IN-DEPTH SURVEY REPORT:

COMPARISON OF PERCHLOROETHYLENE EXPOSURES BEFORE AND AFTER THE INSTALLATION OF LOCAL EXHAUST VENTILATION AT A COMMERCIAL DRY CLEANERS

at

Drycleaning Plus
Cincinnati, Ohio

REPORT ON TASK 2
INTERAGENCY AGREEMENT BETWEEN OSHA AND NIOSH
PERCHLOROETHYLENE IN DRY CLEANING SHOPS

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
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National Institute for Occupational Safety and Health
Division of Physical Sciences and Engineering
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PLANT SURVEYED	Drycleaning Plus 8711 Fields-Ertel Road Cincinnati, Ohio 45249
SIC CODE	7216
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DISCLAIMER

Mention of company names or products does not constitute endorsement by the Centers for Disease Control and Prevention (CDC)

EXECUTIVE SUMMARY

In September 1998, a local exhaust ventilation (LEV) system was installed on a dry-to-dry cleaning machine with a refrigerated condenser and activated charcoal filters In this study, a dry cleaning store was selected that had a single machine that was at least 10 years old, a LEV system was installed at a cost of approximately $2,500, and the reduction of exposures to perchloroethylene (PERC) to the employees was assessed This task was completed as a part of an Interagency Agreement between NIOSH and OSHA

Full-shift time weighted average (TWA), short duration ceiling, and 15 minute short-term exposure level (STEL) PERC exposure concentrations were measured for the workers at the store and in select areas in the store PERC exposures were assessed before and after the LEV system was installed and with and without the LEV system operating Comparisons were made to determine to what extent PERC exposures were reduced with the addition of the LEV system

PERC TWA concentration data gathered for the dry cleaning machine operator before the LEV system was installed showed a mean concentration of 4 69 parts per million (ppm) PERC data gathered for the dry cleaning machine operator after the LEV system was installed was a mean concentration of 2 97 ppm All other workers working in the dry cleaning store had personal breathing zone PERC concentrations less than 1 0 ppm both before and after the LEV system was installed The percent reduction in the machine operator's PERC exposure with the installation of the LEV system was determined to be 37 percent, which was statistically significant at 90 percent confidence ($\alpha = 0\ 10$) General ventilation conditions were different for the before and after LEV installation sampling sessions The temperatures were in the 90's °F and all the doors and windows were open and all the exhaust fans were operating when the air samples were collected before LEV was installed Temperatures were in the 70's °F and some of the doors were kept closed and the exhaust fan in the wall behind the dry cleaning machine was off when the air samples were collected after LEV was installed Because of the differences in general ventilation conditions for the before and after LEV installation sampling sessions, a second round of samples were collected in the winter months when the building was more closed up The temperatures for the two weeks of sampling (one week with the LEV operating and one week with the LEV not operating) in the winter months were in the 40's °F, the doors to the store were kept closed and the exhaust fan in the wall behind the dry cleaning machine was not operated The mean PERC TWA concentration measured for the dry cleaning machine operator with the LEV system operating and not operating were 4 76 and 8 56 ppm, respectively The percent reduction in the machine operator's PERC exposure with the LEV system operating was determined to be 44 percent This reduction in the dry cleaning machine operator's exposure to PERC was found to be statistically significant at 95 percent confidence ($\alpha = 0\ 05$)

The range of PERC STELs measured during the tasks of loading and unloading the dry cleaning machine before the LEV system was installed was 0 5 to 24 6 ppm, with a mean STEL concentration of 6 28 ppm The maximum instantaneous ceiling PERC concentration measured before the LEV system was installed was greater than 2000 ppm The range of PERC STELs

measured during the tasks of loading and unloading the dry cleaning machine after the LEV system was installed was 0 6 to 12 9 ppm, with a mean PERC STEL concentration of 3 75 ppm The maximum instantaneous ceiling PERC concentration measured after the LEV system was installed was 1207 ppm The percent reduction in mean PERC STEL concentration between before and after installation of the LEV system was determined to be 40 3 percent, which was statistically significant at 90 percent confidence ($\alpha = 0\ 10$) The range of PERC STELs measured during the week in the winter when the LEV system operated was 0 85 to 26 8 ppm, with a mean STEL concentration of 3 48 ppm The maximum instantaneous ceiling PERC concentration measured during this time was 810 ppm The range of PERC STEL measured during the week in the winter when the LEV system was not operating was 0 47 to 27 0 ppm, with a mean STEL concentration of 5 83 ppm The maximum instantaneous ceiling PERC concentration measured during this time was 873 ppm The percent reduction in mean PERC STEL concentrations between LEV operating and not operating was determined to be 40 3 percent, which was statistically significant at 90 percent confidence ($\alpha = 0\ 10$)

The LEV system installed demonstrated that a simple inexpensive system can be installed that will significantly reduce worker exposure to PERC fumes while loading and unloading cloths from a dry cleaning machine

INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH), a Federal agency located in the Centers for Disease Control and Prevention under the Department of Health and Human Services, was established by the Occupational Safety and Health Act of 1970 This legislation mandated NIOSH to conduct research and educational programs separate from the standard setting and enforcement functions conducted by the Occupational Safety and Health Administration (OSHA) in the Department of Labor An important area of NIOSH research deals with methods for controlling occupational exposure to potential chemical and physical hazards

The Engineering Control Technology Branch (ECTB) of the Division of Physical Sciences and Engineering (DPSE), has the lead within NIOSH to study and develop engineering controls and assess their impact on reducing occupational illness Since 1976, ECTB has conducted a large number of studies to evaluate engineering control technology based upon industry, process, or control technique The objective of each of these studies has been to document and evaluate control techniques and to determine their effectiveness in reducing potential health hazards in an industry or at specific processes Information on effective control strategies is subsequently published and distributed throughout the affected industry and to the occupational safety and health community

This study was conducted to determine the extent of exposure and to gather control and operational information to assist in determining technological feasibility of controlling worker exposure to PERC OSHA funded this study under an interagency agreement attached as Appendix A to this document

The study set up under the interagency agreement was designed to determine both 1) the extent of exposure of employees, and, 2) the extent of use of control technology in small and medium sized dry cleaning establishments The results of the study provide OSHA with data to be utilized in determining technological feasibility of controlling worker exposure to PERC Described in a separate report, dry cleaning plants were selected and data collected to characterize worker exposure levels and control technology for "fourth generation" closed-loop, dry-to-dry machines (with an integrated, in-line refrigeration condenser and a carbon absorber to recover PERC vapors during the dry cycle), and "fifth generation" machines, having the same features as fourth generation machines, plus an internal monitor/interlock system to prevent door opening at PERC concentrations above a set concentration

This report describes task two of that study, in which a local exhaust ventilation (LEV) system was installed on a dry-to-dry machine with refrigerated condenser, to measure its effectiveness to reduce exposure to PERC Prior to the installation of the LEV system, personal breathing zone and area air samples were collected to determine the extent of exposure to PERC Next, a contractor was hired to fabricate and install a LEV system using a design developed by NIOSH researchers Finally, personal breathing zone and area air samples were collected to determine

the extent of worker exposure to PERC after the LEV system was installed The data collected before and after installation of the LEV system was then compared to determine to what extent workers' exposures to PERC in the dry-cleaning industry can be reduced by the installation of LEV to existing equipment In addition to the air samples collected, real time PERC concentrations were measured during loading and unloading of cloths into the dry cleaning machine and during the cleaning of the lint and button traps using a photoionization detector

SHOP DESCRIPTION

The Drycleaning Plus store is located in a small strip mall in suburban Cincinnati and began operations in December 1986 Located on either side of the store are a sandwich shop and a shoe store, as shown in Figure 1 The general shop layout is shown in Figure 2 The shop had one set of doors for customer entrance in the front of the store and one other door in the back of the store used by the employees and delivery people The ceiling of the store was approximately 18 feet high Finished clothing was stored on an overhead conveyor located on the left side of the store Pressing of shirts was done in the front right side of the store near windows which were opened during the day for general ventilation when weather permitted Pressing of garments was also done in the middle of the store The dry cleaning machine was located in the middle of the store along the back wall A wall exhaust fan was located behind the dry cleaning machine Located near the back right side of the store were three wet washing machines which were used primarily to wash shirts There were two ceiling exhaust fans, one located in the ceiling in the middle of the store and the other located in the ceiling above the washing machines In a separate room in the rear right hand side of the store was the boiler room

MACHINE DESCRIPTION

There was one dry cleaning machine at this store It was a Suprema Speedomatic 50, Suprema Dry Cleaning Division, Bologna, Italy The dry cleaning machine had a 50 pound load capacity and was twelve years old The machine was a dry-to-dry machine with refrigeration PERC vapor recovery, activated charcoal filters, and a distillation purification system The store was open from 7 00 a m to 7 00 p m on Monday through Saturday

PROCESS DESCRIPTION

Clothes were brought to the store and to the customer counter The clothes were tagged and sorted into dry cleaning and water washing loads Prior to being loaded into the dry cleaning machine, clothes were inspected and sorted according to weight, color, and finish Clothes with visible, localized stains were treated at the spotting station, which was located directly in front of the dry cleaning machine The store manager (also the vice-president) operated the machine and performed any spotting that was necessary The clothing was weighed in a basket prior to loading into the machine The store cleaned between 600 and 700 pounds of clothes per week A load of clothing weighed between 5 to 45 pounds, and four to seven loads were cleaned per day The weight of every load was logged onto a daily record Clothes were washed in PERC,

the PERC was extracted, and the clothes were tumbled dry The clothes were removed from the machine, pressed, bagged, and tagged

EVALUATION CRITERIA

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for PERC is 100 ppm for an eight-hour time weighed average (TWA) The acceptable ceiling concentration is 200 ppm for five minutes in any three-hour period, not to exceed a maximum peak of 300 ppm [1] OSHA had lowered the PEL to 25 ppm TWA in 1989 under the Air Contaminants Standard [2] In July 1992, however, the 11th Circuit Court of Appeals vacated this standard OSHA is currently enforcing the 100 ppm TWA standard, however, some states operating their own OSHA-approved safety and health programs continue to enforce the lower limit of 25 ppm OSHA continues to encourage employers to follow the 25 ppm limit [3]

NIOSH considers PERC to be a potential occupational carcinogen and recommends minimizing workplace concentrations and limiting the number of workers exposed [4]

The American Conference of Governmental Industrial Hygienists (ACGIH) has a threshold limit value (TLV) of 25 ppm for an eight-hour workday, and short-term exposure limit (STEL) of 100 ppm as a 15-minute TWA exposure [5] The ACGIH Chemical Substance TLV Committee classifies PERC as a confirmed animal carcinogen with unknown relevance to humans

METHODOLOGY

INDUSTRIAL HYGIENE SAMPLING

Industrial hygiene air sampling was conducted to evaluate the extent of exposure of workers at Drycleaning Plus to PERC and to measure to what extent the addition of a LEV to the dry cleaning machine reduces worker exposure to PERC Personal breathing zone and area air samples were collected using 100 mg/50 mg coconut shell charcoal tubes connected by tubing to personal air sampling pumps, which were calibrated for an air flow rate of 0 10 liters of air per minute (LPM) Personal breathing zone and area air samples were also collected using 575 Series Passive Sampling monitors containing 350 milligrams of charcoal and manufactured by SKC, Inc , Eighty Four, PA

The charcoal tubes were analyzed by gas chromatography (GC) according to NIOSH Manual of Analytical Methods (NMAM) 4th edition method 1003 with modifications [6] Samples were desorbed for 30 minutes in 1 0 milliliter (ML) of carbon disulfide containing 0 5 microliters per milliliter benzene as an internal standard They were analyzed using a Hewlett-Packard Model 5890A GC equipped with a 30-meter by 0 32 millimeter diameter fused silica capillary coated internally with 0 5 micrometer of DB-wax The GC oven was held at 55°C for 6 0 minutes, and a flame ionization detector was used

The SKC passive monitor samples were analyzed by GC according to NMAM 4th edition method 1003 with modification Samples were desorbed for one-hour in 2 0 milliliters of carbon disulfide containing 0 5 microliters per milliliter n-hexane as an internal standard, and analyzed using a Hewlett-Packard Model 5890IIA gas chromatograph equipped with a 30-meter by 0 32-millimeter diameter fused silica capillary coated internally with 0 5 micrometer of DB-wax, under isothermal oven conditions of 50°C with a retention time of 10 5 minutes and flame ionization detection

Industrial hygiene air sampling for PERC concentrations at Drycleaning Plus was conducted in two phases Phase I sampling was done in the summer during the week before the LEV system was installed and during the week after the LEV system was installed Phase II sampling was done in the winter when the store was more closed up and there was less natural ventilation Sampling was done one week with the system on and one week with the system off rather than turning the system on or off randomly because the number of dry cleaning loads varied with the day of the week, with more loads ran on Monday and fewer loads ran on Friday

REAL-TIME MONITORING

Real-time monitoring was used to study how specific manual tasks and maintenance operations affect worker exposure to PERC Some of these procedures occurred frequently throughout the day, such as loading/unloading the machine, while others, such as cleaning the lint and button traps, occurred less often Most tasks took between 1 and 30 minutes Real-time monitoring of PERC exposures was performed using a Photovac 2020™ Photoionization Air Monitor (Photovac, Inc , Markham, Ontario, Canada) with a 10 6 eV ultraviolet lamp This instrument uses a photoionization detector to provide an analog output response proportional to the concentration of ionizable pollutants present in the air The 2020™ was calibrated for PERC before and after a shift using a gas PERC standard of 198 ppm from Scott Specialty Gas (Troy, MI) The 2020™ electronically recorded the instrument readings in 15 seconds increments Following the end of a shift the data were downloaded to a computer file for analysis

RESULTS AND DISCUSSION

Phase I (August/September 1998)

A LEV system was installed at Drycleaning Plus on September 1, 1998, by Spring Grove Sheet Metal Company, Cincinnati, Ohio Figure 3A through 3D shows the front, side, top, and exhaust stack side views of the LEV system, respectively, and Figures 4, 5, and 6 show a front view, a side view, and outside exhaust stack photographs of the LEV system, respectively The cost of fabrication, installation, and electrical wiring of the system was $2,560 The system exhausted air from in front of the dry cleaning machine door only when the door was opened

Before Local Exhaust Ventilation Installation

Prior to the installation of the LEV system, on August 25-28, 1998, personal breathing zone and area air samples were collected and analyzed for PERC A total of 27 charcoal tube and 27 passive monitor badge samples were collected These results are listed in Table 1 Nineteen of the charcoal tubes and 19 of the badges were personal breathing zone samples collected on six workers, and eight of the charcoals and eight of the badge samples were area air samples collected in two locations Four charcoal tubes and four badge personal breathing zone air samples were collected on the dry cleaning machine operator (DP-01) The mean charcoal tube PERC concentration for the machine operator was 4 7 parts per million (ppm) with a standard deviation of 1 8 ppm The mean badge PERC concentration for the machine operator was 4 0 ppm with a standard deviation of 1 5 ppm

Five other workers worked at this dry cleaning store and were assigned worker ID numbers DP-02 through DP-06 Their work activities involved washing shirts, pressing clothes, bagging clothes, and waiting on customers at the counter The overall mean PERC charcoal tube concentration for workers DP-02 through DP-06 was 0 4 ppm and the overall mean badge PERC concentration was 0 5 ppm with individual results shown in Table 1 Area air samples were collected in two locations in the store, on top of the dry cleaning machine (DA–01) and in the middle of the store (DA–02), as shown in Figure 2 The mean charcoal tube PERC concentrations for areas DA–01 and DA–02 were 1 7 and 0 5 ppm, respectively The mean badge PERC concentrations for areas DA–01 and DA–02 were 1 7 and 0 6 ppm, respectively During these four days of air sampling for PERC, the outside temperature averaged in the mid 90's °F and all doors and windows were opened and ceiling and wall fans were operating the entire day

After Local Exhaust Ventilation Installation

After the LEV system was installed, air sampling for PERC was repeated in the same manner as before the installation Air sampling was done on September 8-11, 1998 A total of 55 charcoal tube and badge samples were collected and analyzed for PERC These results are shown in Table 2 On the last day of sampling, September 11, 1999, the distillation unit on the dry cleaning machine developed a leak and PERC poured out of the still on to the floor As a result of this spill, sample results were all very high in concentration and atypical Therefore, means and standard deviations were calculated without using this day's data Four charcoal tubes and four badge personal breathing zone air samples were collected on the dry cleaning machine operator, but only the first three days were used to calculate the mean values The mean charcoal tube PERC concentration for the machine operator was 3 0 ppm with a standard deviation of 0 5 ppm The mean badge PERC concentration for the machine operator was 3 1 ppm with a standard deviation of 0 5 ppm

Four other workers were sampled during this sampling session, DP-02, -03, -04, and -05 The overall mean PERC charcoal tube concentration for workers DP-02 through DP-05 was 0 6 ppm

and the overall mean badge PERC concentration was 0 6 ppm with individual results shown in Table 2

Area air samples were collected again in the same two locations in the store, one on top of the dry cleaning machine (DA-01) and one in the middle of the store (DA-02), as shown in Figure 2 The mean charcoal tube PERC concentrations for areas DA-01 and DA-02 were 1 5 and 0 7 ppm, respectively The mean badge PERC concentrations for areas DA-01 and DA-02 were 1 3 and 0 6 ppm, respectively During these four days of air sampling for PERC, the outside temperature averaged in the mid 70's °F and the doors and windows were not opened and ceiling and wall fans were not operating the entire day Instead, the doors and windows were opened later in the day as the store heated up Similarly, the ceiling fans and the wall fan behind the dry cleaning machine were turned on later in the day when the store heated up

Phase I Comparison

Comparisons were made between the mean PERC charcoal tube data collected before and after the installation of the LEV system These results are shown in Table 3 The percent difference between the pre- and post-installation mean PERC charcoal tube concentration for the dry cleaner machine operator was 36 7 percent Statistical examination of the percent difference results for both the personal breathing zone and area PERC air samples using Student's t test showed the percent difference for the dry cleaning machine operator was statistically significant at 90 percent confidence (α - 0 10) None of the other differences were statistically significant at 90 percent confidence (α = 0 10)

The badge monitoring data gave similar results with a percent difference between the pre- and post-installation mean PERC badge concentration for the dry cleaning machine operator being 23 8 percent, as shown in Table 4 This difference was not found to be statistically significant at 90 percent confidence (α - 0 10) The percent difference found for the area air sample collected on top of the dry cleaning machine was 20 6 percent, which was found to be statistically significant at 90 percent confidence All other worker and one of the area PERC air sample differences were not statistically significant at 90 percent confidence

Real-Time Results

Real-time PERC air monitoring was also done during the pre- and post-installation of the LEV system sampling dates Shown in Tables 5-12 are the data for the eight days of sampling Real-time PERC concentrations were measured during loading and unloading the dry cleaning machine and during the cleaning of the lint and button traps The results were downloaded from the Photovac to a computer daily data are shown in Tables 5-12 for the periods August 25-28 and September 8-11, 1998 In each of these tables, for each 15-seconds, the following information was recorded the minimum PERC concentration, the average PERC concentration, and the maximum PERC concentration

For each task where the PERC concentrations were measured a 15-minute short-term exposure level (STEL) was calculated by using the average PERC concentration for each of the 15-second periods recorded and 0 5 ppm PERC concentration for the remainder of the 15-minute time period The 0 5 ppm PERC concentration was used because this was the background concentration measured in the store away from the dry cleaning machine

Along with each table listing real-time PERC concentrations, a graph was constructed plotting sampling time verses PERC concentration for the minimum PERC concentration, average PERC concentration, and maximum PERC concentration These graphs are shown in Figures 7-14 The highest PERC STEL concentrations were measured during the loading of the first load of the day and during the cleaning of the lint and button traps The mean STEL PERC concentrations measured for the first load of the day before the LEV system was installed was 20 5 ppm, and after the LEV system was installed was 4 5 ppm After the LEV was installed, the mean STEL PERC concentration was reduced by 78 percent, which was statistically significant at 99 percent confidence ($\alpha = 0\ 01$)

Phase II (January/February 1999)

Examination of the worker's mean PERC exposure concentrations shows that three of the workers' exposure concentrations to PERC increased for the second week of sampling after the LEV system was installed when compared to the first week exposure PERC concentrations One explanation for the increase in exposure to PERC was the fact that the natural ventilation rate for the store was greater during the first week of sampling because the doors and windows were always open and the wall and ceiling fans operated the entire time This was not the case during the second week of sampling If the reduced natural ventilation rates of the second week of sampling significantly increased worker exposures to PERC, then the 37 percent reduction seen in the machine operator's exposure concentration to PERC with the addition of the LEV system may be an underestimate of its effectiveness To examine this hypothesis, a second set of samples were collected in the winter time when the store was more closed Personal breathing zone and area air samples were collected January 25-29 and February 1-5, 1999 Samples collected January 25-29 were collected with the LEV system turned on Samples collected February 1-5 were collected with the LEV system turned off As was the case with the first sampling sessions, PERC air samples were collected using charcoal tubes attached to personal air sampling pumps and passive badge monitors

A personal breathing zone air sample was collected on the dry cleaning machine operator For comparison reasons two passive badge samplers were placed on the left and right lapel, and the charcoal tube was placed on the right lapel of the dry cleaning machine operator The other workers at the store were not samples during phase II because during phase I the PERC concentration for these workers were all less than 1 0 ppm and did not change much whether the LEV system was or was not operating Area air samples were collected in four locations for each day of sampling These locations were on top of the dry cleaning machine (DA-01), in the middle of the store (DA-02), in front of the dry cleaning machine on the spotting table (DA-03),

and in the front of the store on the tagging counter (DA-04) On each day of sampling, at each location, a charcoal tube and badge sample were collected

Local Exhaust Ventilation Operating

Table 13 shows sample results collected January 25-29, 1999, with the LEV system operating A total of five charcoal tubes and ten badge samples were collected on the dry cleaning machine operator (DP-01) The PERC concentrations measured on January 28 were 4 to 12 times greater than the PERC concentrations measured on the other days of the week when the LEV system was operated The PERC concentrations were higher because the distillation unit on the dry cleaning machine was in operation and the distillation unit had a leak in one of its pipes, causing the high PERC air concentrations As a result of this increased PERC exposure due to the leak in the distillation unit, mean PERC concentrations reported in Table 13 were calculated without using January 28 results

The mean PERC charcoal tube concentration for the machine operator was 4 8 ppm with a standard deviation of 1 8 ppm The mean PERC passive badge concentration for the machine operator was 4 8 ppm with a standard deviation of 2 2 ppm The overall mean PERC charcoal tube concentration results for area samples was 1 8 ppm The overall mean area PERC passive badge concentration results with the LEV operating was 1 8 ppm The temperature for the five days of sampling averaged in the low to mid 40's with the humidity less than 50 percent During the week, no doors were kept open and the wall fan behind the dry cleaning machine was never operated The two ceiling fans were on part of the time and windows in the front of the store near the shirt pressing operations were opened part of the time

Local Exhaust Ventilation Not Operating

Table 14 shows results of the samples collected February 1-5, 1999, with the LEV not operating A total of five charcoal tubes and ten badge samples were collected on the machine operator (DP-01) The PERC concentrations measured on February 3, 1999 were two to four times greater than the PERC concentrations measured on the other days of the week The reason for the higher PERC concentrations on this day was because the distillation unit on the dry cleaning machine was in operation, and the leak had not been fixed As a result of this increased PERC exposure due to the operation of the distillation unit, mean PERC concentrations reported in Table 14 were calculated without using February 3, 1999, results

The mean PERC charcoal tube concentration for the machine operator was 8 5 ppm with a standard deviation of 1 2 ppm The mean PERC passive badge concentration for the machine operator was 8 7 ppm with a standard deviation of 2 2 ppm The charcoal tube overall mean PERC concentration for the four area air samples was 2 8 ppm The passive badge mean PERC concentrations for the four area air samples was 3 2 ppm Conditions during the week were temperatures in the low to mid 40's and humidity below 40 percent During the week, no doors were kept open and the wall fan behind the dry cleaning machine was never operated The two

ceiling fans were on part of the time and windows in the front of the store near the shirt pressing operations were opened part of the time These weather conditions and windows, doors, and fan conditions were similar to those conditions observed during the first week of sampling when the LEV system was in operation

Phase II Comparison

Comparisons of charcoal tube results for phase II are shown in Table 15 Examining the mean charcoal tube PERC concentrations for the dry cleaning machine operator yields a 44 percent reduction in PERC exposures when the LEV system was operating Statistical examination of the percent difference result for the machine operator was statistically significant at 95 percent confidence ($\alpha = 0\ 05$) The percent difference found in the area air samples collected on top of the dry cleaning machine and in the middle of the store were found to be statistically significant at 99 percent and 90 percent confidence, respectively

Similarly, a 45 percent reduction in the machine operator's PERC exposure is seen with passive badges when the LEV system was in operation This difference is statically significant at 95 percent confidence ($\alpha = 0\ 05$) The percent difference found in the area air samples collected on top of the dry cleaning machine and in the middle of the store were found to be statistically significant at 99 percent and 90 percent confidence, respectively These results are listed in Table 16

Badge samples were collected on the left and right lapels of the machine operator to evaluate if there were any differences in PERC exposure due to placement When the machine operator loaded and unloaded clothes from the dry cleaning machine, the left lapel badge was closer to the machine than the right side lapel badge samples Using badge lapel PERC concentration data shown in Tables 13 and 14, the correlation between the left and right results was a $R^2 = 0\ 9853$ or very good correlation The mean PERC concentration for the badges collected on the left lapel was 9 2 ppm with a standard deviation of 6 0 ppm, while the mean PERC concentration for the right side was 9 6 ppm with a standard deviation of 6 5 ppm Four of the left lapel badge sample PERC concentrations were greater than the right, while five of the right lapel samples were greater than the left One of the sample sets was equal There is no significant difference between the right and left placement of the badge samples

Real-time PERC concentrations were also measured during loading and unloading the dry cleaning machine and during cleaning the lint and button traps during phase II A summary of these data are listed in Table 17 The 15-minute STELs shown in Table 17 were calculated using the mean PERC concentration times the amount of time to perform the task plus an assume background PERC concentration of 0 5 ppm for the remainder of the 15-minute time period During the week when the LEV system was operating (January 25-29, 1999), the highest STEL PERC concentration of 31 4 ppm was measured during cleaning the lint and button traps on January 29, 1999 The largest unloading STEL PERC concentration of 26 8 ppm was measured during unloading drapes on January 29, 1999, with the maximum PERC concentration of

810 ppm measured during this task During the week when the LEV system was not operating (February 1-5, 1999), the highest STEL PERC concentration of 27 0 ppm was measured during unloading third load and loading fourth load on February 3, 1999 A STEL PERC concentration of 22 6 ppm was measured during cleaning the lint and button traps on February 1, 1999 A maximum PERC concentration of 873 ppm was measured during the loading of the first load on February 5, 1999

For comparison purpose, the STEL concentrations determined for the tasks and listed in Table 17 were summarized by task descriptions and are shown in Table 18 Mean STEL PERC concentrations were calculated for the task descriptions clean lint and button traps, load the first load, unload first load and load second load, etc for the days when the LEV was operating and for days when it was not

Charcoal tubes and passive badge monitors were collected together in pairs for personal breathing zone and area air samples Comparisons between charcoal tube and passive badge monitor PERC concentration pairs was conducted Comparison of charcoal tube to passive badge monitor PERC results for all the pairs gave a correlation coefficient $R^2 = 0\ 98$ and a $t = 27\ 8$ This shows that there is a very high linear correlation between the tube and badge data Critical t for this sample set is 2 79 at 99 percent confidence, since $27\ 8 > 2\ 79$ there is a linear correlation at 99 percent confidence

CONCLUSIONS AND RECOMMENDATIONS

During the summer months, the dry cleaning machine operator's (DP-01) average exposure to PERC based on personal breathing zone samples was reduced 37 percent when comparing PERC concentrations measured before and after the installation of a LEV system This reduction was statistically significant at 90 percent confidence Three of the other workers personal breathing zone mean PERC concentration exposures increased after the LEV system was installed indicating that the amount of general ventilation of the store may have caused an underestimation of the controls effectiveness, thus, the reduction in the machine operator's exposure may have been greater than 37 percent A second set of PERC air samples was collected during the winter months when the store was more closed and general ventilation of the store was limited Samples were collected for five days with the LEV system on and five days with the LEV system off The results from this second set of samples showed that the machine operator's personal breathing zone mean PERC concentration was reduced by 44 percent with the use of the LEV system This reduction in exposure to PERC for the machine operator was statistically significant at 95 percent confidence The overall conclusion that can be made from this study is that, with the addition of LEV, the machine operators' exposure to PERC can be reduced approximately 40 percent

The second set of PERC sampling results showed that for the days when the distillation unit on the dry cleaning machine was in operation, PERC exposure concentrations were much greater than days when the unit was not operating On days when the distillation unit was operating,

operator exposures were either four times higher (LEV on) or twice as high (LEV off) compared to the days when the distiller was not operating These results led to the discovery of a leak in the distillation system which was later fixed Routine monitoring can assist in the location and correction of leaks

The passive badge and charcoal tube PERC sample result pairs had a very high correlation coefficient of $R^2 = 0.98$, indicating good agreement between the two sampling methods The use of passive badges provides a more economical method for PERC air sampling, requiring no maintenance, and no possibility for mechanical pump failure Placement of the badge on the right or left lapel appears to not have any effect on the result

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Figure 1
Photograph of the Front of Drycleaning Plus
Cincinnati, Ohio

Figure 2
General Shop Layout
Drycleaning Plus
Cincinnati, Ohio

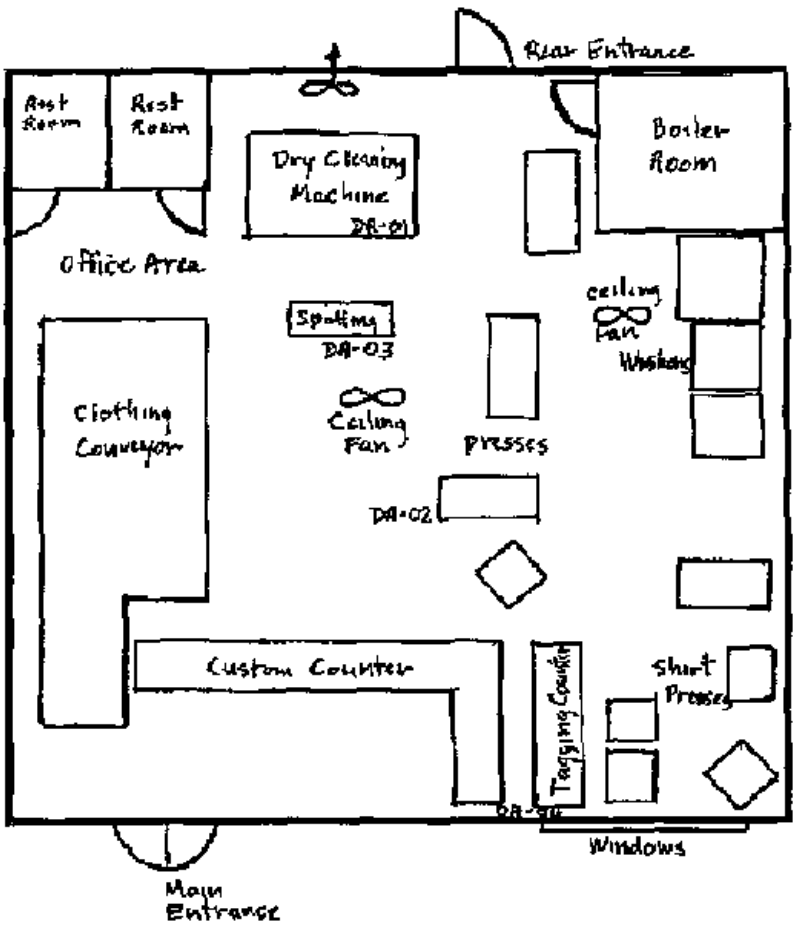

Figure 3A
Front View Diagram of Local Exhaust Ventilation System
Drycleaning Plus, Inc
Cincinnati, Ohio

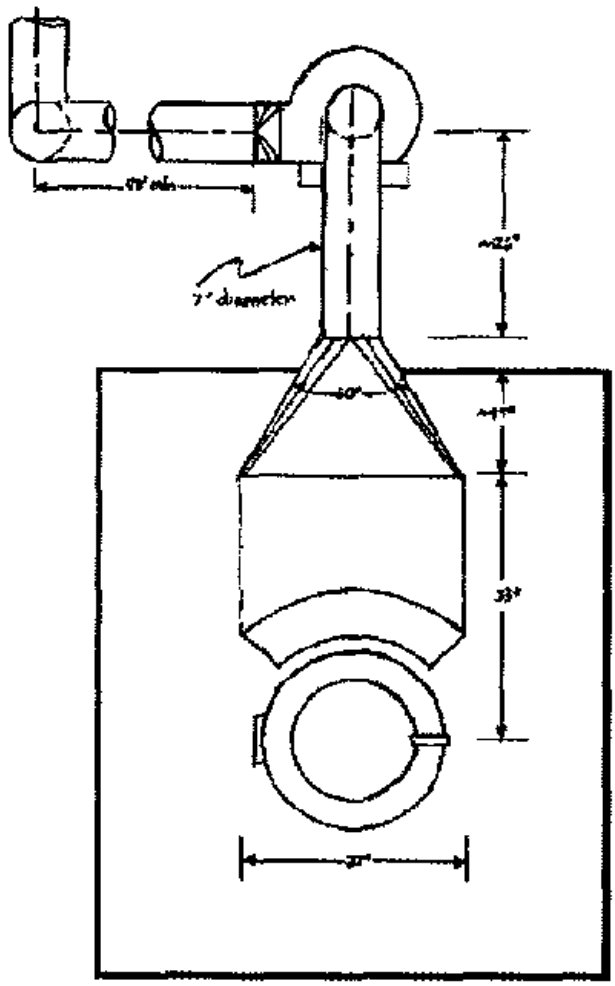

Figure 3B
Side View Diagram of Local Exhaust Ventilation System
Drycleaning Plus, Inc
Cincinnati, Ohio

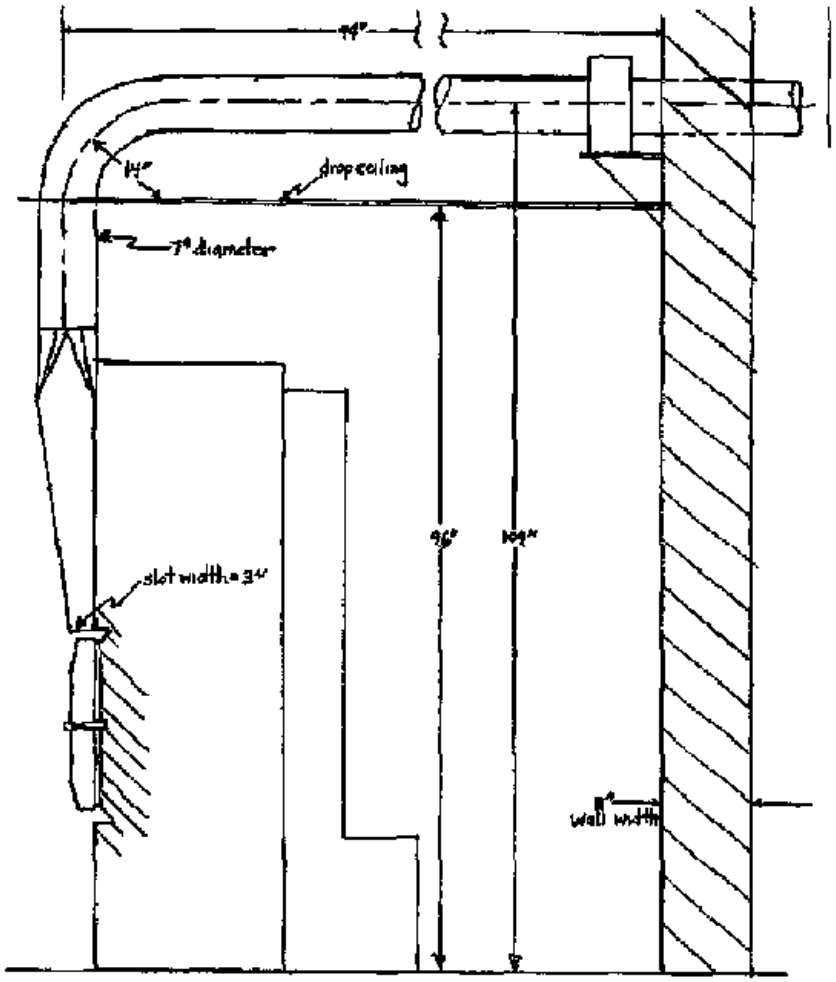

Figure 3C
Top View Diagram of Local Exhaust Ventilation System
Drycleaning Plus, Inc
Cincinnati, Ohio

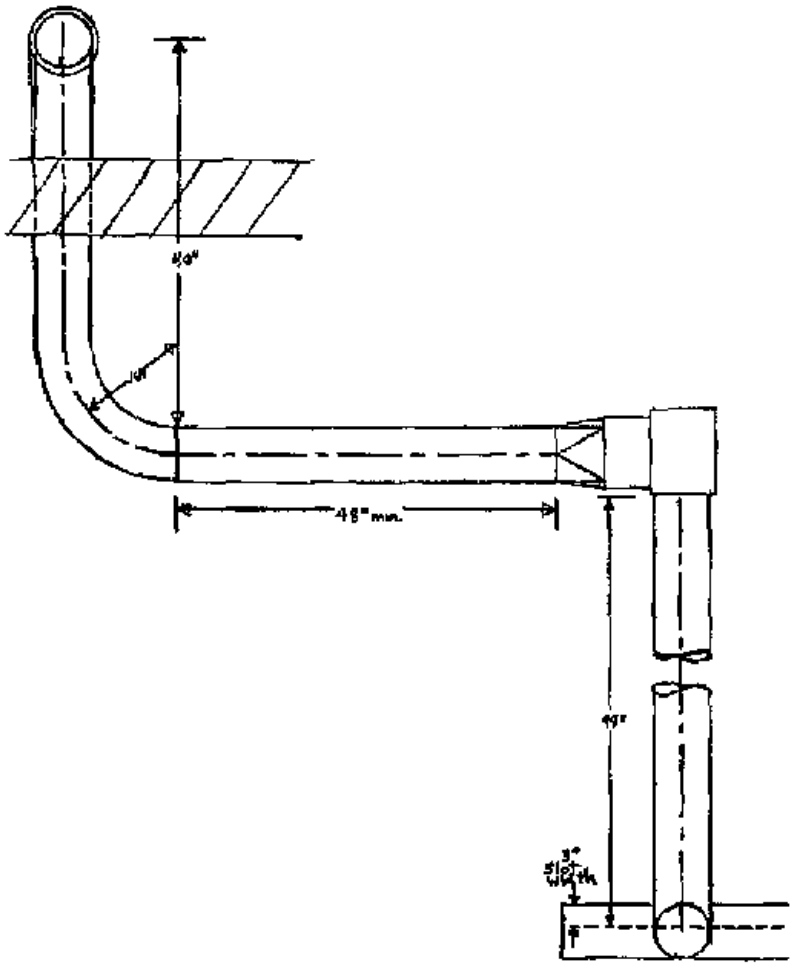

Figure 3D
Side View Diagram of Outside Exhaust Stack
Drycleaning Plus, Inc
Cincinnati, Ohio

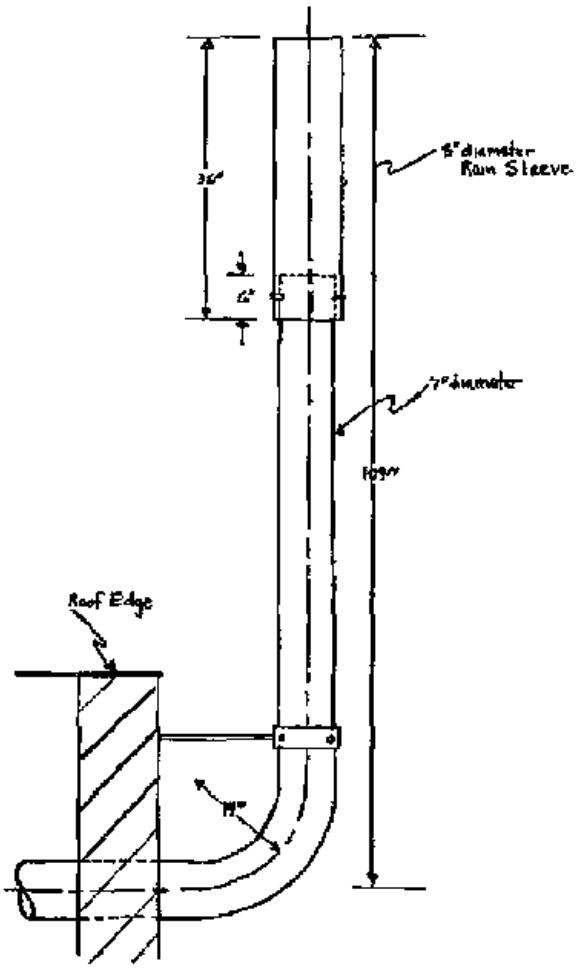

Figure 4
Front View Photograph of the Local Exhaust Ventilation System
Drycleaning Plus, Inc
Cincinnati, Ohio

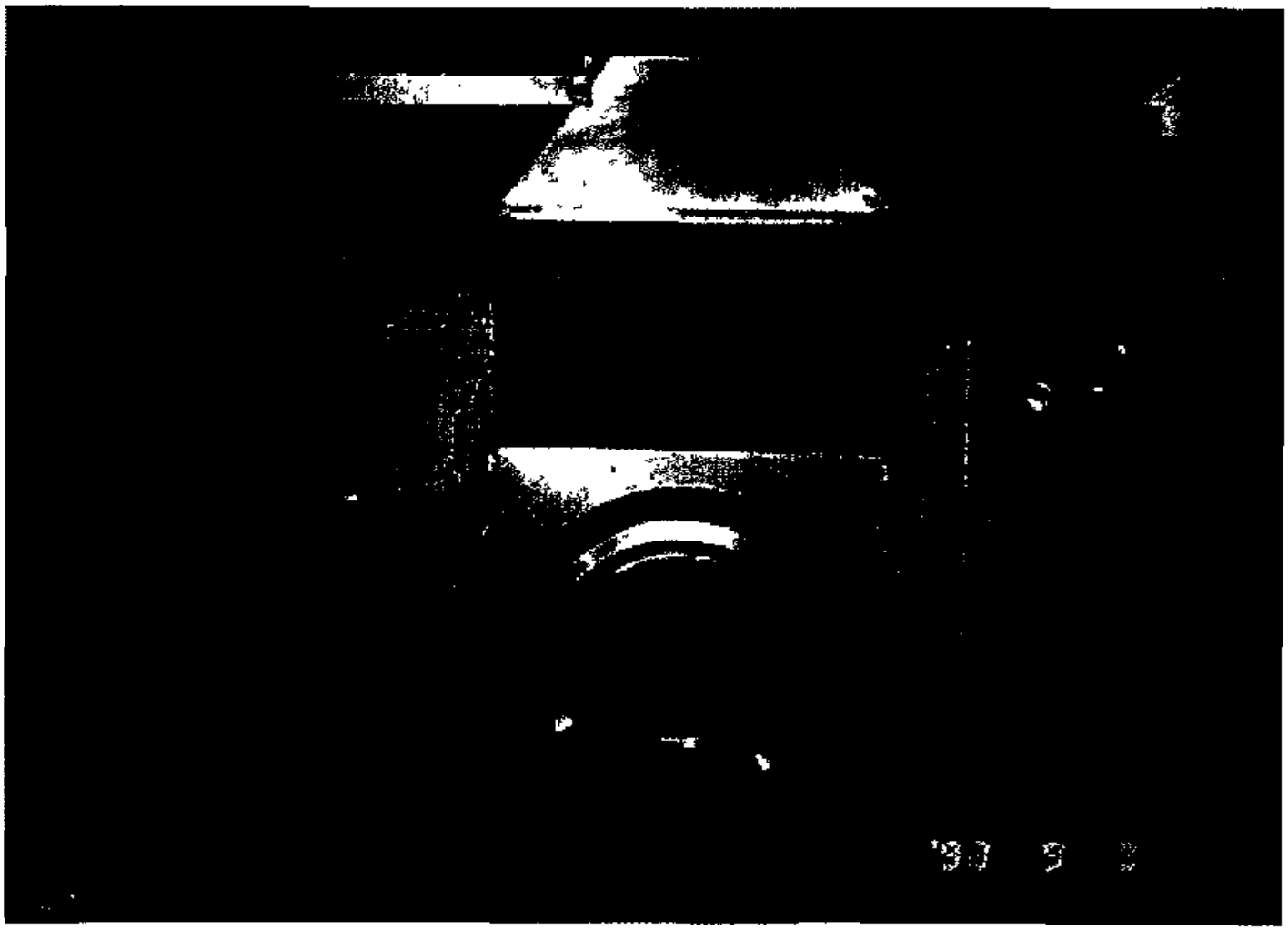

Figure 5
Side View Photograph of the Local Exhaust Ventilation System
Drycleaning Plus, Inc
Cincinnati, Ohio

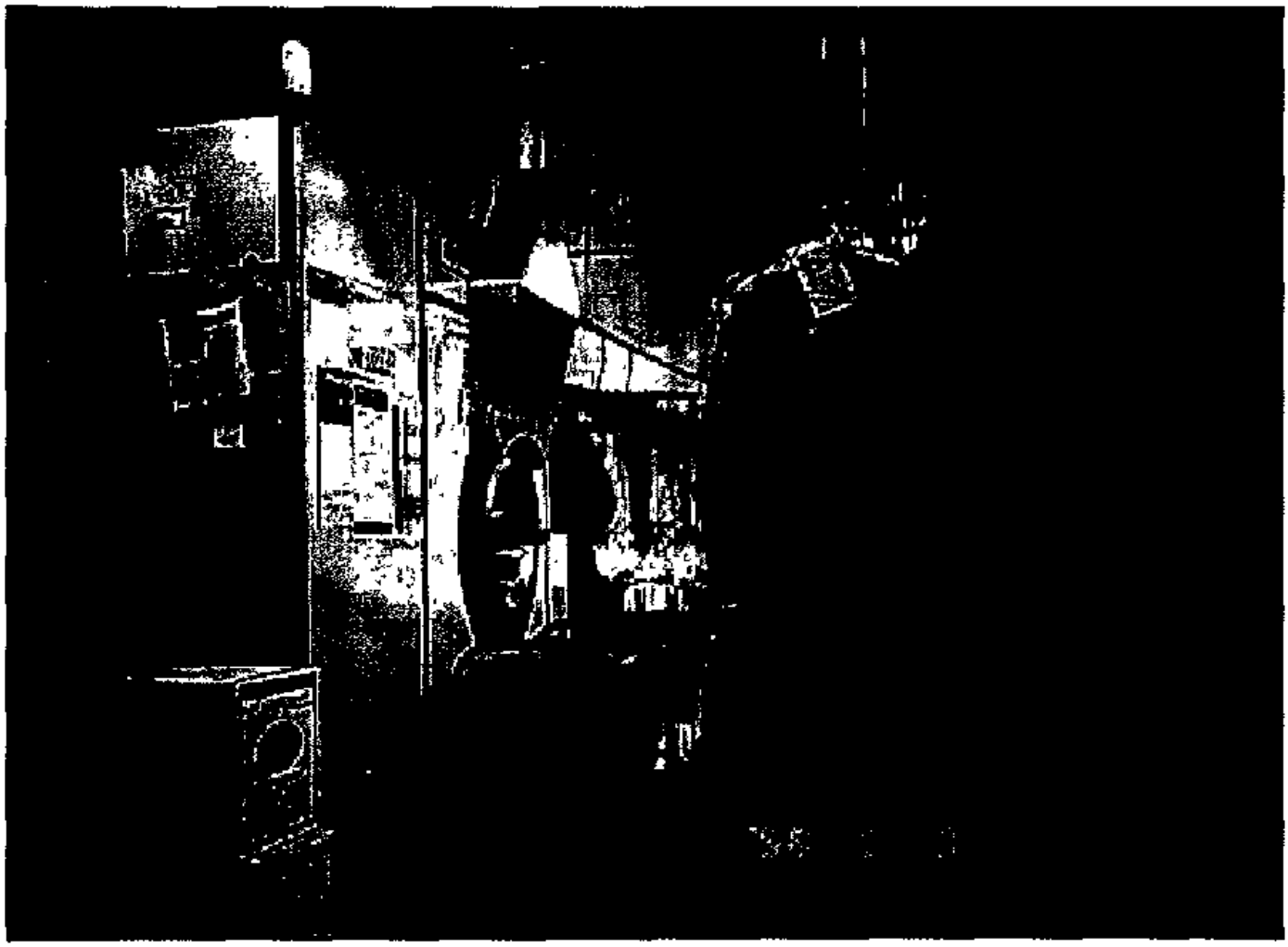

Figure 6
Outside Stack View Photograph of the Local Exhaust Ventilation System
Drycleaning Plus, Inc
Cincinnati, Ohio

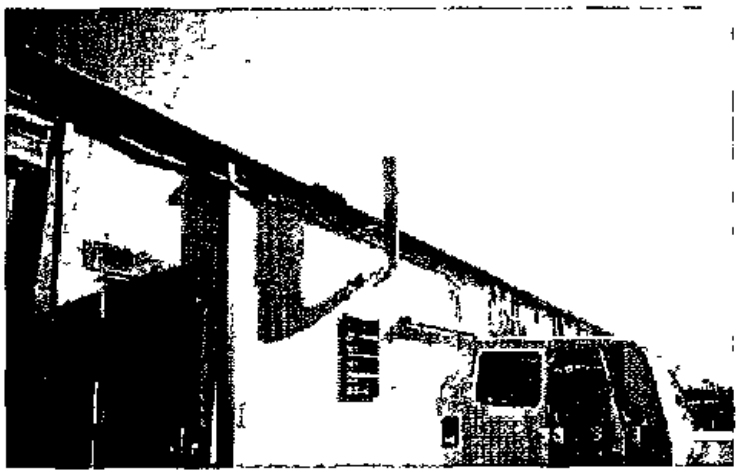

Table 1
Perchloroethylene Worker and Area Air Exposure Concentrations
Prior to Local Exhaust Ventilation Installation
Drycleaning Plus
Cincinnati, Ohio
August 25-28, 1998

Sample Date	Worker or Area ID Number	Job Description	Sampling Time (min)	PERC Conc (ppm) (tube)	PERC Conc (ppm) (badge)	Mean PERC Conc (ppm) (tube)	Mean PERC Conc (ppm) (badge)
08/25/98	DP-01	Operate dry cleaning machine	277	2 98	2 43	4 69 (1 84)	4 04 (1 51)
08/26/98	DP-01	Operate dry cleaning machine	283	7 30	6 06		
08/27/98	DP-01	Operate dry cleaning machine	315	4 31	3 99		
08/28/98	DP-01	Operate dry cleaning machine	287	4 16	3 66		
08/25/98	DP-02	Pressing	351	0 35	0 42	0 29 (0 12)	0 36 (0 15)
08/26/98	DP-02	Pressing	337	0 19	0 25		
08/27/98	DP-02	Pressing	336	0 19	0 23		
08/28/98	DP-02	Pressing	274	0 43	0 54		
08/25/98	DP-03	Bagging shirts	314	0 66	0 65	0 58 (0 45)	0 67 (0 56)
08/26/98	DP-03	Bagging shirts	281	0 18	0 27		
08/27/98	DP-03	Bagging shirts	221	0 29	0 28		
08/28/98	DP-03	Bagging shirts	287	1 18	1 47		

PERC = Perchloroethylene = tetrachloroethylene
tube = charcoal tube sampler collected using an air sampling pump
badge = passive air sampling badge containing charcoal 575 Series by SKC Inc
ID = identification
NA = not available
ppm = parts PERC per million parts air
( ) = numbers in parenthesis are the standard deviation for the mean value above it

Table 1 (con't)
Perchloroethylene Worker and Area Air Exposure Concentrations
Prior to Local Exhaust Ventilation Installation
Drycleaning Plus
Cincinnati, Ohio
August 25-28, 1998

Sample Date	Worker or Area ID Number	Job Description	Sampling Time (min)	PERC Conc (ppm) (tube)	PERC Conc (ppm) (badge)	Mean PERC Conc (ppm) (tube)	Mean PERC Conc (ppm) (badge)
08/25/98	DP-04	Pressing	350	0 88	0 93	0 62 (0 41)	0 66 (0 32)
08/26/98	DP-04	Pressing	340	0 19	0 34		
08/27/98	DP-04	Pressing	324	0 37	0 42		
08/28/98	DP-04	Pressing	296	1 05	0 93		
08/25/98	DP-05	Pressing	329	0 38	0 49	0 29	0 36
08/26/98	DP-05	Pressing	340	0 20	0 22		
08/27/98	DP-06	Pressing	311	0 12	0 48	0 12	0 48
08/25/98	DA-01	On top of dry cleaning machine	349	1 94	1 93	1 71 (0 33)	1 65 (0 27)
08/26/98	DA-01	On top of dry cleaning machine	336	1 54	1 33		
08/27/98	DA-01	On top of dry cleaning machine	344	1 33	1 53		
08/28/98	DA-01	On top of dry cleaning machine	292	2 02	1 80		
08/25/98	DA-02	In middle of room	345	0 73	0 72	0 52 (0 43)	0 56 (0 46)
08/26/98	DA-02	In middle of room	338	0 08	0 14		
08/27/98	DA-02	In middle of room	346	0 26	0 24		
08/28/98	DA-02	In middle of room	292	1 01	1 14		

PERC = Perchloroethylene = tetrachloroethylene
tube = charcoal tube sampler collected using an air sampling pump
badge = passive air sampling badge containing charcoal 575 Series by SKC Inc
ID = identification
NA = not available
ppm = parts PERC per million parts air
( ) = numbers in parenthesis are the standard deviation for the mean value above it

Table 2
Perchloroethylene Worker and Area Air Exposure Concentrations
After Local Exhaust Ventilation Installation
Drycleaning Plus
Cincinnati, Ohio
September 8-11, 1998

Sample Date	Worker or Area ID Number	Job Description	Sampling Time (min)	PERC Conc (ppm) (tube)	PERC Conc (ppm) (badge)	Mean PERC Conc (ppm) (tube)	Mean PERC Conc (ppm) (badge)
09/08/98	DP-01	Operate dry cleaning machine	348	3 47	3 28	2 97 (0 47)	3 10 (0 51)
09/09/98	DP-01	Operate dry cleaning machine	397	2 53	2 53		
09/10/98	DP-01	Operate dry cleaning machine	392	2 90	3 50		
09/11/98	DP-01	Operate dry cleaning machine	312	4 06	4 03		
09/08/98	DP-02	Pressing	334	0 38	0 38	0 44 (0 09)	0 48 (0 10)
09/09/98	DP-02	Pressing	383	0 39	0 48		
09/10/98	DP-02	Pressing	381	0 54	0 57		
09/11/98	DP-02	Pressing	337	6 56	6 45		
09/08/98	DP-03	Bagging shirts	270	0 43	0 42	0 57 (0 15)	0 63 (0 23)
09/09/98	DP-03	Bagging shirts	373	0 55	0 58		
09/10/98	DP-03	Bagging shirts	326	0 72	0 88		
09/11/98	DP-03	Bagging shirts	285	1 45	1 56		

PERC = Perchloroethylene = tetrachloroethylene
tube = charcoal tube sampler collected using an air sampling pump
badge = passive air sampling badge containing charcoal 575 Series by SKC Inc
ID = identification
NA = not available
ppm = parts PERC per million parts air
( ) = numbers in parenthesis are the standard deviation for the mean value above it

Table 2 (cont'd)
Perchloroethylene Worker and Area Air Exposure Concentrations
After Local Exhaust Ventilation Installation
Drycleaning Plus
Cincinnati, Ohio

Sample Date	Worker or Area ID Number	Job Description	Sampling Time (min)	PERC Conc (ppm) (tube)	PERC Conc (ppm) (badge)	Mean PERC Conc (ppm) (tube)	Mean PERC Conc (ppm) (badge)
09/08/98	DP-04	Pressing	342	0 60	0 74	0 80 (0 23)	0 89 (0 17)
09/09/98	DP-04	Pressing	391	0 75	0 85		
09/10/98	DP-04	Pressing	381	1 05	1 08		
09/11/98	DP-04	Pressing	298	1 44	1 42		
09/08/98	DP-05	Pressing	288	0 23	0 32	0 40 (0 21)	0 44 (0 17)
09/09/98	DP-05	Pressing	375	0 33	0 37		
09/10/98	DP-05	Pressing	397	0 63	0 63		
09/11/98	DP-05	Pressing	343	7 31	8 00		
09/08/98	DA-01	On top of dry cleaning machine	338	1 35	1 18	1 46 (0 18)	1 31 (0 21)
09/09/98	DA-01	On top of dry cleaning machine	397	1 67	1 55		
09/10/98	DA-01	On top of dry cleaning machine	398	1 37	1 21		
09/11/98	DA-01	On top of dry cleaning machine	337	4 16	4 75		
09/08/98	DA-02	In middle of room	338	0 48	0 47	0 65	0 64 (0 14)
09/09/98	DA-02	In middle of room	399	NA	0 72		
09/10/98	DA-02	In middle of room	396	0 82	0 72		
09/11/98	DA-02	In middle of room	343	4 73	5 00		

PERC = Perchloroethylene = tetrachloroethylene
tube = charcoal tube sampler collected using an air sampling pump
badge = passive air sampling badge containing charcoal 575 Series by SKC Inc
ID = identification
NA = not available
ppm = parts PERC per million parts air
( ) = numbers in parenthesis are the standard deviation for the mean value above it

Table 3
Comparison of Charcoal Tube Mean Perchloroethylene Air Concentrations
Before and After Installation of Local Exhaust Ventilation System
Drycleaning Plus
Cincinnati, Ohio
August 25-28 and September 8-11, 1998

Worker or Area ID Number	Pre-Installation Tube Mean PERC Conc (ppm)	Post-Installation Tube Mean PERC Conc (ppm)	% Difference (Pre-Post)(100)/(Pre) (%)	t value	Critical t at 90% Confidence	Critical t at 95% Confidence
DP-01	4 69	2 97	36 7	1 55	1 48	2 02
DP-02	0 29	0 44	-51 7	-1 76	1 48	2 02
DP-03	0 58	0 57	1 72	0 02	1 48	2 02
DP-04	0 62	0 80	-29 0	-0 67	1 48	2 02
DP-05	0 29	0 40	-37 9	-0 62	1 64	2 35
DA-01	1 71	1 46	14 6	1 34	1 48	2 02
DA-02	0 52	0 65	-25 0	-0 62	1 53	2 13

ID = identification
PERC = Perchloroethylene = tetrachloroethylene
ppm = parts PERC per million parts air

Table 4
Comparison of Passive Sampling Badge Mean Perchloroethylene Air Concentrations
Before and After Installation of Local Exhaust Ventilation System
Drycleaning Plus
Cincinnati, Ohio
August 25-28, and September 8-11, 1998

Worker or Area ID Number	Pre-Installation Badge Mean PERC Conc (ppm)	Post-Installation Badge Mean PERC Conc (ppm)	% Difference (Pre-Post)(100)/(Pre) (%)	t value	Critical t at 90% Confidence	Critical t at 95% Confidence
DP-01	4 07	3 10	23 8	1 01	1 48	2 02
DP-02	0 36	0 48	-33 3	0 71	1 48	2 02
DP-03	0 67	0 63	5 97	0 09	1 48	2 02
DP-04	0 66	0 89	-34 8	-1 23	1 48	2 02
DP-05	0 37	0 44	-18 9	-0 52	1 64	2 35
DA-01	1 65	1 31	20 6	1 75	1 48	2 02
DA-02	0 56	0 64	-14 3	-0 30	1 48	2 02

ID = identification
PERC = Perchloroethylene = tetrachloroethylene
ppm = parts PERC per million parts air

Table 5
Real-Time Perchloroethylene Air Concentrations
Drycleaning Plus
Cincinnati, Ohio
August 25, 1998

Time	Min	Avg	Max	STEL	Description of Task or Event
7 40 53	0	17 5	67 7	3 2	Unloading 1st load (30 lb)
7 41 08	67 7	103	172		Loading 2nd load (45 lb)
7 41 23	5	24 9	88 5		
7 41 38	4	7 3	13 8		
7 41 53	2 8	10 4	34 6		
8 27 59	0	0	0 2	4 6	Unloading 2nd load
8 28 14	0	0	0 1		Loading 3rd load (25 lb)
8 28 29	0	36 6	182		
8 28 44	63 9	89 2	182		
8 28 59	27 9	50 9	69 6		
8 29 14	24 7	45 3	82 9		
8 29 29	5 1	18 8	38 1		
8 29 44	1 8	5 5	10 7		
8 29 59	2 2	3 8	7 5		
8 30 14	0 5	1 4	2 7		
8 30 29	0 1	0 8	1 9		
9 22 10	0	52 2	188	5 6	Unloading 3rd load
9 22 25	54 3	107	154		Loading 4th load (10 lb)
9 22 40	7	28 7	98 8		
9 22 55	1 4	2 9	7		
9 23 10	0 1	1 4	2 8		
9 23 25	0	0	0 2		
9 23 55	0	0 1	0 9		
9 24 10	0	4 7	57 8		
9 24 25	0	115	221		
9 24 40	4 9	1	5 1		
10 15 04	0	0	0 5	3 1	Unloading 4th load
10 15 19	0	99 8	190		Loading 5th load (10 lb)
10 15 34	0 2	51 9	96 5		
10 15 49	14 6	5 8	19 3		
10 16 04	0 3	0 2	1		
11 06 28	0	15 3	72 1	1 8	Unloading 5th load
11 06 43	0	18 3	72 1		Loading 6th load (10 lb)
11 06 58	0	4 4	31 8		
11 07 13	0	41 2	154		
11 07 28	0	0	1		

Figure 7
Real-Time Perchlorocthylene Air Concentrations vs Time of Day
Drycleaning Plus, Inc
Cincinnati, Ohio
August 25,.1998

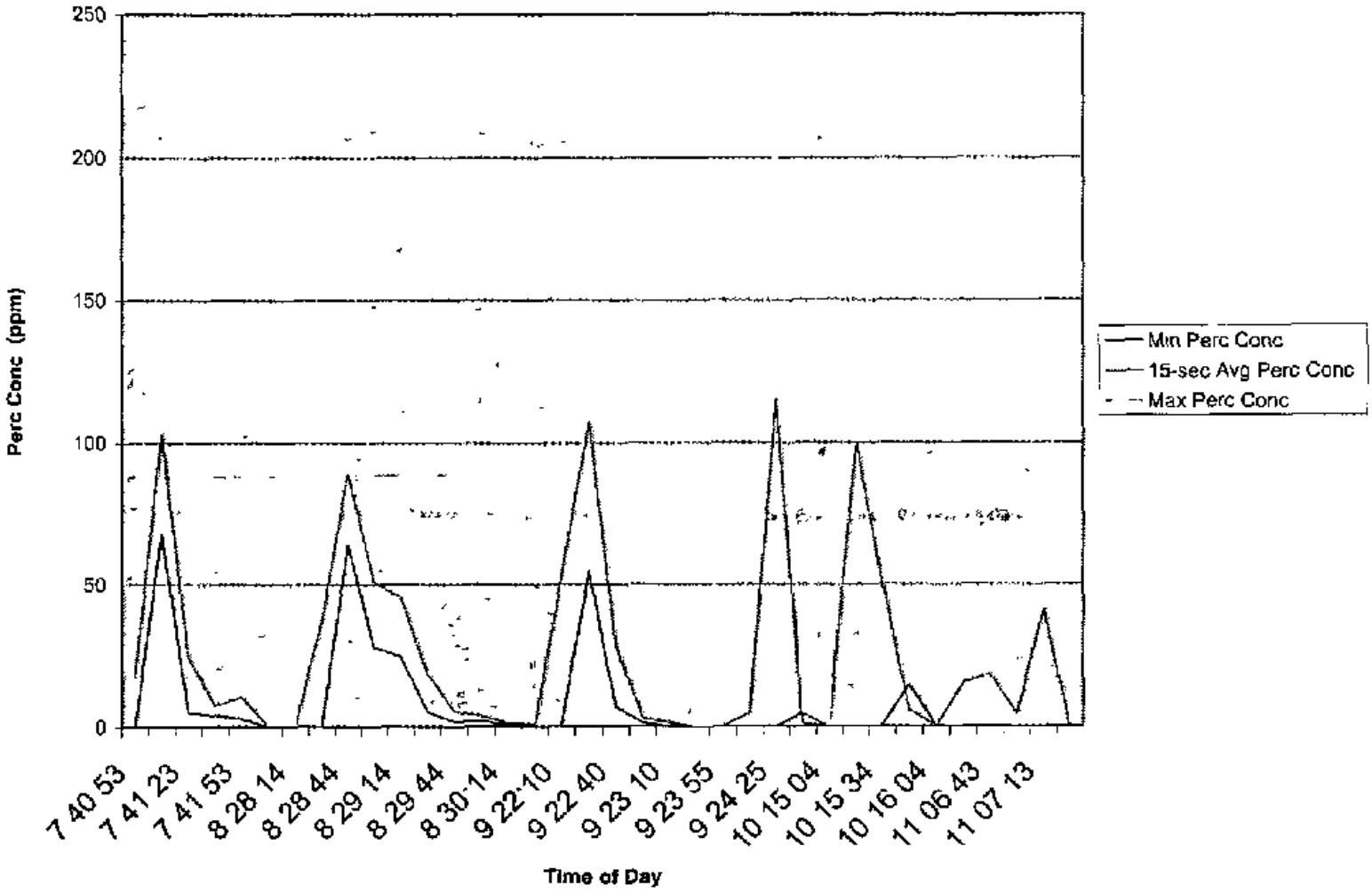

Table 6
Real-Time Perchloroethylene Air Concentrations
Drycleaning Plus
Cincinnati, Ohio
August 26, 1998

Time	Min	Avg	Max	STEL	Description of Task or Event
6 38 38	0	2 4	3 4	23 8	Loading 1st load (30 lb)
6 38 53	2 4	2 5	2 9		
6 39 08	1 7	1 9	2 4		
6 39 23	1 5	1 6	1 7		
6 39 38	1 2	1 3	1 5		
6 39 53	1	1 1	1 2		
6 40 08	0 8	0 8	1		
6 40 23	0 6	0 6	0 8		
6 40 38	0 5	0 5	0 7		
6 40 53	0 6	719	1874		
6 41 08	47 5	224	646		
6 41 23	42 9	281	476		
6 41 38	36 2	110	155		
6 41 53	20 9	44 5	75		
6 42 08	9 5	16 1	25 2		
7 31 01	0	0 9	6 7	5 5	Unloading 1st load
7 31 16	0	69 3	164		Loading 2nd Load (25 lb)
7 31 31	72 4	139	250		
7 31 46	2 5	41 4	182		
7 32 01	1 7	52 2	165		
7 32 16	0	0 3	1 7		
7 32 31	0	0	0		
8 22 57	0	0 6	4 2	9 3	Unloading 2nd load
8 23 12	0	3 4	39 8		Loading 3rd load (30 lb)
8 23 27	39 8	137	204		
8 23 42	15 9	92 4	228		
8 23 57	64 7	223	341		
8 24 12	1 7	76 3	306		
8 24 27	0	0 2	1 7		
8 24 42	0	0	0		
8 24 57	0	0	0		
10 10 25	0	27 2	98 4	0 9	Unloading 3rd load
10 10 40	0	0 2	1 7		Loading 4th load (5 lb)
10 10 55	0	0	0		

Table 6 (cont'd)
Real-Time Perchloroethylene Air Concentrations
Drycleaning Plus
Cincinnati, Ohio
August 26, 1998

Time	Min	Avg	Max	STEL	Description of Task or Event
10 17 25	0	92	377	3 2	Unloading 4th load
10 17 40	0	12 9	42 1		Loading 5th load (10 lb)
10 17 55	1 5	45 5	163		
10 18 10	1 4	15	163		
10 18 25	0 8	1 7	4		
10 18 40	0	0 1	2		

Figure 8
Real-Time Perchloroethylene Air Concentrations vs Time of Day
Drycleaning Plus
Cincinnati, Ohio
August 26, 1998

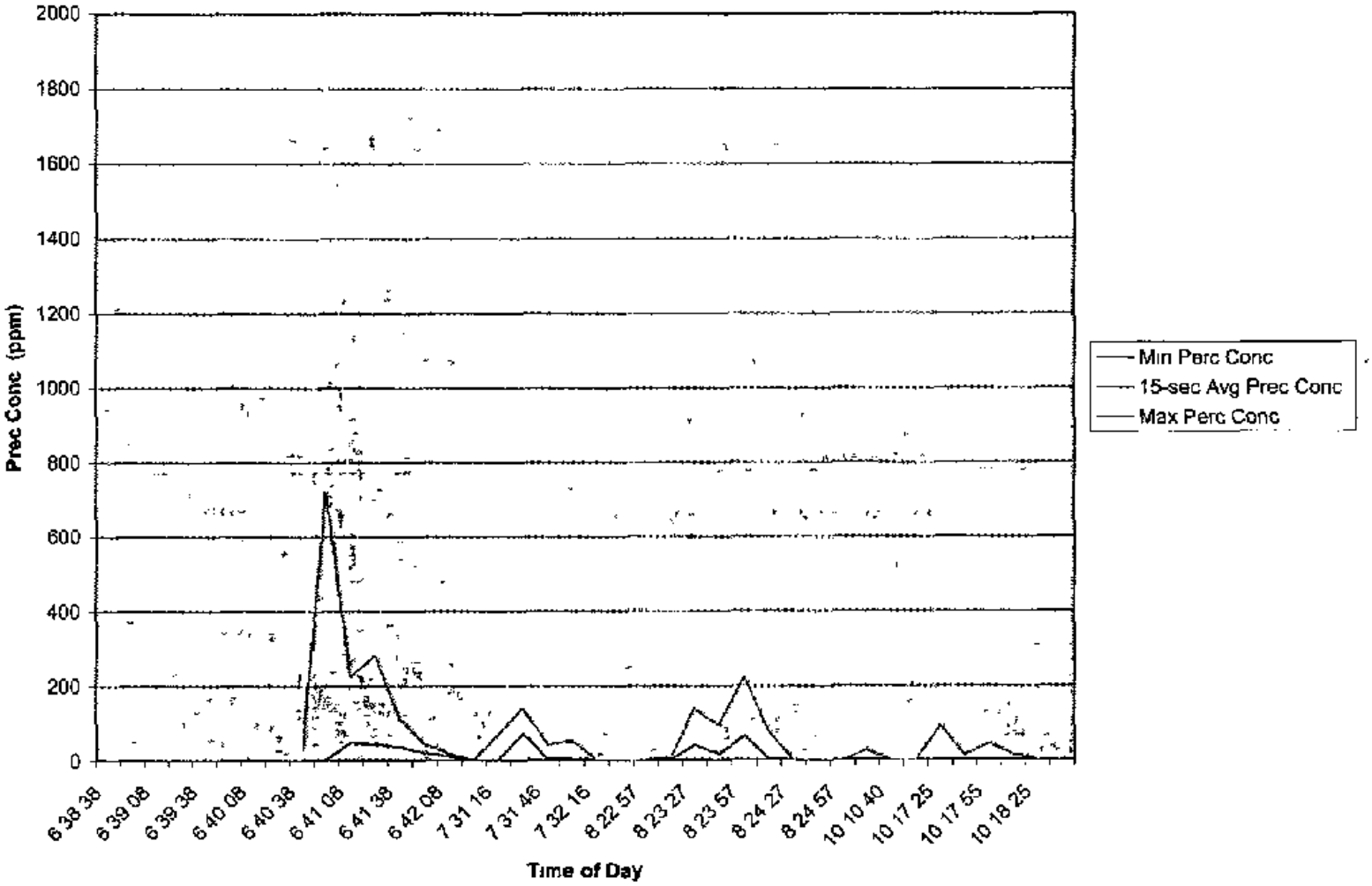

Table 7
Real-Time Perchloroethylene Air Concentrations
Drycleaning Plus
Cincinnati, Ohio
August 27, 1998

Time	Min	Avg	Max	STEL	Description of Task or Event
6 40 03	0	12 1	155	24 6	Loading 1st load (40 lb)
6 40 18	155	1233	2000		
6 40 33	19 9	205	907		
7 30 51	0	1 1	8 7	4 4	Unloading 1st load
7 31 06	0	67 2	342		Loading 2nd load (30 lb)
7 31 21	2 6	54 2	342		
7 31 36	2	10 6	19 9		
7 31 51	6 3	12 7	20 5		
7 32 06	3 8	32 9	55 1		
7 32 21	0 3	5 8	14 7		
7 32 36	6 3	47 3	164		
7 32 51	2 6	9	46 7		
7 33 06	0	1 1	3 2		
8 19 22	0	3	19 7	1 6	Unloading 2nd load
8 19 37	14 9	30 3	43		Loading 3rd load (30 lb)
8 19 52	10 8	26	42 9		
8 20 07	0	5 8	26 8		
8 20 22	0	2 6	8 9		
8 20 37	0	0 4	8 7		
10 02 25	0 2	2	4 1	0 9	Unloading 3rd load
10 02 40	2 3	22 8	52		Loading 4th load (5 lb)
10 02 55	0 5	3 1	7		
10 03 10	0	1	2 4		
10 51 07	0	8	21 5	9 7	Unloading 4th load
10 51 22	0	1	16 8		Loading 5th load (10 lb)
10 53 22	0	6 2	27 7		Cleaning lint and button traps
10 53 37	4 3	72 7	173		
10 53 52	28 9	39 7	69 7		
10 54 07	14 1	89	314		
10 54 22	132	227	381		
10 54 37	19 2	67 5	153		
10 54 52	10 3	32	72 5		
10 55 07	1 3	6 8	13 5		
10 55 22	0 7	8 9	23 1		
10 55 37	0	0	0 7		
10 56 52	0	0 7	2 9		
10 57 07	0	0	0		
11 47 29	0	0 2	2 3	0 5	Unload 5th load

Figure 9
Real-Time Perchloroethylene Air Concentrations vs Time of Day
Drycleaning Plus
Cincinnati, Ohio
August 27, 1998

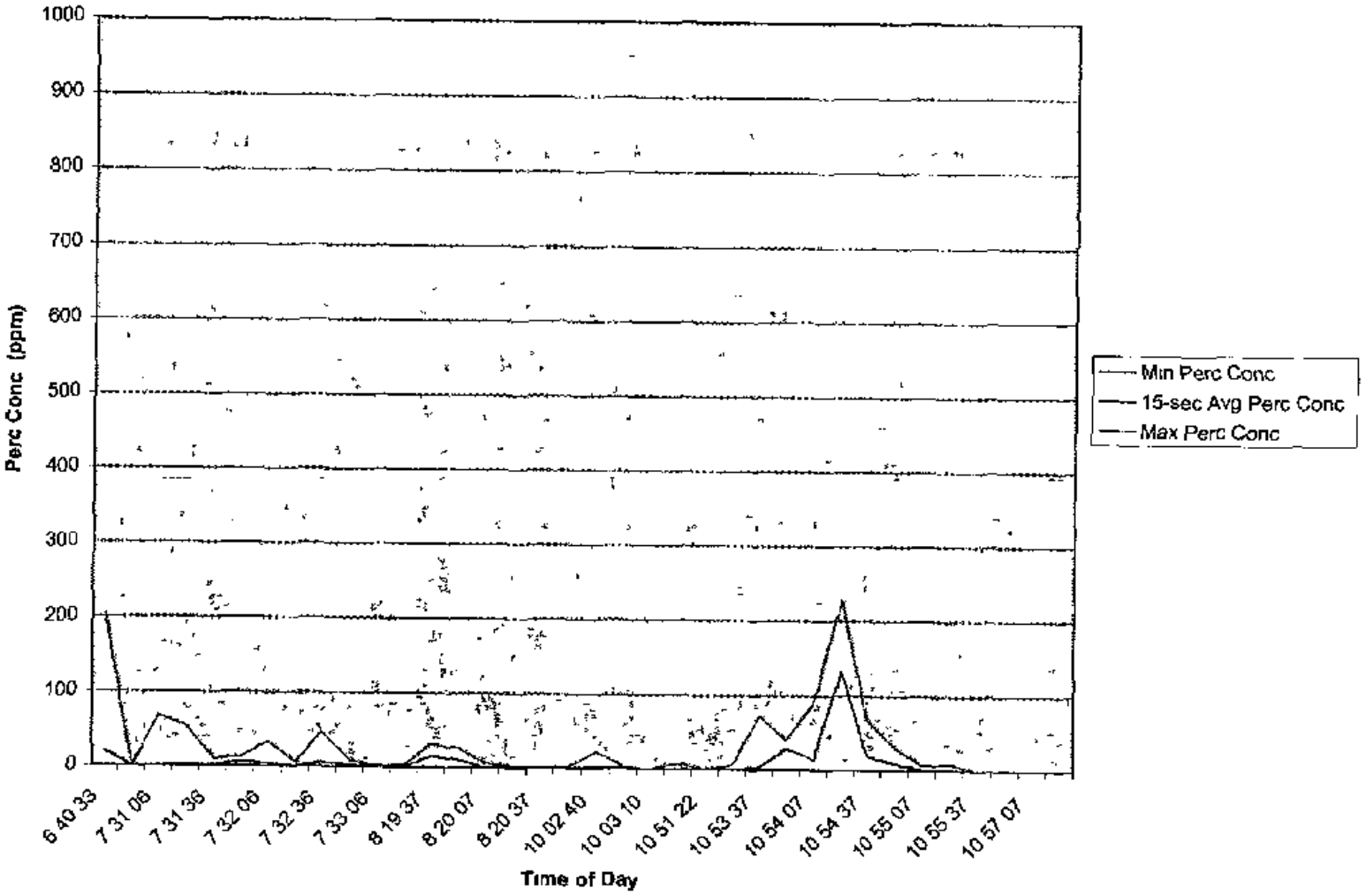

Table 8
Real-Time Perchloroethylene Air Concentrations
Drycleaning Plus
Cincinnati, Ohio
August 28, 1998

Time	Min	Avg	Max	STEL	Description of Task or Event
6 45 05	0	2 3	3 2	13 2	Cleaning lint and button trap
6 45 20	2 3	14 2	38 6		
6 45 35	8 3	29	78		
6 45 50	3 8	8 7	13 5		
6 46 05	6 1	24 3	51 9		
6 46 20	3 1	9 1	21		
6 46 35	8 4	18 8	31 3		
6 46 50	3 8	21 3	90 8		
6 47 05	50 2	200	463		
6 47 20	152	297	595		
6 47 35	46 4	107	255		
6 47 50	6 6	33 4	71 2		
6 48 05	6 6	128	411	7 3	Loading 1st load (20 lb)
6 48 20	15 2	63 4	133		
6 48 35	19 2	37 1	50 1		
6 48 50	19	28 2	40 1		
6 49 05	22 8	63 2	156		
6 49 20	34 6	42 9	48 2		
6 49 35	8	29	45 8		
6 49 50	3 6	7 3	12 1		
6 50 05	3 6	5 7	9		
6 50 20	1 1	4 3	9 9		
6 50 35	0	3	7 2		
7 43 11	0	2 8	10 9	1 5	Unloading 1st load
7 43 41	9 2	33 3	73 8		Loading 2nd load (40 lb)
7 43 41	7 1	20 9	34 7		
7 44 11	0	6	19 3		
7 44 11	0	2 1	15 3		
7 44 26	0	0	0		

Table 8 (cont'd)
Real-Time Perchloroethylene Air Concentrations
Drycleaning Plus
Cincinnati, Ohio
August 28, 1998

Time	Min	Avg	Max	STEL	Description of Task or Event
8 49 50	0	53 6	193	13 4	Unloading 2nd load
8 50 05	63	174	260		Loading 3rd load (5 lb)
8 50 20	9 8	45 8	124		
8 50 35	29	86 4	342		
8 50 50	73 5	187	801		
8 51 05	67 4	125	176		
8 51 20	29	42 6	67 4		
8 51 35	8 5	41 2	56 1		
8 51 50	0	14 3	34 7		
8 52 05	0	8	24 3		
9 49 36	0	2 3	23 2	0 7	Unloading 3rd load
9 49 51	3 9	10 2	23 2		

Figure 10
Real-Time Perchloroethylene Air Concentrations vs Time of Day
Drycleaning Plus
Cincinnati, Ohio
August 28, 1998

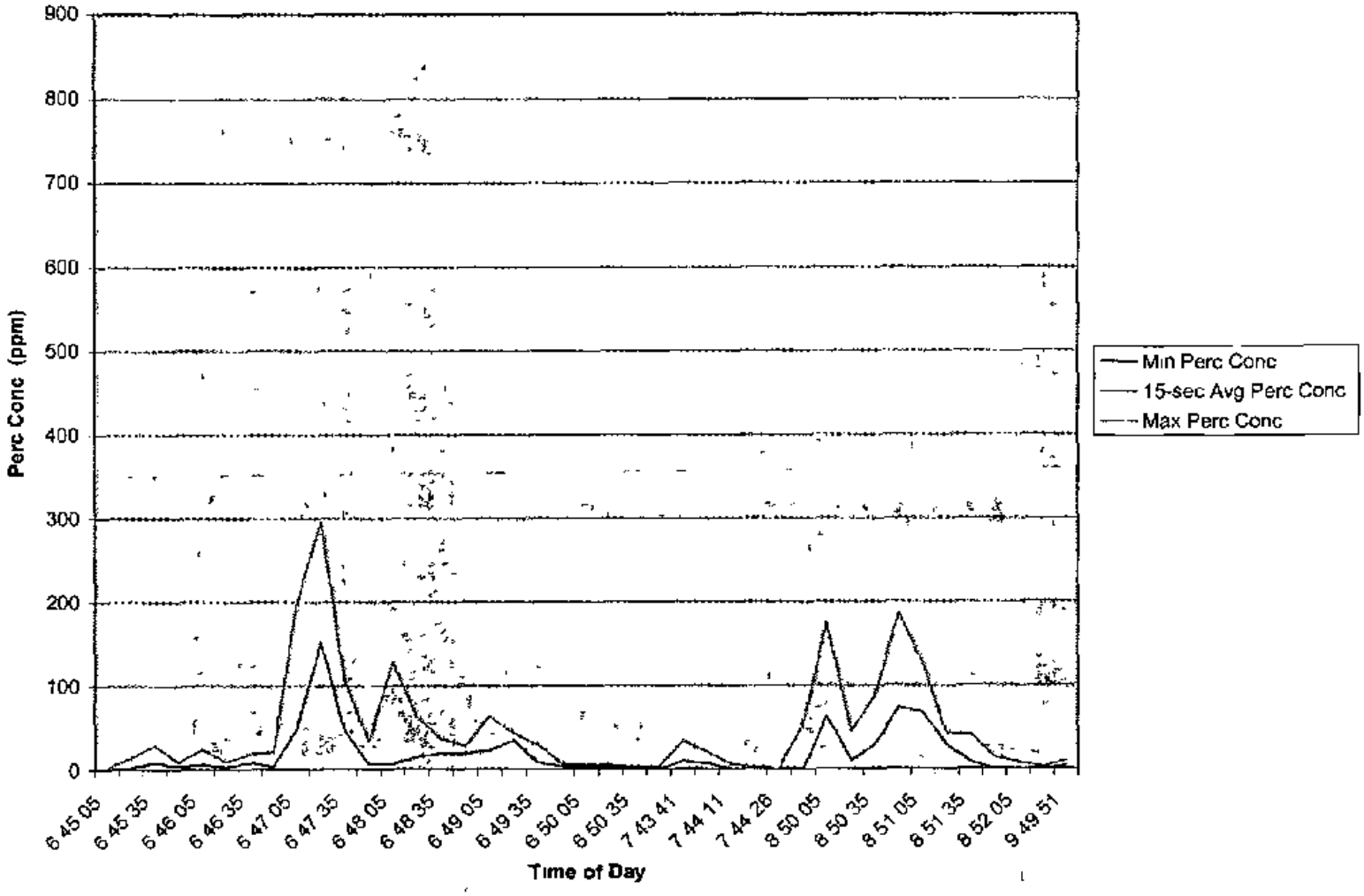

Table 9
Real-Time Perchloroethylene Air Concentrations
Drycleaning Plus
Cincinnati, Ohio
September 8, 1998

Time	Min	Avg	Max	STEL	Description of Task or Event
6 30 41	0 0	16 4	98 1	6 9	Loading 1st load (30 lb)
6 30 56	2 0	63 7	140 0		
6 31 11	71 0	165 0	315 0		
6 31 26	37 2	98 8	157 0		
6 31 41	2 0	26 5	48 7		
6 31 56	1 4	6 5	11 4		
6 32 11	0 0	10 2	37 5		
6 32 26	0 4	2 6	9 8		
6 32 41	0 0	0 2	0 7		
6 32 56	0 0	0 4	1 0		
7 22 43	0 0	7 2	11 9	3 5	Unloading 1st load
7 22 58	1 7	31 2	81 4		Loading 2nd load (25 lb)
7 23 13	31 0	71 2	179 0		
7 23 28	14 6	56 6	179 0		
7 23 43	1 1	2 9	22 2		
7 23 58	0 3	1 2	2 2		
7 24 13	0 0	2 5	13 0		
7 24 28	5 4	3 8	57 4		
7 24 43	0 0	2 4	6 9		
7 24 58	1 4	5 8	15 8		
7 25 13	0 0	0 8	4 0		
8 16 04	0 0	0 2	2 8	3 1	Unloading 2nd load
8 16 19	0 0	54 7	146 0		Loading 3rd load (35 lb)
8 16 34	22 2	65 2	138 0		
8 16 49	5 3	27 8	85 9		
8 17 04	3 7	12 5	85 9		
8 17 19	0 0	1 0	4 2		
10 09 59	0 0	0 0	0 5	1 6	Unloading 4th load (40 lb)
10 10 14	0 0	11 8	30 1		Loading 5th load (5 lb)
10 10 29	11 9	35 7	52 1		
10 10 44	0 0	10 3	33.5		
10 10 59	0 0	0 0	0 6		
11 01 01	0 0	4 3	20 1	0 7	Unloading 5th load
11 01 16	1 7	8 6	17 2		Loading 6th load (20 lb)
11 01 31	0 0	0 2	2 8		

Table 9 (cont'd)
Real-Time Perchloroethylene Air Concentrations
Drycleaning Plus
Cincinnati, Ohio
September 8, 1998

Time	Min	Avg	Max	STEL	Description of Task or Event
11 50 27	0 0	0 0	1 3	1 3	Unloading 6th load
11 50 42	0 0	0 9	3 0		
11 50 57	0 0	11 5	39 1		
11 51 12	1 0	10 0	23 1		
11 51 27	13 5	24 0	63 6		
11 51 42	3 5	6 5	16 2		
11 51 57	0 0	1 5	5 4		
11 53 57	0 0	48 9	141 0	16 3	Cleaning lint and button traps
11 54 12	0 0	9 3	68 9		
11 54 27	0 0	8 4	71 8		
11 54 42	0 0	36 5	284 0		
11 54 57	0 0	153 0	878 0		
11 55 12	29 4	219 0	621 0		
11 55 27	3 7	10 7	29 4		
11 55 42	0 2	50 1	184 0		
11 55 57	25 3	43 2	133 0		
11 56 12	37 7	117 0	219 0		
11 56 27	20 4	91 4	326 0		
11 56 42	33 8	95 8	242 0		
11 56 57	19 5	47 4	100 0		
11 57 12	10 8	20 9	25 5		
11 57 27	0 9	5 5	13 4		
11 57 42	0 0	0 7	1 6		

Figure 11
Real-Time Perchloroethylene Air Concentrations vs Time of Day
Drycleaning Plus
Cincinnati, Ohio
September 8, 1998

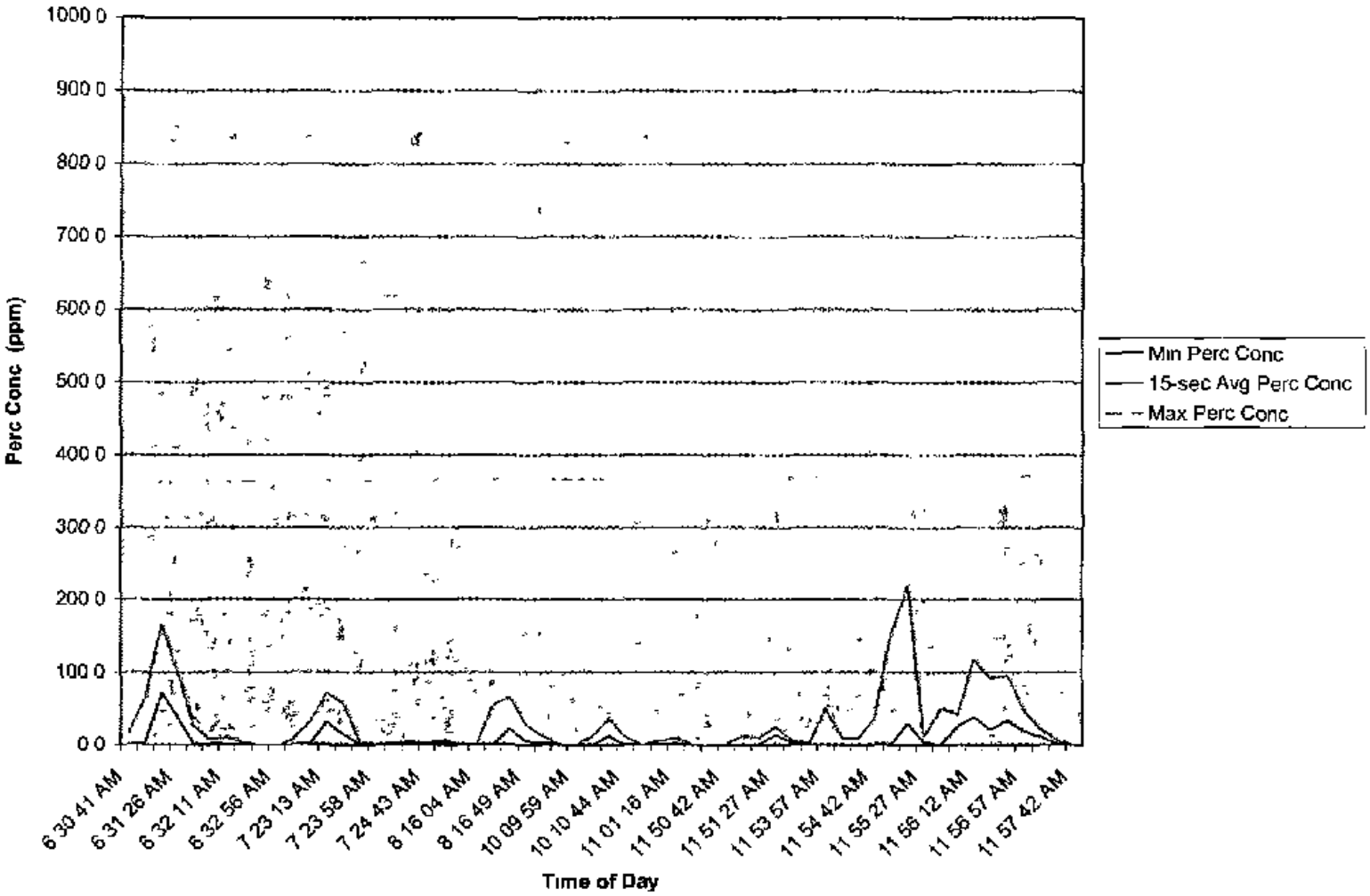

Table 10
Real-Time Perchloroethylene Air Concentrations
Drycleaning Plus
Cincinnati, Ohio
September 9, 1998

Time	Min	Avg	Max	STEL	Description of Task or Event
6 29	0 0	1 1	2 4	4 6	Loading 1st load (30 lb)
6 29	1 3	25 4	212 0		
6 29	5 4	95 2	217 0		
6 30	5 2	96 9	191 0		
6 30	1 9	22 9	122 0		
6 30	0 9	6 0	18 9		
6 30	0 3	0 4	0 9		
6 31	0 1	0 2	0 4		
6 31	0 1	1 2	3 2		
6 31	0 0	0 1	1 7		
7 24	0 0	0 2	1 6	3 3	Unloading 1st load
7 24	0 0	35 1	76 6		Loading 2nd load (20 lb)
7 25	29 3	62 8	105 0		
7 25	38 6	56 7	86 5		
7 25	3 1	15 0	48 4		
7 25	1 6	3 0	5 2		
7 26	0 7	1 0	3 0		
7 26	0 6	1 0	1 7		
7 26	0 1	0 3	1 7		
7 26	0 0	0 0	0 1		
8 16	0 0	0 1	1 5	3 4	Unloading 2nd load
8 16	0 0	20 5	49 7		Loading 3rd load (20 lb)
8 16	22 3	44 9	83 1		
8 16	31 8	65 8	100 0		
8 17	2 6	25 3	72 6		
8 17	4 9	22 1	53 2		
8 17	0 0	0 8	7 7		

Table 10 (cont'd)
Real-Time Perchloroethylene Air Concentrations
Drycleaning Plus
Cincinnati, Ohio
September 9, 1998

Time	Min	Avg	Max	STEL	Description of Task or Event
9 14	0 0	12 1	42 6	5 4	Unloading 3rd load
9 14	38 3	119 0	196 0		Loading 4th Load (40 lb)
9 15	23 5	148 0	348 0		
9 15	0 0	6 6	26 6		
9 15	2 0	13 0	23 1		
9 15	0 0	0 0	2 0		
10 05	0 0	4 3	17 6	2 1	Unloading 4th load
10 05	10 3	40 6	106 0		Loading 5th load (15 lb)
10 06	4 0	32 5	73 7		
10 06	2 8	18 9	58 1		
10 06	0 0	1 8	4 9		
10 06	0 0	0 2	2 0		
11 08	0 0	67 9	277 0	4 1	Unloading 5th load
11 08	12 2	141 0	368 0		Loading 6th load (5 lb)
11 09	0 0	10 9	25 3		
11 09	0 0	0 9	5 4		
11 09	0 0	0 0	0 0		
11 59	0 0	0 9	11 3	0 7	Unloading 6th load
11 59	3 3	12 8	32 4		
11 59	0 0	0 4	5 1		

Figure 12
Real-Time Perchloroethylene Air Concentrations vs Time of Day
Drycleaning Plus
Cincinnati, Ohio
September 9, 1998

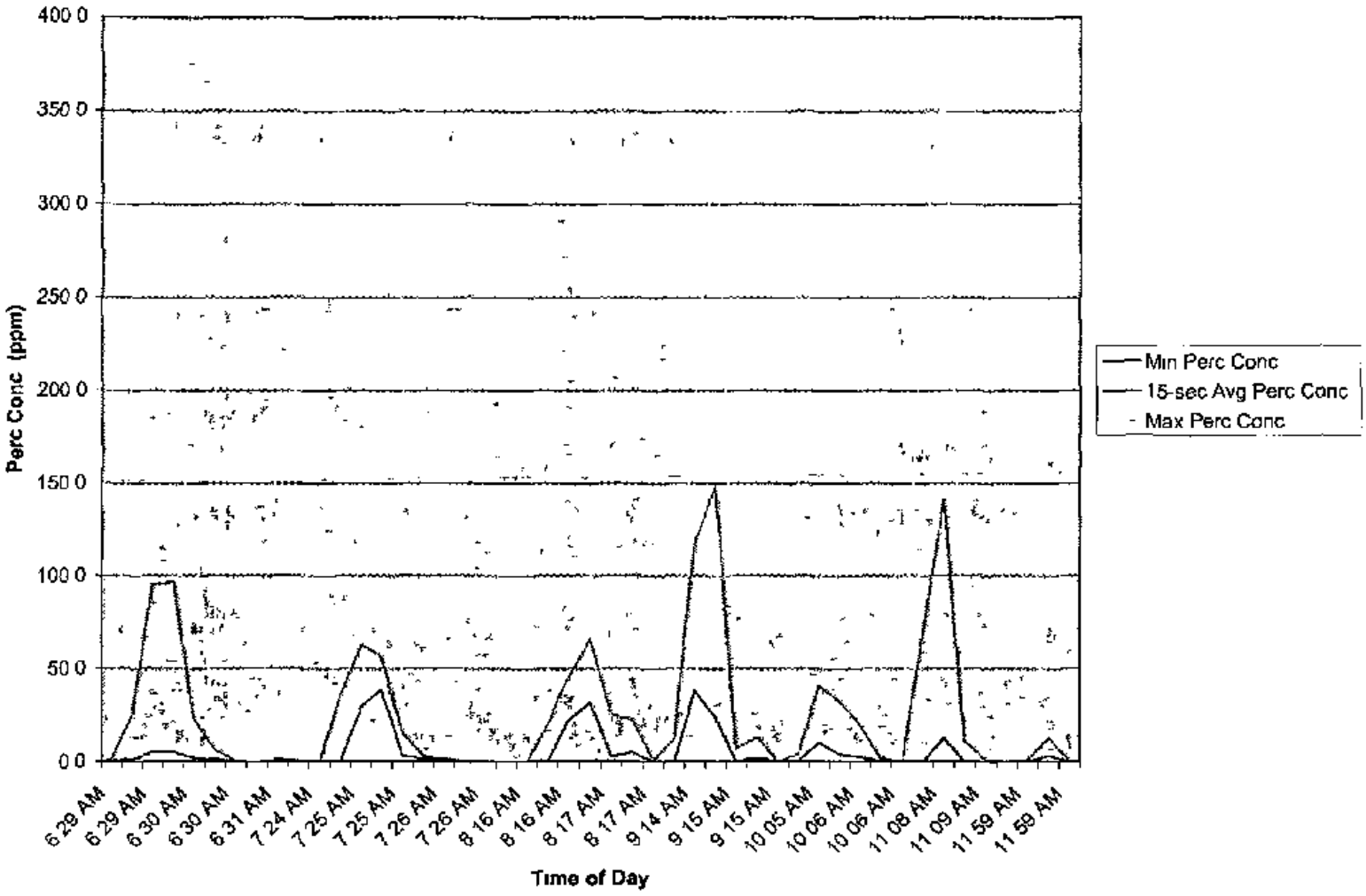

Table 11
Real-Time Perchloroethylene Air Concentrations
Drycleaning Plus
Cincinnati, Ohio
September 10, 1998

Time	Min	Avg	Max	STEL	Description of Task or Event
6 32	0 0	20 6	275 0	8 0	Cleaning lint and button
6 32	43 2	200 0	519 0		traps
6 32	36 8	97 6	384 0		
6 33	0 7	15 1	95 0		
6 33	0 4	59 2	425 0		
6 33	0 2	4 2	45 3		
6 33	0 0	12 9	51 0		
6 34	0 0	6 9	36 3		
6 34	0 5	32 2	81 5		
6 34	0 0	5 6	31 7		
6 40	0 0	0 2	2 2	2 6	Loading 1st load (20 lb)
6 41	0 0	1 3	13 0		
6 41	0 1	47 6	174 0		
6 41	27 9	67 7	174 0		
6 41	0 0	9 2	32 1		
7 32	0 0	18 1	84 2	2 1	Unloading 1st load
7 32	19 8	45 0	77 2		Loading 2nd load (40 lb)
7 33	9 3	23 7	46 5		
7 33	4 0	5 8	9 3		
7 33	1 5	3 0	5 2		
7 33	0 0	1 0	2 7		
9 20	0 0	10 5	47 0	12 9	Unloading 2nd load
9 20	46 3	377 0	868 0		Loading 3rd load (10 lb)
9 20	33 6	184 0	380 0		
9 21	13 3	56 7	174 0		
9 21	23 9	68 6	185 0		
9 21	11 5	23 9	44 1		
9 21	10 7	12 7	16 0		
9 22	5 3	7 3	12 3		
9 22	3 9	5 0	6 0		
9 22	0 0	2 2	5 7		
9 22	0 5	1 7	2 9		

Table 11 (cont'd)
Real-Time Perchloroethylene Air Concentrations
Dryclcaning Plus
Cincinnati, Ohio
September 10, 1998

Time	Min	Avg	Max	STEL	Description of Task or Event
11 01	0 0	7 3	32 7	0 6	Unloading 4th load
11 02	0 0	2 3	17 0		
10 11	0 0	0 2	1 8	1 1	Unloading 3rd load
10 11	0 0	0 0	0 0		Loading 4th load (5 lb)
10 11	0 0	12 3	29 5		
10 12	5 5	22 7	43 8		
10 12	0 0	4 0	17 4		
10 12	0 0	0 2	1 0		
10 12	0 0	0 0	0 1		
11 55	0 0	0 1	1 4	5 1	Loading 5th load (10 lb) after
11 55	0 0	263 0	1207 0		PERC distillation
11 55	0 0	9 2	39 9		
11 55	0 0	4 3	14 6		
11 56	0 0	1 6	13 2		
11 56	0 0	0 0	0 8		
12 49	0 0	0 0	1 3	1 7	Unloading 5th load
12 49	1 3	69 8	184		
12 49	0 0	0 9	9 4		

Figure 13
Real-Time Perchloroethylene Air Concentrations vs Time of Day
Drycleaning Plus
Cincinnati, Ohio
September 10, 1998

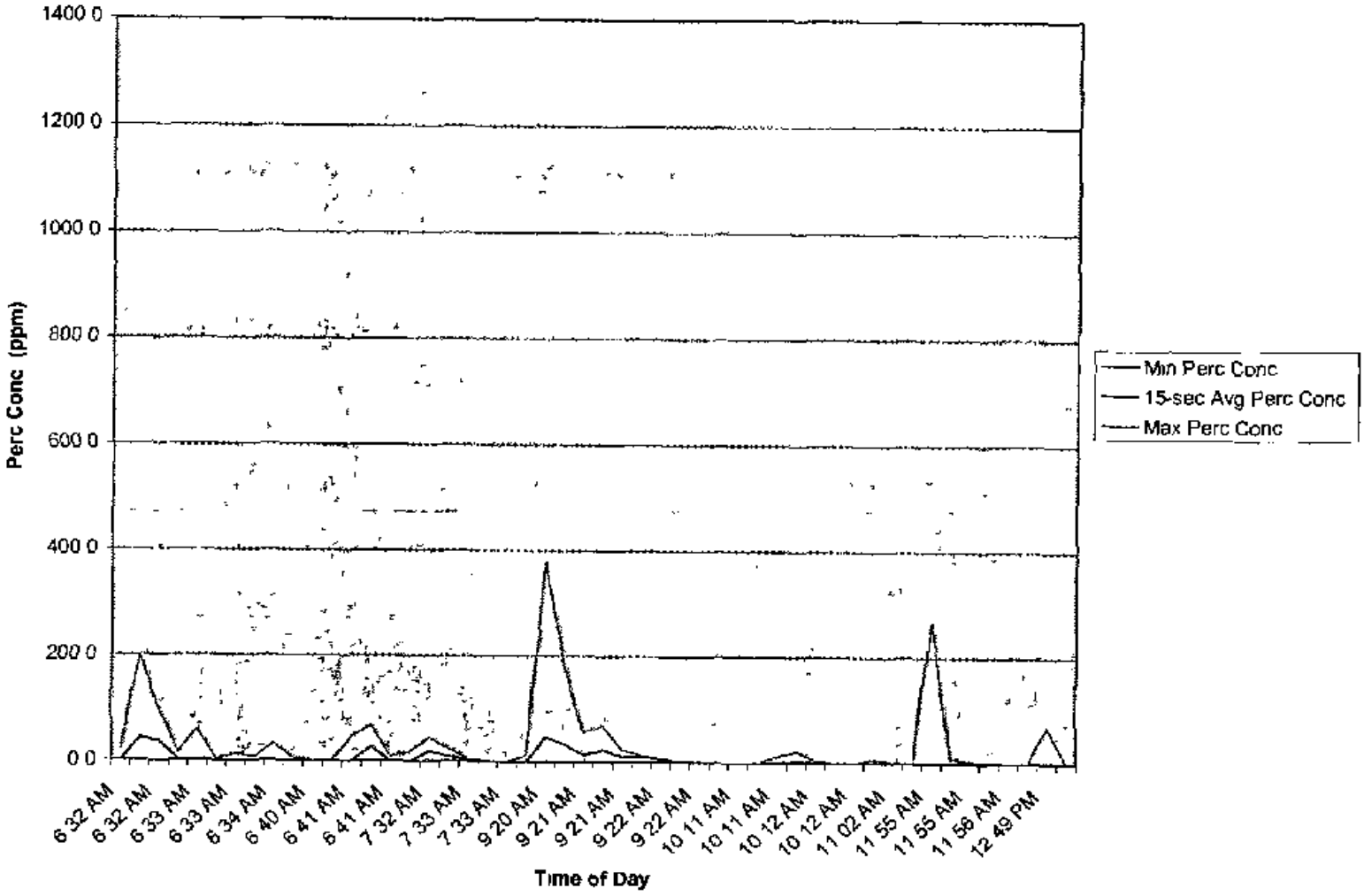

Table 12
Real-Time Perchloroethylene Air Concentrations
Drycleaning Plus
Cincinnati, Ohio
September 11, 1998

Time	Min	Avg	Max	STEL	Description of Task or Event
6 41	0 0	0 0	0 0	10 1	Cleaning lint and button traps
6 41	0 0	4 2	15 5		
6 41	0 5	16 5	67 3		
6 41	20 8	268 0	539 0		
6 42	8 8	37 1	137 0		
6 42	5 3	13 3	20 9		
6 42	2.1	24 2	79 2		
6 42	0 0	2 0	6 2		
6 43	0 0	0 0	0 0		
6 43	0 0	40 9	309 0		
6 43	4 6	73 6	309 0		
6 43	1 2	18 2	104 0		
6 44	0 0	1 1	9 0		
6 44	0 0	3 8	12 1		
6 44	4 3	32 9	82 2		
6 44	4 6	35 8	88 0		
6 45	0 0	15 8	67 2		
6 53	0 0	0 0	0 8	4 0	Loading 1st load (40 lb)
6 53	0 0	142 0	340 0		
6 54	27 2	59 2	186 0		
6 54	0 0	9 0	45 1		
7 44	0 0	53 7	96 1	4 3	Unloading 1st load
7 44	29 4	49 0	75 4		Loading 2nd load (20 lb)
7 44	46 3	81 2	146 0		
7 45	2 1	26 8	68 2		
7 45	1 5	16 2	40 5		
7 45	0 0	6 2	28 7		
9 35	0 0	91 5	414 0	12 0	Unloading 2nd load
9 36	239 0	420 0	810 0		Loading 3rd load (25 lb)
9 36	21 3	123 0	258 0		
9 36	7 1	56 5	196 0		
9 36	1 1	3 4	7 1		
9 37	0 0	0 1	2 3		
9 37	0 0	0 0	0 0		

Table 12 (cont'd)
Real-Time Perchloroethylene Air Concentrations
Drycleaning Plus
Cincinnati, Ohio
September 11, 1998

Time	Min	Avg	Max	STEL	Description of Task or Event
10 33	0 0	0 3	2 9	4 8	Unloading 3rd load
10 33	0 0	0 7	11 4		Loading 4th load (10 lb)
10 34	11 4	48 1	79 9		
10 34	69 7	159 0	219 0		
10 34	13 9	39 6	124 0		
10 34	1 3	3 2	14 2		
10 35	0 0	9 9	44 3		
11 32	0 0	6 1	62 6	1 9	Unloading 4th load
11 32	18 7	75 6	180 0		
11 32	0 0	3 2	22 5		

Figure 14
Real-Time Perchloroethylene Air Concentrations vs Time of Day
Drycleaning Plus
Cincinnati, Ohio
September 11, 1998

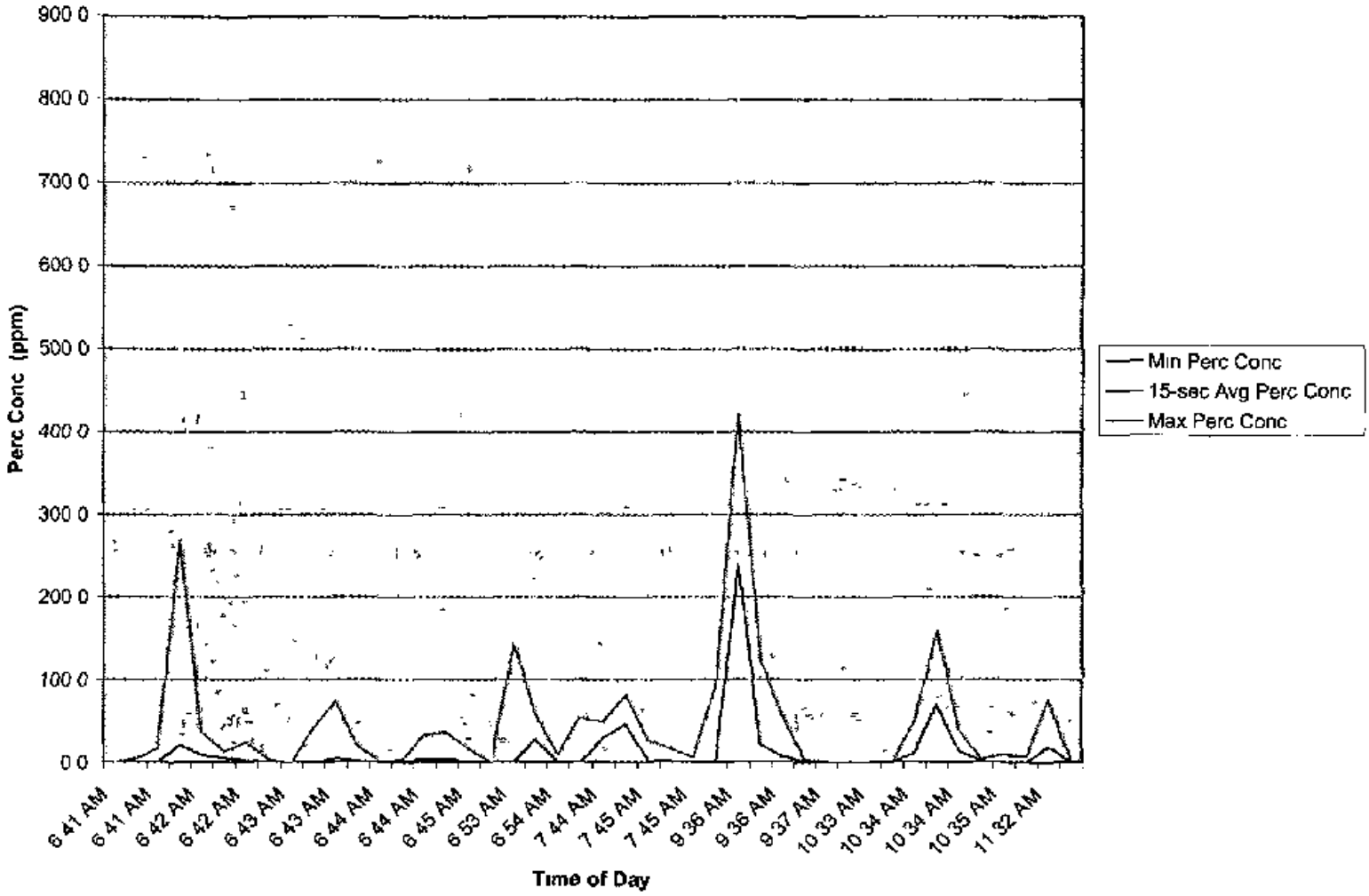

Table 13
Perchloroethylene Worker and Area Air Exposure Concentrations
with Local Exhaust Ventilation System Operating
Drycleaning Plus
Cincinnati, Ohio
January 25-29, 1999

Sample Date	Worker or Area ID Number	Job Description	Sampling Time (min)	PERC Conc (ppm) (tube)	PERC Conc (ppm) (badge)	Mean PERC Conc (ppm) (tube)	Mean PERC Conc (ppm) (badge)
01/25/99	DP-01	Operate machine	367	2 69	3 08L	4 76 (1 84)	4 80 (2 24)
01/25/99	DP-01	Operate machine	367		2 71R		
01/26/99	DP-01	Operate machine	296	4 53	3 78L		
01/26/99	DP-01	Operate machine	296		3 86R		
01/27/99	DP-01	Operate machine	221	4 67	4 14L		
01/27/99	DP-01	Operate machine	221		4 14R		
01/28/99	DP-01	Operate machine	276	21 9	21 5L		
01/28/99	DP-01	Operate machine	276		22 0R		
01/29/99	DP-01	Operate machine	309	7 16	8 51L		
01/29/99	DP-01	Operate machine	309		8 14R		
01/25/99	DA-01	On top of machine	378	2 42	2 45	2 77 (0 63)	2 94 (0 56)
01/26/99	DA-01	On top of machine	307	2 35	3 03		
01/27/99	DA-01	On top of machine	226	2 61	2 58		
01/28/99	DA-01	On top of machine	299	17 8	17 6		
01/29/99	DA-01	On top of machine	342	3 71	3 68		

PERC = Perchloroethylene = tetrachloroethylene
tube = charcoal tube sampler collected using an air sampling pump
badge = passive air sampling badge containing charcoal 575 Series by SKC Inc
ID = identification
NA = not available
ppm = parts PERC per million parts air
( ) = numbers in parenthesis are the standard deviation for the mean value above it
R = right lapel
L = left lapel

Table 13 (con't)
Perchloroethylene Worker and Area Air Exposure Concentrations
with Local Exhaust Ventilation System Operating
Drycleaning Plus
Cincinnati, Ohio
January 25-29, 1999

Sample Date	Worker or Area ID Number	Job Description	Sampling Time (min)	PERC Conc (Ppm) (tube)	PERC Conc (Ppm) (badge)	Mean PERC Conc (Ppm) (tube)	Mean PERC Conc (Ppm) (badge)
01/25/99	DA-02	In middle of store	374	0 67	0 79	0 91 (0 27)	1 11 (0 24)
01/26/99	DA-02	In middle of store	307	1 23	1 34		
01/27/99	DA-02	In middle of store	244	1 03	1 22		
01/28/99	DA-02	In middle of store	298	10 4	10 8		
01/29/99	DA-02	In middle of store	342	0 69	1 10		
01/25/99	DA-03	In front of machine	371	1 67	2 10	2 87 (1 18)	2 60 (0 47)
01/26/99	DA-03	In front of machine	298	3 17	3 22		
01/27/99	DA-03	In front of machine	229	4 38	2 45		
01/28/99	DA-03	In front of machine	292	21 2	21 9		
01/29/99	DA-03	In front of machine	340	2 26	2 62		
01/25/99	DA-04	In front of store	364	0 25	0 63	0 46 (0 16)	0 63 (0 11)
01/26/99	DA-04	In front of store	307	0 62	0 74		
01/27/99	DA-04	In front of store	245	0 46	0 47		
01/28/99	DA-04	In front of store	293	5 54	6 63		
01/29/99	DA-04	In front of store	340	0 52	0 67		

PERC = Perchloroethylene = tetrachloroethylene
tube = charcoal tube sampler collected using an air sampling pump
badge = passive air sampling badge containing charcoal 575 Series by SKC Inc
ID = identification
NA = not available
ppm = parts PERC per million parts air
( ) = numbers in parenthesis are the standard deviation for the mean value above it
R = right lapel
L = left lapel

Table 14
Perchloroethylene Worker and Area Air Exposure Concentrations
with Local Exhaust Ventilation System Not Operating
Drycleaning Plus
Cincinnati, Ohio
February 1-5, 1999

Sample Date	Worker or Area ID Number	Job Description	Sampling Time (min)	PERC Conc (ppm) (tube)	PERC Conc (ppm) (badge)	Mean PERC Conc (ppm) (tube)	Mean PERC Conc (ppm) (badge)
02/01/99	DP-01	Operate machine	341	8 19	8 02L	8 54 (1 22)	8 67 (2 15)
02/01/99	DP-01	Operate machine	341		8 69R		
02/02/99	DP-01	Operate machine	297	9 86	11 9L		
02/02/99	DP-01	Operate machine	297		11 5R		
02/03/99	DP-01	Operate machine	276	17 1	16 6L		
02/03/99	DP-01	Operate machine	276		19 5R		
02/04/99	DP-01	Operate machine	293	7 02	6 61L		
02/04/99	DP-01	Operate machine	293		6 22R		
02/05/99	DP-01	Operate machine	243	9 07	7 03L		
02/05/99	DP-01	Operate machine	243		9 37R		
02/01/99	DA-01	On top of machine	400	4 79	5 14	5 06 (0 55)	5 61 (0 64)
02/02/99	DA-01	On top of machine	336	5 72	6 48		
02/03/99	DA-01	On top of machine	284	20 7	20 1		
02/04/99	DA-01	On top of machine	290	4 47	5 12		
02/05/99	DA-01	On top of machine	261	5 25	5 69		

PERC = Perchloroethylene = tetrachloroethylene
tube = charcoal tube sampler collected using an air sampling pump
badge = passive air sampling badge containing charcoal 575 Series by SKC Inc
ID = identification
NA = not available
ppm = parts PERC per million parts air
( ) = numbers in parenthesis are the standard deviation for the mean value above it
R = right lapel
L = left lapel

Table 14 (cont'd)
Perchloroethylene Worker and Area Air Exposure Concentrations
with Local Exhaust Ventilation System Not Operating
Drycleaning Plus
Cincinnati, Ohio
February 1-5, 1999

Sample Date	Worker or Area ID Number	Job Description	Sampling Time (min)	PERC Conc (ppm) (tube)	PERC Conc (ppm) (badge)	Mean PERC Conc (ppm) (tube)	Mean PERC Conc (ppm) (badge)
02/01/99	DA-02	In middle of store	397	1 26	1 53	1 38 (0 50)	1 63 (0 38)
02/02/99	DA-02	In middle of store	331	2 05	2 14		
02/03/99	DA-02	In middle of store	293	3 52	4 29		
02/04/99	DA-02	In middle of store	290	1 37	1 62		
02/05/99	DA-02	In middle of store	259	0 85	1 24		
02/01/99	DA-03	In front of machine	398	2 67	2 73	3 80 (2 21)	4 72 (2 83)
02/02/99	DA-03	In front of machine	333	7 09	8 93		
02/03/99	DA-03	In front of machine	293	12 6	15 2		
02/04/99	DA-03	In front of machine	291	2 99	3 69		
02/05/99	DA-03	In front of machine	260	2 44	3 56		
02/01/99	DA-04	In front of store	397	0 32	0 58	0 76 (0 47)	0 83 (0 44)
02/02/99	DA-04	In front of store	326	1 36	1 44		
02/03/99	DA-04	In front of store	293	1 36	2 03		
02/04/99	DA-04	In front of store	301	0 88	0 87		
02/05/99	DA-04	In front of store	257	0 47	0 44		

PERC = Perchloroethylene = tetrachloroethylene
tube = charcoal tube sampler collected using an air sampling pump
badge = passive air sampling badge containing charcoal 575 Series by SKC Inc
ID = identification
NA = not available
ppm = parts PERC per million parts air
( ) = numbers in parenthesis are the standard deviation for the mean value above it
R = right lapel
L = left lapel

Table 15
Statistical Comparison of Charcoal Tube Mean Perchloroethylene Air Concentrations with the Local Exhaust Ventilation System Operating and Not Operating
Drycleaning Plus
Cincinnati, Ohio
January 25-29, 1999 and February 1-5, 1999

Worker or Area Number	Mean PERC Conc With LEV On (ppm) (tubes)	Mean PERC Conc With LEV Off (ppm) (tubes)	Percent PERC Conc Reduced (tubes)	t Value	Critical t at 90% Confidence	Critical t at 95% Confidence	Critical t at 99% Confidence
DP-01	4 76	8 54	44 3	3 43	1 64	2 35	4 54
DA-01	2 77	5 06	45 3	5 48	1 64	2 35	4 54
DA-02	0 91	1 38	34 1	1 70	1 64	2 35	4 54
DA-03	2 87	3 80	24 5	0 74	1 64	2 35	4 54
DA-04	0 46	0 76	39 5	1 20	1 64	2 35	4 54

PERC = Perchloroethylene
LEV = local exhaust ventilation
ppm = parts PERC per million parts air
tube = charcoal sampling tube

Table 16
Statistical Comparison of Passive Sampling Badge Mean Perchloroethylene Air Concentrations with the Local Exhaust Ventilation System Operating and Not Operating
Drycleaning Plus
Cincinnati, Ohio
January 25-29, 1999 and February 1-5, 1999

Worker or Area Number	Mean PERC Conc With LEV On (ppm) (badges)	Mean PERC Conc With LEV Off (ppm) (badges)	Percent PERC Conc Reduced (badges)	t Value	Critical t at 90% Confidence	Critical t at 95% Confidence	Critical t at 99% Confidence
DP-01	4 80	8 67	44 6	3 54	1 64	2 35	4 54
DA-01	2 94	5 61	47 6	6 33	1 64	2 35	4 54
DA-02	1 11	1 63	27 4	2 32	1 64	2 35	4 54
DA-03	2 60	4 72	31 9	1 48	1 64	2 35	4 54
DA-04	0 63	0 83	24 1	0 90	1 64	2 35	4 54

PERC = Perchloroethylene
LEV = local exhaust ventilation
ppm = parts PERC per million parts air
tube = charcoal sampling tube
badge = passive sampler badge, SKC 575 Series Passive Sampler

Table 17
Summary of Real-Time Perchloroethylene Air Concentrations
Drycleaning Plus
Cincinnati, Ohio
January 25-29 and February 1-5, 1999

Date	Time of Day	Task Performed	Min PERC Conc (ppm)	Mean PERC Conc (ppm)	Max PERC Conc (ppm)	STEL PERC Conc (ppm)	Task Time (min)	Weight of Load (lbs)	LEV Operation Status
1/25/99	6 44 AM	unload a load from previous day, load 1st load	0 0	14 1	52 8	2 31	2	30	On
1/25/99	7 35 AM	unload 1st load, load 2nd load	0 0	17 9	56 7	1 66	1	35	
1/25/99	9 32 AM	unload 2nd load, load 3rd load	0 0	8 3	40 8	1 02	1	15	
1/25/99	10 20 AM	unload 3rd load, load 4th load	0 1	13 9	59 1	2 29	2	30	
1/25/99	11 11 AM	unload 4th load, load 5th load	0 0	5 8	22 7	0 85	1	30	
1/25/99	12 09 PM	unload 5th load, load 6th load	0 0	14 4	86 6	1 43	1	10	
1/26/99	6 20 AM	clean lint and button traps	0 4	19 4	140 0	4 28	3		On
1/26/99	6 33 AM	load 1st load	0 0	8 7	37 3	1 59	2	20	
1/26/99	7 24 AM	unload 1st load, load 2nd load	0 0	14 6	51 4	1 44	1	30	
1/26/99	8 19 AM	unload 2nd load, load 3rd load	0 0	28 9	103 0	2 39	1	30	
1/26/99	10 00 AM	unload 3rd load, load 4th load	0 0	19 8	73 3	1 79	1	15	
1/26/99	11 13 AM	load 4th load, load 5th load	0 0	5 7	22 7	0 85	1	5	
1/27/99	6 24 AM	clean lint and button traps	0 5	105 0	452 0	14 4	2		On
1/27/99	6 35 AM	load 1st load	0 0	19 8	69 0	1 79	1	30	
1/27/99	7 25 AM	unload 1st load, load 2nd load	0 0	18 9	94 6	1 73	1	30	
1/27/99	8 16 AM	unload 2nd load, load 3rd load	0 0	18 6	103 0	1 71	1	20	
1/27/99	9 12 AM	unload 3rd load, load 4th load	0 0	18 6	131 0	1 71	1	35	
1/27/99	9 59 AM	unload 4th load	0 0	16 4	52 2	1 56	1		
1/28/99	6 32 AM	clean lint and button traps	8 0	22 7	92 4	4 94	3		On
1/28/99	6 35 AM	load 1st load	3 4	32 8	220 0	6 96	3	25	
1/28/99	7 27 AM	unload 2nd load, load 3rd load	9 0	30 1	93 0	6 42	3	30	
1/28/99	8 18 AM	unload 2nd load, load 3rd load	3 2	22 9	55 0	3 49	2	15	
1/28/99	9 15 AM	unload 3rd load, load 4th load	5 7	21 0	199 0	4 60	3	35	
1/28/99	10 05 AM	unload 4th load, load 5th load	6 2	28 7	71 6	8 02	4	5	
1/29/99	6 38 AM	clean lint and button traps	6 6	155 0	384 0	31 4	3		On
1/29/99	6 41 AM	unload drapes from previous day	0 0	198 0	810 0	26 8	2		
1/29/99	6 48 AM	load 1st load	1 0	44 1	213 0	3 41	1	35	
1/29/99	7 40 AM	unload 1st load, load 2nd load	0 0	25 2	90 0	2 15	1	25	
1/29/99	8 32 AM	unload 2nd load, load 3rd load	0 0	23 7	75 3	2 05	1	20	
1/29/99	9 50 AM	unload 3rd load, load 4th load	0 0	10 5	58 2	1 17	1	20	
1/29/99	10 55 AM	unload 4th load, load 5th load	0 0	34 5	136 0	2 77	1	10	

Table 17 (con't)
Summary of Real-Time Perchloroethylene Air Concentrations
Drycleaning Plus
Cincinnati, Ohio
January 25-29 and February 1-5, 1999

Date	Time	Task Performed	Min PERC Conc (ppm)	Mean PERC Conc (ppm)	Max PERC Conc (ppm)	STEL PERC Conc (ppm)	Task Time (min)	Weight of Load (lbs)	LEV Operation Status
2/1/99	7 00 AM	clean lint and button traps	3 7	66 7	339 0	22 6	5		Off
2/1/99	7 15 AM	load 1st load	0 0	49 0	224 0	3 73	1	40	
2/1/99	9 19 AM	unload 2nd load, load 3rd load	0 0	187 0	479 0	12 9	1	35	
2/1/99	10 09 AM	unload 3rd load, load 4th load	12 3	73 6	226 0	10 2	2	40	
2/1/99	11 01 AM	unload 4th load, load 5th load	0 0	10 3	55 3	0 55	1	25	
2/1/99	11 51 AM	unload 5th load, load 6th	0 0	47 9	125 0	3 66	1	30	
2/2/99	6 40 AM	clean lint and button traps	3 4	61 7	217 0	16 8	4		Off
2/2/99	6 56 AM	load 1st load	0 0	69 7	496 0	5 11	1	25	
2/2/99	7 47 AM	unload 1st load, load 2nd load	0 0	61 7	141 0	4 58	1	5	
2/2/99	8 20 AM	unload 2nd load, load 3rd load	0 0	25 7	104 0	3 86	2	30	
2/2/99	9 13 AM	unload 3rd load, load 4th load	0 0	56 1	250 0	4 21	1	30	
2/2/99	9 46 AM	unload 4th load, load 5th load	0 0	75 0	212 0	5 47	1	10	
2/2/99	10 42 AM	unload 5th load, load 6th	0 0	0 9	13 8	0 53	1	10	
2/2/99	11 33 AM	unload 6th	0 0	8 6	125 0	1 04	1		
2/3/99	6 20 AM	clean lint and button traps	0 2	104 0	307 0	14 3	2		Off
2/3/99	6 25 AM	load 1st load	0 0	88 5	392 0	6 37	1	25	
2/3/99	7 15 AM	unload 1st load, load 2nd load	5 7	93 5	187 0	12 9	2	30	
2/3/99	8 05 AM	unload 2nd load, load 3rd load	1 9	41 2	119 0	5 93	2	30	
2/3/99	9 10 AM	unload 3rd load, load 4th load	3 9	199 0	557 0	27 0	2	30	
2/3/99	10 03 AM	unload 4th load, load 5th load	0 0	60 5	170 0	4 50	1	15	
2/4/99	6 20 AM	clean lint and button traps	0 0	16 7	180 0	3 74	3		Off
2/4/99	6 23 AM	load 1st load	0 2	76 1	315 0	10 6	2	20	
2/4/99	7 19 AM	unload 1st load, load 2nd load	0 0	10 9	66 4	1 19	1	40	
2/4/99	8 11 AM	unload 2nd load, load 3rd load	0 0	43 3	116 0	3 35	1	5	
2/4/99	9 58 AM	unload 4th load, load 5th load	0 0	0 0	1 8	0 47	1	5	
2/4/99	10 16 AM	check garment for fading	13 0	61 6	217 0	8 65	2		
2/5/99	6 24 AM	clean lint and button traps	1 6	64 1	257 0	8 98	2		Off
2/5/99	6 34 AM	load 1st load	0 0	55 8	873 0	4 19	1	30	
2/5/99	7 25 AM	unload 1st load, load 2nd load	0 0	80 5	214 0	5 83	1	25	
2/5/99	8 30 AM	unload 2nd load, load 3rd load	0 0	46 7	118 0	3 58	1	30	
2/5/99	9 34 AM	unload 3rd load, load 4th load	0 0	10 8	195 0	1 19	1	5	

STEL = short-term exposure limit
PERC = Perchloroethylene
ppm = parts PERC per million parts air
LEV = local exhaust ventilation

Table 18
Comparison of Short-Term Exposure Limit Real-Time PERC Air Concentrations with the Local Exhaust Ventilation System Operating and Not Operating
Drycleaning Plus
Cincinnati, Ohio
January 25-29 and February 1-5, 1999

Task Description	STEL PERC Conc (ppm) LEV On 1/25/99	1/26/99	1/27/99	1/28/99	1/29/99	Mean STEL PERC Conc (ppm) LEV On	STEL PERC Conc (ppm) LEV Off 2/1/99	2/2/99	2/3/99	2/4/99	2/5/99	Mean STEL PERC Conc (ppm) LEV Off	Percent PERC Conc Reduction
Clean lint and button traps		4 28	14 4	4 94	31 4	13 8	22 6	16 8	14 3	3 74	8 98	13 3	-3 5
Load 1st load	2 31	1 59	1 79	6 69	3 41	3 21	3 73	5 11	6 37	10 6	4 19	6 00	46 5
Unload 1st load, load 2nd load	1 66	1 44	1 73	6 42	2 15	2 68		4 58	12 9	1 19	5 83	6 13	56 2
Unload 2nd load, load 3rd load	1 02	2 39	1 71	3 49	2 05	2 13	12 9	3 86	5 93	3 35	3 58	5 92	64 0
Unload 3rd load, load 4th load	2 29	1 79	1 71	4 60	1 17	2 31	10 2	4 21	27 0		1 19	10 7	78 3
Unload 4th load, load 5th load	0 85	0 85	1 56	8 02	2 77	2 81	0 55	5 47	4 5	0 47		2 75	-2 3
Unload 5th load, load 6th load	1 43					1 43	3 66	0 53				2 10	31 7

STEL = short-term exposure limit
PERC = Perchloroethylene
ppm = parts PERC per million parts air
LEV = local exhaust ventilation

98-03
NIOSH's copy

INTERAGENCY AGREEMENT
BETWEEN
THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION
AND
THE NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

MEMORANDUM OF AGREEMENT

THIS MEMORANDUM SETS FORTH THE TERMS OF AGREEMENT BETWEEN THE DEPARTMENT OF HEALTH AND HUMAN SERVICES, PUBLIC HEALTH SERVICE, CENTERS FOR DISEASE CONTROL, NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH AND U.S DEPARTMENT OF LABOR, OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION

I DESCRIPTION OF SERVICE

The Occupational Safety and Health Administration has funded a study of control technologies for perchloroethylene in the dry cleaning industry to determine the extent of exposure, to gather control and operational information, and to assist in determining technological feasibility of controlling worker exposure to perchloroethylene (Perc)

This study will determine the extent of exposure of employees and control technology in small and medium sized dry cleaning establishments to provide OSHA data to be utilized in determining technological feasibility of controlling worker exposure to perchloroethylene Plants will be selected and data taken to characterize worker exposure levels and control technology for "fourth generation" dry cleaning machines (closed-loop, dry-to-dry machines, with an integrated, in-line refrigerated condenser and a carbon absorber to recover perchloroethylene vapors during the dry cycle) and "fifth generation" machines, having the same features as a fourth generation machine plus an internal monitor / interlock system to prevent door opening at perc concentrations above a set level In addition, local exhaust ventilation will be added to a "third generation" dry-to-dry machine with refrigerated condenser to measure its effect on employee exposure

Exposure and control technology data will be provided to OSHA within 10 months following the effective date of this Agreement The results of this study will be summarized in a written report and raw data will be appended

NIOSH will coordinate the study with any parallel OSHA study to assure consistency of data and to preclude geographical overlap

II DURATION OF AGREEMENT

Agreement will begin upon signature through September 30, 1998

III ESTIMATED COST BY FISCAL YEAR

Estimated cost for this Agreement FY 98

Contract
Direct Costs $38,095
Overhead $1,905
Support
Direct Costs $50,000
Overhead $10,000

Total Costs $100,000

IV PAYMENT TO BE MADE TO

National Institute for Occupational Safety and Health by OPAC system.

Billing should be sent to Mr Gregory Semkoski, Fiscal Officer, Room N-3104, U S Department of Labor (OSHA), 200 constitution Ave , N W , Washington, D C 20210

V REIMBURSING AGENCY LOCATION CODE (TREASURY STATION SYMBOL)

The accounting for this Agreement is FO62-8-$-SYBU-26000-2589-IA0
Agency Location Code is 16-01-2012 Document number W9F80002

VI TRAVEL

Travel under this Agreement is subject to allowances authorized in accordance with the Federal Travel Regulations, Joint Federal Travel Regulations, and/or Foreign Service Regulations

VII EQUIPMENT

Any equipment which is procured in order to provide service will be retained by the National Institute for Occupational Safety and Health

VIII PROJECT OFFICER

Mr Paul Bolon (202-219-5692) for OSHA,
Mr G E Burroughs for NIOSH (513-841-4275)

This Agreement may be canceled within 60 days notice, whereby both parties mutually agree in the cancellation

IX APPROVALS

APPROVED AND ACCEPTED FOR THE CENTERS FOR DISEASE CONTROL AND PREVENTION

BY. _____ 11/14/97
(Signature) (Date)

TITLE Diane D Porter, Associate Director for Management

APPROVED AND ACCEPTED FOR THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION BY.

BY. _____ 11/24/97
(Signature) (Date)

TITLE Acting Director, Directorate of Policy
Occupational Safety and Health Administration

NOTE If the Agreement is of a category needing approval of the Public Health Service (based on PHS General Administration Manual Chapter 8-77-10) or the Department (based on HHS General Administration Manual Chapter 8-77-60), this signature section should be adapted accordingly See the next page for format guidance Contact the Financial Management Office for category guidance

NOTE This agreement is made under the authority of the Economy Act of 1932 as amended (31 U S C 1535 and 1536)

Clearance
FMO, Budget Analyst

_____ Budget Analyst 11/14/97
(Signature) (Title) (Date)