

Environmental Control Best Practices:

Guidelines to Reduce TB Transmission in Homeless Shelters and Drop-In Centres

2007

 **TORONTO** Public Health

Acknowledgement

An Expert Panel developed the Environmental Control Guidelines. The Implementation Guide was adapted from the Francis J. Curry National Tuberculosis Center document¹ and modified for local use by the Stakeholder Advisory Committee.

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Introduction

In the past six years, two outbreaks of tuberculosis (TB) in the homeless population have occurred in Toronto. Toronto Public Health (TPH) managed both of these outbreaks through intensive case management and contact follow-up in partnership with City of Toronto Shelter, Support and Housing Administration Division, shelter staff, TB clinics, the provincial public health laboratory and community partners.

In 2004, the Office of the Chief Coroner called an inquest into a homeless TB case who died during the 2000 – 2002 outbreak. In the report, the Coroner's jury made a recommendation to the Ontario government regarding the establishment of TB air quality standards for shelters to reduce the possible spread of TB. Since there are no ventilation standards specifically related to shelters in the Ontario Building Code, TPH developed guidelines to reduce TB transmission in homeless shelters and drop-in centers using environmental controls.

Toronto Public Health's Project Management Team assembled an Expert Panel and a Stakeholder Advisory Group to assist with the development of the environmental control best practice guidelines. Membership of the groups is listed in the acknowledgement. The aim was to develop guidelines which are based on expert opinion and best practices yet are practical enough to implement in Toronto. Existing conditions in 9 homeless shelters and 1 drop-in centre were assessed by engineering consultants between October and December 2006. Their report contributed to deliberations by the Expert Panel in arriving at the final guidelines.

A. How This Document Is Organized

This document is meant to be used as a reference manual and is divided into two parts – environmental control guidelines and implementation guide. The best practice guidelines recommend minimum ventilation and air disinfection targets to reduce TB transmission. It also prioritizes environmental measures for high-risk areas such as dormitories and dining areas.

The implementation guide supplements the guidelines by providing additional information about the following:

- Shelter and drop-in system in Toronto
- Tuberculosis and how it is spread
- Ways to reduce TB transmission in shelters and drop-in centres
- Environmental control measures (e.g. ventilation, UVGI, filtration)
- Glossary
- References

B. Purpose of This Document

The goal of this document is to help homeless shelter and drop-in operators implement the means to proactively reduce TB transmission risk by the use of environmental control measures (e.g. ventilation, UVGI).

It also aims to help these individuals:

- Understand how TB is spread in a shelter or drop-in
- Understand how to reduce TB transmission in a shelter or drop-in
- Understand administrative and work practice control measures
- Understand how ventilation and UVGI can help reduce the risk of TB transmission in a shelter or drop-in
- Implement the most appropriate environmental control measures in a shelter or drop-in
- Maintain environmental control measures to ensure that they are effective
- Make informed decisions about planning, funding and selection of environmental control measures

These best practice guidelines make recommendations about *minimum* environmental control targets which shelters and drop-ins should achieve. They are NOT standards and this document is NOT a design manual. Instead, users are advised to refer to good engineering practice appropriate to the circumstances and the requirements of the applicable laws and regulations in their region.

C. Who Should Use This Document

Directors and facility managers of homeless shelters and drop-in centres, as well as ventilation engineers are the primary audience for these guidelines. Others with an interest in reducing the risk of TB in shelters would also find it useful, including:

- designers of homeless shelters or drop-in centres, such as architects and engineers
- TB control program managers and nurses in public health departments
- workers in shelters
- funding agencies for shelters and drop-in centres
- others who provide services to homeless shelters or drop-in centres, including:
 - health care staff
 - TB screening staff
 - case workers
 - volunteers
 - environmental health officers
 - occupational health inspectors
 - building inspectors
 - educators

D. How to Use This Document

Readers should only refer to the guidelines after gaining knowledge about tuberculosis AND environmental controls. Individuals who are unfamiliar with TB and/or environmental controls should read the implementation guide before reading the guidelines. Those who are familiar with TB should read about environmental controls while those familiar with environmental controls should read about TB. Due

to the technical nature of environmental controls, some readers may need assistance from an engineer to interpret the information provided.

A glossary of medical and engineering terms is provided at the end of the implementation guide. This explains terminology used in this document as well as abbreviations. A list of relevant documents about TB control can be found in the reference.

Environmental Control Best Practice Guidelines

Tuberculosis can be transmitted when an individual inhales airborne *M. tb* droplets produced by an infectious case. This can occur when people share the same air space or when contaminated air is re-circulated through a building via the mechanical ventilation system². Operators of shelters and drop-in centres can take steps to significantly reduce the risk of TB transmission by:

1. Administrative and work practice control measures; and
2. Environmental control measures such as ventilation, ultraviolet germicidal irradiation and filtration.

Administrative and work practice control measures potentially have the greatest impact in preventing TB transmission, so they must be adhered to at all times. These include early identification of suspect cases of TB and immediately separating the person with TB symptoms, having the person wear a mask and arranging for

² Wells WF. Aerodynamics of droplet nuclei. In: Airborne contagion and air hygiene. Cambridge: Harvard University Press, 1955:13-9.

medical care. Appropriate space utilization to reduce the risk of TB transmission must also be considered e.g. reduce double bunking, minimize overcrowding etc. For a further discussion about administrative and work practice control measures, readers are referred to the Environmental Control Implementation Guide, Section E in Background.

Environmental control measures act to a) dilute infectious particles by mixing fresh air into a space or b) disinfect the air space by ultraviolet germicidal irradiation or filtration. However, environmental control measures are insufficient when used alone; they need to act in concert with administrative practices to reduce the risk of TB transmission. Further descriptions about environmental control measures can be found in the implementation guide but brief summaries are included below.

There are two general types of ventilation: Natural ventilation and mechanical ventilation. Natural ventilation refers to fresh dilution air that enters and leaves a building through openings such as open windows, doors, and skylights. In the Francis J. Curry National Tuberculosis Center document³, natural ventilation was offered as an option to reduce the spread of TB. Natural ventilation brings fresh dilution air into a building but this is only possible when weather permits. In Toronto where winters are long and cold, this is not feasible most of the year.

Mechanical ventilation refers to the movement of air throughout a building by a system of ducts, fans and diffusers. For TB control, the gold standard ventilation system is one without recirculation—that is, a 100% outside air, or once-through, arrangement. However, this type of system is the most expensive and energy

³ TB in Homeless Shelters: Reducing the Risk through Ventilation, Filters and UV (2000), Francis J. Curry National Tuberculosis Center, Institutional Consultation Services, and California Department of Health Service.

inefficient. Therefore, ventilation systems with some recirculation are the norm. New air handling units in such systems should be designed so that air is not circulated from one shelter room to any other room or to a public corridor. In addition, a central ventilation system can interrupt TB transmission by:

- 1) introducing fresh *outside air* to replace room air. The volume and percentage of fresh air is specified by the Ontario Building Code and is seen as a minimum requirement;
- 2) using in-duct *ultraviolet germicidal irradiation (UVGI)* lamps to disinfect re-circulated air; OR
- 3) using in-duct high efficiency (HEPA) *filters* to remove infectious particles from re-circulated air to produce disinfected air.

These features work together and can be incorporated into the design of a new system or can be added to an existing system. Further guidance about their use is provided in this document.

All mechanical ventilation systems and disinfection units require maintenance to ensure their proper function (see Section B). Before proceeding with any building assessment or upgrade, shelters and drop-ins should ensure that existing systems are functioning at their optimal levels.

A. Environmental Control Best Practice Guidelines

The following section prioritizes environmental control measures in shelters and drop-ins to protect everyone from TB. The first priority provides *minimum* environmental control targets to reduce the transmission of TB in areas where staff and residents spend time. The second and third priorities provide guidance about

additional measures to reduce TB transmission in high-risk settings within these facilities.

First Priority

Provide a **minimum of 6 total air changes per hour (TACH)** year round in all rooms or areas where staff and /or clients spend time.

This should be made up of fresh outside air and recirculated air to meet the minimum requirements under the Ontario Building Code (OBC) and the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE). For new buildings supply no less than 25 cfm/person of *outside* air and in older buildings supply no less than 15 cfm/person of *outside* air⁴.

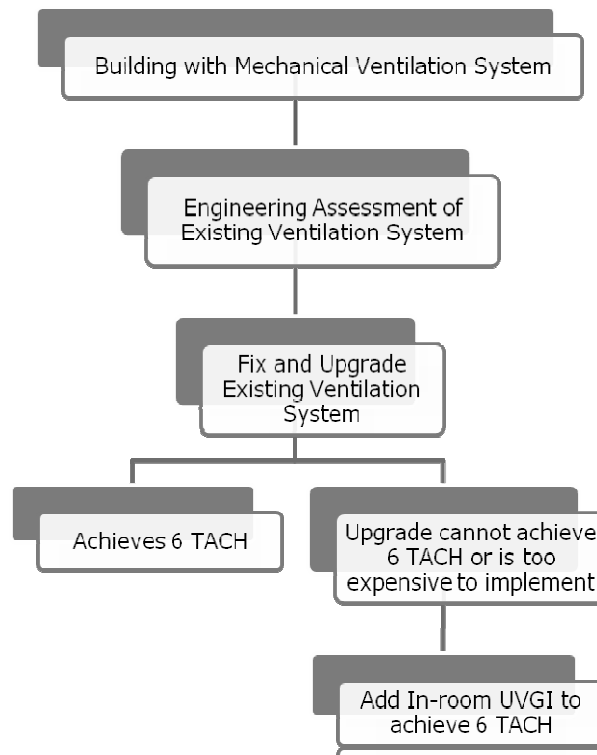
1. Buildings with mechanical ventilation systems should:
 - a. Ensure existing systems are maintained and are functioning properly.

⁴ One air change occurs in a room when a quantity of air equal to the volume of the room is supplied and/or exhausted. The most common unit used is *air changes per hour (ACH)*. This is the volume of air (usually expressed in cubic feet) exhausted or supplied every hour divided by the room volume (also usually expressed in cubic feet). Airflow is usually measured in cubic feet per minute (CFM). Room volume is equal to width X length X height. If a room is 8 feet wide by 10 feet long and 9.5 feet high, then the room volume equals: $8 \times 10 \times 9.5 = 760$ cubic feet

In order to calculate required airflow for a ventilation rate of 6 ACH:

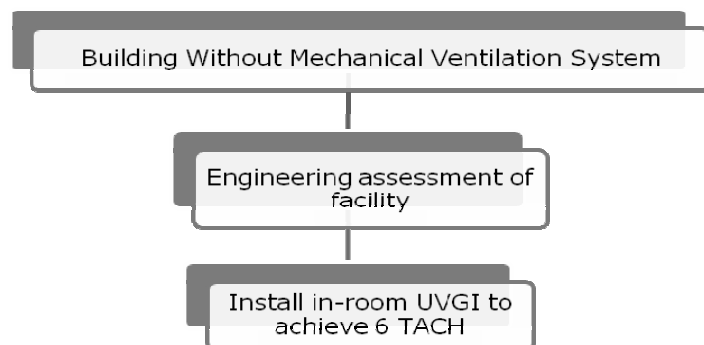
$$\begin{aligned} \text{Room volume} \times 6 \text{ ACH} &= 760 \times 6 \\ &= 4,560 \text{ cubic feet per hour} \\ &= 4,560/60 \text{ cubic feet per minute} \\ &= 76 \text{ CFM} \end{aligned}$$

- b. Obtain professional engineering assessment of existing systems to determine whether the minimum target of 6 TACH is met.
- c. If the target is not met, upgrade the existing ventilation system to achieve a minimum of 6 TACH.
- d. If upgrade of the existing ventilation system cannot achieve the minimum target or is too expensive to implement, install in-room UVGI units (i.e. upper-room UVGI or in-room enclosed UVGI) to achieve the equivalent of 6 TACH.



- 2. Buildings without mechanical ventilation systems should hire a professional engineering firm with UVGI expertise to install in-room UVGI units (i.e. upper-

room UVGI or in-room enclosed UVGI unit) to achieve the equivalent of 6 TACH⁵.



Second Priority

Enhanced Air Disinfection for Sleeping Rooms \geq 20 People

In sleeping rooms with 20 people or more, in addition to the 6 TACH as above, the preferred system should be supplemental air disinfection by a properly planned and installed upper UVGI system⁶.

Only if upper-room UVGI is not technically feasible⁷, use in-room disinfection units i.e. portable or free-standing units with enclosed UVGI **or** HEPA filtration. These units should be sized to provide at least an additional 2 equivalent ACH of disinfected air. It should be noted that these units do not need to have both UVGI

⁵ Even though 6 TACH is achieved, this would not meet OBC requirement for outdoor air.

⁶ First MW, Nardell EA, Chaisson W, Riley R. Guidelines for the application of upper-room ultraviolet germicidal irradiation for preventing transmission of airborne contagion – Part I: Basic Principles, and Part II: Design and Operations Guidance. ASHRAE Technical Papers 1999; 105: 869-876, 877-887.

⁷ Factors that might preclude the use of upper-room UVGI include ceiling heights under 9 ft, poor room air mixing and no possibility of adding room air mixing fans, or the use of bunk beds which would place some room occupants too close to the upper, irradiated portion of the room.

and HEPA filtration since this does not increase the amount of disinfected air they produce⁸.

If it is not possible to obtain at least an additional 2 equivalent TACH of disinfected air, do not proceed with the upgrade at this time.

Third Priority

Enhanced Air Disinfection for Other High-Risk Areas

- a. In multiple sleeping areas with less than 20 people per room that are on the same ventilation circuit, in addition to providing 6 TACH, install in-duct UVGI units to reduce the risk of re-circulated contaminated air⁹.
- b. In short-term congregate areas where 20 people or more meet during the day, use properly planned and installed upper-room UVGI to provide additional air disinfection. If technically not feasible, use in-room disinfection units with enclosed UVGI **or** HEPA filtration to add at least an additional equivalent of 2 ACH of disinfected air, but not both as explained above.
- c. In other high risk areas identified by the engineering assessment, see item b above.

⁸ In-room fan-UV or fan-filtration units tend to re-process the same regional air, while other room air goes untreated. Therefore, even if calculations suggest 2 additional TACH, one should ask if there is reasonable distribution of the disinfected air.

⁹ The UVGI dose should achieve a greater than 99% kill of the airborne TB bacteria, so the minimum dose should be $>2000 \mu\text{J}/\text{cm}^2$ or a URV of 13 (Kowalski WJ, Bahnfleth WP (2004). Proposed Standards and Guidelines for UVGI Air Disinfection. IUVA News 6 (1): 20-25).

In situations where in-duct UVGI air disinfection appliances are designed and installed to provide an equivalent of 6 ACH of disinfected air, or greater, the outside air requirements can be the minimum values allowed by OBC and ASHRAE which may be less than those stated in priority 1.

If it is not possible to obtain at least an additional 2 equivalent TACH of disinfected air, do not proceed with the upgrade at this time.

B. Maintenance and Operation

Shelters and drop-ins must develop and implement a regular inspection and maintenance schedule based on manufacturer and supplier recommendations as well as other accepted guidelines. Best practices recommend the inspection of mechanical ventilation systems every 6 months by trained personnel to ensure that they are in good condition. More frequent inspection and maintenance may be required for certain systems.

All exterior air handlers should be equipped with economizers and these should be set as per these guidelines. Area uses should be laid out to minimize cross-ventilation between staff and resident ventilation zones.

Cleaning, inspection and replacement of filters and UV lamps will be required as per the manufacturer's instructions by trained personnel. They should be inspected at least once per month or at a frequency that reflects actual site conditions.

The importance of maintenance cannot be over-emphasized. Facility operations personnel should have on site Operation and Maintenance manuals, “as-built” drawings and a list of contractors on retainer with the facility. They should also be trained on the installation of HVAC equipment, mode of operation and maintenance frequency. They should have checklists of maintenance items and service frequency.

The Implementation Guide contains additional information about this topic.

Out-of-the-Cold Program

The Out-of-the-Cold Program is operated by faith groups in Toronto from October to March each year. Churches and synagogues open one day a week to provide shelter and food to homeless persons. This consists of overnight shelter as well as supper and breakfast. The initiative started in 1987 with St Michael’s School but at present approximately 20 such programs operate around the city. Staff consists mostly of faith group volunteers and a core group of paid staff.

Because these facilities do not operate all year, and are only used to house the homeless one night a week for 24 nights a year, the risk of TB transmission is reduced but is nevertheless present. Considering the limited amount of time spent by the homeless at these sites compared to shelters, the cost to upgrade ventilation systems to meet environmental control guidelines is not warranted.

Instead, in such facilities, the Expert Panel recommends the following:

1. Improve air mixing with the use of destratification fans.
2. Achieve 6 TACH in rooms where staff and clients spend time.

- a. If feasible, use upper-room UVGI
- b. If this is not feasible, use in-room disinfection units¹⁰

¹⁰ HEPA filtration is not recommended unless sufficient units are available to achieve 6 TACH.

Example: In a room that is 50 feet long by 50 feet wide and 20 feet high, the volume is 50,000 cubic feet. The required cubic feet per minute (CFM) to achieve 6 TACH is: $(50,000 \times 6) / 60$ minutes = 5000 CFM.

In order to achieve this level of air disinfection, 10 units @ 500 CFM would need to be used in the room. Since the cost for each unit is several thousand dollars, the cost to disinfect 6 TACH would be prohibitive.

Environmental Control Implementation Guide:

Best Practices to Reduce TB Transmission in Homeless Shelters and Drop-In Centres

2007



Adapted from:
TB in Homeless Shelters: Reducing the Risk
through Ventilation, Filters, and UV (2000)
Francis J. Curry National Tuberculosis
Center, Institutional Consultation Services,
and California Department of Health Service



Background

A. Shelters and Drop-in Centres in Toronto

Shelters

There are 65 permanent shelters in Toronto. The City of Toronto operates some of these facilities while community and/or faith groups operate others. Emergency shelters are intended for shorter-term stay of homeless individuals, though this is not always what happens. Transitional shelters are intended for longer-term stay of homeless individuals as a “bridge” between the emergency shelter system and permanent housing. Occasionally, a temporary facility is set up to meet immediate urgent needs.

Shelters accommodate a range of individuals including single men, single women, co-ed adults, families and youth, although the majority only cater to one of these client groups at a time. Most facilities have just one use - to provide shelter - while a few are multi-use/multi-service facilities. The facilities range in size from 10 beds to 545 beds. Some have dormitory style bedrooms, while others have small congregate bedrooms, and still others have individual bedrooms. Most offer meals and supports.

Drop-In Centres

There are approximately 50 drop-in centres serving homeless, marginally housed and socially isolated people in Toronto. Individuals who use their service are those who are living in poverty such as street-involved youth, psychiatric survivors, marginally housed/homeless women and men, shelter residents, ‘hidden homeless’, seniors citizens, and refugees/newcomers.

All drop-in programs provide basic necessities such as meals, showers and laundry. Many assist with housing, addictions and/or mental health issues, and some also offer recreational, artistic and cultural activities.

The drop-in centre approach is based on easy access to service. Unlike most other programs, drop-in centres do not require clients to complete an intake process. Drop-ins exist in a wide variety of physical settings; some are attached to shelters while others are in church basements. Sites range from recently renovated buildings to older facilities which have been in use for many decades. Shelters and drop-in centres operate on limited funding and provide necessary services to a highly transient population with many and varied needs.

B. How TB Is Spread

The bacterium *Mycobacterium tuberculosis* (*M.tb*) causes tuberculosis (TB). A person who has TB disease in his/her lungs or larynx (throat) can release tiny particles containing *M.tb* into the air by coughing, sneezing, singing, shouting, talking, or breathing. These particles are invisible to the naked eye and are approximately 1 to 5 microns in size. These tiny particles are called droplet nuclei. Droplets containing *M.tb* can remain airborne in the air for a long period of time, until they are removed by natural or mechanical ventilation. *M. tb* is usually transmitted through air, not surface contact.

In order for TB to spread, there must be a source that produces *M. tb* (person with TB) and someone to inhale droplet nuclei containing *M. tb*. Anyone who shares air with a TB case is at risk, although the disease is not usually spread by brief contact. When another person inhales one or more of these particles, he/she becomes infected with TB, or, in other words, develops TB infection (see glossary for definition of TB infection vs. TB disease). Typically, 5%-10% of persons who have TB infection will develop TB disease during their lifetime. The risk for progression of TB infection to TB disease is highest during the first few years after infection (TB Standards, 1998).

C. When TB is Contagious

Persons with TB in their lungs or larynx are contagious; if they have developed cavities in their lungs due to damage by *M.tb*, they are even more contagious. The risk of TB transmission increases with close and prolonged exposure to a contagious case. Exposure is intensified if the space is small and has poor ventilation (CDC 2005).

Cases can remain contagious for a long time if they do not seek medical care. This may occur because cases minimize their symptoms or they do not have access to medical services. Research has shown that once a TB case starts treatment, he/she becomes less contagious very quickly; however, treatment needs to be continued until the recommended course is finished. Unfortunately, some cases stop treatment early and their disease recurs and they become contagious again. Cases that are infected with *M.tb* that is resistant to TB drugs can also remain contagious for a long time because standard treatments do not work.

D. Why TB is a Problem in Homeless Shelters and Drop-Ins

The shelter and drop-in environment increases the chance of TB spread because building ventilation is often inadequate and clients are in congregate living situations, typically for 8 to 12 hours at a time. One of the most critical risks for shelters and drop-in centres is clients with unrecognized TB disease. These contagious cases enter a shelter or drop-in centre and socialize with other clients and staff thus exposing them to *M.tb*.

The homeless are also more likely to acquire TB for the following reasons:

- greater chance of exposure to a TB case because of higher TB prevalence among homeless
- poor nutrition
- poor access to health care delaying diagnosis of TB and treatment

- poor adherence to follow-up visits and prescribed treatment for TB infection
- substance abuse, especially injection drug use and alcoholism
- underlying medical conditions e.g. HIV, psychological stress
- incomplete treatment resulting in relapse of disease

E. How Shelters Can Reduce the Risk of Spreading TB

Operators of shelters and drop-in centres can take steps to significantly reduce the risk of TB transmission. There are two ways which this can be done:

1. Administrative and work practice control measures;
2. Environmental controls such as ventilation, UVGI and HEPA filtration.

Administrative and work practice control measures have the greatest impact in preventing TB transmission, so they must be adhered to at all times. Environmental control measures work in concert with administrative practices to reduce the risk of TB transmission but they are insufficient when used alone. Thought should also be given to space utilization to reduce the risk of TB transmission by reducing double bunking, minimizing overcrowding etc.

Administrative and work practice control measures include:

- Early identification of suspect cases of TB
 - TB should be suspected in any homeless person who has a fever and a productive cough (i.e. not a dry cough) that lasts over three weeks. Other symptoms of TB include coughing up blood, night sweats, weight loss, fatigue and loss of appetite. If a person in a shelter has a cough and one or more of the other symptoms, they should be considered a suspect case of TB.
- Immediately separate the person with TB symptoms and arrange for medical care

- Place a surgical mask over the client's mouth and nose. Separate this person from other staff and residents by placing him/her in a separate room. Arrange medical care as soon as possible. This may mean sending the person to the Emergency Department of the hospital as persons with suspect TB are often identified after regular clinic hours.
 - The staff person providing care for this person should wear an N95 mask.
- Ensure that TB cases successfully complete treatment.

For information about TB control in shelters and drop-ins, readers can consult two documents. One is the **Interim Guidance for the Prevention and Control of Tuberculosis in Homeless Shelters and Drop in Centres (2005)** published by the Ontario Ministry of Health and Long Term Care (MOHLTC) and Ministry of Labour. It can be found in Appendix 1.

The other is **Breaking the Chain: Infection Control Manual for Homeless and Housing Service Providers (March 2006)** published by Toronto Public Health.

It is available online at:

<http://www.toronto.ca/health/cdc/pdf/infectioncontrolmanual.pdf>.

Other guidelines are listed in the Reference section.

Additional information about administrative controls can be found at:

Centers for Disease Control Interactive Core Curriculum on TB, Chapter on Administrative Control:

http://www.cdc.gov/nchstp/tb/webcourses/corecurr/TB_Course/Chapter_7/cdctb_07_04_100.htm#

F. Environmental Control Best Practice Guidelines

Toronto Public Health's Project Management Team assembled an Expert Panel and a Stakeholder Advisory Group to assist with the development of the environmental control best practice guidelines. The aim was to develop guidelines which are based on expert opinion and best practices yet are practical enough to implement. Existing conditions in nine homeless shelters and one drop-in centre were assessed by engineering consultants between October and December 2006. Their report contributed to deliberations by the Expert Panel in arriving at the final guidelines. The following section prioritizes environmental control measures in shelters and drop-ins to protect everyone from TB. The first priority provides *minimum* environmental control targets to reduce the transmission of TB in areas where staff and residents spend time. The second and third priorities provide guidance about *additional* measures to reduce TB transmission in high-risk settings within these facilities.

First Priority

Provide a **minimum of 6 total air changes per hour (TACH)** year round in all rooms or areas where staff and /or clients spend time.

This should be made up of fresh outside air and recirculated air to meet the minimum requirements under the Ontario Building Code (OBC) and the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE). For new buildings

supply no less than 25 cfm/person of *outside* air and in older buildings supply no less than 15 cfm/person of *outside* air¹.

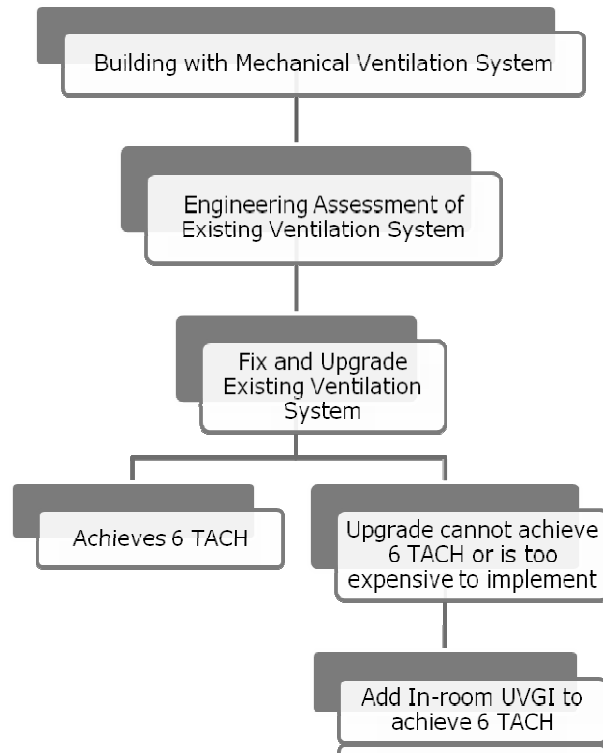
1. Buildings with mechanical ventilation systems should:
 - a. Ensure existing systems are maintained and are functioning properly.
 - b. Obtain professional engineering assessment² of existing systems to determine whether the minimum target of 6 TACH is met.
 - c. If the target is not met, upgrade the existing ventilation system to achieve a minimum of 6 TACH.
 - d. If upgrade of the existing ventilation system cannot achieve the minimum target or is too expensive to implement, install in-room UVGI units (i.e. upper-room UVGI or in-room enclosed UVGI) to achieve the equivalent of 6 TACH.

¹ One air change occurs in a room when a quantity of air equal to the volume of the room is supplied and/or exhausted. The most common unit used is *air changes per hour (ACH)*. This is the volume of air (usually expressed in cubic feet) exhausted or supplied every hour divided by the room volume (also usually expressed in cubic feet). Airflow is usually measured in cubic feet per minute (CFM). Room volume is equal to width X length X height. If a room is 8 feet wide by 10 feet long and 9.5 feet high, then the room volume equals: $8 \times 10 \times 9.5 = 760$ cubic feet

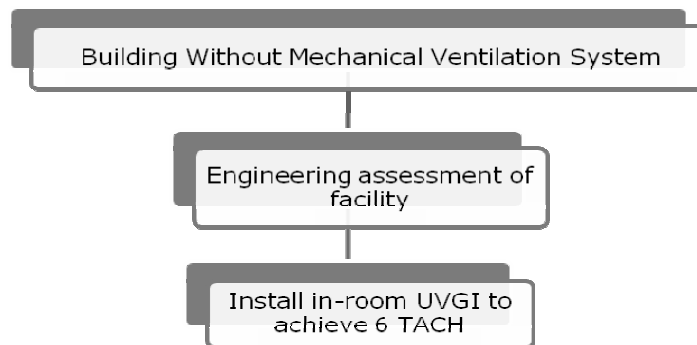
In order to calculate required airflow for a ventilation rate of 6 ACH:

$$\begin{aligned} \text{Room volume} \times 6 \text{ ACH} &= 760 \times 6 \\ &= 4,560 \text{ cubic feet per hour} \\ &= 4,560/60 \text{ cubic feet per minute} \\ &= 76 \text{ CFM} \end{aligned}$$

² See Appendix 5



2. Buildings without mechanical ventilation systems should hire a professional engineering² firm with UVGI expertise to install in-room UVGI units (i.e. upper-room UVGI or in-room enclosed UVGI unit) to achieve the equivalent of 6 TACH³.



³ Even though 6 TACH is achieved, this would not meet Ontario Building Code requirement for outdoor air.

Second Priority

Enhanced Air Disinfection For Sleeping Rooms >20 People

In sleeping rooms with 20 people or more, in addition to the 6 TACH as above, the preferred system should be supplemental air disinfection by a properly planned and installed upper UVGI system⁴.

Only if upper-room UVGI is not technically feasible⁵, use in-room disinfection units i.e. portable or free-standing units with enclosed UVGI **or** HEPA filtration. These units should be sized to provide at least an additional 2 equivalent ACH of disinfected air. It should be noted that these units do not need to have both UVGI and HEPA filtration since this does not increase the amount of disinfected air they produce⁶.

If it is not possible to obtain at least an additional 2 equivalent TACH of disinfected air, do not proceed with the upgrade at this time.

Third Priority

Enhanced Air Disinfection For Other High-Risk Areas

- a. In multiple sleeping areas with less than 20 people per room that are on the same ventilation circuit, in addition to providing 6 TACH, install in-duct UVGI units to reduce the risk of re-circulated contaminated air⁷.
- b. In short-term congregate areas where 20 people or more meet during the day, use properly planned and installed upper-room UVGI to provide additional air disinfection. If technically not feasible, use in-room disinfection units with enclosed UVGI **or** HEPA

⁴ First MW, Nardell EA, Chaisson W, Riley R. Guidelines for the application of upper-room ultraviolet germicidal irradiation for preventing transmission of airborne contagion – Part I: Basic Principles, and Part II: Design and Operations Guidance. ASHRAE Technical Papers 1999; 105: 869-876, 877-887.

⁵ Factors that might preclude the use of upper-room UVGI include ceiling heights under 9 ft, poor room air mixing and no possibility of adding room air mixing fans, or the use of bunk beds which would place some room occupants too close to the upper, irradiated portion of the room.

⁶ In-room fan-UV or fan-filtration units tend to re-process the same regional air, while other room air goes untreated. Therefore, even if calculations suggest 2 additional TACH, one should ask if there is reasonable distribution of the disinfected air.

⁷ The UVGI dose should achieve a greater than 99% kill of the airborne TB bacteria, so the minimum dose should be >2000 $\mu\text{J}/\text{cm}^2$ or a URV of 13 (Kowalski WJ, Bahnfleth WP (2004). Proposed Standards and Guidelines for UVGI Air Disinfection. IUVA News 6 (1): 20-25).

filtration to add at least an additional equivalent of 2 ACH of disinfected air, but not both as explained above.

- c. In other high-risk areas identified by the engineering assessment, see item b above.

In situations where in-duct UVGI air disinfection appliances are designed and installed to provide an equivalent of 6 ACH of disinfected air, or greater, the outside air requirements can be the minimum values allowed by OBC and ASHRAE which may be less than those stated in priority 1.

If it is not possible to obtain at least an additional 2 equivalent TACH of disinfected air, do not proceed with the upgrade at this time.

Environmental Controls⁸

A. Ventilation

There are two general types of ventilation:

- *Natural ventilation* relies on open doors and windows to bring in air from the outside.
- *Mechanical ventilation* usually refers to the use of mechanical air-moving equipment that circulates air in a building and may involve heating and/or cooling. Mechanical ventilation systems may or may not bring in air from the outside.

a. How Ventilation Helps Reduce the Likelihood That TB Will Spread

Ventilation can reduce the spread of TB through *dilution* and *removal*. When clean or fresh air enters a room, by either natural or mechanical ventilation, the fresh air

⁸ Due to the technical nature of the information, this section may be difficult for the average reader to understand. Assistance may be required from someone with technical expertise such as an engineer.

dilutes the concentration of particles, such as droplet nuclei, in room air. This is similar to opening doors and windows to dilute objectionable odors.

The *removal* effect occurs when potentially contaminated room air is either:

- exhausted outdoors to a safe place, or
- *filtered or irradiated* to trap or inactivate some or all droplet nuclei containing *M. tb.*

In any ventilated space, air is constantly entering (being supplied) and leaving (being exhausted). When introducing air into a space, it will mix to a certain extent with the air already in the room. This will dilute any airborne pollutants to create an air mixture. The mixture is then exhausted. The more effective the mixing of air, the better will be the dilution of infectious particles.

b. Air Supply and Exhaust Locations

The effectiveness of any given ventilation rate in clearing a space of air contaminants depends on how well the air is mixed. In turn, air mixing depends largely on how and where air enters and leaves the space. The most common causes of poor air mixing are *stagnation* and *short-circuiting*. Avoid both because they reduce the benefits of ventilation.

Stagnation occurs when part of the room does not benefit from the fresh supply air. It also occurs in a room that does not have any ventilation. People in a stagnant location would probably feel that the air is stuffy. Infectious particles in a stagnant area are not diluted or removed quickly.

Short-circuiting occurs when clean air is removed before it has mixed well with room air, such as when the exhaust is located right next to the supply of incoming air. A room must not only have a satisfactory amount of clean air supplied to it, but this air must also mix with the air already in the room.

c. Directional Airflow

Ventilation can also help reduce the *local* concentration of infectious particles in a room. This is done by matching the location of people in a room to the airflow. Simply stated, people whom you are trying to protect from TB exposure should be located near supply air (i.e. air coming in). Situate clients who may be infectious near where air is exhausted from the space (i.e. air going out). To determine directional air flow one needs to be able to determine the location of the supply air versus the return air to a room. The supply air diffuser is usually in the ceiling and one can feel air entering the room at these sites.

In the homeless shelter setting, this principle can help protect staff from an unidentified TB patient. For example, use of directional airflow can help reduce the chance that TB will spread from a shelter client to a staff member doing intake interviews. If you know the air direction, the staff member should sit near the fresh air source, and the clients should sit near the exhaust location.

In a room in which there are large numbers of clients, such as a dormitory or a TV room, anyone could be a source of TB, and TB could spread to others in the room. Therefore, the direction of air movement does not matter. It is more important to achieve good air mixing in all locations so that particles are more quickly diluted and removed. In high-density areas, higher ventilation of disinfected air is required. Therefore, determine if the existing mechanical ventilation system can reach levels recommended in the Environmental Control Guidelines. If mechanical ventilation systems cannot achieve this, then add the appropriate UVGI units (see Section E).

B. Natural Ventilation

Natural ventilation, that is opening a window to exhaust air or to introduce fresh air, is discussed in the Francis J. Curry National Tuberculosis Center document⁹. When weather permits, this is one means of diluting air in a room. However, this is not a feasible option most of the year in Toronto because of the long and cold winters.

⁹ TB in Homeless Shelters: Reducing the Risk through Ventilation, Filters, and UV (2000)
Francis J. Curry National Tuberculosis Center, Institutional Consultation Services, and California Department of Health Service.

C. Air Mixing with Fans

Air mixing dilutes infectious particles by spreading them throughout the room. Propeller fans are an inexpensive way to increase air mixing. They include:

- Small fans that sit on a desk or other surface
- Fans that stand on the floor
- Low velocity ceiling fans are the best way to assure air mixing where ceiling height permits.

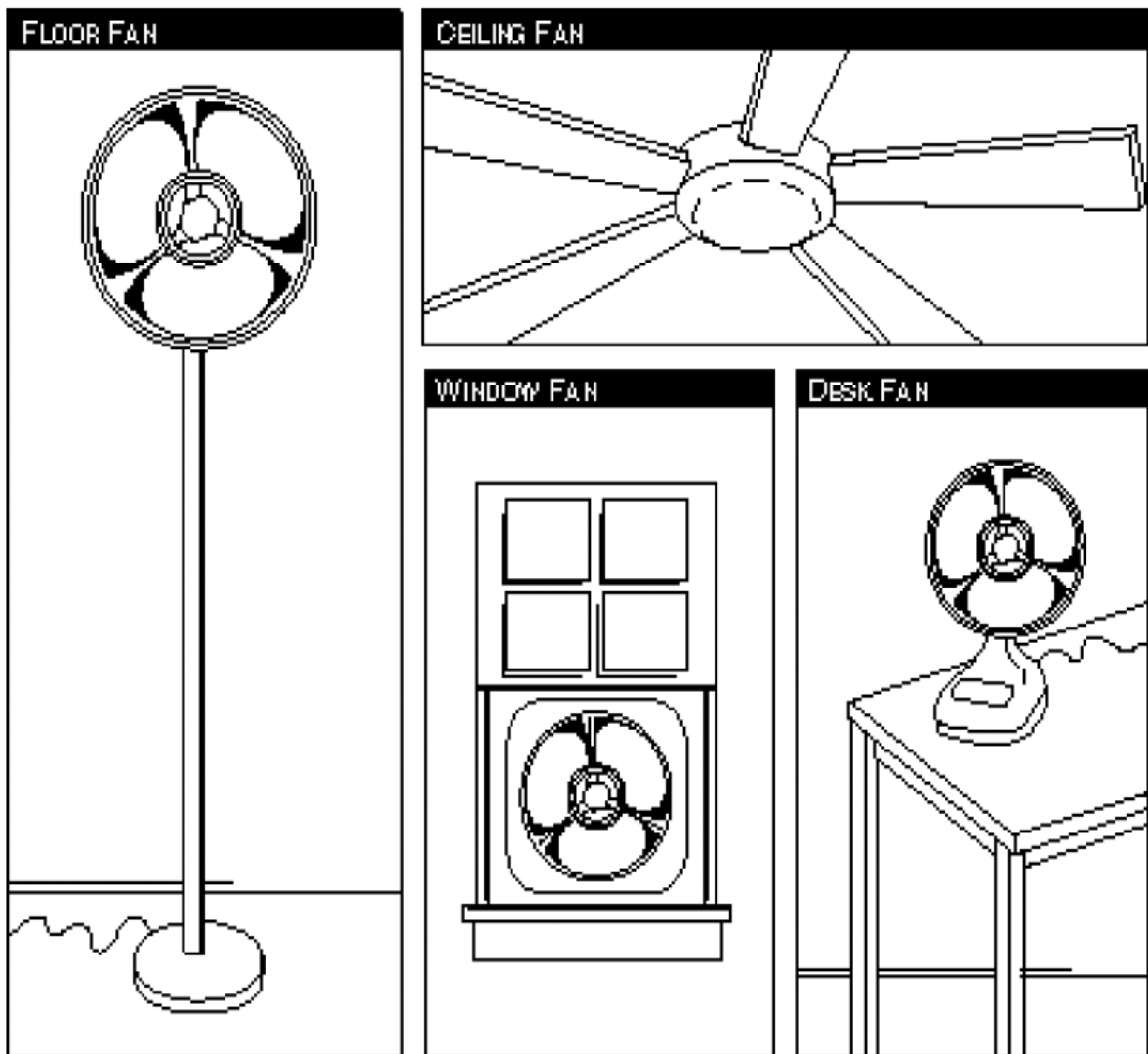


Figure 1: Propeller fans

D. Central Ventilation System

Central ventilation systems, also called *forced-air systems* or *HVAC systems*, are mechanical systems that circulate air in a building. Central ventilation systems come in many different configurations. The basic components of such a system are usually the same and may include some or all of the following:

- filters (to clean air before recirculation)
- a fan (to move the air through the unit)
- a furnace (for heating)
- an air-conditioning section (for cooling)

These components may all be installed in a single unit or may be in separate sections. A system may also include other parts, such as:

- a thermostat and controls (to turn the fan on and off and to control the temperature)
- ductwork, diffusers, and/or grilles (to distribute and collect air)

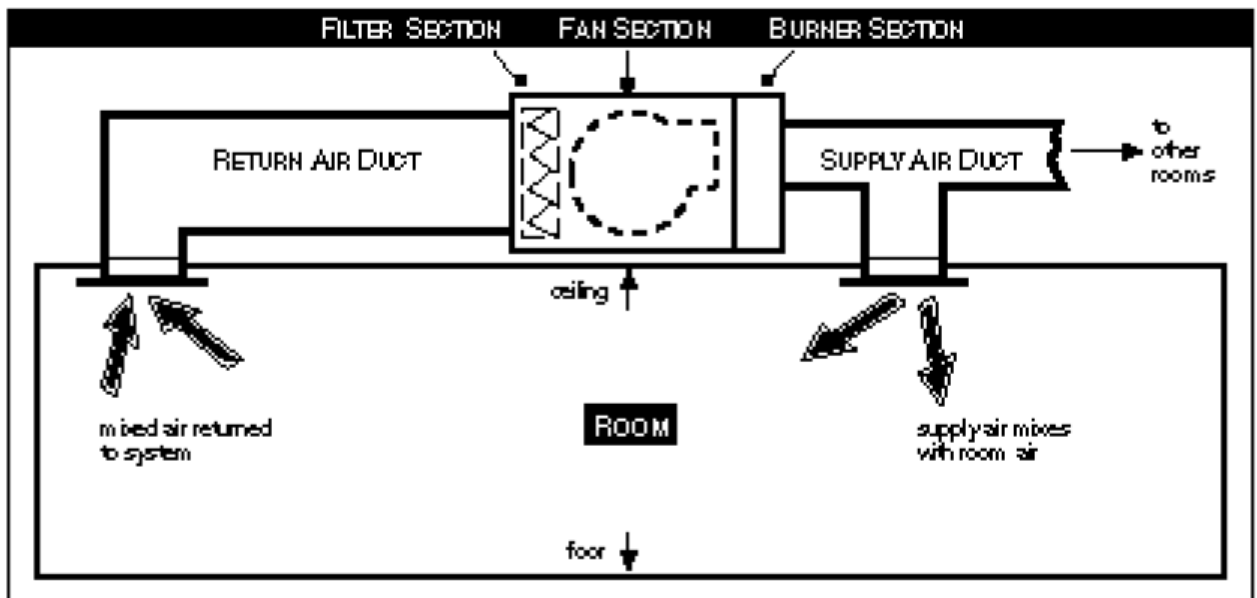


Figure 2: Central Ventilation Unit

For TB control, the best type of system is one without recirculation—that is, a 100% outside air, or once-through, arrangement. In this case, all supply air is fresh outside air, which is filtered and then heated or cooled before it is supplied. All potentially contaminated room air is exhausted directly outside the building. But once-through systems are uncommon because it is expensive to continuously heat or cool air from the outside to a comfortable room temperature. With long, cold winters in Toronto, a 100% outside air system would not be feasible.

Instead, most mechanical ventilation systems use some re-circulated air to supply air into a room. Such a system can reduce TB transmission by:

- Introducing some fresh outside air to replace room air to meet the minimum requirements under the OBC and ASHARE. For new buildings supply no less than 25 cfm/person of outside air, and in older buildings supply no less than 15 cfm/person of outside air.
- Disinfecting re-circulated air by using ultraviolet germicidal irradiation (UVGI) lamps or HEPA filters.

In addition, design new air handling units so the air is exhausted rather than re-circulated from one shelter room to another room or to a public corridor.

a. Ventilation Rate of a Mechanical System

An engineer can calculate a room's mechanical ventilation rate. You can then compare the ventilation rate to rates listed in published codes, standards, and recommendations. The ventilation rate is usually expressed in *air changes per hour (ACH)*. One *air change* occurs in a room when a *volume of air* equal to the *volume of the room* is supplied and/or exhausted.

Airflow is usually measured in cubic feet per minute (CFM). Room volume is equal to width X length X height. If a room is 8 feet wide by 10 feet long and 9.5 feet high, then the room volume equals:

$$8 \times 10 \times 9.5 = 760 \text{ cubic feet}$$

In order to calculate required airflow for a ventilation rate of 6 ACH:

$$\begin{aligned}\text{Room volume X 6 ACH} &= 760 \times 6 \\ &= 4,560 \text{ cubic feet per hour} \\ &= 4,560/60 \text{ cubic feet per minute} \\ &= 76 \text{ CFM}\end{aligned}$$

b. What Facility Operators Should Know About Ventilation Systems

1. Operators need to understand how the mechanical systems in their facility operate and how they must be maintained. The design philosophy should be fully understood for efficient, safe operation of the installed equipment. All operators should receive adequate training.
2. Facility Operators should have on site:
 - A complete and up-to-date set of drawings of the mechanical systems of the building.
 - One complete set of Operation and Maintenance manuals.
 - The latest air balancing report and any other supporting documentation.
3. No unauthorized adjustment should be made to air delivery systems. Any authorization of work should come from facility management personnel.
4. Note any changes made to the mechanical ventilation systems on the "As-Built" drawings with date and description of work. The person completing the work should sign changes.
5. Ventilation systems should operate continuously. During occupied hours, the system should be in "Fan On" mode.

6. All air handlers designed to provide ventilation to the interior spaces should run continuously. Without the air handlers running, there is minimal air movement and this does not meet the intent of the Environmental Control Guidelines.

c. Routine Upkeep of Existing Central Ventilation Systems (See Checklist in Appendix 2)

1. Check filters every month and replace when required. Make sure the appropriate filters are installed correctly in the filter track and not jammed into position. When installing a new set of filters, write the replacement date on the cardboard frame of the filter. Track the average life of the filters so a replacement schedule can be determined.
2. Clean diffusers, grilles, and in-duct UVGI lamps every month.
3. Clean return air ductwork with a vacuum cleaner every year. Remove the grille and clean as far back as the vacuum cleaner can reach.
4. Check ventilation units and thermostats every year. Make sure that thermostats turn on units and those units are running.
5. Keep records of all routine maintenance activities and dates.

d. Low Cost Measures to Improve Ventilation Systems

1. Seal all supply ductwork above ceilings so that the air delivered from the air handler is supplied to the occupied zone of the room, not the ceiling space.
2. Repair insulation and replace exterior ductwork weatherproof insulation covers, if needed.

3. Separate staff and client areas, based on underlying mechanical ventilation systems.
 - Separation of spaces based upon function will reduce risk of transmission of TB.
 - Service staff areas by independent air handling units to reduce risk of transmission of TB.
4. Maintain occupant densities at levels that can be handled by the HVAC system serving the zone.
5. Replace filters often or as determined by experience and observation. Clogged filters decrease the air delivery rates into the space and increase the risk of air bypassing the filter due to leakage.
6. Clean and drain the flat roof areas periodically.
 - Air handlers located on the roof are more likely to draw in odours and contaminants from decaying and contaminated debris on the roof near air handler intakes.
7. Locate thermostats and zone sensors centrally away from heat sources and exterior doors.
 - They should be located in areas which best represent the actual conditions in the HVAC zone.
 - Move printers, monitors, partitions, filing cabinets, etc. away from sensors.
8. Avoid use of interior perforated spiral delivery ducts because they cannot be balanced for effective air distribution.
 - Replace all perforated ducting in occupied spaces and install new ducting and room supply grilles with dampers that can be used in the air balancing process.
9. Service all occupied areas by air handling units.
 - Where possible, extend existing systems or install new fully featured units and ducting.

- Alternatively, install in-room re-circulation units equipped with UVGI air purification capability. Outside air volume requirements must be met.

10. Make sure economizers are specified and supplied with new re-circulating air handlers.

11. Retro-fit re-circulating roof top air handlers with economizers. These should be set to provide the required minimum outside air volumes specified by the Environmental Control Guidelines.

12. Install and/or replace filters in the air distribution system with a minimum 2-inch media type with a MERV (Minimum Efficiency Reporting Value) rating of 6. Filters must be selected to fit the appliance for which it is to be installed¹⁰.

E. Ultraviolet Germicidal Irradiation (UVGI)

Ultraviolet is the part of electromagnetic radiation between 100 and 400 nm and is visible to the human eye. The UV spectrum is subdivided into three bands:

UV-A (long wave)	from 315 to 400 nm
UV-B (medium wave)	from 280 to 315 nm
UV-C (short wave)	from 200 to 280 nm

A strong germicidal effect is provided by radiation in the UV-C band. Specially designed ultraviolet germicidal irradiation (UVGI) lamps can generate UV radiation at 254nm. Because of this ability, UVGI has been used to reduce TB transmission by disinfecting the air. There are two types of UVGI systems: in-duct UVGI system and in-room (e.g. upper-room, in-room enclosed) UVGI systems.

UVGI's effectiveness *increases* with:

¹⁰ Filters placed in close proximity to any UVGI lamps must be a polyester cotton blend or wet laid fibreglass, suitable for exposure to ultraviolet rays.

- *intensity of the radiation* which depends on the wattage, condition, and age of the lamp. The intensity of a lamp fades over time and to a lesser extent, as dust accumulates on the lamp.
- *length of exposure time* depends on how fast air containing infectious particles moves past the lamp.
- *proximity of infectious particles to the UVGI lamp* depends on the placement and number of lamps used.

UVGI's effectiveness *decreases* with:

- *relative humidity*: UVGI is not recommended for rooms in which the relative humidity of the air is greater than 70%. Fortunately in Ontario this level of humidity is rarely reached.

Health Effects of UVGI:

UV-C is mostly absorbed by the top layer of dead skin but exposure can lead to temporary inflammation of the skin (dermatitis) resulting in redness. In addition, UV-C exposure can cause keratoconjunctivitis of the eyes resulting in redness, pain, excessive tearing and foreign-body sensation. Fortunately, UV-C does not penetrate to the lens of the eye.

Nardell et al reviewed reports of dermatitis and keratoconjunctivitis following exposure to UVGI and found that all incidents were the result of overexposure following human error. Those affected had mild clinical symptoms that resolved 8 hours to 4 days following cessation of exposure. In a study of over 3,600 staff and residents in 15 homeless shelters with upper-room UVGI, only one definite instance of UV-related keratoconjunctivitis was found. This person was occupying the upper bunk of a double bunk bed in a dormitory that was fitted for single bed use when UV fixtures were installed. The problem was resolved by moving the UVGI fixture higher on the wall (Nardell, under review).

The information sheet on the next page can be posted in rooms with UVGI to inform occupants about its health effects.

Health Effects of Ultraviolet Germicidal Irradiation (UVGI)

- Ultraviolet (UV) lighting is used to kill germs in the air such as tuberculosis (TB).
- This light (UV-C) has wavelengths between 200-280 nanometers.
- The glow from the lamp is harmless but it is important not to stare at the light.
- Most of this light is absorbed by the top layer of dead skin but very long exposure can lead to temporary redness of the skin as well as pain, tearing and redness of the eyes.
- In a large study of ultraviolet lighting in 15 homeless shelters in the US with over 3600 staff and residents, only 1 case of red eye was found following exposure to ultraviolet light. The condition was temporary and the person fully recovered.
- There are some health risks associated with ultraviolet light so it is important to follow these safety rules:
 - **Do not look at the lamp(s)**
 - **Do not tamper with the lamp(s)**
 - **The lamps must be switched OFF before servicing**
 - **Wear protective gloves when handling ultraviolet lamps**

a. In-duct UVGI

UVGI lamps can be used inside an air duct to disinfect air removed from a room before re-circulation. They are located in the existing ductwork of the HVAC system either before or after the air handler. An appropriately designed, installed, and maintained in-duct UVGI system could effectively disinfect most re-circulated air which supply multiple rooms on the same ventilation circuit.

Pros: Protection against vandalism, reduced risk of UVGI exposure to occupants.

Cons: Lamps are more difficult to access for maintenance

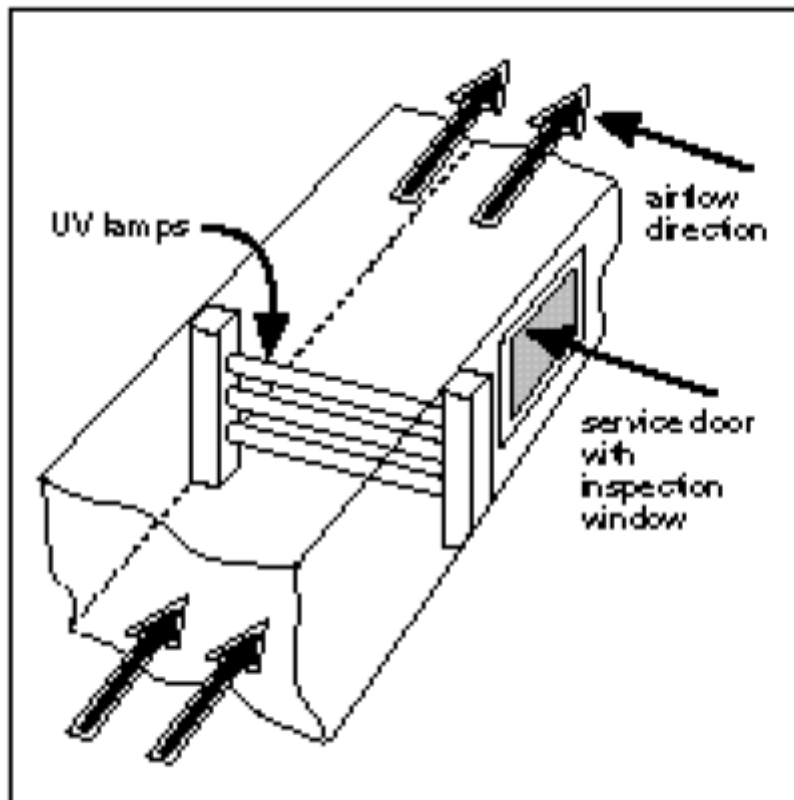


Figure 3: In-duct UVGI

i. Installation and Maintenance of In-duct UVGI

A UVGI installation should be designed and installed by an experienced professional, such as a UVGI lamp manufacturer, a mechanical engineer, or a mechanical or electrical contractor.

Lamps are installed in a row at right angles to the airflow direction. The number and spacing of the lamps should be selected to ensure that all air is exposed to the radiation. Detailed calculations and measurements based on airflow and duct size will be required. The UV intensities used inside a duct can be, and should be greater than for upper-room UVGI because the lamps are mounted inside the ductwork. The required intensity of the lamps will depend on air speed in the duct.

A duct access door should be provided so that the lamps can be cleaned, checked, and replaced. The duct access door should be electrically linked to the lamps' power supply so the lamps are switched off when the access door is opened. This will protect maintenance staff from accidental exposure to UVGI. A warning sign alerting staff of the danger to the skin and eyes of direct exposure to the bulbs should be posted on, or adjacent to, the viewing window. Monitoring and maintenance is crucial, because the intensity of lamps fades over time.

See Appendix 3b: General Recommendations for Maintenance and Inspection of UVGI Fixtures

If you have in-duct UVGI:

- Check that lamps are operating at least once a month
- Clean lamps every month. Turn off lamps for at least 15 minutes before cleaning with a dampened cloth. Do not use glass cleaners.
- Replace lamps at least once a year or as recommended by the manufacturer. Dispose of used lamps as the manufacturer recommends.

b. Upper-room UVGI

UVGI lamps can be mounted high on walls or hung from the ceiling in a room where there is a risk of TB transmission. Upper-room UVGI fixtures are designed and installed so that levels of UV-C radiation are directed into the upper room.

Minimal UVGI levels are present in the lower room where the occupants are located. Vertical air mixing has been shown to disinfect air in the occupied space effectively even though disinfection is limited to the upper room. A properly planned and installed upper-room UVGI system should be able to provide the equivalent of 6 to 10 ACH of disinfected air.

In rooms with upper-room UVGI, air movement can be induced by the use of in-room fans. Existing overhead central ventilation systems with properly designed diffusers can also provide sufficient air movement in the room. Some upper-room UVGI fixtures also include built-in fans.

Wall-mounted fixtures must have louvers to block downward radiation or be positioned such that lower room UV-C levels meet safety standards. Ceiling mounted fixtures must be designed to block radiation below the horizontal plane of the UV tube. At no location should the UVGI intensity be more than the American Conference of Governmental Industrial Hygienists (ACGIH) TLV (See Appendix 3).

Three factors are important in the efficacy of upper-room UVGI:

- a. Upper room disinfection rate
- b. Air volume ratio for the irradiated upper room and non-irradiated lower room
- c. Air mixing rate between the upper and lower rooms.

Disinfection rate in the upper room depends on the UV dose and the UV susceptibility of the microorganism. UV dose is the product of UV irradiance and exposure time. Susceptibility of microorganisms to UV depends on the complexity of the microorganism's structure, its reparability and its general sensitivity (First 1999). As the UV dose becomes higher and microbial susceptibility to UVGI increases, the efficacy of upper-room UVGI increases.

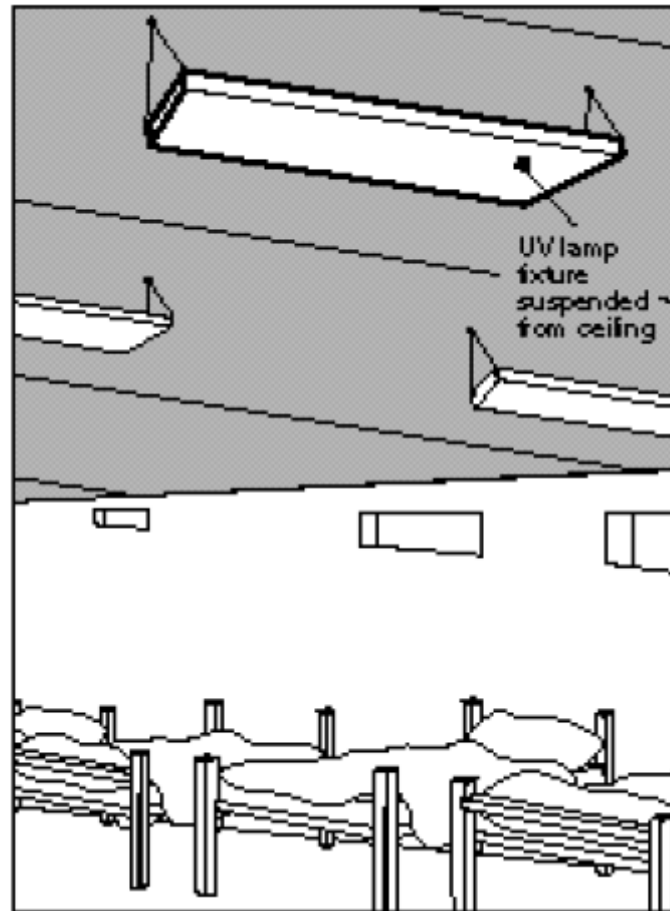


Figure 4: Upper-room UVGI

Pros: Able to disinfect large volumes of air at once compared with in-duct systems or in-room enclosed systems, relatively inexpensive to purchase and operate, limited impact on building structure and mechanical systems.

Cons: Cannot use in rooms with low ceilings, potential risk from UV-C exposure, requires special expertise to design and install, cannot use in rooms with poor air mixing, unit can be tampered with since it is not enclosed, light may bother some people who are trying to sleep.

Care must be taken in the design, installation, and maintenance of UVGI because of safety concerns, because effectiveness can vary, and because every installation is unique.

i. Ensuring Safe Radiation Levels

Radiation can reach the lower occupied part of the room through reflection from the ceilings and walls and perhaps directly from the fixtures. The actual radiation levels of an upper-room UVGI installation are difficult to predict. For a given fixture, final radiation levels will vary for every room and for different parts of the same room. Factors that affect each installation include:

- the type of lamps used
- the effectiveness of the fixture baffles at preventing radiation from reaching occupied areas
- the locations of the fixtures
- the reflectivity of the walls and ceilings

The only way to tell if an installation is safe is to measure radiation levels in the occupied part of the room. Measurements should be made by a qualified technician or a qualified contracted technician using a calibrated UVC radiometer at numerous locations and elevations where people may be exposed for long time periods. For example, in a dormitory room, readings should be taken at the heads of beds. Readings should be made at the time of installation, at 6 months, at the time of lamp replacement and then periodically afterwards e.g. after architectural or decorative changes to the room.

If elevated UV-C measurements are recorded, turn OFF power to the UVGI device until corrections are made.

ii. Recommended Exposure Limit

The American Conference of Governmental Industrial Hygienists (ACGIH) has published a threshold limit value (TLV) for UVGI wavelength of 254 nanometres.

The ACGIH currently recommends that measured UV irradiance in the lower room should be less than or equal to 0.2 mW/cm² for 8 hours of exposure.

See Appendix 4 for ACGIH values.

iii. Determining If Upper-Room UVGI Is Suitable for a Particular Room

A room must meet the following criteria if upper-room UVGI is to be used:

- *Upper-room UVGI is not recommended in rooms with ceilings less than 9 feet high.* The lamps must be installed sufficiently high so that people cannot look into the lamps or bump into them. Therefore UVGI lamps need to be installed so that there is at least 7 feet of clearance above the floor.
- *Upper-room UVGI should not be used in rooms with bunk beds unless it can be installed with sufficient clearance above the upper bunk.* Otherwise a client who is sitting/standing on the top bunk may be exposed to UV-C in the upper, radiated, part of the room. In a room with bunk beds, UVGI lamps need to be installed with at least 7 feet of clearance above bunk beds.
- *Room fans or ventilation system are recommended* to help mix the disinfected air in the upper room with the potentially contaminated air below. The fans or ventilation system should be operating continuously when the building is occupied.

iv. Preparing for an Upper-Room UVGI Installation

Upper-room UVGI design and installation requires specialized expertise and equipment. Only an engineer with upper UVGI training and experience should be hired to undertake this work.

A poorly installed upper-room UVGI system could result in:

- harmful radiation levels in the occupied space, and
- ineffective radiation levels in the upper room bacterial kill zone

v. Planning an Installation of Upper-Room UVGI

- UVGI fixtures should be located so that radiation in the upper room is uniform, continuous, and complete.
- The installation contract should include measurements of radiation levels after installation. These measurements should be taken before the job is accepted and payment is made. A written report should be submitted to the owner.
- The UVGI system should not be commissioned until readings have been taken in the occupied zone to ensure that radiation levels are below the ACGIH TLV. Readings should be taken in a number of locations corresponding to where people will be exposed.
- Radiometer readings should be taken at 6 ft to measure effective irradiance to ensure that the radiation intensity meets $0.2 \mu\text{W}/\text{cm}^2$.
- Nonreflective paint may need to be added to ceilings and walls. Some ceiling paints can reflect too much radiation down to the occupied room below. If meter readings indicate excessive radiation in the occupied area, the ceiling may need to be painted with nonreflective paint. This should be included in the budget for the planned installation. Paint containing titanium dioxide is recommended for reducing reflection from surfaces.
- *Warning signs*, in all appropriate languages, should be posted on the UVGI fixtures and the wall to alert maintenance staff of UV-C exposure hazard. Damaged or illegible signs must be replaced immediately. The signs should carry the following or a similar message:

! CAUTION

Turn the main power switch OFF to the UVC lamp module before performing any maintenance or component replacements.
--

! Warning

Equipment Damage Warning: UVC Germicidal light can cause color shift or structural degradation of plastic HVAC materials.

Select a mounting location that prevents direct exposure to plastic components with unknown resistance to germicidal ultraviolet light (UVC).

! Caution

Ultraviolet light UVC has the shortest wavelength of all UV radiation and is harmful to bare skin and eyes. Never look at the lamps while illuminated. To prevent exposure to the ultraviolet lamps the power switch must be in the off position before servicing any part of the air purifier. Failure to do so may result in severe burns and long-term injury to the eyes.

Be careful when removing and inserting ultraviolet lamps into the lamp base. Wear protective cotton gloves when handling lamps.

Turn power off for 15 minutes before removing the UVC germicidal lamp.

- Staff and clients may have concerns regarding health hazards from UVGI. To address these concerns, provide education on the purpose, benefits, and risks associated with upper-room UVGI.
- Staff should be trained about UVGI. Also, consider posting an information sheet on the wall of the room.
- The on/off switch for the lamps should be accessible to appropriate staff members but not located where individuals may turn off the fixtures.

vi. Routine Upkeep of Upper-Room UVGI

(See Appendix 3a for Maintenance Checklist for Upper-Room UVGI)

- Designate a staff member to be the in-house monitor for UVGI fixtures. This person should be trained in the basic principles of UVGI operation and safety and should be responsible for cleaning, maintaining, and replacing the lamps.
- The UV-C lamp replacement should be determined from the time use log or based on cumulative time. Typically the recommended replacement cycle is 9,000 hours.
- If lamps fail to light or they flicker to an objectionable extent, they should be replaced.
- Before replacing filters or UV-C lamps, the power of the unit must be turned off for at least 15 minutes to allow cooling of the lamp before replacement. Verify that the lamps are off when a blue glow cannot be seen from a distance.

- Check and clean lamps and fixtures every 3 months. Use a cloth dampened with water. Do not use glass cleaners.
- Use soft cotton gloves to handle old or new lamps to prevent deposit of oily film on the lamps and to avoid breakage
- Replace lamps once a year or as recommended by the manufacturer. The violet blue glow emitted by a lamp is not an indicator of the lamp's effectiveness. Take radiometer readings at each new lamp to ensure that radiation levels meet the manufacturer's recommendations. Dispose of used lamps as recommended by the lamp manufacturer.
- Keep a record of all maintenance and monitoring, including radiometer readings and dates. This will help determine the average life of the lamps. Lamps should be purchased close to your planned replacement time because prolonged storage may result in a loss of radiation intensity.
- See General Recommendations for Maintenance and Inspection of UVGI Fixtures in Appendix 3b.

F. In-room Disinfection Units

a. In-room UVGI Enclosed System

These are fully enclosed UVGI units which use a fan to induce air movement through the fixture at the design air volumes. Careful selection is needed to ensure that the desired disinfection rate is achieved. Multi-stage filtration is often included for particulate removal and to help keep the fixture and lamps clean. Fan speed controllers are common in these units but multi-speed functions may not be suitable for shelters because fan speed can be altered or turned off. Such units can be mounted on the wall or ceiling.

In-room enclosed units can be used:

- where no central forced air system exists
- where there is no in-room air movement

- where existing central forced air system cannot deliver the required rate of disinfected air
- where a tamper-proof design is desired
- where UV light must be enclosed in the fixture

Portable UVGI enclosed units similar to those described above are available and these can be easily moved.

In-room portable enclosed units can be used:

- in rooms where there is periodic high occupancy densities requiring augmentation of the existing ventilation system
- where the existing central forced air system cannot deliver the required rate of disinfected air
- where the portable feature is desired for rooms which have unexpected airborne risk

b. Air Filters

Filters can be used to remove airborne particulate, as part of the ventilation system. Only HEPA (High-Efficiency Particulate Arrestance) filters can effectively remove all airborne *M. tb*. However, it is usually not possible to retrofit HEPA filters into existing ventilation systems because they impede air flow.

Pleated filters are used in some re-circulating air systems to remove particles in the air as they pass through them. However, they can only remove a percentage of the particles in the size range of TB droplet nuclei; the percentage removal is dependant on the filter's MERV (Minimum Efficiency Reporting Value) rating. Therefore they are NOT recommended to be used on their own. Instead, UVGI lamps can be installed in conjunction with pleated filters to disinfect the air. Ultraviolet germicidal irradiation is a specially designed light fixture which generates UV radiation (UV-C); this type of radiation has been shown to kill or inactivate *M. tb* in air. Thus, the air would first pass through the filters and then be disinfected by UVGI.

i. What Is a HEPA Filter Unit?

Self-contained HEPA filtration units are available and have been shown to be effective in removing aerolized bacterial and viral particles from the air.

HEPA filter units are available in a variety of sizes and configurations, but all consist of:

- a HEPA filter (to remove small particles from the air)
- a prefilter (to remove coarser particles and thereby prolong the life of the HEPA filter)
- a fan (to circulate air past the HEPA filter and into the room)
- controls (for example, on/off switch and fan speed control)

The most common types of units are portable, freestanding devices. Small units can deliver 150 to 250 CFM and large units can deliver 300 to 1,000 CFM. Ceiling-mounted and wall-mounted units are also available. Portable units have the advantage of greater flexibility and ease of installation and service. HEPA filter units are based on the amount of air they deliver, usually expressed in cubic feet per minute (CFM). Most units include a switch that can be used to vary the airflow.

Drawbacks of HEPA systems include: noise, requirement to change filters on a regular basis, and the ability to disconnect/switch off.

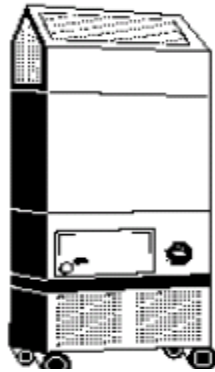


Figure 5: HEPA filter unit

ii. HEPA Filter Unit Selection

- Select HEPA filter units to provide an air change rate for desired ACH.
- Units may deliver less than the manufacturers' listed airflow, and output may decrease as the filters load up. To compensate for this, add a safety factor of 25% to the required airflow.
- Because of the increased noise, people tend to use the units at low settings. Therefore, the low setting should be the basis for unit selection.

EXAMPLE

- Room volume (first column) is room length X width X ceiling height. For example, a room that is 30 feet long by 30 feet wide with a 10-foot-high ceiling would have a volume of 9,000 cubic feet.
- The required airflow in cubic feet per minute (CFM) to achieve 2 ACH is calculated as follows:
$$(\text{room volume} \times 2 \text{ ACH}) / 60 \text{ minutes per hour} = 300 \text{ CFM}$$
- To achieve this level of air disinfection, a unit with 375 CFM (i.e. with 25% safety factor) would need to be used in the room.

iii. Routine Upkeep of HEPA Filter Units

- Designate a staff person to be the in-house monitor of the HEPA filter units. This person should be aware of the basic principles of HEPA filter unit operation, including effective placement and maintenance. This person should also implement a written schedule for changing the prefilters and HEPA filters.
- Maintenance consists of replacing the prefilter and the HEPA filter at regular intervals. The manufacturer's data should explain how this is done. In general, the prefilters should be replaced every 6 months, and the HEPA filters should be replaced every 1 or 2 years. Actual replacement time will depend mainly on how often the units are used and how dusty the room air is.

G. Pros and Cons of UVGI and HEPA Filtration

	Pros	Cons
In-duct UVGI	<ul style="list-style-type: none"> • Install in duct UVGI where rooms are on the same mechanical ventilation circuit 	<ul style="list-style-type: none"> • Difficult to access for maintenance • Can only disinfect air removed from a room before it is recirculated into another space
Upper-Room UVGI	<ul style="list-style-type: none"> • Able to disinfect large volumes of air at once compared with in-duct systems or in-room enclosed systems. • Relatively inexpensive to purchase and operate • Limited impact on building structure and mechanical systems • No noise or draft 	<ul style="list-style-type: none"> • Potential health risks from UV-C exposure • Requires special expertise to design and install • Each installation is site-specific • Cannot use in rooms with ceilings < 9 feet • Cannot use in rooms with poor air mixing • Unit can be tampered with since it is not enclosed • Light may bother some people • Radiometer readings need to be taken following installation and periodically afterwards
In-room Enclosed UVGI Unit	<ul style="list-style-type: none"> • Can be used in rooms with low ceilings • Less prone to tampering 	<ul style="list-style-type: none"> • Smaller volumes of air are disinfected than upper UVGI system
HEPA Filter Units	<ul style="list-style-type: none"> • Portable • No health risks associated with use • Easy to install • Have adjustable airflow rate 	<ul style="list-style-type: none"> • Noisy and drafty • Smaller volumes of air are disinfected than UVGI units • Relatively expensive • Filters need to be changed on a regular basis • Can be unplugged

H. Cost Estimates to Upgrade Environmental Controls

The values referenced below were provided by Van 'A' Engineering Ltd. to assist facility owners and operators to estimate costs required to implement the Environmental Control Guidelines.

1. Engineering Assessment

- a. Estimated cost of **FULL** Engineering Assessment, and action plan (\$/sq. ft.) **\$0.50/sq. ft.**
- b. Estimated cost of **PARTIAL** engineering Assessment – rough scope of work **\$0.25/sq. ft.**
- c. Draw up plans and specifications for improvements to meet recommendations **By quotation**

2. Upgrade Ventilation System

- a. New sealed ductwork from air handler to diffuser with thermal insulation and 8 ft of acoustical insulation after air handler flex to diffusers- installed. **\$ 2,000/ToR**
- b. Balancing of Air Systems and lock balancing dampers in position: **\$ 0.40/sq. ft.**
- c. Commissioning and Demonstration by Commissioning Agent: **\$ 1,000/day**
- d. Complete check-out and maintenance overhaul of installed and new mechanical equipment. **\$ 400/ unit**
- e. Seal Supply Ducting **\$ 60/hr.**

- f. Install economizer into existing roof top air handler, complete with barometric relief air damper either on the unit or the ducting on the roof. **\$ 2,000/economizer**
- g. Set up economizer's minimum air position on each roof top air handling unit to provide the requisite outdoor air, parts extra **\$ 500/ economizer**
- h. Work to replace roof top air handler onto existing roof curb without crane charges **\$ 2,000/unit**
- i. General maintenance and inspection of the ducted air system within the building, ducting layout, clean return air grilles, and other impediments to air flow. **\$750/day + materials**
- j. Set – up of positive air pressure rooms complete with purified supply air from central or adjacent spaces. **\$ 5,000 to \$10,000**
- k. New Roof top air handlers with hoisting, accessories and warrantee but without curbs, or roofing charges that may apply. **\$ 1,200/ToR**
- l. Gas Piping and regulator at each gas fired unit: **\$ 1,000/unit**
- m. Diffusers, grilles, dampers without motorized actuators **\$ 200 each**
- n. Zone control damper, motor, disconnects, transformers, relays and wiring. **\$ 2,000/zone**

3. Install UVGI Units

- a. In-duct UVGI systems directly after handling unit and in ceiling for individual systems < 2000 cfm/unit **\$ 4.00/cfm**
- b. In-duct UVGI systems > 5000 cfm/unit **\$2.00/cfm**
- b. Upper-room UVGI systems Ceilings <8.5' (\$/sq.ft. of area served) **\$8.00/sf space**

- c. Upper-room UVGI systems Ceilings >9.75 ft. **\$2.50/sf space**
 - d. In-Room fan forced appliance UVGI system **\$ 6.00/cfm**
- 4. HEPA Filtration Unit** **\$8000 for 500 CFM Unit**

I. Building Suitability for Use as Shelter In Relation to Ventilation

When reviewing a building's suitability for use as a shelter, consider the following:

1. Note type of HVAC system (preferably central forced air) and age of existing air handlers.

- Get condition report from HVAC contractor or mechanical engineer about installed system, air handler, ducting energy conservation measures i.e., duct insulation, duct sealing, return air provisions and zoning.
- Check overall performance against Environmental Control Guidelines

2. Conduct building inspection and specifically look for water damage and mould. Building should be DRY.

3. Can the air handling equipment and ducting system provide air circulation rates based on Environmental Control Guidelines without major renovations?

4. Can the staff areas be serviced with a dedicated "staff area" air handler or zoned system? This can be achieved using UVGI in most cases.

5. Do roof top units have economizers? If so, what is their condition?

- What is the capacity of air handler with economizer?
- Are the HVAC system controls up-to-date and functioning? Are they properly located?

6. Can the interior space be set up to include an isolated area(s) for sick residents without cross ventilation?

7. Check condition of exhaust air systems, in bathrooms and kitchen area. Do they meet Ontario Building Code?

- Is sufficient make-up air provided to the building to offset the aforementioned exhaust volumes?

8. Are the exterior outdoor air intakes in good repair and free from rodent and garbage threats?

- Are they located in such a way as to avoid introduction of pollutants from the local environment?
- Where are the location of local sources of environmental dust, industrial pollutants, odours, vehicle exhaust and noise?

9. Are "As-Built" drawings, Operating and Maintenance manuals available?

J. Ventilation Evaluation of Buildings and Occupied Spaces

A. Engage the services of a professional engineer¹¹ who has experience assessing HVAC systems. If UVGI units need to be installed, hire an engineer with design and installation experience in this area.

B. Conduct a Survey of Building and Occupied Spaces

1. Obtain drawings of the building layout that fairly represent the “as-built” conditions of the mechanical ventilation system(s).
2. Determine how interior spaces will be used, hours of occupancy and occupancy levels e.g. dining room, office, rehabilitation rooms, program rooms, bedrooms, barracks, queuing corridors, etc. and tabulate results.
3. Document the condition and design capacity of the existing mechanical ventilation system.
4. Determine how the system provides and distributes heating and ventilation air within the building. Characterize the mechanical system(s) as re-circulating, make-air, interior furnace, roof top unit, split system, fan coils system, baseboard heating, electrical resistance heating, hot water heating, or gas fired forced air.
5. Determine the method by which the HVAC system introduces outdoor air into the various rooms. Locate the air distribution ducting and determine which rooms are serviced by which air handlers; also determine any other HVAC system characteristics.
6. Identify on the drawings the zoning of the building as it relates to the ventilation distribution system.

¹¹ See Appendix 5

7. Identify staff and client populated rooms on the drawings.

C. Evaluate Results of Building Assessment

1. Complete a survey of the mechanical HVAC system as outlined above.
2. Determine whether the system re-circulates indoor air within the building.
3. Calculate the required outside air requirements of the building, zone by zone and room by room, to meet recommendations set out in the Environmental Control Guidelines and the Ontario Building Code.
 - Use the higher of the two outside air requirements for each room.
 - Preferred means for introducing outside air is via the central HVAC system; or through ducting off a make-up air unit from a heat recovery ventilation unit; or energy recovery ventilation unit.
 - Introduction of make-up air should not reduce the comfort of the occupied space. Therefore, it is usually introduced by mixing with re-circulated air, heated or cooled before supply to the occupied space.
4. Determine occupancy of each room and each zone of the building. Determine if any rooms, areas or corridors should be equipped with auxiliary UVGI appliances. Refer to recommendations in the Environmental Control Guidelines.
5. Calculate the Total Air Changes per hour (TACH) required for each room and each zone as recommended by the Environmental Control Guidelines. It is preferable to adjust installed mechanical equipment while maintaining a balanced HVAC system to achieve required TACH.
6. Assess the existing mechanical systems (air handling equipment and ducting) to determine if the existing equipment can meet the needs of the facility when used as a shelter or drop-in centre.

7. Review with the facility operator HVAC zoning in staff and client use areas so cross ventilation is minimized.
8. See environmental control guidelines for recommendations for use of in-duct and in-room UVGI appliances.

a. Develop an Action Plan for each facility

1. List what changes are required to meet the Environmental Control Guidelines
2. Estimate the cost of the work
3. Prioritize actions as economics allow.

N.B. When redesigning the interior of a building, consideration should be given to ventilation standards and existing equipment. Changes made to rooms can change their ventilation effectiveness.

K. Applying Guidelines to an Example

An 800 square foot bedroom in an older building with 9 ft high ceilings is occupied by 3 persons. The air handler only serves this room and is located on the roof. It is not on the same ventilation circuit as any other bedroom.

Priority 1:

The room should be supplied with 6 TACH which can be calculated as follows:

$800\text{sf} * 9\text{ft} * 6 \text{ TACH} / 60 \text{ minutes} = 720 \text{ cfm}$ of delivery air to the room.

This air can made up of outdoor air and re-circulated air.

AND

The room should be supplied with a minimum of 15 cfm of outdoor air per person

For this room, the outdoor air component would be $15\text{cfm} * 3 \text{ persons} = 45 \text{ cfm}$ of outdoor air.

ASHRAE 62.1-2004 says the minimum for this room shall be $5\text{cfm/p} * 3 \text{ persons} + 0.06 \text{ cfm/sf} * 800\text{sf} = 63 \text{ cfm}$ of outdoor air. Therefore, the larger value of 63 cfm of outdoor air would be used. This 63 cfm of outdoor air is most reasonably introduced at the roof top air handling unit through an economizer.

Priority 2:

Not applicable since this room sleeps less than 20 people.

Priority 3: Not applicable since this room is not on the same ventilation circuit as other bedrooms.

Source: Modified from Van A Engineering and Associates Ltd, 2007.

Glossary

ACGIH

American Conference of Governmental Industrial Hygienists

ACH

Air changes per hour. This is a measurement commonly used to express the ventilation rate of a space. ACH is the number of times an amount of air equal to the volume of the space is exhausted or supplied every hour.

$$\text{ACH} = \frac{\text{airflow per hour}}{\text{room volume}}$$
$$= \frac{\text{CFM} \times 60 \text{ minutes}}{\text{cubic feet}}$$

ACH is air changes per hour

60 is a constant (60 minutes per hour)

Airflow (usually in cubic feet per minute)

Room volume (usually in cubic feet) is *room width* (ft) x *room length* (ft) x *room height* (ft)

Administrative controls

These are measures intended primarily to reduce the risk of exposing uninfected persons to persons who have infectious TB.

Air Stratification

Stratified air is a natural condition normally found in buildings. Heat rises up to the ceiling while the cold air remains on the floor.

ASHRAE

American Society of Heating, Refrigeration, and Air-Conditioning Engineers.

CDC

Centers for Disease Control and Prevention

CFM

Cubic feet per minute. *Airflow* is usually measured in cubic feet per minute (CFM). Airflow hoods usually provide readouts in CFM.

Contact

A person who has spent time with a person with TB disease.

Glossary (cont'd)

Destratification Fan

A wide, slowly rotating electrical propeller fan that is suspended from the ceiling which vertically circulates air in the room in which it is located.

Diffuser

Mechanical device, installed on a ceiling, that supplies air to a room.

Disinfected Air

Air stream that is passed through an appliance with a high efficiency filtration system documented and proven to remove > 99% of *M. tb* from the air stream; OR has been irradiated by UVGI lamps of sufficient wattage and duration to deliver an effective UV dosage >2000 $\mu\text{J}/\text{cm}^2$ (URV of 13), thus killing >99% of *M. tb*. In either case, the air stream is free of *M. tb*.

Droplet nuclei

Microscopic particles (1–5 microns in size) that can become airborne when a person coughs, sneezes, shouts, sings, breathes, or talks. Droplet nuclei produced by a person who has TB disease of the lungs or larynx in an infectious state can remain airborne for a long time and can spread TB to others.

Economizers: An apparatus installed on an air handling unit, designed to introduce outdoor air into the air handler.

Exhaust air

Air that is removed from a building by a fan system, as opposed to air that is removed from a space and then re-circulated or returned.

Grille

Mechanical device that usually removes exhaust or return air from a room. Grilles are usually on the ceiling but can be on the wall or floor. If a grille is on a ceiling or floor or low on a wall, it is usually for exhaust or return air. However, if a grille is high on a wall, it can be exhaust, return, or supply.

HEPA filter

High-Efficiency Particulate Arrestance filter. This is a filter that is capable of removing 99.97% of particles 0.3 micron in diameter or greater. HEPA filters remove all particles in the size range of TB droplet nuclei.

HEPA filter unit

This is a self-contained device consisting mainly of a HEPA filter, a prefilter, and a fan. These units can be used to provide clean air to supplement a building ventilation system.

HVAC

Heating, ventilation and air conditioning systems

HVAC Zone:

This is an area within the building that is treated as a unit, or as a whole, by the mechanical equipment and has its own space comfort controls.

Glossary (cont'd)

ICS

Institutional Consulting Services is part of the Francis J. Curry National Tuberculosis Center, funded by the Centers for Disease Control and Prevention, and the California Department of Health Services.

Make-up Air Handler: This is an air handling unit, placed on the roof of a building to introduce outdoor air into the building for ventilation and to offset and equal the building exhaust system.

MERV

Minimum Efficiency Reporting Value describes filter performance.

MOHLTC

Ministry of Health and Long Term Care, is a provincial ministry in Ontario.

M.tb

Mycobacterium tuberculosis

Large numbers of persons

The calculated occupant load exceeds the referenced codes in Ontario Building Code/ASHRAE.

NIOSH

National Institute for Occupational Safety and Health

Ontario Building Code (OBC)

This is a collection of regulations and requirements which pertain to specific subjects (such as exiting and fire protection systems) that regulate specific practices (such as designing, constructing or remodelling buildings).

The purpose of the OBC is to protect the health, safety and welfare of the public and building occupants. The Province of Ontario is responsible for the development of the Ontario Building Code Act, regulations and Ontario Building Code. Each municipality is then responsible for the enforcement of the Act and Code in the areas that fall within its jurisdiction.

Further information is available at the OBC website at:

http://www.obc.mah.gov.on.ca/scripts/index_.asp

Occupant Density: The number of persons in a room or space, per thousand cubic feet of space (persons/1000 cubic feet).

OSHA

Occupational Safety and Health Administration

Glossary (cont'd)

Recirculation

Ventilation system in which supply air includes air that has been previously removed from an interior space.

REL

Recommended exposure limit

Return air

Air that is removed from a space by a mechanical system, but not all of it is discharged directly outdoors. This air is usually returned to the mechanical system, where a portion of it is exhausted. The remainder is diluted with some outdoor air, filtered, conditioned (or heated), and then distributed.

Short-circuiting

Clean air is removed before it has mixed well with room air.

Stagnation

A part of the room that does not have fresh supply air so particles in the area are not diluted or removed quickly.

Supply air

This is air that is introduced into a space by a mechanical system.

TACH

Total Air Changes per Hour

TB control measures

These are steps taken to reduce the risk of TB transmission. TB control measures are usually divided into a hierarchy: (1) administrative (work practice) controls, (2) engineering controls, and (3) respiratory protection.

TB Disease

This is an illness in which TB bacteria are multiplying and attacking different parts of the body. The symptoms of TB disease include weakness, weight loss, fever, no appetite, chills, and sweating at night. Other symptoms of TB disease depend on where in the body the bacteria are growing. If TB disease is in the lungs (pulmonary TB), the symptoms may include a bad cough, pain in the chest, and coughing up blood.

TB Infection

This is a condition in which TB bacteria are alive but inactive in the body. People with TB infection have no symptoms, do not feel sick, cannot spread TB to others, and usually have a positive skin test reaction. However, they may develop TB disease later in life if they do not receive preventive therapy.

Glossary (cont'd)

TB Skin Test (Mantoux PPD Skin Test)

A test that is often used to detect TB infection. A small amount of test material is injected into the forearm and the result is read in 48-72 hours. A positive reaction indicates TB infection.

ToR (Tonnes of Refrigeration)

The amount of air conditioning that a room or building requires or the amount of air conditioning installed. It is calculated based upon many factors including the number of persons occupying the room, window area, room area, other equipment in the room and the lighting present in the room.

TLV

Threshold Limit Value is the maximum permissible concentration of a material, generally expressed in parts per million in air for some defined period of time (often 8 hours, but sometimes for 40 hours per week over an assumed working lifetime).

TPH

Toronto Public Health

URV

Ultraviolet germicidal irradiation rating values

UVGI

UltraViolet Germicidal Irradiation. Ultraviolet radiation is used to kill or inactivate microorganisms.

UVGI lamps

These are lamps that kill or inactivate microorganisms by emitting ultraviolet germicidal irradiation, predominantly at a wavelength of 254 nanometers (i.e. UV-C). UVGI lamps are used in ceiling or wall fixtures for upper-room UVGI and inside air ducts or air cleaners for in-duct UVGI.

Ventilation

This is the movement of air in a building and replacement of air with air from outside. There are two general types of ventilation:

- *Natural ventilation* relies on open doors and windows to bring in air from the outside. Fans may also assist in this process and distribute the air.
- *Mechanical ventilation* usually refers to the use of mechanical air-moving equipment that circulates air in a building and may also involve heating and/or cooling. Mechanical ventilation systems may or may not bring in air from the outside.

Ventilation rate

This is the quantity of air that is removed from or supplied to a room. It is usually expressed in air changes per hour (ACH).

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Appendix 1: Interim Guidance

Ministry of Health
And Long-Term Care

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et des Soins de longue durée



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Interim Guidance for the Prevention and Control of Tuberculosis (TB) in Homeless Shelters and Drop-In Centres¹

1. Homelessness and TB

Homelessness is a significant risk factor for TB infection and progression to active TB disease. A homeless person may face an increased risk of TB infection due to: overcrowding in shelters, where the person may be exposed to a person who has active disease; poor ventilation in shelters that can result in the concentration of contaminated air; and underlying medical conditions of homeless persons such as HIV infection, alcohol or drug use and poor nutrition, which make the person more susceptible to developing TB disease. Persons who are homeless also may have difficulty in taking medications on a regular basis or attending scheduled medical appointments resulting in their disease not being recognized or effectively treated.

2.Reducing the Risk of TB Spreading in Homeless Shelters

Shelters should develop and implement a TB management program based on the recommendations provided in the references below. The Francis J. Curry National TB Center (see reference below) has made the following recommendations that will assist shelter operators and staff to reduce the risk of TB transmission in homeless shelters.

2.1 General Measures

Education: The shelter should provide education and information on TB to their staff, volunteers and clients.

Tissues: The shelter should make tissues available. Clients, staff and volunteers should be instructed to cover their noses and mouths with tissues when coughing and sneezing.

¹ This document has been prepared to assist in the prevention and control of TB in Ontario's shelters and drop-in centres for the protection of workers and clients. Employers and other workplace parties are reminded that they have legal duties under the Occupational Health and Safety Act (OHSA) to protect workers. The Guidance Document is not a statement of the legal requirements. In this regard reference should be made to the OHSA.

Bed placement: Beds should be arranged as far from neighbouring beds as possible, with a head to foot arrangement.

2.2 Administrative and Work Practice Measures

Identifying Suspect Cases of TB: TB should be suspected in any homeless person who has a fever and a productive cough (not a dry cough) that lasts over three weeks. Other symptoms of TB include coughing up blood, night sweats, weight loss, fatigue and loss of appetite. If a person in a shelter has a cough and one or more of the other symptoms, they should be considered a suspect case of TB.

The shelter staff should:

Immediately separate the suspect case of TB and arrange for medical care. The person with TB symptoms should be immediately separated from other staff and residents by placing them in a separate room. A surgical mask should be placed over the client's mouth and nose. Medical care should be arranged as soon as possible. This may mean sending the person to the Emergency Department of the hospital as persons with suspect TB are often identified after regular clinic hours.

Notify the local public health unit. The shelter staff should also immediately notify their local public health unit.

2.3 Ventilation, Filters, Ultraviolet Germicidal Irradiation (UVGI)

Ventilation can reduce the spread of TB by diluting the concentration of TB particles and removing contaminated room air. Use of fans, opening windows, and the installation of High-Efficiency Particulate Air (HEPA) filters and UVGI can dilute the air and/or remove TB organisms.

2.4 Use of Respiratory Protection

TB Suspect case

It is most important that the suspect TB case wear a regular surgical mask.

Staff at the shelter

Staff should only use N95 respirator masks when transporting a resident suspected of having TB or when entering a room in which a suspect case of TB has been placed temporarily to separate him or her from other staff and residents.

Staff assigned to use an N95 respirator mask should be fit-tested to ensure the mask fits properly and be trained in the use, care and limitations of the mask. It is generally not necessary for shelter staff to wear an N95 respirator mask to carry out their duties in other situations. It is not necessary to have all shelter staff prepared to use an N95 respirator mask. One staff person per shift may be sufficient to meet operational needs for most shelters.

2.5 Tuberculosis testing for staff and volunteers pre-placement

Shelter workers and volunteers should be screened for TB infection prior to placement (post-hire) to provide a baseline in the event of a future exposure. A baseline two-step Mantoux test should be performed unless there is appropriate documentation of a previous tuberculin skin test (TST) with the result recorded in mm, not "positive" or "negative".

2.5.1 Contraindications to a Mantoux TST: (Canadian TB Standards, 5th Edition, 2000)

The following persons should not have a TST:

- Persons with severe blistering reactions in the past.
- Persons with documented active TB or a clear history of treatment for TB infection or disease in the past.
- Persons with extensive burns or eczema.
- Persons who have major viral infections or who have had live-virus vaccinations in the past month (this does not include persons with a common cold). These persons can be tested 4-6 weeks after the viral infection or the live-virus vaccination.

2.5.2 Negative Mantoux TST:

An individual who can provide documentation of a Mantoux TST within the preceding year should have a single initial skin test performed and should be managed on the basis of that result. There is no need for a second test (i.e. the second step of the two-step test) since the earlier test is, in effect, the first of a two-step test. A history of BCG (Bacille Calmette-Guerin) vaccine is not a contraindication to TST.

2.5.3 Routine TST:

Annual routine repeat screening of employees and volunteers would only be recommended after an assessment by the local public health unit. The shelter should contact the TB control program staff of their local public health unit to see if annual screening of employees and volunteers should be conducted in their shelter.

2.5.4 Testing Following Contact with an Active Case of TB

Staff, residents, and volunteers should be tested if they are exposed to a case of TB in the shelter or drop-in centre or elsewhere in the community.

2.5.5 Previously Positive Mantoux TST:

Persons who have a documented positive Mantoux TB skin test should have a baseline pre-placement chest X-ray and be medically assessed in order to rule out active TB disease. They should be instructed to promptly report any symptoms suggestive of TB (e.g. cough, fever, anorexia, weight loss).

3. Proper Documentation in Homeless Shelters

Shelter workers should be reminded to always keep adequate and accurate documentation including bed logs, client health history and TB symptoms (such as coughing).

In the event that there is a case of TB in the shelter, adequate and accurate documentation will assist the local public health unit in carrying out their investigation of the disease, determining the infectious period of the TB case, and identifying the contacts.

4. Resources and Information

4.1 Local Public Health Unit

Your local public health unit can assist you by providing information and education sessions about TB and infection control. Your local Ministry of Labour office can provide information on the requirements under the *Occupational Health and Safety Act*.

4.2 Other Resources

TB in Homeless Shelters: *Reducing the Risk through Ventilation, Filters, and UV*. Francis J. Curry National Tuberculosis Center.

<http://www.nationaltbcenter.edu/catalogue/downloads/tbhomelessshelters.pdf>

Centers for Disease Control. Prevention and Control of Tuberculosis Among Homeless Persons Recommendations of the Advisory Council for the Elimination of Tuberculosis. MMWR 1992;41(RR-5).

<http://www.cdc.gov/mmwr/preview/mmwrhtml/00019922.htm>

Health Canada. Canadian Tuberculosis Standards, 5th edition, Canadian Lung Association.

http://www.lung.ca/tb/TBStandards_Eng.pdf

Public Health Agency of Canada. Guidelines for Preventing the Transmission of Tuberculosis in Canadian Health Care Facilities and Other Institutional Settings. CCDR Volume: 22S1, April 1996.

http://www.phac-aspc.gc.ca/publicat/ccdr-mtc/96vol22/22s1/22s1n_e.html

Tuberculosis Prevention and Control Guidelines for Homeless Service Agencies in Seattle-King County, Washington

<http://www.metrokc.gov/HEALTH/tb/tbguidelines.pdf>

San Francisco Department of Public Health. TUBERCULOSIS (TB) INFECTION CONTROL GUIDELINES FOR HOMELESS SHELTERS

<http://www.dph.sf.ca.us/PHP/TB/TBControl4HomelessShelters.pdf>

Ministry of Labour local offices

http://www.gov.on.ca/LAB/english/about/req_offices.html

Local public health units in Ontario

http://www.health.gov.on.ca/english/public/contact/phu/phuloc_mn.html

Appendix 2: Maintenance Checklist

MAINTAINING CENTRAL VENTILATION SYSTEM _____ (Year)

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Check Filters and replace												
Clean diffusers												
Clean grilles												
Clean in-duct UVGI lamps												

Once a Year

- a. Clean return air ductwork with a vacuum cleaner: _____ (date done)
- b. Make sure ventilation units are working: _____ (date done)
- c. Make sure thermostats are working: _____ (date done)
- d. Make sure filters are installed correctly: _____ (date done)

Appendix 3b: UVGI Recommendations

General Recommendations for Maintenance and Inspection of UVGI Fixtures

A maintenance schedule should be developed in accordance with manufacturer's guidelines.

1. The UV-C lamp replacement should be determined from the time use log or based on cumulative time. Typically the recommended replacement cycle is 9,000 hours.
2. If lamps fail to light or they flicker to an objectionable extent, they should be replaced.
3. Before replacing filters or UV-C lamps, the power of the unit must be turned off for at least 15 minutes to allow cooling of the lamp before replacement. Verify that the lamps are off when a blue glow cannot be seen from a distance.
4. The UV-C lamp should be checked periodically for dust build-up. If the tube is dirty, it should be allowed to cool for at least 15 minutes before being cleaned with a damp cloth.
5. Do not use glass cleaners to clean lamps because they leave a thin film that will reduce the UV-C output.
6. Use soft cotton gloves to handle old or new lamps to prevent deposit of oily film on the lamps and to avoid breakage.
7. Maintenance of in-duct or in-room UVGI units requires that the UV-C air purification unit be turned off before accessing the ducts or the upper-part of the room.
8. Some UVGI units have filters which need to be replaced periodically.
9. Some UVGI units have access door switches or flow switches that should be checked to ensure proper operation. Consult manufacturer's instructions for method of testing.
10. Light deflection devices found on upper-room fixtures must always be in place and should be replaced if bent or deformed.
11. On/off switches for UV-C lamps and fixtures should not be located in the same location as light switches for the room. The UVGI appliance switch should be locked and accessible only to authorized personnel.
12. Document inspection, maintenance, lamp cleaning or lamp replacement of UVGI fixtures in the maintenance manual.

Appendix 4: Threshold Limit Values for UV-C
American Conference of Governmental Industrial Hygienists

Permissible Ultraviolet Exposures

Duration of exposure per day	Effective irradiance E_{eff} (μW/cm²)
8 hours	0.2
4 hours	0.4
2 hours	0.8
1 hour	1.7
30 mins.	3.3
15 mins.	6.6
10 mins.	10
5 mins.	20
1 min	100

■ Table 1. Permissible 254 nm Ultraviolet exposures, according to ACGIH.

Source: ACGIH 1999-2000

Appendix 5: How to Find an Engineering Consultant¹²

1. Contact the Professional Engineers of Ontario for a listing of professional engineers at:
<http://www.peo.on.ca/>
2. Specifications for HVAC Consultant:
 - Consulting firm employs a Healthcare Facility Design Professional (HFDP) who has a minimum of 5 years' experience in HVAC&R design, experience with UVGI applications and systems.
 - Knowledge of healthcare facility HVAC&R design and UVGI applications.
 - Knowledge and experience with superior mechanical air systems design and operation.
 - Understands principles involved in HVAC&R design while implementing UVGI air purification for healthcare facilities.
 - Well versed in the application of "Environmental Control Guidelines: Best Practice to Reduce TB Transmission in Homeless Shelters and Drop-in Centres in Toronto, June 2007."

Qualifications:

- Registered Professional Engineer (P.E.) license.
- Engineering Consultant and staff must meet the following requirements:
 - Effective verbal and written communication skills;
 - Conceptual, preliminary and detailed design capability;
 - Project supervision experience with Healthcare Facilities;
 - Experience with the operation of Indoor Air Quality assessment tools and equipment;
 - Knowledgeable and experienced with the Ontario Building Code, Fire Code, and Plumbing Code.

Familiarity with:

- ASHRAE's Healthcare Facilities-Best Practice HVAC Design Considerations and Criteria, ASHRAE 62-2001, and OBC as they apply to Healthcare Facilities.
- CDC's *Guidelines for Environmental Infection Control in Health-Care Facilities*. Centers for Disease Control and Prevention, Morbidity and Mortality Weekly Report (MMWR), June 6, 2003. [www.cdc.gov]
- CDC's *Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Settings*, 2005. Centers for Disease Control and Prevention, Morbidity and Mortality Weekly Report (MMWR), December 30, 2005. [www.cdc.gov]

¹² Source: Van 'A' Engineering and Associates Ltd & L2B Environmental Systems Inc., May 2007.

References

- Minimum of 3 project references applicable to Indoor Air Quality design experience with UVGI application.