Assessment of Exposure to *o*-Toluidine and Other Aromatic Amines in a Rubber Chemical Manufacturing Plant

Exposure Assessment Update Documentation Report

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ABSTRACT

In 1991 and 2000, the National Institute for Occupational Safety and Health (NIOSH) published the results of a retrospective cancer incidence study and a mortality study, respectively, of the 1,749 workers employed at a rubber chemical manufacturing plant in NY. These workers were believed to have been occupationally exposed to ortho-toluidine (*o*-toluidine) and aniline, suspected bladder carcinogens in animals. Thirteen cases of bladder cancer were observed versus 3.61 expected [standardized incidence ratio (SIR) = 3.6; 90 percent confidence interval (CI) = 2.1-5.7]. Among workers considered to have definite exposure (DE) to *o*-toluidine and aniline, the bladder cancer excess risk was 6.5-fold, while for those with possible exposure (PE), the excess risk was nearly 4-fold. The risk of cancer was strongly associated with increased duration of employment in the department where *o*-toluidine was used, with a 27-fold excess risk among workers with 10 or more years of employment.

The original exposure characterization for the cohort utilized a surrogate measure of exposure based on departments in which each worker was ever employed, comparing bladder cancer incidence among exposure groups within the cohort. The exposure assignments included: 1) Definitely Exposed (DE), workers who had ever worked in the department where *o*-toluidine and aniline were used, even if they had periods of employment outside of that department; 2) Possibly Exposed (PE), workers who had ever worked in maintenance, shipping, janitorial, or yard work; and 3) Probably Not Exposed (PNE), all other workers who were not likely to have been exposed to *o*-toluidine and aniline.

NIOSH is in the process of updating the bladder cancer mortality and incidence studies among current and former employees at the plant, since nineteen new bladder cancer cases within the original study cohort have been reported. To support the epidemiology studies, the exposure assessment has also been updated. The goal of the exposure assessment update is to provide the most accurate possible account of which job titles were exposed to *o*-toluidine, aniline, and/or nitrobenzene, and approximate the extent of exposure during defined eras of production. The updated assessment includes additional years of employment (1988-2005) and additional cohort members were also identified since the original study.

In support of the exposure assessment revision, documents related to the project on file at NIOSH were reviewed. A site visit to the company plant was conducted, and additional exposure information was obtained from a plant walkthrough, interviews with employees, management and union representatives, and review of additional records. In addition, the company provided available job title descriptions and electronic exposure data on aniline, *o*-toluidine, and nitrobenzene exposure from 1976 to present (2005). Finally, replies to a list of 64 questions seeking clarification of worker-reported jobs and departments,

differences between similar job titles in the same department, and confirmation about the possible exposures of some jobs were provided by Company and Union representatives.

The original exposure groups were adjusted to reclassify some departments based on information identified after the initial publications. Alternate revised exposure groups (and codes) were also created based on each department-job title combination as opposed to only department. The alternate groups account for exposure intensity and regularity of exposure as defined by the following codes: 1) Definitely exposed moderate/high and regularly (DER); 2) Probably exposed low and regularly (PER); 3) Probably exposed low and irregularly/occasionally (PEI); and 4) Probably not exposed (PNE).

An approximated rank of "relative" exposure level to each exposure combination (i.e., for each department-job-year) was also assigned. The ranks are based relatively on the quantitative exposure levels, as available or by professional judgment. A ranking scale of 0 to 10 was qualitatively selected to provide enough latitude to characterize exposures of different groups based on relative exposures interpreted between jobs and departments over time. The numerical ranking scale will be applied to each cohort member by multiplying the exposure rank by duration for job held based on comprehensive work histories, to obtain individual cumulative exposure estimates. Cohort members will be ranked by cumulative estimated exposure, from lowest to highest, and tertiles or quartiles of cohort members will be compared.

Inclusion of job title in addition to department is considered to be a necessary modification to improve surrogate exposure measures. Job duration will be included in the exposure characterization, to build a cumulative measure of exposure. Because exposure is ongoing, but to a lesser degree, the four level grouping scale might allow for better differentiation between exposure groups without reducing statistical power from having too many exposure groups. The cumulative numerical scale has the advantage of providing a continuous spectrum of exposure approximations for the entire cohort. These revised exposure classification schemes will be used to analyze the updated bladder and other cancer incidence and mortality data.

1. INTRODUCTION

1.1 Background

In 1988, the National Institute for Occupational Safety and Health (NIOSH) began a Health Hazard Evaluation of a rubber chemical manufacturing plant in NY, where nine cases of bladder cancer had been reported among current and former employees between 1973 and 1988. These workers were believed to have been occupationally exposed to ortho-toluidine (*o*-toluidine) and aniline, suspected bladder carcinogens in animals. Subsequently, NIOSH conducted a retrospective cancer incidence study of the 1,749 workers ever employed at the plant (Ward et al., 1991). Thirteen cases of bladder cancer were observed versus 3.61 expected [standardized incidence ratio (SIR) = 3.6; 90 percent confidence interval (CI) = 2.1-5.7]. Among workers considered to have definite exposure (DE) to *o*-toluidine and aniline, the bladder cancer excess risk was 6.5-fold, while for those with possible exposure (PE), the excess risk was nearly 4-fold. Furthermore, risk of cancer was strongly associated with increased duration of employment in the department where *o*-toluidine was used, with a 27-fold excess risk among workers with 10 or more years of employment. A retrospective cohort mortality study at the plant (Prince et al., 2000) also reported an excess risk of death for bladder cancer among DE workers, but the association was not statistically significant [standardized mortality ratio (SMR) = 3.8; 95% CI = 0.1-21.1]. This finding was expected given the high survival rate of bladder cancer.

In 1990, NIOSH also conducted a study of exposure to *o*-toluidine and aniline at the plant. Biological monitoring determined that even before the workday, exposed workers had significantly higher urinary levels of *o*-toluidine and aniline than did unexposed workers. At the end of the workday, urinary levels of aniline and *o*-toluidine were 7 and 35 times higher in exposed than in unexposed workers, respectively (Ruder et al., 1992). And even “unexposed” workers had higher levels than did the general population.

NIOSH also evaluated hemoglobin (Hb) adducts, biomarkers that reflect longer term exposures, in workers at the plant. The results showed that *o*-toluidine Hb adduct levels were significantly higher in exposed than in unexposed workers in the same plant (e.g., 11 times higher) and more than 100 times higher than the means in unexposed populations previously studied (Ward et al., 1996). Moreover, *o*-toluidine Hb adduct levels were 10 times higher in the “unexposed” group than those previously reported for other unexposed populations reported in three previously published studies (Sitwell et al., 1987; Skipper, 1987; Bryant, et al., 1988).

NIOSH is in the process of updating the bladder cancer mortality and incidence studies among current and former employees at the plant. The impetus for these updates is a published article reporting 19 new bladder cancer cases within the original study cohort (Markowitz and Levin, 2004; Markowitz, 2005). In addition, nitrobenzene was not addressed in the original study since it was formerly classified as a proprietary chemical. The specific aims of the update are: (1) determine if there is an increased risk of mortality from the a priori causes of interest among workers employed in the departments with exposure to *o*-toluidine, aniline, or nitrobenzene; and (2) reassess the risk to these workers for cancer incidence and mortality. A nested case-control study is also being considered, which would look at genetic polymorphisms in specific enzymes related to bladder cancer.

To support the epidemiology studies, the exposure assessment has also been updated. The goal of the exposure assessment update is to provide the most accurate possible account of which job titles were exposed to *o*-toluidine, aniline, and/or nitrobenzene, and approximate the extent of exposure during defined eras of production. The updated assessment includes additional years of employment (1988-2005) and additional cohort members were also identified since the original study. This report documents the process and decisions made in updating the exposure assessment for this cohort.

1.2 Activities Completed for the Exposure Assessment Update

In support of the exposure assessment revision, a number of activities were completed, as provided below:

- Project Orientation. A project orientation between the Westat's Task Order Leader and NIOSH project staff took place from September 7-9, 2005. The orientation comprised two activities: 1) review of documents related to the project on file at NIOSH, and 2) meeting with NIOSH project staff to discuss the project goals and task activities.

- Recommendation for sampling during the Site Visit. Westat was asked to consider and recommend whether sampling would be useful during a site visit to be held in the Fall of 2005. It was concluded that sampling would not be the best use of limited time and resources at the facility.

- Site visit to the plant. NIOSH project staff and Westat's Task Order Leader conducted a site visit to the plant on November 2-3, 2005, to collect additional information required for the bladder cancer mortality and incidence study update. The site visit included a plant walkthrough; individual and group interviews with current and former employees,

management, and union representatives; and review of records relevant to employee work history and past exposures.

- Review of additional exposure data. During the site visit, NIOSH requested and received additional information from the company, including available job title descriptions and electronic exposure data on aniline, *o*-toluidine, and nitrobenzene exposure from 1976 to present (December 5, 2005). The electronic exposure data were consolidated with older hardcopy exposure data and reviewed as part of the exposure re-assessment project.

- Revision of the Exposure Assessment. Based on the above activities, recommendations were made to improve the original exposure assessment groupings. Westat's Task Order Leader and NIOSH project staff cleaned the quantitative company database file to more easily evaluate various department and job title exposures over time. Revised grouping codes and exposure ranks were assigned to each Year-Department-Job Title combination included in the cohort work histories.

1.3 Goals of this Report

This *Exposure Assessment Update Documentation Report* first describes and summarizes the available exposure information discovered from the completed activities (Chapter 2). A discussion of the original exposure grouping scheme and alternate approaches that were considered for revision are then presented (Chapter 3). Chapter 3 also describes the revised exposure characterization and basis for changes and assignments. The report concludes with a discussion of the use of numerical exposure ranks, outstanding issues, and separation of the three chemicals of interest (Chapter 4).

2. AVAILABLE EXPOSURE INFORMATION

Information available for updating the exposure assessment for the epidemiology study of bladder cancer among plant workers included information on file with NIOSH, information collected during the November 2005 site visit, as well as exposure and other data provided by the company following the site visit. A summary of the information from each of these sources is presented in this chapter.

2.1 Exposure Information in NIOSH files

During the project orientation, the Westat Task Order Leader reviewed materials on file at NIOSH relevant to the project. Documents reviewed were dated from 1979 to 2005; these included published articles and reports, as well as unpublished documents.

Published information included the NIOSH Hazard Evaluation and Technical Assistance (HETA) reports related to the plant from 1979 forward; relevant NIOSH HETA reports on other plants; published articles; comments on the original NIOSH epidemiology study and subsequent exposure assessment study (including urine and hemoglobin adduct sampling and analyses); and articles and information on the carcinogenicity of chemicals used at the plant. While the 1992 HETA report presents air monitoring data for 46 workers conducted in 1990, the focus of this sampling was to assess worse-case exposures (NIOSH, 1992). Unpublished information in the NIOSH files relevant to this study included:

A. Study-related support items, such as phone logs, study protocols, employee lists, department and job codes, and New York State cancer registry documents.

B. Company-provided work histories for the original cohort members on microfiche cards. These were checked to see if any of the handwritten information might contain relevant information (e.g., about spills or exposures); however, none were found.

C. Technical information, including specifications on raw materials, processes, and products. This information was marked confidential, but verified from what was known from other documents. Material Safety Data Sheets were also present.

D. NIOSH letters and memoranda addressing possible chemical interactions; requests for site visits and additional information; results of dermal patch testing of workers at the plant; and confidential notification letters providing results to participants.

E. Various letters and memoranda from the company and union about the chemicals used and processes, trade secret issues, and legal correspondence.

F. NIOSH's printed Master File Listing of participant employees and extracted work history data for the original study.

G. Information provided by the company to NIOSH since the original study, including seven hard copy appendices containing monitoring data for 1975-1980 and industrial hygiene data from 1980-1998; summary of process changes; volumes of raw materials purchased since 1960; laboratory analysis results for process intermediates; accident and injury reports for 1994-1998; and some urinary aniline results.

2.2 Exposure Information Obtained from the Site Visit

During the site visit to the plant on November 2-3, 2005, additional exposure information was obtained from a plant walkthrough, interviews with employees, company management and union representatives, and review of additional records.

2.2.1 Plant Walkthrough

A plant walkthrough was conducted during the site visit to observe the current facility and process in relation to the historical reports and descriptions (refer to Appendix A for a map of the facility). Management and union representatives accompanied NIOSH staff on the walkthrough. Only limited operations were underway during the walkthrough. Departments 145 (Vinyl Chloride, NIOSH Department code 14) and 232 (Rubber Compound, NIOSH Department code 23) buildings and equipment were no longer present. Likewise, much of the equipment associated with production of a rubber accelerant in Department 245 (NIOSH Department code 24) had been removed.

The facility opened in 1946 for production of polyvinyl chloride. Beginning in 1957, the plant made an antioxidant used in tire manufacturing. A family of rubber accelerators was also produced from the mid 1950s until 1970, with one accelerator being produced from 1970 to 1994.

Antioxidant production (Department 245C, later Department 255, NIOSH Department code 24). The antioxidant is made with *o*-toluidine, aniline, hydroquinone, and toluene (until 1992) or xylene (1992-2005) and a catalyst; *o*-toluidine constitutes over 50 percent of the amine compounds used in production. Phenol and diphenylamine are by-products of the reaction. All liquid raw chemical materials are received in an outdoor "tank farm" and pumped into storage tanks. From the storage tanks,

o-toluidine and aniline are pumped to the "premix" tank. Prior to 1978, operators manually opened and closed valves on the storage tanks when pumping chemicals to the weigh tanks. In 1978, a "premix charge reactor feed system" was installed. Under this system, storage tank valves are operated from a control room rather than operated manually. Automation of the premix charge system significantly reduced the potential for exposure to these chemicals for some jobs. Hydroquinone powder is received in bulk bags at the warehouse. In 1984, a 3300 lb. semi-bulk bag system for hydroquinone replaced 300 lb. fiber drums. The premix tank solution is pumped to a reactor where it is mixed with a catalyst to start the reaction. In 1980, the company installed a closed system to feed liquid catalyst. The reactant is then degassed, and the product is filtered or centrifuged, solidified, and made into pastilles, which are packaged in bulk or 50-pound bags.

Accelerator production (Department 245A, NIOSH Department code 24). Liquid raw materials for accelerator production were received at the tank farm and pumped to storage tanks, while solid chemicals were stored in a warehouse. The chemicals were blended in the "charge room" and held there in two tanks as mixtures: one tank held a mixture of carbon disulfide and flaked sulfur; the other held a mixture of nitrobenzene, aniline, and benzothiazole. These mixtures were passed through a series of enclosed, autoclaves for reaction. The product of the last autoclave was mercaptobenzothiazole (MBT), which was mixed with morpholine, isopropylene, water, and sulfur in an oxidation tank. This mixture was transferred to a second oxidation tank and from there to the product reactor where bleach was added during the reaction. The product flowed out the top of the reactor into a holding tank where it was quenched with water. The quenched product was sent through a centrifugal dryer and then to a fluid bed dryer. After drying, the finished product (a dry powder) was conveyed by gravity to a vacuum bagger.

Changes/procedures reported to have been implemented by the company to minimize exposures (as presented in Appendix B) were confirmed during the walkthrough. No new controls had been implemented beyond those described. Employees noted that the centrifuge area pumps using double seals have since been replaced with pumps using packing. On the plant walkthrough, areas of potential exposure other than production areas were identified, which included the wastewater treatment building, tank farm, laboratory and shop areas, and possibly the cafeteria and locker room/shower areas. While dust and grime were observed throughout the work areas, break areas were reasonably clean and the change area was very clean. However, manufacturing activities were very limited during the site visit and walk through.

2.2.2 Employee Interviews

During the site visit, NIOSH and Westat staff interviewed current and former/retired employees, focusing on those who had been at the plant during the years 1957-1988 as well as those who held a

variety of jobs and worked in different departments. Interviewees included workers who were previously classified as Definitely Exposed (DE), Possibly Exposed (PE), and Probably Not Exposed (PNE) as defined by Ward et al. (1991).

Group discussions were held with site visit participants during the opening conference, as well as during the walkthrough. In addition, one-on-one informal discussions were held with 15 workers and several management and union representatives. Workers assigned to help with the site visit were also asked about other jobs in the original study, including Co-op, Accounting and office staff, Powerhouse alternate, and guards. The following topics were addressed during the interviews:

- Progression of jobs and department changes during employment;
- Basic job duties for their job(s);
- Effects of process changes;
- Frequency/times periods/activities when chemicals got on skin or clothes;
- Movement between processes, departments, and areas of plant in job(s);
- Willingness to participate in a study that asked about work at the plant, medical history, smoking and drinking habits (including water and non-alcoholic beverages), and other information relevant to a case-control study;
- Participation in company-sponsored screening program for early detection of bladder cancer among those workers that have not developed bladder cancer, and
- Other questions determined by the interviewers to be useful.

Employee interviews identified a few general trends relevant to the exposure assessment:

A. Among the manufacturing workers, a common job progression was to start as a Production Operator, move to Chemical Operator, and then move into a Maintenance job. Production and Chemical Operators rotate shifts, while Maintenance is generally scheduled as a day shift job unless corrective maintenance is required.

B. Despite previous reports that workers regularly moved back and forth between departments, it was reported that for some jobs this occurred as assignments rather than on a day-to-day basis. Interviewed workers reported that when formally assigned as a Production or Chemical Operator in either Department 145 or 245, they stayed in the assigned departments. However, employees in other departments, such as maintenance, worked wherever they were needed.

C. The antioxidant and accelerator manufacture were parallel operations in the same buildings and rooms. As a result, employees considered everyone in that building to be “exposed.” It

was agreed by employees that contemporary air sampling would not reflect historical exposures.

D. The tasks reported by employees to have the highest potential for exposure to chemicals of concern, including potential dermal exposure were:

   i. Changing the Sparkler filters (company representatives reported that *o*-toluidine concentrations in the antioxidant processed through the filter were typically 0.02 – 0.04%);
   ii. Hooking rail car to transfer line (historic);
   iii. Unclogging frozen recycle lines;
   iv. Pump and pipe line repair and maintenance, including removal of obsolete chemical pipe lines;
   v. Collection of raw material and recycle samples; and
   vi. Use of hoses by maintenance workers causing unknown liquids to drip on their clothes.

E. Workers universally reported that the use of personal protective equipment (PPE) was practically nonexistent prior to NIOSH's 1990 visit and recommendations.

F. Because laboratory workers had been specifically highlighted as potentially misclassified in the previous study, extra time was devoted to talking to current and former laboratory workers. Several vinyl chloride and accelerator tests were reported to cause noticeable chemical vapors in the laboratory, (e.g., during a test done in an unventilated water bath). Other tests on raw materials that were not performed within a laboratory hood included specific gravity, clarity, and spectrophotometry. Noticeable solvent odors were reported to be common in the laboratory and surfaces could have chemical contamination.

G. Further, it was established that at least some Laboratory Technicians also acted as shift monitors. This required that they check for leaks on a regular basis using direct reading instrumentation around all areas of the plant, including both Departments 145 and 245. One technician reported spending about 60% of work time in the plant, while another technician reported spending about 2 hours a day in the plant. Thus, while previously coded Probably Not Exposed, Lab Technicians likely had mild to moderate exposure. Guards were also required to walk through the plant on a regular basis, thus having intermittent exposure.

H. There appeared to be a few jobs where exposure was likely none to minimal. These included accountants, office workers, and sanitary engineer/janitor.

I. Union representatives reported that plant employees worked more overtime now than in the past. They said there were only 69 union workers at the time of the November 2005 site visit. The antioxidant production had increased in the past 10 years: 21 million pounds had been produced in the previous year; each 100 pounds of antioxidant required 35 pounds *o*-toluidine and 35 pounds of aniline.

J. The plant was still on a weekly rotation schedule. For example, a group worked Wednesday—Tuesday evening shift; off 2 days; Friday—Thursday day shift; off 2 days; Saturday/Sunday to Friday/Saturday graveyard shift; off 4 days. Maintenance worked only on the day shift, unless called in for emergency repair work.

2.2.3 Records Reviewed during the Site Visit

Despite a thorough review of company information, only a few new records were identified that were relevant for updating the exposure assessment. There were no time cards or other records which characterized specific tasks conducted by anyone at a given time. While work orders were occasionally used, most tasks were done as needed without waiting for an order. New information that was identified from reviewing company records included:

A. Detailed work histories. More detailed work histories were written on the covers of personnel folders than were provided on the work history cards which had been copied and computerized for the original study. Additional details included specific dates assigned to different departments, job titles (and operation) at each change, and clear dates of employment/unemployment. Given recall error, a comparison of interview self-reports of work history matched the folder cover information surprisingly well for a sample of six workers. This information should allow for better classification as to whether a worker was ever exposed as well as duration of exposure. The company provided this information, which was in custom software requiring programming to retrieve it in a useful form, electronically.

B. Existing exposure data. NIOSH previously had been provided with hard copy plant exposure data for 1975 through 1998. However, these were received after the 1990 study and were not used for the original assessment; their potential use for the exposure update had not yet been evaluated. Following the site visit, the company provided existing electronic exposure data from 1980 to 2005 from the company's IH database for the three chemicals of interest (i.e.,

aniline, *o*-toluidine, nitrobenzene), as well as data for other rubber chemicals used at the facility.

C. Existing job descriptions. Company representatives noted that in the late 1990s, they established homogenous exposure groups (HEGs) for air sampling purposes. This involved drafting job descriptions. Existing job descriptions for a number of different jobs at the plant were examined by the NIOSH team, a few from the 1970s and others from the mid-1990s. While some useful information was obtained (e.g., explanation of some job history acronyms; clarification that general duties of different classes of the same job title were similar; and many jobs had required variable shift work), the descriptions were generic relative to exposure, serving primarily to confirm or refine what had been discovered from employee interviews.

D. Shift assignments. During the site visit, current shift assignment sheets were used to determine who was working and to identify potential employees for NIOSH to interview.

Additional records were examined related to the epidemiology update including sample medical histories and information on the current bladder cancer screening program. The company also generated a list of every person ever employed in the plant including names, Social Security numbers, birthdates, and current addresses. This information was used to determine if there were people who worked in the plant from 1946 to 1988 who had not been included in the original cohort.

2.3 New Exposure Information provided by Company

Following the site visit, the company provided the following information for the period of January 1, 1980, to December 5, 2005:

A. Four-part Excel spreadsheet entitled "NIOSH Update 2005.xls," containing:
- Table I. Codes & Definitions for understanding the company's IH database.
- Table II. Results of IH Monitoring for Department 245: All rubber chemical agents.
- Table III. Results of IH Monitoring for departments other than 245 for the three chemicals of interest: aniline, *o*-toluidine and nitrobenzene.
- Table IV. Results of IH Monitoring for departments other than 245: All rubber chemical agents except aniline, *o*-toluidine and nitrobenzene.

B. A settlement agreement between the company and union required the company to conduct four cycles of personal air monitoring and concurrent urine monitoring to assess aniline and

o-toluidine exposures. Four spreadsheets were included showing the results. Two cycles of monitoring were collected in 1999 (March and November) and two in 2000 (May and August). The first phase included all hourly associates in departments 245, 111, and 199. The second, third and fourth phases were limited to associates who worked primarily in Department 245, with a few in departments 111 and 199.

C. "Protocol for Biological and Personal Air Monitoring for Aniline and *o*-Toluidine, Years 1999 – 2000."

D. "Corporate Industrial Hygiene Laboratory Method for the Determination of Aniline and *o*-Toluidine in Air, 8/94."

E. Detailed work histories from the company's custom software. This resulted in 9,321 individual work history reports (as compared to 5,604 that had been copied from plant records and entered in the original NIOSH database). The additional work history reports were coded for department and job.

Quantitative air monitoring data from these sources were merged with the hardcopy data received previously for 1975-1980 into an Excel database entitled *Master_Working 07-18-06.xls*, provided as a supplement to this report. Minor clean-up tasks on these data were performed. In the original data monitoring files, job titles were often included under task rather than job title, hence, data clean-up increased the number of samples for a given job title.

2.4 Company/Union Replies to Questions

In February 2007, NIOSH and Westat drafted a list of 64 questions seeking clarification of worker-reported jobs and departments, differences between similar job titles in the same department, and confirmation about possible exposures of some jobs. Replies were provided by May 3, 2007, in a matrix format itemizing responses from plant personnel, corporate (industrial hygiene) staff, and the union attorney. This matrix is presented in Appendix C and will be referred to as "Company/Union Replies."

3. REVISION OF ORIGINAL EXPOSURE ASSESSMENT

The objective of exposure characterization for epidemiological studies is to develop a reliable measure of each participant's exposure to chemical agents (i.e., aniline, *o*-toluidine, and nitrobenzene) so the epidemiology study can examine the relationship of exposure and disease outcome, with the exposure assessment performed blinded to disease status. Exposures can be defined for individuals or groups of study participants and may involve single or multiple chemical agents. There are three key data elements to exposure characterization for occupational epidemiology studies:

1. A means to identify study participants. – NIOSH previously identified those employed at the plant from 1957-1988 and has updated the complete population from 1954-2005.

2. A means to describe study participants' work activities. – Work activities were previously described from work history cards which recorded date, department, and job title. These were further refined using the more detailed work histories as found on the covers of employee records and in a custom company database.

3. A means of linking work activities to direct or indirect (surrogate) measure of exposure. – Selection of the exposure measures was based on the type, extent, and reliability of available information.

In the following sections, we first describe the original exposure characterization for the cohort (Section 3.1). We then describe the revisions to the original exposure characterization (Section 3.2), as well as two additional characterization approaches developed at NIOSH's request – exposure group assignment based on department and job (Section 3.3) and exposure rank assignment based on department, job, and year (Section 3.4). Appendix E presents the complete list of study participants' work history departments and jobs for time period 1954-2005, along with the assigned exposure categories and ranks for all four characterization approaches. Appendix F presents charts summarizing area and personal air sample and urine sample results from the company quantitative data file. While these data are referred to in Sections 3.2-3.3, they are discussed in more detail in Section 3.4.

3.1 Original Exposure Groups

The original exposure characterization for the cohort utilized two classic surrogate measures of exposure: 1) the very general "factory worker," comparing bladder cancer incidence in the cohort to that in the general population, and 2) a more specific surrogate measure based on departments in which each

worker was ever employed, comparing bladder cancer incidence among exposure groups within the cohort. Surrogate measures have been found to work well as long as enough is known about the work tasks and exposures in the department so that workers are assigned to the correct exposure group. The exposure assignments are listed in the column entitled *Original Code (Dept)* in Appendix E. The three codes (i.e., DE, PE, and PNE) were assigned for employment dates from 1957-1988, as follows:

i. Definitely Exposed (DE) – Employees who had ever worked in Department 245 or A (Accelerator and Antioxidant), even if they had periods of employment outside of that department.
ii. Possibly Exposed (PE) – Employees who had ever worked in maintenance, shipping, janitorial, or yard work, but had never worked in Department 245/A.
iii. Probably Not Exposed (PNE) – Employees who had never worked in Department 245/A, maintenance, shipping, janitorial, or yard work.

3.2 Revised Original Exposure Groups

Based on the findings as described in Chapter 2, it was concluded that some of the original exposure assignments should be revised. These revised original exposure assignments are listed in the column titled *Revised Original Code (Dept)* in Appendix E.2.

Before describing the specific revisions made, it should be noted that the term "Possibly Exposed" was defined by the original study investigators based strictly on department and opportunity for exposure. There was no extent or intensity of exposure implied in the definition beyond yes or no exposure. Markowitz and Levin (2004; Markowitz, 2005) proposed that some of the workers assigned to the Possibly Exposed group were definitely exposed but only intermittently and stated that the group would be more properly classified as "intermittently exposed." While an original working definition for Possibly Exposed beyond department assignments is not available, the term suggests that this category includes departments for which it was unknown whether exposure occurred, but because the workers could have been in the plant, they could have been exposed. For the revision work, the original term has been retained, incorporating this working definition. Revisions to the original exposure assignment were made to the following departments:

- Maintenance (NIOSH Department Code 11) – Employee interviews revealed that maintenance personnel worked in all areas of the plant and that because they were making repairs, there was often liquid chemical in the area, sometimes getting on their hands and clothing. Written job descriptions confirmed that most maintenance jobs required work in the plant on a regular basis. A few maintenance jobs specified "bench work" in the shop, but with

the caveat that all employees were expected to work in the plant as required. Further, interviews and site observations showed that bench work would include repairing parts that were contaminated or contained bulk amounts of the chemicals of concern. This information confirmed that maintenance workers did in fact come in direct contact with liquid and airborne chemicals. Thus, this department was *reassigned from the Possibly Exposed (PE) to the Definitely Exposed (DE) group.*

- Quality Control, Laboratory, Lab – Research and Development, (NIOSH Department Codes 40, 46, and 48) – Findings from the site visit observations and interviews showed that lab workers were exposed daily in the laboratory while handling samples and conducting analysis, as well as in the plant during sample collection and area air monitoring. Thus, these departments were *reassigned from the Probably Not Exposed (PNE) to the Definitely Exposed (DE) group.*

- Temporary assignment from company headquarters (NIOSH Department Code 98) – "Company/union Answers to Questions" noted that these workers "would probably have worked in assignments similar to plant associates" with the same job title, and might have worked anywhere during work stoppages. A number of job titles (e.g., Chemical Engineer, Engineer, Quality Control, Area Manager, etc.) suggest that exposure could have occurred had they been assigned to Department 245. Because it is unknown where the line jobs were conducted, this department was *reassigned from the Probably Not Exposed (PNE) to the Possibly Exposed (PE) group.*

- None Assigned (New NIOSH Department Code 69) – As with Department Code 98 above, many of the jobs in this department code had line job titles suggesting that exposure could have occurred had they been assigned to Department 245 (e.g., APO, General Utility Operator, Chemical Operator, etc.). Because it is unknown where the line jobs were conducted, this department was *reassigned from the Probably Not Exposed (PNE) to the Possibly Exposed (PE) group.*

Department assignments that were considered for revision, but which were not changed include the following departments:

- Yard/Janitor (NIOSH Department Code 19) – Job descriptions and interview findings indicated that yard workers primarily performed groundskeeping, and drove lift trucks to transport supplies and materials. Janitors were responsible for cleaning restrooms and locker

rooms throughout the plant and the front offices. These workers were out in the plant area and could have been exposed, and the *Possibly Exposed (PE) assignment was retained.*

- Shipping, Packaging, & Warehouse (NIOSH Department Code 21) – Job descriptions and interview findings indicated that workers in this department had a variety of assignments, including loading/unloading materials, railcar placement, checking and unloading deliveries against orders, gathering/loading product orders, providing and affixing shipping labels to product, and rearranging stock. These workers were out in the plant area and could have been exposed, and the *Possibly Exposed (PE) assignment was retained.*

- Rubber Chemicals (NIOSH Department Code 33) – Even though the name of this department is Rubber Chemicals, a term also used to refer to Department 245, "Company/union Answers to Questions" notes that "Department 232 was the compounding plant which used the PVC resins made in Department 145 to make PVC compound." Thus the *Probably Not Exposed (PNE) assignment was retained.*

- Sales, company headquarters employees (NIOSH Department Code 99) – As with Department Codes 69 and 98 above, there are line jobs included and it is unknown where the line jobs were conducted. However, "Company/union Answers to Questions" noted that the "sales office located here was for PVC group." Thus, the *assignment for this department was not revised from Probably Not Exposed (PNE).*

3.3 Alternate Revised Exposure Groups Based on Department and Job

A number of surrogate measures of exposure may be used in a cohort study. These measures may range in specificity from very general to more detailed. As noted above, the original study used two surrogate measures: 1) employees compared to other New York State residents and 2) comparisons of employees who worked in different departments. Job titles were not used in the original characterization, but were readily available for the cohort and provide another level of specificity. When linked with department, job titles tend to be good indicators of worker exposure and can provide a link to the combination of chemicals to which they were exposed.

Based on review of available information, some jobs originally classified as Probably Not Exposed, in fact, likely had mild to moderate exposure on an irregular basis, (e.g., guards), or on a regular basis, (e.g., laboratory personnel). Conversely, some jobs originally classified as Possibly Exposed likely had no to minimal exposure, such as secretaries and accountants assigned to "exposed" departments.

Given this, alternate revised exposure groups (and codes) are proposed, based on each department-job title combination as opposed to only department. Further, the alternate groups account for exposure intensity and regularity of exposure as defined by the following codes:

i. Definitely exposed moderate/high and regularly (DER)
ii. Probably exposed low and regularly (PER)
iii. Probably exposed low and irregularly/occasionally (PEI)
iv. Probably not exposed (PNE)

These new exposure group assignments are listed in the column entitled *Alternate Revised Codes (Dept, Job)* in Appendix E. The assumptions used are provided below:

- Department 0 (Error in Entry), Manager (NIOSH Job 8) – Assignment *as Definitely exposed moderate/high and regularly (DER)* is based on the assumption that they worked in Dept 245; however, they could have been assigned to PVC (Dept 145) or 232 (Rubber Chemicals). This assignment also assumes that plant managers were "working" managers; this seems to be true as air sampling, which was focused on workers who could have been exposed, was conducted on area managers.

- Maintenance (NIOSH Department 11), Manager (NIOSH Job 8), Area Manager (NIOSH Job 19), and Trainee (NIOSH Job 21) – As with Department 0 above, it was assumed that plant managers were "working" managers. "Company/Union Answers to Questions" indicates that the Trainee would be an Area Manager Trainee. Because maintenance staff were often working on equipment in the plant and air sampling in the maintenance shop showed significant levels of the chemicals of concern, these jobs were *assigned as Definitely exposed moderate/high and regularly (DER).*

- Maintenance (NIOSH Department 11), Foreman (NIOSH Job 34), Supervisor (NIOSH Job 36), E-I Mechanic (NIOSH Job 38), Mechanic (NIOSH Job 39), I-R Mechanic (NIOSH Job 40), I-Mechanic (NIOSH Job 41), Craftman (NIOSH Job 42), Electrician (NIOSH Job 44), Millwright (NIOSH Job 46), Pipefitter (NIOSH Job 47), Welder (NIOSH Job 49), Unknown (NIOSH Job 95) – These jobs are difficult to separate from an exposure perspective. They were all exposed both in the shop and in the plant in the process of maintaining and repairing valves, gauges, equipment, etc. While workers in some jobs may have been in the shop more often, (e.g., welders), their job descriptions referred to welding inside tanks, on pipes as well as working in and around the plant. Further, in 1996, due to personnel reductions, welder duties increased to include millwright work. Job descriptions for Instrument & Electronics (I&E) Mechanics and Electricians overlapped with Millwrights and Craftman. Even the

Millwright Program Developer Instructor (PDI) was required to "work as millwright as time permits" and "to fill in for trainees." Thus all these jobs were *assigned as Definitely exposed moderate/high and regularly (DER).*

- Rubber Chemicals - Accelerator, Antioxidant (NIOSH Department 24), all production jobs (Area Manager, Antioxidant Packaging Operator, Chemical & Utility Operator, Chemical Operator, General Utility Operator, Chemical Oper-C-2, Production Operator, Foreman, and Supervisor) – Job descriptions for Production Operators indicated that they handled bulk materials in trucks, cars and silos, and conducted all filtering, centrifuging, drying and packaging equipment. Chemical Operators were responsible for charging reactors, transferring batches, weighing/mixing raw materials, making solutions, operating water units, tank car unloading, operating expensive equipment gauges and monitors, and sampling product and recycle. Job descriptions for both Production Operators and Chemical Operators mentioned use of PPE, and self contained breathing apparatus (SCBA), air-line, and other respirators. Utility Operator could be assigned either Production Operators' or Chemical Operators' tasks. The interviews indicated that all would respond to spills and other emergencies. These jobs were all exposed to the chemicals on a regular basis and were *assigned as Definitely exposed moderate/high and regularly (DER).*

- All Departments except PVC, Vinyl (NIOSH Job 14), Chemical Engineer (NIOSH Job 11), R&D Engineer (NIOSH Job 13), Engineer, (NIOSH Job 14), and Co-op (NIOSH Job 98) – Interviews found that individuals with these jobs regularly worked in Dept 245 doing engineering tasks - monitoring processes, diagnosing problems, designing modifications, and occasionally getting wet with raw liquid. However, these jobs did not generally help with repair of equipment, clean-up of spills, etc. "Company/union Answers to Questions" indicated that co-ops generally worked with engineers, hence were a*ssigned as Probably exposed low and regularly (PER)*. These assumptions need to be confirmed by the company and union for the co-op job. Note that Co-ops (NIOSH Job 98) assigned to PVC (NIOSH Department 14) or Sales, Akron (NIOSH Department 99) were assigned as PVC workers.

- Maintenance (NIOSH Department 11), Painter/Insulator (NIOSH Job 43) – Based on the interviews and job descriptions, the nature of a Painter's work (e.g., erecting scaffolds/platforms; surface and paint preparation; brush and spray painting; stenciling; and after 1996, removing asbestos insulation), did not require hands-on contact with chemicals. However, since the job required frequently working in the plant close to operations, this job was *assigned as Probably exposed low and regularly (PER).*

- Rubber Chemicals - Accelerator, Antioxidant (NIOSH Department 24), OBT Trainer (NIOSH Job 57) – Based on job descriptions, the PDI trainer was a hands-on trainer for Millwrights. It was assumed that an OBT trainer was as well. Thus, these trainers were a*ssigned as Probably exposed low and regularly (PER).*

- Quality Control (NIOSH Department 40) – "Company/Union Answers to Questions" suggested that this department was housed in the lab area, noting that the QC Manager "was mostly in the office/lab area; QC Laboratory Technician worked in the plant for sampling/process support." Thus these jobs were *assigned as Probably exposed low and regularly (PER).*

- Laboratory Technician (NIOSH Job 17), all departments – "Company/Union Answers to Questions" noted that "a lab tech would test raw material, in-process materials, and final products," working between 5% to 10% percent of time in Department 245, taking readings with detector tubes, and collecting samples of antioxidant and raw materials. In the laboratory, Technicians tested raw materials, including *o*-toluidine and aniline, for purity and recycle mixture for solvent content. There were some reports that gloves were not always worn when handling samples in the lab. Site observations confirmed that many tests were not carried out under ventilated laboratory hoods and vapor exposure was likely during various testing. This job required hands-on contact with the chemicals both in the lab and in the plant so it was *assigned as Probably exposed low and regularly (PER).*

- Laboratory Supervisor (NIOSH Job 18), Chemist (NIOSH Job 12), Laboratory Manager (NIOSH Job 8), and Laboratory Section Head (NIOSH Job 37), all departments – "Company/union Answers to Questions" noted that their "main duties would be in the lab along with trips to operations for collections and process support." Thus, it was assumed these jobs were primarily in the lab and were *assigned as Probably exposed low and regularly (PER).*

- Personnel (NIOSH Department 10) and Medical (NIOSH Department 18), Guard (NIOSH Job 6) – Employee interviews identified that guards were required to walk through the plant on a regular basis, checking around all production equipment. "Company/union Answers to Questions" noted that "guards' work is normally limited to the gate house. They do walk a security route which includes a brief walk through of all areas of the plant and the perimeter of the grounds." This was deemed sufficient evidence to *classify guards as Probably exposed low and irregularly/occasionally (PEI).*

- All Departments, Safety Engineer, ER Coordinator (NIOSH Job 16) – "Company/Union Answers to Questions" notes that "safety personnel's duties took them to all areas of the plant." Job descriptions indicated they were responsible for some training and respirator fit testing. Thus, this job has been *assigned as Probably exposed low and irregularly/occasionally (PEI) for all departments.*

- Maintenance (NIOSH Department 11), Drafter (NIOSH Job 64) – While a draftsman might be considered a front-office job, several of the maintenance jobs mentioned making drawings as a required task. Thus without further information, this job is assumed to require at least occasional work in the shop and plant and was *assigned as Probably exposed low and irregularly/occasionally* (*PEI).*

- Medical (NIOSH Department 18) – Operations Manager (NIOSH Job 19), and Project Coordinator (NIOSH Job 95) - It was assumed that these were working jobs and would go into the plant occasionally, thus bein*g assigned as Probably exposed low and irregularly/occasionally* (*PEI).*

- Yard/Janitor (NIOSH Department 19), all jobs – There was moderate disagreement in "Company/union Answers to Questions" about potential for exposure among workers in this group. It was noted that "there is negligible potential for exposure in the warehouse, shipping, packaging, or receiving areas," and "the Janitors definitely had exposure since they regularly cleaned the bathrooms and other areas in Department 245 which were contaminated." Since janitorial work appears to have been limited to cleaning and emptying trash in bathrooms, lunchrooms, etc., and yard workers primarily did outdoor work, such as cutting grass, shoveling snow, picking up garbage, etc., any exposure would have been low and intermittent. Because they worked in and around the plant, these jobs were *assigned as Probably exposed low and irregularly/*occasionally (*PEI).*

- Shipping, Packaging, & Warehouse (NIOSH Department 21), all jobs (except those assumed to be front office jobs) – Job descriptions for this department included Clerks (checking and unloading deliveries against orders), Dispatcher (line up product orders, provide and affix shipping labels), Storeroom Operator (assist clerks, rearrange stock), Warehouse Helper (load/unload trucks), and General Material and Merchandise Control (GMMC) Utility Operator (primarily loading/unloading materials, railcar placement, grounds upkeep, and janitorial). Because they worked in and around the plant, and jobs overlapped with Yard/Janitor duties, these jobs were *assigned as Probably exposed low and irregularly/occasionally (PEI).*

- Rubber Chemicals - Accelerator, Antioxidant (NIOSH Department 24), Secretary/Steno (NIOSH Job 2) – "Company/Union Answers to Questions" noted that "the 245 stenographer wouldn't normally go beyond the offices or the 34 building warehouse" and "we believe that there was a 'secretary/steno' whose work station was inside Department 245." Thus secretaries assigned to Dept 24 were *assigned as Probably exposed low and irregularly/occasionally (PEI).*

- Rubber Chemicals - Accelerator, Antioxidant (NIOSH Department 24) – Clerk (NIOSH Job 3) – Although "Company/Union Answers to Questions" noted that clerks conducted "office work, no risk of exposure," job descriptions suggest that clerks had to be in the plant warehouse and shipping areas on a regular basis. Thus, this job was *assigned as Probably exposed low and irregularly/occasionally (PEI).*

- All Departments, Accounting (NIOSH Job 1) – This job was assumed to be a front office job and has been *assigned as Probably Not Exposed (PNE) in all cases.*

- Personnel (NIOSH Department 10), Clerk (NIOSH Job 3) – It was assumed that these clerks did not work in the plant as clerks assigned to Shipping were likely to have done. *Assigned as Probably not exposed (PNE).*

- Maintenance (NIOSH Department 11) and Powerhouse (NIOSH Department 16), Powerhouse operator (NIOSH Job 45) and unknown (NIOSH Job 95) – "Company/Union Answers to Questions" reported that "the steam plant [powerhouse] operators were not exposed as part of their steam plant responsibilities." These jobs were *assigned as Probably not exposed (PNE).*

- Rubber Chemical (NIOSH Department 33) - all jobs – "Company/Union Answers to Questions" indicated that "Department 232 was the compounding plant which used the PVC resins made in Department 145." Thus these jobs were *assigned as Probably not exposed (PNE).*

- Temporary assignment from company headquarters (NIOSH Job 98) – "Company/Union Answers to Questions" noted that these jobs "could have worked anywhere depending on their assignment." Thus, *job titles were used for assigning exposure category*.

- Sales, Akron employee (NIOSH Job 99) – Conflicting information was noted in "Company/Union Answers to Questions." One comment stated that "the sales office was located here for PVC group, office area." Another notes that they were "not sure which associates this question refers to. The titles that match up with existing titles in RC group would probably have worked in assignments similar to plant associates. Those other titles may have worked in various areas during work stoppage." It was assumed for the current assignment that the job title represented the work being done for each job in the PVC area, and that there was not a separate laboratory for PVC. These assumptions need to be confirmed by the company and union.

3.4 Exposure Ranks Based on Department, Job, and Year

The surrogate measures described above place workers into broad categories, which do not vary based on the relative intensity of exposure or year of exposure. When there is good exposure monitoring data, quantitative estimates can be applied to various groups of workers for given time periods (i.e., creating a job exposure matrix, or JEM). Although the company provided air monitoring data from 1975 to 2005 for aniline, *o*-toluidine, and nitrobenzene (refer to Appendix F), it was decided that these would not be used directly to develop quantitative exposures for the cohort. The reasons for this decision included:

A. These kinds of data typically overestimate the mean levels because problem areas tend to be over sampled. Often the reason for sampling is to determine where high levels exist that may exceed permissible exposure limits or in response to an employee concern, biasing the exposure data. Examples of this tendency in the company data set include Department 145 (Vinyl) where: two of six personal aniline samples were collected during cleaning of the antioxidant filter; the only 1990 nitrobenzene personal sample was collected in Building C-2 (Appendix F, Table 1c); and four 1991 area samples were collected in the containment basin (Appendix F, Table 1g). These samples are not representative of Department 145 worker exposures; rather these samples were collected when and where high exposures were suspected.

B. Job titles suspected to be highly exposed tended to be the jobs most frequently sampled (refer to Appendix F, Tables 2c-f, 3c-f, and 4c-e for job titles included in sampling). Not all potentially exposed job titles were sampled. For example, there are jobs known to have involved significant amounts of time working in the plant for which no samples were collected (e.g., engineers), or to have limited exposure which were never sampled (e.g.,

guards). Thus, the relative exposures for these jobs must be estimated based on information from the workers, plant and company personnel, union representatives, and expert judgment.

C. For some jobs, there often were very limited sample days and tasks (or areas) that were monitored. Examples in this data set include: Department 145 mentioned above; Department 111, where only one 1993 nitrobenzene personal sample was listed for a millwright in Building 32 (Appendix F, Table 1d); and in 1991, Department 111 when only three area samples were collected in the main manager's office and tool crib (Appendix F, Table 1h).

D. Detection limits and ways of reporting data varied over time depending on the analytical instrumentation utilized (refer to Table II of Appendix C). For a brief, several-month period, one-tenth of the TLV was reported by the laboratory for non-detectable measurements. Further, the analytical methodology and therefore the detection limit used before 1980 is unknown; possibly changed in 1980; and is known to have changed in 1993.

E. Because aniline, *o*-toluidine, and nitrobenzene can penetrate the skin, air exposure measurements do not reflect total exposure. Dermal exposure is known to have been a significant source, especially prior to 1989. Dermal exposure varies by task and other conditions which cannot be quantified, especially in a retrospective exposure assessment. Furthermore, gloves that were used (and re-used as confirmed by the plant walk through) were not impermeable to organic amines for more than a few hours.

Based on the above information, and the fact that there were no air sampling data prior to 1975, it was decided to use the air monitoring data only to support the creation of an assigned ranking scheme to account for differences in exposure. This involved assignment of an approximated rank of "relative" exposure level to each exposure combination (i.e., for each department-job-year). The ranks are based relatively on the quantitative exposure levels, as available. This approach works well when there are some, but limited exposure data. Because year is incorporated into the assessments, a job exposure matrix (JEM) is effectively created. The assigned exposure ranks are listed in the column titled *Assigned Exposure Ranks (0-10)* in Appendix E. Assumptions used in assigning ranks are provided below:

A. Ranking Scale – A ranking scale of 0 to 10 was qualitatively selected to provide enough latitude to characterize exposures of different groups based on relative exposures interpreted between jobs and departments over time. Because of the difficulty in distinguishing among various jobs with high exposure, the ranks 6, 7, and 9 have not been assigned; ranks of 8 and 10 for the high exposure jobs were used to provide sufficient separation from those jobs perceived to have much lower potential for exposure.

i. 1954-1960 - For the period of 1954 to 1960, the rank of 1 corresponds to the Probably not exposed (PNE) alternate code, the ranks 1-2 to the Probably exposed low and irregularly/occasionally (PEI) alternate code, the ranks 2-3 to the Probably exposed low and regularly (PER) alternate code, and the ranks 4-5 to the Definitely exposed moderate/high and regularly (DER) alternate code.

ii. 1961-1994 - For the period of 1961 to 1994, the rank of 1 corresponds to the Probably not exposed (PNE) alternate code, the ranks 2-4 to the Probably exposed low and irregularly/occasionally (PEI) alternate code, the ranks 3-5 to the Probably exposed low and regularly (PER) alternate code, and the ranks 8-10 to the Definitely exposed moderate/high and regularly (DER) alternate code.

iii. 1995-2005 - For the time period 1995-2005, the correspondence is rank 0 for PNE, ranks 1-2 for PEI, rank 2 for PER and ranks 2-3 for DER.

B. Time Periods – [Preface: Confidential production volume documents indicated that aniline and nitrobenzene use started in 1954, and *o*-toluidine use started in 1957. During employee interviews, it was stated that "rubber chemicals started in 1956-57." We conservatively have used 1954 for the date of first exposure to organic amines. It is assumed that no exposure occurred before 1954 and thus *an exposure rank of 0 is assigned to all department-jobs prior to 1954.*]

i. 1954-1960 - There were no quantitative exposure data for years 1954-1974. There are some confidential production data, which suggest that production of accelerator (and thus use of aniline and nitrobenzene) increased between 1954 and 1957. In 1957, antioxidant production began, adding *o*-toluidine and increasing aniline usage at the facility. Between 1960 and 1965, significant increase in antioxidant production (and use of *o*-toluidine and aniline) occurred. Because production information was available for only 5-year increments until 1980, we have conservatively selected 1960 as the cut-off for a lowered exposure rank time period. For this lower exposure time period, given the lack of exposure information other than that production was about half of the later period, we have used ranks of 1-5, approximately half the exposure rank for 1961-1994.

ii. 1961-1994 – After 1957, antioxidant production and use of aniline and *o*-toluidine continued to increase until 1965; after which production varied up and down around the same mean until accelerator production was discontinued in 1994. Further, these were

years during an era when it is believed that effectiveness of controls was less than in later years. Thus, lowered exposure estimates cannot be assumed for the 1961-1974 time period when no air monitoring data is available.

Company-provided process descriptions, engineering controls, and procedural changes do not show changes that would have impacted air levels until 1978 when a control room with fresh air supply was installed. Interviewed employees indicated that operations were "pretty much the same in the 1970s as they were in the 1960s." No information was discovered to suggest that workers' exposures differed significantly through these decades (i.e., 1961-1992).

The next time period for reducing exposure ranks was initially considered as beginning in 1991-1992. This was when a number of important controls had been implemented, partially based on NIOSH findings and recommendations, including leak protection, local exhaust ventilation for process sampling and holding tanks, and raw material sample ports on tank cars. However, the air sampling results summary in Appendix F, does not show that the overall air levels were noticeably lowered in 1992, particularly for aniline and *o*-toluidine, the two priority chemical exposures of interest.

Nitrobenzene exposure ceased in 1994 when the accelerator operation was discontinued. Air levels of aniline were also substantially lowered beginning in 1995, presumably due to cessation of accelerator production. Additional controls were also installed, most notably the centrifuge equipment which reduced air emissions from changing the sparkler filter (refer to Appendix F, Table 2a). Thus, 1995 was used as the basis for lowering the assigned exposure ranks for all jobs. *There were no "0" ranks assigned during the 1954-1994 time period - ranks ranged from 1-10 based on department and jobs.*

iii. 1995–2005 – Production of Antioxidant continued from 1995-2005 with a few additional exposure controls [e.g., laundering of towels and underwear (although not all employees utilize the latter service), hand washing sink in break room, new pastille (pelletizer) equipment]. Air levels were fairly consistent in production areas from year to year (refer to Appendix F, Table 1b, 2a, and 3a). There was an awareness of the association between bladder cancer and exposure to aniline and *o*-toluidine. This likely caused workers to more judiciously wear personal protective equipment, and front office workers were probably less likely to enter production areas. *Hence, the assigned exposure ranks range from 0-3 for the 1995-2005 time period.*

C. Jobs – Most of the assigned ranks are explained based on the discussions above in Sections 3.3 and 3.4. When additional information provides a better understanding of the rank assignments, the rationale is provided below. When air monitoring data were available, full shift personal (P-TWA) samples were given greater weight than area samples. Area samples also show that chemical vapors were present in these locations but do not account for exposure variability due to workers' mobility.

i. Rubber chemical, Antioxidant and Accelerator workers (Department 245, NIOSH Department 24) – All managers and operators were assumed to have the highest regular exposures in the plant. Their exposures were highly variable, but were lower after 1994 (Appendix F, Tables 2c, 2d). *Thus, their exposure ranks were 5 for 1954-1960, 10 for 1961-1994 and 3 for 1995-2005.*

ii. Maintenance workers (NIOSH Department 11) – Maintenance personnel typically had the highest aniline and nitrobenzene exposures (Appendix F, Table 2a), but it was assumed they did not work in the plant all the time. *Thus their ranks are assigned values slightly below Department 245 workers (e.g., 4 for 1954-1960, 8 during 1960-1994; 3 or 2 during 1995-2005)* .After 1994, painters took on responsibilities as an insulator, which requires occasional removal of chemical laden insulation *(thus the painter's rank has been set at a 2 for 1954-1960, 3 for 1961-1994,and 2 for 1995-2005.)*

iii. Engineers – Engineers were assumed to work with chemicals in the plant on a regular basis. It was assumed that chemical and R&D engineers had slightly more exposure *(e.g., rank 5 for 1954-1994; rank 2 for 1995-2005)* than engineers and co-ops *(e.g., rank 2 for 1954-1960, rank 4 for 1961-1994; rank 2 for 1995-2005).*

iv. Lab workers – All lab workers were assumed to be exposed in the lab due to the open bench testing. It was assumed that lab technicians, who went into the plant to test the air and collect chemical samples, had higher exposure than chemists and other workers who were more likely to stay in the lab area. Personal samples collected on lab workers show lower exposures to aniline than maintenance, shipping, or Department 245 workers (Appendix F, Table 2a) and exposures to *o*-toluidine comparable to those of Department 245 workers and higher than those of maintenance workers (Appendix F, Table 3a). In 1992 and 1993, lab workers' exposures to nitrobenzene were lower than those of Department 245 workers (Appendix F, Table 4a). *Thus, assigned exposure ranks for lab technicians were 3 for 1954-1960, 5 for 1961-1994 and 2 for 1995-2005; other lab workers were assigned 2 for 1954-1960; 3 for 1961-1994, and 2 for 1995-2005.*

v. Nurses, safety engineers – Nurses and safety engineers are *assigned slightly higher exposure ranks than guards (i.e., 2 during 1954-1960, 3 during 1961-1994, and 2 during 1995-2005).* This is based on an assumption that these jobs entailed entering the plant or being in closer proximity to contaminated workers than was required by the guards.

vi. Shipping, packaging, warehouse workers (Departments 121, 137, 328, 402A, 402A3, 442, 826, 845, 922, NIOSH Department 21) – Shipping/packaging aniline, *o*-toluidine, and nitrobenzene air samples in 1992 were approximately the same as maintenance (Table 2a, 3a, 4a). For the warehouse helper and the storeroom worker, exposures were lower. *Their assigned exposure ranks were 2 for 1954-1960, 3 for 1961-1994, and 2 for 1995-2005.*

vii. Yard/janitor workers (Department 191, NIOSH Department 19) – No air samples were collected for these workers, but job descriptions indicated they worked in the plant on a periodic basis. *Their assigned exposure ranks were 2 for 1954-1960, 3 for 1961-1994, and 1 for 1995-2005*.

viii. Vinyl workers (Department 145, NIOSH Department 14); Powerhouse Operators (Department 116, NIOSH Department 16); Rubber chemical workers (Department 232, NIOSH Department 23) – These workers were *assigned an exposure rank of 1 for 1954-1960, 2 for 1961-1994, and 1 for 1995-2005* due to the fact that they were out in the plant. Based on air monitoring data, it also appears that some Department 145 workers helped out with antioxidant filter cleaning, at least occasionally. Vinyl production ended about 1996 or before, and thus not many vinyl work history reports are expected for the latter time period.

Department 145 Utility Operators spent time in the recycle area, where *o*-toluidine was processed beginning in about 1980. Rather than create a new time period for the entire cohort, it is noted that *the exposure rank for these workers was assigned a 4 for 1980-1994.*

ix. Guards – Guards are assigned a slightly higher exposure rank than front office workers due to the fact that they were required to enter plant production areas on a regular schedule. *Their assigned ranks are low (e.g., 1 for 1954-1960, 2 for 1961-1994, and 1 during 1995-2005)* because they had no direct interaction with process chemicals and their exposures were limited to vapors and/or surface contamination.

x. Front Office jobs (personnel, secretary, accounting, operator, etc.) – There are no air monitoring data available for these jobs. It was assumed that these jobs had very little exposure. However, during the 1954-1994 time period, it was assumed that all workers at the plant had some exposure, even front office workers, by virtue of other workers coming into the front office area, and the possibility of front office workers occasionally going into the plant. Moreover, front office personnel could be exposed to low levels due to the proximity of offices to chemical buildings allowing vapor intrusion through windows, doors, or air intakes. *These workers are assigned a rank of 1 for the 1954-1960 and 1961-1994 time periods and 0 for 1995-2005.*

4. CONCLUSION

Three new exposure assessment schemes were developed for this cohort study based on consideration of available data. All approaches described meet NIOSH's criteria that the exposure groups remain mutually exclusive (i.e., each worker assigned to only one exposure group) or based on updated work histories (i.e., job-department-year). Additional work which was conducted to improve the characterization included:

- Extended the exposure characterization to 2005 for all those still employed, or to date of retirement for those who retired after 1988. This might be important for workers diagnosed since the original study.

- Improved each individual's work histories by using the detailed work histories listed on the cover of employee personnel folders.

- Reviewed and compiled replies to additional questions posed to the company and union to verify information.

- Conducted additional evaluation of the quantitative data available to support the exposure assessment.

Each exposure classification scheme has advantages and disadvantages. (In addition, there are other possible approaches not evaluated nor presented in this report.) However, inclusion of job title in addition to department is considered to be a necessary modification to improve surrogate exposure measures. It is also recommended that job duration be included. Because exposure is ongoing, but to a lesser degree than in previous eras, the four-level grouping scale might allow for better differentiation between exposure groups (rather than a three-level scale). However, each sub-grouping reduces the population size with a corresponding reduction in power to detect the same risk of disease. If the original strategy to use only departments to group workers is retained, the revised, not the original groups, should be used.

4.1 Use of Numerical Exposure Ranks

The approaches based on exposure categories do not differentiate workers who were exposed for only short time periods from those who were exposed for much longer periods. For example, someone who worked in Department 145 (PVC, vinyl) for 29 years and in Department 245 (Rubber Chemicals) for only one year (Worker 1) would be grouped in the same exposure code as someone who had worked in Department 245 for 30 years (Worker 2).

One way to incorporate the duration of work in each exposure group is to utilize assigned exposure ranks. The assigned rank multiplied by duration (in years) yields a cumulative exposure rank for the worker's duration of employment at this company. In the example above, if a rank of 1 were assigned to Department 145 chemical operators and a rank of 10 were assigned to Department 245 chemical operators, then cumulative and average annual exposure rankings could be calculated as follows:

Worker 1: Cumulative exposure rank = (1 x 29) + (10 x 1) = 39
Average annual exposure rank = 39/30 = 1.3

Worker 2: Cumulative exposure rank = (10 x 30) = 300
Average annual exposure rank = 300/30 = 10

A numerical ranking calculated for each worker creates a more diverse spectrum of exposure approximations that can be analyzed by continuous statistical methods. This varies from the approach used in the original study where workers were stratified by three homogenous exposure groups and broad duration categories of <5 years; 5 to 10 years; 10 to 20 years; and >20 years.

4.2. Outstanding Issues

The major source of exposure misclassification occurs when employees work in areas of the plant or conduct tasks other than those for their assigned jobs or departments (e.g., during a work stoppage or when replacing an absent co-worker, etc.). In a cohort study, sufficient funds are generally not available to assign exposure for each individual based on detailed work histories derived from interviews. Further, it is often impossible to do so due to recall error or loss of an employee from retirement, death, etc. Hence, exposure estimates are often assigned based on best available knowledge for groups of workers.

It was reported during employee interviews that workers who might normally be unexposed were required to work in exposed areas under some circumstances. For example, Department 145 (PVC) workers might occasionally fill in for Department 245 workers. In a cohort study such as this one, where

exposures are based on assigned departments and jobs without daily task or location lists, this source of bias typically cannot be corrected. If such exposures were frequent and unknown, this could be a serious source of bias. Employee interviews and job descriptions indicated that workers generally worked in their assigned departments. Employee interviews and "Company/union Answers to Questions" suggest that "Sales, headquarters employees" and "some office workers" may have worked around the plant during work stoppages (i.e., union strikes), but there is no specific information about which job titles were affected nor when these stoppages occurred. A nine month strike in 1976 was the only work stoppage mentioned in employee interviews. Other misclassification sources include:

- Date of first exposure – If production did not start until after 1954, a few jobs will be misclassified as exposed for the years between 1954 and the actual start of exposure.

- Unknown job responsibilities – There are still some jobs for which potential exposure is not fully understood. For example, because the Program Developer/Instructor (M/W PDI) was assigned to the Maintenance department and the job description notes that this position also "works as millwright as time permits and…fills in for trainee," it was assigned a millwright exposure code. If a person in this job worked significantly less time as a millwright than other millwrights, the assignment could overestimate exposure.

- Unknown department codes – There remain a number of department codes in individual work histories for which job duties and/or locations are not fully defined. A list of these was provided to the company and union for resolution, especially with respect to identification as to whether the department was located on or off this plant site. If unknown department codes cannot be resolved, analyses could be done with and without those departments to assess the potential impact on study results.

- Department 145, Warehouse activity – It is unclear if there were shipping, packaging, and warehouse activities in Department 145; if so, it would be useful to differentiate those who worked in Department 145 from those who worked in 245.

4.3 Separation of exposure to three chemicals of interest

With regards to ways to separate exposures to the three chemicals of interest (i.e., *o*-toluidine, aniline, and nitrobenzene), workers in Department 245 were exposed to at least two, and usually all three chemicals, depending on the year. Aniline and *o*-toluidine were used concurrently from 1954-2005, while nitrobenzene was also used in the same areas from 1970-1994. The antioxidant and accelerator processes

were parallel in the same buildings, with some overlapping equipment and piping. Moreover, personnel records identified the department and general job title for each worker, but did not specify assignment between antioxidant or accelerator processes. No records were identified that provided more specific detail about job or task. Even if they did, it would be difficult to differentiate between chemical exposures from adjacent, parallel processes. Consequently, it was not possible to determine whether one worked in the antioxidant or in the accelerator process, nor approximate workers' exposures separately to each chemical based on assigned job titles and work histories.

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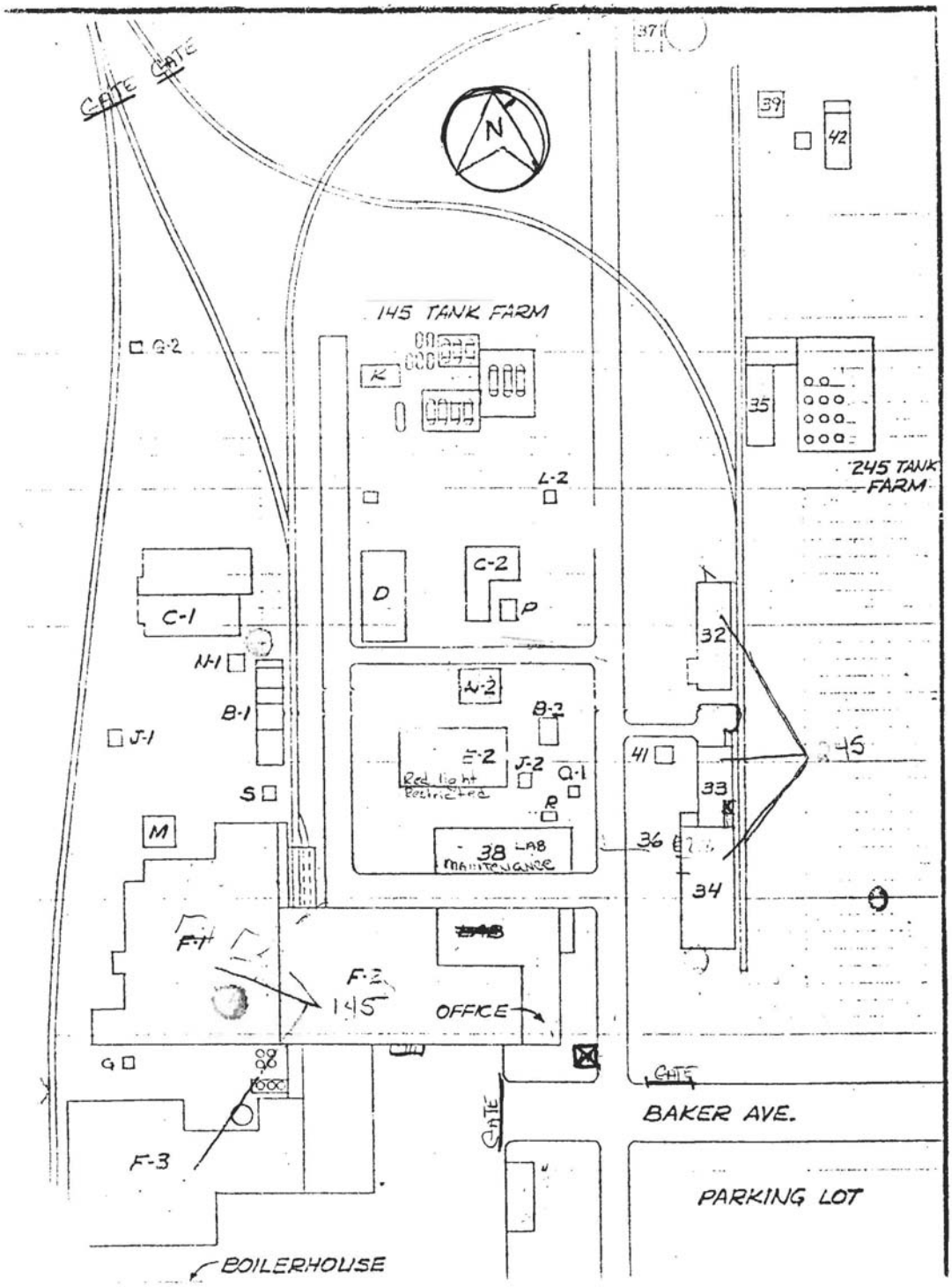
APPENDIX A

MAP OF FACILITY AND GROUNDS

Figure A.1 - Map of facility and grounds



APPENDIX B

CONTROLS/PROCEDURES IMPLEMENTED BY THE COMPANY TO MINIMIZE EXPOSURES

Table B.1 - Changes/procedures implemented to minimize exposure to chemicals

1978	Installed premix charge reactor feed system operated from a control room (prior to this, manual operation) Fluid bed dryer installed (Accelerator)
1980	Installed closed system to feed liquid catalyst
1981	Raised air intake stacks from 6' to 30' to bring fresh air into Bldg 32 Installed closed Hercules filter (did not replace sparkler filter)
1982	Purification of Captax discontinued
1984	Installed semi-bulk bag system for hydroquinone
1987	Implemented provision for company laundering of work clothing
1991	Implemented "streamlining" program to reduce antioxidant recycle material
	Implemented procedure to weld pipes to minimize potential for leaky threads
	Installed vacuum lines from product holding tanks.
	Provided worker training and personal protection equipment (PPE) to prevent skin contact with liquid aniline and/or *o*-toluidine during sparkler filter cleaning operations. PPE included gloves, boots, and air respirators with coveralls and hoods.
1992	Installed redundant leak protection controls
	Installed local exhaust ventilation for process sampling
	Installed samplers for raw materials from tank car/trucks
	Initiated/implemented monthly ventilation system performance check system
	Initiated/implemented quantitative fit testing for respirators.
1993	Installed a change room/shower facility with sauna to allow workers the opportunity to wash/shower and change clothes before returning to their homes
	Implemented routine cleaning/decontamination of the change-room/shower facility, and workers' training in proper work practices and personal hygiene practices
1994	Installed centrifuge equipment to eliminate need to change out sparkler filters
	Provided laundered fire-retardant clothing for all workers, each work day
1997	Provided laundered towels and underwear each workday (although some workers did not or do not utilize the latter service)
	Installed pastille finishing line equipment, a more-closed system (less dust potential)
1998	Installed automatic bagging system for pastilles
	Installed hand washing sink in break room, separate from sink for dish/glass washing.

APPENDIX C

COMPANY AND UNION ANSWERS TO QUESTIONS

Table C.1 – Company and Union answers to questions

1	NIOSH Question/Topic	General interviewee type	Plant Answers Provided by Plant Associates	Corporate IH Answers Provided by Corporate Safety & Health Eng. Consultant	Union Answers Provided by Steve Wodka (Union Attorney)
2	What would a lab tech and co-op do who were assigned to this dept?	Accounting	A lab tech would test raw material, in-process materials, and final products. A co-op could perform similar tasks as an engineer and could include working in the reactor building, C2, tank farm, finishing building, and the lab.		
3	Was Dept 245 stenographer really exposed? How?	Dept 245 staff	The 245 stenographer wouldn't normally go beyond the offices or the 34 bldg warehouse.		
4	When did company discontinue use of open "French" floor drains and dyked drains that discharged to the storm sewer in 245? What was new system? Was exposure lowered, or did new waste stream processing add/change exposures?	Dept 245 staff	To my knowledge there never were any drains or trenches that went to the storm sewer. Prior to installing the containment basin, they went to the city sanitary sewer. As the hazardous nature of the plant's various chemicals became known, engineering controls in the form of ventilation, pump styles, pipe materials, procedures, etc. along with PPE were implemented to control exposure. The term "French Drain" is not used correctly in this questions. The installation of dikes in the buildings and tank farm were to protect the environment.		Open French drains exist to today but discharge to a sump.
5	What job titles emptied the tank cars?	Dept 245 staff	This was (and is) usually done on overtime and could be any of the RC classifications who had been certified in Tank Farm operations		Tank cars were regularly emptied by Department 245 Chemical Operator Utility, Department 245 General Operator Utility, and by the C-2 Operator. However, on overtime, anyone trained to do the job could have the assignment.
6	Within 245, what were higher exposure job titles, why? What percent of time spent doing high expsoure tasks?	Dept 245 staff	Reactor and C2 operators and COU were the titles whose duties would include working around raw materials.		
7	Lab supervisor - If assigned to 245, where did they actually work? Duties? Opportunities for exposure?	Dept 245 staff	Main duties would be in the lab along with trips to operations for collections and process support		

1	NIOSH Question/Topic	General interviewee type	Plant Answers Provided by Plant Associates	Corporate IH Answers Provided by Corporate Safety & Health Eng. Consultant	Union Answers Provided by Steve Wodka (Union Attorney)
8	What would a guard assigned to medical do? Opportunity for exposure?	Guard, medical			
9	Guards - years where they walked plant? Exposures as compared to now - more detail.	Guards	The guards work is normally limited to the gate house. They do walk a security route which includes a brief walk thru of all areas of the plant and the perimeter of the grounds.		
10	Instrument mechanics - fix gauges, switches, not pumps and pipes, but what were other duties? Ever drafted into exposed tasks? Did they have different exposures than other mechanics?	Instrument mechanic	I/E mechanics also repair control valves and other non-manual valves that might expose them. Their exposure would typically be less than a millwright's because of the millwrights work covers more equipment.		Instrument mechanics had the same exposures as the maintenance mechanics (millwrights).
11	Where is this located? Would all listed job titles work there? What are potential exposures over years?	Lab - Research and Development	There was no R&D work done at this plant although there was experimentation performed periodically that could have exposed personnel.		
12	Lab workers - were there titles that did the sampling and monitoring, and titles that did not do these activities? Duties of chemists vs lab techs? % time amine vapors could be smelled in lab?	Lab workers - chemist	Most of the lab personnel could be required from time to time to sample as necessary.	NF has required PPE (chemical resistant gloves) at least as far back as 1989 when NIOSH (Dr. Elizabeth Ward, et al) first visited the plant. Gloves were to be worn by all associates, including lab workers, when there was potential for contacting liquid aniline, *o*-toluidine or plant recycle. A written PPE Program has been in the Plant QSI database of work instructions since at least since 1994.	XX was a lab worker who was diagnosed with bladder cancer in 2001 at age 53. In 1974, XX became a lab technician. Beginning in 1974, XX worked 5% to 10% percent of his time in Department 245, taking readings with detector tubes. XX took samples of Antioxidant from Department 245 and tested them for purity. As a lab technician, XX tested raw materials, including ortho-toluidine, for purity with a spectrometer. The samples of raw material were delivered by personnel in small plastic container. From 1974 to 1976, XX spent 4 to 6 hours per week testing ortho-toluidine. He also tested aniline for purity. XX did not wear any gloves in the laboratory when XX was handling samples of ortho-toluidine and this material would contaminate XX hands. These

1	NIOSH Question/Topic	General interviewee type	Plant Answers Provided by Plant Associates	Corporate IH Answers Provided by Corporate Safety & Health Eng. Consultant	Union Answers Provided by Steve Wodka (Union Attorney)
					liquids frequently seeped out of the sample containers. XX also tested recycle every shift, which contained ortho-toluidine. YY was a lab worker …From 1975 to 1978, YY was a lab technician assigned to Department 460. In YYY second assignment, from September 1978 to 1987, YY was as a chemist in the same department. While working as a lab technician, YY routinely performed quality control checks on samples of ortho-toluidine that were brought directly to the lab upon the delivery and unloading of this raw material. The ortho-toluidine would get on YY skin and YY inhaled the vapors. YY also ran lab tests on recycle which contained ortho-toluidine. YY would get recycle on her skin and YY smelled the recycle samples. As a chemist, exposure to ortho-toluidine through sampling and testing continued, but YY exposure was less frequent. YY also performed bench-scale studies of Antioxidant production. Both as a lab technician and as a chemist,YY routinely went into Department 245 to perform air monitoring and to obtain samples.
13	Did sampling methods change during 1975-2005?	Lab/ IH		See Table II below. Before 2/93, NF followed NIOSH Method 2002 (collecting air samples on silica gel tubs). After 2/93, NF followed OSHA Method 73 (collecting samples on two glass fiber filters treated with 0.5 mL of 0.26N H_2SO_4 & separated in 37 mm polystyrene cassettes).	

1	NIOSH Question/Topic	General interviewee type	Plant Answers Provided by Plant Associates	Corporate IH Answers Provided by Corporate Safety & Health Eng. Consultant	Union Answers Provided by Steve Wodka (Union Attorney)
				Prior to 6/19/80, all air samples were analyzed outside of the company's accredited IH Lab, e.g., in the NF lab or possibly by outside labs.	
14	Why was detection limit so high in 2005? Did LOD change over time (1975-2005)?	Lab/ IH		See Table II below. The LOD changed several times depending on which GC detector was available/used (FID vs NPD) and chemist proficiency with these instruments (per Table II below).	
15	Explain monitoring strategy at plant. Mostly hi- risk vs all jobs? All depts? And during which eras?	Lab/ IH		Plant has always attempted to monitor all jobs, not just high risk. During earlier years, source monitoring (area) was performed at lot to define risk areas/processes. However, since ~ 1996, greater emphasis was placed on personal monitoring strategy; workforce was apportioned into representative exposure groups (HEGs) to define representative exposures. HEGs were characterized by: Dept., Process or machine, Job, Task and finally agents. Sampling strategy (for aniline and *o*-t) recommended that at least 11 samples be collected and spaced over a 3-year period for each HEG defined - to establish geo-mean and max exposures for each HEG.	
16	Nitrobenzene exposure data - 0.1 seems to be half of all data points - analysis issue?	Lab/ IH		Virtually all of the 0.01 ppm values (noted no 0.1 values) have an "ND" also indicated in	

1	NIOSH Question/Topic	General interviewee type	Plant Answers Provided by Plant Associates	Corporate IH Answers Provided by Corporate Safety & Health Eng. Consultant	Union Answers Provided by Steve Wodka (Union Attorney)
				the DETECT column. This means that nitrobenzene was not detected (ND) at or above 0.01 ppm in air. The company's IH database does not provide (< or >) signs for values, so we indicate "less than" values by adding an ND.	
17	Secretary/steno, data processing, chem engr, research and dev engr, engineer, section head, co-op, squad, - where actually worked?	Laboratory	Engineers, section head, co-op's, and squad engineers would work in every part of the plant.		
18	Accountant, secretary - where did they actually work? Opportunity for exposure?	Maintenance	Front office. None		
19	Lab supervisor - what were duties when assigned to Maintenance? Where did they actually work?	Maintenance	Lab supervisor was not assigned to maintenance.		
20	Maintenance - did they move around depts or assigned to a dept - if so, do we know which? Were they intermittently exposed? Would they agree that Instrument mech, mech, and craftsman were definitely exposed? That an electrician, millwright, pipefitter, and welder were possibly exposed? That a powerhouse operator was likely not exposed?	Maintenance	All maintenance trades had the opportunity for exposure. The question is frequency. Some trades were exposed more often than others. The steam plant operators were not exposed as part of their steam plant responsibilities but could have been before or after they operated the steam plant.	Exposure to AN & o-T primarily occurs as a result of working around liquid AN, o-T, or plant "recycle". This might occur when unloading railcars, or working on pumps, pipes or process equipment containing liquids. Exposure to "Antioxidant" product (flakes, pastils or liquid) should not be confused with potential for exposure to liquid AN, or o-T. Solid Antioxidant in the bagging areas, warehouses and most of the plant is not a significant source for AN or o-T exposure since it contains only traces of residual AN & o-T. Same for liquid Antioxidant.	Maintenance workers did move around the departments. WE are unaware of any system which kept track of which department that they were in at any given point in time. You would need to interview each maintenance worker in order to develop an estimate of the overall percentage of their time spent in each department. We believe that the use of the term "intermittent" to describe their exposure in incorrect since they had definite exposure when working in Department 245. All maintenance workers listed—instrument mechanic, mechanic, craftsman, electrician, millwright, pipefitter, and welder—were definitely exposed. The powerhouse operator was not likely to be exposed, but he may have had a prior assignment which permitted exposure.

1	NIOSH Question/Topic	General interviewee type	Plant Answers Provided by Plant Associates	Corporate IH Answers Provided by Corporate Safety & Health Eng. Consultant	Union Answers Provided by Steve Wodka (Union Attorney)
21	Are people working in other plants (Akron, Beaumont, Gadsden, Houston, etc.), likely to be exposed to *o*-toluidine, aniline or nitrobenzene?	Company	Those that worked in Niagara Falls in rubber chemicals.	Air sampling has been conducted in the company's plants; all measurements have been ND for both aniline and *o*-toluidine.	
22	Explain when/why Dept 255 was created ~1994. We think it was new department number assigned to Antioxidant when Accelerator operation shut down. So any difference between 245 and 255?	Company/ union	I'm not sure of the timing, but 245A was the accelerator side of rubber chemicals and 245C the antioxidant side. A new computer system was installed that did not allow for the A or C. 245 was used for accelerators and 255 for antioxidants. It had nothing to do with the discontinuation of Accelerator.		Your explanation for the 245/255 designations is correct.
23	Are mezzanine and solution deck the same area?	Company/ union	Yes		The main mezzanine and solution deck are the same.
24	Is there reason for highest exposures occurring in 1979 - process, production rate, other?	Company/ union	I am not aware of anything that occurred in 1979 that would have resulted in high exposures although I do know that in the 70's and later measures to tighten up the processes to reduce exposure were taken.		A likely explanation might be a change in sampling methods. We are unaware of any process or production rate changes which would have accounted for the difference.
25	Akron temp assignment - What exposures exist at that plant? Can we assume they (Secretary/steno, Chem Eng, Engineer, QC, Area Mgr, Co-op, Squad) served in same capacity in NF? If not, what did they do/which Dept?	Company/ union	Akron temps could have worked anywhere depending on their assignment.		
26	Sales, Akron employees (Accounting, secretary/steno, clerk, switchboard oper, personnel staff/non-mgr, guard, janitor, manager, data processing, chem engr, chemist, research and dev engr, engr, lab tech, chem op, foreman, super, section head, mechanic, craftsman, pipefitter, tech, yardman, buyer/merchandise coord, Pathfinder NF, co-op, squad) - did they do what workers did?	Company/ union	Not sure which associates this question refers to. The titles that match up with existing titles in RC group would probably have worked in assignments similar to plant associates. Those other titles may have worked in various areas during work stoppage.		

1	NIOSH Question/Topic	General interviewee type	Plant Answers Provided by Plant Associates	Corporate IH Answers Provided by Corporate Safety & Health Eng. Consultant	Union Answers Provided by Steve Wodka (Union Attorney)
27	Co-op employees - did they do what workers did?	Company/ union	A co-op (engineering) would have assignments similar to those of an engineer.		
28	Was nitrobenzene only used in dept 245 process?	Company/ union	Yes. Accelerator process.		Nitrobenzene was only used in the Accelerator process in Department 245.
29	Any use of aniline, OT, or nitrobenzene in 145?	Company/ union	No.		No
30	What were NIOSH Department Codes 22 and 23? Assume 23 was 232 (Rubber chemicals) - what were chemicals used here? Year closed?	Company/ union	Department 232 made PVC compounds using numerous chemicals. I have no knowledge of which ones. It closed in the late 70's.		Department 232 was the compounding plant which used the PVC resins made in Department 145 to make PVC compound.
31	Is it true that "no process changes occurred in Accelerator production (1970-1994) that would have changed significantly the potential for exposure"?	Company/ union	No. Equipment that had the potential for emitting vapors was ventilated. Some open equipment was closed to prevent emitting vapors. In the early 80's a purification, intermediate step was eliminated which further reduced exposure potential.		We are unaware of any such process changes.
32	Would you agree that accountants, office workers, and sanitary engineer/janitor had zero to minimal exposure over all decades?	Company/ union	Office personnel would have had negligible exposure. Up until the 90's, janitorial staff were assigned to the entire plant.		These office worker job classifications need to be addressed on an individual basis. Some of these people worked in Department 245 during a nine month strike in 1976 and had considerable exposure. So far, one of them, a buyer, whose only exposure was during the strike, has developed bladder cancer. We can make his records available to you. Some office workers may have needed to go into Department 245 on a regular basis.
33	Controls added since 1988?	Company/ union	Much of the equipment has been ventilated since before then. The ventilation has been improved in every area where exposure is possible. Plus, the systems have been tightened, response to leakage improved, materials of construction upgraded, equipment installed reducing exposure, procedures modified, and control room		

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			makeup air intakes relocated. An entire locker room system was installed with clean and dirty side.		
34	Provide a description for the following department codes (from GEMS): 0011, 011, 0450, 0995, 0996, 0097, 0098, 0999, 255, 31, 1110, 1210, 1450, 2450, 2459, 9999, CHEM	Company/ union	These are work center codes used to describe what area work was being done for (accounting reasons). 0011 & 011 – Tank Farm 0450 – Nitrogen 0995 – Water 0996 – Electrical 0097 – Office EQ 0098 – HVAC 0999 – Lighting 255 – Rubber Chemical Prodution 31 – Steam Plant 1110 – Maintenance 1210 – Receiving 1450 – Vinyl 2450 – Accelerators 2459 – 9999 – Misc. work CHEM –		
35	Is the location: NIAGARA FALLS PLT (FIELD LOCN) the same as the Niagara Falls Plant? Location codes are GT0050 and GT137, respectively	Company/ union	Yes.		
36	Job titles (provide definitions) - Shift vs. skill level: A & B; CLA & CLB; CLASS A & B; 1st & 2nd class	Company/ union	Not clear on what job titles you are asking about.		
37	Job titles (provide definitions) - Apprentice vs. Manager trainee	Company/ union	Apprentice is normally used to describe a maintenance worker who is new to the assignment (working with a journeyman). This designation is while they are in the Apprenticship Program. Manager Trainee normally is used for someone training for a salaried managers operations (i.e. Area Manager).		

1	NIOSH Question/Topic	General interviewee type	Plant Answers Provided by Plant Associates	Corporate IH Answers Provided by Corporate Safety & Health Eng. Consultant	Union Answers Provided by Steve Wodka (Union Attorney)
38	Job titles (provide definitions) - E&I Mechanic vs. Instrument mechanic	Company/ union	Refer to same classification.		
39	Job titles (provide definitions) - Section Head vs. Manager vs. Supervisor. Time spent in plant, lab & office?	Company/ union	These titles are used for various management positions. Responsibilities are similar and work area depends on assignment.		
40	Job titles (provide definitions) - GAC, Prod Bal Fin, GT&R, R&W Chem Operator, OBT Trainer	Company/ union	Not sure on where these titles are coming from.		
41	Job titles (provide definitions) - Operations with numeric codes, such as 137-09003-M-21, etc.	Company/ union			
42	Job titles (provide definitions) - Chem Op vs. Prod Op. Is one involved with the wet chemical and the other with the final (reacted) product?	Company/ union	Yes, and exposure was significantly less when handling finished product		It is correct that the chemical operator was involved with the "wet" chemicals and the production operator worker worked with the final reacted product, but the close proximity of their work and the type of work performed—charging reactors or flipping sparkler filters—allowed for similar exposures overall.
43	Job titles (provide definitions) - SCALEMAN (Involved in production (packaging end) vs. yard (RR tankers) vs. warehouse (loading trucks)?	Company/ union			
44	Job titles (provide definitions) - Sales. Office vs. off-site work?	Company/ union	Sales office was located here for PVC group. Office area.		
45	Job titles (provide definitions) - Non-bargaining vs. salary	Company/ union	Non-bargaining would refer to any associate who is not represented by the union. They could include salary, temp or contract associates.		
46	Job titles (provide definitions) - Co-op employees. Were they involved in operations?	Company/ union	They could be used on various plant areas depending on assignment.		
47	Job titles (provide definitions) - Squad/Akron Employees. Are they management?	Company/ union	These were usually short term temporary assignments used for development purposes.		
48	Would a nurse have opportunity for exposure?	Nurse	No		

1	NIOSH Question/Topic	General interviewee type	Plant Answers Provided by Plant Associates	Corporate IH Answers Provided by Corporate Safety & Health Eng. Consultant	Union Answers Provided by Steve Wodka (Union Attorney)
49	What are difference between various operators (chemical, utility, reactor, packaging, etc) wrt to actual work done?	Operator	Generally, the type of job and how the job was performed determined the degree of exposure. The 'wet' operations had much more potential that the 'dry'.		With respect to actual exposure among the various operators, we do not believe that the differences in titles resulted in any significant or consistent differences in exposure. They all worked in close proximity to each other under similar conditions.
50	Personnel - coop - where actually worked? Duties/exposures?	Personnel	Refer to question 47		
51	Safety engineer/personnel - what were duties? Actual work location? How much exposure?	Personnel, safety engineer	The safety personnel's duties took them to all areas of the plant.		
52	Quality Control Department (Manager, Quality Control, Lab tech) - what were their duties/exposures?	QC staff	Manager mostly office/lab area. Lab tech in plant for sampling/process support		
53	Way to assess product line for these folks? Did they move between lines?	Shipping/ packaging/ warehouse/ receiving	Not sure which associates you are referring to in this question.		Shipping, packaging, warehouse, receiving: First, “packaging” should be removed from this description because “packaging” in bags was performed by the production operators in Department 245. It should be noted that when liquid Antioxidant was produced in drums, 60 to 80 drums of liquid Antioxidant would be placed in the warehouse with their bungs open to cool down for a 24 hour period. This liquid Antioxidant was produced about twice per year. We believe it would be correct to describe these job titles as “intermittently exposed.”

1	NIOSH Question/Topic	General interviewee type	Plant Answers Provided by Plant Associates	Corporate IH Answers Provided by Corporate Safety & Health Eng. Consultant	Union Answers Provided by Steve Wodka (Union Attorney)
54	Shipping/receiving - did they move around depts or assigned to a dept - if so, do we know which? Were they intermittently exposed?	Shipping/ packaging/ warehouse/ receiving	There is negligible potential for exposure in the warehouse, shipping, packaging, or receiving areas. These areas were and are mainly used for storage & shipping of finished product which contains only minute trace amounts of aniline & o-t.		Shipping, packaging, warehouse, receiving: First, "packaging" should be removed from this description because "packaging" in bags was performed by the production operators in Department 245. It should be noted that when liquid Antioxidant was produced in drums, 60 to 80 drums of liquid Antioxidant would be placed in the warehouse with their bungs open to cool down for a 24 hour period. This liquid Antioxidant was produced about twice per year. We believe it would be correct to describe these job titles as "intermittently exposed."
55	Where would secretary/steno, data processor, buyer/merchandise coord work? Opportunity for exposure?	Shipping/ packaging/ warehouse/ receiving	Office work, not risk of exposure.		We believe that there was a "secretary/steno" whose work station was inside Department 245. With respect to the buyer, see our response to no. 32 above.
56	Where would clerk, stores/stock clerk, dispatcher work? Opportunity for exposure?	Shipping/ packaging/ warehouse/ receiving	Office work, not risk of exposure.		
57	Where would section head, supervisor, manager, foreman work? Opportunity for exposure?	Shipping/ packaging/ warehouse/ receiving	Refer to question 52		Shipping, packaging, warehouse, receiving: First, "packaging" should be removed from this description because "packaging" in bags was performed by the production operators in Department 245. It should be noted that when liquid Antioxidant was produced in drums, 60 to 80 drums of liquid Antioxidant would be placed in the warehouse with their bungs open to cool down for a 24 hour period. This liquid Antioxidant was produced about twice per year. We believe it would be correct to describe these job titles as "intermittently exposed."

1	NIOSH Question/Topic	General interviewee type	Plant Answers Provided by Plant Associates	Corporate IH Answers Provided by Corporate Safety & Health Eng. Consultant	Union Answers Provided by Steve Wodka (Union Attorney)
58	Where would chem engr, chem operator work? Opportunity for exposure?	Shipping/ packaging/ warehouse/ receiving	Chemical engineer would be mainly office area with some time spent in process area. Chem operator would be part of the RC group.		
59	Where would yardman work? Opportunity for exposure?	Shipping/ packaging/ warehouse/ receiving	There is negligible potential for exposure in the warehouse, shipping, packaging, or receiving areas		
60	Class A shop mechanic - did they work mostly in the shop? Did they ever go into plant? If so, all departments?	Shop mechanic	All maintenance associates worked in the shop area as well as various areas of the plant depending on assignment.		Class A shop mechanics did go into Department 245. In addition, equipment such as pumps came into the shop containing ortho-toluidine and thus the mechanics in the shop definitely had exposure.
61	Janitors - 67 listed as PNE - Need to confirm - Did they perform "in-plant" housekeeping? did they move around depts or assigned to a dept - if so, do we know which? Were they intermittently exposed?	Yard/ Janitor	Yes		The janitors definitely had exposure since they regularly cleaned the bathrooms and other areas in Department 245 which were contaminated.
62	What would a Chem Operator assigned to Yard/Janitor dept do? Opportunity for exposure?	Yard/ Janitor	Yard/Janitor duties were limited to clean up of various areas of the plant.		
63	Confirm that yardman would help clean spills in yard? Also in plant? How often?	Yard/ Janitor	Yard duties were normally limited to lawn/area maintenance.		A yardman would cut grass, shovel snow, pick up garbage, etc. We believe that yardmen had possible exposure.
64	Would supervisor have opportunity for exposure?	Yard/ Janitor	Supervisors would work throughout the plant during their normal working shifts.		

Table C.2 - Chronology of analytical methods & lower limits of detection used to measure IH samples for airborne aniline & *o*-toluidine

Time Period [1]	Sample Collection Method	Analytical Method	LOD [2] (µg/sample)	Comments
8/14/75 – 6/9/80				Air samples analyzed outside of company IH lab, e.g., at plant
6/19/80 – 2/93	Silica gel tubes 0.1 LPM sampling rate	NIOSH Method 2002 GC FID	~3 µg/sample with FID	LOD for *o*-toluidine air samples = 3ug/sample: 3ug/44L = (0.068mg/M3 X 24.45) / 107.2 = 15 ppb o-T Used until increased sensitivity was needed to correlate air with urine samples.
2/3/93 – 9/19/03	(0.26N) H_2SO_4 treated glass fiber filters, 2 per cassette-separated, @ 1.0 LPM sampling rate	Company method based on OSHA Method 73. Used NPD detector	~0.2 µg/sample 0.13 µg/s aniline 0.17 µg/s o-tol	Eliminated derivatization with heptafluorobutyric acid anhydride – so both aniline & *o*-toluidine could be analyzed via nitrogen-phosphorus detector vs aniline and *o*-toluidine standards. Increased sensitivity to 1 ppb in air samples.
9/19/03 – 12/2/04	Same	Same But switched back to GC with FID detector	2- 5 µg /sample	New IH Chemist (XX) not fully proficient in use of GC NPD. Therefore, used only GC FID.
5/8/05 – 7/19/05	Same	GC FID	300 µg /sample	New IH Chemist was reporting "all" detection limits at 0.1 TLV during this brief (2-month) period until told to report actual LODs. Switched to Clayton Labs (Bureau Veritas) soon after.

[1] No samples were collected outside of date-ranges given above.
[2] LOD: Lower Limit Of Detection - based on analytical method and GC detector used (FID, EC, or NPD).

Process Flow Diagram – Provided to NIOSH, but withheld from publication at request of company

APPENDIX D

UPDATED DEPARTMENT AND JOB TITLE CODES (1954-2005)

Table D.1 - Updated department codes (1954-2005)

DEPT IN COMPANY PERSONNEL RECORDS	DESCRIPTION	NIOSH ASSIGNED DEPT CODE
110D	Not a Dept. but a Code for correction of an error in entry	00
110E	Not a Dept. but a Code for correction of an error in entry	00
110X	Not a Dept. but a Code for correction of an error in entry	00
	Leave of Absence	00
100	Personnel	10
100A	Personnel	10
101	Personnel	10
400	Personnel	10
111	Maintenance	11
145	PVC, Vinyl	14
116	Powerhouse	16
108	Medical	18
108G	Medical	18
191	Yard/Janitor	19
121	Shipping, Packaging, & Warehouse	21
137	Shipping, Packaging, & Warehouse	21
328	Shipping & Packaging	21
402A	Shipping & Packaging	21
402A3	Shipping & Packaging	21
442	Shipping & Packaging	21
826	Shipping & Packaging	21
845	Shipping & Packaging	21
922	Shipping & Packaging	21
232	Rubber Chemicals	23
245	Rubber Chemicals-Accelerator, Antioxidant	24
104	Quality Control	40
046	Laboratory	46
102	Lab	46
104I	Lab	46
460	Lab	46
998	Lab	46
302G	Lab - Research & Development	48
455B	Lab -- R & D	48
480	Lab -- R & D	48
480D	Lab -- R & D	48
484B	Lab -- R & D	48
199	Accounting	64
199A	Accounting	64
640	Accounting	64
	None assigned*	69
Various	Off NF site location*	90
	Unknown*	95

Updated Department Codes (1954-2005) - continued

DEPT IN COMPANY PERSONNEL RECORDS	DESCRIPTION	NIOSH ASSIGNED DEPT CODE
105	Temp. Assignment from Akron	98
105A	Temp. Assignment from Akron	98
105B	Temp. Assignment from Akron	98
105C	Temp. Assignment from Akron	98
105T	Temp. Assignment from Akron	98
106C	Temp. Assignment from Akron	98
744	Sales, Akron Employee	99
830	Sales, Akron Employee	99

* New Department Codes since original study

Table D.2 - Updated job codes (1954-2005)

NIOSH CODE	JOB TITLE DESCRIPTION
00	Leave of Absence
01	Accounting
02	Secretary/Steno
03	Clerk
04	Switchboard Oper
05	Personnel Staff (non-manager)
06	Guard
07	Janitor
08	Manager
09	Nurse
10	Data Processing
11	Chemical Engineer
12	Chemist
13	Research & Development Engineer
14	Engineer
15	Quality Control
16	Safety Engineer
17	Lab Technician
18	Lab Supervisor
19	Area Manager
20	Antioxidant Packaging Operator (245)
21	Trainee
22	Chemical & Utility Operator
23	Chemical Oper -- Accelerator (245)
24	Chemical Oper -- Steam Stripper (245)
25	Chemical Oper -- Utility (245)
26	Chemical Oper
27	Chemical Oper -- C-2 (245)
28	General Utility Oper (145)
29	Helper
30	Production Oper -- Accelerator Dryer (245)
31	Production Oper Atom/ Bagger (145)
32	Production Oper
33	Production Oper -- Spray Dryer (145)
34	Foreman
35	Foreman Accelerator -- Accelerator (245)
36	Supervisor
37	Section Head
38	Electric-Instrument Mechanic
39	Mechanic
40	Inst & Refrig Mechanic
41	Instrument Mechanic
42	Craftman
43	Painter

Updated job codes (1954-2005) - continued

NIOSH CODE	JOB TITLE DESCRIPTION
44	Electrician
45	Powerhouse Oper
46	Millwright
47	Pipefitter
48	Technician
49	Welder
50	Yardsman
51	Buyer/Merchandise Coordinator
52	Stores Clerk/Stock Clerk
53	Dispatcher
54	Lift Truck Oper
55	Storeroom Oper
56	Warehouse Helper
57	OBT Trainer
58	Pathfinder Niagara Falls
New job codes since original study	
60	Automotive Technician
61	Hourly
62	Scaleman
63	Special assignment
64	Draftsman
65	Director
66	Operations coordinator
67	Baler
95	Unknown
96	Sales
97	Non-bargaining
98	Co-op employee
99	Squad/Akron Employees

APPENDIX E

WORK HISTORY EXPOSURE ASSIGNMENTS FOR JOB TITLES, DEPARTMENTS, AND YEARS

Table E.1 - Summary of assigned exposure ranks

	Assigned exposure ranks		
	1954-1960	**1961-1994**	**1995-2005**
Offsite	0	0	0
Front office jobs, includes secretary/stenos (except 245), data processors, draftsman, accounting, operator, director	1	1	0
Sales	1	1	0
Clerks, dispatchers, 245 Sec'y/steno	1	2	1
Guard (non PVC)	1	2	1
Medical Operations	1	2	1
145-PVC (except utility operator); Powerhouse operator, rubber cemicals (33)	1	2	1
Trainers, automotive	1	2	1
Hourly	1	2	1
Nurse, safety engineer	2	3	2
Maintenance - electrician	2	3	1
Maintenance - painter	2	3	2
Non-bargaining	2	3	1
Yard, janitor (nonPVC)	2	3	1
Shipping, warehouse, scaleman, lift truck op (nonPVC)	2	3	2
Chemist, lab supervisor	2	3	2
145-PVC Utility Operator	2	2/4	2
Engineer, Co-op	2	4	2
Lab tech, technician, QC	3	5	2
Chem Engr, R&D Engr (non PVC)	3	5	2
Helper	3	5	2
Co-op	3	5	2
Squadron/Akron	3	5	2
APO	4	8	2
Maintenance - Craftsman, welder, foreman, supervisor	4	8	2
Maintenance - E&I Mech, Mech, , millwright, pipefitter	4	8	3
245-Rubber - Chem Op, Prod Op, Utility Op, Foreman, Supervisor, Section head, Area manager (nonPVC)	5	10	3
Alternate Code			
PNE	1	1	0
PEI	1-2	2-4	1-2
PER	2-3	3-5	2
DER	4-5	5-10	2-3

Table E.2 - Subject work history (department/job/year) exposure assignments

NIOSH Dept code	Dept name*	Job code	Job name/years*	Original Code (Dept)†	Revised Original Code (Dept)	Alternate Revised Code (Dept, Job)‡	Assigned Exposure Rank (0-10)			Comments, assumptions, explanation/Outstanding issues
							1954-1960	1961-1994	1995-2005	No amines in use until 1954.
0	Error in entry	0	Leave of Absence	PNE	PNE	PNE	0	0	0	Not a job.
0	Error in entry	8	Manager - Chem Plant 62-68	PNE	PNE	DER	5	10	3	Assume Dept 245. Could have been assigned to PVC in those years.
0	Error in entry	11	Chemical Engineer 55; 64-92	PNE	PNE	PER	3	5	2	Assume Dept 245. Could have been assigned to PVC in those years.
0	Error in entry	14	Engineer 59-86	PNE	PNE	PER	2	4	2	Assume Dept 245. Could have been assigned to PVC in those years.
10	Personnel	2	Secretary/Steno 61-01	PNE	PNE	PNE	1	1	0	
10	Personnel	3	Clerk 52-54; 72-05	PNE	PNE	PNE	1	1	0	Assume worked in personnel department.
10	Personnel	4	Switchboard Oper 54-56	PNE	PNE	PNE	1	1	0	
10	Personnel	6	Guard 51-78	PNE	PNE	PEI	1	2	1	
10	Personnel	8	Manager 72-05	PNE	PNE	PNE	1	1	0	Assume manager of personnel staff.
10	Personnel	9	Nurse 80-83	PNE	PNE	PEI	2	3	2	Despite response to questions 5-07(48), workers could be wearing contaminated clothing. Did they ever go out into plant to respond to emergency health issue?
10	Personnel	16	Safety Engineer 63-68	PNE	PNE	PEI	2	3	2	Response to questions 5-07(51).
10	Personnel	36	Supervisor 71	PNE	PNE	PNE	1	1	0	Assume supervisor of personnel staff.
10	Personnel	63	Special assignment 83-96	PNE	PNE	PNE	1	1	0	This is unknown job title.
10	Personnel	95	Unknown 69-71; 85-03	PNE	PNE	PNE	1	1	0	This is unknown job title.
10	Personnel	97	Non-bargaining 83-84	PNE	PNE	PNE	1	1	0	This is unknown job title.
10	Personnel	98	Co-op employee 52-54; 68-69; 93	PNE	PNE	PER	1	4	2	
11	Maintenance	1	Accounting 68-69	PE	DE	PNE	1	1	0	Based on interviews, response to questions 5-07(18).

NIOSH Dept code	Dept name*	Job code	Job name/years*	Original Code (Dept)†	Revised Original Code (Dept)	Alternate Revised Code (Dept, Job)‡	Assigned Exposure Rank (0-10)			Comments, assumptions, explanation/Outstanding issues
							1954-1960	1961-1994	1995-2005	No amines in use until 1954.
11	Maintenance	2	Secretary/Steno 67-84	PE	DE	PNE	1	1	0	Based on interviews, response to questions 5-07(18).
11	Maintenance	8	Manager 72-05	PE	DE	DER	2	3	1	Based on response to questions 5-07(39), interviews.
11	Maintenance	11	Chemical Engineer 80-96	PE	DE	PER	3	5	2	
11	Maintenance	14	Engineer 57-05	PE	DE	PER	2	4	2	
11	Maintenance	16	E-R Coordinator 94-96	PE	DE	PER	2	3	2	Is ER Coordinator same as Safety Engineer?
11	Maintenance	18	Lab Supervisor 57-61	PE	DE	PEI	2	3	2	Response to questions 5-07(19,39).
11	Maintenance	19	Area Manager 94; 04	PE	DE	DER	2	3	1	Based on response to questions 5-07(39).
11	Maintenance	21	Trainee 57-59	PE	DE	DER	4	8	3	
11	Maintenance	34	Foreman 52-96	PE	DE	DER	4	8	2	
11	Maintenance	36	Supervisor 57-02	PE	DE	DER	4	8	2	Response to questions 5-07(39).
11	Maintenance	38	Electric-Instrument Mechanic 81-04	PE	DE	DER	4	8	3	Based on interviews and response to questions 5-07(10,38).
11	Maintenance	39	Mechanic 46-90	PE	DE	DER	4	8	3	
11	Maintenance	40	Inst & Refrig Mechanic 53-63	PE	DE	DER	4	8	3	
11	Maintenance	41	Instrument Mechanic 51-85	PE	DE	DER	4	8	3	
11	Maintenance	42	Craftman 55-96	PE	DE	DER	4	8	2	Based on interviews and response to questions 5-07(10,38).
11	Maintenance	43	Painter 52-01	PE	DE	PER	2	3	2	In 1994, painter took on insulator responsibilities.
11	Maintenance	44	Electrician 53-85	PE	DE	DER	2	3	1	
11	Maintenance	45	Powerhouse Oper 69-80	PE	DE	PNE	1	2	1	Based on interviews, and response to questions 5-07(20).
11	Maintenance	46	Millwright 53-05	PE	DE	DER	4	8	3	

NIOSH Dept code	Dept name*	Job code	Job name/years*	Original Code (Dept)†	Revised Original Code (Dept)	Alternate Revised Code (Dept, Job)‡	Assigned Exposure Rank (0-10)			Comments, assumptions, explanation/Outstanding issues
							1954-1960	1961-1994	1995-2005	No amines in use until 1954.
11	Maintenance	47	Pipefitter 46-51	PE	DE	DER	4	8	3	
11	Maintenance	49	Welder 55-93	PE	DE	DER	4	8	2	
11	Maintenance	64	Drafter 92-95	PE	DE	PEI	2	3	1	Assume worked with Maintenance, sometimes in shop and plant.
11	Maintenance	95	Unknown 59-00	PE	DE	DER	4	8	2	Unknown jobs.
11	Maintenance	98	Co-op 93	PE	DE	PER	2	4	2	Assume engineer. Based on response to questions 5-07(2,27).
14	PVC, Vinyl	2	Secretary/Steno 58-83	PNE	PNE	PNE	1	1	0	
14	PVC, Vinyl	7	Janitor 54-67	PNE	PNE	PNE	1	1	0	
14	PVC, Vinyl	8	Manager 94-95	PNE	PNE	PNE	1	2	1	
14	PVC, Vinyl	11	Chemical Engineer 80-96	PNE	PNE	PNE	1	2	1	
14	PVC, Vinyl	13	Research & Development Engineer 82	PNE	PNE	PNE	1	2	1	
14	PVC, Vinyl	14	Engineer 82-00	PNE	PNE	PNE	1	2	1	
14	PVC, Vinyl	16	Safety Engineer 68	PNE	PNE	PNE	1	2	1	Response to questions 5-07(51).Would Safety Engineer assigned to PVC go to all areas of plant?
14	PVC, Vinyl	19	Area Manager 71-02	PNE	PNE	PNE	1	2	1	Based on response to questions 5-07(39).
14	PVC, Vinyl	22	Chemical & Utility Operator (145) 73-03	PNE	PE	PEI	1	2 (1961-1979); 4 (1980-1994)	1	After 1980, o-toluidine processed in C-2.
14	PVC, Vinyl	26	Chemical Oper 46-02	PNE	PNE	PNE	1	2	1	
14	PVC, Vinyl	28	General Utility Oper (145) 79-88	PNE	PE	PEI	1	2 (1961-1979); 4 (1980-1994)	1	After 1980, o-toluidine processed in C-2.
14	PVC, Vinyl	31	Production Oper Atom/ Bagger (145) 86-99	PNE	PNE	PNE	1	2	1	

NIOSH Dept code	Dept name*	Job code	Job name/years*	Original Code (Dept)†	Revised Original Code (Dept)	Alternate Revised Code (Dept, Job)‡	Assigned Exposure Rank (0-10)			Comments, assumptions, explanation/Outstanding issues
							1954-1960	1961-1994	1995-2005	No amines in use until 1954.
14	PVC, Vinyl	32	Production Oper 56-03	PNE	PNE	PNE	1	2	1	
14	PVC, Vinyl	33	Production Oper -- Spray Dryer (145) 71-98	PNE	PNE	PNE	1	2	1	
14	PVC, Vinyl	34	Foreman 57-04	PNE	PNE	PNE	1	2	1	
14	PVC, Vinyl	36	Supervisor 48-96	PNE	PNE	PNE	1	2	1	
14	PVC, Vinyl	37	Section Head 82-93	PNE	PNE	PNE	1	2	1	Based on response to questions 5-07(39).
14	PVC, Vinyl	38	E&I Mechanic 87-90	PNE	PNE	PNE	1	2	1	
14	PVC, Vinyl	43	Painter 59-60; 90	PNE	PNE	PNE	1	2	1	
14	PVC, Vinyl	48	Technician 84	PNE	PNE	PNE	1	2	1	
14	PVC, Vinyl	49	Welder 50-84	PNE	PNE	PNE	1	2	1	
14	PVC, Vinyl	57	Trainer 84-88	PNE	PNE	PNE	1	2	1	
14	PVC, Vinyl	61	General Hourly 83-84	PNE	PNE	PNE	1	2	1	
14	PVC, Vinyl	66	Operations coordinator 93-96	PNE	PNE	PNE	1	2	1	
14	PVC, Vinyl	95	Unknown 66-92	PNE	PNE	PNE	1	2	1	
14	PVC, Vinyl	97	Non-bargaining 83-84	PNE	PNE	PNE	1	2	1	
14	PVC, Vinyl	98	Co-op employee 83-93	PNE	PNE	PNE	1	2	1	
16	Powerhouse	45	Powerhouse Oper 67-02	PNE	PNE	PNE	1	2	1	Based on interviews, response to questions 5-07(9).
16	Powerhouse	95	Unknown 76-87; 78-02	PNE	PNE	PNE	1	2	1	Assume operator.
18	Medical	6	Guard 46-57	PNE	PNE	PEI	1	2	1	

NIOSH Dept code	Dept name*	Job code	Job name/years*	Original Code (Dept)†	Revised Original Code (Dept)	Alternate Revised Code (Dept, Job)‡	Assigned Exposure Rank (0-10)			Comments, assumptions, explanation/Outstanding issues
							1954-1960	1961-1994	1995-2005	No amines in use until 1954.
18	Medical	8	Manager 80-05	PNE	PNE	PNE	1	1	0	
18	Medical	9	Nurse 70-96	PNE	PNE	PEI	2	3	2	Response to questions 5-07(44) - Workers could be wearing contaminated clothing. Did they ever go out into plant?
18	Medical	16	Safety Engineer 83-93	PNE	PNE	PEI	2	3	2	
18	Medical	19	Operations manager 92-96	PNE	PNE	PEI	1	1	0	Assume these people go into plant periodically.
18	Medical	95	Project Coordinator 00	PNE	PNE	PEI	1	1	0	Assume these people go into plant periodically.
19	Yard/Janitor	7	Janitor 50-90	PE	PE	PEI	2	3	1	
19	Yard/Janitor	26	Chemical Oper 59-60	PE	PE	DER	5	10	3	Assumes work as Chem Operator in 245. Could have been assigned to PVC in those years.
19	Yard/Janitor	36	Supervisor 77-82	PE	PE	PEI	5	10	3	Based on response to questions 5-07(39).
19	Yard/Janitor	50	Yardsman 51-88; 93	PE	PE	PEI	2	3	1	
19	Yard/Janitor	56	Warehouse Helper 50-93	PE	PE	PEI	2	3	1	
19	Yard/Janitor	95	Unknown 74-95	PE	PE	PEI	2	3	1	Unknown job.
21	Shipping, Packaging, & Warehouse	0	Leave of Absence 88	PE	PE	PNE	0	0	0	Not a job.
21	Shipping, Packaging, & Warehouse	1	Accounting 82-98	PE	PE	PNE	1	1	0	Assume a front office job.
21	Shipping, Packaging, & Warehouse	2	Secretary/Steno 47-88	PE	PE	PNE	1	1	0	Assume a front office job.
21	Shipping, Packaging, & Warehouse	3	Clerk 67-89	PE	PE	PEI	1	2	1	Based on response to questions 5-07(55).
21	Shipping, Packaging, & Warehouse	4	SWITCHBOARD OPERATOR 72-78	PE	PE	PNE	1	1	0	Assume a front office job.
21	Shipping, Packaging, & Warehouse	5	Personnel staff 73-77	PE	PE	PEI	1	1	0	
21	Shipping, Packaging, & Warehouse	8	Manager 60-04	PE	PE	PEI	2	3	2	Based on response to questions 5-07(39,57).
21	Shipping, Packaging, & Warehouse	9	Nurse 80-84	PE	PE	PEI	2	3	2	

NIOSH Dept code	Dept name*	Job code	Job name/years*	Original Code (Dept)†	Revised Original Code (Dept)	Alternate Revised Code (Dept, Job)‡	Assigned Exposure Rank (0-10)			Comments, assumptions, explanation/Outstanding issues
							1954-1960	1961-1994	1995-2005	No amines in use until 1954.
21	Shipping, Packaging, & Warehouse	10	Data Processing 74-93	PE	PE	PNE	1	1	0	Based on response to questions 5-07(55).
21	Shipping, Packaging, & Warehouse	11	Chemical Engineer 68-88	PE	PE	PER	3	5	2	
21	Shipping, Packaging, & Warehouse	13	Research & Development Engineer 72-79	PE	PE	PER	3	5	2	
21	Shipping, Packaging, & Warehouse	14	Engineer 72-01	PE	PE	PER	2	4	2	
21	Shipping, Packaging, & Warehouse	17	Lab Technician 72-04	PE	PE	PEI	3	5	2	Assume worked in lab.
21	Shipping, Packaging, & Warehouse	18	Lab Supervisor 72-80	PE	PE	PEI	2	3	2	Assume worked in lab.
21	Shipping, Packaging, & Warehouse	19	Area Manager 72-98	PE	PE	PEI	2	3	2	
21	Shipping, Packaging, & Warehouse	26	Chemical Oper XX	PE	PE	DER	5	10	3	Unknown years. Assume a chemical operator in 245.
21	Shipping, Packaging, & Warehouse	28	Utility Operator 78-93	PE	PE	PEI	5	10	3	Assume a GMMC utility operator.
21	Shipping, Packaging, & Warehouse	34	Foreman 51-02	PE	PE	PEI	2	3	2	
21	Shipping, Packaging, & Warehouse	36	Supervisor 72-01	PE	PE	PEI	2	3	2	
21	Shipping, Packaging, & Warehouse	37	Section Head 70-05	PE	PE	PEI	2	3	2	Based on response to questions 5-07(39).
21	Shipping, Packaging, & Warehouse	39	Mechanic 82-06	PE	PE	PER	4	8	3	Assume this job was in maintenance.
21	Shipping, Packaging, & Warehouse	49	Welder 84	PE	PE	PER	4	8	2	Assume this job was in maintenance.
21	Shipping, Packaging, & Warehouse	50	Yardsman 56	PE	PE	PEI	2	3	1	
21	Shipping, Packaging, & Warehouse	51	Buyer/Merchandise Coordinator 54-96	PE	PE	PEI	1	2	1	
21	Shipping, Packaging, & Warehouse	52	Stores Clerk/Stock Clerk 56-03	PE	PE	PEI	1	2	1	Based on response to questions 5-07(55-56). Is this really front office job?
21	Shipping, Packaging, & Warehouse	53	Dispatcher 46-91	PE	PE	PEI	1	2	1	

NIOSH Dept code	Dept name*	Job code	Job name/years*	Original Code (Dept)†	Revised Original Code (Dept)	Alternate Revised Code (Dept, Job)‡	Assigned Exposure Rank (0-10)			Comments, assumptions, explanation/Outstanding issues
							1954-1960	1961-1994	1995-2005	No amines in use until 1954.
21	Shipping, Packaging, & Warehouse	54	Lift Truck Oper 57-96	PE	PE	PEI	2	3	2	
21	Shipping, Packaging, & Warehouse	55	Storeroom Oper 65-96	PE	PE	PEI	2	3	2	
21	Shipping, Packaging, & Warehouse	56	Warehouse Helper 47-96	PE	PE	PEI	2	3	2	
21	Shipping, Packaging, & Warehouse	62	Scaleman 71-72	PE	PE	PEI	2	3	2	
21	Shipping, Packaging, & Warehouse	65	Director 75-80	PE	PE	PEI	1	2	1	
21	Shipping, Packaging, & Warehouse	95	Unknown 55-03	PE	PE	PEI	2	3	2	Unknown job.
23	Rubber Chemicals	2	Stenographer/Secretary 72-73	PNE	PNE	PNE	1	2	1	Based on response to questions 5-07(55-56).
23	Rubber Chemicals	32	Production Operator 72	PNE	PNE	PNE	1	2	1	
23	Rubber Chemicals	34	Foreman 72-73	PNE	PNE	PNE	1	2	1	
23	Rubber Chemicals	36	Supervisor 72-73	PNE	PNE	PNE	1	2	1	
23	Rubber Chemicals	95	69-74	PNE	PNE	PNE	1	2	1	
24	Rubber Chemicals-Antioxidant, Accelerant	2	Secretary/Steno 53-00	DE	DE	PEI	1	2	1	Based on response to questions 5-07(3).
24	Rubber Chemicals-Antioxidant, Accelerant	3	Clerk 86-91	DE	DE	PEI	1	2	1	Based on response to questions 5-07(55-56). Is this really front office job?
24	Rubber Chemicals-Antioxidant, Accelerant	9	Nurse 87-91	DE	DE	PEI	2	3	2	
24	Rubber Chemicals-Antioxidant, Accelerant	11	Chemical Engineer 68-04	DE	DE	PER	3	5	2	
24	Rubber Chemicals-Antioxidant, Accelerant	14	Engineer 88-99	DE	DE	PER	2	4	2	
24	Rubber Chemicals-Antioxidant, Accelerant	17	Lab Tech 72-74	DE	DE	PER	3	5	2	
24	Rubber Chemicals-Antioxidant, Accelerant	18	Lab Supervisor 54-66	DE	DE	PEI	2	3	2	Based on response to questions 5-07(7,39).
24	Rubber Chemicals-Antioxidant, Accelerant	19	Area Manager 82-02	DE	DE	DER	5	10	3	Based on response to questions 5-07(39).

NIOSH Dept code	Dept name*	Job code	Job name/years*	Original Code (Dept)†	Revised Original Code (Dept)	Alternate Revised Code (Dept, Job)‡	Assigned Exposure Rank (0-10)			Comments, assumptions, explanation/Outstanding issues
							1954-1960	1961-1994	1995-2005	No amines in use until 1954.
24	Rubber Chemicals-Antioxidant, Accelerant	20	Antioxidant Packaging Operator (245) 70-77	DE	DE	DER	5	10	3	
24	Rubber Chemicals-Antioxidant, Accelerant	22	Chemical & Utility Operator 80-06	DE	DE	DER	5	10	3	Based on interviews, response to questions 5-07(5,49).
24	Rubber Chemicals-Antioxidant, Accelerant	23	Chemical Oper -- Kagarax (245) 54-95	DE	DE	DER	5	10	3	Based on interviews, response to questions 5-07(5,49).
24	Rubber Chemicals-Antioxidant, Accelerant	24	Chemical Oper -- Steam Stripper(245) 58-62; 70-94	DE	DE	DER	5	10	3	
24	Rubber Chemicals-Antioxidant, Accelerant	25	General Utility Oper 86-91	DE	DE	DER	5	10	3	Based on interviews, response to questions 5-07(5,6,49).
24	Rubber Chemicals-Antioxidant, Accelerant	26	Chemical Oper 52-06	DE	DE	DER	5	10	3	
24	Rubber Chemicals-Antioxidant, Accelerant	27	Chemical Oper -- C-2 (245) 84-06	DE	DE	DER	5	10	3	Based on interviews, response to questions 5-07(5,6,49).
24	Rubber Chemicals-Antioxidant, Accelerant	30	Production Oper -- Kagarax Dryer (245) 77-78; 83-94	DE	DE	DER	5	10	3	
24	Rubber Chemicals-Antioxidant, Accelerant	32	Production Oper 67-06	DE	DE	DER	5	10	3	
24	Rubber Chemicals-Kagarax, Nailax	33	Production Oper -- Spray Dryer (145) 85-86	DE	DE	DER§	5	10	3	Should this job be assigned to Dept 145? PNE?
24	Rubber Chemicals-Kagarax, Nailax	34	Foreman 67-93	DE	DE	DER	5	10	3	
24	Rubber Chemicals-Kagarax, Nailax	35	Foreman Accelerator -- Kagarax (245) 53-62	DE	DE	DER	5	10	3	
24	Rubber Chemicals-Kagarax, Nailax	36	Supervisor 57-05	DE	DE	DER	5	10	3	Based on response to questions 5-07(39).
24	Rubber Chemicals-Kagarax, Nailax	37	Section head 82-95	DE	DE	DER	5	10	3	
24	Rubber Chemicals-Kagarax, Nailax	46	Millwright 84	DE	DE	DER	4	8	3	Assumed a maintenance job.
24	Rubber Chemicals-Kagarax, Nailax	55	Storeroom Oper 75	DE	DE	PEI	2	3	2	Assumed a Shipping, Packaging, and Warehouse job.

NIOSH Dept code	Dept name*	Job code	Job name/years*	Original Code (Dept)†	Revised Original Code (Dept)	Alternate Revised Code (Dept, Job)‡	Assigned Exposure Rank (0-10)			Comments, assumptions, explanation/Outstanding issues
							1954-1960	1961-1994	1995-2005	No amines in use until 1954.
24	Rubber Chemicals-Antioxidant, Accelerant	57	Development instructors, OBT Trainers 87, 92-05	DE	DE	PER	5	10	3	Still need to know what OBT means, what did OBT trainer do? Assume hands-on trainers.
24	Rubber Chemicals-Antioxidant, Accelerant	66	Operations Coordinator 93-06	DE	DE	DER	5	10	3	
24	Rubber Chemicals-Antioxidant, Accelerant	95	Production Specialist, Unknown 66-05	DE	DE	DER	5	10	3	Unknown job title
24	Rubber Chemicals-Antioxidant, Accelerant	98	Co-op employee 87-88; 90-95	DE	DE	PER	2	4	2	Based on response to questions 5-07(2). Assume an engineer in training.
40	Quality Control	3	Clerk 96	PNE	DE	PNE	1	1	0	Assume a front-office job.
40	Quality Control	8	Manager 71-01	PNE	DE	PER	2	3	2	Based on response to questions 5-07(52).
40	Quality Control	11	Chemical Engineer 86-90	PNE	DE	PER	3	5	2	
40	Quality Control	12	Chemist 87-89	PNE	DE	PER	2	3	2	
40	Quality Control	14	Engineer 90	PNE	DE	PER	2	4	2	
40	Quality Control	15	Quality Control 72-00	PNE	DE	PER	2	3	2	
40	Quality Control	17	Lab Technician 65-79	PNE	DE	PER	3	5	2	Based on response to questions 5-07(2,11,12).
40	Quality Control	95	GT & R 71-72	PNE	DE	PER§	3	5	2	Unknown job.
40	Quality Control	98	SUMMER HELP 95	PNE	DE	PER	3	5	2	Assume a lab tech or co-op.
46	Laboratory	1	Accounting 92-98	PNE	DE	PNE	1	1	0	
46	Laboratory	2	Secretary/Steno 56-05	PNE	DE	PNE	1	1	0	
46	Laboratory	8	Manager 72-01	PNE	DE	PER	2	3	2	
46	Laboratory	11	Chemical Engineer 50-57; 63-98	PNE	DE	PER	3	5	2	Based on response to questions 5-07(11,17).
46	Laboratory	12	Chemist 57-95	PNE	DE	PER	2	3	2	Based on response to questions 5-07(2,11,12).

NIOSH Dept code	Dept name*	Job code	Job name/years*	Original Code (Dept)†	Revised Original Code (Dept)	Alternate Revised Code (Dept, Job)‡	Assigned Exposure Rank (0-10)			Comments, assumptions, explanation/Outstanding issues
							1954-1960	1961-1994	1995-2005	No amines in use until 1954.
46	Laboratory	13	Research & Development Engineer 79-82	PNE	DE	PER	3	5	2	Based on response to questions 5-07(11,17).
46	Laboratory	14	Engineer 54-02	PNE	DE	PER	2	4	2	
46	Laboratory	16	Safety Engineer 93-05	PNE	DE	PEI	2	3	2	
46	Laboratory	17	Lab Technician 46-02	PNE	DE	PER	3	5	2	Based on response to questions 5-07(2,12).
46	Laboratory	36	Supervisor 84-95	PNE	DE	PER	2	3	2	Based on response to questions 5-07(39).
46	Laboratory	37	Section Head 57-71; 72-04	PNE	DE	PER	2	3	2	Based on response to questions 5-07(17,39).
46	Laboratory	48	Technician 98-01	PNE	DE	PER	3	5	2	
46	Laboratory	51	PSM Coordinator 94-99	PNE	DE	PEI	2	3	2	Unknown job.
46	Laboratory	64	Draftsman 53-55; 95-01	PNE	DE	PNE	2	3	2	Assume office job.
46	Laboratory	95	76-87; 88-03	PNE	DE	PER	2	3	2	
46	Laboratory	98	Co-op employee 73-83; 92-93	PNE	DE	PER	2	4	2	Based on response to questions 5-07(2,27).
46	Laboratory	99	Squad/Akron Employees 79-80	PNE	DE	PER	2	3	2	Based on response to questions 5-07(17).
48	Lab - Research & Development	8	Manager 82-94	PNE	DE	PER	2	3	2	Based on response to questions 5-07(11,39).
48	Lab - Research & Development	12	Chemist 62-72	PNE	DE	PER	2	3	2	Based on response to questions 5-07(2,11,12).
48	Lab - Research & Development	13	Research & Development Engineer 60-87	PNE	DE	PER	3	5	2	Based on response to questions 5-07(11,17).
48	Lab - Research & Development	14	Engineer 69-90	PNE	DE	PER	2	4	2	Based on response to questions 5-07(11,17).
48	Lab - Research & Development	15	Quality Control 74-76	PNE	DE	PER	2	3	2	
48	Lab - Research & Development	17	Lab Technician 66-98	PNE	DE	PER	3	5	2	Based on response to questions 5-07(2,11,12).

NIOSH Dept code	Dept name*	Job code	Job name/years*	Original Code (Dept)†	Revised Original Code (Dept)	Alternate Revised Code (Dept, Job)‡	Assigned Exposure Rank (0-10)			Comments, assumptions, explanation/Outstanding issues
							1954-1960	1961-1994	1995-2005	No amines in use until 1954.
48	Lab - Research & Development	37	Section Head 68-82	PNE	DE	PER	2	3	2	Based on response to questions 5-07(11,17,39).
48	Lab - Research & Development	48	Technician 64-65	PNE	DE	PER	3	5	2	Based on response to questions 5-07(2,11,12).
48	Lab - Research & Development	95	GT & R 62-68	PNE	DE	PER§	2	3	2	Unknown job.
48	Lab - Research & Development	98	Co-op employee 75	PNE	DE	PER	2	4	2	Based on response to questions 5-07(2,27).
64	Accounting	1	Accounting 52-91	PNE	PNE	PNE	1	1	0	
64	Accounting	2	Secretary/Steno 50-06	PNE	PNE	PNE	1	1	0	
64	Accounting	3	Clerk 64-88	PNE	PNE	PNE	1	1	0	
64	Accounting	4	Switchboard Oper 76-82	PNE	PNE	PNE	1	1	0	
64	Accounting	7	Janitor 93-05	PNE	PNE	PEI	1	1	0	Unknown whether this janitor stays in office areas.
64	Accounting	8	Manager 72-99	PNE	PNE	PNE	1	1	0	Based on response to questions 5-07(39).
64	Accounting	10	Data Processing 75-99	PNE	PNE	PNE	1	1	0	
64	Accounting	22	GMMC Utility 83-05	PNE	PNE	PEI	2	3	2	This is warehouse job.
64	Accounting	50	Yardman 93-96	PNE	PNE	PEI	2	3	1	
64	Accounting	98	Co-op employee 78-85	PNE	PNE	PER§	2	4	2	Based on response to questions 5-07(2,27). Still question if this co-op could have been doing accounting?
69	NONE ASSIGNED§	2	Secretary/Steno 70-72	PNE	PE	PNE	1	1	0	
69	NONE ASSIGNED§	8	Development Manager 78-00	PNE	PE	PER§	5	10	3	Based on response to questions 5-07(39). Are these trainers? Are they out in plant?
69	NONE ASSIGNED§	20	Antioxidant Packaging Operator (245) 71-75	PNE	PE	DER	5	10	3	Assume 245
69	NONE ASSIGNED§	22	General Utility Operator 78-92	PNE	PE	DER	5	10	3	Assumes work in 245. Could have been assigned to PVC in those years.

NIOSH Dept code	Dept name*	Job code	Job name/years*	Original Code (Dept)†	Revised Original Code (Dept)	Alternate Revised Code (Dept, Job)‡	Assigned Exposure Rank (0-10)			Comments, assumptions, explanation/Outstanding issues
							1954-1960	1961-1994	1995-2005	No amines in use until 1954.
69	NONE ASSIGNED§	26	Chemical Oper 69-73	PNE	PE	DER	5	10	3	Assumes work in 245. Could have been assigned to PVC in those years.
69	NONE ASSIGNED§	32	Production Oper 86	PNE	PE	DER	5	10	3	Assumes work in 245. Could have been assigned to PVC in those years.
69	NONE ASSIGNED§	36	Supervisor 54-92	PNE	PE	DER	5	10	3	Assumes work in 245. Could have been assigned to PVC in those years.
69	NONE ASSIGNED§	61	Hourly 52-54	PNE	PE	DER	2	4	2	Assumes work in 245. Could have been assigned to PVC in those years.
69	NONE ASSIGNED§	95	52-04	PNE	PE	DER	5	10	3	Assumes work in 245. Could have been assigned to PVC in those years.
90	OFF SITE		Various	PNE	PNE	PNE	0	0	0	
95	UNKNOWN		LOCATIONS TBD	PNE§	PNE§	PNE§	0	0	0	Waiting for company/union review of the unknown departments spreadsheet list.
98	Temp. Assignment from Akron	2	Secretary/Steno 72-76	PNE	PE	PNE	1	1	0	
98	Temp. Assignment from Akron	11	Chemical Engineer 71-75	PNE	PE	PER	3	5	2	Assumes work in 245. Could have been assigned to PVC in those years.
98	Temp. Assignment from Akron	14	Engineer 72-86	PNE	PE	PER	2	4	2	Based on response to questions 5-07(17,25). Could have worked in PVC 145.
98	Temp. Assignment from Akron	15	Quality Control 62-65	PNE	PE	PER	1	3	2	Based on response to questions 5-07(52).
98	Temp. Assignment from Akron	19	Area Manager 87-91	PNE	PE	DER	5	10	3	Assumes work in 245. Could have been assigned to PVC.
98	Temp. Assignment from Akron	32	Production trainee 62-64	PNE	PE	DER	2	4	2	Assumes co-op work in 245. Could have been assigned to PVC.
98	Temp. Assignment from Akron	61	Hourly 55-72	PNE	PE	DER	2	4	2	Assumes co-op work in 245. Could have been assigned to PVC.
98	Temp. Assignment from Akron	95	G T AND R 62	PNE	PE	DER	2	4	2	Assumes co-op work in 245. Could have been assigned to PVC.
98	Temp. Assignment from Akron	98	Co-op employee 78-80	PNE	PE	PER	2	4	2	Assumes co-op work in 245. Could have been assigned to PVC.
98	Temp. Assignment from Akron	99	Squad/Akron Employees 61-94	PNE	PE	DER	2	4	2	Assumes co-op work in 245. Could have been assigned to PVC.
99	Sales, Akron Employee	1	Accounting 45-59	PNE	PNE	PNE	1	1	0	
99	Sales, Akron Employee	2	Secretary/Steno 72-88	PNE	PNE	PNE	1	1	0	Based on response to questions 5-7(26, 44).
99	Sales, Akron Employee	3	Clerk 57-67	PNE	PNE	PNE	1	1	0	Based on response to questions 5-7(26, 44).

NIOSH Dept code	Dept name*	Job code	Job name/years*	Original Code (Dept)†	Revised Original Code (Dept)	Alternate Revised Code (Dept, Job)‡	Assigned Exposure Rank (0-10)			Comments, assumptions, explanation/Outstanding issues
							1954-1960	1961-1994	1995-2005	No amines in use until 1954.
99	Sales, Akron Employee	4	Switchboard Oper 61-72	PNE	PNE	PNE	1	1	0	
99	Sales, Akron Employee	5	Personnel staff (non-manager) 87-88	PNE	PNE	PNE	1	1	0	Based on response to questions 5-7(26, 44).
99	Sales, Akron Employee	6	Guard 46-60	PNE	PNE	PNE	1	1	0	Based on response to questions 5-7(26, 44).
99	Sales, Akron Employee	7	Janitor 52-63	PNE	PNE	PNE	1	2	1	Based on response to questions 5-7(26,44). Would this janitor go elsewhere?
99	Sales, Akron Employee	8	Manager 46-88	PNE	PNE	PNE	1	2	1	
99	Sales, Akron Employee	10	Data Processing 79-82	PNE	PNE	PNE	1	1	0	Based on response to questions 5-7(26, 44).
99	Sales, Akron Employee	11	Chemical Engineer 47-75	PNE	PNE	PNE	1	2	1	Assume for PVC.
99	Sales, Akron Employee	12	Chemist 66-82	PNE	PNE	PEI§	2	3	2	Dept. Based on response to questions 5-7(26,44). Would this chemist have worked in same lab as the other techs?
99	Sales, Akron Employee	13	Research & Development Engineer 76-77	PNE	PNE	PNE	1	2	1	Based on response to questions 5-7(44).Assume for PVC.
99	Sales, Akron Employee	14	Engineer 55-71	PNE	PNE	PNE	1	2	1	Based on response to questions 5-7(44).Assume for PVC.
99	Sales, Akron Employee	15	Quality Control 65	PNE	PNE	PER§	2	3	2	Based on response to questions 5-7(26, 44).
99	Sales, Akron Employee	17	Lab Technician 77-82	PNE	PNE	PER§	3	5	2	Based on response to questions 5-7(26, 44).
99	Sales, Akron Employee	26	Chemical Oper 49-61	PNE	PNE	PNE	1	2	1	Assume PVC.
99	Sales, Akron Employee	34	Foreman 65-77	PNE	PNE	PNE	1	2	1	Based on response to questions 5-7(26, 44).
99	Sales, Akron Employee	36	Supervisor 52-67	PNE	PNE	PNE	1	2	1	
99	Sales, Akron Employee	37	Section Head 62-65	PNE	PNE	PNE	1	2	1	Based on response to questions 5-7(26, 44).
99	Sales, Akron Employee	39	Mechanic 46-55	PNE	PNE	PNE§	1	2	1	Did they work in a separate maintenance area?
99	Sales, Akron Employee	42	Craftman 55-56	PNE	PNE	PNE§	1	2	1	Based on response to questions 5-7(26, 44).

NIOSH Dept code	Dept name*	Job code	Job name/years*	Original Code (Dept)†	Revised Original Code (Dept)	Alternate Revised Code (Dept, Job)‡	Assigned Exposure Rank (0-10)			Comments, assumptions, explanation/Outstanding issues
							1954-1960	1961-1994	1995-2005	No amines in use until 1954.
99	Sales, Akron Employee	47	Pipefitter 45-46	PNE	PNE	PNE§	1	2	1	
99	Sales, Akron Employee	48	Technician 58-82	PNE	PNE	PNE§	1	2	1	Based on response to questions 5-7(26, 44).
99	Sales, Akron Employee	50	Yardsman 53-63	PNE	PNE	PNE	1	2	1	
99	Sales, Akron Employee	51	Buyer/Merchandise Coordinator 49-51; 65-83	PNE	PNE	PNE	1	1	0	
99	Sales, Akron Employee	58	Pathfinder Niagara Falls XX	PNE	PNE	PNE	1	2	1	Based on response to questions 5-7(26,44). Unknown job/date. Pathfinder original Company plant name.
99	Sales, Akron Employee	95	Unknown 53-87	PNE	PNE	PNE	1	2	1	
99	Sales, Akron Employee	96	Sales 74-81	PNE	PNE	PNE	1	2	1	Based on response to questions 5-7(26, 44).
99	Sales, Akron Employee	98	Co-op employee 75-83	PNE	PNE	PER	1	2	1	Based on response to questions 5-7(26, 44).
99	Sales, Akron Employee	99	Squad/Akron Employees 49-75	PNE	PNE	PNE	1	2	1	
99	Sales, Akron Employee	26	Chemical Oper 49-61	PNE	PNE	PNE	1	2	1	
99	Sales, Akron Employee	34	Foreman 65-77	PNE	PNE	PNE	1	2	1	Based on response to questions 5-7(26, 44).
99	Sales, Akron Employee	36	Supervisor 52-67	PNE	PNE	PNE	1	2	1	Based on response to questions 5-7(26, 44).
99	Sales, Akron Employee	37	Section Head 62-65	PNE	PNE	PNE	1	2	1	Based on response to questions 5-7(26, 44).
99	Sales, Akron Employee	39	Mechanic 46-55	PNE	PNE	PNE	1	2	1	
99	Sales, Akron Employee	42	Craftman 55-56	PNE	PNE	PNE	1	2	1	Based on response to questions 5-7(26, 44).
99	Sales, Akron Employee	47	Pipefitter 45-46	PNE	PNE	PNE	1	2	1	
99	Sales, Akron Employee	48	Technician 58-82	PNE	PNE	PNE	1	5	2	Based on response to questions 5-7(26, 44).
99	Sales, Akron Employee	50	Yardsman 53-63	PNE	PNE	PEI	1	2	1	Based on response to questions 5-7(26, 44).
99	Sales, Akron Employee	51	Buyer/Merchandise Coordinator 49-51; 65-83	PNE	PNE	PNE	1	1	0	Based on response to questions 5-7(26, 44).

NIOSH Dept code	Dept name*	Job code	Job name/years*	Original Code (Dept)†	Revised Original Code (Dept)	Alternate Revised Code (Dept, Job)‡	Assigned Exposure Rank (0-10)			Comments, assumptions, explanation/Outstanding issues
							1954-1960	1961-1994	1995-2005	No amines in use until 1954.
99	Sales, Akron Employee	58	Pathfinder Niagara Falls XX	PNE	PNE	PNE	1	2	1	Based on response to questions 5-7(26,44). Unknown job. Pathfinder original GY plant name.
99	Sales, Akron Employee	95	Unknown 53-87	PNE	PNE	PNE	1	2	1	Based on response to questions 5-7(26, 44).
99	Sales, Akron Employee	96	Sales 74-81	PNE	PNE	PNE	1	1	0	Based on response to questions 5-7(26, 44).
99	Sales, Akron Employee	98	Co-op employee 75-83	PNE	PNE	PNE	1	2	1	Based on response to questions 5-7(26, 44).
99	Sales, Akron Employee	99	Squad/Akron Employees 49-75	PNE	PNE	PNE	1	2	1	Based on response to questions 5-7(26, 44).
11§	Maintenance	95	137-XXXX 79-80	PE§	DE§	DER§	1	8	2	Unknown jobs.
14§	PVC, Vinyl		Various 87-92	PNE§	PNE§	PNE§	1	2	1	
19§	Yard/Janitor	57	Hourly trainer 80-94	PE§	PE§	PEI§	2	3	1	
21§	Shipping, Packaging, & Warehouse	3	Clerk 86-89	PE§	PE§	PEI§	1	2	1	
24§	Rubber Chemicals-Kagarax, Nailax	57	OBT Trainer 92	DE§	DE§	PER§	5	10	3	Still need to know what OBT means, what did OBT trainer do?

*From Qry_EDMS_GNF_WorkHistory.xls 11/27/06 plus 8/07/07

†Original, Revised Codes (Dept): DE = Definitely Exposed; PE = Possibly Exposed; PNE = Probably Not Exposed.

‡Alternate Revised Codes (Dept, Job): PNE – probably not exposed; PEI – probably exposed low and irregularly/occasionally; PER – probably exposed low and regularly; DER – definitely exposed moderate/high and regularly

§Company assigned department codes are unknown and thus exposure assignments are suspect. Best guesses have been made.

APPENDIX F

SELECTED AIR SAMPLING DATA CHARTS

Tables F.1 - All analytes

Table F.1a - Geometric mean p-TWA[i] (ppm) for each analyte for Company Department 245 by year 1976- 1994

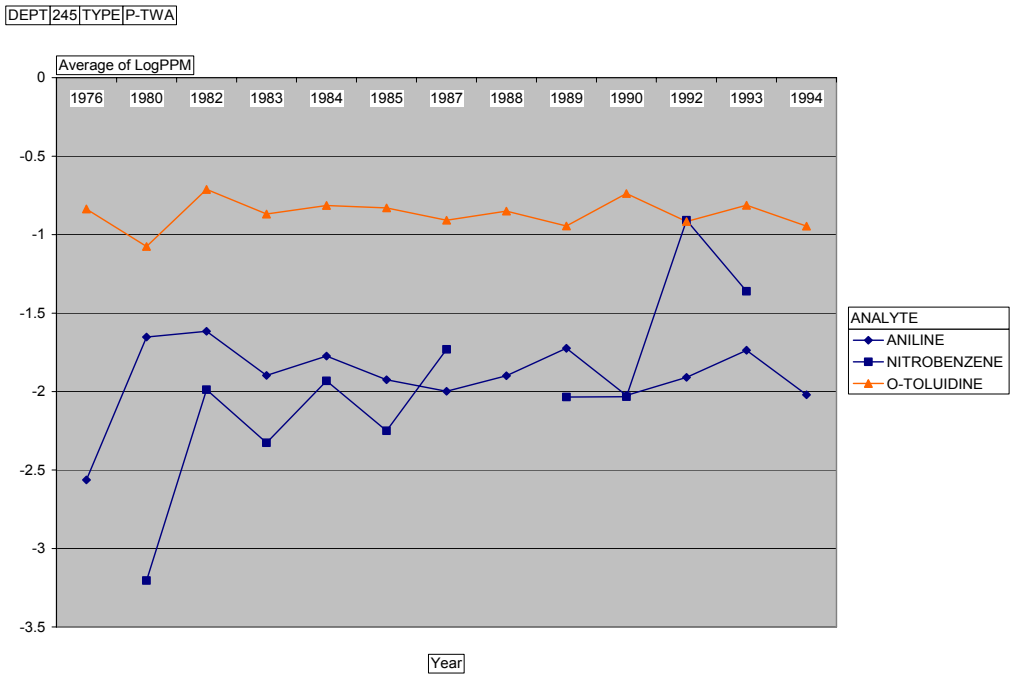


Table F.1b - Geometric mean p-TWA (ppm) for each analyte for Company Department 255 by year 1995- 2005

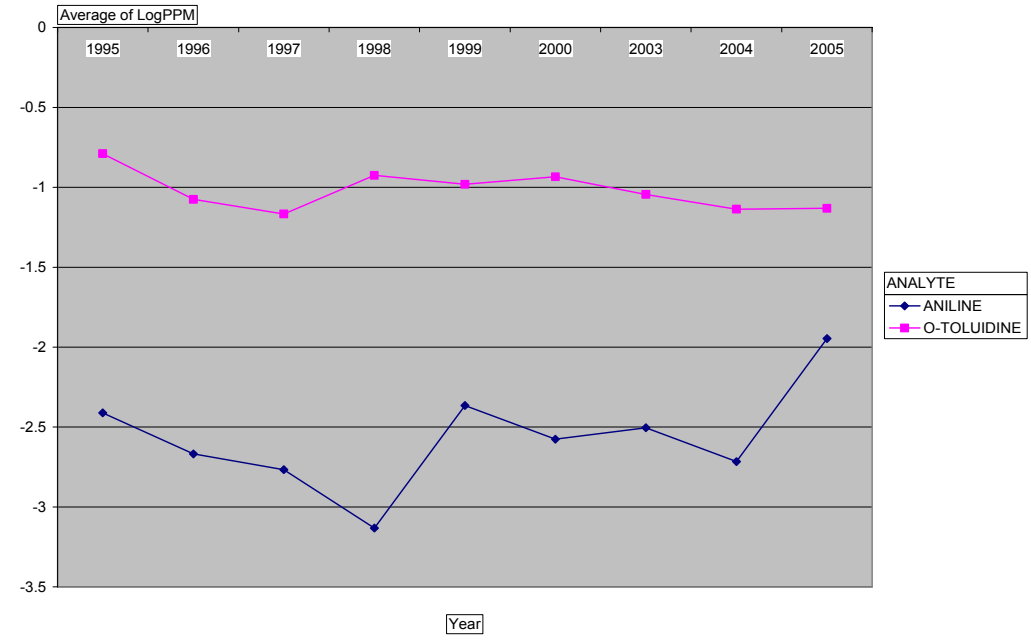


Table F.1c - Geometric mean p-TWA (ppm) for each analyte for Company Department 145 by year 1990- 1994

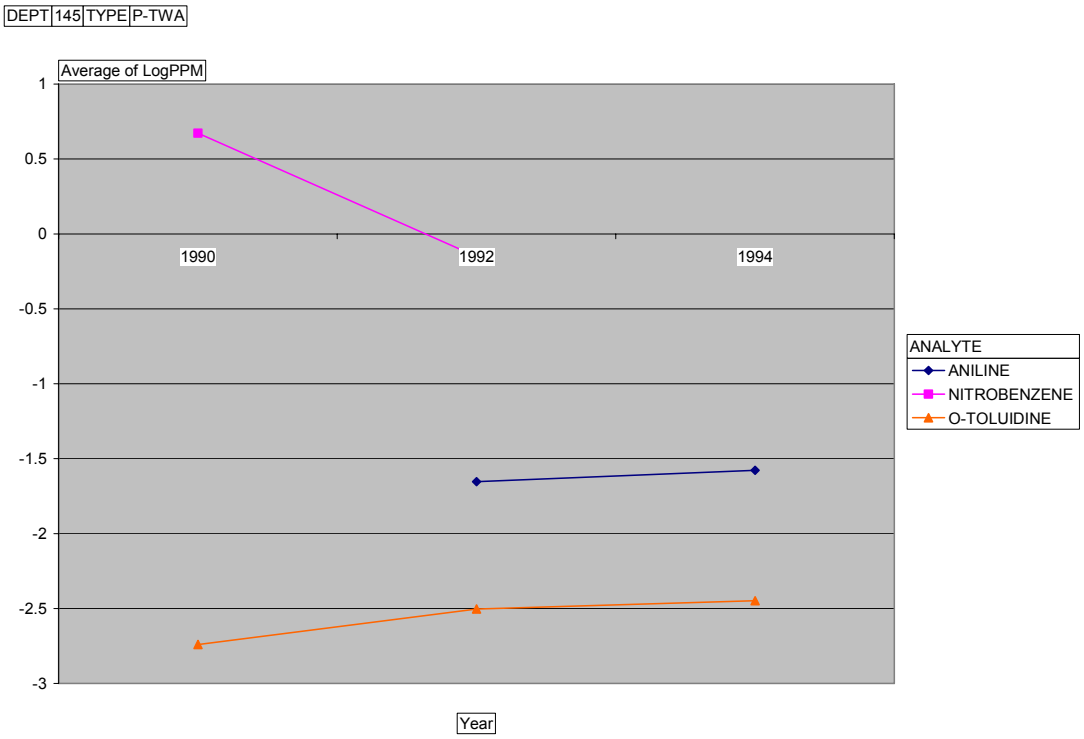


Table F.1d - Geometric mean p-TWA (ppm) for each analyte for Company Department 111 by year 1984- 2005

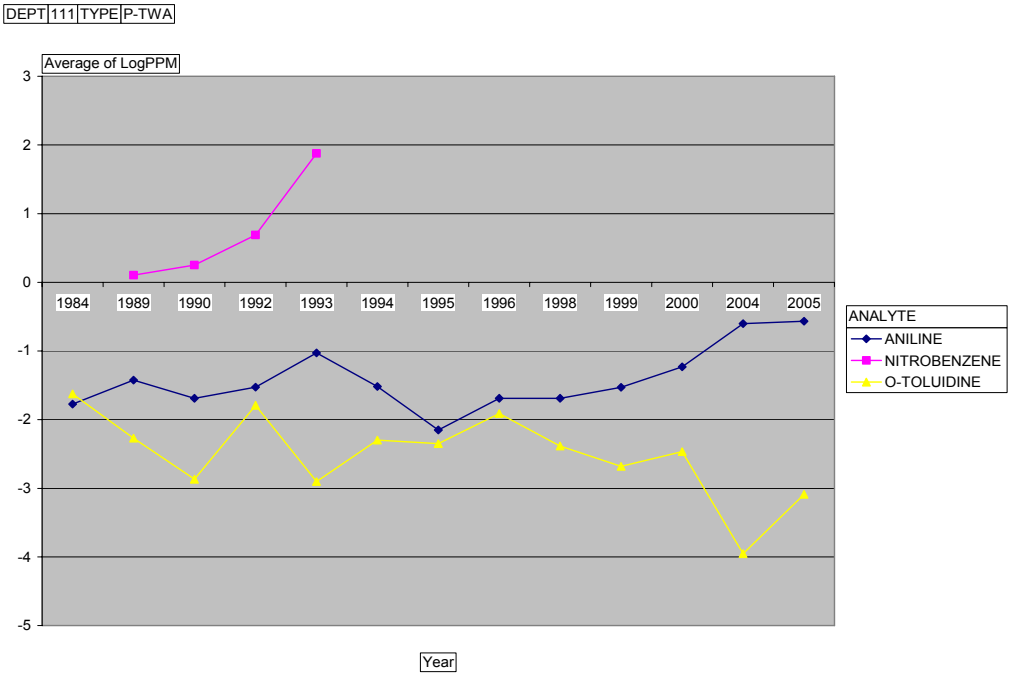


Table F.1e - Geometric mean a-TWA (PPM) for each analyte for Company Department 245 by year 1975- 1994

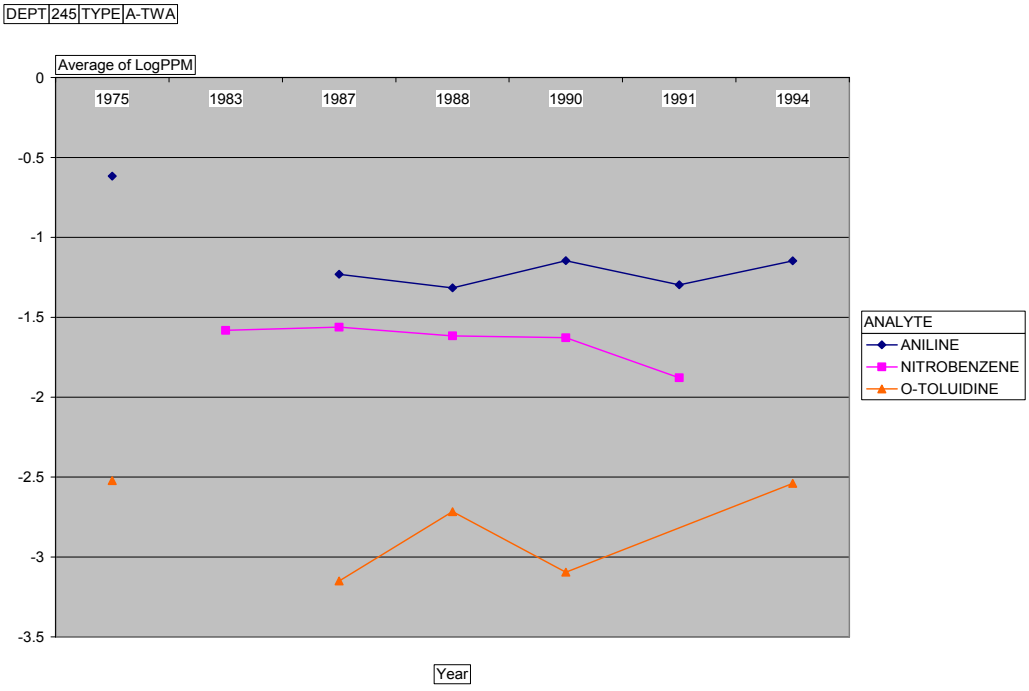


Table F.1f - Geometric mean a-TWA (ppm) for each analyte for Company Department 255 by year 1994- 2005

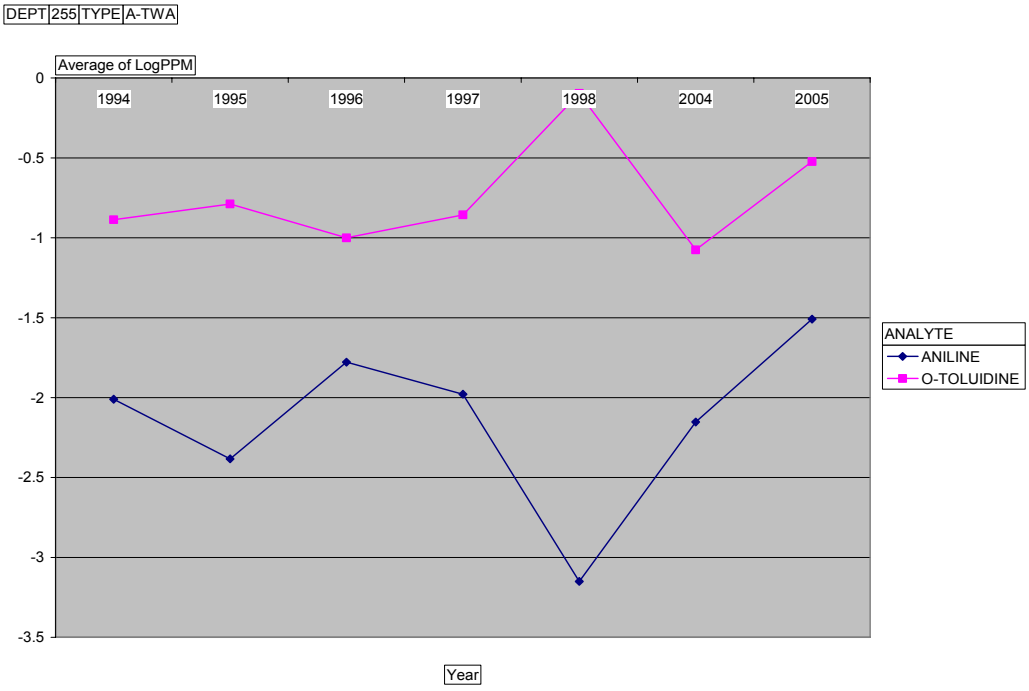


Table F.1g - Geometric mean a-TWA (ppm) for each analyte for Company Department 145 by year 1991- 1994

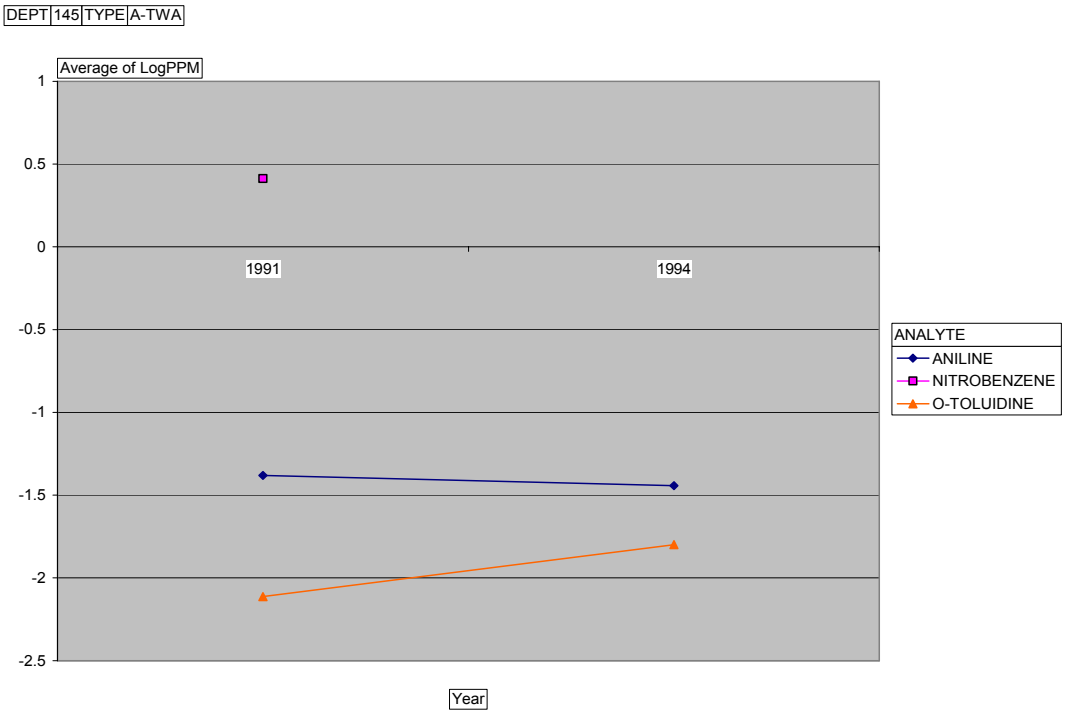
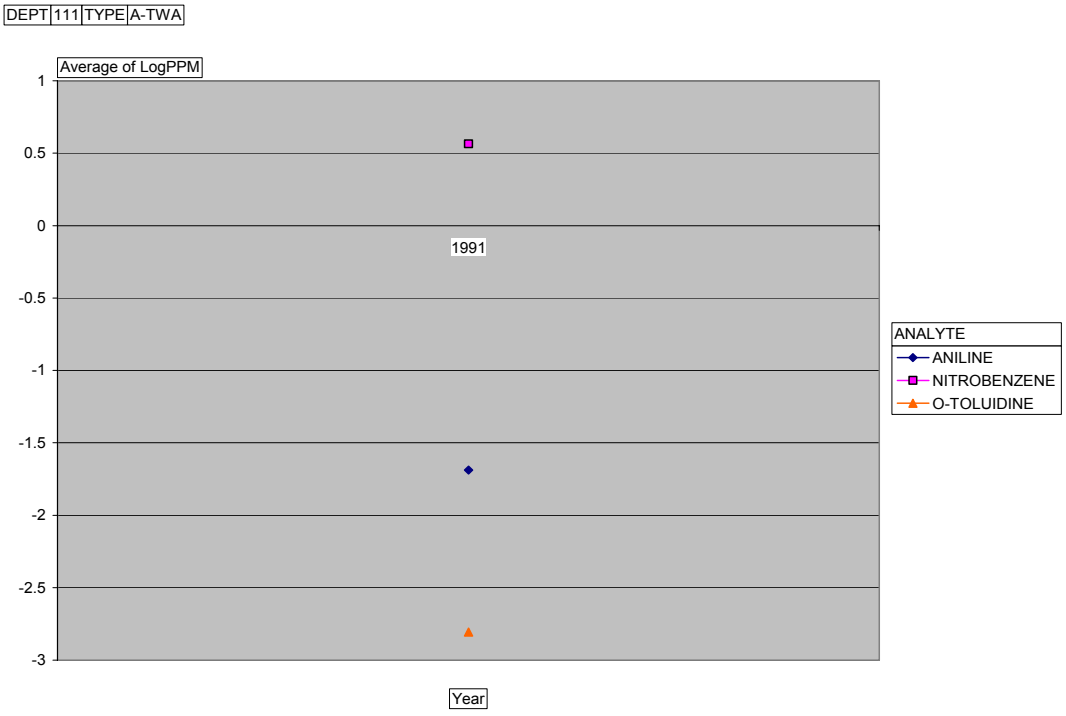


Table F.1h - Geometric mean a-TWA (PPM) for each analyte for Company Department 111 by year 1991



Tables F.2 - Aniline

Table F.2a - Geometric mean p-TWA (ppm) aniline by Company Department by year 1976-2005

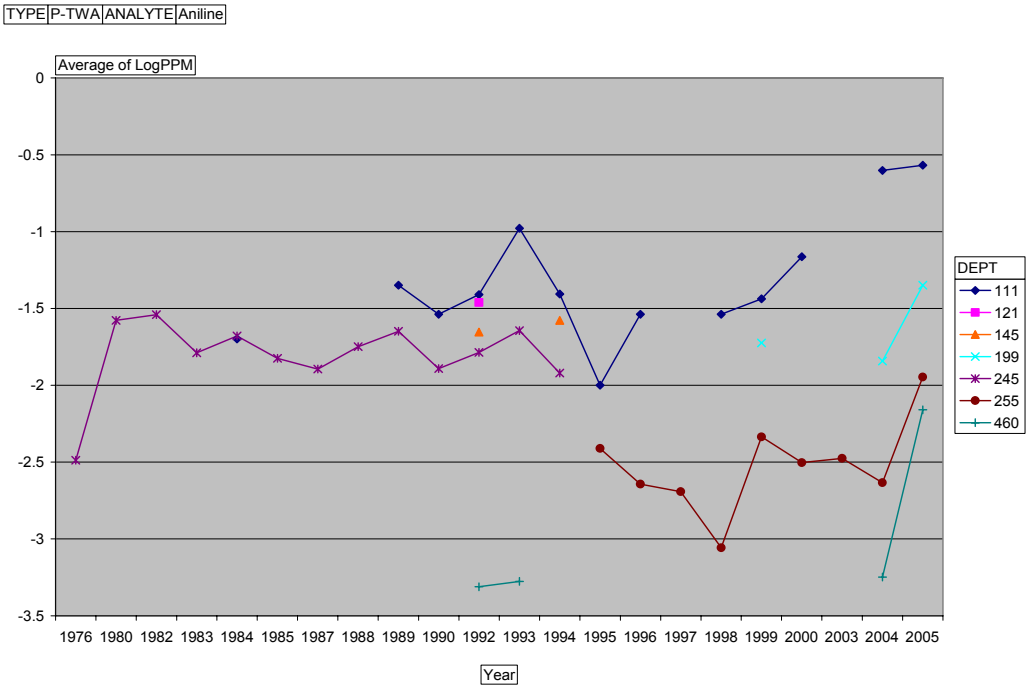


Table F.2b - Geometric mean a-TWA (ppm) aniline by Company Department by year 1975-2005

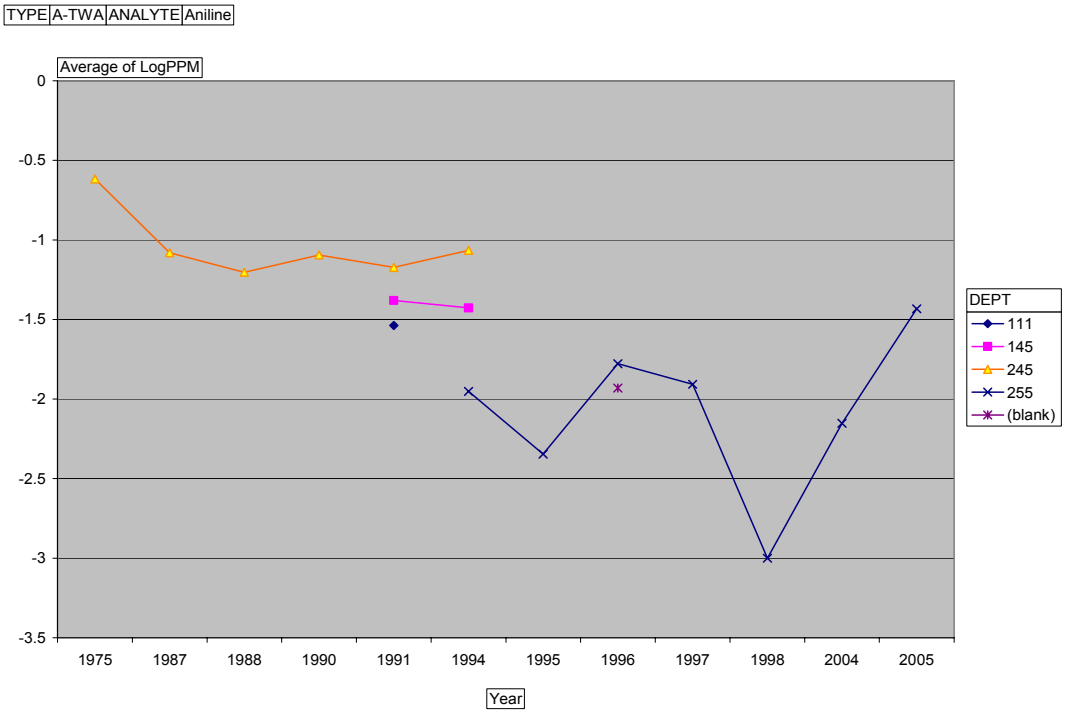


Table F.2c - Geometric mean p-TWA (ppm) aniline for Company Department 245 by year 1976-1994

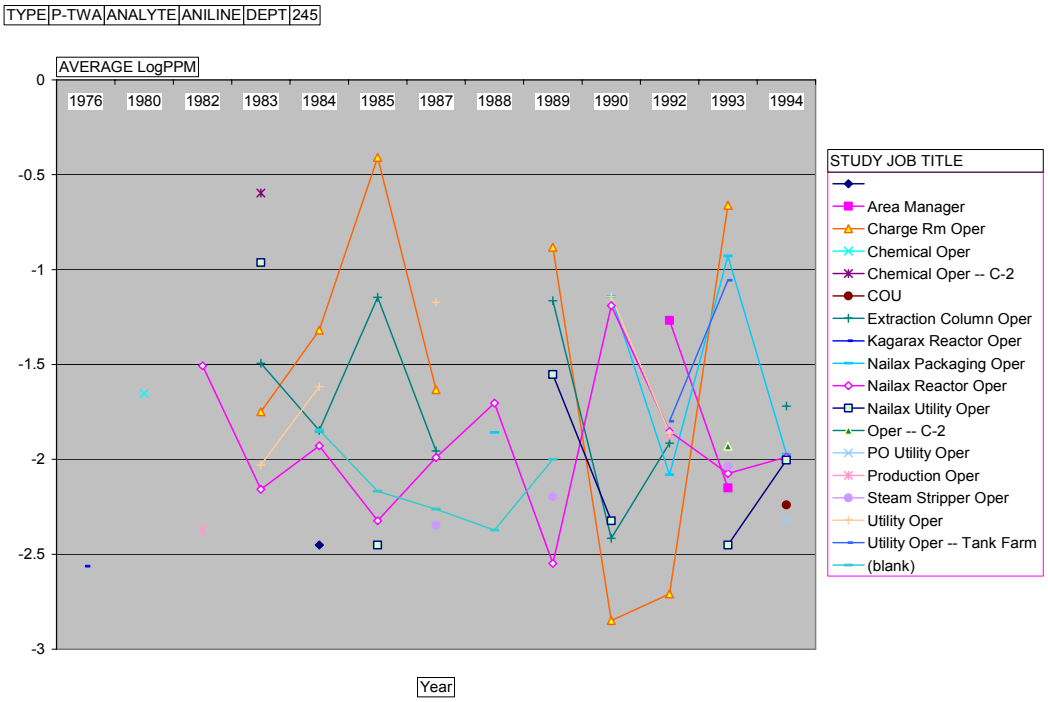


Table F.2d - Geometric mean p-TWA (ppm) aniline for Company Department 255 by year 1995-2005

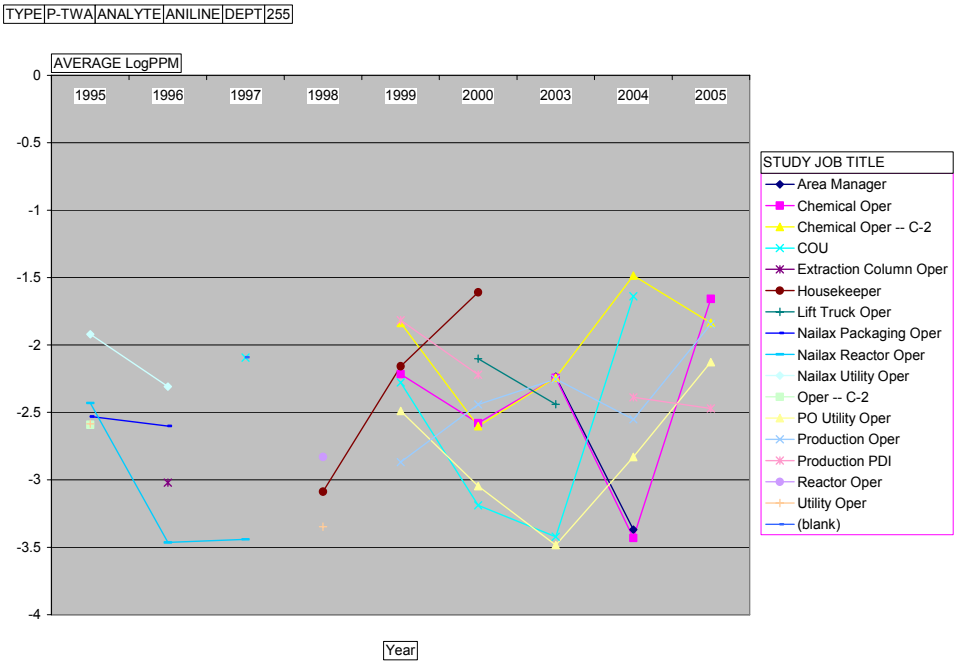


Table F.2e - Geometric mean p-TWA (ppm) aniline for Company Department 145 by job by year 1992-1994

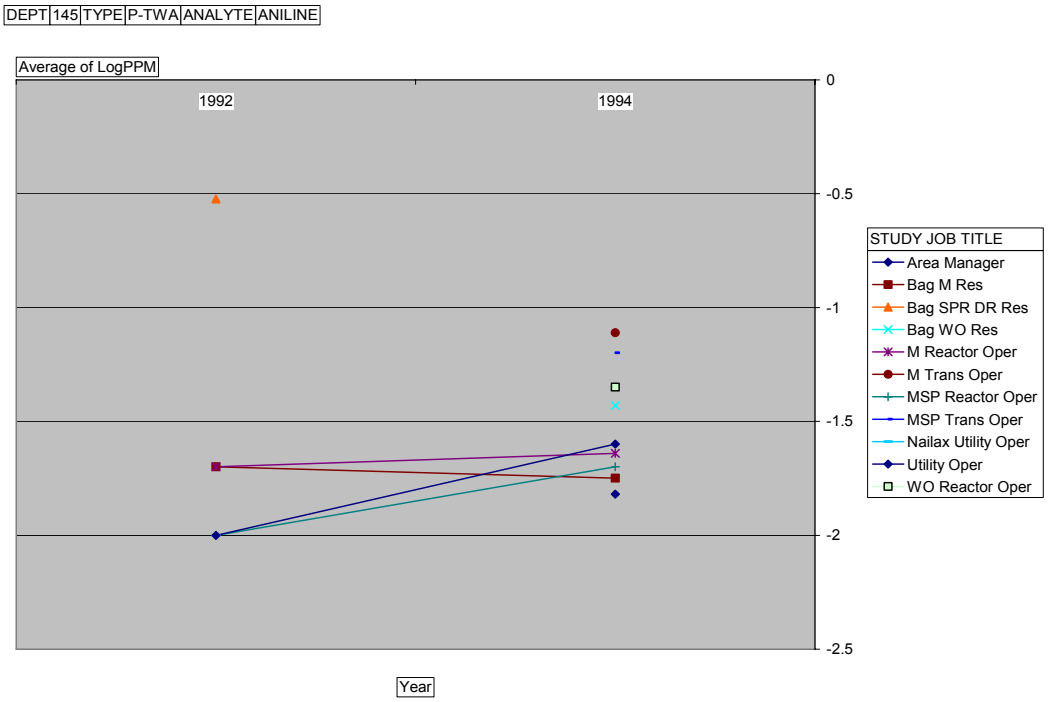
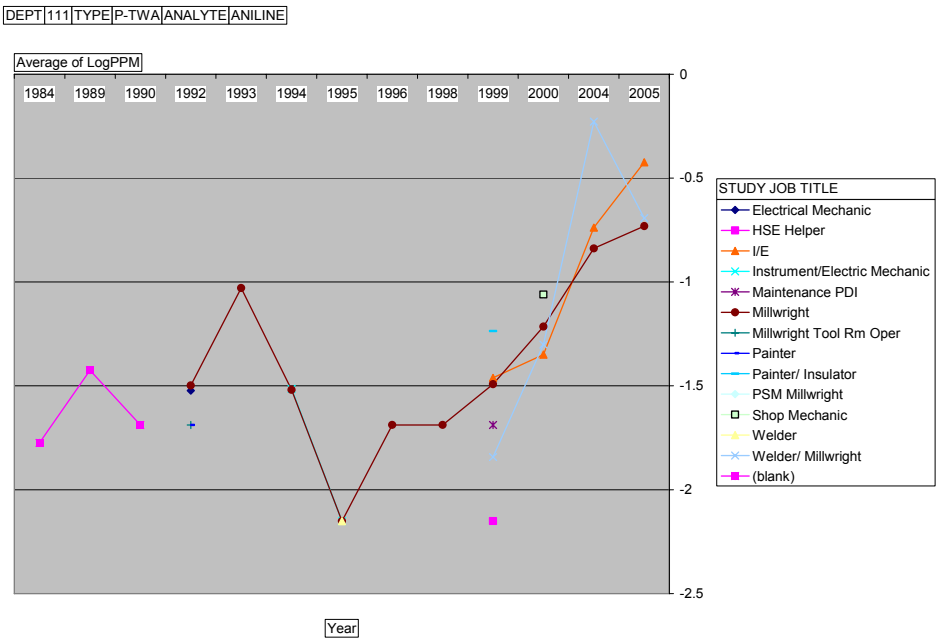


Table F.2f - Geometric mean p-TWA (ppm) aniline for Company Department 111 by job by year 1984-2005



Tables F.3. *o*-Toluidine

Table F.3a - Geometric mean p-TWA (ppm) *o*-toluidine by Company Department by year 1976- 2005

TYPE P-TWA ANALYTE O-TOLUIDINE

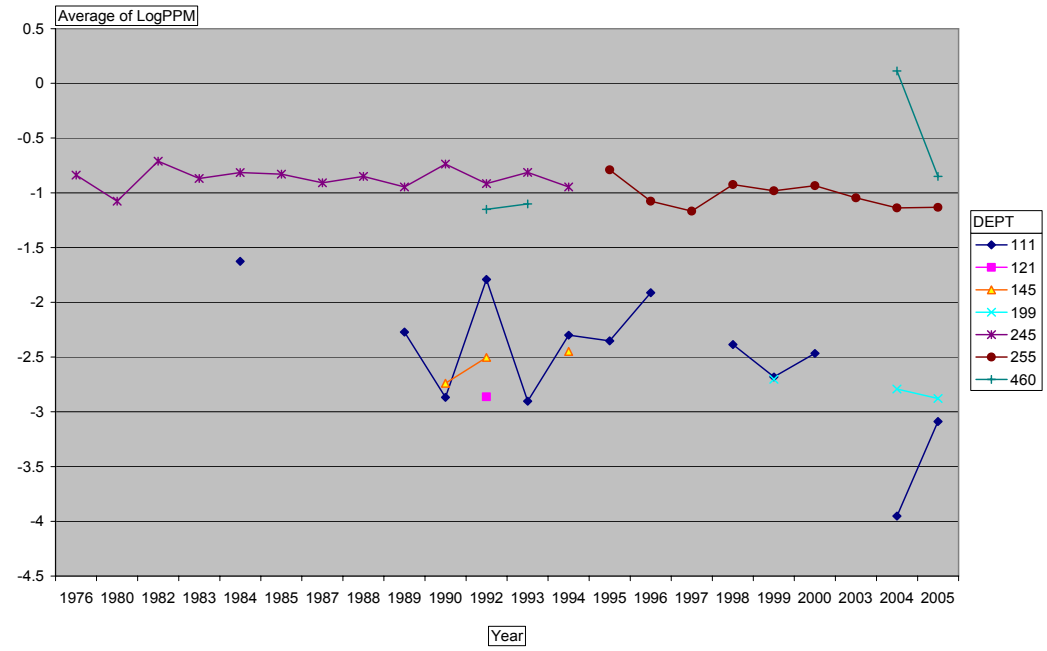


Table F.3b - Geometric mean a-TWA (ppm) *o*-toluidine by Company Department by year 1975- 2005

TYPE A-TWA ANALYTE O-TOLUIDINE

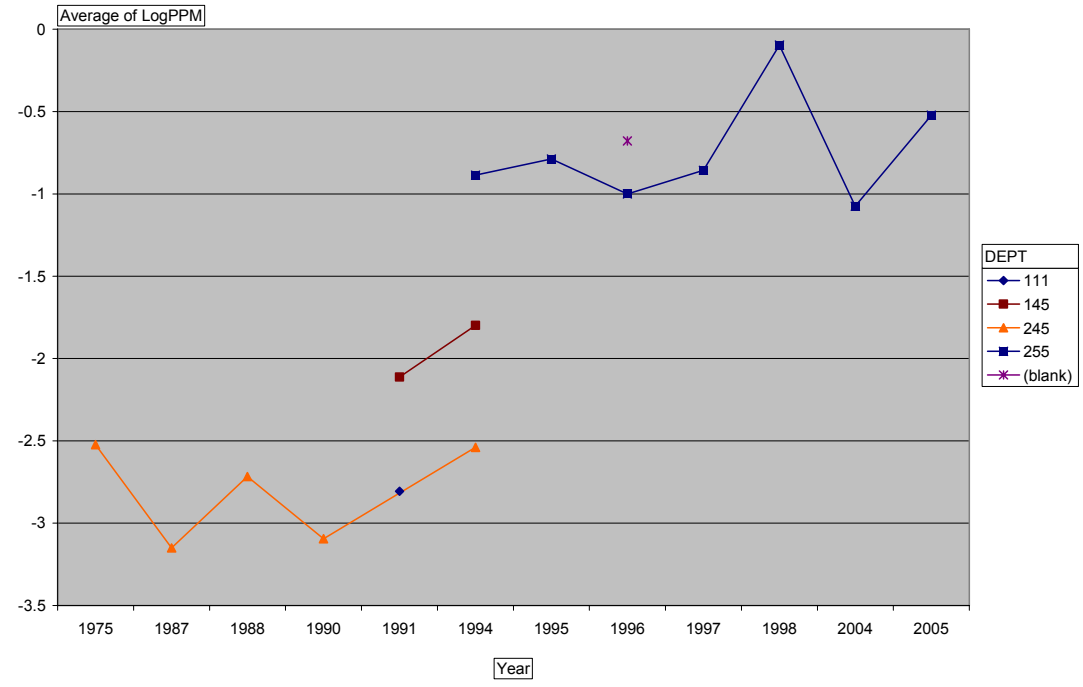


Table F.3c - Geometric mean p-TWA (ppm) *o*-toluidine for Company Department 255 by year 1976-1994

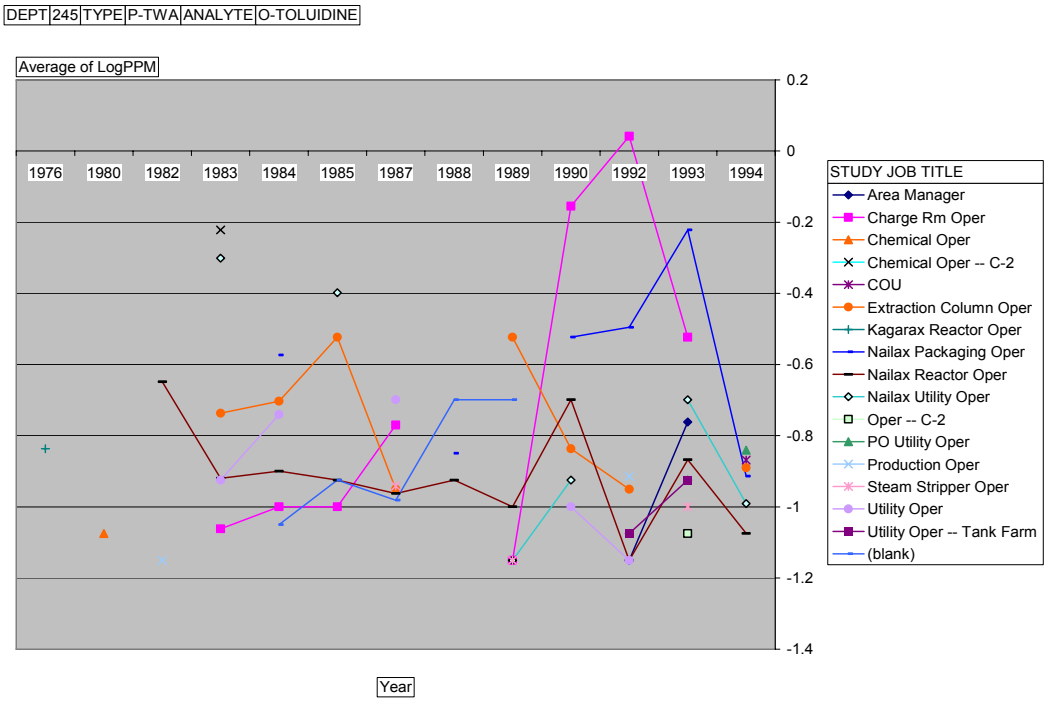


Table F.3d - Geometric mean p-TWA (ppm) *o*-toluidine for Company Department 255 by year 1995-2005

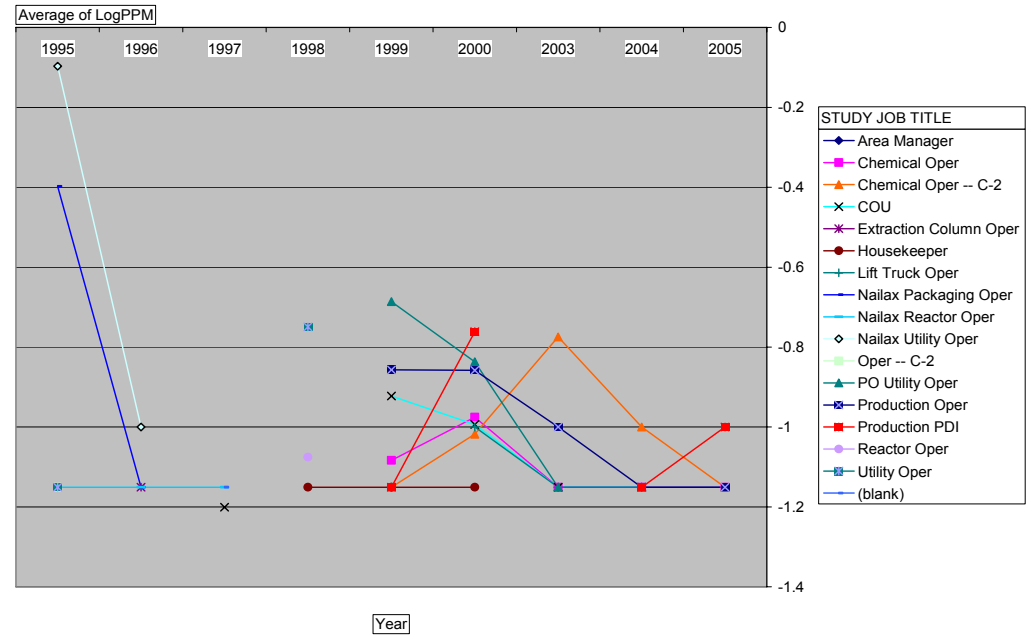


Table F.3e - Geometric mean p-TWA (ppm) *o*-toluidine for Company Department 145 by job by year 1990-1994

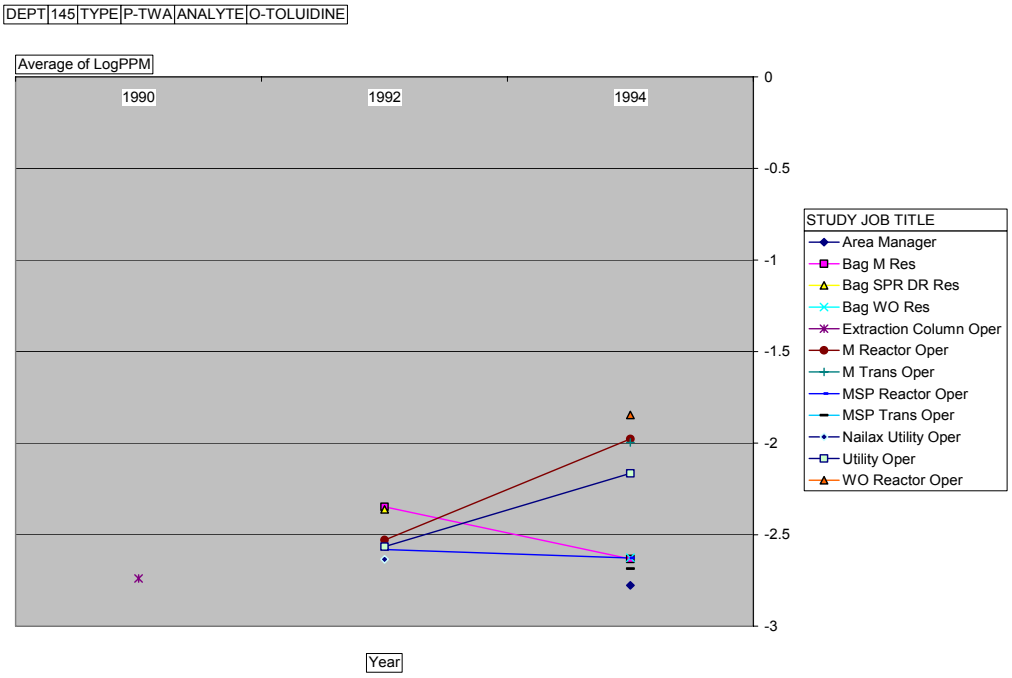
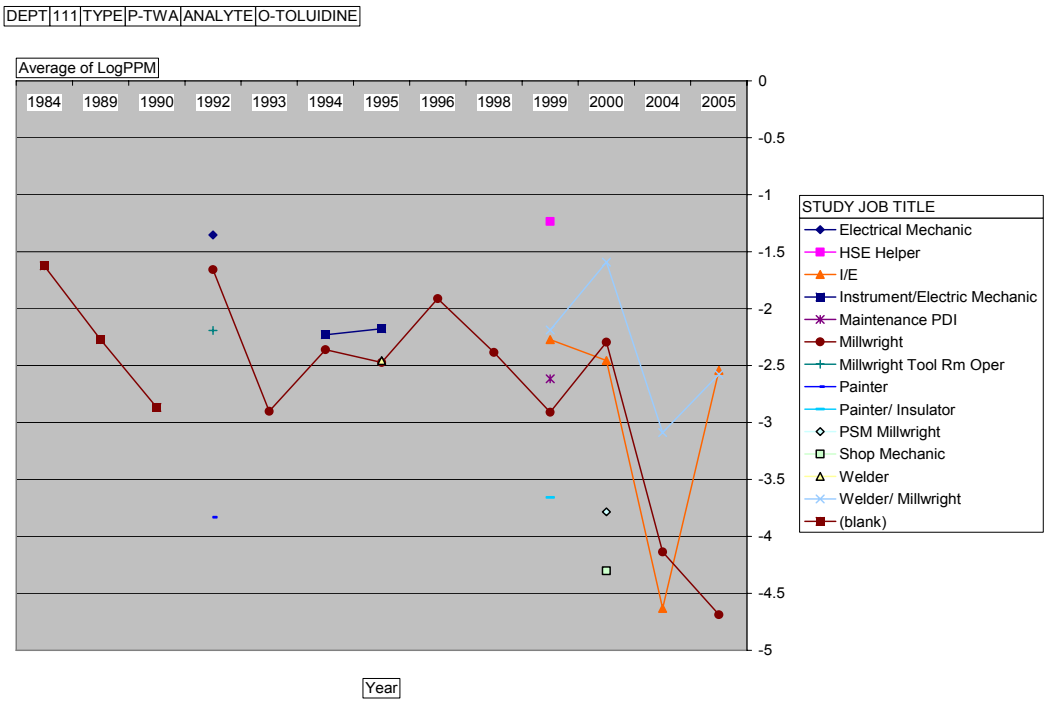


Table F.3f - Geometric mean p-TWA (ppm) *o*-toluidine for Company Department 111 by job by year 1984-2005



Tables F.4 - Nitrobenzene

Table F.4a - Geometric mean p-TWA (ppm) nitrobenzene by Company Department by year 1980-1993

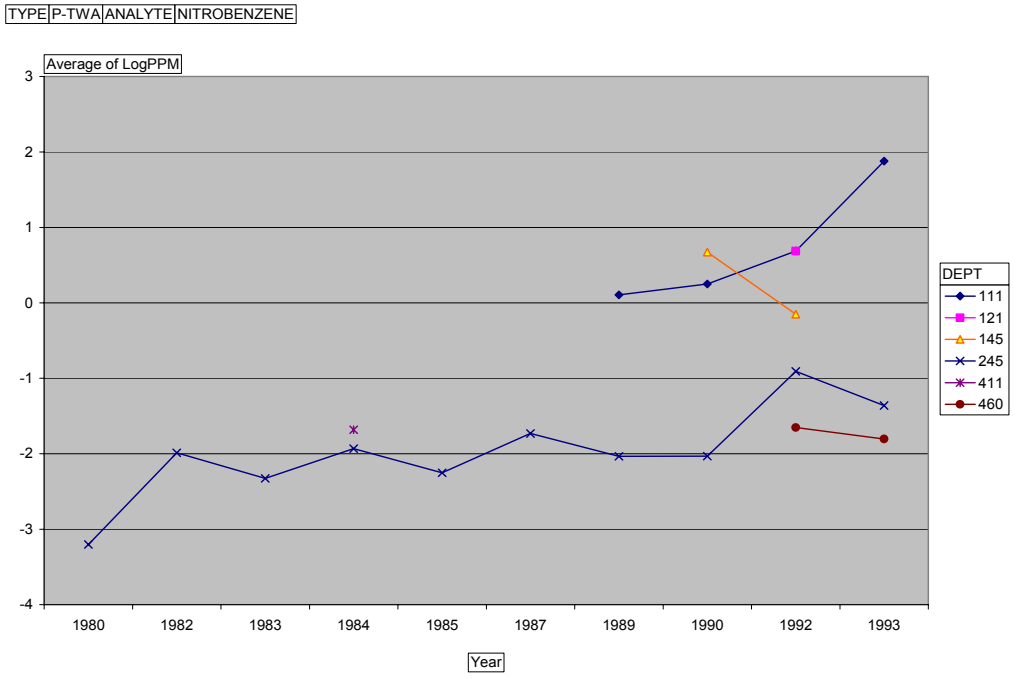


Table F.4b. Geometric mean a-TWA (ppm) nitrobenzene by Company Department by year 1983- 1991

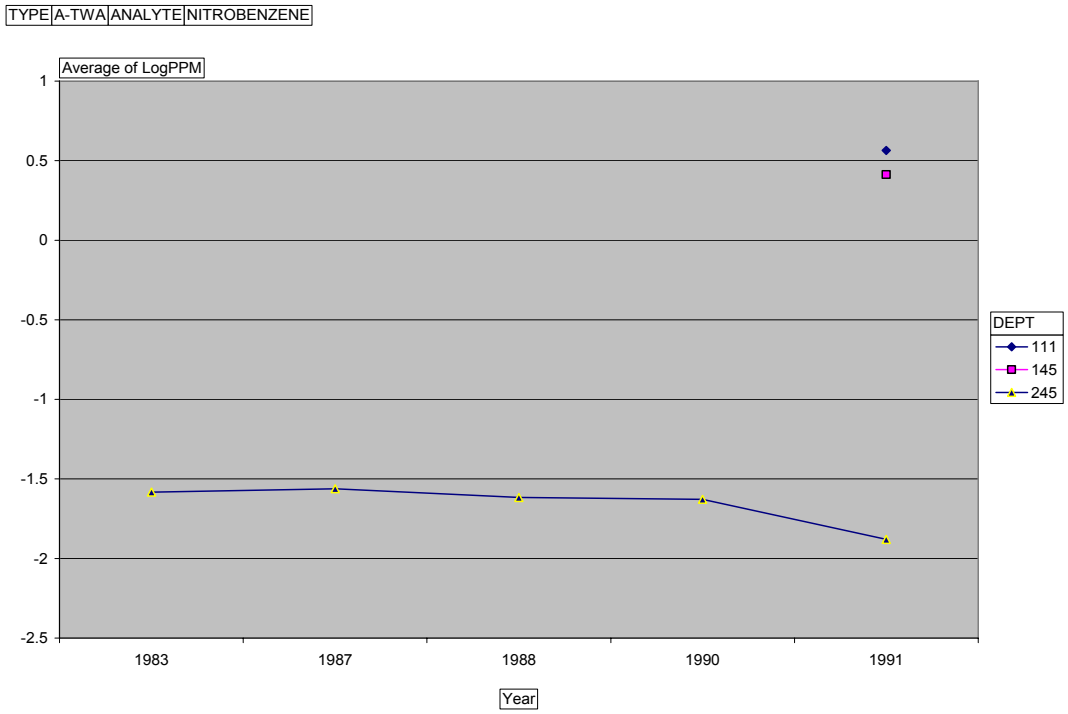


Table F.4c - Geometric mean p-TWA (ppm) nitrobenzene for Company Department 245-255 by year 1980-1993

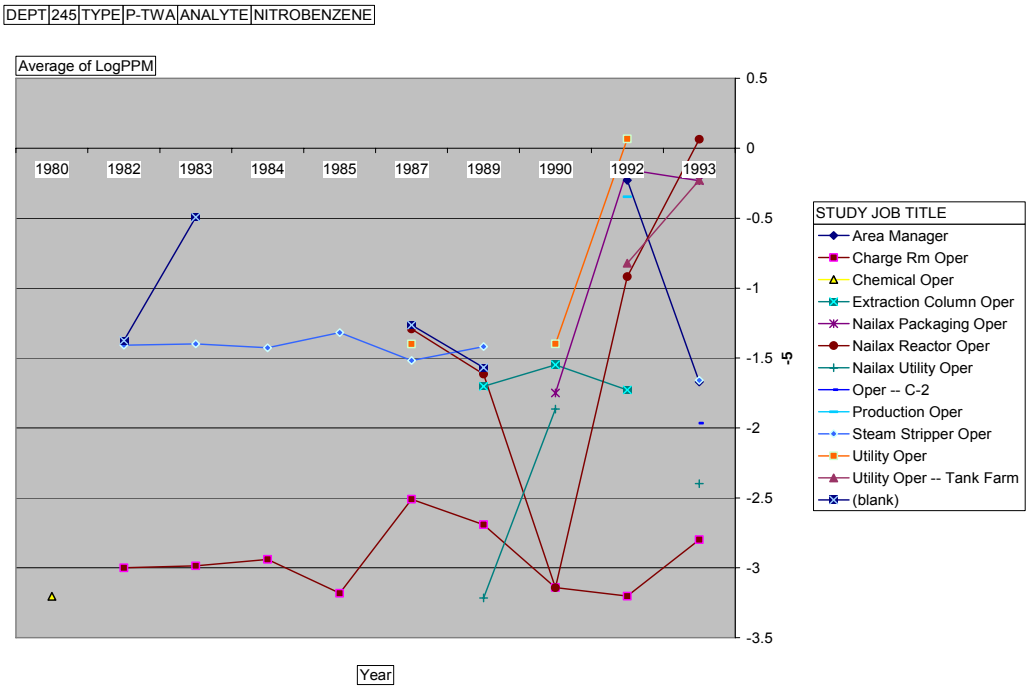


Table F.4d - Geometric mean p-TWA (ppm) nitrobenzene for Company Department 145 by job by year 1990-1992

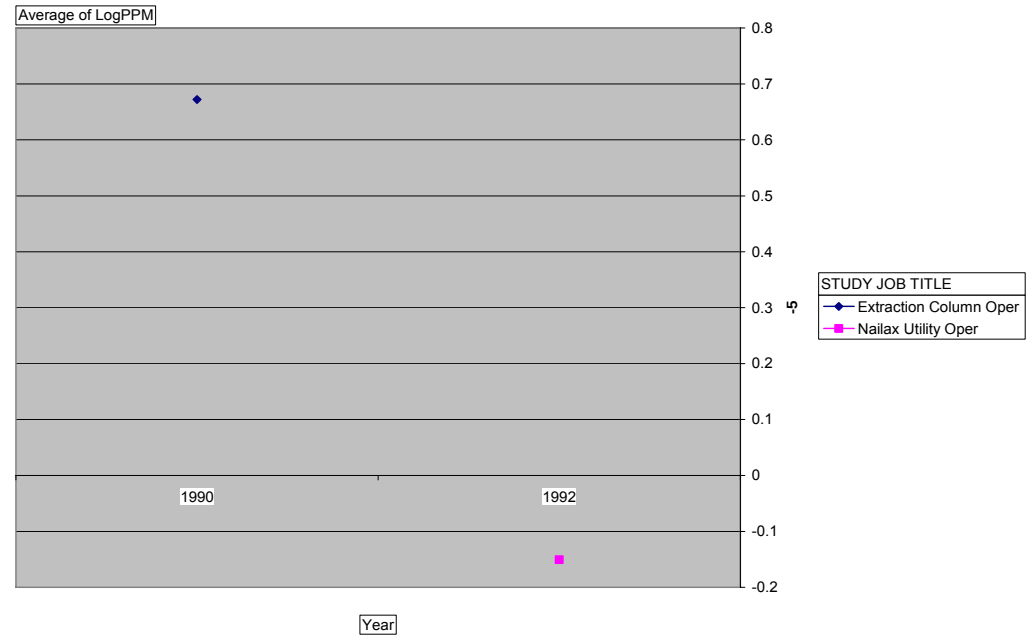
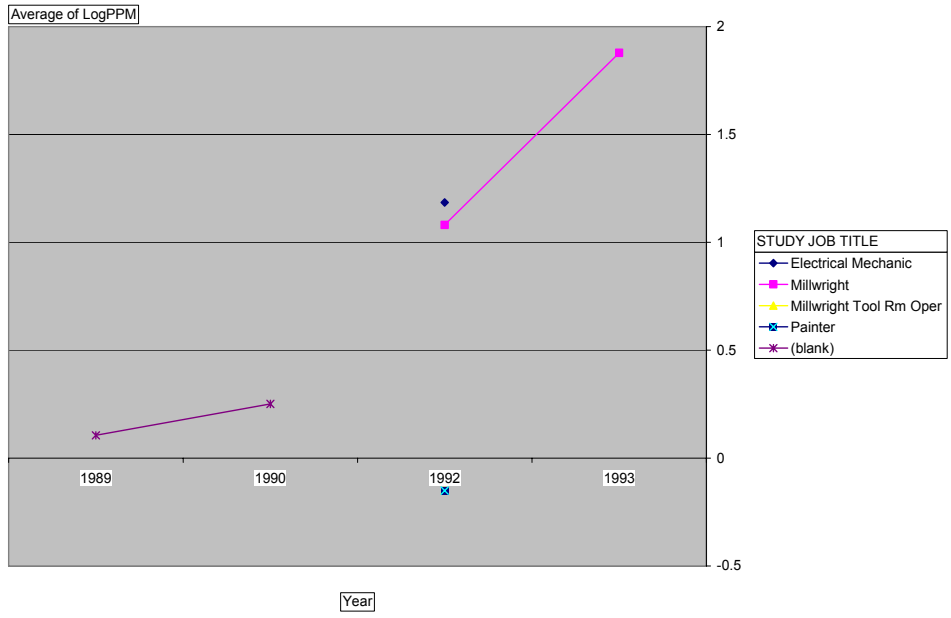


Table F.4e - Geometric mean p-TWA (ppm) nitrobenzene for Company Department 111 by job by year 1989-1993

DEPT 111 TYPE P-TWA ANALYTE NITROBENZENE



[i] Abbreviations: p-TWA – personal time weighted average, a-TWA – area time weighted average, ppm – parts per million