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An Exposure Matrix for the NIOSH Dioxin Registry

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ABSTRACT

A systematic procedure has been developed in order to assess the extent of potential exposure to dioxin for use in the retrospective cohort mortality study of U.S. production workers. Using informaton such as process descriptions; job descriptions; analytical data on dioxin content in substances from the various processes; and industrial hygiene, safety and medical data, estimates of potential exposure to dioxin will be developed. Presented is the rationale used to develop these estimates and an example of the estimation procedure.

OBJECTIVE

To develop and use a systematic procedure for estimating the extent of exposure to dioxin* for a cohort of U.S. production workers and to identify any potentially confounding chemical exposures associated with the plant operations.

INTRODUCTION

In 1979, a Dioxin Registry was initiated which defines a cohort of workers who are identified by company records as having worked in the production of chemicals with a known potential for dioxin contamination. All U.S. production sites, which produced chlorophenols and phenoxy acid herbicides, with adequate records are included in the Registry because production of these chemicals is not labor - intensive. By including all production sites with adequate records the Registry cohort will be large enough to give adequate statistical power to detect potential work-related mortality in the cohort. The Registry consists of workers from fourteen U.S. production sites. Building on the exposure rationale presented by Esmen and Corn[1,2] and Gamble and Spirtas,[3] an exposure estimation procedure or matrix for dioxin is presented.

DESIGN AND METHODS FOR ESTIMATION OF EXPOSURE

A systematic procedure has been developed in order to assess the extent of potential exposure to dioxin for use in the retrospective cohort mortality study of U.S. production workers. Using information such as process descriptions, job descriptions, analytical data on dioxin content in substances from the various processes, and industrial hygiene, safety and medical data, estimates of potential exposure to dioxin will be developed. Exposure to dioxin will be assigned using the following rationale:

(1) the amount of dioxin in a plant product is controlled by the type of process, its operating conditions, and the particular step in the process;

* The term dioxin is a generic term in the text of this protocol and will refer to tetra-, penta-, hexa-, hepta-, and octachlorodibenzo-p-dioxin isomers.

(2) each process has a defined set of tasks that must be performed by workers operating the process;

(3) potential exposure can be assigned to a task in a given plant, if the process, its operating conditions and location in the process where the task is performed are known (this assignment can be aided by industrial hygiene records and data on dioxin content);

(4) the potential for contact with dioxin can be assigned to a worker at a point in time if his job title is known, and the set of tasks that are part of that job are known.

Thus each plant's processes, operating conditions and job definitions will be assessed over the operating life of the plant, so that exposures can be assigned to the study subjects who worked at the plant. The estimation procedure will be broken down into two phases. The first phase will assess the extent of potential exposure for those workers in the Registry's cohort where industrial hygiene data are available to aid the assessment. The second phase will be to assess the potential exposure to dioxin for those workers in the cohort where no industrial hygiene data were available. The assessments determined in phase two will be based on the similarities of the processes job descriptions, etc. to those in phase one. This approach is based on the assumption that similar processes with similar operating conditions and job activities will produce similar exposures. Appendix A provides an illustration of the procedure to be used in making the assessments for workers involved in the production of 2,4,5-trichlorophenol. This example is hypothetical, based on information available in the literature and knowledge of similar operations.

The information to be used in assessing the extent of potential exposure to dioxin has been collected or will be collected from several sources. The process descriptions will be based on available operation manuals and interviews with knowledgable people who were involved with a process or processes (e.g. foremen and production engineers). Job descriptions have been or will be developed from company personnel and industrial hygiene records and union records. The analytical data on dioxin content in substances from various processes will be collected or already has been collected from company records, other federal agencies, consulting laboratories, and from the Air Force's Agent Orange data base.[4] The analytical data on dioxin content, and the industrial hygiene, safety and medical data will be collected or already has been collected from company records, other federal agencies and private consulting organizations.

The extent and specificity of the information primarily depends on the company's information for that site and processes included in the Registry. In general, the extent and specificity of the information collected to date reflects the thoroughness of each company's record system for each plant.

A. Phase One

The first phase in assessing the extent of potential exposure to dioxin for the Registry's cohort involves the evaluation of the extent of potential exposure to dioxin at those plants where industrial hygiene data are available. In assessing exposures at each plant a two step process will be used. (1) The process will be evaluated to determine the tasks associated with the process and a directory of uniform tasks (UTs) will be developed. (2) A directory of the UTs associated with each occupational title (OT) will be developed. This will permit assignment of exposure to workers based on their job or occupational titles.

1. Uniform Tasks (UT) Directories

For each plant included in the Registry a process description will be prepared. The process description describes the steps, and operations at each step, that take place throughout a process, and any major changes made and the date of the change. From the process descriptions, a list of uniform tasks where there was a potential for exposure to dioxin will be constructed. These are called uniform tasks (UTs) because they are uniformly required whenever this type of process is operated. These lists of tasks will be referred to as UT directories, with each task listed being referred to as a UT. A directory will be constructed for each process in the scope of the Registry study at each site and for each time period during which there were no major process changes.

Each UT directory will contain UT codes, UT descriptions, UT time periods, dioxin concentration, factor for type of exposure, and UT potential exposure rating. The UT code will be a four digit number with the first two digits identifying the process and the second two digits identifying the UT number. Each UT code will have a UT description associated with it. The UT description will define the task being performed. The UT time period will be the approximate period of time to perform the task. The dioxin

concentration will be an approximate average concentration of dioxin in the substance involved in the task, and it will be derived from the analytical data associated with that process. The dioxin concentration values are less accurate the earlier in time the analysis was performed. Analytical techniques for measuring dioxin were first developed in 1965 and have steadily improved in the years following.

The UT exposure factor will account for the three types of exposure to dioxin: (1) skin contact to surfaces contaminated with dioxin; (2) skin wetting due to splashing, spilling, dripping or handling of substances contaminated with dioxin; and (3) inhalation of airborne materials containing dioxin. Throughout the entire Registry cohort the amount of industrial hygiene data is limited; however, data are available for plants containing approximately 42% of the cohort. The industrial hygiene measurement data for dioxin is predominately surface wipe samples. A surface was wiped with filter paper, the filter paper was extracted with a solvent, and the solvent extract analyzed for dioxin. There is very little data on airborne dioxin levels. Based on the nature of the processes and work activities, most of the exposure to dioxin was through skin contact: touching contaminated surfaces, spilling and splashing of substances containing dioxins, and some handling of substances containing dioxins. Drying and flaking operations where dusts and fumes were generated represent situations where inhalation exposure to dioxin could have taken place.

The UT potential exposure ratings will represent the potential exposure to dioxin for the tasks listed in the UT directories. The exposure rating will be based on the concentration of dioxin in the process materials and the frequency and duration of daily contact. Therefore, for a given process UT directory and a given task, a potential exposure rating will be calculated from the product of the UT time period multiplied by the dioxin concentration multiplied by the type of exposure weighting factor. The type of exposure weighting factor will be a value which reflects probability of dioxin occurring and will be based on the nature of the industrial hygiene data and records available.

2. Occupational Title (OT) Directories

Each process at each plant site included in the Registry was located in a department. Each department had workers with plant specific job titles who performed tasks associated with a

process or processes. Therefore a job or occupational title (OT) was associated with a set of tasks in that department.

An OT directory will be constructed for each process at each site and for each time period where there were no major process changes. Therefore, there will be a matching OT directory for each UT directory. Each OT directory will consist of OT codes, the OTs, the years the OTs were effective, descriptions of the OTs, OT potential exposure rating values, and applicable UT codes. The OT codes will be four digit numbers, with the first two digits representing the process, and the second two digits will represent the OT. The OT description will describe the tasks that the OT performed. The OT potential exposure rating will be the sum of the daily UT potential exposure ratings associated with task in the OT. The association between an OT and its' UTs will be determined from the OT description.

Having calculated an OT potential exposure rating value for each OT through the years of operation for the various processes, the final step will be to calculate cumulative potential exposure rating values for the workers based on their work histories. These calculations will be performed using the NIOSH Life Table Analysis System.[5]

B. Phase Two

Phase two of the assessment procedure will be to calculate the potential exposure to dioxin for those members of the cohort where industrial hygiene data and information are not available. The procedure in phase two will be the same as that used in phase one. For each process at each site there will be a process description. A UT directory will be constructed from the process description and will have the same type of information as was provided in the UT directories constructed in phase one. If there are gaps in the information known about a process in phase two, the gaps will be filled based on the similarities between a process in phase one to the process in phase two. In general, these processes are very similar to each other throughout the industry. An OT directory also will be constructed for each process at each site.

Figure A-1
2,4,5-Trichlorophenol Production Process Block Flow Diagram

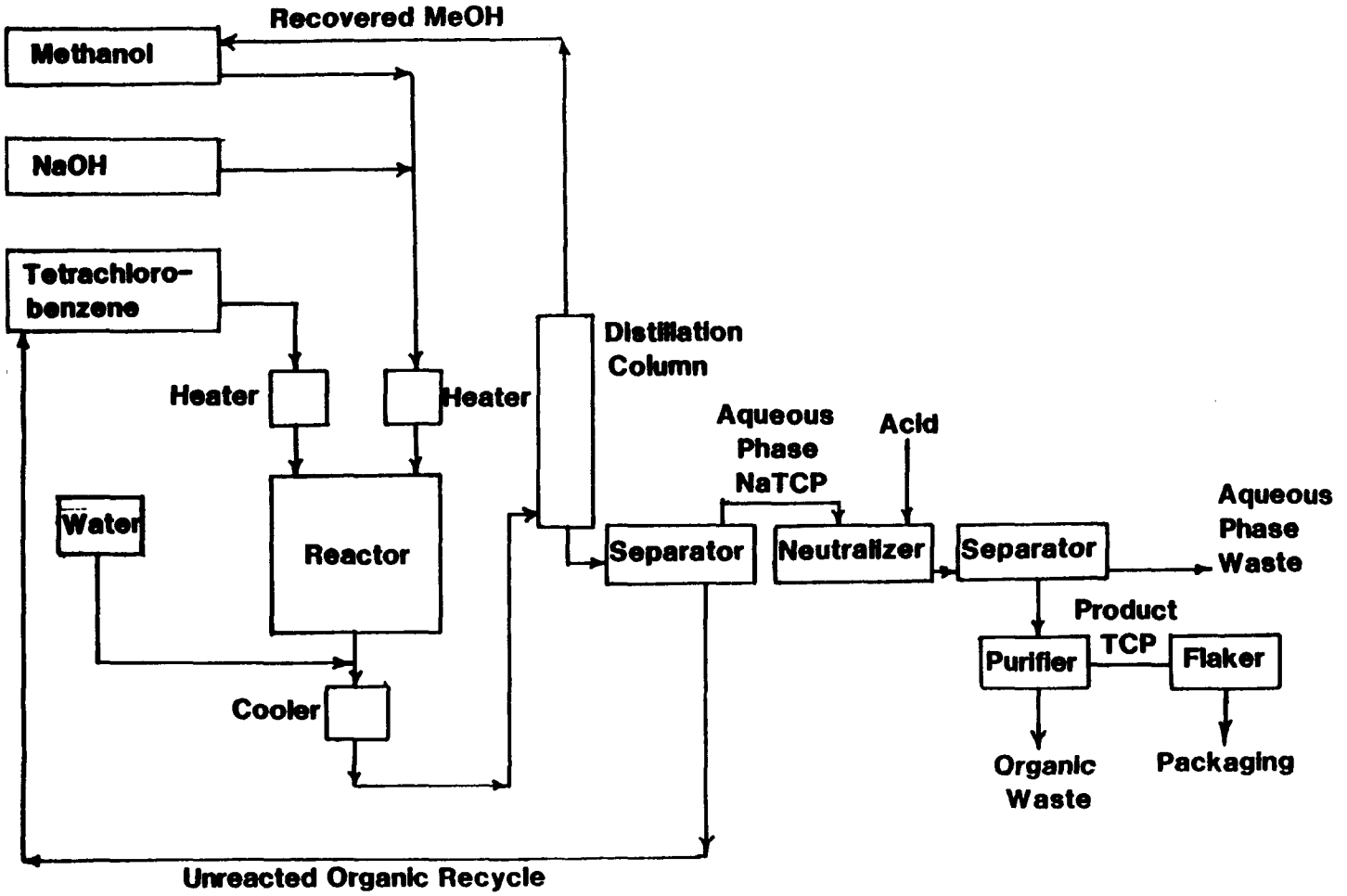
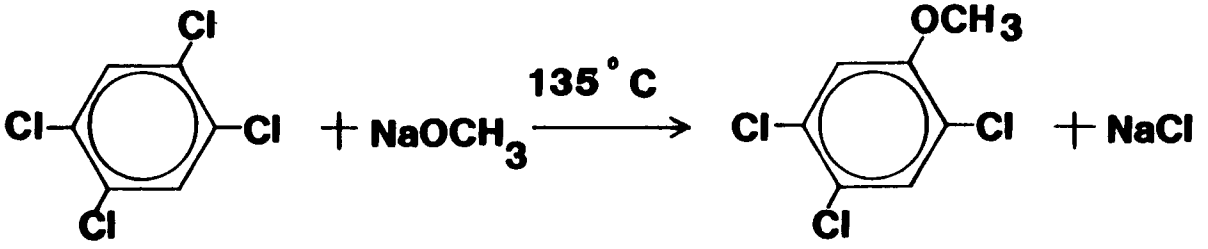


Figure A-2

Formation of Sodium 2,4,5-Trichlorophenate



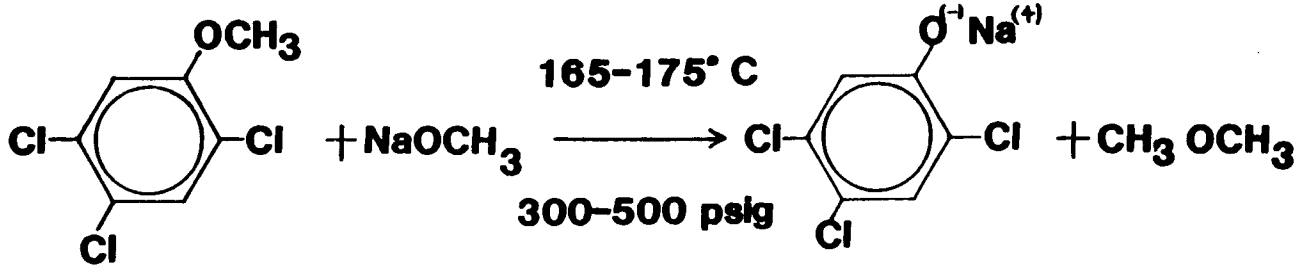


Figure A-3

Formation of 2,3,7,8-Tetrachlorodibenzo-p-dioxin

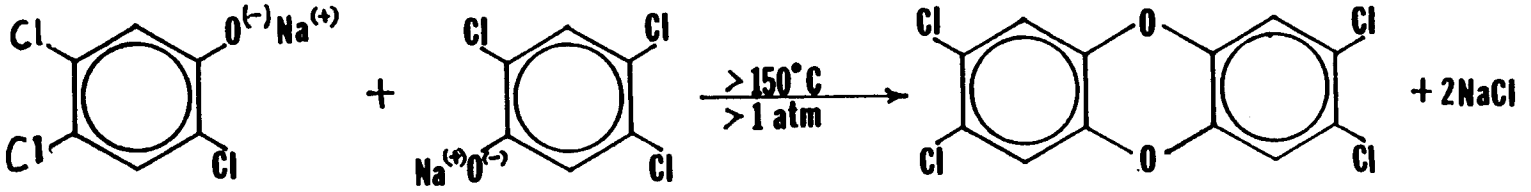


Figure A-4

Uniform Task (UT) Directory

Example Line Entry

Example 2,4,5-Trichlorophenol Production Process

UT Code	UT Description	Time Involved in Task (day)	Conc. of Dioxin Present in Task (ppm)	Type of Exposure Factor	UT Potential Exposure Rating (ppm day)
0208	Collecting samples from reactor	0.0625	50	0.1	0.3125
type of process	task description number	description of the task performed	amount of time to perform task on a daily basis	geometric mean concentration of dioxin in substance involved in task	type of exposure in performing the task, a weighting factor	potential exposure rating value associated with performing task, a product of time involved times dioxin conc. times type of exposure factor

TABLE A-1

Occupational Title Directory
Example 2,4,5-Trichlorophenol Production Process

OT Code	Occupational Title	Effective Years	Job Description	OT Rating (ppm day)	Applicable UT Codes
0244	TCP Mixer Operator		Responsible for operating MeOH, NaOH, and TCB drop tanks and heaters and MeOH distillation column. Also spends 1/3 time assisting TCP Reactor Operator and 1/3 time assisting TCP Flaker Operator.		0201 0202 0203 + 1/3 (0243) + 1/3 (0247)
0243	TCP Reactor Operator		Responsible for operating the reactor, cooler, both separators, and neutralizer and disposing the aqeous waste		0240 0211 0205 0212 0206 0213 0207 0214 0208 0215 0209 0216 0210 0217
0247	TCP Finishing Operator		Responsible for operating the purifier and flaker and for packing operation and disposing the organic waste		0218 0219 0220 0221 0222 0223

The OT directories constructed in phase two will contain the same type of information as those constructed in phase one. As in phase one, the OTs in phase two will be matched with appropriate UT potential exposure rating values to yield OT potential exposure rating values which will represent the potential exposure to dioxin on a daily basis. Finally, using the NIOSH Life Table Analysis System, cumulative potential exposure rating values will be calculated a for the workers based on a workers' work histories.

CONCLUSIONS

The exposure matrix presented will be able to estimate potential exposure to dioxin to workers in the Registry cohort relative to each other. Workers in the Registry cohort can be grouped based on their cumulative potential exposure ratings. These various groupings then can be compared to determine the workers' relative risk of adverse health outcomes due to exposure to dioxin.

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Appendix A can be obtained from the author.