# Facilities Systems Best Practices for re-opening during the COVID-19 pandemic

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## This lesson's objectives

- General school facilities re-opening considerations
- Some specific pandemic resources for facilities management
- Scope of best practices guidelines
- Worker health
- Ventilation basics
- Ventilation strategies to reduce airborne viral transmission
- Other resources

Note: People have protocols; viruses don't

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## Some important regulatory authorities

- OSHA: Defines employer/ employee responsibilities & regulates to ensure safe & healthy workplace
- CDC: Implement regulations related to protection from health & and safety threats & public health security
- Illinois State Board of Education (ISBE)
- State & local Departments of Public Health
- Workers compensation
- Americans w/ Disabilities Act (ADA)
  - Disabilities vs risk factors

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## Re-opening considerations

- Occupant characteristics
- Workforce characteristics & job descriptions
- Student characteristics, grade levels, ages, etc
- Access & security
- Environment: Distancing, scheduling, work flow
- Cleaning
- Communications
- Worker rights & Human Resources issues
- Facilities/ built environment

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# Resources for facilities: Professional organizations & checklists

- ASHRAE Epidemic Task Force; Schools and Universities (Outline, includes checklists 7/17/20): https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-reopening-schools-and-universities-c19-guidance.pdf
- ASHRAE Epidemic Task Force; Filtration & Disinfection (8/7/20): https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-filtration_disinfection-c19-guidance.pdf
- BOMA International's Coronavirus Resource Center (several guidance documents and other resources): https://www.boma.org/coronavirus
- CDC Considerations for K-12 Schools: Readiness and Planning Tool: https://www.cdc.gov/coronavirus/2019-ncov/downloads/community/School-Admin-K12-readiness-and-planning-tool.pdf
- Preparing K-12 School Administrators for a Safe Return to School in Fall 2020: https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/prepare-safe-return.html
- Harvard TH Chan School of Public Health: Schools for Health https://schools.forhealth.org/

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# Scope of best practices guidelines

Typically checklists that address:

- Policies for entry, security, health checks, occupancy, distancing, scheduling, reporting, cleaning, disinfection, planning, responsible parties, etc. (Administrative controls)

- Resources addresses most of those issues, but this presentation will focus on some engineering controls & modifications to facilities, especially ventilation (relies a lot on ASHRAE guidance)

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## Disclosure/ handling of COVID-19 cases

- Legal authorities not always clear
- Administration/ Employers provide guidelines regarding when to stay home, taking leave, etc.
- Proper notification & privacy protection for persons testing positive for COVID-19
- Appropriate response protocols in place (assume an occupant will test positive at some point)
- Consider tests for disease & symptoms relative to infectious period
- Be familiar w/ difference between viral RNA test & antibody test

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## Worker health

Characterize work force:

- Age
- Job descriptions & tasks
- Potential for exposure
- Appropriate policies for sick leave, care of sick family, positive test results
- Compliance w/ OSHA, IL OSHA, State of Illinois

Note: Some facilities tasks, such as servicing HVAC equipment, may expose workers to virus or other contamination. Appropriate Respiratory Protection & PPE training & use is advised

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# Survival time in air/ on surfaces (lab studies)

Note: Viable (living) virus is transmissible. Non-viable (non-transmissible) virus can show up as positive in some tests

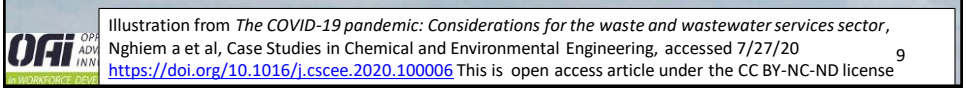

Illustration from *The COVID-19 pandemic: Considerations for the waste and wastewater services sector*, Nghiem a et al, Case Studies in Chemical and Environmental Engineering, accessed 7/27/20 https://doi.org/10.1016/j.cscee.2020.100006 This is open access article under the CC BY-NC-ND license

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# Airborne transmission: Droplets vs aerosols

Primary mode of transmission of COVID-19 disease is usually thru air to respiratory system; virus can be airborne & transmissible thru droplets & aerosols

Illustration from : Environ Res. 2020 Sep; 188: 109819., Published online 2020 Jun 13. doi: 10.1016/j.envres.2020.109819, PMCID: PMC7293495 PMID: 32569870, *Transmission of COVID-19 virus by droplets and aerosols: A critical review on the unresolved dichotomy*, Jayaweera, et al

CDC updates COVID-19 transmission webpage to clarify information about types of spread: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/how-covid-spreads.html

# Re-opening: Water, water vapor, food storage

- Unoccupied building water becomes stagnant; films form in pipes & fixtures
- Information on (supply) disinfection w/ chlorine: https://www.cdc.gov/healthywater/drinking/public/chlorine-disinfection.html#:~:text=Chlorination%20is%20the%20process%20of,Ca(OCl)2%201
- Moisture, water leaks, poor ventilation & fungal proliferation
- Refrigerators & stored food

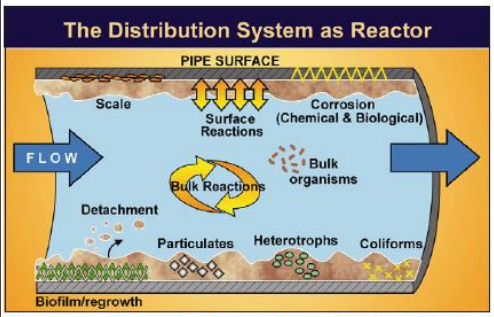
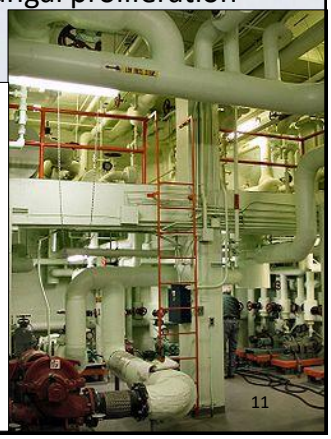



Figure 1-2. Distribution System Interactions that Affect Water Quality (Adapted from: MSU, 2005).

Illustration: Water Distribution System Analysis: Field Studies, Modeling and Management EPA/600/R-06/028 December 200 Photo Attribution: P199 at English Wikipedia



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# Re-opening: Water systems (flush & test)

- **Legionella**

See IDPH plumbing systems & water quality guidance http://www.dph.illinois.gov/covid19/community-guidance/plumbing-systems-water-quality-guidance



Illustrations: https://www.cdc.gov/vitalsigns/legionnaires/index.html

# Toilets

- Some belief that infected persons can shed virus in feces; unknown is whether virus is viable in this scenario
- Flushing & toilet seat covers

Photo attribution: https://health.howstuffworks.com/diseases-conditions/infectious/5-diseases-toilet.htm

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# Ventilation

Air flow rules:

- Air take the path of least resistance
- If one part of air path is changed, it also changes something else

Illustration: https://image.slidesharecdn.com/highriseresidentialbuilding-141112212835-conversion-gate02/95/high-rise-residential-building-4-638.jpg?cb=1415827757

# Ventilation language

- ACH: air changes per hour (number of times all of the air in a space is replaced)
- FPM: feet per minute (speed of air movement)
- CFM: cubic feet per minute (volume of air usually for supply)
- Fresh air: Outside air, sometimes filtered air (currently 7.5 – 10 cfm per person in schools)
- Negative & positive pressure (relative to adjacent spaces)
- Distribution: Configuration of supply, return, exhaust duct openings for efficiency of air flow to occupants

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# Example of air flow calculations under CDC Guidelines for tuberculosis patient rooms

- Control of droplet nuclei in healthcare settings, assuming negative pressure rooms & existing Respiratory Protection of workers
- Recommended minimum 6 ACH in existing facilities, 12 ACH in new facilities, negative pressure relative to adjacent areas

ACH = (exhaust air flow (cfm)/room air volume ($ft^3$) x 60 min/hr

In room 20 ft (L) x 20 ft (W) x 10 ft (H), room volume = 4,000 $ft^3$

For 6 ACH: 4,000 $ft^3$ x 6 AC/hr x 1 hr/60 min = 400 cfm of fresh air

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# Ventilation

Building Owners & Management Association (BOMA) recommends "consider increasing exhaust and infusion of outside air…"

How and how much?

- Open fresh air dampers (Note: If $CO_2$ demand system, disable or increase sensor $CO_2$ concentration thresholds)
- Increase fan speed? (What are the problems with this option)
- How much? **Not specified at this time**
- Some recommendations for full ventilation operation well before & after facilities occupied

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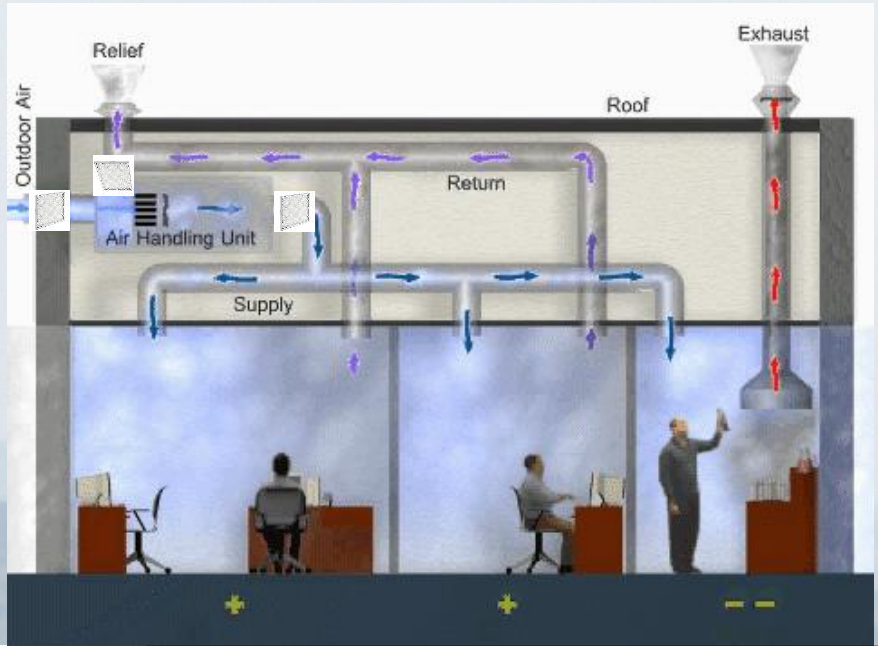


Illustrations: https://19january2017snapshot.epa.gov/indoor-air-quality-iaq/animation-series-visual-reference-modules-indoor-air-quality-building_.html & https://www.grainger.com/product/11C876

# HVAC configurations in schools

Usually some combination of conditioned central air distribution (previous slide), wall units, & peripheral (wall/ window) heating/ cooling systems

Photos: http://bridgebusinessbrokers.ca/?ait-item=diversified-hvac-business & https://www.grainger.com/product/494L38?gclid=EAIaIQobChMIxtmJzbeY6wIVNAnnCh2gRAHUEAYYBCABEgLDxvD_BwE&cm_mmc=PPC:+Google+PLA&ef_id=EAIaIQobChMIxtmJzbeY6wIVNAnnCh2gRAHUEAYYBCABEgLDxvD_BwE:G:s&s_kwcid=AL!2966!3!264955916051!!!g!437083570253! & Marco, Cagnetti et al, Energy saving project for heating system with ZigBee wireless control network, 10.1109/EEEIC.2012.6221443 IO - 2012 11th International Conference on Environment and Electrical Engineering, EEEIC 2012 - Conference

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# General control strategies for microorganisms

Assume an identifiable contaminant source (people):

- Source control: Replacement, source reduction, isolation
- Ventilation (general and local)
- Air cleaning (This may also include filtration, & portable filtration, electronic, gas sorption, ozone, cleaning, vacuuming) http://www.epa.gov/iaq/aircleaners/index.html
  - Also UVGI
- Surface cleaning
  - EPA pesticides: http://epa.gov/oppad001/
  - EPA disinfectant lists: http://epa.gov/oppad001/chemregindex.htm
  - USEPA List N: Disinfectants for Use Against SARS-CoV-2: https://www.epa.gov/pesticide-registration/list-n-disinfectants-use-against-sars-cov-2
- Exposure control (as in personal exposure)
  - Scheduling
  - Re-location & restricted areas
- Personal Protective Equipment & Respirators

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# Pressure differentials/ air flow direction

- **Reduction**
- **Elimination**
- **Replacement**
- **Diversion**
- **Isolation of localized sources**

Examples:

- Ventilation configurations in infectious disease isolation rooms (source control)
- In research laboratories, pathogens replaced w/ attenuated (weakened) versions so researchers can safely perform experiments. Attenuated pathogens also used to formulate vaccines against disease.

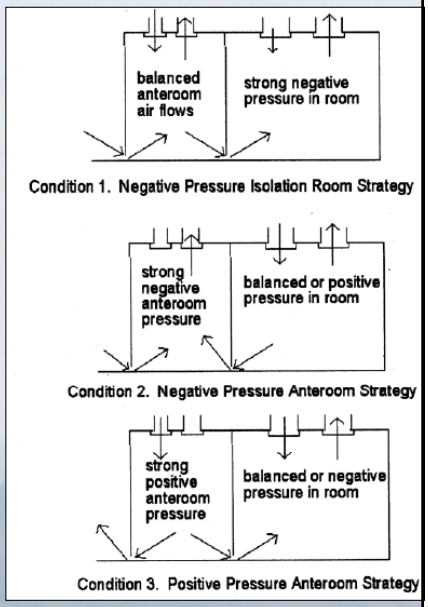


Illustration from "First do no harm, S Cali, et al, 2009

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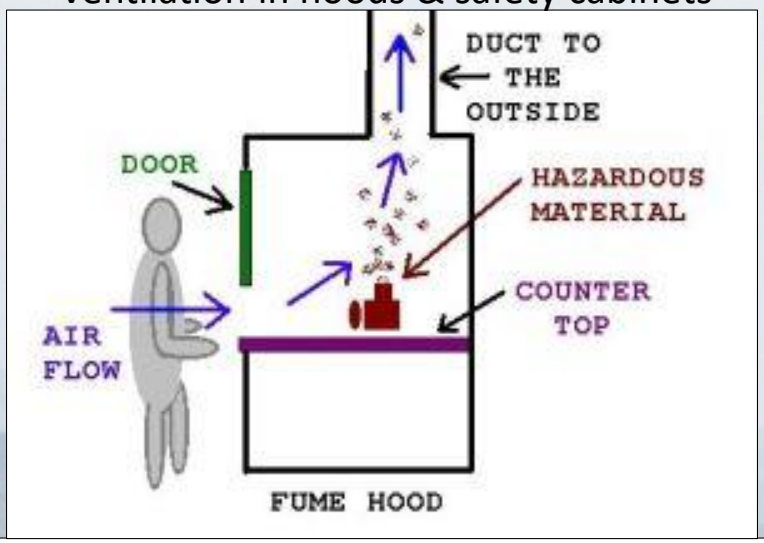
# Engineering control: Ventilation in hoods & safety cabinets




Chemical fume hoods capture, contain, & exhaust particulate & vapors generated by hazardous chemicals. Most laboratory experiments should be conducted in a fume hood or safety cabinet.

Image & paraphrased text from USDA: http://www.ars.usda.gov/News/docs.htm?docid=14605&page=2

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# Filtration:

Most guidance now recommends minimum rating MERV 13 filters (close to hospital grade; normal in offices is MERV 8 or higher)

- Filter rack may not accommodate MERV 13; If the existing filters and filter bank are 2" or thicker, install MERV 13. Can 1" rack be refitted w/ larger rack?

If filter racks can accept MERV 13 filter, but were not part of original design, following analysis can be completed by internal staff or consulting engineer:

- Calculate velocity of existing filter bank to determine existing filter pressure drop when clean (Typical velocity 300-500 fpm)
- Determine initial & final pressure drop for filters in original system design
- Calculate increase in filter pressure drop after installing new MERV 13 filters. Remember final pressure drop of any filter is an operational choice
- Review original design and equipment shop drawings to determine available External Static Pressure for equipment
- Determine effect of additional external static pressure on fan

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Text & Illustration: https://www.ashrae.org/technical-resources/reopening-of-schools-and-universities

# How particulate filtration works

Filters do not work like fish nets; see

- Risk Bites on YouTube (2.5 min): https://www.youtube.com/watch?v=WhiTlkZlwl4
- Physics of N95 masks (6:07): https://www.youtube.com/watch?v=eAdanPfQdCA&pbjreload=101
- Atlas Copco Compressor Technique (3 min): https://www.youtube.com/watch?v=AuVbcvPcjAw

**Note:** These concepts apply to many types of filtration (respirator, HVAC, air purifiers, and vacuum filters) but efficiency (especially at 0.3 um size) differs

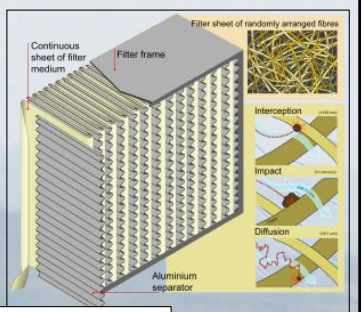


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Illustration: Work released into public domain by its author, LadyofHats https://en.wikipedia.org/wiki/HEPA#/media/File:HEPA_Filter_diagram_en.svg

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# Portable air cleaners

Photos from:
https://nlr.com.au/articles/air-scrubber-vs-negative-air-machine &
http://www.cleanlodge.com/gallery/asbestosgal/pages/HEPA%20negative%20pressure%20machines.htm

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# MERV ratings & HVAC system filters

Table from: https://www.nafahq.org/understanding-merv-nafa-users-guide-to-ansi-ashrae-52-2/

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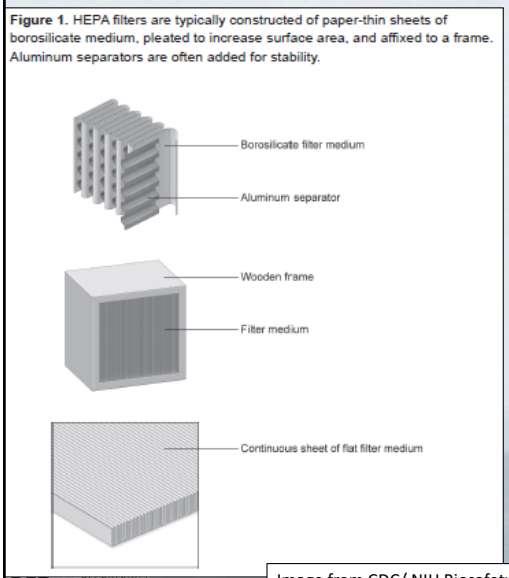
# Air cleaning: Note about HEPA filters




Used in many applications:

- Specialized ventilation systems
- Portable air cleaners
- Personal respirators
- Vacuums

Do NOT remove chemical vapors, but do filter most particulate, even atomic size particles & small pathogens such as viruses.

Image from CDC/ NIH Biosafety 5th edition: http://www.cdc.gov/biosafety/publications/bmbl5/index.htm

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# Engineering/ administrative control: Cleaning

- Surface cleaning & air cleaning to prevent spread of transmissible virus (especially in healthcare)
- Methods specific to pathogens & exposures
- Best practice: Initial cleaning w/ detergent (SARS CoV-2 is an enveloped virus & is susceptible to soap)
- Careful about successive cleaning w/ different chemicals
- Special care w/ common ingredients:
  - Sodium hypochlorite (bleach; very reactive) & sodium hydroxide (strongly irritating, corrosive, can cause severe burns & permanent damage to human tissue); See: https://www.atsdr.cdc.gov/MMG/MMG.asp?id=246&tid=45)

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**Never, ever, mix bleach (sodium hypochlorite) w/ anything other than water** (See: https://www.doh.wa.gov/YouandYourFamily/HealthyHome/Contaminants/BleachMixingDangers & Graphic from: http://www.howtocleanstuff.net/is-it-safe-to-mix-cleaning-products-with-bleach/ )

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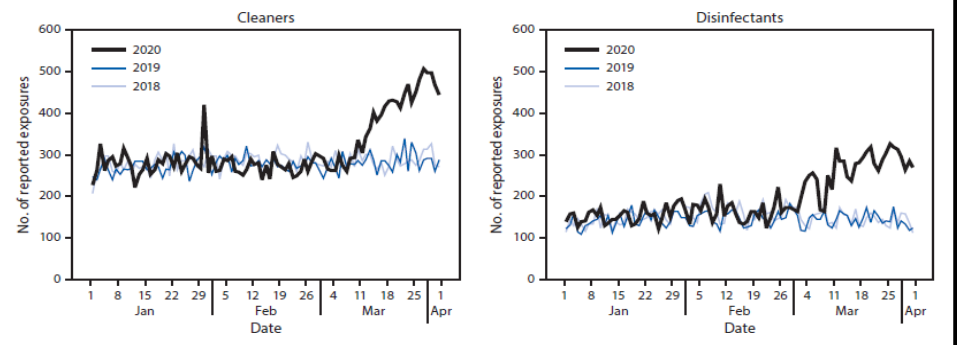
# Potential misuse of cleaning products

**FIGURE. Number of daily exposures to cleaners and disinfectants reported to U.S. poison centers — United States, January–March 2018, 2019, and 2020*,†**




* Excluding February 29, 2020.
† Increase in exposures to cleaners on January 29, 2020, came from an unintentional exposure to a cleaning agent within a school.

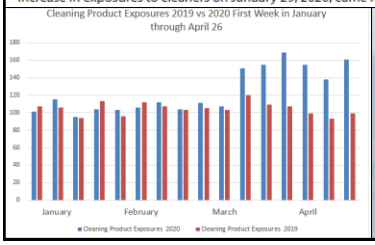



Figure from: Cleaning & Disinfectant Chemical Exposures & Temporal Associations with COVID-19 NPDS United States, Jan 1, 2020– Mar 31, 2020 https://www.cdc.gov/mmwr/volumes/69/wr/pdfs/mm6916e1-H.pdf

Figure from Illinois Poison Center Blog: http://ipcblog.org/2020/04/28/coronavirus-dont-let-cleaning-and-disinfecting-your-home-harm-you/

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# Definitions for certain microbial controls

**Cleaning agents**

- Disinfectants: Destroy vegetative forms of harmful microorganisms, but not necessarily bacterial spores
- Sanitizers: Diminish but don't always eliminate microorganisms
- Sterilizers: Destroy all microorganisms on surface of item or in fluid. Ideally, destroy or eliminate all forms of microbial life including spores
- Antiseptics: Used on people or animals to destroy variety of microbials; antiseptics are considered pharmaceuticals & regulated by FDA

Paraphrased from USEPA, CDC, & other sources:
http://www.epa.gov/pesticides/glossary/index.html#a &
http://www.cdc.gov/hicpac/Disinfection_Sterilization/6_0disinfection.html

See: Disinfection 101 (Iowa State: http://www.cfsph.iastate.edu/Disinfection/Assets/Disinfection101.pdf ) & CDC flyer re: Disinfection & SARS CoV-2: https://www.cdc.gov/coronavirus/2019-ncov/community/disinfecting-building-facility.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fprepare%2Fdisinfecting-building-facility.html



# Healthcare environmental cleaning measures

- Cleaning practices/disinfection standardized for all areas: Routine vs isolation
- Standardized training & monitoring compliance
- Focus on surfaces frequently touched w/ contaminated hands
- Sequence of cleaning always clean to dirty
- Minimize dust accumulation

- Use appropriate agent & follow manufacturer's directions re: **amount and dilution**
- Cleaning is different from & necessary pre-requisite to **disinfecting**
- **Contact time** of cleaning agent & surface is critical

Photo by S Cali

# Disinfection methods & agents

**Some liquid agents:**

- Iodophors (Iodine & surfactants): Intermediate-level disinfectants, effective against vegetative bacteria, enveloped viruses, fungi, and some mycobacteria
- Chlorine solutions: Broad spectrum widely used as sporicidal disinfectant & sterilant in liquid form
- Alcohol (ethyl; isopropyl): Ethyl Alcohol slightly better virucide than IPA. 70% solution (of Ethyl Alcohol 95%) denatures proteins & dissolves lipids; effective against most bacteria, fungi & many viruses, ineffective against bacterial spores. 70% better than pure alcohol because penetrates before blocked by coagulation

Paraphrased from multiple sources including NIH Office of Research Services, Biological Safety & Compliance, Decontamination & Sterilizationhttp://www.ors.od.nih.gov/sr/dohs/BioSafety/decon/Pages/decontamination.aspx & https://www.cdc.gov/infectioncontrol/guidelines/disinfection/disinfection-methods/chemical.html

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# Cleaning methods & agents

**More liquid agents:**

- Hydrogen peroxide: Bactericidal, virucidal, sporicidal, & fungicidal properties
- Phenolic compounds, aqueous: Bactericidal, fungicidal, virucidal, & tuberculocidal
- Quarternary ammonium compounds, aqueous (QATs): Widely used in healthcare; fungicidal, bactericidal, & virucidal against lipophilic (enveloped) viruses; not sporicidal & generally not tuberculocidal or virucidal against hydrophilic (nonenveloped) viruses

Paraphrased from multiple sources including NIH Office of Research Services, Biological Safety & Compliance, Decontamination & Sterilizationhttp://www.ors.od.nih.gov/sr/dohs/BioSafety/decon/Pages/decontamination.aspx & https://www.cdc.gov/infectioncontrol/guidelines/disinfection/disinfection-methods/chemical.html

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## Disinfection with UVGI (Ultraviolet germicidal irradiation)

Short-wavelength ultraviolet radiation (UV-C) is photochemical process

Disinfection: Microorganism exposed to high intensity UV radiation for optimal periods of time. UV breaks down molecular bonds, causing cellular membrane or DNA/RNA destruction.

UVGI system applications in healthcare settings include:

- Upper area &/ or ventilation system disinfection
- Surface disinfection

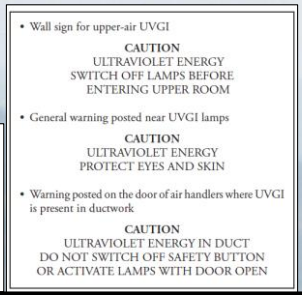


Figure from CDC: http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5417a1.htm & photo from https://www.moh.gov.my/moh/resources/penerbitan/mymahtas/MaHTAS%20COVID-19%20Rapid%20Evidence/Disinfectant%20And%20Sterilisation/Hyper_Light_Disinfection_Robot.pdf

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## Cautions for disinfection with UVGI (Ultraviolet germicidal irradiation)

**Intensity:**

- Need sufficient time & intensity to be effective
- Reduced by dust/ dirt on surfaces & lamps
- Decreases quickly by distance
- Decreases in lamps over time; requires periodic monitoring w/ UV meter

**Lamps:**

- Require frequent maintenance
- Can cause damage to human skin & eyes; require PPE & shields
- In biosafety cabinets must be decontaminated for maintenance

UV radiation does not eliminate necessity for routine good practices & procedures.

Photo Retrofit Magazine: https://www.retrofitmagazine.com/ceiling-mounted-ultraviolet-light-system-provides-no-touch-disinfection/amp/

*NOTE:* (Adapted from NIH statement) *NIH does **not** recommend or support use of ultraviolet (UV) radiation in laboratories…. The 253.7-nm wavelength emitted by germicidal lamp has limited penetrating power & is effective against unprotected microbes on exposed surfaces or in air.*

Paraphrased from NIH Office of Research Services, Biological Safety & Compliance, Decontamination & Sterilization http://www.ors.od.nih.gov/sr/dohs/BioSafety/decon/Pages/decontamination.aspx

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## Example engineering Controls for SARS-CoV-2

- Install high-efficiency air filters
- Increase ventilation rates in work environment
- Open windows (fans & cross-ventilation)
- Install physical barriers, i.e. clear plastic sneeze guards
- Install drive-through window for customer service.
- Negative pressure areas/ rooms (Airborne infection isolation rooms (AIIR) for sick persons

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## What actually works to prevent disease transmission?

- Social distancing
- Outside air
- Masks to some degree
- N95 or better respirators to large degree

  Entry control, occupancy limits, mask requirements, availability of handwashing, hygiene, etc.
- Disease testing, reporting, community tracking
- Common sense & care for others

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Photo by S Cali

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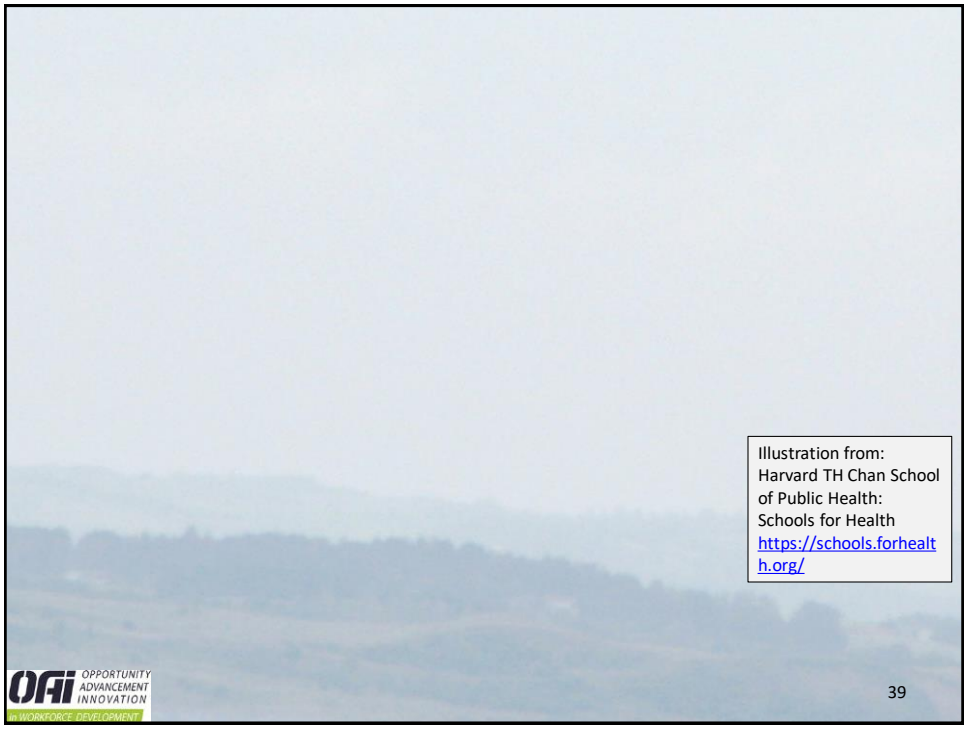


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## Selected Back-to-Work Tips and Resources

(Including some Illinois resources)

- Summary of School Re-Opening Models and Implementation Approaches During the COVID 19 Pandemic (an interesting comparison of school re-opening plans by country, includes impact (success in control of transmission); mostly administrative issues (7/6/20): https://globalhealth.washington.edu/sites/default/files/COVID-19%20Schools%20Summary%20%28updated%29.pdf
- **CDC Resuming Business Toolkit (Checklist): https://www.cdc.gov/coronavirus/2019-ncov/downloads/community/Resuming-Business-Toolkit.pdf
- **CDC Employer information for Office Buildings: https://www.cdc.gov/coronavirus/2019-ncov/community/office-buildings.html (Note: Menu on left site provides links to specific topics and some industries)
- IDPH: http://www.dph.illinois.gov/topics-services/diseases-and-conditions/diseases-a-z-list/coronavirus/business-guidance
- IDOL: https://www2.illinois.gov/idol/Pages/default.aspx
- Illinois Manufacturer's Association: https://ima-net.org/covid-19/

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## Selected Back-to-Work Tips and Resources
(Including some Illinois resources)

- OSHA: Hazard assessments: https://www.osha.gov/shpguidelines/hazard-Identification.html
- NIH/ NIEHS Workplace Checklist for Prevention of Exposure to SARS-CoV-2 Virus in Non-Healthcare Industries (under COVID-19 Toolbox https://tools.niehs.nih.gov/wetp/covid19worker/
- NFPA Fire & Life Safety Checklist for reopening a building https://www.nfpa.org/-/media/Files/Coronavirus/CoronavirusReopeningBuildingsChecklist.ashx
- BOMA: Getting back to work: Preparing Buildings for Re-Entry Amid COVID-19 https://www.boma.org/BOMA/Research-Resources/3-BOMA-Spaces/Newsroom/Press_Room/2020/Getting_Back_to_Work.aspx
- COVID-19 Guide for Workers in Illinois: https://publichealth.uic.edu/news-stories/covid-19-guide-for-workers-in-illinois/ Has lots of info on worker rights & resources, in IL and Federal
- OSHA COVID-19 enforcement memos: https://www.osha.gov/memos/2020-04-16/discretion-enforcement-when-considering-employers-good-faith-efforts-during

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## OSHA Respiratory protection standards

- Be very careful about respirators & OSHA requirements; involved & stringent: See https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.134
- Also see https://www.osha.gov/SLTC/covid-19/
- Minimum requirements for voluntary use: https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.134AppD & transcript for the OSHA Training Video Entitled Voluntary Use of Respirators (w/ view video option): https://www.osha.gov/video/respiratory_protection/voluntaryuse_transcript.html

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# Course summary

- Questions?
- How can we improve this training?
- Certificates & value
- Thank you!

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