CONTROL OF OCCUPATIONAL HEALTH HAZARDS IN THE DRY CLEANING INDUSTRY

Instructor's Guide

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PREFACE

The course described in this instructor's guide was developed on the basis of an assessment of engineering control technology in the dry cleaning industry. This field study was performed by Arthur D. Little, Inc. for NIOSH and is documented within DHHS(NIOSH) Publication No. 80-136. The subject material has been divided into four units of instruction, but the instructor should feel free to subdivide the material to fit the format in which the material will be taught. The following groups are identified as good recipients of instruction contained in this guide:

1. Dry cleaning industry management.

2. Dry cleaning industry workers.

3. OSHA compliance and consultation staff.

4. Manufacturers of dry cleaning equipment.

5. Students studying engineering, industrial hygiene, and environmental health.

On November 22, 1982 a pilot presentation of the course was given which was graciously hosted by the International Fabricare Institute in Silver Spring, Maryland. Twenty-three individuals reviewed the course including representatives from the dry cleaning industry, two trade associations, the government, and two universities. Thanks are due to the participants in the pilot session who prepared written critiques and helped shape the content of the course. Special thanks are also due to the following individuals who served as technical reviewers:

1. Ralph Allan, University of California, Irvine.

2. Paul Caplan, NIOSH.

3. William Fisher, International Fabricare Institute.

4. Eric Frumin, Amalgamated Clothing and Textile Workers Union.

5. Mervyn Sluizer, Institute of Industrial Launderers.

Finally, it is with very fond memories that this guide is dedicated to the memory of Donald E. Hurley who served as the NIOSH Project Officer on the field study. Mr. Hurley passed away suddenly in February of 1981. His efforts and interest in worker protection in the dry cleaning industry are acknowledged and will be remembered by all who knew and worked with him.

ABSTRACT

This manual contains instructor's information for a training module covering the engineering control of occupational health hazards in the dry cleaning industry. The intended primary audience for the course is the dry cleaning facility operator, who is responsible for developing and implementing solutions to occupational health hazard problems. The purpose of this course is to teach the principles and concepts behind engineering control through evaluation and discussion of in-place and functioning control measures from industry. Before control measures are discussed, basic dry cleaning processes are briefly described along with air contaminant hazards and their sources. Maintenance and monitoring of control system performance is also discussed in addition to housekeeping and personal protection.

Instructor's materials include this manual, 35 mm slides, and student outlines. To simplify preparation, all of the slides have been incorporated into this manual.

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UNIT I--INTRODUCTION TO THE DRY CLEANING INDUSTRY

Methods	Lecture	Length: 60 minutes
Purpose	To introduce the course and briefly describe the dry cleaning industry and its occupational health hazards	
Objectives	To enable the participant to understand the sources of occupational health hazards in the dry cleaning industry	
Instructor Materials	35 mm slides 35 mm projector	
Training Materials	Course outline	

INTRODUCTION TO THE DRY CLEANING INDUSTRY

OBJECTIVE AND SCOPE

The purpose of this course is to present the principles of occupational health hazard control technology in the dry cleaning industry. The discussion will include identification of control measures and discussion of the considerations which determine the ultimate effectiveness of health hazard control measures. However, this is not a course in engineering design of control systems. Therefore, design calculations and factors will be kept to a minimum. Detailed design information is covered in other available courses and in the literature.

An understanding of the principles of health hazard control requires prior knowledge of the sources of air contaminants and of their properties. These issues will be discussed prior to addressing the application of control measures. However, no attempt will be made to provide a complete list of all potential air contaminant hazards or of their toxic effects and permissible exposure limits. This course will cover all categories of engineering control measures.

Air contaminant control cannot be discussed as a separate and distinct consideration. Air contaminant control in dry cleaning plants is interrelated with, among other things, control of heat stress and safety hazards such as fires. In some cases, control of these potential hazards will be discussed so that the interrelationships may be better understood.

In many cases, the problem with implementing effective engineering control measures is not limited to devising and installing measures which have the potential for effective control; the problem extends to maintaining the performance of both process and control equipment over long periods of time. Maintenance and monitoring of control system parameters will be discussed.

This course includes some background information on the dry cleaning process that may be unnecessary for those familiar with the industry. The Course discusses controls at a level that those familiar with industrial hygiene may find to be basic. Users of this material are encouraged to adjust their emphasis as best suits their needs.

INDUSTRY OVERVIEW

"Dry cleaning" is the process of removing soil from garments and other items (such as draperies, shop towels, etc.) through the use of a non-aqueous solvent. This process is utilized in commercial (retail) dry cleaning establishments, industrial dry cleaning firms (such as those doing high-volume cleaning of uniforms), and in coin-operated machines found within some coin laundry facilities. Dry cleaning solvents are generally classified as "petroleum" (i.e., Stoddard solvent and other combustible hydrocarbon solvents) and "synthetic." Perchloroethylene is the most widely utilized synthetic solvent, with a limited amount of trifluorotrichloroethane (Fluorocarbon 113) used as an alternative synthetic solvent.

The dry cleaning process is a batch process which involves the washing of work by immersion in solvent, extracting (in a spin cycle) solvent from the cleaned items, and drying ("tumbling") the damp items with warm air. In most commercial perchloroethylene facilities, the washing and extraction steps are carried out by a single machine (Figure I-1), and damp material is then manually transferred to a "tumbler" for drying. This is known as the "transfer" process. Some newer commercial equipment (Figure I-2) performs all three steps in one machine (referred to as the "dry-to-dry" process), eliminating the handling of solvent-laden clothing. All coin-operated dry cleaning equipment is "dry-to-dry," while industrial units are both transfer-type (Figure I-3) and dry-to-dry. Some industrial equipment (as well as a few very old commercial units) requires two clothing transfers since washing, extraction, and drying are done in three separate machines. This double transfer process is characteristic of petroleum solvent dry cleaning equipment.

There are currently approximately 25,000 commercial dry cleaners in the United States, and an estimated 75% of these establishments utilize perchloroethylene. Of the remaining commercial cleaners, most employ petroleum solvents while a small number utilize fluorocarbon solvent exclusively. Some larger cleaners utilize both fluorocarbon solvent and perchloroethylene. More than 80% of

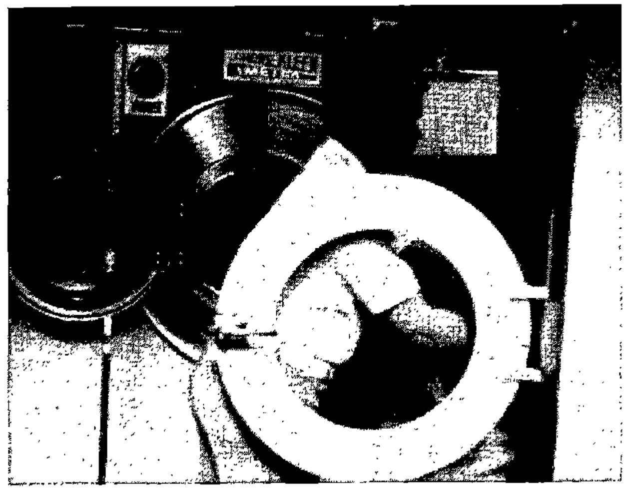

Figure I-1. Garment transfer (commercial plant).

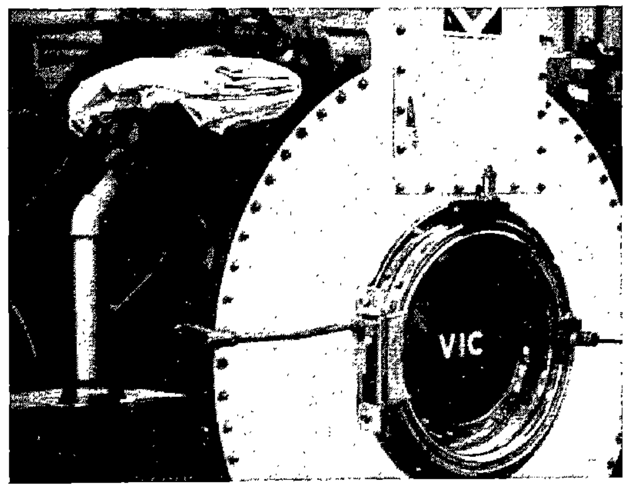

Figure I-2. Dry-to-dry machine.

Figure I-3. Industrial transfer.

existing perchloroethylene equipment is of the transfer design, while the remainder employs the newer dry-to-dry design. The average commercial dry cleaner has fewer than 10 employees.

The distinction between transfer and dry-to-dry installations is important in considering employee exposure to perchloroethylene. The profile of cleaning machine operator exposure levels during the processing of one batch of garments in transfer equipment can be represented by Figure I-4. This figure indicates that a relatively low background level of perchloroethylene is maintained during most of the 20-minute cleaning cycle; however, when damp garments are manually transferred from the washer to the tumbler, a short duration exposure peak occurs. The use of dry-to-dry equipment eliminates this transfer step and the machine operator's exposure level is more uniform throughout the day.

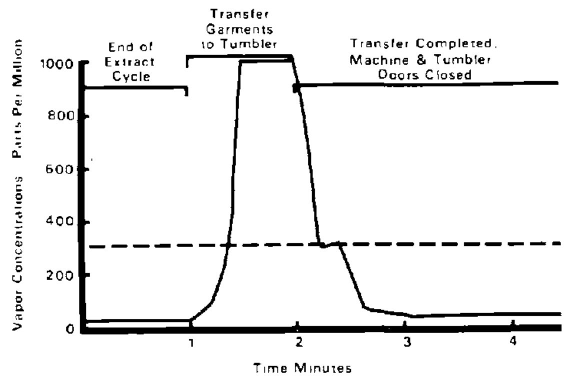

Figure I-4. Typical solvent vapor concentration in operator's breathing zone during a cycle.

That segment of the laundry and dry cleaning industry that services uniform rental businesses and other wholesale clients is referred to as the "industrial" segment (Figure I-5). There are more than 1,000 industrial cleaning and laundry establishments. The average industrial launderer

Figure I-5. Industrial plant.

employs approximately 50 workers; however, no more than 5 of these employees will typically be engaged in the handling of solvent-laden garments and the routine maintenance of equipment.

The coin-operated, or coin-op, segment of the dry cleaning industry includes those self-service facilities that offer dry cleaning with or without laundry service. At most of these facilities, an attendant is present to assist customers in utilizing the equipment (as well as to provide security and perform routine facility cleaning and maintenance). This attendant is exposed to the low background levels of solvent that are present around dry-to-dry equipment.

PROCESS OVERVIEW

In each commercial or industrial dry cleaning plant, several discrete operations are performed. (In coin-op establishments, only dry cleaning and solvent treatment are done.) Each of these operations will be described in the following section.

SPOTTING

"Spotting" involves the selective application of chemicals, steam, detergent, and/or water to loosen or remove specific stains from soiled garments. Spotting is sometimes done prior to dry cleaning (pre-spotting), but may also be necessary following the dry cleaning step to remove stubborn stains. Depending upon the size of the dry cleaning plant and the nature of the dry cleaning process, spotting can require a full-time employee; however, this step is usually handled by the dry cleaning machine operator. Industrial dry cleaning plants seldom use spotting operations.

Figure I-6. Spotting chemicals in plastic squeeze bottles.

The chemicals typically utilized by spotters include chlorinated solvents, amyl acetate, bleaching agents, acetic acid, aqueous ammonia, oxalic acid, hydrogen peroxide, and dilute hydrogen fluoride solutions. These chemicals generally are applied from plastic squeeze-bottles (Figure I-6) and are then either rubbed into the fabric with a brush, a spatula, or by hand, allowed to soak into the fabric (which is subsequently handled), or flushed with steam applied from a steam gun. Thus, employees engaged in spotting may be exposed to toxic materials through both skin contact with liquids and inhalation of airborne vapors and mists. However, the problem of inhalation exposures is minimized by the small amount of time that an employee is typically engaged in spotting, the small quantity of chemicals used, and the intermittent nature of this operation.

DRY CLEANING

Dry cleaning is a process during which batches of clothing and/or other materials are immersed in solvent and agitated within a horizontally mounted cylinder. This "washing" step is followed by a spin cycle to extract solvent and a drying operation to evaporate any remaining solvent from the damp work. Most equipment employing petroleum solvents combines the washing and extraction steps in a single machine, with a manual transfer (Figure I-7) of damp items necessary prior to the drying (tumbling) step. Some older petroleum machinery involves three separate units: one for washing, a second for extraction, and a third for drying. This three-step process requires two manual transfers of items, the first of which necessitates handling items which are "wet" with solvent.

Figure I-7. Transfer operation.

Most commercial perchloroethylene equipment involves the use of two machines (shown schematically in Figure I-8), the first to wash and extract, and the second to dry. As with petroleum solvents, this "transfer" equipment requires the manual handling of damp items. Some perchloroethylene equipment combines the washing, extraction, and drying steps into a single unit. This type of equipment, known as "dry-to-dry", is utilized by a relatively small percentage of commercial dry cleaners; the need for larger capacity units to achieve production comparable to that of a transfer plant (due to longer residence of a load in a dry-to-dry machine) has limited its spread.

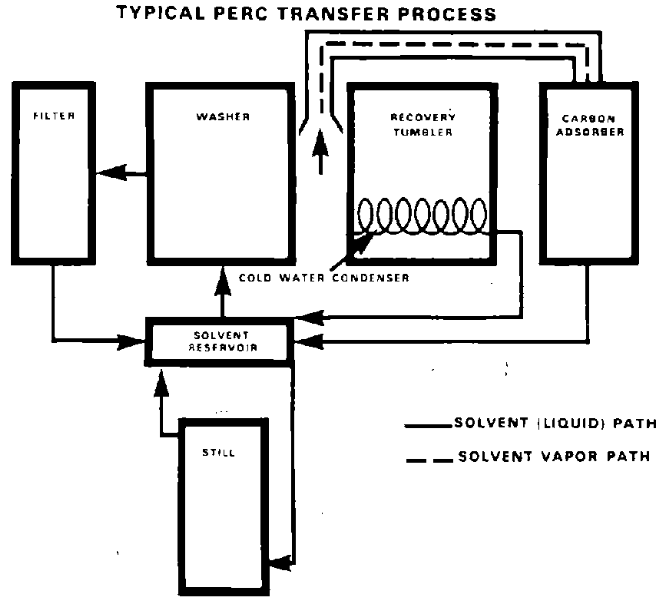

Figure I-8. Schematic diagram of dry cleaning process.

Fluorocarbon 113 equipment is exclusively of the dry-to-dry type. This design is necessary with fluorocarbon 113 since the solvent is both highly volatile and costly. In order to make fluorocarbon 113 economically competitive with perchloroethylene, the fluorocarbon 113 solvent manufacturer has established a program of machine certification which requires that a certified unit meet stringent criteria on solvent loss rates. The small extent of dry cleaning market penetration by fluorocarbon 113 is usually attributed to the need for this expensive special equipment.

Because of the different physical and chemical properties of the commonly used solvents, machinery designed for use with any one solvent cannot be used with any other solvent. As a result, switching among solvents rarely occurs at any plant (although some larger plants will have equipment for, and use, two different solvents for different types of work).

GARMENT FINISHING

The term "finishing" is employed in the dry cleaning industry to indicate the "pressing" of cleaned and dryed work to remove wrinkles and restore each garment to its original size, shape, and appearance. Pressing equipment is heated with super-heated (roughly 300°F) steam, and pressers may be exposed to elevated heat levels throughout their work shifts. In addition, the application of heat during the finishing step will drive off any residual solvent from the cleaned work, so that pressers may be exposed to solvent vapor.

SUPPORTING ACTIVITIES

Dry cleaners undertake several activities to maintain the purity of the cleaning solvent. During normal retail operation, solvent is continuously filtered. The filter medium typically consists of either a series of wire mesh strips coated with diatomaceous earth or of a replaceable filter cartridge. Periodically, the filter medium must be replaced. Where cartridge filters are utilized, they must be drained and discarded, a process which often results in excessive employee exposures to residual solvent. Where diatomaceous earth is employed, the filter medium is removed from its "muck" carrier by a back wash system, by air bubbling, or by mechanical agitation. The collected filter medium is then either discarded (presenting a handling problem) or, as is usually done at perchloroethylene plants, is "cooked" to recover solvent from the filter "muck." Most dry cleaners also employ distillation to purify their solvent, and many perchloroethylene dry cleaners use activated carbon adsorbers to recover solvent from washer and dryer exhaust lines and from general plant air.

HAZARD OVERVIEW

Cleaning Solvents Used

There are three alternative solvents used in the United States for dry cleaning. Perchloroethylene is most commonly used, and offers the advantages of being (1) recoverable through carbon adsorption and distillation, and (2) not flammable. Stoddard solvent is combustible and a recovery tumbler for Stoddard solvent has only become available in recent years; however, Stoddard solvent has been available for many years at relatively low cost. A fluorochlorocarbon (Trichlorotrifluoroethane, or Fluorocarbon 113) is also used to a limited extent, but it is expensive and requires special equipment.

Perchloroethylene

Commonly known in the industry as "perc", perchloroethylene is used by an estimated 75% of retail dry cleaning establishments, 50% of industrial dry cleaning plants, and 99% of coin-op locations. Perc is a colorless liquid which has a distinctive odor and boils at 250°F (i.e., slightly above the boiling temperature of water). Perc is not flammable, but it can decompose in a fire and produce toxic and irritating chemicals (such as hydrogen chloride, and under unusual circumstances phosgene).

Exposure to high levels of perc vapor can rapidly cause dizziness, eye irritation and tearing, lightheadedness and incoordination, headaches, and other central nervous system effects. In animal tests, exposure to perc vapor for prolonged periods has caused liver damage. The National Cancer Institute has found that perc caused liver cancer in laboratory mice, but has not reached any conclusions about the possibility that prolonged perc exposure could cause cancer in humans.

The current OSHA standard for worker exposure to perc is 100 parts of perc vapor per million parts of air (ppm) averaged over an eight-hour day. OSHA permits, during the day, a ceiling concentration of 200 ppm with a maximum peak above the ceiling of 300 ppm for five minutes in any three hours, as long as the 100 ppm eight-hour average is not exceeded.

NIOSH has published a recommended standard for perc of 50 ppm averaged over a full day's work shift (up to ten hours) with a permissible ceiling averaged over a 15-minute period of 100 ppm. NIOSH has also published a Current Intelligence Bulletin in which, based on the unresolved issues of cancer risk laboratory tests, NIOSH concludes that "it is prudent to handle tetrachloroethylene (perchloroethylene) in the workplace as if it were a human carcinogen."

Stoddard Solvent

Stoddard solvent is a colorless liquid with a kerosene-like odor which boils at a temperature of 300-390°F. It is a combustible liquid with a flash point of 102-140°F, and must be handled with attention to its flammability. Storage permits from local fire marshalls or fire departments are often needed for Stoddard solvent.

Stoddard solvent can be irritating to the eyes, nose, and throat, and can cause dizziness at high levels after brief exposures.

The OSHA standard for worker exposure to Stoddard solvent is 500 ppm averaged over an eight-hour day. NIOSH has published a recommended standard of 60 ppm averaged over a full work shift (up to 10 hours) with a maximum permissible ceiling level of approximately 300 ppm averaged over a 15-minute period.

Trichlorotrifluoroethane
(Fluorocarbon 113)

Fluorocarbon 113 is a colorless liquid which evaporates rapidly at normal temperatures and boils at 118°F. This solvent has few recognized health hazards, and is not flammable (although it can decompose if heated in a fire and produce toxic and irritating vapors). At very high concentrations, fluorocarbon 113 can cause throat irritation and feelings of drowsiness.

The current OSHA standard for Fluorocarbon 113 is 1000 ppm averaged over an eight-hour work shift.

Sources of Cleaning Solvent Exposure

The dry cleaning machine operator generally is exposed to the highest concentration of solvent within each plant. One major source of direct employee exposure to solvent vapor is the transfer of cleaned work. Transfer usually is done manually, and typically involves holding items wet or damp with either petroleum or synthetic solvents directly in the employee's breathing zone. Manual transfer of wet items also results in skin contact with the dry cleaning solvent. Most dry cleaners should be able to comply with OSHA's current permissible exposure levels of 100 ppm perchloroethylene or 500 ppm Stoddard solvent over an 8-hour time-weighted average; however, manual transfer operations result in employee exposures which can exceed the peak allowable concentration (300 ppm) specified by OSHA in 29 CFR 1910.1000 for perchloroethylene. Furthermore, it is unknown how many dry cleaners currently meet the lower exposure levels recommended by NIOSH for perchloroethylene and Stoddard solvent.

There are several solvent emission sources compounding the employee exposures which occur during garment transfer operations. Among the common sources of solvent emissions are leaking washer and tumbler door gaskets (see Figure I-9), tumbler aeration dampers, lint trap and button trap doors, improperly operating water separators, and pump gaskets. These emission sources are generally indicative of inadequate maintenance programs; however, they highlight the

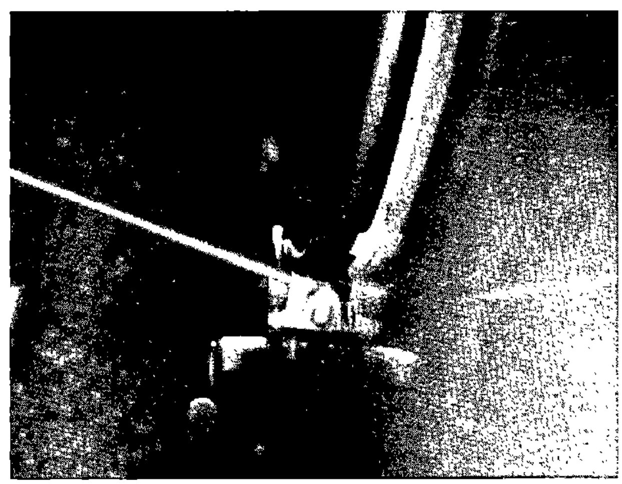

Figure I-9. Door gasket with gap.

need for equipment design that minimizes routine maintenance requirements.

Another source of emissions is the premature removal of garments from the drying cycle. This problem may result from attempts to shorten the cycle for increased productivity or from the presence of solvent-retaining items such as comforters.

Exposures can also occur in the techniques used by dry cleaners to maintain their solvent purity. There are many potential leak points (gaskets, joints, etc.) in the still itself, and misadjustment of the still's water separator can result in the presence of solvent in open-top wastewater containers. Perchloroethylene stills have another potential emission source: the still's relief vent is often located inside the plant building, and may discharge small quantities of air saturated with perchloroethylene vapor.

When activated carbon adsorbers are utilized and the carbon bed is not regenerated properly by steam stripping, significant quantities of solvent may be emitted through discharge which is sometimes within the plant (Figure I-10).

Figure I-10. Adsorber discharging solvent-laden steam into a plant.

Muck cooking can result in significant solvent emissions since the cooker itself contains gaskets which may leak and, if the cooking process is not properly carried out, large amounts of residual solvent may escape into the plant environment when the cooker is opened. Cleanout of "muck" (residual solids) can result in some skin exposure to solvents due to residual solvent in the muck.

An additional source of solvent emissions is solvent spills, which may result from the sloppy transfer of solvent from collection buckets to the solvent reservoir, or from equipment failure.

Other Exposures

As previously noted, spotters can be exposed to a variety of chemicals, but the exposures tend to be brief, intermittent, and represent a small part of the work day. In addition, some dry cleaning workers (particularly pressers) can be exposed to relatively high heat and humidity. However, these exposures are generally within levels recommended by the

American Conference of Governmental Industrial Hygienists.

DISCUSSION QUESTIONS

1. Newer dry cleaning equipment incorporates the dry-to-dry design which eliminates garment transfer. If this equipment were to replace all existing equipment, solvent exposure problems in the dry cleaning industry would be eliminated. Agree or disagree, and explain your answer.

2. Which tasks in a dry cleaning plant are most likely to involve worker exposure to solvent vapor?

3. Because garment transfer may take an accumulated total of only 10 minutes daily, it presents little problem from an occupational health viewpoint when compared with a full-time task like pressing.

ANSWERS

1. Solvent exposure can arise from many of the operations performed in dry-to-dry plants, such as distillation and muck cooking. "Fugitive" emissions from leaks and spills are also a problem in dry-to-dry plants.

2. Garment transfer and muck clean-out are two tasks with particular solvent exposure potential.

3. The dose of solvent received depends on both the exposure duration and level. Transfer involves very high levels for short times. Pressing involves very low levels for long times. The significance of exposures during transfers is greater than that of pressing, particularly because there is a recommended ceiling on allowable exposure levels.

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UNIT OVERVIEW

UNIT II--CONTROL THROUGH LOCAL EXHAUST VENTILATION

Method	Lecture	Length: 40 minutes
Purpose	To describe local exhaust ventilation and its uses in the dry cleaning plant	
Objectives	To enable the participant to understand the need for and uses of local exhaust ventilation and recognize important factors relating to local exhaust system effectiveness	
Instructor Materials	35 mm slides 35 mm projector	
Trainee Materials	Course outline	

CONTROL THROUGH LOCAL EXHAUST VENTILATION

ADVANTAGES OF CONTROL AT THE SOURCE

Local exhaust ventilation is the type of control system that provides exhaust at the point(s) from which solvent will escape. The intention of local exhaust ventilation is to capture the air contaminant most efficiently and effectively.

A major advantage of local exhaust is that it captures an emission where the contaminant is most concentrated (i.e., before it is diluted by room air). This means that the least amount of exhaust air must be used, and the amount of exhaust air moved is directly related to the energy cost of the system.

Handling an emission while it is concentrated also results in more efficient operation of solvent recovery systems. Both carbon adsorption systems and refrigeration-based recovery systems are able to recover a much higher percentage of the solvent in a stream of air containing a high solvent concentration than in a stream of air containing a low solvent level.

Another important advantage of local exhaust ventilation is that it can capture the solvent emission before the solvent reaches the air which an employee is breathing (the employee's "breathing zone"). Because some dry cleaning workers are often in close contact with emission sources (e.g., during garment transfer), a local exhaust approach which captures the evaporating solvent quickly and pulls it away from the worker is important.

Finally, local exhaust ventilation is advantageous in that it prevents solvent emissions from becoming diluted and spread throughout the plant, which would unnecessarily increase the "background" solvent levels to which every employee is exposed.

INTEGRAL EXHAUST SYSTEMS

The design of dry cleaning washers and dryers which provides for air exhausted through the machine doors into the machines when the doors are open is an example of local exhaust ventilation. This exhaust airflow keeps solvent vapors present within the machines from escaping into the room, and provides a draft of clean air over garments being removed from the machines. As Figure II-1 shows, this serves to keep solvent vapor away from the operator's breathing zone.

Although the value of machine exhaust has been recognized for many years (and is required by state regulations in Michigan), many times poor installation will compromise the performance of this approach. The effectiveness of exhaust will depend upon the duct systems to which the machines are connected, a subject addressed in greater detail in the next section.

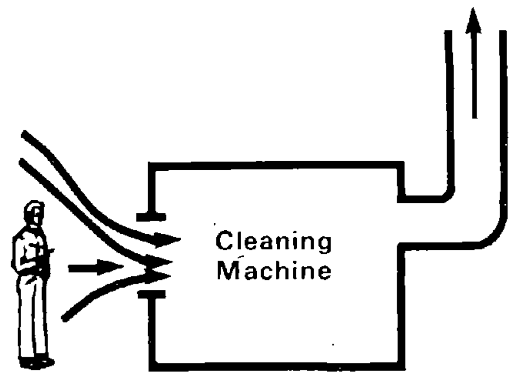

Figure II-1. Airflow from machine floor exhaust.

LOCAL EXHAUST HOODS

Exhaust hoods of various types can be provided to capture vapors and carry them away from the breathing zone at places where emissions are known to, or likely to, occur. The most common locations of this type are the garment transfer area and the muck cooker clean-out door.

Control of Transfer Emissions

During garment transfer, the handling of damp work results in a brief but intense exposure to the operator, and this exposure is responsible for most of the cumulative exposure during a work day (see Figure II-2). The use of a local exhaust hood can significantly reduce the operator's exposure if the hood is properly designed.

For many years, the widely accepted design within the industry for collection of transfer emissions was the placement of a pick-up duct at floor-level (see Figure II-3). This design was the standard installation provided with carbon adsorption units, and was based upon the belief that perc vapor, being 5.7 times heavier than air, would sink to the floor. However, it is not physically possible to have an atmosphere (at normal temperature and pressure) containing more than approximately 8.6% perc (if more were present, it would condense and form droplets--in other words, 8.6% perc in air is like having a relative humidity of 100%). When 8.6% perc is present in air, this perc-air mixture is 1.4 times heavier than air; however, this mixture contains 86,000 ppm perc. A very potent 5,000 ppm perc-air mixture is only 1.02 times heavier than air, and with this small difference the tendency for settling to the floor is overpowered by normal room air currents. Thus, it is illogical to assume that a perc concentration which is of interest

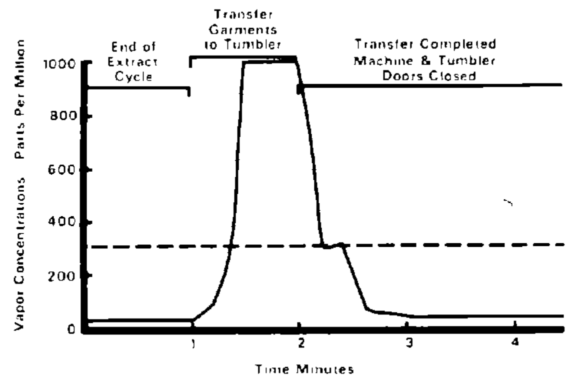

Figure II-2. Typical solvent vapor concentration in operator's breathing zone during a cycle.

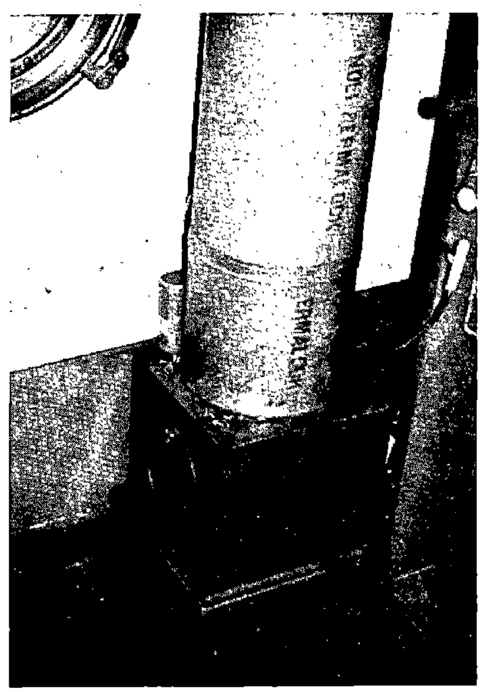

Figure II-3. Typical floor pick-up for carbon adsorber.

from an occupational health perspective (i.e., 100-300 ppm) will settle to the floor.

The logical place to locate a local exhaust hood is in the area where the initial emission originates. In the case of garment transfer, this is between the washer and dryer, at the level at which garments are carried. Figures II-4 and II-5 show several examples of this placement, and Table II-1 indicates the lower exposures received during transfer when an elevated hood is used.

The design of exhaust hoods is a subject to which many sophisticated engineering concepts may be applied. However, in the control of dry cleaning transfer emissions, good results are obtained when the simplest concepts are employed, and these concepts are not always recognized. You should not assume that the sheet metal contractor hired to install ductwork is familiar with the principles of good ventilation design.

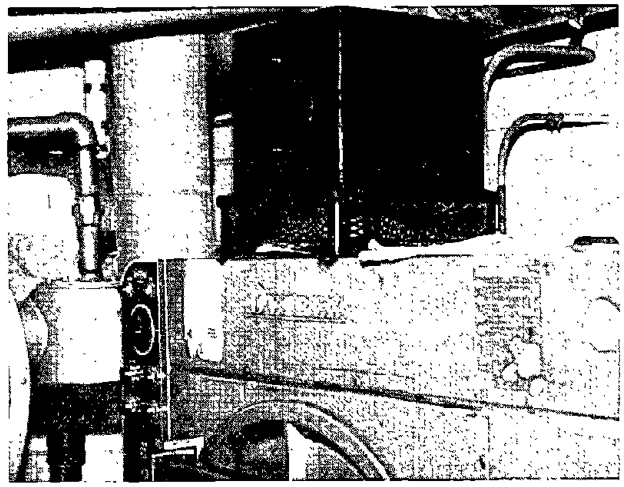

Figure II-4. "Floor" pick-up placed above machine.

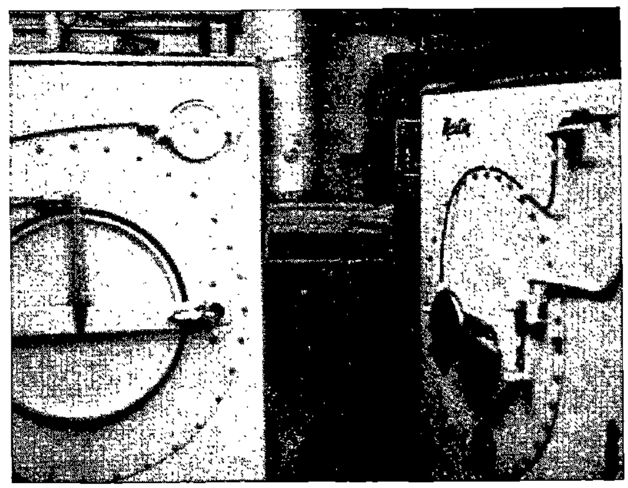

Figure II-5. Exhaust pick-up placed between washer and dryer.

Avg. Level During Transfers:

Floor Pick-up	55 ppm
4 Ft. Pick-up	32 ppm

Table II-1. Vapor levels during transfer.

One important consideration is that exhaust air should be drawn from the direction of the solvent emission. As Figure II-6 indicates, when a typical exhaust trunk (a square duct terminating in an open grate on four sides) is modified to draw exhaust from the direction of solvent emission, the tripling of face velocity results in a substantial reduction in ceiling exposure level during transfer (Table II-2).

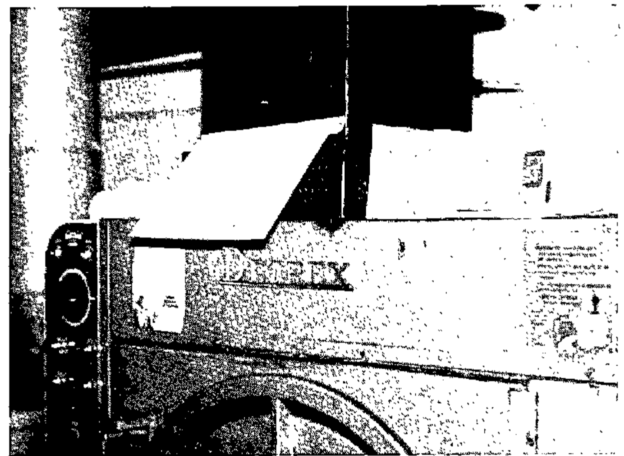

Figure II-6. Pick-up modified with baffle.

Another factor to be considered is that a slot-type design is more effective than a larger hood face since, with equal volumes of exhausted air, the slot results in higher capture velocity. As Figure II-7 shows, capture velocity (the air flow velocity into the exhaust system) drops off rapidly with distance from the hood, and a higher face velocity results in a larger zone within which the exhaust system can capture vapor.

Level During Transfers:

Old Design:	**16-43 ppm**
Modified:	**4-9 ppm**

Table II-2. Vapor levels during transfer.

The area which is to be controlled lthrough local exhaust ventilation should be isolated from strong air drafts. Room air currents (such as drafts from make-up air blowers) can interfere with the flow of contaminated air into the exhaust system.

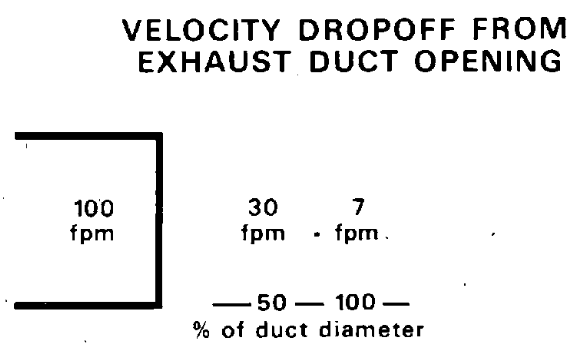

Figure II-7. Drop in capture velocity with increasing distance from exhaust pick-up.

Flanges are a useful method of enhancing the effectiveness of slot hoods. Because a flange design (such as that shown in Figure II-8) reduces the interferences and turbulence caused by back drafts, a flange improves hood capture effectiveness.

Duct systems connecting local exhaust hoods to exhaust fans (with or without adsorbers) and outlets should be designed to properly distribute exhaust through the various branches. Air in a ventilation system will tend to "prefer" to flow through the path of least resistance, and the resistance presented by each leg of a ventilation system depends upon the duct size and length, angles of connection with other (main) ducts, and number of elbows. In a system where a 2" diameter duct is tapped into a 12" diameter duct at a 90% junction (see Figure II-9), one would expect virtually no airflow through the 2" branch. However, where a 12" duct has a 6" branch connected at a 30° angle and reduces to a 8" main (see Figure II-10), some of the air will be drawn from each branch. Designing a ventilation system so that airflows are naturally distributed in the desired pattern is an exercise which should be referred to ventilation engineers; however, the

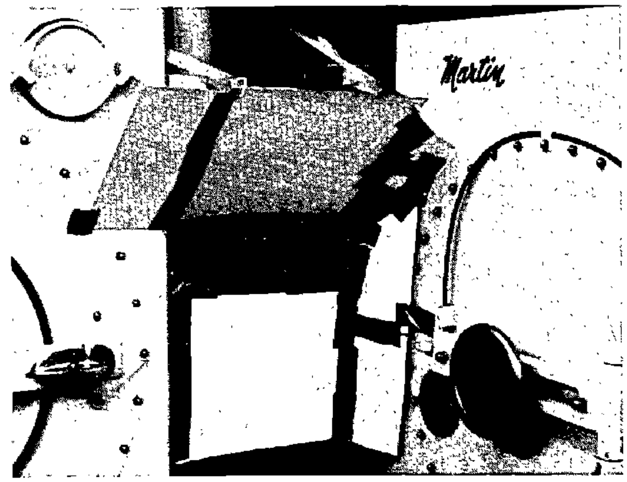

Figure II-8. Flanged pick-up between machines.

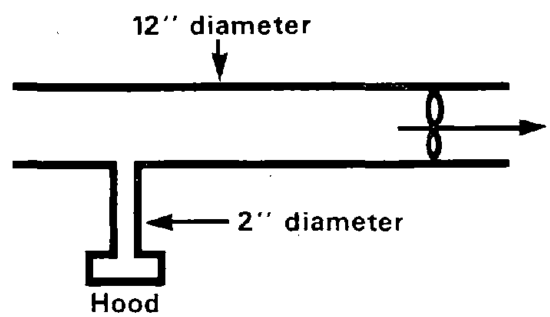

Figure II-9. Example of poor duct sizing.

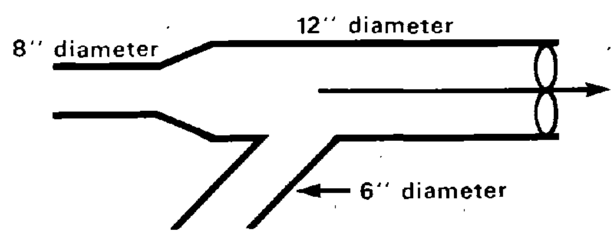

Figure II-10. Example of good duct connections.

use of in-line dampers allows one to adjust flows in various lines (balancing the system) after installation of the system. Some general rules to follow in evaluating a ventilation system without becoming involved in detailed design are:

- Junctions should be made at small angles (30° is preferred) (see Figure II-11).

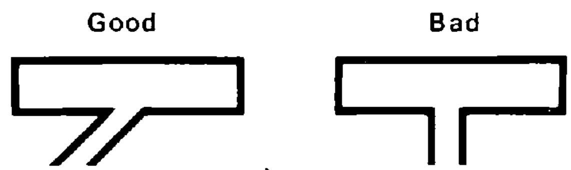

Figure II-11. Ductwork junctions.

- When a duct size is reduced, the reduction should be tapered (not as shown in Figures II-12, II-13, and II-14).

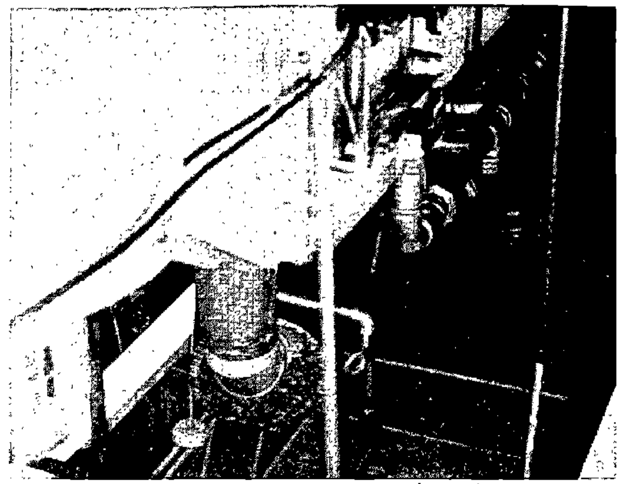

Figure II-12. Poor ductwork - abrupt diameter change (head-on view).

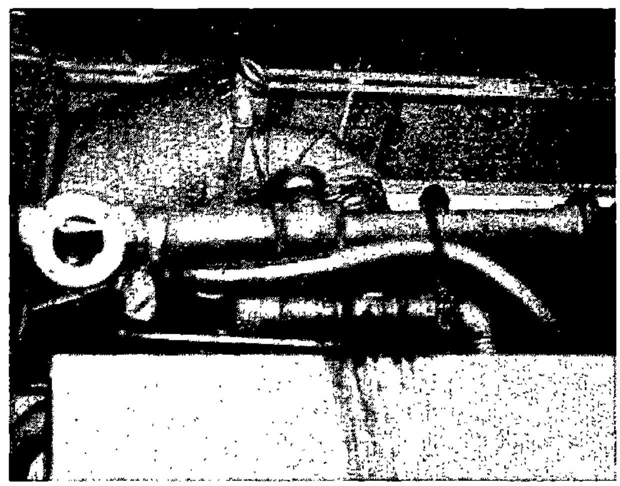

Figure II-13. Poor ductwork - abrupt diameter change (end view).

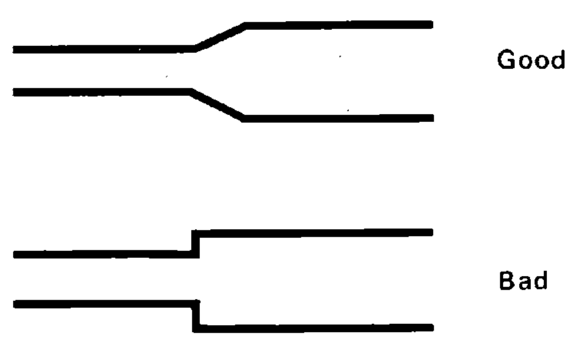

Figure II-14. Duct diameter changes.

- The number of elbows in each branch should be minimized (see Figure II-15).

- The distance between the hood and the first elbow in ductwork should be at least three times the duct diameter (e.g., if the duct has 6" diameter, an 18" or longer straight length of duct should be connected to the hood) (see Figure II-16).

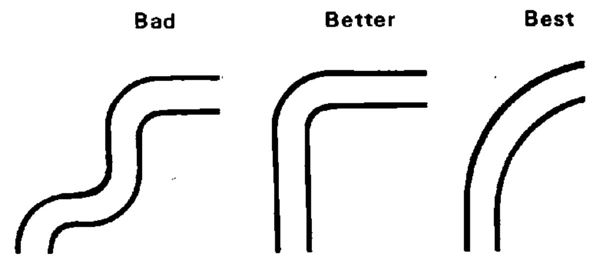

Figure II-15. Use of duct elbows.

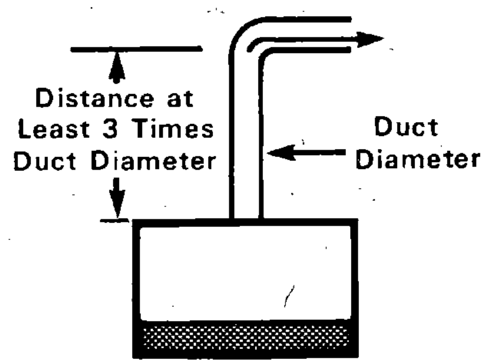

Figure II-16. Proper location of duct bends.

Control of Filter Emissions

In connecting a ventilation system, care should bel taken to ensure that solvent-laden air blown into the system (e.g., by a machine door fan) will not "back up" through another system branch (such as an exhaust pick-up). The use of one-way "butterfly" dampers in exhaust ducts can safeguard against "blow-back;" however, if the system has properly-sized ductwork to maintain a balance of air pressure among the system branches, blow-back should not occur.

Dry cleaners employ in-line filtration to remove impurities from their solvent. The filter media may be an adsorbent powder or a cartridge filter.

When cartridge filters are employed, they must be drained and dried before discarding, and this can be a source of solvent emissions.

Most perc dry cleaners utilize filter powder. This powder is generally "cooked" periodically to remove perchloroethylene and is then discarded and replaced with fresh powder. The "cooker" may leak around gaskets, joints and seals, and may also produce perchloroethylene emissions when opened after cooking if the filter "muck" has not been completely cooked.

Local exhaust has been used successfully to control emissions from both cartridge filters and powder filters.


Figure II-17. Exhaust pick-up for muck clean-out.

Cartridge filters can be transferred to an exhausting cabinet and solvent allowed to evaporate into the exhaust air. For muck clean-out, "elephant trunks" of flexible ducting connected to the exhaust system (or carbon adsorber) can capture emissions before they spread throughout the plant (see Figure II-17).

In either case, when the emission capturing branch is connected to a main duct line (e.g., to lead to a carbon adsorber), the considerations already mentioned for elbows, junction points, and duct sizing should be remembered.

RECIRCULATION FROM ADSORBERS

Carbon adsorption units are designed to remove solvent vapor from air and permit re-use of recovered solvent in the process. Simultaneously, they cleanse the exhaust airstream so that pollutant emissions are reduced, and capture-solvent laden air which would otherwise contribute to worker exposures. However, many dry cleaners return the air from the adsorber to the plant (Figure II-18), and this is a poor practice.

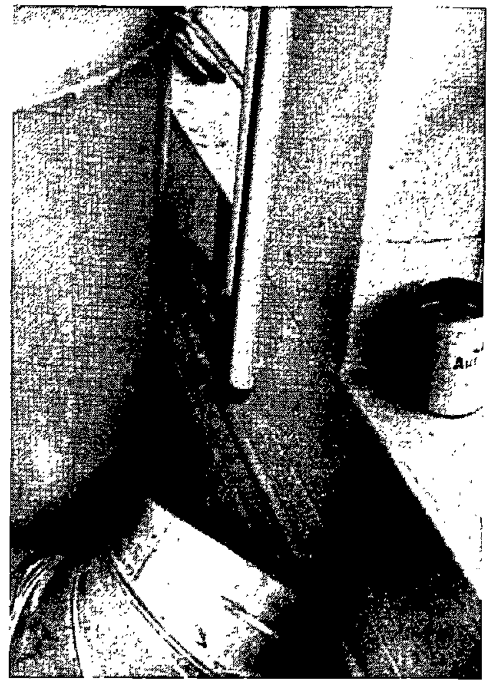

Figure II-18. Adsorber discharging into plant.

This "recirculation" of exhaust air minimizes the introduction of fresh air into the plant. As a result, the low background level of solvent in the exhaust of even a well maintained, properly operated adsorber is allowed to contribute to overall plant background solvent levels. The problem can become serious if, through poor maintenance or improper operation, the adsorber is not efficiently removing solvent and an air stream with fairly high solvent levels is returned to the plant. Ducting adsorber exhaust outside eliminates these concerns. However, local and Federal environmental rules must be observed when making such installations.

DISCUSSION QUESTIONS

1. Since local exhaust ventilation only influences the environment in a relatively small area, why is it a more desirable control approach than simply using a large, through-the-wall exhaust blower?

2. List three visible items which would indicate to you that a local exhaust system is not well designed.

3. Where is the ideal location for a hood to capture transfer emissions?

ANSWERS

1. Local exhaust captures vapor when it is most concentrated, and removes it before it can spread throughout the plant.

2. Sharp angle bends, non-gradual changes in duct size, unnecessary elbows, elbow close to pick-up or hood.

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UNIT OVERVIEW

UNIT III--GENERAL MECHANICAL VENTILATION

Methods	Lecture	Length: 20 minutes
Purpose	To describe general mechanical ventilation and its uses in the dry cleaning plant	
Objectives	To enable the participant to understand the uses and limitations of general mechanical ventilation	
Instructor Materials	35 mm slides 35 mm projector	
Trainee Materials	Course outline	

CONTROL THROUGH GENERAL MECHANICAL VENTILATION

INTRODUCTION

General mechanical ventilation refers to the removal of general plant air and introduction of fresh air. Typically, general exhaust is accomplished by using large through-the-wall exhaust fans (see Figure III-1). Replacement air may be allowed to enter naturally through open windows, doors, and dampers, or may be introduced mechanically by a blower. In contrast with local exhaust ventilation, which captures relatively small volumes of heavily contaminated air, general ventilation exhausts large quantities of air which is more typical of the plant's overall background solvent level. General mechanical ventilation should be used in conjunction with local exhaust ventilation in controlling solvent levels within each plant.

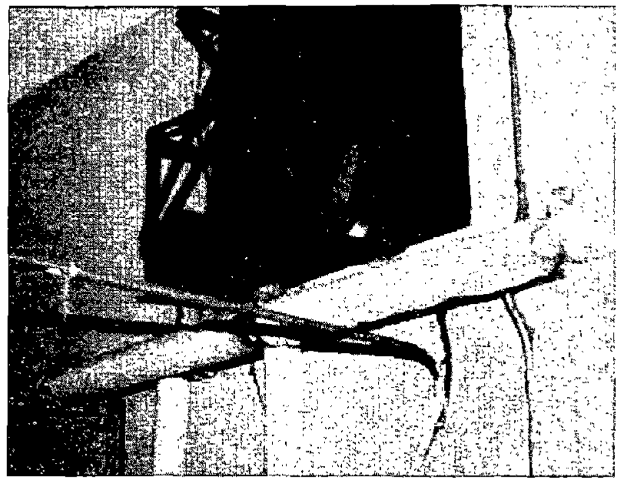

Figure III-1. General exhaust fan.

HEAT STRESS ALLEVIATION

There are many sources of heat in a dry cleaning plant, ranging from garment tumblers to stills to pressing machines. A plant is typified by high temperature and high humidity, which can make working conditions uncomfortable during warm weather.

General mechanical ventilation is an effective technique for expelling the heat and humidity generated in the plant. Since heat and humidity are necessary by-products of the dry cleaning process, maintaining air movement within the plant is important.

Effect on Solvent Levels

General mechanical ventilation has the effect of diluting solvent emissions and spreading them throughout the plant. General ventilation does not capture emissions, but in spreading them throughout the plant the dilution that results raises background levels to which those workers not adjacent to emission sources are exposed.

Although general mechanical ventilation can spread solvent emissions through the plant, its ability to flush the plant with clean air and to dissipate heat and humidity are important. To be most beneficial, general mechanical ventilation must be designed properly.

To the extent possible, it is desirable to design general mechanical ventilation systems such that clean make-up air passes through the dry cleaning area last (i.e., just prior to exhaust). This arrangement tends to assure that emissions from the dry cleaning area are not spread throughout the plant. Figure III-2 displays an example of an undesired exhaust arrangement. In these arrangements, air is drawn from the source of contaminant emission through the support areas such as pressing. This will cause workers in those areas to be exposed to background solvent levels above those that might otherwise exist.

Figure III-3 shows an arrangement of general mechanical exhaust which takes the emission of solvent into account. In arrangements, uncontaminated air is drawn through support areas, and pass through potential emission points immediately before being exhausted. With this type of layout, general mechanical ventilation can contribute to the removal of solvent

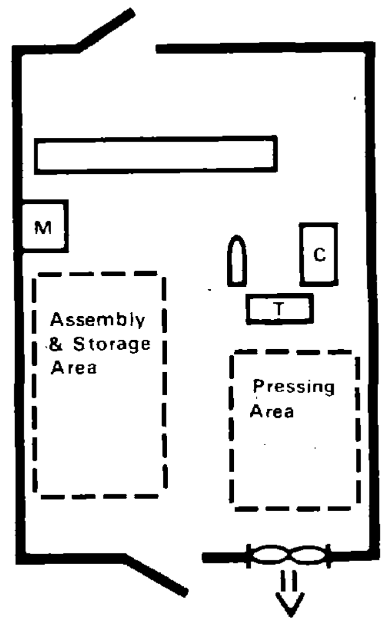

Figure III-2. Poor general ventilation layout.

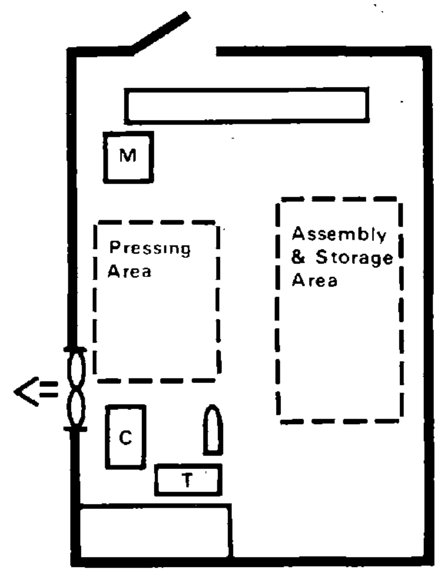

Figure III-3. Good general ventilation layout.

emissions from work areas. It should be noted that if general ventilation air passes first through the pressing area, heat may be unnecessarily spread through the plant.

In some dry cleaning plants, the washer and extractor are located in an area separated from the remainder of the plant by walls. This arrangement is most often found in larger (industrial) cleaners where plants tend to be larger, and in petroleum solvent plants, where fire hazard considerations often result in segregated cleaning rooms.

When the principal emission sources are in a separate room, contaminant control can be achieved by ensuring that air flows from the main plant into the cleaning room. This ensures that solvent vapor does not flow from the cleaning room to the main plant.

Airflow into the cleaning room is achieved by exhausting a larger quantity of air than one supplies to the cleaning room. To achieve balance between air entering and leaving the room, air will flow into the room from the adjacent plant areas.

DISCUSSION QUESTIONS

1. Why is general mechanical ventilation not the best method of contaminant control?

2. What advantages does general mechanical ventilation have over local exhaust ventilation?

ANSWERS

1. General mechanical ventilation will spread airborne contaminants through the plant rather than capturing and removing them.

2. General mechanical ventilation is important for comfort, particularly for heat and humidity control.

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UNIT OVERVIEW

UNIT IV--FUGITIVE EMISSION CONTROL AND OTHER CONTROL MEASURES

Methods	Lecture	Length: 30 minutes
Purpose	To discuss emission of solvent from "fugitive" sources and the importance of work practices in exposure control	
Objectives	To enable the participant to recognize the relationship between effective exposure control and good maintenance and work practices	
Instructor Materials	35 mm slides 35 mm projector	
Trainee Materials	Course outline	

FUGITIVE EMISSION CONTROL AND OTHER CONTROL MEASURES

FUGITIVE EMISSIONS

The most common sources of leaking solvent (liquid and vapor) from dry cleaning machines are loose pipe joints and unions, and ineffective (improperly fit or inflexible through wear) door gaskets (see Figure IV-1). Other gaskets and seals (e.g., around pumps, valves, and lint trap doors) can also be emission sources, and should be inspected regularly and maintained as necessary.

Figure IV-1. Gap in door gasket.

In tumbling (drying) garments subsequent to washing and extraction, leaks again present a problem to dry cleaners. A tumbler has two aeration dampers (inlet and exhaust) which are closed during most of the drying cycle, and are opened at the end of the cycle to facilitate garment cool-down and remove residual solvent vapor (and odor). These dampers, if not regularly maintained, are potential leak points. Other sources of perchloroethylene emissions include door gaskets and open buckets employed to collect solvent coming from the tumbler's condenser (discussed later).

The condenser, which is designed to remove perchloroethylene vapor from the tumbler's circulating air, causes other concerns: The balance between condenser water temperature and drying air temperature is important and must be carefully watched. If the condenser is not sufficiently cold, its efficiency in recovering solvent is decreased. If, however, the condenser water is too cold, recirculating tumbler air will not be reheated enough for effective drying. Any reduction in drying efficiency, when not corrected by extended drying time, may release increased quantities of perchloroethylene into the workplace. Tumbler efficiency can also be reduced by overloading and by the build-up of lint on condenser cooling fins.

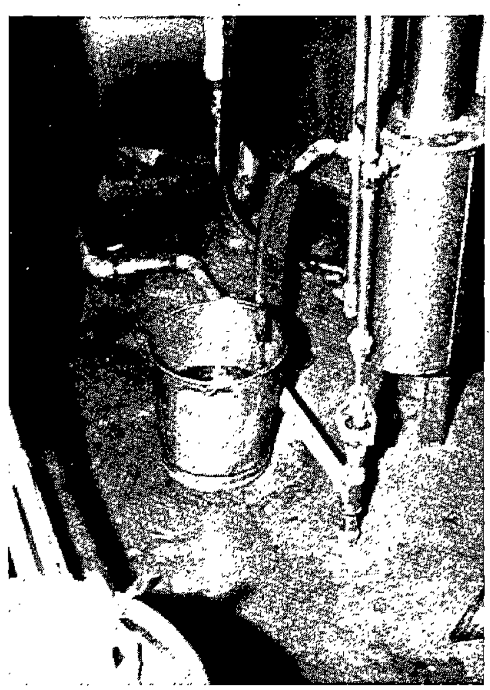

Figure IV-2. Recovered solvent collected in open bucket.

Dry cleaners distill a portion of their solvent periodically to improve its purity. Beyond the potential gasket, joint and seal leakage problems, a still may introduce perchloroethylene vapor into the atmosphere through the collection of clean solvent in open buckets (see Figure IV-2). A piped connection between the still's solvent outlet and the washer solvent reservoir eliminates this emission source. Alternatively, a covered solvent collection vessel can be used (see Figure IV-3).

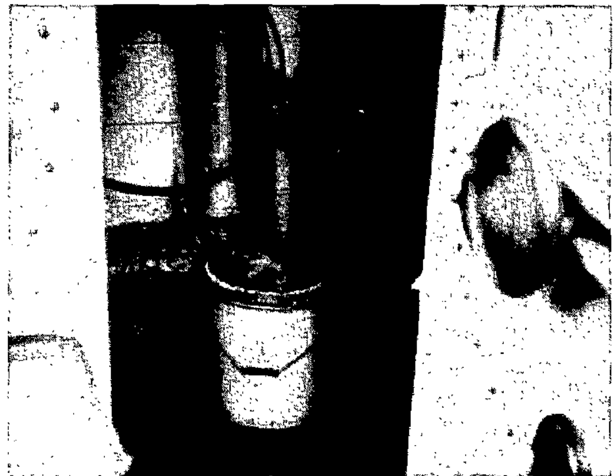

Figure IV-3. Cover on recovered solvent collection bucket.

Improper operation of stills can result in perchloroethylene loss when the still's water separator functions improperly and perchloroethylene is present in the open-top waste water collector. Another potential emission source is the still's vent which is often inside the plant and may discharge small quantities of air saturated with perchloroethylene vapor. The still's vent should discharge outside of the building, and must meet local and Federal environmental regulations.

The dampers used to isolate a carbon adsorber from associated ductwork during stripping can cause important problems when leaks occur. The concentrated perchloroethylene vapor evolving from the carbon bed can escape through leaking dampers into the ductwork, causing perchloroethylene to "back-up" into the equipment ducted to the adsorber (i.e., washer, dryer) and through the floor duct. (While the typical floor duct has a gravity damper to close the duct when no vacuum is applied, these dampers are not air-tight after a reasonable time in service.) Concentrated solvent vapor also can escape through a leaking "bottom" (downstream of bed) damper, entering the plant where the adsorber is not vented outdoors. The detection of adsorber damper leaks can be difficult and, to minimize this problem, in addition to periodic servicing of these dampers, the doors of equipment ducted to an adsorber should remain tightly closed during stripping, and the floor duct (or any other hood connected to the adsorber) should be closed off with a damper during stripping.

The stripping of adsorbers can result in emission of concentrated perchloroethylene vapor through the water separator vent. This emission often occurs between the time that steam is introduced to heat the carbon bed and the time that condensation of solvent begins. Lasting for 5 to 10 minutes, an effluent containing 1500 - 2000 ppm perchloroethylene is released into the plant. A second source of concentrated perchloroethylene was observed in those plants in which the adsorber air outlet terminated within the plant: Upon resumption of normal operation after stripping, the air leaving the adsorber contained high levels of perchloroethylene for a short time. Venting of the adsorber outlet and the water separator back to the adsorber inlet, or outside of the plant, would eliminate these sources of worker exposure.

OTHER CONTROL MEASURES

Work Practices

In operating transfer dry cleaning equipment, one general rule is important in minimizing solvent losses: Machinery doors should be kept open for as brief a period of time as possible. In this equipment, the more rapidly that the transfer occurs, the less solvent will be lost. Location of the washer and dryer as close together as possible will make rapid transfer easier. In both transfer and dry-to-dry equipment, the extraction ("spin") portion of the cleaning cycle must be sufficiently long to effectively remove solvent from the garment load. In removing items from the washer, the operator should try to reach in with his arms rather than leaning his face into the machine. Figure IV-4 shows the improper way to remove work.

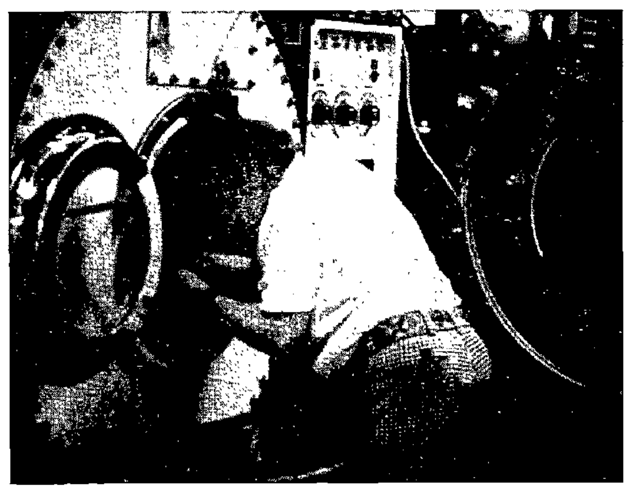

Figure IV-4. Poor transfer technique.

In operating a tumbler, it is important to permit sufficient drying time as well as aeration time (to remove the fraction of perchlorethylene that cannot be recovered due to tumbler efficiency limitations.) The tumbler must be loaded as quickly as possible and must not be allowed to stand fully loaded with an open door.

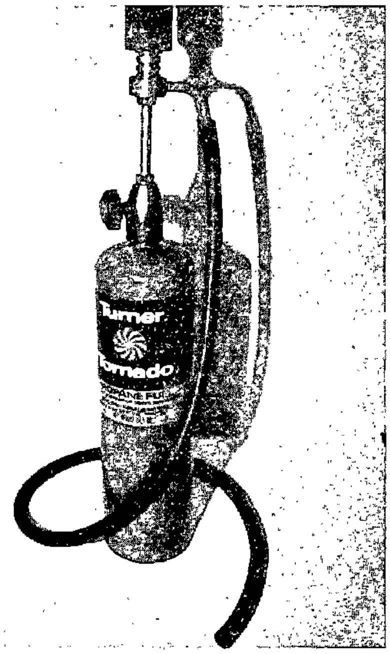

Figure IV-5 Halide torch.

Leak Monitoring

While liquid leaks and worn gaskets may be detected visually, even the most conscientious dry cleaner can not detect vapor leaks around equipment without employing detection equipment. A "halide torch" (see Figure IV-5) can be utilized for perc detection, as can detector tube apparatus.

The halide torch is a device which provides a flame whose color changes when chlorinated solvent is present. The device is difficult to use since interpretation of flame color can involve considerable judgement; however, it can be easily moved around gaskets and joints to detect leaks. Battery-operated leak detectors are also available that give an audible signal which increases with higher vapor levels. (see Figure IV-6). Detector tubes are small glass tubes through which air is pulled with a hand pump. A color change in the tube's packing indicates the presence of solvent. More expensive direct reading instruments can be used to monitor solvent emissions, but the expense of such

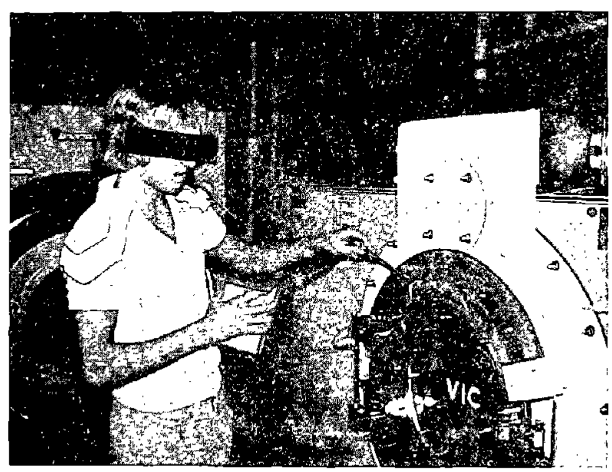

Figure IV-6 Use of leak dector.

equipment makes it impractical for most dry cleaners.

An indirect method of discovering operating losses of solvent is to maintain records of pounds of garment cleaned per gallon of solvent consumed. These "mileage" statistics can show undetected solvent losses and initiate maintenance and checking of equipment.

Protective Equipment

Respiratory protective equipment can be worn to provide protection against solvent exposure, but respirators are not recommended as a long-term solution to excessive exposure situations.

Figure IV-7. Organic vapor respirator.

An air-purifying, "chemical cartridge respirator (see Figure IV-7) is most commonly used in the dry cleaning industry. This respirator should have an "organic vapor" cartridge to provide protection against cleaning solvent exposures. When a respirator is used a specific individual must be responsible for assuring that respirator fitting, cleaning, maintenance, and training are performed.

The fit of the chemical cartridge respirator on the user should be checked by having the user see if he can detect the odor of isoamyl acetate while wearing the respirator. If he can, the respirator does not fit properly. A more sophisticated fit-testing technique ("quantitative fit testing"), involves measuring the amount of contaminant inside of the respirator while it is being worn.

Respirator cartridges should be changed periodically and whenever the user can begin to detect odor through the cartridge. Respirators should be cleaned daily by removing the cartridges asnd washing the facepiece in water and detergent. The respirator should be stored within a plastic bag in a clean place, and should be stored so that the face mask shape will not become deformed.

A chemical cartridge respirator is only useful when there is plentiful (19.5%) oxygen in the air. The respirator will remove air contaminants but does not supply any air. In emergency situations where there may not be enough oxygen (less than 19.5%) a chemical cartridge respirator should not be used. Also, because a half facepiece (orinasal) organic vapor chemical cartridge respirator is not approved for use in atmospheres with more than 1,000 ppm organic vapor, in emergency situations where very high solvent levels are expected (e.g., a large solvent spill), a chemical cartridge respirator should not be used. In such cases, special self-contained breathing apparatus, like those used by firefighters, should be used.

As mentioned in an earlier unit, there are opportunities for skin contact with solvent during transfer, muck cleanout, and spill cleanup. Where a significant amount of skin contact is likely, gloves should be worn. Gloves of the proper material should be chosen to ensure that the glove is resistant to the solvent in use. For both perc and Stoddard solvent, gloves made of nitrile rubber are recommended.

DISCUSSION QUESTIONS

1. Discuss the ways in which a carbon adsorption unit can create exposure problems when it is not maintained and/or operated properly.

2. What is the best technique readily available for detecting solvent leaks?

3. Under what circumstances should a chemical cartridge respirator not be used, and why?

4. Name four common sources of fugitive solvent emissions.

ANSWERS

1. A leaking damper can allow solvent-laden air to enter the plant. Vapors can "back up" into the duct system. Gaskets and joints can leak or drip. Recovered solvent collected in an open container can evaporate.

2. A halide torch can be useful for pinpointing leaks. Good mileage records can show a general problem.

3. When solvent levels may exceed 1000 ppm (e.g., emergency situations), because not enough protection will be afforded to prevent overexposure. When there is inadequate oxygen (less than 19.5%) present or when the solvent has poor warning properties

4. Door gaskets (washer, tumbler, lint trap), atmospheric still's vent (if indoors), pipe joint leaks, open solvent containers, open door of newly-loaded tumbler, leaking adsorber dampers.

Unit IV--Fugitive Emission Control and Other Control Measures

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APPENDIX A

STUDENT COURSE OUTLINE

APPENDIX A

STUDENT COURSE OUTLINE

I. INTRODUCTION TO THE DRY CLEANING INDUSTRY

A. Purpose--To discuss the control of occupational health hazards in the dry cleaning industry

B. Industry Overview

1. Three sectors: commercial, industrial, coin-op

2. Batch process involving washing, extraction, and drying

3. Many small establishments, most using perchloroethylene

4. Dry-to-dry vs. transfer process

C. Process Overview

1. Spotting: many low-level exposures

2. Dry cleaning: washing, extraction and drying

3. Finishing: heat, humidity

4. Supporting Activities

a. Filtration
b. Distillation
c. Recovery

D. Hazard Overview

1. Solvent Used

a. Perchloroethylene
b. Stoddard solvent
c. Fluorocarbon 113

2. Sources of Solvent Exposure

a. Transfer
b. Leaking gaskets
c. Leaking dampers
d. Premature removal of garments
e. Interior relief valves
f. Adsorber vent
g. Muck cooking

3. Other Exposures

   a. Spotting chemicals
   b. Heat and humidity

II. LOCAL EXHAUST VENTILATION

A. Advantages of Control at Emission Source

   1. Contaminant most concentrated

   2. Capture before breathing zone

   3. Prevents dilution and spread

B. Integral Exhaust Systems: Capture Vapor Within Machine

C. Local Exhaust Hoods

   1. Transfer Emissions

      a. Position near garment path
      b. Direct exhaust toward emission
      c. Slot vs. large face
      d. Flanges
      e. Duct systems: sizing, angles of junctions, elbows important

   2. Filter Emissions

      a. Cartridge dry-out boxes
      b. Muck cooker clean-out

D. Recirculation From Adsorbers Undesirable

III. GENERAL MECHANICAL VENTILATION

A. Introduction

   1. General Plant Air

   2. Not at Contaminant Source

   3. Large Volumes

B. Heat Stress Alleviation: Major Benefit of General Mechanical Ventilation

C. Effect on Solvent Levels

1. Dilutes, Doesn't Capture
2. Raises Background Levels
3. Arranges for Clean-To-Dirty Flow of Air
4. Keep Washer Room Under Negative Pressure

IV. FUGITIVE EMISSION CONTROL AND OTHER CONTROL MEASURES

A. Fugitive Emissions

1. Pipe Joints, Unions, Gaskets
2. Tumbler Aeration Dampers
3. Condenser Operation
4. Still Outlet and Collector
5. Adsorber Dampers
6. Adsorber Water Separator

B. Other Control Measures

1. Work Practices
    a. Rapid Transfer
    b. Proper Cycle Time
2. Leak Monitoring
3. Protective Equipment