation of this document. General support was provided by Versar Inc. under EPA Contract Numbers 68-D5-0051 and 68-W-99-041. David Cleverly of NCEA served as the EPA Work Assignment Manager providing overall direction and coordination of the production effort as well as technical assistance and guidance.

TABLE OF CONTENTS

| | <u>Page No.</u> |
|--|-----------------|
| 1. INTRODUCTION | 1 |
| 2. USING THE DATABASE | 2 |
| 2.1 GETTING STARTED | 3 |
| 2.2 SOURCE CATEGORY INTERFACE | 6 |
| 2.3 FACILITY DATA FILES | 9 |
| 2.4 USER NOTES | 10 |
| 3. DATABASE STRUCTURE | 10 |
| 3.1 OVERALL STRUCTURE | 10 |
| 3.2 SUMMARY FILE STRUCTURE | 14 |
| 3.3 DATA FILE STRUCTURE | 16 |
| 3.3.1 Worksheet 1 - Facility Data | 16 |
| 3.3.2 Worksheet 2 - Emission Factor (EF) | 17 |
| 3.3.3 Worksheet 3 - TEQ Emission Factors | 17 |
| 3.3.4 Miscellaneous Worksheets | 17 |
| 4. CALCULATIONS AND QUALITY CONTROL MEASURES | 26 |
| 4.1 STANDARDIZATION | 26 |
| 4.2 CALCULATION OF EMISSION FACTORS | 27 |
| 4.3 QUALITY CONTROL MEASURES | 28 |
| 5. ANNUAL CDD/CDF EMISSION CALCULATIONS | 29 |
| BIBLIOGRAPHY | 37 |

LIST OF TABLES

| | <u>Page No.</u> |
|--|-----------------|
| Table 1. A Sample of Summary Table in the Source Category Summary File | 8 |
| Table 2. TEF Schemes for CDD/CDFs | 11 |
| Table 3. Database Directory Breakdown | 13 |
| Table 4. Data Fields for Facility Data Worksheet | 18 |
| Table 5. Emission Factor (EF) Worksheet Contents | 22 |
| Table 6. TEQ Emission Factor (EF) Worksheet Contents | 24 |
| Table 7. Confidence Rating Scheme for U.S. Emission Estimates | 32 |
| Table 8. List of Known and Suspected CDD/CDF Sources | 34 |

LIST OF FIGURES

| | |
|---|----|
| Figure 1. National Database Introductory Screen | 3 |
| Figure 2. Search Dioxin Database Screen | 4 |
| Figure 3. Search Dioxin Database based on Combustion Category | 5 |
| Figure 4. Search Dioxin Database Results | 5 |
| Figure 5. Source Category Interface | 7 |
| Figure 6. Database Directory Structure | 12 |
| Figure 7. Example of a Summary File | 15 |
| Figure 8. Example of the Facility Data Sheet in a Facility Data File | 21 |
| Figure 9. Example of an Emission Factor Sheet in a Facility Data File | 23 |
| Figure 10. Example of a TEQ Sheet in a Facility Data File | 25 |
| Figure 11. Sample CDD/CDF Concentration Standardization Calculation | 27 |
| Figure 12. Sample Emission Factor Calculations | 28 |

1. INTRODUCTION

The *National Database of Sources of Environmental Releases of Dioxin-like Compounds in the United States* has been developed by EPA's Office of Research and Development (ORD) to be a repository of congener-specific chlorinated dibenzo-p-dioxin/dibenzofuran (CDD/CDF) emission data extracted from original test reports. The database was designed to accommodate facility-based emission data, as well as non-facility based sources (e.g., mobile sources such as automobiles, and area sources such as residential wood combustion). Test reports from various State agencies, trade associations, EPA program offices, and EPA regulatory dockets were consolidated and assimilated into the database. Most of the emission data in Version 3.0 of the database concern releases to air because few data are currently available on releases to other media.

The database contains information that can be analyzed to track emissions of CDD/CDF over time, compare homologue and congener profiles between and among source categories, and develop source-specific emission factors that can then be used to develop emission estimates. In a separate report (Volume 1, *Sources of Dioxin-Like Compounds in the United States*) (U.S. EPA, 2001), ORD has used the database to develop a national inventory of annual releases from a variety of sources for two reference years: 1987 and 1995. EPA selected 1987 primarily because, prior to this time, little empirical data existed for making source specific emission estimates. The year 1987 also corresponds roughly with the time when significant advances occurred in emissions measurement techniques and in the development of high resolution mass spectrometry and gas chromatography necessary for analytical laboratories to achieve low level detection of CDD and CDF congeners in environmental samples. Soon after this time, a number of facilities began upgrades specifically intended to reduce CDD/CDF emissions. Consequently, 1987 is also the latest time representative of the emissions occurring before widespread installation of dioxin-specific emission controls.

EPA selected 1995 as the latest time period that could practically be addressed consistent with the time table for producing the rest of the document. The data collected in the companion document to this document on CDD/CDF and dioxin-like PCB levels in environmental media and food were used to characterize conditions in the mid-1990s. So the emissions data and media/food data in these two volumes are presented on a roughly consistent basis. Since 1995, EPA has promulgated regulations limiting CDD/CDF emissions for a number of the source categories that contribute to the inventory including municipal waste combustors, medical waste incinerators, hazardous waste incinerators, cement kilns burning hazardous waste, and pulp and paper facilities using chlorine bleached processes. Consequently, the estimate of releases in

the 1995 inventory should not be assumed to accurately represent post-1995 releases. EPA intends to periodically revise this inventory.

The remainder of this document is divided into four sections. Instructions for using the database are discussed in Section 2. The structure of the database and the flow of information into and out of the database are described in Section 3. Assumptions made to standardize the data are described in Section 4 and sample calculations are provided in Section 5. Section 5 also describes the process used in U.S. EPA (2001) to develop nationwide annual CDD/CDF TEQ emission estimates based, to a large extent, on emission factors calculated using this database.

The *National Database* was created using Microsoft Excel 97[®] (hereafter, Excel 97[®]) in the manner of linked “workbooks.” Certain calculations and manipulations of data performed in Excel[®] may be lost if the database is converted for use with other software; therefore, any recalculations for the data in the *National Database* should be performed using Excel[®]. The Excel[®] workbooks should be compatible with the MacPower version of Excel.

Because the database is stored on a CD-ROM, a CD player is required for use. Although there do not appear to be any memory constraints in using the CD-ROM, a computer with a 486 or Pentium processor and an adequate amount of RAM should be used.

2. USING THE DATABASE

Version 1.2 of the *National Database* was created in Excel 97[®]. This version of the database contains an interface that allows the user to link summary and individual facility files from an introductory screen (i.e. the main table) via the “hyperlink” function provided by Excel 97[®]. The user must first select which TEQ version of the Database to use (i.e., “I-TEFs” or “WHO98TEFs”).

Version 3.0 of the *National Database* features a user-friendly interface (Figure 1), which has been designed to help users quickly locate information in the Database. Search capabilities have also been included in the Database to allow the user to locate facility emissions based on an EPA Identification Number, the State, the Facility’s Name, or the Facility’s Combustion Category.

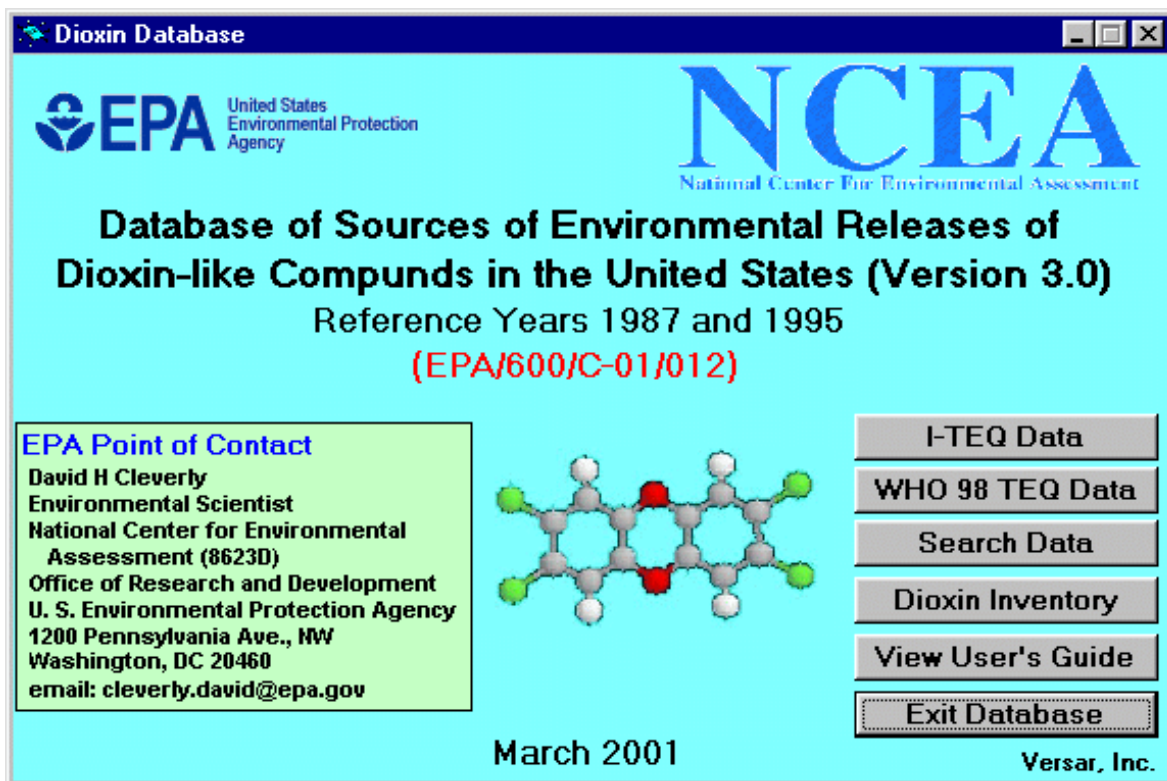


Figure 1. National Database Introductory Screen

2.1 GETTING STARTED

The *National Database* should automatically start upon placing the CD into the CD-ROM drive. However, if the introductory screen does not appear after a few seconds, use the following steps to start the database:

- Open **Windows Explorer**.
- Select the drive which represents the CD-ROM and open the introductory screen by clicking **DioxinDb**, the file name of the dioxin database executable file.

Note: The DioxinDb program will only work for Windows-based computers. Computers with other operating systems should proceed to Section 3.1 for a discussion of the CD's directory structure.

The introductory screen for the *National Database* allows the user to select from the I-TEQ data, the WHO 98 TEQ data, or to search for data in the database. The introductory screen also allows the user to view the User's Guide and the Dioxin Inventory of I-TEQ_{DF} and TEQ_{DF}-WHO₉₈ releases for 1995 and 1987, both PDF files. Selecting the **I-TEQ Data** button or the **WHO 98 TEQ Data** button will open the appropriate Source Category Interface. The Source

Category Interfaces are Excel 97[®] files which allow the user to view data based on the combustion source category. For more information on these interfaces, please refer to Section 2.2.

To search the *National Database* for data from a particular facility, the user should select the **Search Data** button. Upon pressing this button the Search Dioxin Database screen should appear (Figure 2). The user can search for data based on an EPA Identification number, a State of interest, a Facility's Name, or by Combustion Category.

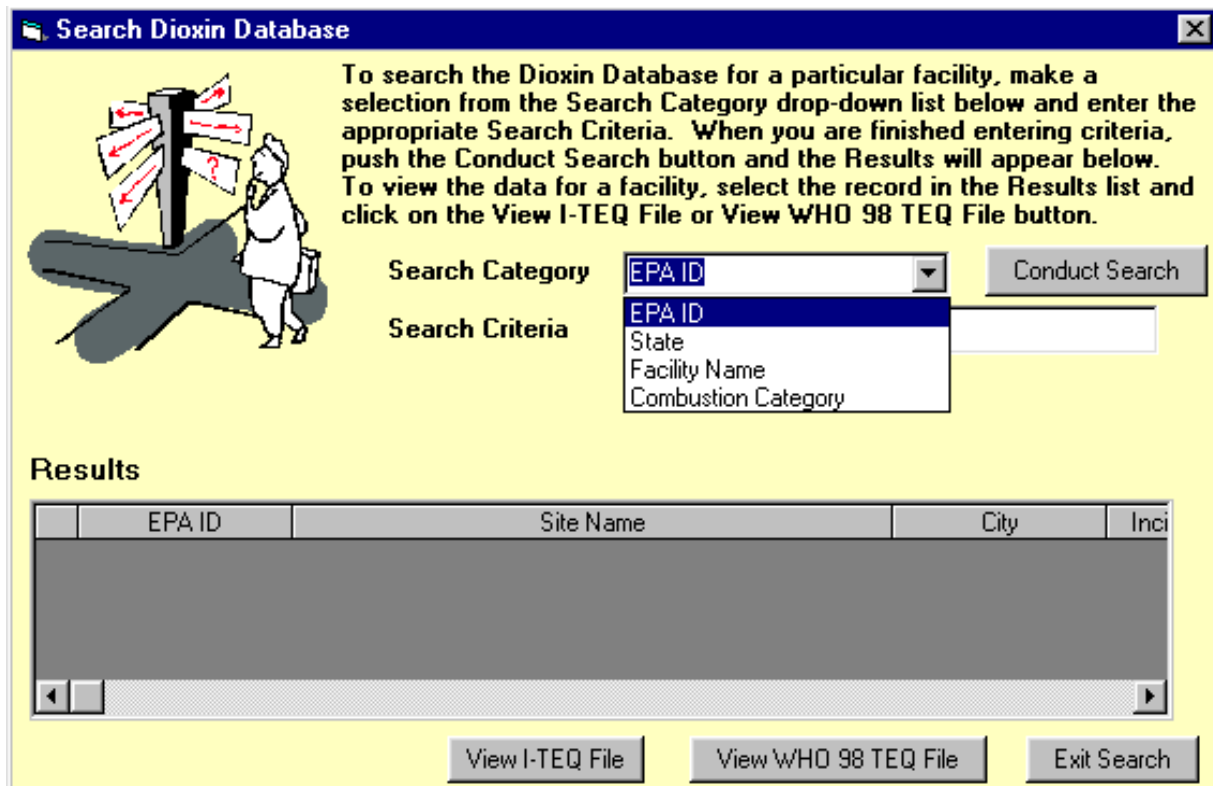


Figure 2. Search Dioxin Database Screen

To search the database, the user should first select the desired **Search Category** from the drop-down list. If the user decides to search for data based EPA ID and Facility Name, a text box will appear that will allow the user to enter the EPA ID or facility name. If the user chooses to search for data based on a State of interest or a Combustion Category, a drop-down list will appear providing the user with applicable choices (Figure 3). Next, the user should enter or select the appropriate **Search Criteria** in the text box or drop-down list which appears and push the **Conduct Search** button. The results of the search will appear in the **Results** table (Figure 4). If none of the records in the *National Database* meet the criteria entered, the **Results** table will appear blank.

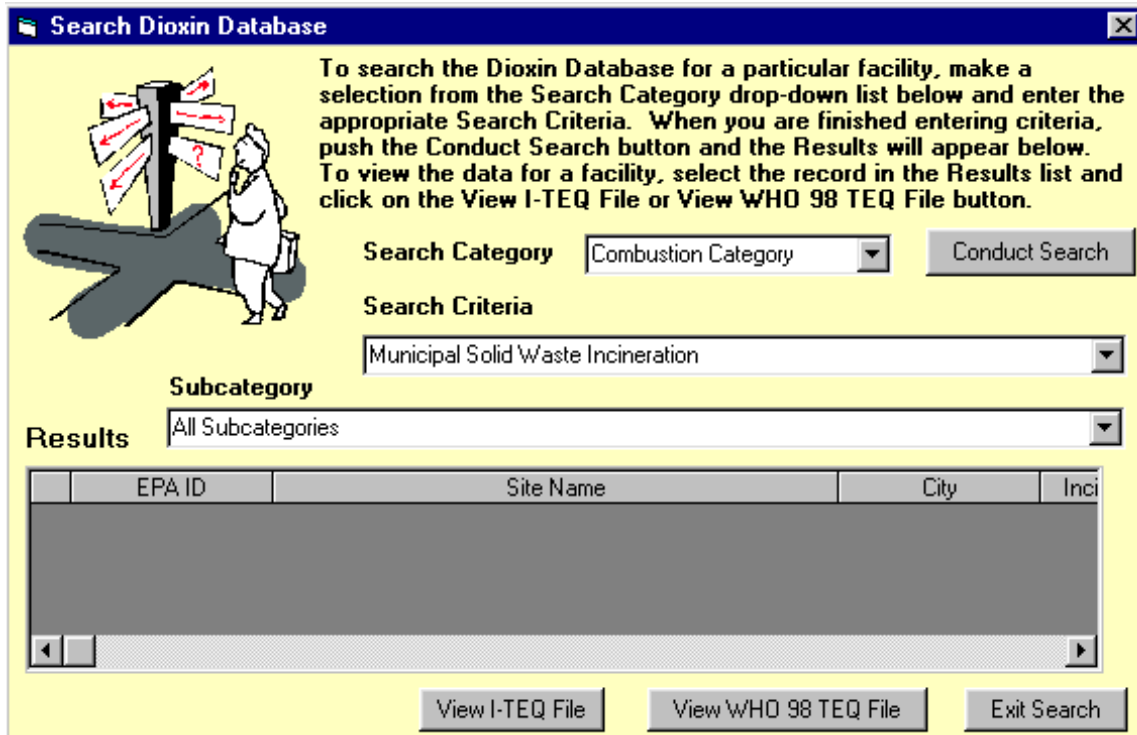


Figure 3. Search Dioxin Database based on Combustion Category

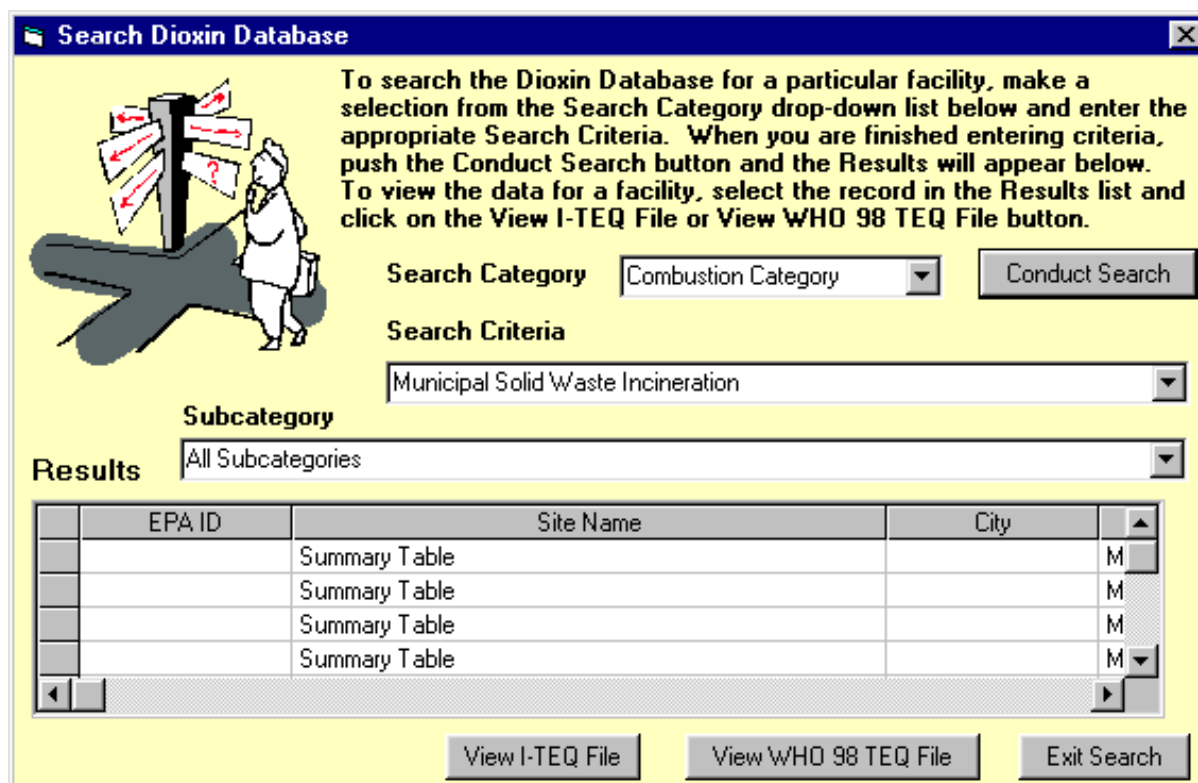


Figure 4. Search Dioxin Database Results

After the results of a search have been displayed, the user can go to the Excel 97[®] data file by highlighting the row with the result of interest and pushing the **View I-TEQ File** or the **View WHO 98 TEQ File** button. To exit the Search Dioxin Database screen, the user should simply press the **Exit Search** button at the bottom of the screen.

2.2 SOURCE CATEGORY INTERFACE

The *National Database* contains Excel 97[®] files that permit the user to view data based on the combustion source. These files can be accessed by selecting the **I-TEQ Data** button or the **WHO 98 TEQ Data** button on the introductory screen for the *National Database* program, or can access them from Excel 97[®]. An example of the Source Category Interface is depicted in Figure 5.

To access the Source Category Interfaces from Excel 97[®]

- Place the CD into the CD-ROM drive and open the Excel 97[®].
- Click the menu **File** and the selection **Open**.
- Select the drive which represents the CD-ROM and open the interface by clicking **Filetree**, the file name of the main table.
- Select the source category of interest in the interface by clicking with a mouse or moving the cell pointer to the source category followed by hitting the key **Enter**.
- Click the facility name listed in the summary table to access facility data.
- Click the button located at the up-right corner of the first worksheet in the facility file to return to the summary table, or click the bar located under the facility inventory in the summary table of summary files to return to the introductory screen.

The emission source categories listed in the Source Category Interface have been linked to source category summary files. By clicking a source category, the user will open the summary table worksheet in the summary file for that category. A more detailed description and discussion of each source category is provided in U.S. EPA(2000). An example of a summary table is shown in Table 1. This summary table lists the average emission factors and average TEQ emission factors of congener-specific and total CDD/CDF data. The facility names in the summary files have been further linked to facility data files in the Database. The user can further access individual facility data by clicking the corresponding facility names. The other

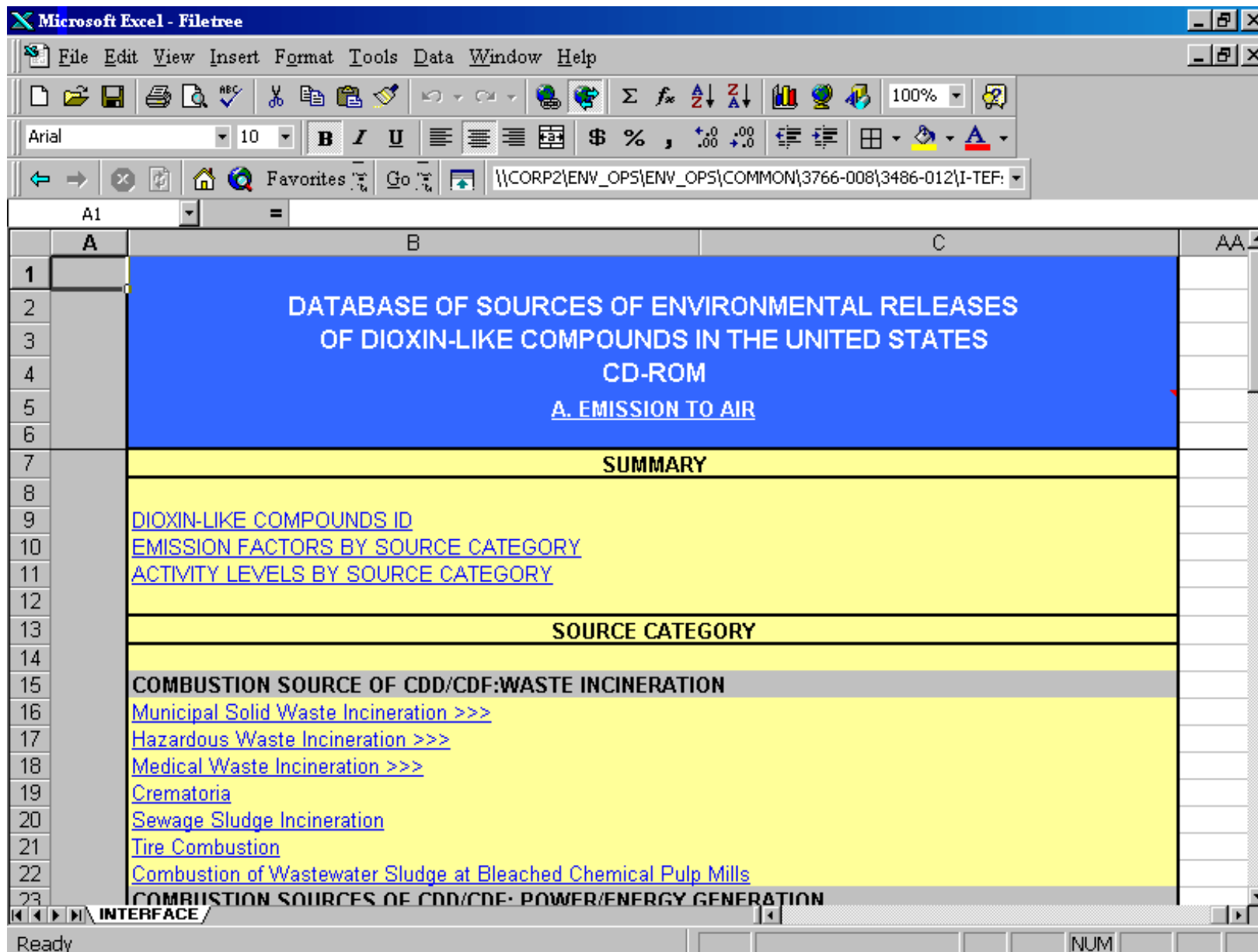


Figure 5. Source Category Interface

Table 1. A Sample of Summary Table in the Source Category Summary File

| Congener-Specific and Total Emission Factor/TEQ Emission Factor for Medical Waste Incineration without Air Pollution Control Device | | | | | | | | Facility |
|---|--|-----------|---|----------|--|--|-----------------------------|-----------------------------------|
| All 8 facilities (ng/kg) | | | | | 3 Facilities w/ Act. Level Less than or Equal to Average of 8 Facilities | | | Return to Medical W. Incineration |
| Data | Average Emission Factor (ng per kg processed) (ND=0) | | Average TEQ Emission Factor (ng per kg processed) (ND=1/2LOD) | | Data | Average Emission Factor (ng per kg processed) (ND=0) | | |
| | 4D 2378 | 50.6246 | 50.8187 | 50.6246 | | 50.8187 | 4D 2378 | 68.1309 |
| 5D 12378 | 238.4363 | 238.7338 | 119.2182 | 119.3669 | 5D 12378 | 267.9765 | Saint Bernardines Hospital | |
| 6D 123478 | 313.3423 | 314.6967 | 31.3342 | 31.4697 | 6D 123478 | 346.4856 | Saint Agnes Medical Center | |
| 6D 123678 | 417.3794 | 417.9778 | 41.7379 | 41.7978 | 6D 123678 | 507.1574 | Sutter General Hospital | |
| 6D 123789 | 539.9241 | 541.2223 | 53.9924 | 54.1222 | 6D 123789 | 494.2692 | USC Medical Center | |
| 7D 1234678 | 3304.8169 | 3304.8169 | 33.0482 | 33.0482 | 7D 1234678 | 4668.8728 | Cape Fear Memorial Hospital | |
| 8D 12346789 | 4178.6403 | 4178.6403 | 4.1786 | 4.1786 | 8D 12346789 | 4875.0240 | Central Carolina Hospital | |
| 4F 2378 | 242.5086 | 242.5086 | 24.2509 | 24.2509 | 4F 2378 | 294.5708 | Lenoir Memorial Hospital | |
| 5F 12378 | 772.5877 | 772.5877 | 38.6294 | 38.6294 | 5F 12378 | 820.4208 | | |
| 5F 23478 | 1061.1568 | 1061.1568 | 530.5784 | 530.5784 | 5F 23478 | 1140.7055 | | |
| 6F 123478 | 2677.9219 | 2677.9219 | 267.7922 | 267.7922 | 6F 123478 | 2383.7040 | | |
| 6F 123678 | 2078.3440 | 2078.3440 | 207.8344 | 207.8344 | 6F 123678 | 2443.8214 | | |
| 6F 123789 | 197.7000 | 197.7000 | 19.7700 | 19.7700 | 6F 123789 | 193.0556 | | |
| 6F 234678 | 2326.4227 | 2326.4227 | 232.6423 | 232.6423 | 6F 234678 | 2227.4655 | | |
| 7F 1234678 | 7980.5156 | 8009.4301 | 79.8052 | 80.0943 | 7F 1234678 | 7570.3947 | | |
| 7F 1234789 | 1576.3957 | 1576.3957 | 15.7640 | 15.7640 | 7F 1234789 | 1890.5541 | | |
| 8F 12346789 | 9320.9849 | 9320.9849 | 9.3210 | 9.3210 | 8F 12346789 | 15902.1712 | | |
| 4D Total | 733.1726 | 733.3173 | | | 4D Total | 1021.5414 | | |
| 5D Total | 1782.7250 | 1782.7250 | | | 5D Total | 2225.6611 | | |

worksheets included in summary files can also be accessed by clicking worksheet tabs located at the bottom of the screen.

The Source Category Interfaces were created in Excel 97[®] and, as such, will only operate using Excel 97[®], or a later version. Any attempt to use these interfaces with earlier versions of Excel[®] will result in disabling the interfaces.

2.3 FACILITY DATA FILES

Upon opening a facility data worksheet, Excel 97[®] will inform the user that the worksheet contains links and will ask the user if they wish to re-establish the links. The user should only re-establish the links in a worksheet if they intend to update the worksheet with new available test data or changed TEF values in the chemical data worksheet (**Chemid**) and then recalculate EFs and TEQs. The user should keep in mind that re-establishing links may take a few minutes, depending on the speed of their computer.

The links in the worksheets retrieve congener-specific data contained in a chemical data worksheet. This chemical worksheet contains information on the chemical's name, abbreviations, and toxic equivalency factors so that the chemical data only needs to be entered once.

Excel[®] creates the link between this chemical worksheet and facility data files through the *Vlookup* function. The *Vlookup* function searches the chemical data in the chemical worksheet, matches the corresponding row, and inserts a particular congener's Toxic Equivalency Factor, a 2378 Toxicity flag, the Congener flag, and the Homologue flag to the facility data file.

A workbook for each facility contains three worksheets (see Section 3.3 for more details). The user can move around in a worksheet by using the arrow keys on the keyboard or by using the mouse and the vertical and horizontal slide bar located at the right and bottom of the screen, respectively. The user can move from worksheet to worksheet by moving the mouse to the appropriate tab in the lower portion of the screen and pressing the mouse button.

The EF and TEQ worksheets were created through the use of Excel[®]'s Pivot Table function. A pivot table is an interactive worksheet table that enables the user to summarize and analyze data from existing tables¹. Pivot tables were created from the facility data worksheets to determine the average, maximum, and minimum EF and TEQ values and count of test runs for each congener identified. For more information on Excel[®]'s Pivot Table command, please consult Excel[®]'s Help screens.

¹ Chester, Thomas. Mastering Excel 5 for Windows. Sybex, Inc. Alameda, CA. 1995

2.4 USER NOTES

Users can conduct data analysis directly on the files contained on the CD-ROM. However, any analysis or changes to the data cannot be saved back to the CD-ROM, but must be saved to a separate disk or drive.

The summary files on the CD-ROM were created by using the Data Consolidate command provided by Excel 97[®]. Data from the EF and TEQ worksheets were pulled from each of the data files and consolidated into the summary files. For more information on Excel 97[®]'s Data Consolidate command, please consult Excel 97[®]'s Help screens.

3. DATABASE STRUCTURE

3.1 OVERALL STRUCTURE

The overall structure of the database is a series of linked spreadsheets contained within Excel[®] "workbooks". This structure was selected over several others because of its versatility for entering data from the original test reports, standardizing the data, and calculating emission factors. An overarching criterion for the design of this database was that the data storage and calculations using the data be transparent to users of the database. ORD believes that this transparency is better achieved through the use of spreadsheets which allows the user to follow the calculations, than through the use of a custom database application.

Version 3.0 of the *National Database* consists of two databases which differ only in the toxicity equivalency factor (TEF) scheme used. One database uses the International TEF approach (U.S. EPA, 1989d); the other uses the 1998 World Health Organization approach (Van den Berg et al., 1998) (see Table 2).

Each of the two databases consists of approximately 270 spreadsheet files, distributed among over 30 directories and subdirectories. Figure 6 illustrates the directory structure. Each directory/subdirectory was given a unique name to indicate the type of emission source that was being analyzed. For instance, the directory name "CK-NHW" was used for Cement Kilns Burning Non-Hazardous Waste. Table 3 lists the directories/subdirectories which make up the *National Database* and the category/subcategory to which directory refers.

Table 2. TEF Schemes for CDD/CDFs

International TEF Scheme

| CDD Congeners | TEF | CDF Congeners | TEF |
|---------------------|--------|---------------------|--------|
| 2,3,7,8-TCDD | 1.0 | 2,3,7,8-TCDF | 0.1 |
| 1,2,3,7,8-PeCDD | 1.0 | 1,2,3,7,8-PeCDF | 0.05 |
| 1,2,3,4,7,8-HxCDD | 0.1 | 2,3,4,7,8-PeCDF | 0.5 |
| 1,2,3,6,7,8-HxCDD | 0.1 | 1,2,3,4,7,8-HxCDF | 0.1 |
| 1,2,3,7,8,9-HxCDD | 0.1 | 1,2,3,6,7,8-HxCDF | 0.1 |
| 1,2,3,4,6,7,8-HpCDD | 0.01 | 1,2,3,7,8,9-HxCDF | 0.1 |
| OCDD | 0.0001 | 2,3,4,6,7,8-HxCDF | 0.1 |
| | | 1,2,3,4,6,7,8-HpCDF | 0.01 |
| | | 1,2,3,4,7,8,9-HpCDF | 0.01 |
| | | OCDF | 0.0001 |

1998 World Health Organization Scheme

| CDD Congener | TEF | CDF Congener | TEF |
|---------------------|-------|---------------------|------|
| 2,3,7,8-TCDD | 1.0 | 2,3,7,8-TCDF | 0.1 |
| 1,2,3,7,8-PeCDD | 0.5 | 1,2,3,7,8-PeCDF | 0.05 |
| 1,2,3,4,7,8-HxCDD | 0.1 | 2,3,4,7,8-PeCDF | 0.5 |
| 1,2,3,6,7,8-HxCDD | 0.1 | 1,2,3,4,7,8-HxCDF | 0.1 |
| 1,2,3,7,8,9-HxCDD | 0.1 | 1,2,3,6,7,8-HxCDF | 0.1 |
| 1,2,3,4,6,7,8-HpCDD | 0.01 | 1,2,3,7,8,9-HxCDF | 0.1 |
| OCDD | 0.001 | 2,3,4,6,7,8-HxCDF | 0.1 |
| | | 1,2,3,4,6,7,8-HpCDF | 0.01 |
| | | 1,2,3,4,7,8,9-HpCDF | 0.01 |
| | | OCDF | |

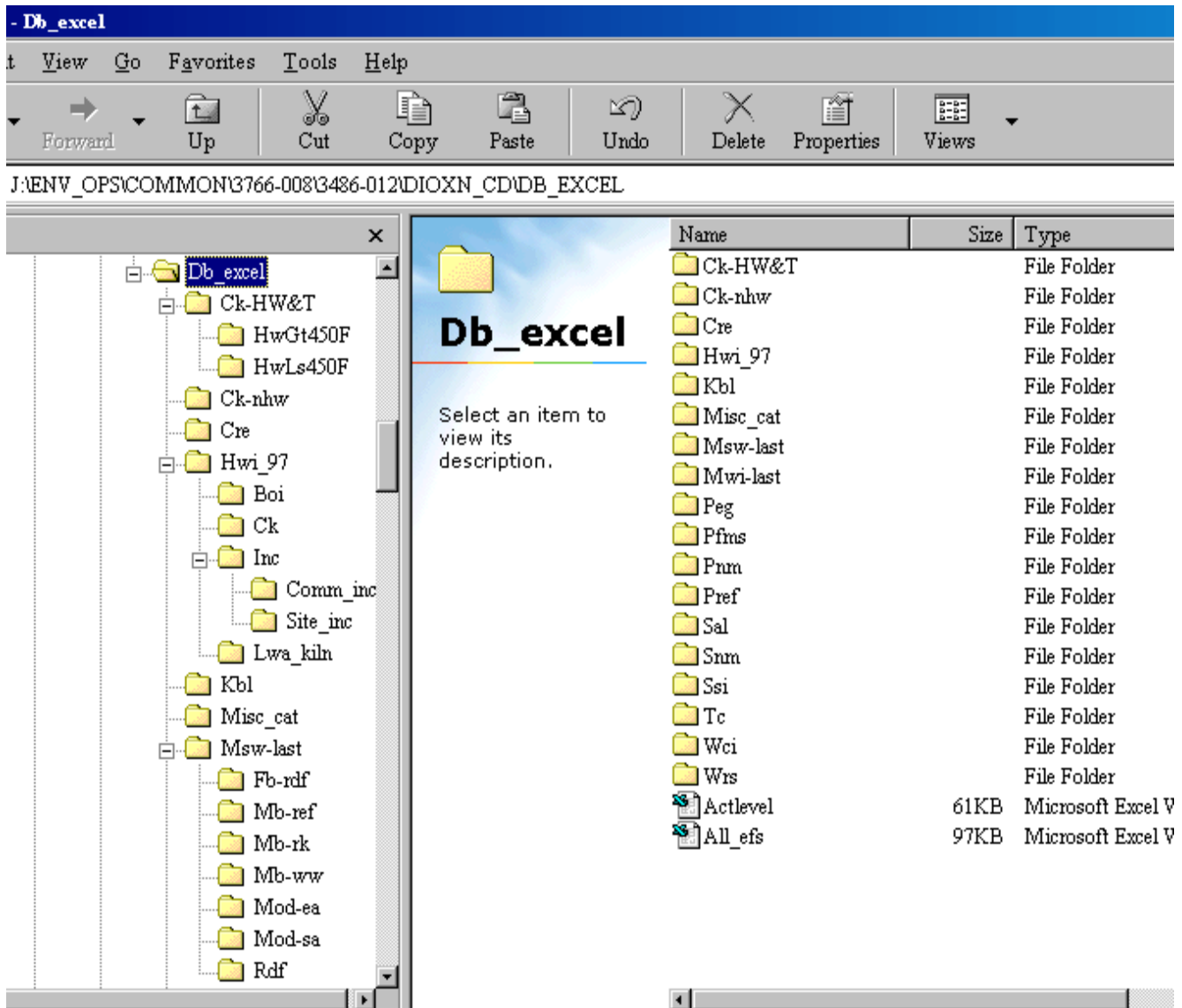


Figure 6. Database Directory Structure

Table 3. Database Directory Breakdown

| Directory | Subdirectory | Subdirectory | Category |
|-----------|--------------|--------------|--|
| Ck-HW&T | HwGt450F | | Cement Kilns Burning Hazardous Waste with inlet temp of APCD> 450F |
| | HwLs450F | | Cement Kilns Burning Hazardous Waste with inlet temp of APCD< 450F |
| Ck-nhw | | | Cement Kilns Burning Nonhazardous Waste |
| Cre | | | Crematoria |
| Hwi-97 | | | Hazardous Waste Incinerators |
| | Boi | | Boilers - Haz Waste |
| | Ck | | Cement Kilns - Haz Waste |
| | Inc | | Incinerators - Haz Waste |
| | | Comm_inc | Commercial Incinerators |
| | | Site_inc | On-site Incinerators |
| | Lwa_kiln | | Lightweight Aggregate Kilns |
| Kbl | | | Kraft Black Liquor Recovery Boilers |
| Misc-cat | | | Miscellaneous Sources |
| MSW-last | | | Municipal Solid Waste Incinerators |
| | Fb-rdf | | Fluidized Bed - refuse-derived fuel |
| | Mb-ref | | Mass burn - refractory-wall |
| | Mb-rk | | Mass burn - rotary kiln |
| | Mb-ww | | Mass burn - water-wall |
| | Mod-ea | | Modular excess-air |
| | Mod-sa | | Modular starved-air |
| | Rdf | | Refuse derived fuel |
| Mwi-last | | | Medical Waste Incinerators |
| Peg | | | Power Energy Generation |
| Pfms | | | Primary Ferrous Metal Smelting |
| Pnm | | | Primary Non-ferrous Metal Smelting |
| Pref | | | Petroleum Refining Catalyst Regeneration |
| Sal | | | Secondary Aluminum Smelting |
| Snm | | | Secondary Non-ferrous Metal Smelting |
| Ssi | | | Sewage Sludge Incineration |
| Tc | | | Tire Combustion |
| Wci | | | Industrial Wood Incineration |
| Wrs | | | Combustion of Wastewater Sludge at Bleached Chemical Pulp Mills |

Each directory/subdirectory contains two types of files: summary files (typically one) and data files. The summary file was constructed to provide a consolidated view of the facilities within a particular emission source category. The data files in each directory/subdirectory contain raw data and calculations for determining emission factors (EFs) for CDD/CDFs both in chemical-specific units and dioxin toxicity equivalent (TEQ) units.

3.2 SUMMARY FILE STRUCTURE

As discussed earlier, summary files located in each directory/subdirectory display consolidated data from each of the facilities within a particular emission source category. The nomenclature used for the summary files is typically:

***-sum.xls

where, *** indicates an abbreviation for the category or subdirectory in which the file is located. In the case of the municipal solid waste incinerator and medical waste incinerator categories, summary files were based on the type of air pollution control device, and are so named. For example, a summary file of facilities with a dry scrubber and fabric filter would be called: ds-ff.xls.

Figure 7 presents an example of the second sheet in a summary file for the source category "cement kilns not burning hazardous waste." There are typically five sheets in a summary file. They are: Emission Factor (nondetects (ND)=0); Emission Factor (ND=half limit of detection (LOD)); TEQ Emission Factor (ND=0); TEQ Emission Factor (ND=half LOD); and Table. The Emission Factor and TEQ Emission Factor sheets present the average emission factor and corresponding TEQ emission factor for each congener (from all of the facility test runs) from the emission factor and TEQ worksheets within each data file. These sheets were formed using the "Data Consolidate" command in Excel 97[®]. The Table worksheet presents the average emission factor and corresponding TEQ emission factor for each congener across all facilities in the summary file. The Table sheet was created by linking the values from the last row of data in the four sheets mentioned above. In addition, the Table worksheet includes the facility inventory from which the users can link to individual facility data files. This facility inventory was created for the database in the Excel 97[®] version only.

Microsoft Excel - Clnhwsun

File Edit View Insert Format Tools Data Window Help

Times New Roman 8 B I U \$ % , .00 +.00

AA1 = Comment

| | A | B | C | D | E | F | G | H | I | J |
|----|-----------------------|--------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|----|
| 1 | Data | 4D 2378 | 5D 12378 | 6D 123478 | 6D 123678 | 6D 123789 | 7D 1234678 | 8D 12346789 | 4F 2378 | 5F |
| 2 | Ckcacal | 0.003461846 | 0.008991914 | 0.004615795 | 0.022314838 | 0.052682441 | 0.43846954 | 1.457394075 | 0.033703158 | 0 |
| 3 | Ckcacalt | 0.001431654 | 0 | 0 | 0.007983263 | 0 | 0.023199794 | 0.041916295 | 0.100165778 | 0 |
| 4 | Ckcakai | 0 | 0 | 0 | 0 | 0 | 0.026362337 | 0.24797711 | 0 | 0 |
| 5 | Ckcamit | 0 | 0 | 0 | 0 | 0 | 0 | 0.002045294 | 0.000117733 | 0 |
| 6 | Ckcariv | 0 | 0 | 0 | 0 | 0 | 0.143990653 | 0.088903524 | 0.060743989 | 0 |
| 7 | Ckcohol | 0 | 0 | 0 | 0 | 0 | 0.096241872 | 0.164908958 | 0 | 0 |
| 8 | Ckflcen | 0 | 0 | 0.054896113 | 0 | 0 | 0.604683866 | 2.033754138 | 0.384627058 | 0 |
| 9 | Ckmdleh | 0.096178355 | 0.314678865 | 0.24958639 | 0.398586776 | 0.453803527 | 3.106576299 | 0.931589176 | 7.086577406 | 0 |
| 10 | Ckmtash | 0 | 0 | 0 | 0 | 0 | 0 | 0.018215452 | 0.065331665 | 0 |
| 11 | Ckneash | | | | | | | 0.279649009 | | |
| 12 | Cktxcap | 0.00054835 | 0.001657667 | 0.003463521 | 0.01088057 | 0.005979717 | 0.219092255 | 2.916576637 | 0.037751849 | |
| 13 | Ckwaash | 0.028359444 | 0.049820644 | 0 | 0.017628843 | 0.014562958 | 0.024527086 | 0.120315461 | 0.248435749 | 0 |
| 14 | Average | 0.011816332 | 0.034104463 | 0.028414711 | 0.041581299 | 0.047911695 | 0.425740337 | 0.691937094 | 0.72885949 | 0 |
| 15 | | | | | | | | | | |
| 16 | Sum of Average | 21.44357124 | | | | | | | | |
| 17 | | | | | | | | | | |
| 18 | | | | | | | | | | |
| 19 | | | | | | | | | | |
| 20 | | | | | | | | | | |
| 21 | | | | | | | | | | |
| 22 | | | | | | | | | | |
| 23 | | | | | | | | | | |
| 24 | | | | | | | | | | |
| 25 | | | | | | | | | | |
| 26 | | | | | | | | | | |

Table. CK NHW Emission Factors Emission Factor (ND=0) Emission Factor (ND=half LOD) TEQ (ND=0) TEQ (ND=half LOD)

Ready NUM

Figure 7. Example of a Summary File

The user should note that the number of significant figures displayed in this worksheet and other worksheets in the database do not necessarily reflect the level of certainty in the data. EPA recommends using no more than three significant figures for any emission factor estimates derived from these data.

In some cases, the summary files contain profile worksheets (for ND=0 and ND=half LOD). These sheets present the ratio of a specific congener's emission factor relative to the total CDD/CDF emission factor for a specific facility in the summary file.

3.3 DATA FILE STRUCTURE

Data files located in each directory/subdirectory are the repositories of the raw data compiled from various facility test reports and other sources. Data files also contain some calculations and manipulations of data to determine EFs. Data files were named using the following nomenclature:

1. The first 2-3 characters of the name represent the category or subcategory (e.g., CK for cement kiln);
2. The next 2 characters represent the state abbreviation where the facility is located; and
3. The remaining letters are comprised of the first 3-4 characters from the facility name.

For example, the file CKARASH.XLS was derived from

CK - cement kiln,
AR - Arkansas, and
ASH - Ash Grove Cement Company.

Data files normally contain three separate worksheets: the facility data worksheet; the EF worksheet; and, the TEQ EF worksheet.

3.3.1 Worksheet 1 - Facility Data

The first worksheet, the facility data worksheet, in each data file contains the raw data obtained from a facility's test report or similar source. The raw data were used to calculate congener and homologue group emission factors and the corresponding TEQ emission factors, generally in units of ng/kg of material combusted, for each congener in each test run. This spreadsheet is "linked" to other data containing standard chemical names, abbreviations, and toxic equivalency factors. In some cases, the emission factors could not be calculated because the

facility data were incomplete (e.g., missing activity level, or volumetric flow rate). Table 4 provides a listing of the data fields contained in the facility data worksheet. For the category of cement kiln burning hazardous waste, one additional column for the inlet temperature of the air pollutant control device was created for facilities with available data. Figure 8 presents an example of the facility data worksheet.

3.3.2 Worksheet 2 - Emission Factor (EF)

The second worksheet, the EF worksheet, is based on data from the facility data worksheet and presents the average, maximum, and minimum EF as well as the count of test runs for a particular congener at the given facility. Excel[®]'s Pivot Table function was used to create this worksheet. Table 5 provides a listing of the data fields calculated in this worksheet. Figure 9 presents an example of an EF worksheet. Many of the EF worksheets include a row that calculates congener profiles, which are the ratio of a specific congener's emission factor relative to the total emission factor (for all homologue groups) for that facility.

In several cases, insufficient data were available in the facility data worksheet to properly perform the EF analysis. In these cases, the EF worksheets were not developed. For those cases where the EF worksheets were developed, the pivot tables need to be "refreshed" (a command provided by Pivot Table) should the source data be revised.

3.3.3 Worksheet 3 - TEQ Emission Factors

The third worksheet, the TEQ emission factor worksheet, is based on data from the facility data worksheet and presents the average, maximum, and minimum TEQ emission factors as well as the count of test runs for a particular congener at the given facility. Excel[®]'s Pivot Table function was used to create this worksheet. Table 6 provides a listing of the data fields calculated in this worksheet. Figure 10 presents an example of a TEQ worksheet.

As was the case with the congener EF Worksheet, there were several cases where not enough data were available in the facility data worksheet to properly run the TEQ emission factor analysis. In these cases, the worksheets were not developed. For those cases where the TEQ worksheets were developed, as with the EF Worksheet, the pivot tables need to be "refreshed" should the source data be revised.

3.3.4 Miscellaneous Worksheets

Some of the data files contain several miscellaneous worksheets not yet discussed. These include profile worksheets which may be contained in the summary files or in the facility data files.

Table 4. Data Fields for Facility Data Worksheet

| Field | Units | Comments/Explanation |
|-----------------------------------|--|--------------------------------|
| EPA ID Number | unitless | |
| Facility | unitless | |
| City | unitless | |
| State | unitless | |
| Latitude | degrees, minutes, seconds | |
| Longitude | degrees, minutes, seconds | |
| Release Media | unitless | air, water, or land |
| Number of Incinerators | Combustion Units | applicable for releases to air |
| Total Annual Combustion Capacity | tons per day | applicable for releases to air |
| Activity Level | kilograms (kg) or liters (L) per unit time | |
| Source Category | unitless | |
| Source Subcategory | unitless | |
| Technology Design Category | unitless | |
| Technology Design Subcategory | unitless | |
| Air Pollution Control Device 1 | unitless | applicable for releases to air |
| Air Pollution Control Device 2 | unitless | applicable for releases to air |
| Pipe or Stack Number | unitless | applicable for releases to air |
| Stack Height | feet (ft) | applicable for releases to air |
| Stack Diameter | inches (in) | applicable for releases to air |
| Stack Flow (Volumetric Flow Rate) | dry standard cubic feet per minute (dscfm) | applicable for releases to air |
| Stack Flow (Volumetric Flow Rate) | dscfm standardized to 7% O ₂ | applicable for releases to air |

Table 4. Data Fields for Facility Data Worksheet (continued)

| Field | Units | Comments/Explanation |
|---|--|--|
| Stack Exit Velocity | feet per second | applicable for releases to air |
| Stack Temperature (Exit Temperature) | degrees Fahrenheit (°F) | applicable for releases to air |
| Stack O ₂ | percent (%) | applicable for releases to air |
| Stack CO ₂ | percent (%) | applicable for releases to air |
| Stack Moisture | percent volume (% V) | applicable for releases to air |
| Chlorine Content of Waste Feed | percent (%) | |
| Pipe Flow | cubic feet per second | applicable for releases to water |
| Run ID | unitless | |
| Test Date | unitless | |
| Report Date | unitless | |
| COC (Chain of Custody) Date | unitless | |
| Substance | unitless | CDD/CDF congeners |
| Detect - Non-Detect Flag | unitless | |
| Emission Amount - Concentration as Reported | see next field | When "Concentration as Calculated" is shown, it indicates that a concentration has been calculated from raw data reported. |
| Concentration Units (as Reported) | units vary depending on data source | |
| Standardized Emission Amount | see next field | |
| Standardized Units | ng/dscm @ 7% O ₂ | applicable for releases to air |
| Emission Rate, as Reported | units vary depending on data source | |
| Conversion Factor | units necessary to convert "Emission Rate, as Reported" to pounds per hour | |

Table 4. Data Fields for Facility Data Worksheet (continued)

| Field | Units | Comments/Explanation |
|---------------------------------|--|---|
| Emission Rate | pounds per hour (lbs/hr) | |
| Concentration (ND=0) | ng/dscm @ 7% O ₂ | applicable for releases to air |
| Concentration (ND=1/2 LOD) | ng/dscm @ 7% O ₂ | applicable for releases to air |
| Toxic Equivalency Factor (TEF) | unitless: developed from Lookup file | |
| TEQ Emission Factor (ND=0) | varies depending on activity level units | |
| TEQ Emission Factor (ND=1/2LOD) | varies depending on activity level units | |
| 2378 Toxicity Flag | unitless: developed from Lookup file | “Y” indicating a toxicity equivalency factor (TEF) is available |
| Congener Flag | unitless: developed from Lookup file | |
| Homologue Flag | unitless: developed from Lookup file | |
| Emission Factor (ND=0) | varies depending on activity level units | |
| Emission Factor (ND=1/2LOD) | ng/kg processed | |
| Receiving Stream | unitless | applicable for releases to water |
| Reach Number | unitless | applicable for releases to water |
| Data Source Reference | unitless | |
| Comments | unitless | |

Microsoft Excel - Ckccal

File Edit View Insert Format Tools Data Window Help

Times New Roman 8 B I U

F3 =

| | A | B | C | D | E | F | G | H | I | J | K | L | BD |
|----|---------------|----------|---------|-------|----------|-----------|---------------|------------------------|----------------------------------|------------------------|-----------------|--------------------|-------------------------|
| 1 | EPA ID Number | Facility | City | State | Latitude | Longitude | Release Media | Number of Incinerators | Total Annual Combustion Capacity | Activity Level (kg/hr) | Source Category | Source Subcategory | Return to Summary Table |
| 2 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 3 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 4 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 5 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 6 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 7 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 8 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 9 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 10 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 11 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 12 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 13 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 14 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 15 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 16 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 17 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 18 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 19 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 20 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 21 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 22 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 23 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |
| 24 | | Company | Redding | CA | | | Air | | | 77084 | WI | CK | |

Calaveras Cement Co, Redding CA / Emission Factors / TEQs /

Ready NUM

Figure 8. Example of the Facility Data Sheet in a Facility Data File

Table 5. Emission Factor (EF) Worksheet Contents

| Data Analysis | Typical Units |
|--|---|
| at Non-Detect (ND) = 0 Average Emission Factor (EF) Maximum EF Minimum EF Count of EFs | ng/kg processed ng/kg processed ng/kg processed |
| at ND = 1/2 LOD Average EF Maximum EF Minimum EF Count of EFs | ng/kg processed ng/kg processed ng/kg processed |

Microsoft Excel - Ckcaal

File Edit View Insert Format Tools Data Window Help

Courier 10 B I U \$ % , +.0 -.0

A23 = Ratio Analysis for Profiles (ND=1/2 LOD)

| | A | B | C | D |
|----|---|-------------|-------------|-----------|
| 1 | | Substance | | |
| 2 | Data | 4D 2378 | 5D 12378 | 6D 123478 |
| 3 | Average of Emission Factor (ng per kg produced) (ND=0) | 0.003461846 | 0.008991914 | 0.0046157 |
| 4 | Max of Emission Factor (ng per kg produced) (ND=0)2 | 0.020771075 | 0.027694767 | 0.0276947 |
| 5 | Min of Emission Factor (ng per kg produced) (ND=0)3 | 0 | 0 | |
| 6 | Count of Emission Factor (ng per kg produced) (ND=0)4 | 6 | 6 | |
| 7 | | | | |
| 8 | Sum of Average Total Congeners | | | |
| 9 | 8.067172599 | | | |
| 10 | | Substance | | |
| 11 | Data | 4D 2378 | 5D 12378 | 6D 123478 |
| 12 | Average of Emission Factor (ng per kg produced) (ND=1/2LOD) | 0.009579858 | 0.013747317 | 0.0115512 |
| 13 | Max of Emission Factor (ng per kg produced) (ND=1/2LOD)2 | 0.020771075 | 0.027694767 | 0.0276947 |
| 14 | Min of Emission Factor (ng per kg produced) (ND=1/2LOD)3 | 0.001227825 | 0.00245565 | 0.002455 |
| 15 | Count of Emission Factor (ng per kg produced) (ND=1/2LOD)4 | 6 | 6 | |
| 16 | | | | |
| 17 | Sum of Average Total Congeners | | | |
| 18 | 8.073239197 | | | |
| 19 | Ratio Analysis for Profiles (ND=0) | 4D 2378 | 5D 12378 | 6D 123478 |
| 20 | | 0.000429128 | 0.00111463 | 0.000572 |
| 21 | | | | |
| 22 | | | | |
| 23 | Ratio Analysis for Profiles (ND=1/2 LOD) | 4D 2378 | 5D 12378 | 6D 123478 |
| 24 | | 0.001186619 | 0.001702825 | 0.0014308 |
| 25 | | | | |
| 26 | | | | |
| 27 | | | | |

Calaveras Cement Co, Redding CA Emission Factors / TEQs /

Ready NUM

Figure 9. Example of an Emission Factor Sheet in a Facility Data File

Table 6. TEQ Emission Factor (EF) Worksheet Contents

| Data Analysis | Typical Units |
|--|---|
| at Non-Detect (ND) = 0 Average TEQ Maximum TEQ Minimum TEQ Count of TEQs | ng/kg processed ng/kg processed ng/kg processed |
| at ND = 1/2 LOD Average TEQ Maximum TEQ Minimum TEQ Count of TEQs | ng/kg processed ng/kg processed ng/kg processed |

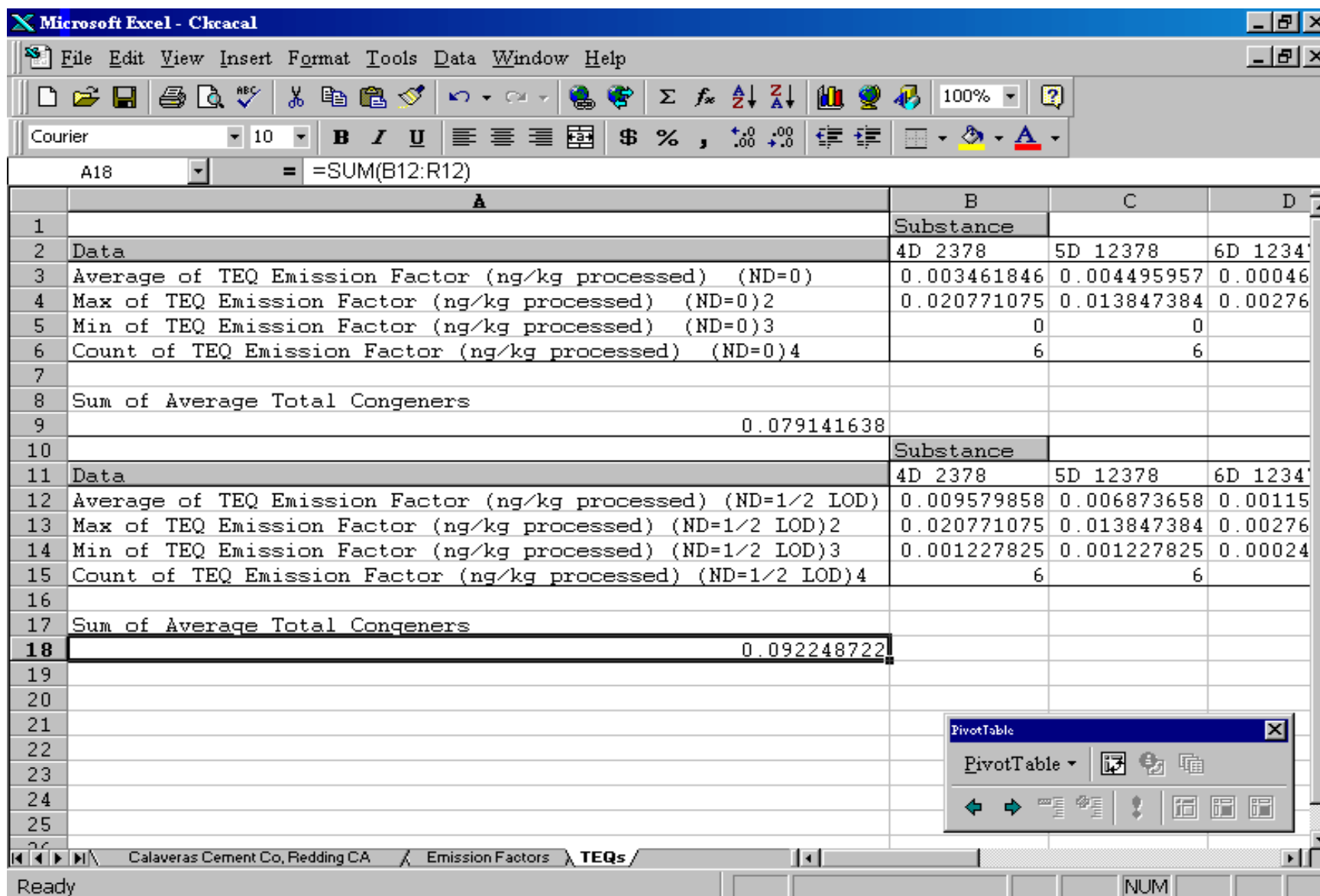


Figure 10. Example of a TEQ Sheet in a Facility Data File

4. CALCULATIONS AND QUALITY CONTROL MEASURES

4.1 STANDARDIZATION

Data underwent a process of standardization after they were extracted from the original test reports and before they were entered into the *National Database*. Three areas in particular were standardized -- chemical names, treatment of detects and non-detects, and concentration units of measure.

Chemical names were standardized by matching compounds to a "master" list of dioxin-like compounds. These standard values are linked to the "master" spreadsheets, allowing other parameters (e.g., TEFs, homologue groups) to be retrieved into the facility-specific spreadsheet.

Measured CDD/CDF concentrations are presented in the test reports in a number of ways (e.g., ng/sample, ng/dscm, ng/dscm @ 12% CO₂, etc.). For comparison purposes, stack gas concentrations were generally standardized to units of ng/dscm at 7 percent oxygen. As needed, the volumetric flow rates were standardized to dry standard cubic feet per minute (dscfm) at 7 percent oxygen using the following equation:

$$flow (dscfm) = \frac{(20.9\% O_2 - test\ run\ O_2)}{(20.9\% O_2 - 7\% O_2)}$$

Figure 11 presents sample calculations that demonstrate the estimation of a proxy concentration for a nondetected congener and standardization of that concentration to ng/dscm @ 7% O₂.

Two sets of data were generated to address congeners that were reported as nondetected in the test reports. In the first set, nondetected congeners were assigned a value of zero; while in the second set of data, nondetected congeners were assigned a proxy concentration of half the detection limit for that congener.

| <u>Congener</u> | <u>Non-detect Flag</u> | <u>Concentration (ng/sample)</u> | <u>Sample Volume (dscm/sample)</u> | <u>Percent O₂</u> |
|-----------------|----------------------------|--------------------------------------|--|------------------------------|
| 2378 TCDD | ND | 0.05 | 4.5 | 10 |

Proxy concentration for nondetected 2378 TCDD:

$$0.05 \text{ ng/sample} \div 2 = 0.025 \text{ ng/sample}$$

Concentration (ng/dscm):

$$0.025 \text{ ng/sample} \div 4.5 \text{ dscm/sample} = 0.006 \text{ ng/dscm}$$

The general equation for standardization to 7% O₂ is:

$$\text{ng/dscm @ 7\%O}_2 = \text{Sample Conc. (ng/dscm)} * \frac{(20.9\% \text{ O}_2 - 7\% \text{ O}_2)}{(20.9\% \text{ O}_2 - \text{Sample \% O}_2)}$$

Standardized concentration (ng/dscm @ 7% O₂):

$$\begin{aligned} \text{ng/dscm @ 7\%O}_2 &= 0.006 \text{ (ng/dscm)} * \frac{(20.9\% \text{ O}_2 - 7\% \text{ O}_2)}{(20.9\% \text{ O}_2 - 10\% \text{ O}_2)} \\ &= 0.006 \text{ (ng/dscm)} * \frac{(13.9\% \text{ O}_2)}{(10.9\% \text{ O}_2)} \\ &= 0.006 \text{ (ng/dscm)} * 1.28 \\ &= 0.008 \text{ ng/dscm @ 7\%O}_2 \end{aligned}$$

Figure 11. Sample CDD/CDF Concentration Standardization Calculation

4.2 CALCULATION OF EMISSION FACTORS

Congener- and homolog-specific emission factors are calculated for each facility in units of nanograms emitted per kilogram of material combusted/processed. These emission factors are based on sample concentration, volumetric air flow rate, and activity level (i.e., material throughput). Test runs from single or multiple test reports are averaged for each facility. Two sets of emission factors are presented to reflect nondetected congener concentrations valued at zero, and those estimated at half the detection limit. Figure 12 shows the process for estimating an emission factor for a nondetected congener concentration valued at half the detection limit (when the concentration is valued at zero, the emission factor for that congener is zero). The

calculation of TEQ emission factors involves an additional equation that multiplies the congener-specific emission factor by the TEF for that congener.

| <u>Congener</u> | <u>Concentration</u> (ng/dscm @ 7% O ₂) | <u>Concentration</u> (ng/dscm @ 7% O ₂) | <u>Volumetric</u> <u>Flow Rate (dscf/min)</u> | <u>Activity</u> <u>Level</u> (kg/hr) |
|-----------------|--|--|--|--|
| 2378 TCDD | ND = 0 | ND = ½ LOD | 237 | 48.5 |

The general equation for estimation of emission factor is:

$$\text{ng/kg} = \frac{\text{Conc. (ng/dscm)} * \text{Flow Rate (dscf/min)} * \text{cf (min/hr)}}{\text{cf} \left(\frac{\text{ft}^3}{\text{m}^3} \right) * \text{Activity Level (kg/hr)}}$$

Substituting values from the above table and using ½ LOD concentration:

$$\begin{aligned} \text{ng/kg} &= \frac{0.025 \text{ (ng/dscm)} * 237 \text{ (dscf/min)} * 60 \text{ (min/hr)}}{35.31 \left(\frac{\text{ft}^3}{\text{m}^3} \right) * 48.5 \text{ (kg/hr)}} \\ &= \frac{355.5}{1712.5} = 0.208 \text{ ng/kg} \end{aligned}$$

Figure 12. Sample Emission Factor Calculations

In some cases, oxygen content data in the stack exhausts were not provided. Without knowing the oxygen content, standardized emission concentrations and volumetric air flow rates can not be calculated. However, in several cases, non-standardized reported flow rates and non-standardized reported emission concentrations along with reported activity levels were used to calculate emission factors (EF) and TEQ emission factors (TEQ-EF) assuming that the reported concentrations and flow rates were at the same oxygen content.

4.3 QUALITY CONTROL MEASURES

EPA conducted a data quality audit of the September 1997 draft version of the *National Database* under a contract with Research Triangle Institute (RTI). To conduct the audit, RTI

was provided with a copy of the draft *National Database* on CD-ROM and the draft User's Manual. The draft data base consisted of over 100 Megabytes (Mb) of data in more than 270 individual worksheets. RTI randomly selected 58 of the hard-copy and computer-readable data sources used to construct the data base. These data sources included EPA reports, reports from State environmental agencies, and independent laboratory reports, among others. RTI personnel audited 64 (28%) of the site-specific worksheets using these source documents. The audit searched for data input errors, errors present in the source documents and how these errors were addressed in the data base, spreadsheet formula errors, and cosmetic and other minor problems. The audit report (RTI, 1998) recommended a series of corrective actions all of which were subsequently addressed in developing Version 1.1 of the *National Database*.

5. ANNUAL CDD/CDF EMISSION CALCULATIONS

Because only a few U.S. facilities in most source categories have been tested for CDD/CDF emissions, an extrapolation is needed to estimate national emissions for most source categories. Many of the national emission estimates developed from this database that are presented in EPA's *Sources of Dioxin-Like Compounds in the United States* (U.S. EPA, 2001), were, therefore, developed using a "top down" approach. The first step in this approach is to derive from the available emission test data an emission factor (or series of emission factors) deemed to be representative of the source category (or segments of a source category that differ in configuration, fuel type, air pollution control equipment, etc.). As described in Section 4.2, the emission factor relates mass of CDD/CDFs released into the environment per some measure of activity (e.g., kilograms of material processed per year, vehicle miles traveled per year, etc.). The emission factor was then multiplied by a national value for the activity level basis of the emission factor (e.g., total kg of material processed in the United States annually).

Although no categories had estimates developed in Volume 2 from a true "bottom up" approach (i.e., estimates developed using site-specific emissions and activity data for all individual sources in a category and then summed to obtain a national total), existing facility-specific emissions testing and activity level data for some source categories in the database (e.g., municipal solid waste incinerators) supported a semi- "bottom up" approach. In this approach, facility-specific annual emissions were calculated for those facilities with adequate data. For the untested facilities in the class, a subcategory (or class) emission factor was then developed by averaging the emission factors for the tested facilities in the class. This average emission factor was then multiplied by the measure of activity for the non-tested facilities in the class. Emissions were summed for the tested facilities and non-tested facilities. In summary, this procedure can be represented by the following equations:

$$E_{total} = \sum E_{tested,i} + \sum E_{untested,i}$$

$$E_{total} = \sum E_{tested,i} + \sum (EF_i * A_i)_{untested}$$

Where: E_{total} = annual emissions from all facilities (g TEQ/yr)
 $E_{tested,i}$ = annual emissions from all tested facilities in class i (g TEQ/yr)
 $E_{untested,i}$ = annual emissions from all untested facilities class i (g TEQ/yr)
 Ef_i = mean emission factor for tested facilities in class i (g TEQ/kg)
 A_i = activity measure for untested facilities class i (kg/yr)

Some source categories are made up of facilities that vary widely in terms of design and operating conditions. For these sources, as explained above, an attempt was made to create subcategories that grouped facilities with common features and then to develop separate emission factors for each subcategory. Implicit in this procedure is the assumption that facilities with similar design and operating conditions should have similar CDD/CDF release potential. For most source categories, however, the specific combination of features that contributes most to CDD/CDF or dioxin-like PCB release is not well understood. Therefore, how to best subcategorize a source category was often problematic. For each subcategorized source category in this report, a discussion is presented about the variability in design and operating conditions, what is known about how these features contribute to CDD/CDF or dioxin-like PCB release, and the rationale for subcategorizing the category.

As discussed above, each source emission calculation required estimates of an "emission factor" and the "activity level." For each emission source, the quantity and quality of the available information for both terms vary considerably. Consequently, it is important that emission estimates be accompanied by some indicator of the uncertainties associated with their development. For this reason, a qualitative confidence rating scheme was developed as an integral part of the emission estimate in consideration of the following factors:

- *Emission Factor* - The uncertainty in the emission factor estimate depends primarily on how well the tested facilities represent the untested facilities. In general, confidence in the emission factor increases with increases in the number of tested facilities relative to the total number of facilities. Variability in terms of physical design and operating conditions within a class or subclass must also be considered. The more variability among facilities, the less confidence that a test of any single facility is representative of that class or subclass. The quality of the supporting documentation also affects uncertainty. Whenever possible, original engineering test reports were used. Peer reviewed reports from the open literature were also used for developing some emission factors. In some cases, however, draft reports that had

undergone more limited review were used. In a few cases, unpublished references were used (such as personal communication with experts) and are clearly noted in the text.

- *Activity Level* - The uncertainty in the activity level estimate was judged primarily on the basis of the extent of the underlying data. Estimates derived from comprehensive surveys (including most facilities in a source category) were assigned high confidence. As the number of facilities in the survey relative to the total decreased, confidence also decreased. The quality of the supporting documentation also affects uncertainty. Peer reviewed reports from the open literature (including government and trade association survey data) were considered most reliable. In some cases, however, draft reports that had undergone more limited review were used. In a few cases, unpublished references were used (such as personal communication with experts) and are clearly noted in the text.

The confidence rating scheme, presented in Table 7, presents the qualitative criteria used to assign a high, medium, or low confidence rating to the emission factor and activity level terms for those source categories for which emission estimates can be reliably quantified. The overall "confidence rating" assigned to an emission estimate was determined by the confidence ratings assigned to the corresponding "activity level" term and "emission factor" term. If the lowest rating assigned to either the activity level or emission factor terms is "high," then the category rating assigned to the emission estimate is high (also referred to as "A"). If the lowest rating assigned to either the activity level or emission factor terms is "medium," then the category rating assigned to the emission estimate is medium (also referred to as "B"). If the lowest rating assigned to either the activity level or emission factor terms is "low," then the category rating assigned to the emission estimate is low (also referred to as "C"). It is emphasized that this confidence rating scheme should be interpreted as subjective judgements of the relative uncertainty among sources, not statistical measures.

Table 7. Confidence Rating Scheme for U.S. Emission Estimates

| Confidence Rating | Activity Level Estimate | Emission Factor Estimate |
|--|---|--|
| <i>Categories/Media for Which Releases Can Be Reasonably Quantified</i> | | |
| High | Derived from comprehensive survey | Derived from comprehensive survey |
| Medium | Based on estimates of average plant activity level and number of plants or limited survey | Derived from testing at a limited but reasonable number of facilities believed to be representative of source category |
| Low | Based on data judged possibly nonrepresentative | Derived from testing at only a few, possibly nonrepresentative facilities or from similar source categories |
| <i>Categories/Media for Which Releases Cannot Be Reasonably Quantified</i> | | |
| Preliminary Estimate | Based on extremely limited data, judged to be clearly nonrepresentative | Based on extremely limited data, judged to be clearly nonrepresentative |
| Not Quantified | No data available | <ol style="list-style-type: none"> 1) Argument based on theory but no data, or 2) Data available indicating formation, but not in a form that allows developing an emission factor |

For many source categories, either emission factor information or activity level information were inadequate to support development of reliable quantitative release estimates for one or more media. For some of these source categories, sufficient information was available to make preliminary estimates of emissions of CDD/CDFs; however, the confidence in the activity level estimates or emission factor estimates was so low that the estimates cannot be included in the sum of quantified emissions from sources with confidence ratings of A, B and C. These preliminary estimates were given an overall confidence class rating of D (Table 8, “Preliminary Estimate” column). As preliminary estimates of source magnitude, they can be used, however, to help prioritize future research and data collection. The actual magnitude of emissions from these sources could be significantly lower or higher than these preliminary estimates. Although EPA has chosen not to include them in the more thoroughly characterized emissions of the national inventory, some of these poorly characterized sources have the potential of being major contributors of releases to the environment. As the uncertainty around these sources is reduced, they will be included in future inventory calculations. For other sources, some information exists which suggests that they may release dioxin-like compounds; however, the available data were judged to be insufficient for developing any quantitative emission estimate. These source categories were assigned a confidence category rating of “E” and also were not included in the national inventory (Table 8, “Not Quantifiable” column).

The emission factors developed for the emissions inventory in Volume 1 are intended to be used for estimating the total emissions for a source category rather than for individual facilities. EPA has made uncertainty determinations for each of these emission factors based, in part, on the assumption that by applying them to a group of facilities, the potential for overestimating or underestimating individual facilities will to some extent be self compensating. This means that in using these emission factors one can place significantly greater confidence in an emission estimate for a class than can be placed on an emission estimate for any individual facility. Given the limited amount of data available for deriving emission factors, and the limitations of our understanding about facility-specific conditions that determine formation and control of dioxin-like compounds, the current state of knowledge cannot support the development of emission factors that can be used to accurately estimate emissions on an individual facility-specific basis.

Table 8. List of Known and Suspected CDD/CDF Sources

| Emission Source Category | Contemporary Formation Sources | | | Reservoir Sources | | |
|---|--------------------------------|----------------------|------------------|-------------------|----------------------|------------------|
| | Quantifiable | Preliminary Estimate | Not Quantifiable | Quantifiable | Preliminary Estimate | Not Quantifiable |
| I. COMBUSTION SOURCES | | | | | | |
| <i>Waste Incineration</i> | | | | | | |
| Municipal waste incineration | ✓ | | | | | |
| Hazardous waste incineration | ✓ | | | | | |
| Boilers/industrial furnaces | ✓ | | | | | |
| Medical waste/pathological incineration | ✓ | | | | | |
| Crematoria | ✓ | | | | | |
| Sewage sludge incineration | ✓ | | | | | |
| Tire combustion | ✓ | | | | | |
| Pulp and paper mill sludge incinerators | ✓ | | | | | |
| BioGas combustion | | ✓ | | | | |
| <i>Power/Energy Generation</i> | | | | | | |
| Vehicle fuel combustion | | | | | | |
| - leaded ^b | ✓ | | | | | |
| - unleaded | ✓ | | | | | |
| - diesel | ✓ | | | | | |
| Wood combustion - residential | ✓ | | | | | |
| - industrial | ✓ | | | | | |
| Coal combustion - residential | | ✓ | | | | |
| - industrial/utility | ✓ | | | | | |
| Oil combustion - residential | | ✓ | | | | |
| - industrial/utility | ✓ | | | | | |
| <i>Other High Temperature Sources</i> | | | | | | |
| Cement kilns (haz waste burning) | ✓ | | | | | |
| Cement kilns (non haz waste burning) | ✓ | | | | | |
| Asphalt mixing plants | | ✓ | | | | |
| Petro. refining catalyst regeneration | ✓ | | | | | |
| Cigarette combustion | ✓ | | | | | |
| Carbon reactivation furnaces | ✓ | | | | | |
| Kraft recovery boilers | ✓ | | | | | |
| Manufacture of ball clay products | | | ✓ | | | |

Table 8. List of Known and Suspected CDD/CDF Sources (continued)

| Emission Source Category | Contemporary Formation Sources | | | Reservoir Sources | | |
|---|--------------------------------|----------------------|------------------|-------------------|----------------------|------------------|
| | Quantifiable | Preliminary Estimate | Not Quantifiable | Quantifiable | Preliminary Estimate | Not Quantifiable |
| <i>Minimally Controlled or Uncontrolled Combustion</i> | | | | | | |
| Combustion of landfill gas in flares | | ✓ | | | | |
| Landfill fires | | ✓ | | | | |
| Accidental fires (structural) | | ✓ | | | | |
| Accidental fires (vehicles) | | ✓ | | | | |
| Forest, brush, and straw fires | | ✓ | | | | |
| Backyard barrel burning | ✓ | | | | | |
| Uncontrolled combustion of PCBs | | | ✓ | | | |
| II. METAL SMELTING/REFINING | | | | | | |
| <i>Ferrous metal smelting/refining</i> | | | | | | |
| - Sintering plants | ✓ | | | | | |
| - Coke production | | ✓ | | | | |
| - Electric arc furnaces | | ✓ | | | | |
| - Ferrous foundries | | ✓ | | | | |
| <i>Nonferrous metal smelting/refining</i> | | | | | | |
| - Primary aluminum | | | ✓ | | | |
| - Primary copper | ✓ | | | | | |
| - Primary magnesium | | ✓ | | | | |
| - Primary nickel | | | ✓ | | | |
| - Secondary aluminum | ✓ | | | | | |
| - Secondary copper | ✓ | | | | | |
| - Secondary lead | ✓ | | | | | |
| Scrap electric wire recovery | ✓ | | | | | |
| Drum and barrel reclamation | ✓ | | | | | |
| III. CHEMICAL MANUFACTURING | | | | | | |
| <i>(Releases to the Environment)</i> | | | | | | |
| Bleached chemical wood pulp and paper mills | ✓ | | | | | |
| Mono- to tetrachlorophenols | | | ✓ | | | |
| Pentachlorophenol | | | ✓ | | | |
| Chlorobenzenes | | | ✓ | | | |
| Chlorobiphenyls (leaks/spills) | | | ✓ | | | |
| Ethylene dichloride/vinyl chloride | ✓ | | | | | |

Table 8. List of Known and Suspected CDD/CDF Sources (continued)

| Emission Source Category | Contemporary Formation Sources | | | Reservoir Sources | | |
|---|--------------------------------|----------------------|------------------|-------------------|----------------------|------------------|
| | Quantifiable | Preliminary Estimate | Not Quantifiable | Quantifiable | Preliminary Estimate | Not Quantifiable |
| Dioxazine dyes and pigments | | | ✓ | | | |
| 2,4-Dichlorophenoxy acetic acid | | | ✓ | | | |
| Municipal wastewater treatment | | ✓ | | | | |
| Tall oil-based liquid soaps | | | ✓ | | | |
| IV. BIOLOGICAL AND PHOTOCHEMICAL PROCESSES | | | ✓ | | | |
| V. RESERVOIR SOURCES | | | | | | |
| <i>Natural</i> | | | | | | |
| - Land | | | | | ✓ | |
| - Air | | | | | | ✓ |
| - Water | | | | | | ✓ |
| - Sediments | | | | | | ✓ |
| <i>Anthropogenic Structures</i> | | | | | | |
| - PCP Treated Wood | | | | | | ✓ |

BIBLIOGRAPHY

This bibliography presents references cited in the text of this report as well as references cited in the *National Database*. (File names in parentheses indicate the specific files in the *National Database*.)

- Advanced Technology Systems, Inc. (1995) Report on measurement of hazardous air pollutants from aluminum melt furnace operations at Ravenswood Aluminum Corporation. Project No. IKM-0226. (*salwvrvav.xls*)
- AGES. (1992) Applied Geotechnical and Environmental Services Corp. Source sampling report - comprehensive emissions testing; blast furnace, May/June 1992, Franklin Smelting & Refining Corp. Valley Forge, PA: AGES. Report No. 42614.01-01. (*snmpafra.xls*)
- Air Monitoring Specialists, Inc. (1995) Stationary source sampling report. Emissions testing for hexavalent chromium hydrogen chloride, metals, particulate, 4-8 PCDD/PCDF. Volume 1. Common Incinerator Stack. Waste Converters, Inc., Joppa, MD. Richmond, VA: Air Monitoring Specialists, Inc.
- Air Nova, Inc. (1993) Rahway Hospital emission compliance test report. Log No. 01-89-4195. NJ Stack No. 001. Pennsauken, NJ: Air Nova, Inc. (*mwinjrah.xls*)
- AirSource Technologies (1994a) Report for the test burn on Kiln No. 1, Ash Grove Cement Company, Chanute, Kansas. AirSource Project No. 412017.
- AirSource Technologies (1994b) Report for the test burn on Kiln No. 2, Ash Grove Cement Company, Chanute, Kansas. AirSource Project No. 412017.
- Alliance Technologies Corporation (1989) Field test report NITEP III Mid-Connecticut Facility, Hartford, Connecticut. Volume II. Appendices. (*mswctrxf.xls*)
- Am Test-Air Quality, Inc. (1994) Ash Grove Cement Company. Main cement kiln stack. Seattle, Washington, September 26-27, 1994. (*ckwaash.xls*)
- Am Test-Air Quality, Inc. (1995) Ash Grove Cement Company. Cement kiln precipitator stack. Montana City, Montana, September 29-30, 1994. (*ckmtash.xls*)
- Ash Grove Cement Company (1994) Final Report. RCRA trial burn for Kiln Nos. 1 and 2. Volume I. Chanute, Kansas, Waste-Derived Fuel Facility.
- Ash Grove Cement Company (1995) Report of RCRA trial burn for kiln No. 2. Volume I of IV. Louisville, Nebraska, Waste-Derived Fuel Facility.
- Battelle (1988) Final report on PCDD/PCDF and PAH analyses of modified method 5 and ash samples from Red Wing/Compliance Test to Northern States Power Company. Columbus, OH: Battelle.
- Calcagni, J.; Ciolek, M.; Mulrine, P. (1998) Dioxin emissions from U.S. sinter plants. Abstract. Research Triangle Park, NC: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. (*Sininltv.xls, sinohwci.xls*)

- Cambridge Environmental Inc. (1995a) Comments on *Estimating Exposure to Dioxin-Like Compounds: Review Draft*. Submitted to EPA's Office of Health and Environmental Assessment. January 12, 1995. (*ssi-a.xls, ssi-c.xls, ssi-b.xls, ssi-d.xls, ssi-e.slx, ssi-f.xls, ssi-g.xls, ssi-grs.xls, ssi-h.xls, ssi-i.xls, ssi-j.xls, ssi-k.xls*)
- Cambridge Environmental Inc. (1995b) Addendum to comments on *Estimating Exposure to Dioxin-Like Compounds: Review Draft*. Submitted to EPA's Office of Health and Environmental Assessment. May 11, 1995. (*ssi-l.xls, ssi-m.xls*)
- CARB (1987a) California Air Resources Board. Evaluation test on a hospital refuse incinerator at Saint Agnes Medical Center, Fresno, CA. Engineering Evaluation Branch, Monitoring and Laboratory Division. Technical Report ARB/SS-87-01. (*mwicastg.xls*)
- CARB (1987b) California Air Resources Board. Evaluation test on a hospital refuse incinerator at Cedars Sinai Medical Center, Los Angeles, California. Engineering Evaluation Branch, Monitoring and Laboratory Division. Technical Report ARB/SS-87-11. (*mwicaced.xls*)
- CARB (1988a) California Air Resources Board. Evaluation retest on a hospital refuse incinerator at Sutter General Hospital, Sacramento, CA. Engineering Evaluation Branch, Monitoring and Laboratory Division. Technical Report ARB/ML-88-026. (*mwicasut.xls*)
- CARB (1988b) California Air Resources Board. Evaluation test on a refuse incinerator at Stanford University Environmental Safety Facility, Stanford, California. Engineering Evaluation Branch, Monitoring and Laboratory Division. Technical Report ARB/ML-88-025. (*mwicasta.xls*)
- CARB (1989) California Air Resources Board. Evaluation test on a small hospital refuse incinerator Saint Bernardines Hospital, San Bernardino, California. Engineering Evaluation Branch, Monitoring and Laboratory Division. Technical Report ARB/ML-89-028. (*mwicastb.xls*)
- CARB (1990a) California Air Resources Board. Evaluation test of the Kaiser Permanente Hospital waste incinerator in San Diego. Engineering Evaluation Branch, Monitoring and Laboratory Division. Technical Report ARB/ML-90-030. (*mwicakai.xls*)
- CARB (1990b) California Air Resources Board. ARB evaluation test conducted on a hospital waste incinerator at Los Angeles Co. - USC Medical Center Los Angeles, California. Engineering Evaluation Branch, Monitoring and Laboratory Division. Test Report C-87-122. (*mwicausc.xls*)
- CARB (1990c) California Air Resources Board. Evaluation test on a wood waste fired incinerator at Koppers Company, Oroville, California. Engineering Evaluation Branch, Monitoring and Laboratory Division. Test Report No. C-88-065. (*wcicakop.xls*)
- CARB (1990d) California Air Resources Board. Evaluation test on twin fluidized bed wood waste fueled combustors located in central California. Engineering Evaluation Branch, Monitoring and Laboratory Division. Test Report No. C-87-042. (*wcicacon.xls*)
- CARB (1990e) California Air Resources Board. Evaluation test on a wood waste fired incinerator at Pacific Oroville Power Inc. Engineering Evaluation Branch, Monitoring and Laboratory Division. Test Report No. C-88-050. (*wcicapac.xls*)

- CARB (1990f) California Air Resources Board. Evaluation test on two propane fired crematories at Camellia Memorial Lawn Cemetery. Engineering Evaluation Branch, Monitoring and Laboratory Division. Test Report No. C-90-004. (*crecacam.xls*)
- CARB (1990g) California Air Resources Board. Compliance testing for non-criteria pollutants at a landfill flare. Confidential Report No. ERC-2. Engineering Evaluation Branch, Monitoring and Laboratory Division. [As reported in U.S. EPA, 1995e.] (*land-gas.xls*)
- CARB (1990h) California Air Resources Board. Evaluation test on a wood waste fired incinerator at Louisiana Pacific Hardboard Plant, Oroville, CA. Test Report No. C-88-066. Engineering Evaluation Branch, Monitoring and Laboratory Division. [As reported in NCASI, 1995.]
- CARB (1991a) California Air Resources Board. Emission test of the Modesto energy project tires-to-energy facility. California Air Resource Board. Engineering Evaluation Branch, Monitoring and Laboratory Division. Project No. C-87-072. (*tccamod.xls*)
- CARB (1991b) California Air Resources Board. Evaluation test of a hospital refuse fired incinerator at American Environmental Management Corporation. Engineering Evaluation Branch, Monitoring and Laboratory Division. Test Report No. C-89-001. (*carb-92a.xls*) (*mwicaame.xls*)
- CARB (1992a) Dioxin/furan estimates from a secondary aluminum facility. Confidential Report No. ERC-9. Engineering Evaluation Branch, Monitoring and Laboratory Division. [As reported in U.S. EPA, 1997b.] (*carb-92b.xls*)
- CARB (1993) California Air Resources Board. Emissions measurement of toxic compounds from a cupola baghouse at a steel foundry. Confidential Report No. ERC-61. Engineering Evaluation Branch, Monitoring and Laboratory Division. [As reported in U.S. EPA, 1995e.] (*fefondry.xls*)
- CARB (1999) California Air Resources Board. Determination of emissions from the No. 3 reformer at Tosco Refining Company San Francisco Area Refinery at Avon. Project No. C-96-0396. Engineering and Laboratory Branch, Monitoring and Laboratory Division. (*prcatosc.xls*)
- Carlson Associates (1994) Dioxin/furan emissions from sewage sludge incinerators. Comments submitted 12 December 1994, to EPA's Office of Health and Environmental Assessment concerning the draft document entitled "Estimating Exposure to Dioxin-Like Compounds." (*ssi-8.xls*, *ssi-9.xls*)
- City of Hampton, VA (1988) Letter from City of Hampton, Virginia, Refuse-Fired Steam Generating Facility to J. Topsale, EPA Region 3.
- Clean Air Engineering, Inc. (1988) Report on compliance testing performed at Northern States Power French Island Station Unit 1. Volume 1. Palatine, IL: Clean Air Engineering, Inc. Project No. 4244/2. (*mswwinsp.xls*)
- Clean Air Engineering, Inc. (1990) Report on compliance testing conducted for Hamot Medical Center, Infectious Waste Incinerator, Volume 1. Palatine, IL: Clean Air Engineering, Inc. Project No. 5123. (*mwipaham.xls*)

- Clean Air Engineering, Inc. (1992) Report on diagnostic testing. Conducted at: Continental Cement Company, Inc., Hannibal, Missouri. Palatine, IL: Clean Air Engineering, Inc. Project No. 6394.
- Clean Air Engineering, Inc. (1994a) Report on compliance testing performed for Ogden Martien Systems, Inc. Conducted at I-95 Energy/Resource Recovery Facility Units 1 through 4 SDA Inlets and Stacks. Lorton, VA. Volume 1. Palatine, IL: Clean Air Engineering, Inc. Project No. 7185-2. (*mswvai95.xls*)
- Clean Air Engineering, Inc. (1994b) Report on air emissions testing performed for Ogden Martin Systems, Inc. conducted at Greater Detroit Resource Recovery Facility Unit 12 SDA inlet, ID fan outlet and stack, Detroit, Michigan. Palatine, IL: Clean Air Engineering, Inc. Reference No. X1044-38-2. (*mswmiogd.xls*)
- Clean Air Engineering, Inc. (1994c) Report on polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans testing conducted at Continental Cement Company, Inc., Cement Kiln Stack, Hannibal, Missouri. Palatine, IL: Clean Air Engineering, Inc. Reference No. 164-6831.
- DEECO, Inc. (1994) Emission measurements for PCDD/PCDFs, from a dry process cement kiln #3. Cary, NC: DEECO, Inc.
- ECOSERVE, Inc. (1990a) Pooled air toxics source test program for kraft pulp mills. Report Number One. Gaylord Container Corp. Antioch, California. Pittsburg, CA: ECOSERVE, Inc., Environmental Services. (*kblcagay.xls*)
- ECOSERVE, Inc. (1990b) Pooled air toxics source test program for kraft pulp mills. Report Number Two. Simpson Paper Company. Anderson, California. Pittsburg, CA: ECOSERVE, Inc., Environmental Services. (*kblcaspa.xls*)
- ECOSERVE, Inc. (1990c) Pooled air toxics source test program for kraft pulp mills. Report Number Three. Simpson Paper Company. Fairhaven, California. Pittsburg, CA: ECOSERVE, Inc., Environmental Services. (*kblcaspf.xls*)
- ECOSERVE, Inc. (1990d) Pooled air toxics source test program for kraft pulp mills. Report Number Four. Louisiana Pacific Corp. Samoa, California. Pittsburg, CA: ECOSERVE, Inc., Environmental Services. (*kblcalou.xls*)
- Electric Power Research Institute. 1994. Electric utility trace substances synthesis report. Palo Alto, CA: Electric Power Research Institute. (*peg__102.xls, peg__116.xls, peg-118.xls, peg.119.xls, peg__122.xls, peg__22.xls, peg__bal.xls, peg__bos.xls, peg__car.xls, peg__coa.xls, peg__nil.xls, peg__spr.xls, pwg__yat.xls*)
- EMC Analytical, Inc. (1994) Emission study performed for Solid Waste Authority of Central Ohio, Waste to Energy Facility, Boiler No. 6, Columbus, Ohio. March 16-18, 1994. Gilberts, IL: EMC Analytical, Inc. Project No. 35001. (*mswohcol.xls*)
- Energy and Environmental Research Corp. (1991) Michigan Hospital incinerator emissions test program. Final Report. Volume III: Site Summary Report University of Michigan Medical Center Incinerator. Irvin, CA: Energy and Environmental Research Corporation. (*mwimiuni.xls*)

- Energy and Environmental Research Corp. (1993) Field evaluation of emissions reduction techniques for municipal waste combustors using natural gas. City of Columbus, Solid Waste Reduction Facility, Unit 6. Orrville, OH: Energy and Environmental Research Corporation. (*mswohcol.xls*)
- Energy and Environmental Research Corp. (1995) Emissions testing of Ash Grove Cement Company, Foreman, Arkansas, waste-derived fuel facility, cement kiln no. 3. Volume 1. Final Report. Morrisville, NC: Energy and Environmental Research Corporation. EPA Contract No. 68-D2-0164. (*ckarash1.xls*)
- Energy Systems Associates (1987) Air emission tests at Commerce Refuse-to-Energy Facility, May 26 - June 5, 1987, Volume I. Test Results. Tustin, CA: Energy Systems Associates 20522-449. (*mswcacrf.xls*)
- Energy Systems Associates (1988a) Results of air emission tests during the waste-to-energy demonstration program at the Commerce Refuse-to-Energy Facility. Volume 1. Technical Report. Tustin, CA: Energy Systems Associates No. 20534-621. (*mswcacrf.xls*)
- Energy Systems Associates (1988b) Air emissions tests at the Hampton Refuse-Fired Steam Generating Facility. April 18-24, 1988. Volume I. Test Results. Tustiu, CA: Energy Systems Associates No. 29906-554. (*mswvaham.xls, mswvahrf.xls*)
- Engineering Sciences, Inc. (1989) A report of emission compliance testing of the Regional Waste Systems, Inc., Greater Portland Resource Recovery Facility. Fairfax, VA: Engineering Sciences, Inc. (*mswmerrf.xls*)
- Engineering-Science, Inc. (1990) Report of air pollution source testing for California AB2588 at RMC Lonestar Cement Company, Davenport, California. Pasadena, CA: Engineering Science, Inc. (*ckcarmc.xls*)
- ENSR Consulting and Engineering (1995) Central Wayne County Sanitation Authority, Dearborn Heights, Michigan. Emission testing report. Westmont, IL: ENSR Consulting and Engineering. Document No. 8700-295-400. (*mswmicwc.xls*)
- Entropy Environmentalists, Inc. (1987a) Stationary source sampling report. Dioxins/furans emissions compliance testing. Volume I. Signal Environmental Systems, Inc., Claremont Facility, Claremont, New Hampshire. Research Triangle Park, NC: Entropy Environmentalists, Inc. Reference No. 5553-A. (*mswnhses.xls*)
- Entropy Environmentalists, Inc. (1987b) Stationary source sampling report, Signal RESCO Pinellas County Resource Recovery Facility, St. Petersburg, Florida. Research Triangle Park, NC: Entropy Environmentalists, Inc. Reference No. 5286B. (*mswflrrf.xls*)
- Entropy Environmentalists, Inc. (1989) Stationary source sampling report. Volume I. Text and Appendix A. Wheelabrator Concord Company, LP, Resource Recovery Facility, Penacook, New Hampshire, Units 1 and 2. Research Triangle Park, NC: Entropy Environmentalists, Inc. Reference No. 6302/6401. (*mswnhwhe.xls*)

- Entropy Environmentalists, Inc. (1990) Honolulu Resource Recovery Facility, Ewa Beach, Oahu, Hawaii. Units No. 1 and 2 RDF Boilers. Research Triangle Park, NC: Entropy Environmentalists, Inc. Reference No. 6544. (*mswhihrr.xls*)
- Entropy Environmentalists, Inc. (1991) Stationary source sampling report. Volume I. Camden County Resource Recovery Facility, Camden, New Jersey, Units 1, 2, and 3. Research Triangle Park, NC: Entropy Environmentalists, Inc. Reference No. 10183. (*mswnjcam.xls*)
- Entropy Environmentalists, Inc. (1992a) Stationary source sampling report. Baltimore RESCO Company, Baltimore Maryland. Unit No. 1. Research Triangle Park, NC: Entropy Environmentalists, Inc. Reference No. 10759. (*mswmdbal.xls*)
- Entropy Environmentalists, Inc. (1992b) Stationary source sampling draft report. I-95 energy/resource recovery facility, Lorton, VA, Units No. 1, 2, 3, and 4. Volume II. Appendices B through E. Research Triangle Park, NC: Entropy Environmentalists, Inc. Reference No. 11211. (*mswvai95.xls*)
- Entropy Environmentalists, Inc. (1992c) Stationary source sampling final report. Alexandria Resource Recovery Facility, Alexandria, VA. Volume I. Research Triangle Park, NC: Entropy Environmentalists, Inc. Reference No. 10922. (*mswvaale.xls*)
- Entropy Environmentalists, Inc. (1993) Stationary source sampling report. Volume 1. Text and Appendices. Wheelabrator Claremont, L.P., Claremont, New Hampshire. Units No. 1 and 2. Research Triangle Park, NC: Entropy Environmentalists, Inc. Reference No. 11683. (*mwnhses.xls*)
- Entropy Environmentalists, Inc. (1994) Wheelabrator Falls Resource Recovery Facility, Morrisville, Pennsylvania. Volume 1. Text and Appendix A. Research Triangle Park, NC: Entropy Environmentalists, Inc. Reference No. 12918B. (*mswpawhe.xls*)
- Entropy, Inc. (1994a) Stationary source sampling report. Norfolk Naval Shipyard Waste Combustor, Portsmouth, Virginia. Dioxin/Furan emissions testing. Unit No. 3 boiler outlet and stack. Volume I. Text and Appendices. Research Triangle Park, NC: Entropy, Inc. Reference No. 12858A. (*mswvanns.xls*)
- Entropy, Inc. (1994b) Stationary source sampling report. Norfolk Naval Shipyard Waste Combustor, Units No. 1 and 2. Portsmouth, Virginia. Dioxin/Furan emissions testing. Unit No. 3 boiler outlet and stack. Volume I. Text and Appendices. Research Triangle Park, NC: Entropy, Inc. Reference No. 13199A. (*mswvanns.xls*)
- Entropy, Inc. (1995a) Boiler emissions report. Norfolk Naval Shipyard Waste Combustor, Unit No. 4 SDA inlet and stack, Portsmouth, Virginia. Volume I. Text and Appendices. Research Triangle Park, NC: Entropy, Inc. Reference No. 14234. (*mswvanns.xls*)
- Entropy, Inc. (1995b) Stationary source sampling report. Volume 1. Text and Appendix A. Wheelabrator Concord Company, L.P., Penacook, New Hampshire. Units 1 and 2. Research Triangle Park, NC: Entropy, Inc. Reference No. 13749. (*mswnhwhe.xls*)

- Entropy, Inc. (1995c) Stationary source sampling report. Baltimore Resco Co. Unit No. 3 ESP Outlet. Volume 1. Text and Appendix A. Research Triangle Park, NC: Entropy, Inc. Reference No. 14003.
- Environmental Laboratories, Inc. (1994a) Compliance test report for a PCDD/PCDF emission test program performed at the Harrisonburg, VA RRF. Farmingdale, NY: Environmental Laboratories, Inc. File No. 94682. (*mswvarrf.xls*)
- Environmental Laboratories, Inc. (1994b) Emission test report for PCDD/PCDF and carbon monoxide at the Pulaski Highway Incinerator, Unit #5, Baltimore, MD. Farmingdale, NY: Environmental Laboratories, Inc. (*mswmdphi.xls*)
- Environmental Laboratories, Inc. (1994c) Emission test report for carbon monoxide, chromium (total and hexavalent), dioxin/furan, hydrogen chloride, trace metals, particulate matter, mercury at the Pulaski Highway Incinerator, Units 3 and 4, Baltimore, MD. Farmingdale, NY: Environmental Laboratories, Inc. (*mswmdphi.xls*)
- Environmental Laboratories, Inc. (1995) Compliance test report for particulate matter, trace metals, hydrogen chloride, dioxins/furans, mercury, and hexavalent chromium emissions at the Pulaski Highway Incinerator, Units No. 1 and 2, Baltimore, MD. Farmingdale, NY: Environmental Laboratories, Inc. (*mswmdphi.xls*)
- Environmental Protection Programs Directorate (1983) Report on a stack sampling program to measure the emissions of selected trace organic compounds, particulates, heavy metals, and HCl from the Royal Jubilee Hospital Incinerator, Victoria, BC. Pollution Measurement Division, Environmental Protection Programs Directorate. (*mwibcroty.xls*)
- Environmental Risk Sciences, Inc. (1995) An analysis of the potential for dioxin emissions in the primary copper smelting industry. Vol. I and II. Environmental Risk Sciences, Inc. Prepared for the National Mining Association, Washington, D.C. (*pnmazcyp.xls*, *pnmnmhid.xls*)
- Environmental Sciences Services (1990) Final report Kent County Memorial Hospital incinerator compliance test. Providence, RI: Environmental Sciences Services. (*mwiriken.xls*)
- Envisage Environmental Inc. (1995) Test result summary for development of M.A.C.T. standards (for the secondary Aluminum Smelting Industry). Testing Location Wabash Alloys, Wabash, Indiana. (*salinwab.xls*)
- ETS, Inc. (1989a) Compliance test report for Foster Wheeler Resource Recovery Facility, Charleston, SC. Volume II. PCDD/PCDF and Metals Emissions. Roanoke, VA: ETS, Inc. Contract No. 89-217-T. (*mswscrff.xls*)
- ETS, Inc. (1989b) Compliance test report for Dutchess County Resource Recovery Facility. Volume 2. Roanoke, VA: ETS, Inc. Contract No. 89-108-T. (*mswnydut.xls*)
- ETS, Inc. (1993) Air emissions compliance test report for York County Resource Energy Systems, Inc. Roanoke, VA: ETS, Inc. Contract No. 92-811-T. (*mswpaerf.xls*)

- ETS, Inc. (1994) Air emissions test report for Harrisburg materials, energy, resource and recovery facility. Harrisburg, Pennsylvania.
- Galson Corporation (1995) Source Emission Testing. Emission Points EP00012 and EP00023 at Roth Bros. Smelting Corp., Syracuse, New York. Galson Project No. GQ147. (*salnyrot.xls*)
- Gertler, A.; Sagebiel, J.; Dippel, W.; Faring, R. (1998) Measurement of dioxin and furan emissions factors from heavy duty diesel vehicles. J. of the Air and Waste Mgmt. Assoc. 48:276-278. (*diesel.xls*)
- Gertler, A.W.; Sagebiel, J.C.; Dippel, W.A.; Sheetz, L.H. (1996) A study to quantify on-road emissions of dioxins and furans from mobile sources: phase 2. Reno, NV: Desert Research Institute. (*diesel.xls*)
- Gossman Consulting, Inc. (1995) Hazardous air pollutants test report. Lone Star Industries, Inc. Oglesby, Illinois. (*ckillon.xls*)
- Gossman Consulting, Inc. (1996) Hazardous air pollutants test report. Holnam, Inc. Florence, Colorado. (*ckcohol.xls*)
- Hagenmaier, H.; Dawidowsky, V.; Weber, U.B.; Hutzinger, O.; Schwind, K.H.; Thoma, H.; Essers, U.; Buhler, B.; Greiner, R. (1990) Emission of polyhalogenated dibenzodioxins and dibenzofurans from combustion-engines. Organohalogen Compounds 2:329-334. (*nopb-gas.xls, pb-gas.xls*)
- Harding Lawson Associates (1992) Biennial toxic air emissions inventory report - Calaveras Cement Company, Tehachape Plant, Kern County, California. Novato, CA: Harding Lawson Associates. HLA Project No. 21598 001. (*ckcacalt.xls*)
- Hutzinger, O; Essers, U.; Hagenmaier, H. (1992) Untersuchungen zur emission halogenerer dibenzodioxine und dibenzofurane aus verbrennungsmotoren beim betrieb mit handelsüblichen betriebsstoffen. Universities of Bayreuth, Stuttgart and Tübingen, Germany. GSF-Forschungszentrum, Munich, Germany, ISSN 0937-9932. (*nopb-gas.xls, pb-gas.xls*)
- Interpoll Laboratories (1987) Results of the July 1987 emission performance tests of the Pope/Douglas Waste to Energy Facility MSW incinerators in Alexandria, Minnesota. Circle Pines, MN: Interpoll Laboratories. Report No. 7-2394. (*mswnpdw.xls*)
- Interpoll Laboratories, Inc. (1988a) Results of the June 1988 air emission performance test on the MSW incinerators at the St. Croix Waste to Energy Facility in New Richmond, Wisconsin. Volume 1. Results of Exhaust Gas Testing. Circle Pines, MN: Interpoll Laboratories, Inc. Report No. 8-2560. (*mswwiwef.xls*)
- Interpoll Laboratories, Inc. (1988b) Results of the March 21-26, 1988, air emission compliance test on the No. 2 boiler at the Red Wing Station Test IV (high load). Circle Pines, MN: Interpoll Laboratories. Report No. 8-2526. (*mswmnsp.xls*)
- Interpoll Laboratories, Inc. (1988c) Air emission performance evaluation of fRDF cofiring of the No. 9 boiler at the MG & E Plant in Madison, Wisconsin. Volume 1. Results of Flue Gas Testing. Circle Pines, MN: Interpoll Laboratories, Inc. Report No. 8-2539. (*mswwimge.xls*)

Interpoll Laboratories, Inc. (1989) Results of the April 26 and 27, 1989 non-criteria pollutant emission testing on the No. 8 Recovery Boiler at the Potlatch Corporation Northwest Paper Division in Cloquet, Minnesota. Volume 1: Flue Gas Testing. Report Number 9-2757. (*kblmnpot.xls*)

Kaiser Cement Corporation (1992) Additional data for quantification of HAP's emissions from Kaiser Cement Corporation's Permanente, California, facility. Pleasanton, CA: Kaiser Cement Corporation. (*ckcakai.xls*)

Koogler & Associates (1990) Summary of particulate matter, volatile organic compounds, semi-volatile organic compounds, furans and dioxins, sulfur dioxide, nitrogen oxides, metals, and visible emission measurement. For Central Power and Lime, Inc. in Brooksville, FL. Gainesville, FL: Koogler & Associates. (*ckflcen.xls*)

Lefarge Corporation (1995) PCDD/PCDF emission testing report - Fredonia, Kansas, Cement Plant. Southfield, Michigan: Lefarge Corporation.

Lemieux, P. (2000) Barrel burn experiment results. E-mail from P. Lemieux (EPA/ORD) to D. Cleverly (EPA/ORD) dated September 7, 2000.

Marklund, S.; Andersson, R.; Tysklind, M.; Rappe, C.; Egeback, K.E.; Bjorkman, E.; Grigoriadis, V. (1990) Emissions of PCDDs and PCDFs in gasoline and diesel fueled cars. *Chemosphere* 20(5):553-561. (*pb-gas.xls*)

MD Air and Radiation Management Administration (1995) FAX. Summary of source test results, Units 1-3, Montgomery County Resource Recovery Facility. Air and Radiation Management Administration, Maryland Department of the Environment. (*mswmdmon.xls*)

Mitsubishi Cement Corporation (1992) Report of air pollution source testing, Mitsubishi Cement Company, Lucerne Valley, California. (*ckcamit.xls*)

MRI (1985) Midwest Research Institute. Emissions test report: City of Philadelphia Northwest and East Central municipal incinerators. Volume 1. Technical Report. Kansas City, MO: MRI Project No. 8281-L(1). (*mswpainc.xls*)

MRI (1988a) Midwest Research Institute. Emission testing at an RDF municipal waste combustor. Draft Final Report. Kansas City, MO: MRI Project No. 8910-L(02).

MRI (1988b) Midwest Research Institute. Report of the emission test at the energy from waste (EFW) facility, Occidental Chemical Corporation, Niagara Falls, New York. Final Report. Kansas City, MO: MRI Project No. 8876-L. (*mswnyocc.xls*)

NCASI (1995) National Council of the Paper Industry for Air and Stream Improvement. NCASI summary of PCDD/F emissions from wood residue and black liquor combustion. Attachment to comments submitted on January 13, 1995, to EPA's Office of Health and Environmental Assessment concerning the draft document entitled "Estimating Exposure to Dioxin-Like Compounds." (*wcixxwbf.xls*, *wcixxwbe.xls*, *wcixxwbb.xls*, *wcixxcba.xls*, *wrsxxcbc.xls*, *wrsxxcbd.xls*, *wrsxxcba.xls*, *wcixxbf5*, *wcixxbf4.xls*, *kblcarfb.xls*, *kbllarfe.xls*, *kblmirfg.xls*, *kblmnrfc.xls*, *kblncrff.xls*, *kblnyrfd.xls*)

New York State Department of Environmental Conservation (1986a) Preliminary stack test report on Oneida County ERF, New York State Department of Environmental Conservation, Division of Air Resources. (*mwnyone.xls*)

New York State Department of Environmental Conservation (1986b) Emission source test report. Preliminary stack test report on Cattaraugus County Energy Facility, New York State Department of Environmental Conservation, Division of Air Resources. (*mwnyurf.xls*)

New York State Department of Environmental Conservation (1986c) Emission source test report. Preliminary report on Occidental Chemical Corporation EFW. New York State Department of Environmental Conservation, Division of Air Resources. (*mwnyocc.xls*)

New York State Department of Environmental Conservation (1989) Final Report. Results from the analysis of MSW incinerator testing at Peekskill, New York. Volume I. (*mwnywes.xls*)

Ogden Martin Systems, Inc. (1994a) Environmental test report regarding Lee County Solid Waste Resource Recovery Facility. Fairfield, NJ: Ogden Martin Systems, Inc. Report No. 884. (*mwnfllee.xls*)

Ogden Martin Systems, Inc. (1994b) Entropy Environmentalists Inc. report of compliance testing. Environmental test report regarding Alexandria/Arlington Resource Recovery Units 2 and 3. Fairfield, NJ: Ogden Martin Systems, Inc. Report No. 673. (*mwnvaale.xls*)

Ogden Martin Systems, Inc. (1994c) Environmental test report. Executive Summary. Volume 1. Greater Detroit Resource Recovery Facility. Fairfield, NJ: Ogden Martin Systems, Inc. Report No. 834. (*mwnmiogd.xls*)

Ogden Martin Systems, Inc. (1994d) Environmental test report. Executive Summary. Volume 1. Greater Detroit Resource Recovery Facility. Fairfield, NJ: Ogden Martin Systems, Inc. Report No. 793. (*mwnmiogd.xls*)

Ogden Martin Systems, Inc. (1995a) Environmental test report regarding Union County Resource Recovery Facility. Executive Summary. Fairfield, NJ: Ogden Martin Systems, Inc. Report No. 902. (*mwnjrrf.xls*)

Ogden Martin Systems, Inc. (1995b) Environmental test report regarding Union County Resource Recovery Facility. Executive Summary. Fairfield, NJ: Ogden Martin Systems, Inc. Report No. 963. (*mwnjrrf.xls*)

Ogden Martin Systems, Inc. (1995c) Environmental test report regarding Onondaga County Resource Recovery Facility. Executive Summary. Volume I. Fairfield, NJ: Ogden Martin Systems, Inc. Report No. 928. (*mwnyono.xls*)

Ogden Projects, Inc. (1988) Environmental test report regarding Alexandria/Arlington Resource Recovery Facility Units 1, 2, and 3. Emeryville, CA: Ogden Projects, Inc. Report No. 144B. (*mwnvaale.xls*)

- Ogden Projects, Inc. (1989a) Air emissions test results from the Stanislaus County, California Resource Recovery Facility. International Conference on Municipal Waste Combustion. Conference Proceedings Vol. 2. (*mswcarrf.xls*)
- Ogden Projects, Inc. (1989b) Environmental test report regarding Babylon Resource Recovery Facility, Units 1 and 2. Emeryville, CA: Ogden Projects, Inc. Report No. 193. (*mswnybab.xls*)
- Ogden Projects, Inc. (1989c) Environmental test report regarding Indianapolis Resource Recovery Facility. Emeryville, CA: Ogden Projects, Inc. Report No. 221. (*mswinrrf.xls*)
- Ogden Projects, Inc. (1989d) Recon Systems, Inc. stack sampling report, August 9, 1989, regarding Alexandria/Arlington Resource Recovery Facility, Unit 2. Volume 2 and Executive Summary. Emeryville, CA: Ogden Projects, Inc. Report No. 209B. (*mswvaale.xls*)
- Ogden Projects, Inc. (1996a) Lee County Solid Waste Resource Recovery Facility. Dioxin/furans audit data. Fairfield, NJ: Ogden Projects, Inc.
- Ogden Projects, Inc. (1996b) Montgomery County Resource Recovery Facility. Compliance test report. Fairfield, NJ: Ogden Projects, Inc. Report No. 2023.
- Pennsylvania Bureau of Air Quality Control (1990a) Data file on Hershey Medical Center, Derry Township, Dauphin County, from the Bureau of Air Quality Control, Commonwealth of Pennsylvania. (*mwipaher.xls*)
- Pennsylvania Bureau of Air Quality Control (1990b) Data file on Brookville Hospital, Brookville, Jefferson County, from the Bureau of Air Quality Control, Commonwealth of Pennsylvania. (*mwipabro.xls*)
- Pennsylvania Bureau of Air Quality Control (1990c) Data file on Harrisburg Materials, Energy, Recycling, and Recovery Facility from the Bureau of Air Quality Control, Commonwealth of Pennsylvania.
- Pennsylvania Bureau of Air Quality Control (1994a) Data file on Montenay Montgomery County Resource Recovery Facility, Plymouth Township, Montgomery County, from the Bureau of Air Quality Control, Commonwealth of Pennsylvania. (*mswpamon.xls*)
- Pennsylvania Bureau of Air Quality Control (1994b) Data file on Lancaster County Solid Waste Management Authority, Conoy Township, Lancaster County, from the Bureau of Air Quality Control, Commonwealth of Pennsylvania. (*mswpalan.xls*)
- Pennsylvania Bureau of Air Quality Control (1994c) Data file on Harrisburg Materials, Energy, Recycling, and Recovery Facility Harrisburg, Dauphin County. Bureau of Air Quality Control, Commonwealth of Pennsylvania. (*mswpahme.xls*)
- Pennsylvania Bureau of Air Quality Control (1995) Data file on Waste Resource Energy, Inc. Delaware County Resource Recovery Facility, Chester, Delaware County, from the Bureau of Air Quality Control, Commonwealth of Pennsylvania. (*mswpawre.xls*)

- Radian Corporation (1986) Draft emission test report. Dioxin/furan and total organic chlorides emission testing. Saugus Resource Recovery Facility, Saugus, MA. Research Triangle Park, NC: Radian Corporation. (*mswmasgs.xls*)
- Radian Corporation (1987a) Final test report - Site 12. Sewage Sludge Incinerator SSI-C. National Dioxin Study Tier 4: Combustion Sources. Research Triangle Park, NC: Radian Corporation. (*ssixs12.xls*)
- Radian Corporation (1987b) Emission test report dioxin/furan emission testing, Refuse Fuels Associates, Lawrence, Massachusetts. Research Triangle Park, NC: Radian Corporation. (*mswmarfa1.xls*, *mswmarfa2.xls*)
- Radian Corporation (1988) Data analysis results for testing at a two-stage modular MSW incinerator: Oswego County ERF, Fulton, New York. Draft final report, Volume I. Research Triangle Park, NC: Radian Corp. (*mswny-oc.xls*)
- Radian Corporation (1989a) Municipal waste combustion multipollutant study, emission test report, mass burn refractory incineration, Montgomery County South, Ohio. Volume 1. Summary of Results. Research Triangle Park, NC: Radian Corporation. (*mswohmcs.xls*)
- Radian Corporation (1989b) Results from the analysis of MSW incinerator testing at Peekskill, New York. Volume I. Final Report. Research Triangle Park, NC: Radian Corporation. (*mswnywes.xls*)
- Radian Corporation (1989c) Compliance test report for the Hempstead Resource Recovery Facility, Westbury, New York. Research Triangle Park, NC: Radian Corporation. (*mswnyrrf.xls*)
- Radian Corporation (1989d) Municipal waste combustion multipollutant study, emission test report, Maine Energy Recovery Company Refuse Derived Fuel Facility, Biddeford, Maine. Volume I: Summary of Results. Research Triangle Park, NC: Radian Corporation. (*mswmemai.xls*)
- Radian Corporation (1989e) Final Report. Emissions associated with the combustion of pulp and paper mill primary sludge in a cement kiln (for Simpson Paper Company and Calaveras Cement Company). Sacramento, CA: Radian Corporation. (*ckcacal.xls*)
- Radian Corporation (1991a) Medical waste incineration emission test report: Lenoir Memorial Hospital, Kinston, North Carolina. Vol. I. Research Triangle Park, NC: Radian Corporation. EMB Project No. 90-MWI-05. (*mwinclen.xls*)
- Radian Corporation (1991b) Results of dioxin testing on the catalytic reformer unit #1 exhaust Texaco Refinery; Bakersfield, California. Radian Corp: Sacramento, CA. August 8, 1991. (*pracatexa.xls*)
- Radian Corporation (1994) Organic emissions speciation and risk assessment report: Lafarge Corporation, Alpena, Michigan, plant. Herndon, Virginia: Radian Corporation.
- Radian Corporation (1995) Final Report. Haps test program report for Capitol Aggregates, Inc. San Antonio, Texas. Austin, TX: Radian Corporation (*cktxcap.xls*)

- Radian Corporation (1996) HAPS test report for Lehigh Portland Cement Company, Union Bridge, Maryland facility. Austin, TX: Radian Corporation (*ckmdleh.xls*).
- Riggs, K.B.; T.D. Brown; M.E. Schrock. 1995. PCDD/PCDF emissions from coal-fired power plants. Organohalogen Compounds 24:51-54. (*peg_yat.xls, peg_spp.xls, peg_nil.xls, peg_coa.xls, peg_bal.xls, peg_bos.xls, peg_car.xls*)
- Riverside Cement Company (1992) NESHPS additional information for Riverside Cement Operations. Riverside, CA: Riverside Cement Company. (*ckcariv.xls*)
- RTI (1998) Research Triangle Institute. Data quality audit of EPA's national database of sources of environmental releases of dioxin-like compounds in the U.S. EPA Contract No. 68-D4-0091, Work Assignment No. 98-01. November 25, 1998.
- Schreiber, Grana & Yonley, Inc. (1994a) Emissions update report relating to BIF emissions controls. Prepared for: Continental Cement Company, Inc., Hannibal, Missouri. Fenton, Missouri: Schreiber, Grana & Yonley, Inc.
- Schreiber, Grana & Yonley, Inc. (1994b) Correspondence from Robert J. Schreiber, Jr., President, Schreiber, Grana & Yonley, Inc. to Joe Wood, U.S. Environmental Protection Agency, transmitting data from dioxin testing conducted at Continental Cement Company, Inc. before and after the ESP. (*ck_con.xls*)
- Schwind, K-H.; Thoma, H.; Hutzinger, O.; Dawidowsky, N.; Weberuss, U.; Hagenmaier, H.; Buehler, U.; Greiner, R.; Essers, U.; Bessey, E. (1991) Emission halogenierter dibenzodioxine (PXDD) und dibenzofurane (PXDF) aus verbrennungsmotoren. UWSF-Z. Umweltchem. Oekotox. 3, 291-298. [English translation] (*nopb-gas.xls, pb-gas.xls*)
- Scott Environmental Technology, Inc. (1985) Sampling and analysis of chlorinated organic compound emissions from the Hampton Waste-to-Energy System. Plumsteadville, PA: Scott Environmental Technology, Inc. No. 1516-02-0385. (*mswvahr.xls*)
- Scott Environmental Technology, Inc. (1991) Emission compliance test of a municipal waste combustor, Harford County, MD. Plumsteadville, PA: Scott Environmental Technology, Inc. No. 1442-02-1091. (*mswmdwep.xls*)
- Sverdrup Corp. (1991) Chemetco, Inc., compliance testing, final report. St. Louis, MO: Sverdrup Corp. April 19, 1991. (*snailche.xls*)
- Team Environmental Services, Inc. (1995) Certification of compliance source test report using tire derived fuel. Riverside Cement Company, Oro Grande Facility. August 25, 1995. (*ckcarn.xls*)
- Technical Services, Inc. (1993a) Source test report. Boca Raton Hospital, Boca Raton Florida, Dioxin Emissions, April 1-2, 1993; September 16-17, 1994. Jacksonville, FL: Technical Services, Inc. (*mwiflboc.xls*)
- Technical Services, Inc. (1993b) Source test report. JFK Hospital, West Palm Beach Florida, Dioxin Emissions, June 22-23, 1993. Jacksonville, FL: Technical Services, Inc. (*mwifljk.xls*)

- U.S. Environmental Protection Agency (1987a) National dioxin study Tier 4 - combustion sources. Engineering analysis report. Research Triangle Park, NC: Office of Air Quality Planning and Standards. EPA-450/4-84-014h. (*drum-bar.xls, ssixxs12.xls, scrpwire.xls, sec-copp.xls, snmdcepa.xls*)
- U.S. Environmental Protection Agency (1987b) Municipal waste combustion study. Characterization of the municipal waste combustion industry. Washington, DC: Office of Air and Radiation. EPA/530-SW-87-021b.
- U.S. Environmental Protection Agency (1987c) Municipal waste combustion multipollutant study. Emission test report. Marion County solid waste-to-energy facility. Ogden Martin Systems of Marion, Inc. Brooks, Oregon. Volume 1: Summary and Results. Research Triangle Park, NC: Office of Air Quality Planning and Standards. EMB Report No. 86-MIN-03. (*mswormar.xls*)
- U.S. Environmental Protection Agency (1988a) Municipal waste combustion multipollutant study. Shutdown/startup emission test report. Marion County solid waste-to-energy facility. Ogden Martin Systems of Marion, Inc. Brooks, Oregon. Research Triangle Park, NC: Office of Air Quality Planning and Standards. EMB Report No. 87-MIN-04A. (*mswormar.xls*)
- U.S. Environmental Protection Agency (1988b) Municipal waste combustion multipollutant study. Characterization emission test report. Marion County solid waste-to-energy facility. Ogden Martin Systems of Marion, Inc. Brooks, Oregon. Research Triangle Park, NC: Office of Air Quality Planning and Standards. EMB Report No. 897-MIN-04. (*mswormar.xls*)
- U.S. Environmental Protection Agency (1988c) Municipal waste combustion multipollutant study. Emission test report. Wheelabrator Millbury, Inc. Millbury, Massachusetts. Research Triangle Park, NC: Office of Air Quality Planning and Standards. EMB Report No. 88-MIN-07.
- U.S. Environmental Protection Agency (1988d) Municipal waste combustion multipollutant study. Summary report. Signal Environmental Systems, Inc. North Andover RESCO, North Andover, MA. Research Triangle Park, NC: Office of Air Quality Planning and Standards. EMB Report No. 86-MIN-02A. (*mswmanar.xls*)
- U.S. Environmental Protection Agency (1988e) Municipal waste combustion multipollutant study. Summary report. Marion County Solid Waste-to Energy Facility Ogden Martin Systems of Marion, Inc. Brooks, Oregon. Research Triangle Park, NC: Office of Air Quality Planning and Standards. EMB Report No. 86-MIN-03A. (*mswormar.xls*)
- U.S. Environmental Protection Agency (1989a) Municipal waste combustion multipollutant study: refuse-derived fuel. Uncontrolled CDD/CDF, metals and particulate emissions test report. Mid-Connecticut Resource Recovery Facility, Hartford, Connecticut. Research Triangle Park, NC: Office of Air Quality Planning and Standards. EMB Report No. 88-MIN-09. (*mswctrff.xls*)
- U.S. Environmental Protection Agency (1989b) Municipal waste combustion multipollutant study: Refuse-derived fuel. Summary Report. Mid-Connecticut Resource Recovery Facility, Hartford, Connecticut. Research Triangle Park, NC: Office of Air Quality Planning and Standards. EMB Report No. 88-MIN-09A. (*mswctrff.xls*)

- U.S. Environmental Protection Agency (1989c) Municipal waste combustion multipollutant study. Emission test report, Maine Energy Recovery Company Refuse Derived Fuel Facility, Biddeford, Maine. Volume I and II. Washington, D.C.: Office of Research and Development. EPA-600/8-89-064a and EPA-600/8-89-064b. (*mswmemai.xls*)
- U.S. Environmental Protection Agency (1989d) Interim procedures for estimating risks associated with exposures to mixtures of chlorinated dibenzo-p-dioxins and dibenzofurans (CDDs and CDFs) and 1989 update. Washington, DC: Risk Assessment Forum. EPA/625/3-89/016.
- U.S. Environmental Protection Agency (1990a) Medical waste incineration emission test report. AMI Central Carolina Hospital, Sanford, North Carolina. Volume I. Research Triangle Park, NC: Office of Air Quality Planning and Standards. EMB Report No. 90-MWI-5. (*mwinccen.xls*)
- U.S. Environmental Protection Agency (1990b) Emissions testing of a precalciner cement kiln at Louisville, Nebraska. Washington, DC: Office of Solid Waste, Waste Treatment Branch. (*ckneash.xls*)
- U.S. Environmental Protection Agency (1990c) Emissions testing of a wet cement kiln at Hannibal, Missouri. Washington, DC: Office of Solid Waste, Waste Treatment Branch.
- U.S. Environmental Protection Agency (1990d) Summary report on USEPA/Industry Cooperative Dioxin Study. "The 104 Mill Study." Washington, DC: Office of Water Regulations and Standards. July 1990. (*pulpetal.xls*)
- U.S. Environmental Protection Agency (1990e) Emissions of metals, chromium and nickel species, and organics from municipal wastewater sludge incinerators. Volume I: Summary report. EPA Contract No. 68-C0-0027, Work Assignment No. 0-5. (*ssi-8.xls, ssi-9.xls*)
- U.S. Environmental Protection Agency (1991a) Medical waste incineration emission test report. Morristown Memorial Hospital, Morristown, New Jersey. Volume I. Research Triangle Park, NC: Office of Air Quality Planning and Standards. EMB Report No. 91-MWI-8. (*mwinjmor.xls*)
- U.S. Environmental Protection Agency (1991b) Medical waste incineration emission test report. Borgess Medical Center, Kalamazoo, Michigan. Volume I. Research Triangle Park, NC: Office of Air Quality Planning and Standards. EMB Report 91-MWI-9. (*mswmibor.xls*)
- U.S. Environmental Protection Agency (1991c) Medical waste incineration emission test report: Cape Fear Memorial Hospital, Wilmington, NC; Volume I-III. Research Triangle Park, NC: Office of Air Quality Planning and Standards. EMB Report 90-MWI-05. (*mwinccap.xls*)
- U.S. Environmental Protection Agency (1991d) Medical waste incineration emission test report: Jordan Hospital, Plymouth, Massachusetts. Volume 1. Research Triangle Park, NC: Office of Air Quality Planning and Standards. EMB Report 90-MWI-6. (*mswmajor.xls*)
- U.S. Environmental Protection Agency (1992a) Secondary lead smelter emission test report. East Penn Manufacturing, Lyon Station, PA. Volume 1. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. EMB Report 92-SLS-3. (*snmpaeas.xls*)

- U.S. Environmental Protection Agency (1993a) Emission test report. Field test of carbon injection for mercury control Camden County Municipal Waste Combustor. Washington, DC: Office of Research and Development. EPA-600/R-93-181. (*mwnjcam.xls*)
- U.S. Environmental Protection Agency (1995a) Final emission test report HAP emission testing on selected sources at a secondary lead smelter. Schuykill Metals Corporation, Forest City, Missouri. Volume 1. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. EMB Report 93-SLS-2. (*snmmosch.xls*)
- U.S. Environmental Protection Agency (1995b) Final emission test report HAP emission testing on selected sources at a secondary lead smelter. Tejas Resources, Inc., Terrell, TX. Volume 1. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. EMB Report 93-SLS-1. (*snmtxtej.xls*)
- U.S. Environmental Protection Agency (1995c) Secondary aluminum plant emission test report. Rochester Aluminum Smelting Corporation, Rochester, New York. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. EMB Report 95-SAL-01. (*salnyroc.xls*)
- U.S. Environmental Protection Agency (1995d) Volume II: HWC emissions database. Appendix A: cement kiln detailed data listing. Washington, DC: Office of Solid Waste and Emergency Response. (*many files within hwi__97 directory*)
- U.S. Environmental Protection Agency (1996) EPA OSW hazardous waste combustion data base. Washington, DC: Office of Solid Waste, Waste Management Division. (*many files within hwi__97 directory*)
- U.S. Environmental Protection Agency (1997) Locating and estimating air emissions from sources of dioxins and furans. Draft final report. Research Triangle Park, NC: Office of Air Quality Planning and Standards. Contract No. 68-D2-0160. (*fefondry.xls, sec-copp.xls*)
- U.S. Environmental Protection Agency (2001) Exposure and human health reassessment of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and related compounds. Part I: Estimating exposure to dioxin-like compounds. Volume 2: Sources of dioxin-like compounds in the United States. Washington, DC: Office of Research and Development. EPA/600/P-00/001Ab.
- Van den Berg, M.; Birnbaum, L.; Bosveld, A.T.C.; Brunstrom, B.; Cook, P.; Feeley, M.; Giesy, J.P.; Hanberg, A.; Hasegawa, R.; Kennedy, S.W.; Kubiak, T.; Larsen, J.C.; van Leeuwen, F.X.R.; Liem, A.K.D.; Nolt, C.; Peterson, R.E.; Poellinger, L.; Safe, S.; Schren, D.; Tillitt, D.; Tysklind, M.; Younes, M.; Warn, F.; Zacharewski, T. (1998) Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. *Environmental Health Perspectives*. 106:775-792.
- Vermont Air Pollution Control Division (1996) Source emission test at Safety Medical Systems, Colchester, VT. Waterbury, VT: State of Vermont, Agency of Natural Resources, Air Pollution Control Division. (*mwivtsaf.xls*)
- Westinghouse Electric Corporation (1989a) Dutchess county resource recovery facility. Dioxin and furan emission test results. Pittsburgh, PA: Westinghouse Electric Corporation, Resource Energy Systems Division. (*mwnydut.xls*)

- Westinghouse Electric Corporation (1989b) Dutchess county resource recovery facility. Emission compliance test report, June 15, 1989. Volume 1. Executive Summary. Pittsburgh, PA: Westinghouse Electric Corporation, Resource Energy Systems Division. (*mswnydut.xls*)
- Weston (1986) Source emission test report dioxins and dibenzofurans performed for Vicon Recovery Systems, Inc. West Chester, PA: Weston, Inc. No. 2721-02-01. (*mswmarrf.xls*)
- Weston (1988a) Emission test report, Pigeon Point, DE. West Chester, PA: Weston. (*mswde-pp.xls*)
- Weston (1988b) GE-Penobscott Energy Recovery Company Facility, Orrington, ME, source emission compliance test report incinerator Units A and B. West Chester, PA: Roy F. Weston, Inc. Project No. 0046-40-01. (*mswmegep.xls*)
- Weston (1993) Hazardous Air Pollutant Emissions Study International Paper, Georgetown, South Carolina. Roy F. Weston, Inc. Weston Work Order No. 00157-025-001. (*kblscint.xls*)
- Weston (1994) Emission test report. Grosse Pointes Clinton Refuse Disposal Authority, Clinton Township, Michigan. Morrisville, NC: Roy F. Weston, Inc., Work Order No. 06607-003-001, rev. 1. (*mswmigro.xls*)
- Woodman Engineering, Inc. (1990) Test report emission tests Regional Waste Systems, Portland, Maine. Wayland, MA: Woodman Engineering, Inc. (*mswmerws.xls*)
- York Service Corporation (1992) Final report for an emission compliance test program on boilers A and B at Adirondack Resource Recovery Facility, Hudson Falls, New York. Standord, CT: York Services Corporation. Project No. 4942-02. (*mswnyarr.xls*)