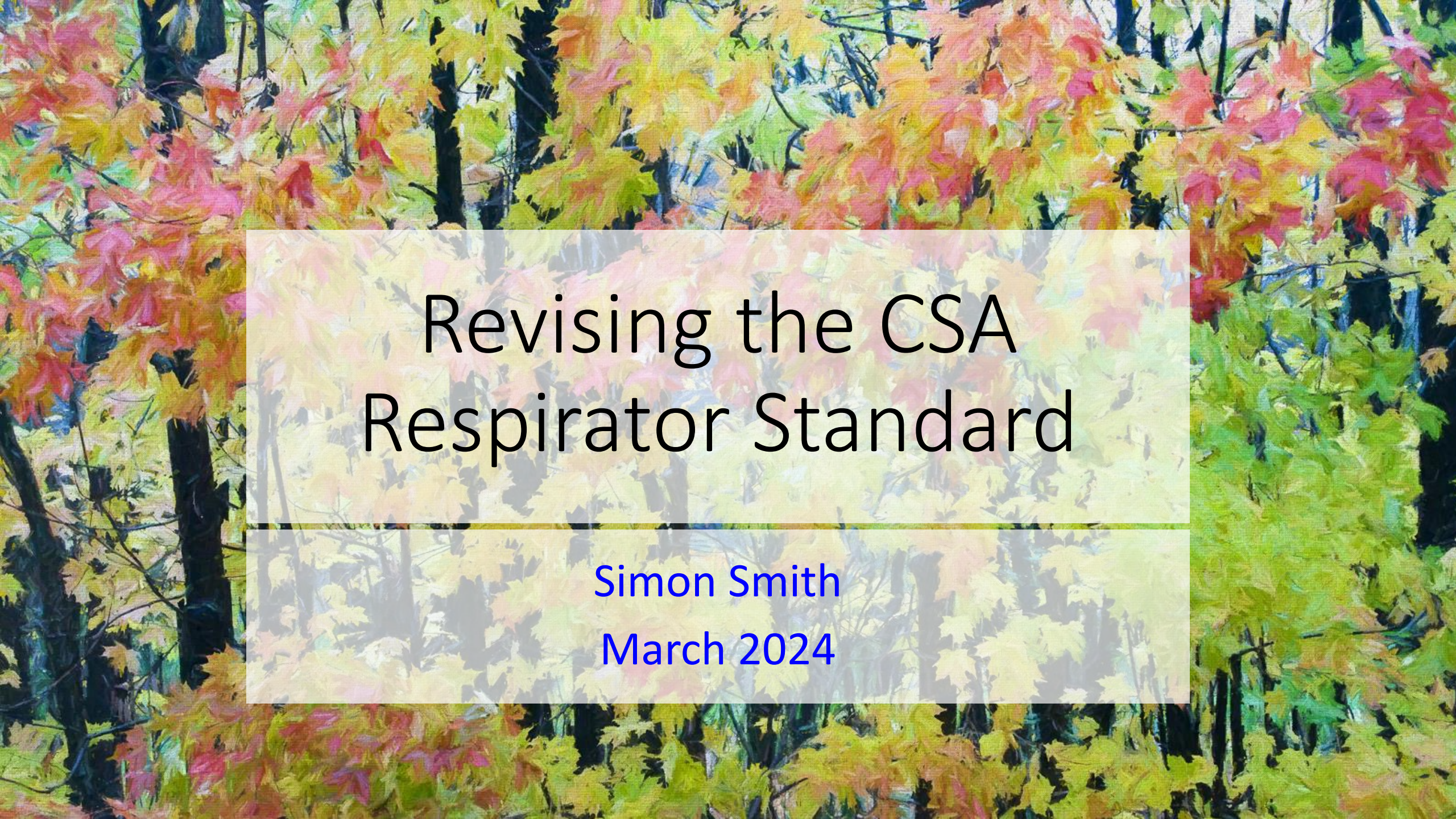


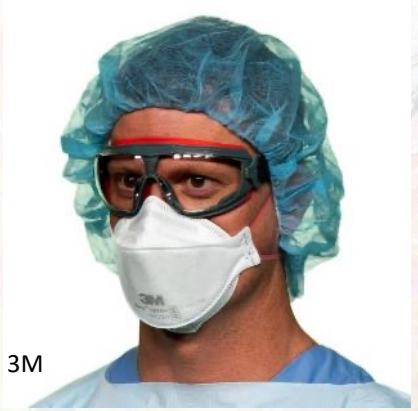
# Revising the CSA Respirator Standard

Simon Smith

March 2024

# Definitions

- Personal Protective Equipment (PPE)
  - A general collective term for device that provide protection including gowns, earplugs, safety glasses, safety boots, face coverings and respirators
- Respirator
  - Specific meaning:  equipment that provides respiratory protection and is approved – by testing and qualification of manufacturing operations – to nationally or internationally recognised standards
- Mask
  - General term used for face coverings that includes both respirators and any other face covering








# Recap – Some Respiratory Protection Fundamentals

## Fit

To work, must be designed to fit

Dräger

Selected with fit testing

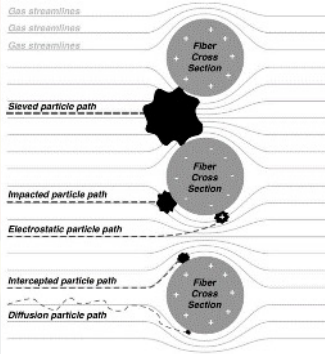
3M

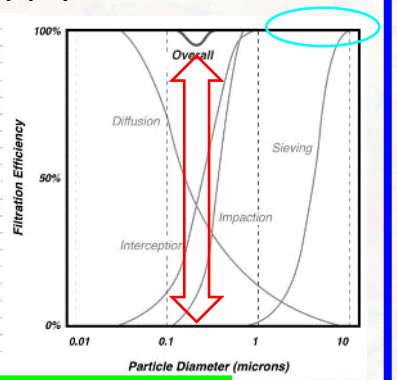
Checked each use, fit testing repeated periodically

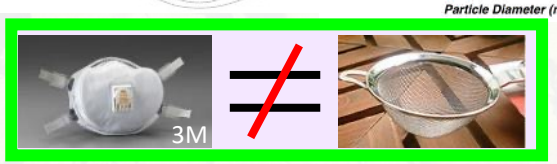
Harvard Medical School

## Filtration

Multiple mechanisms,
Laws of physics apply



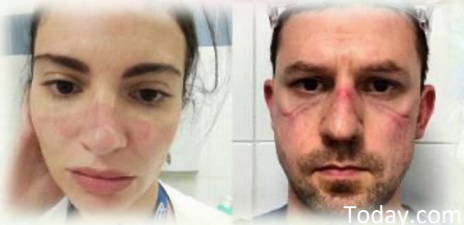
3M

Multiple types of filter

| Negative Pressure | | Type | | |
|---|---|---|---|---|
| | | Non-Oil | Oil 1-shift | Oil indef. |
| | | N | R | P |
| Efficiency | 95 | N95 | R95 | P95 |
| | 99 | N99 | R99 | P99 |
| | 100 | N100 | R100 | P100 |
| Powered | | 100N | HE | 100P |

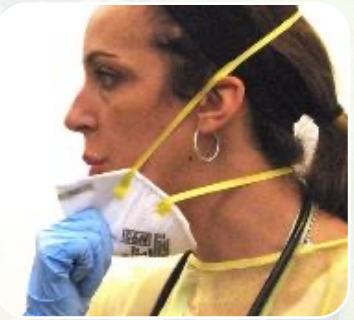
## Function

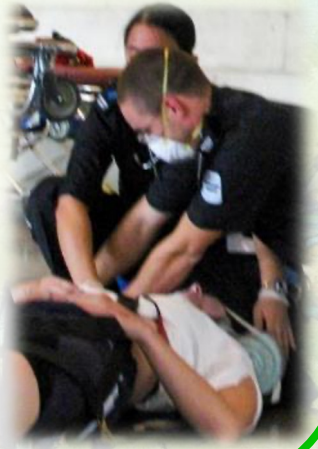
Easy to breathe through,
comfortable to wear?



Today.com

OK for communication and other work functions?





# Canadian Occupational Health & Safety Regulation

- Provincial/Territorial and Federal legislation govern health and safety
  - Regulations may mandate compliance with standards or cite them as a best practice
  - Approval of equipment performance capability by US National Institution for Occupational Safety and Health (NIOSH) is required
- Standards Council of Canada (Fed Gov't) certifies Standards Development Organisations (SDOs)
- Canadian Standards Association (CSA Group), is a not-for-profit SDO covering occupational health and safety equipment performance and selection guidance – with standards setting and product testing
- *Note that* Health Canada (Fed Gov't) approves medical equipment for use in Canada

**Standards Addressing Respiratory Protection**

| Standard No. | CSA Z94.4 | CSA Z94.4.1 | CSA Z180.1 | CSA/CGSB Z1610 | CSA Z1640 |
|---|---|---|---|---|---|
| Title | Selection, Use and Care of Respirators | Performance of Filtering Respirators | Compressed Breathing Air and Systems | Protection of First Responders from CBRN Events | PPE for Investigating and Dismantling Clandestine Drug Laboratories |
| Target Community | General workforce | General workforce | General workforce | Emergency responders and medical staff | Law enforcement, firefighters, municipal workers and contractors |
| Latest Issue Date | 2018 | **2021** | 2019 | 2011 | 2018 |

Selection/Usage Guidance

Performance Requirements

# Pandemic/Respiratory-Related Activities

Start of Pandemic:

- Respirator shortages in healthcare; no national filtering facepiece manufacturers
- Stability of external respirator supplies to Canada becomes a concern


- New Canadian operations want to manufacture but need NIOSH approval (same as last 50 years)
- NIOSH changed prioritization to favour US manufacturers


Health Canada creates Interim Orders

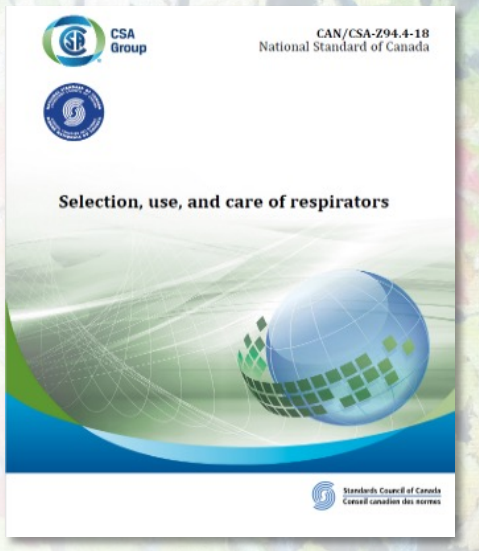
1. Permits healthcare use of respirators with any type of certification (March 2020)
2. Issues a specification to approve certain respirator types for use in healthcare – product performance requirements, manufacturer quality requirements (August 2020)

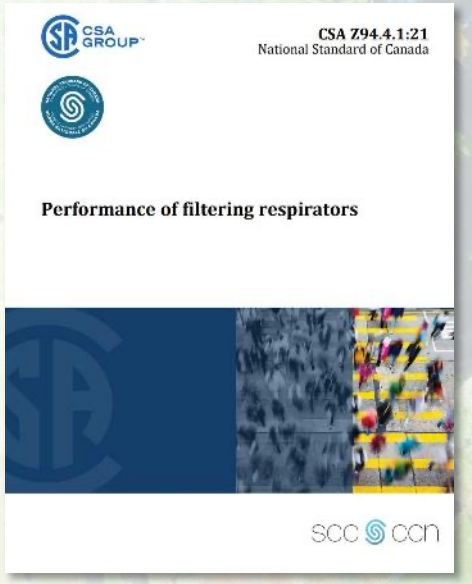
- CSA Group tasked to create a new respirator performance standard as part of a national certification process – started late 2020, published October 2021

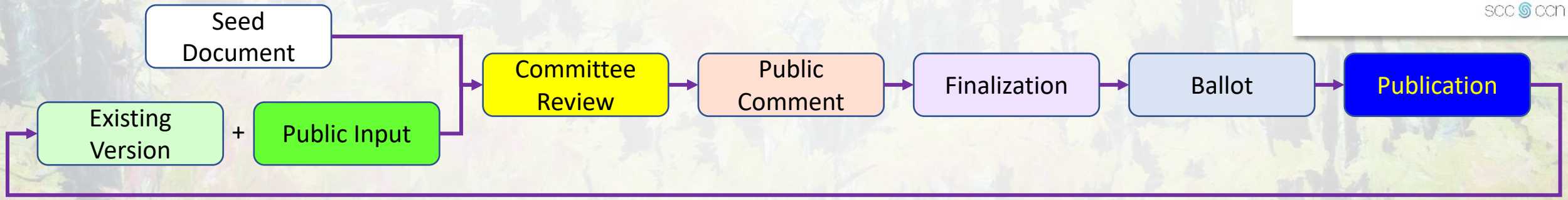

- CSA Group updates its established standard for selection, use and care of respirators to accommodate this new standard and Covid-related factors – started late 2022, in progress

# CSA Process

- CSA Group
  - Establishes the need for, develops and markets standards
  - Conducts testing for product certification
- Standards undergo review and periodic updates
- CSA manages standards committees which have a mandatory balanced mix of stakeholders
- Committees meet regularly and may invite experts and other relevant parties to provide input
- Development Stages:



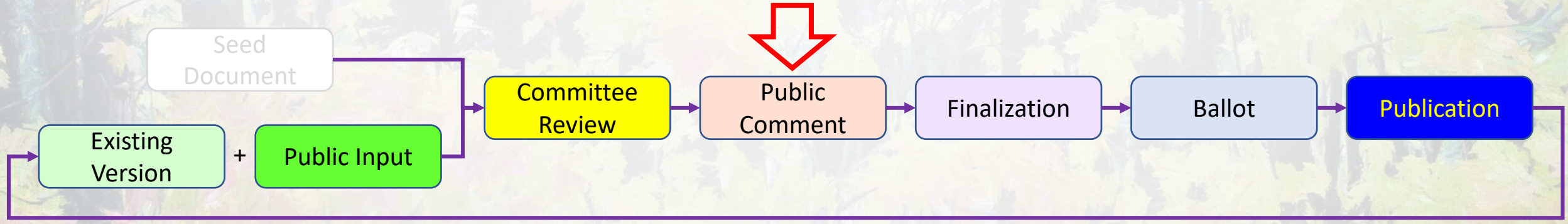



# Current Interests

- CSA Z94.4.1 “Performance of Filtering Respirators” developed 2020-2021
  - Supported an urgently needed new Canadian respirator certification system
  - Created by sub-group of CSA Z94.4 committee with added experts
  - CSA established test capability to certify products to the standard

- CSA Z94.4 “Selection, Use and Care of Respirators”
  - First issued 1982, supports workplace use of respirators under legislation, last updated 2018
  - Updating in progress over 2023
  - Multiple working groups, frequent meetings, including invitation of front-line physicians, nurses, hospital support workers, bioaerosol, ventilation and control banding experts
  - Now at public comment stage



# Canadian standard CSA Z94.4

https://community.csagroup.org/docs/DOC-121294

Supports respirator use in workplaces as covered by Federal, Provincial or Territorial Regulation

Covers equipment from disposable facepieces to SCBA

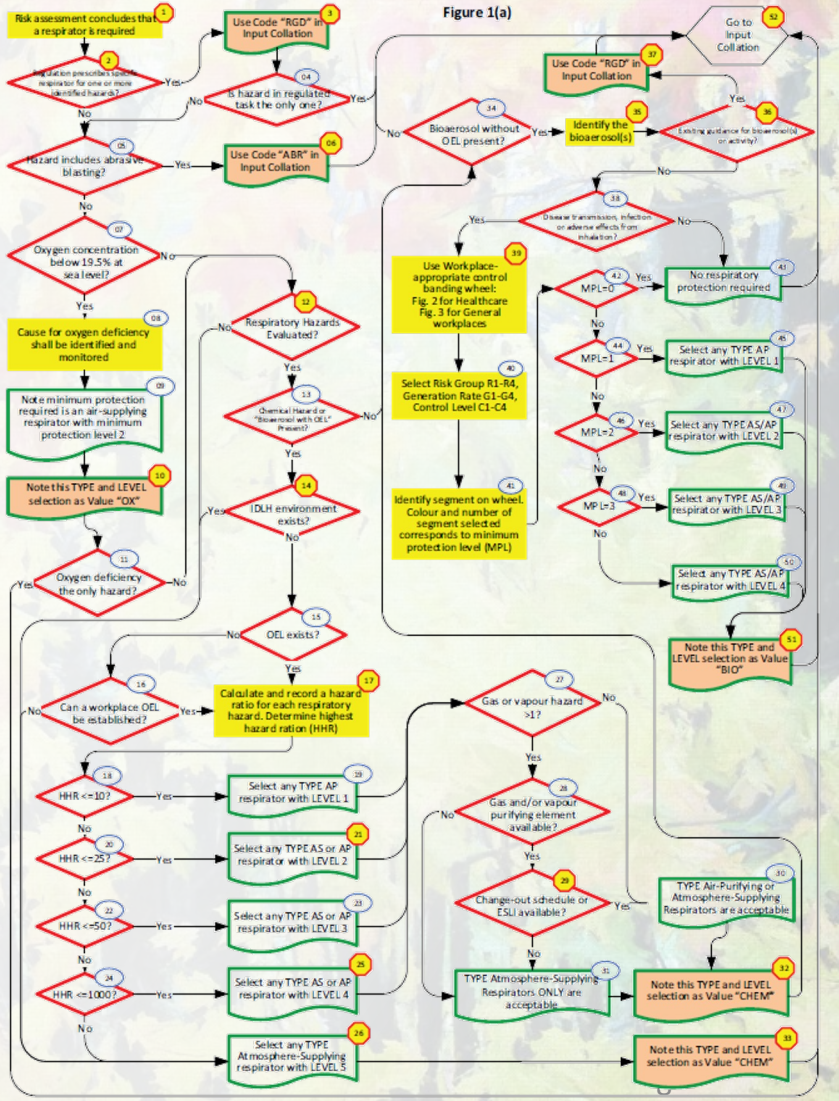
Addresses selection, use and care and is considered a best practice for workplaces to follow

Areas include:

- Respiratory protection programmes
- Medical clearance for prospective wearers
- Hazard and risk assessment
- Selection guidance for appropriate level of protection and type
- Fit testing
- Cleaning, inspection, maintenance and storage of equipment
- Qualifications, training and recordkeeping

CSA Z94.4 was the first standard in the world (2011) to include a systematic guidance protocol for respirator selection for airborne biological hazards

But… the standard has been minimally referenced in guidance from government or medical organisations during the pandemic

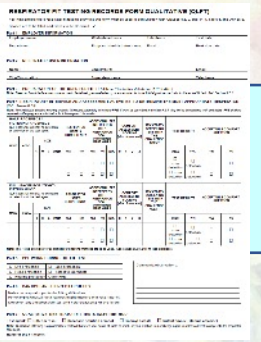


# CSA Z94.4 Update Work: Key Points – General Needs

**Fit Testing**

New abbreviated fit test protocol

New form for fit test documentation



**Barriers to Accessibility**

New section addressing under-served users, special needs and employer strategies for accommodation

**Guidance for the Healthcare Community**

New section for healthcare user guidance

Highlights relevant parts of the standard

Links to healthcare facility ventilation standard CSA Z317.2

Other considerations for healthcare operations

**Proposal**

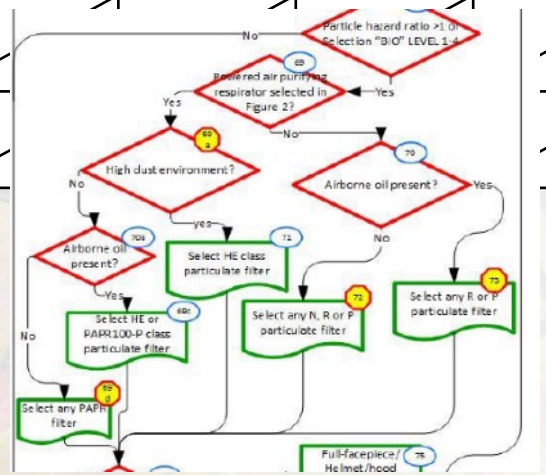
A companion guide to aid healthcare operations in establishing and maintaining respiratory protection programmes and using risk assessment and selection guidance

# General Respirator Selection

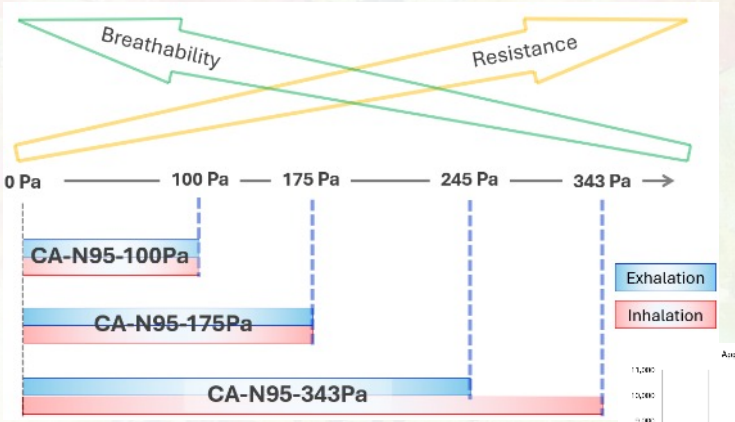
Incorporates respirator classes CSA Z94.4.1 performance standard, and new NIOSH "PAPR" classes for particle filtering respirators

New section on selection considerations beyond protection level

| Type | | Particle Efficiency (Aerosol at Most Penetrating Particle Size) | | | | | |
|---|---|---|---|---|---|---|---|
| | | ≥95.00% | | ≥99.00% | | ≥99.97% | |
| | | CSA | NIOSH | CSA | NIOSH | CSA | NIOSH |
| Non-Powered | Non-Oil | CA-N95-100Pa<br>CA-N95-175Pa<br>CA-N95-343Pa | N95 | CA-N99 | N99 | CA-N100 | N100 |
| Non-Powered | Non-Oil +"Surgical" | CA-N95F-100Pa<br>CA-N95F-175Pa<br>CA-N95F-343Pa | FDA-cleared + NIOSH tests Surgical N95 | CA-N99F | | CA-N100F | |
| Non-Powered | Oil "Resistant" | CA-R95 | R95 | CA-R99 | R99 | CA-R100 | R100 |
| Non-Powered | "Oil-Proof" | CA-P95 | P95 | CA-P99 | P99 | CA-P100 | P100 |
| Powered | PAPR Non-Oil | | | | | CA-PAPR100-N | PAPR100-N |
| Powered | PAPR Oil-Proof | | | | | HE<br>CA-PAPR100-P | HE<br>PAPR100-P |

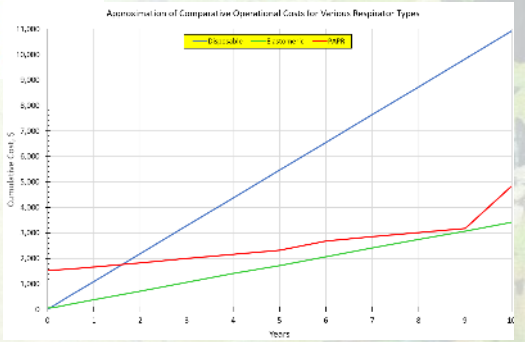



## Breathability

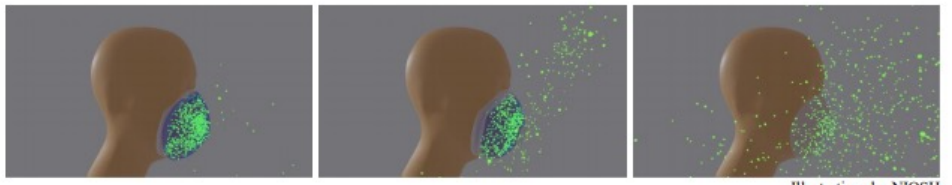



## Comfort, Fluid Resistance

## Single-use or re-usable respirators



## Exhalation Valves



Illustrations by NIOSH

**Figure 1. Simulations of particle exhalation through an FFR without an exhalation valve (left), an FFR with an exhalation valve (center), and a barrier face covering (right). Density of particles near the face represents particles remaining inside the mask.**

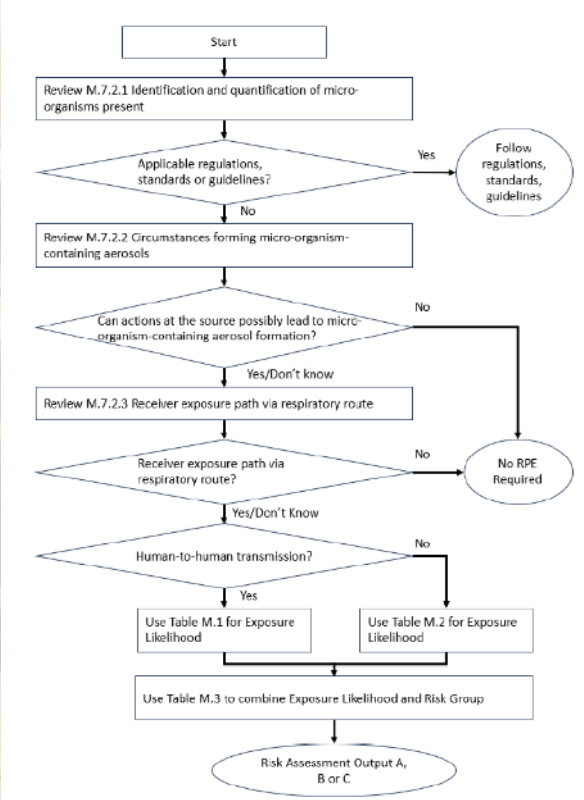
NIOSH [2020]. Filtering facepiece respirators with an exhalation valve: measurements of filtration efficiency to evaluate their potential for source control. Portnoff L, Schall J, et. al. DHHS (NIOSH) Publication No. 2021-107. DOI: https://doi.org/10.26616/NIOSHPUB2021107external icon

# Risk Assessment for Biological Aerosols

Proposed change from descriptive text to a systematic control banding method using “Source-Pathway-Receiver” model with 3-level graded output

Changes recognising latest research and new factors such as

- Comparative impact of “Aerosol Generating Procedures” versus speaking, coughing on aerosol generation
- Respirator user susceptibility




Source ⇒ Pathway ⇒ Receiver

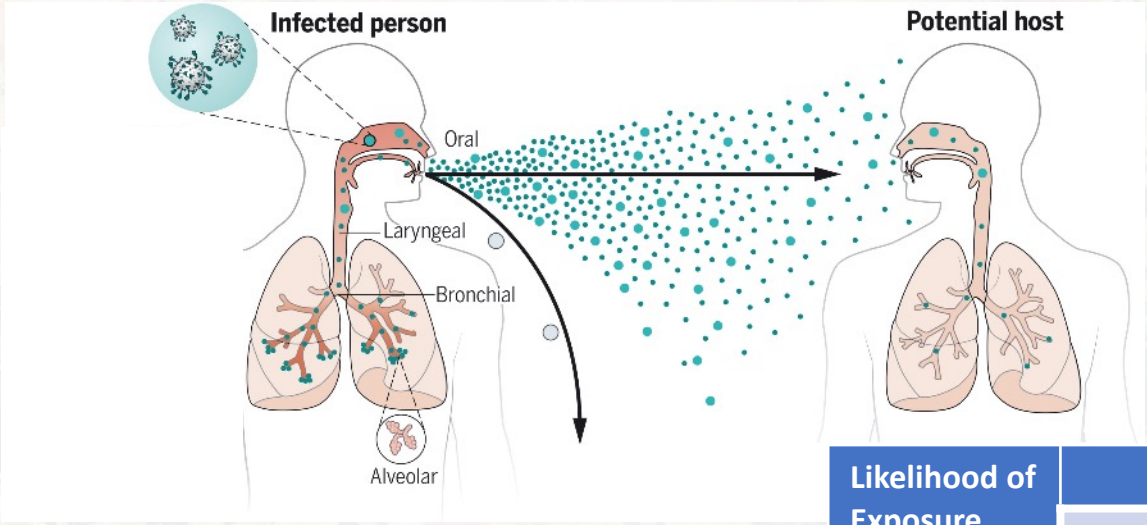



Image Source: https://www.science.org/doi/10.1126/science.abd9149

Airborne transmission of respiratory viruses, Science, August 27, 2021, Vol. 373, No. 6558. Image reproduced with permission.

Table M.2 – Contributors and scaling of likelihood of exposure: Botanical and Physical Sources

| No. | Contribution to Likelihood of Exposure | See Clause | Low | Medium | High |
|---|---|---|---|---|---|
| | **Source Factors** | | | | |
| 1 | Number and types of sources in workspace – include additional waste disposal | M.4.3b | Single source of aerosols | Several sources of aerosols | Multiple sources |
| 2 | Frequency of operation of generating activities | M.4.3d | Infrequent operation when workers present | Occasional operation when workers present | Continuous or frequent operation when workers present |
| 3 | Generation rate of potentially infectious bioaerosol(s) of work or process activities | M.4.3a | Generation rates G1, G2 | Generation rate G3 | Generation rate G4 |
| | Abnormal generation | M.4.3e | No abnormal conditions | Occasional activities with | Frequent activities with |

| Likelihood of Exposure Rank | Micro-organism Risk Group | | | | | |
|---|---|---|---|---|---|---|
| | R1 | R2L | R2H | R3L | R3H | R4 |
| L1 | A | A | A | B | B | B |
| L2 | A | B | B | B | C | C |
| L3 | B | B | C | C | C | C |

# Respirator Selection for Biological Aerosols

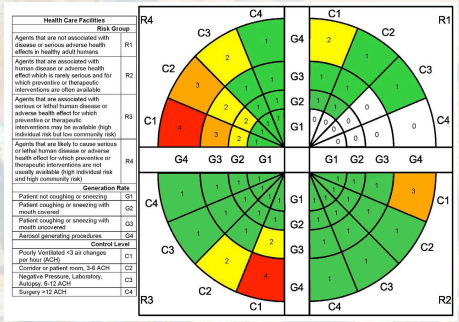
## Changes to Selection Inputs

- Enhanced micro-organism risk group scale
- New generation input rationale
- Single but expanded control level scale

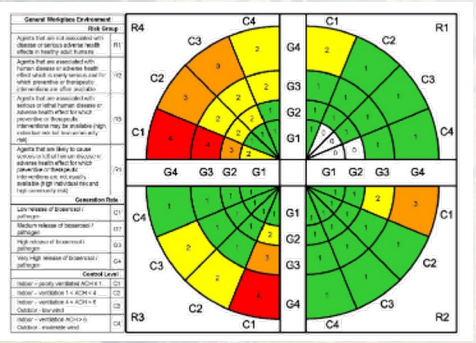
## Changes to Selection Outputs

- Revision of algorithm determining protection levels
- Range of protection levels for typical healthcare needs simplified

**Healthcare**



**General Workplace**



| R | Starting Biosafety Risk Group | Base Description | Qualifying factors* |
|---|---|---|---|
| R1 | RG1 | Not associated with disease or serious adverse health effects in healthy adult humans | Use only if high probability of no adverse effects on exposed workers |
| R2L | | | |
| R2H | | | |
| R3L | | | |
| R3H | | | |
| R4 | RG4 | Causes disease | Frequent fatalities reported in hitherto healthy individuals |

| G | Healthcare Workplace | Public Workplace | General Workplace |
|---|---|---|---|
| G1 | Patients, co-workers, non-patients wearing effective source controls | Low density of public or co-workers present, generally using source controls | Operations in enclosed systems with precautions to minimize leakage |
| G2 | Patients, c… patients no… source con… Aerosol ge… procedure… | | |
| G3 | Patients, c… patients no… source con… sneezing | | |
| G4 | Generation… containing… sawing in s… toilet flush… | | |

| C | ACH Range | Healthcare Workplace Example | General/Public Workplace |
|---|---|---|---|
| C1 | >12 ACH | Surgical suite, local extraction hood | Extraction hoods<br>Outdoor moderate wind or higher |
| C2 | 6-12 ACH | Negative pressure room, laboratory, autopsy | Indoor with good ventilation, windows open<br>Outdoor light wind |
| C3 | 4-6 ACH | Patient Room | Indoor workplace, typical factory or office space<br>Outdoor still air |
| C4 | 1-3 ACH | Corridor | Indoor storage room |
| C5 | ≤1 ACH | Not applicable | Unventilated building |

| Risk and control band | Description | Generation band | | | |
|---|---|---|---|---|---|
| | | G1 | G2 | G3 | G4 |
| R1 | **Not known to cause infection: may cause adverse effects** | | | | |
| C1 | Very High Ventilation (>12 ACH) | 0 | 0 | 0 | 0 |
| C2 | High Ventilation 6-12 ACH | 0 | 0 | 0 | 1 |
| C3 | Medium Ventilation 4-6 ACH | 0 | 1 | 1 | 1 |
| C4 | Low Ventilation 1-3 ACH, Close Contact | 0 | 1 | 1 | 1 |
| C5 | Unventilated <=1 ACH | 0 | 1 | 1 | 2 |
| R2L | **Rarely serious, prevention/therapy available** | | | | |
| C1 | Very High Ventilation (>12 ACH) | 0 | 1 | 1 | 1 |
| C2 | High Ventilation 6-12 ACH | 0 | 1 | 1 | 1 |
| C3 | Medium Ventilation 4-6 ACH | 0 | 1 | 1 | 1 |
| C4 | Low Ventilation 1-3 ACH, Close Contact | 1 | 1 | 1 | 1 |
| C5 | Unventilated <=1 ACH | 1 | 1 | 2 | 3 |
| R2H | **Rarely serious, prevention/therapy available, extended precautions** | | | | |
| C1 | Very High Ventilation (>12 ACH) | 1 | 1 | 1 | 1 |
| C2 | High Ventilation 6-12 ACH | 1 | 1 | 1 | 1 |
| C3 | Medium Ventilation 4-6 ACH | 1 | 1 | 1 | 1 |
| C4 | Low Ventilation 1-3 ACH, Close Contact | 1 | 1 | 1 | 1 |
| C5 | Unventilated <=1 ACH | 1 | 1 | 2 | 3 |
| R3L | **Serious/Lethal, prevention/therapy possible** | | | | |
| C1 | Very High Ventilation (>12 ACH) | 1 | 1 | 1 | 1 |
| C2 | High Ventilation 6-12 ACH | 1 | 1 | 1 | 1 |
| C3 | Medium Ventilation 4-6 ACH | 1 | 1 | 1 | 1 |
| C4 | Low Ventilation 1-3 ACH, Close Contact | 1 | 1 | 1 | 2 |
| C5 | Unventilated <=1 ACH | 1 | 2 | 3 | 4 |
| R3H | **Serious/Lethal, prevention/therapy possible, extended precautions** | | | | |
| C1 | Very High Ventilation (>12 ACH) | 1 | 1 | 1 | 1 |
| C2 | High Ventilation 6-12 ACH | 1 | 1 | 1 | 2 |
| C3 | Medium Ventilation 4-6 ACH | 1 | 1 | 1 | 2 |
| C4 | Low Ventilation 1-3 ACH, Close Contact | 1 | 1 | 2 | 2 |
| C5 | Unventilated <=1 ACH | 1 | 2 | 3 | 4 |
| R4 | **Serious/Lethal, prevention/therapy not readily available** | | | | |
| C1 | Very High Ventilation (>12 ACH) | 1 | 1 | 1 | 1 |
| C2 | High Ventilation 6-12 ACH | 1 | 1 | 1 | 2 |
| C3 | Medium Ventilation 4-6 ACH | 1 | 2 | 2 | 3 |
| C4 | Low Ventilation 1-3 ACH, Close Contact | 1 | 2 | 3 | 4 |
| C5 | Unventilated <=1 ACH | 2 | 3 | 4 | 4 |

# Document Finalization

- Public Review continues to 18th March 2023
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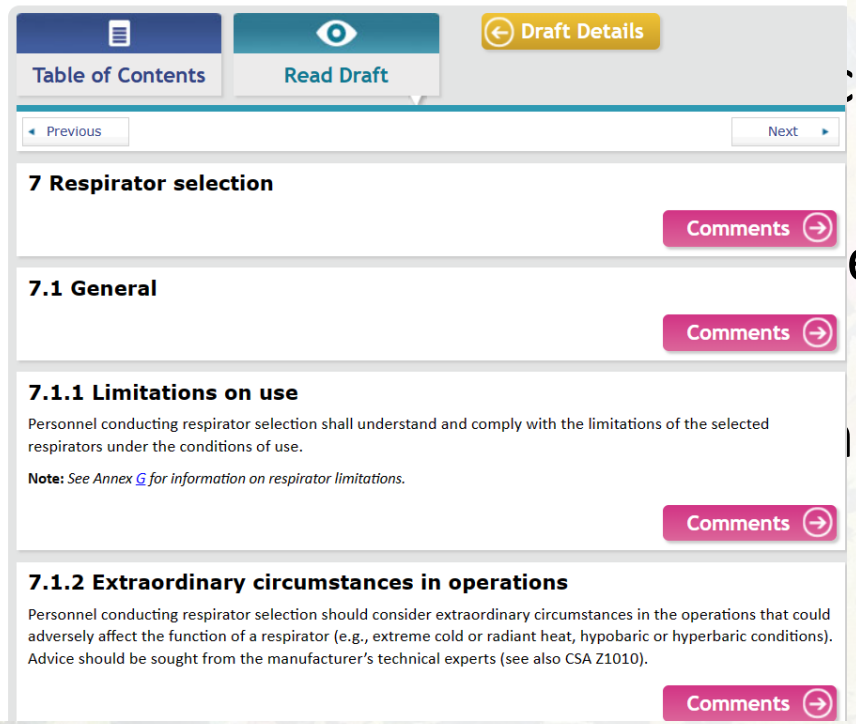
  co
  when draft is finalized
- CSA accepts comments throughout the life of the standard

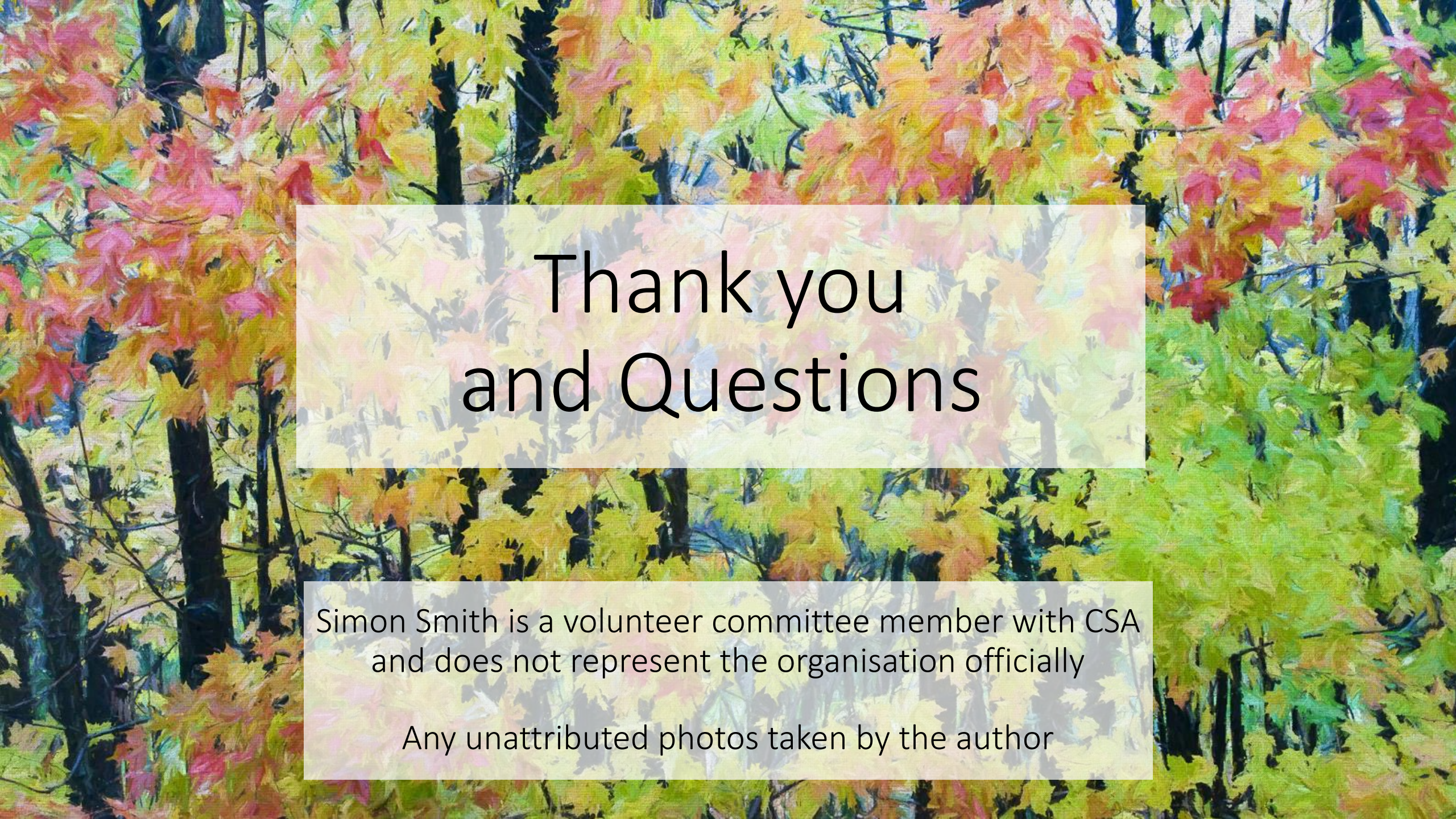



Public Comment website:
https://publicreview.csa.ca/Home/Details/5176

After you register, the website provides facilities to provide comments on each section

If needed for comparison, the current version (CSA Z94.4-18) can be viewed at:

https://community.csagroup.org/docs/DOC-121294.



# Thank you and Questions

Simon Smith is a volunteer committee member with CSA and does not represent the organisation officially

Any unattributed photos taken by the author

# New Standard CSA Z94.4.1 “Performance of Filtering Respirators

- Respirator classes comparable with NIOSH types, with “CA-” appended
- Performance requirements aligned with NIOSH requirements with some additions
- Deletions for areas covered by the CSA certification process

=

NIOSH Requirements for Particle Filtering Respirator performance as in applicable clauses in 42 CFR 84

**IMPORTANT: Certification to the CSA performance standard is not a grant of NIOSH approval nor a substitute for it outside of Canada**

+

Classifications

- Airflow resistance classes for CA-N95
- Fluid resistant “Surgical” respirators

Requirements

- Quantitative Fit Test
- Shelf Life
- Cleaning Statement
- Securing Mechanisms
- Vision
- Biocompatibility
- Mfr Assessment of Reliability
- Non-preconditioned efficiency tests
- Measurements versus general statements
- Applying uncertainty of measurement

−

Non-Performance Requirements in 42 CFR 84

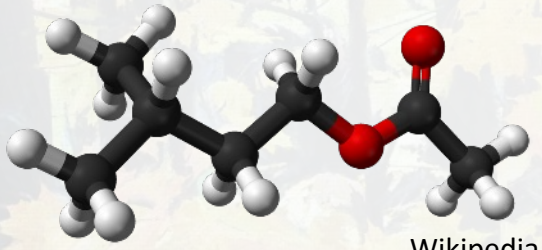
- Application process
- Administration
- Manufacturer quality control & documentation

These are addressed by other components of the Canadian Certification System

# Fit testing

## NIOSH

- Qualitative isoamyl acetate (“banana oil”) test for respirator approval, except for filtering facepieces
- NIOSH has conducted extensive research and contributed to a new ASTM Standard (F3407-20) for a quantitative fit method for half-facepieces, but this is not yet part of the approvals protocol

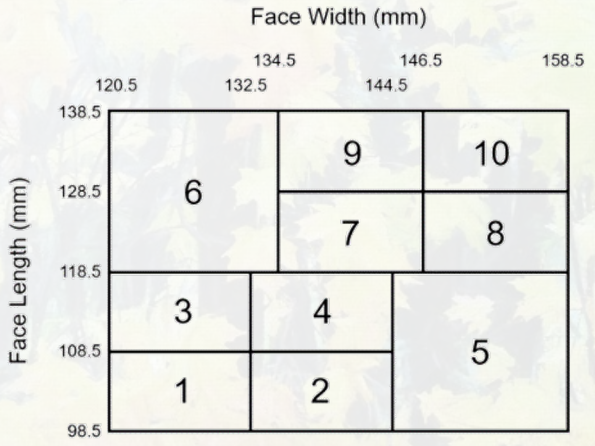


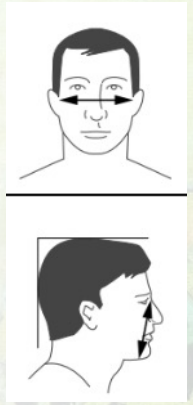
Wikipedia

Isoamyl acetate – from NIOSH qualitive fit test

## CSA Z94.4.1

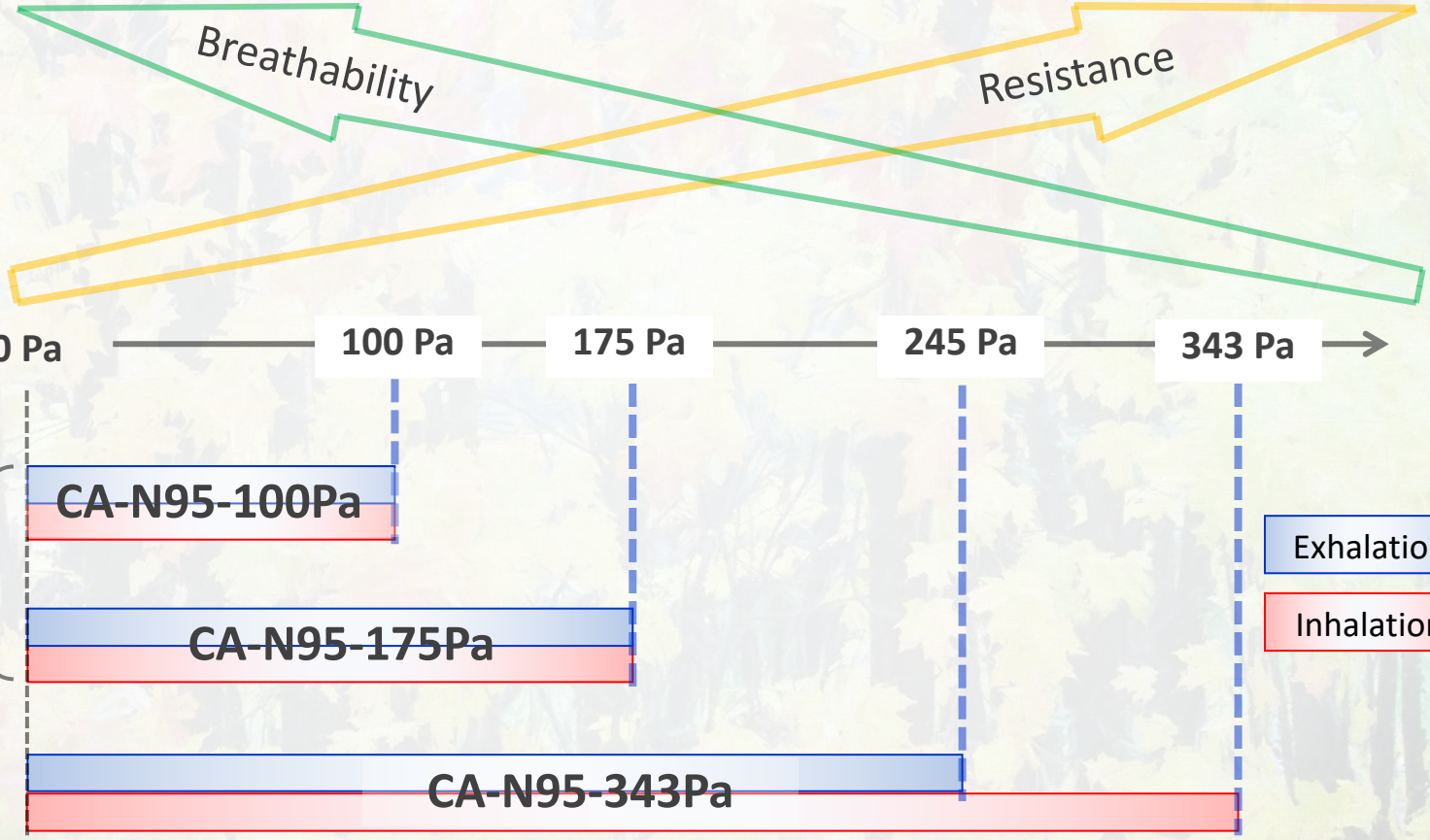
- New protocol for tight-fitting respirators based on the quantitative fit testing method in the CSA Selection, Use and Care standard CSA Z94.4-18 Annex C
- Bivariate panel, Minimum 25 test subjects with 2 to 5 per cell across size range and minimum 30% of one sex
- Standard breathing, movement and speaking exercises in a chamber with controlled particle concentration



# Comfort and Breathability

- Ergonomic and comfort assessment introduced along with fit test measurement
- Breathability identification added to CA-N95/CA-N95F respirators in three classification levels, based on maximum observed resistance value of the set of respirators submitted




1 Pa = 0.102 mm water gauge

Note that the 100 Pa resistance value corresponds with a proposal for a new respirator concept from Project "BREATHE", a major US study

NIOSH sets
35 mm water inhalation
25 mm water exhalation
at 85 l/min

# “Surgical” respirators

## NIOSH+FDA

- “Surgical” designation is added only to N95-type respirators
- FDA sets requirements according to ASTM standard methods originally established for surgical masks:
  - Biocompatibility to ISO 10993
  - Biological filtration
  - Flammability resistance to U.S. Standard 16 CFR 1610.7
  - Fluid resistance to ASTM F1862
- ASTM F1862 fluid resistance test has three levels (derived from human blood pressure ranges) – test involves squirting simulated blood at the respirator and visual examination of penetration
- For surgical respirators, it is not specified which level must be met (though recently to show pressure)

## CSA Z94.4.1

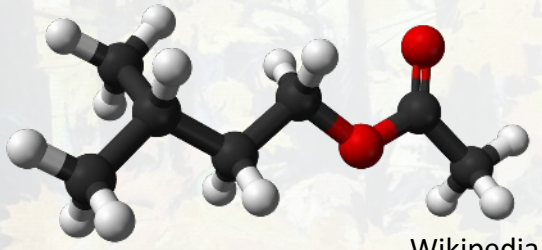
- “Surgical” designation can be added to All N-type respirators (with “F” appended to classification)
- Biocompatibility to ISO 10993 is required for ALL respirators covered by the standard, not just “surgical”
- No biological filtration efficiency requirement, as the N-type efficiency test is worst case
- Same flammability resistance requirement
- Fluid resistance testing to ASTM F1862 Level 3
  - CSA Z94.4.1 includes the highest (worst case) of the ASTM levels only
  - Rationale is to keep selection decisions as simple as possible

Note: Health Canada included biocompatibility, fluid and flammability resistance for “surgical” categories of respirator in its 2020 specification

# Fit testing and Comfort

## NIOSH

- Qualitative isoamyl acetate (“banana oil”) test for respirator approval, except for filtering facepieces
- NIOSH has conducted extensive research and contributed to a new ASTM Standard (F3407-20) for a quantitative fit method for half-facepieces, but this is not yet part of the approvals protocol
- No comfort assessment requirement in 42 CFR 84

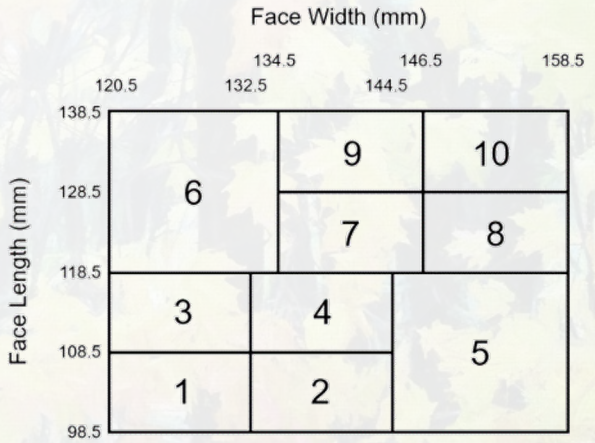


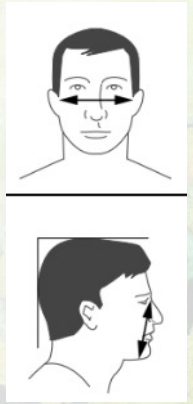
Wikipedia

Isoamyl acetate – from NIOSH qualitive fit test

## CSA Z94.4.1

- New protocol for tight-fitting respirators based on the quantitative fit testing method in the CSA Selection, Use and Care standard CSA Z94.4-18 Annex C
- Bivariate panel, Minimum 25 test subjects with 2 to 5 per cell across size range and minimum 30% of one sex
- Standard breathing, movement and speaking exercises in a chamber with controlled particle concentration
- Assessment of comfort by test subjects is adopted from CSA Z94.4-18;  excessive discomfort rating results in failure



# Shelf Life

- Shelf life is the the time a respirator or respirator component can be stored without performance deterioration below the applicable requirements of the standard prior to use – when stored in accordance with information supplied by the manufacturer
- **NIOSH has no shelf life requirement** for non-CBRN respirators in its standard, though many manufacturers set one
- **CSA Z94.4.1 introduces a shelf life requirement** for:
  - Filters
  - Integrated respirators – types where the filter is permanently attached or incorporated into the respirator – which includes filtering facepieces
- The proposed standard specifies:
  - That manufacturers validate the provided shelf life in some way, and provide documentation of the validation method
  - Marking requirements for shelf life
  - Information from the manufacturer addressing shelf life
- The proposed standard does NOT specify:
  - Requirements for a shelf life duration
  - Methods for validating shelf life
  - Evaluation of the validation methods submitted
  - Methods for shelf life extension
- Manufacturers may optionally set a shelf life for other components
- Shelf life may be expressed as either:
  - A manufacture date plus a pre-use storage duration
  - An expiration date (to nearest month)


# Cleaning

- The pandemic brought into effect the need for re-use of respirators designed as single-use
- Various methods were developed with chemical, heat/steam or radiation-based processes for decontamination
- There was extensive discussion on cleaning and re-use during document development, but it was concluded that a respirator performance standard could not require manufacturers to anticipate every method that might be developed, nor to set re-use criteria for products not designed for re-use

The cleaning requirements are:

- The manufacturer shall identify at least one cleaning method for re-usable respirators and, where applicable, components.
- The manufacturer may additionally identify at least one sanitization or disinfection method.
- If there are commonly available cleaning, sanitization, or disinfection methods that are known to have an adverse effect on the respirator performance or integrity, immediately or with repeated use, these shall be identified.

- **Note:** *For respirators designed and/or intended for use in a healthcare environment, other requirements for sanitization or disinfection might apply and should be observed by the manufacturer*

# Securing mechanisms for respiratory interface

## NIOSH

- "…All facepieces must be equipped with head harnesses designed and constructed to provide adequate tension during use and an even distribution of pressure over the entire area in contact with the face".
- Facepiece head harnesses, except those employed on filtering facepiece respirators must be adjustable and replaceable.

## CSA Z94.4.1

- Respirator mounted on a headform or equivalent fixture, each strap of the harness, buckles, and other adjusting means shall withstand the following forces per attachment point in the direction of pulling when the respirator is donned for 10 seconds:
- Single-Use Respirators: 10 N, following EN 140
- Re-usable half-facepiece respirators: 50 N, following EN 140
- Re-usable full-facepiece respirators: 100 N following EN 136
- No breaks or sliding of the straps, buckles or attachment lugs
- During and after force is applied, test fails on breakage, tearing, separation from the point of fixation to the respirator body, permanent deformation (such as loss of elasticity) remaining after 4 h or other obvious loss of function

Note: the Health Canada specification applied the single-use requirement to all types

# Vision (Actually no change in Canada)

## NIOSH

- "Respiratory inlet coverings must be designed and constructed to provide adequate vision which is not distorted by the eyepieces"

## CSA Z94.4.1

- Incorporates relevant parts of CSA Z94.3 "Eye and face protectors" for vision characteristics – adherence to which is already a requirement in Canada
- Requires quantitative assessment of visual distortion

# Biocompatibility

## NIOSH

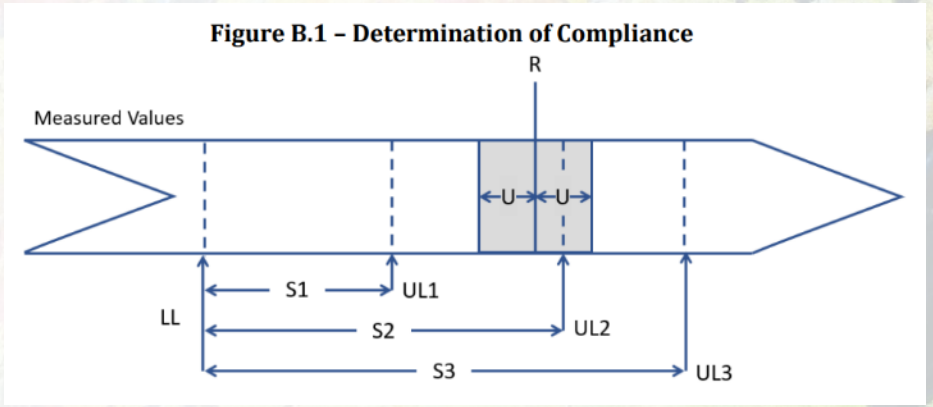
- "Respirator components which come into contact with the wearer's skin shall be made of non-irritating materials"

## CSA Z94.4.1

- Applies requirements in ISO 10993 "Biological evaluation of medical devices" to all respirators

# Other points

- Failure Mode Effects Analysis is required as part of product development
- Application of process for uncertainty of measurement – where measurement precision overlaps with the pass/fail margin
- Use of non-preconditioned samples for N-type filter efficiency measurement (arises from National Research Council studies)
- Hydration device flow rate (based on ISO requirements)
- Airflow resistance range calculation to determine use of pro-rated test flow rates in respirators with multiple filters (based on ISO/EN requirements)
- Flow checking device to be provided for PAPRs (not in NIOSH but a universal industry practice)



# Comparison with NIOSH Respirator Classes

Additional classes with low airflow resistance and fluid resistant categories

| Type | | Particle Efficiency (Aerosol at Most Penetrating Particle Size) | | | | | |
|---|---|---|---|---|---|---|---|
| | | ≥95.00% | | ≥99.00% | | ≥99.97% | |
| | | **CSA** | **NIOSH** | **CSA** | **NIOSH** | **CSA** | **NIOSH** |
| Non-Powered | Non-Oil | CA-N95-100Pa<br>CA-N95-175Pa<br>CA-N95-343Pa | N95 | CA-N99 | N99 | CA-N100 | N100 |
| Non-Powered | Non-Oil +"Surgical" | CA-N95F-100Pa<br>CA-N95F-175Pa<br>CA-N95F-343Pa | FDA-cleared + NIOSH tests Surgical N95 | CA-N99F | | CA-N100F | |
| Non-Powered | Oil "Resistant" | CA-R95 | R95 | CA-R99 | R99 | CA-R100 | R100 |
| Non-Powered | "Oil-Proof" | CA-P95 | P95 | CA-P99 | P99 | CA-P100 | P100 |
| Powered | PAPR Non-Oil | | | | | CA-PAPR100-N | PAPR100-N |
| Powered | PAPR Oil-Proof | | | | | HE<br>CA-PAPR100-P | HE<br>CA-PAPR100-P |

# The Future?

| | |
|---|---|
| Content of the Standard | CSA Standards are created, regularly reviewed and updated by an expert committee of stakeholders – closer to European or Australian approaches than NIOSH – so the standard could change over time |
| | • Proposals for discussion for the next update, work possibly starting 2025<br>  • Add Scope 2 – gas and vapour filtering respirators (with Scope 3 CBRN and atmosphere-supplying respirators in future updates)<br>  • Additional particle filter efficiency and breathability classes<br>  • Respirator re-use and recycling<br>  • Bioburden (cleanliness) test requirement for “F”-type “surgical” respirators<br>  • Communication<br>  • Practical performance tests to demonstrate respirator capability for particular occupations<br>• Test methods<br>  • Review particle tests<br>  • Dedicated test methods in place of cited NIOSH “Standard Test Protocols” |
| Alignment | • Update CSA Z94.4 “Selection, Use and Care of Respirators” to reference Z94.4.1 and align terminology |
| Certification Practicalities | • CSA has set up a test capability for non-powered particle filtering respirators<br>• But for powered air and future gas/vapour requirements, testing by third-party laboratories will be required – again a more European approach than NIOSH |

# Reference List

- CSA Z94.4-18 “Selection, Use and Care of Respirators” viewable version: https://community.csagroup.org/docs/DOC-121294
- CSA Z94.4.1-21 “Performance of Filtering Respirators” viewable version: https://view.csagroup.org/K6UbmP
- IRSST Respirator selection for biological aerosols control banding on-line tool: https://www.irsst.qc.ca/bioaerosol/default.aspx?
- Health Canada Guidance: https://www.canada.ca/en/health-canada/services/drugs-health-products/covid19-industry/medical-devices/personal-protective-equipment/medical-masks-respirators/safety-performance-specifications.html
- ISO Standards addressing respiratory protection: https://www.iso.org/committee/291088/x/catalogue/p/1/u/0/w/0/d/0

All of these are available in English and French

- Electronic version of NIOSH Standard 42 CFR 84: https://www.ecfr.gov/cgi-bin/text-idx?SID=1e52f48c2b606c31f3df95baa80cc78e&mc=true&node=pt42.1.84&rgn=div5
- NIOSH-approved respirators can be searched on the Certified Equipment List: https://www.cdc.gov/niosh/npptl/topics/respirators/cel/default.html
- Searchable list of CSA Approved products (for respirators approved to the new standard, use class number “7204-03”): https://www.csagroup.org/testing-certification/product-listing/ (note no products listed at time presentation)
- US National Institutes of Health “Guidelines for Research Involving Recombinant DNA Molecules”: https://osp.od.nih.gov/wp-content/uploads/NIH_Guidelines.pdf
- Studies from the National Academies of Sciences, Engineering and Medicine on various aspects of respirator testing and use provide useful background: https://www.nationalacademies.org/our-work/standing-committee-on-personal-protective-equipment-for-workplace-safety-and-health

| Aspect | Detail | NIOSH | CSA |
|---|---|---|---|
| All Types Performance | General and construction requirements | Requirements | Requirements |
| | Wearer compatibility and safety | General | Specific |
| | Compliance with other standards | | Specific |
| | Respiratory Interfaces | General | General |
| | Integrated eye protection | General | Specific |
| | Fit, Fit factor requirements, Fit testing | Qualitative | Quantitative |
| | Valves – inhalation and exhalation | Specific | Specific |
| | [illegible] | General | Specific |
| | [illegible] | Specific | Specific |
| | [illegible] | General | General |
| No re | [illegible] | Specific | Specific |
| | [illegible] | Specific | Specific |
| | [illegible] | | Specific |
| Po purifying respirators | [illegible] | Specific | Specific |
| | [illegible] | Specific | Specific |
| | [illegible] | Specific | Specific |
| | Noise and Communication | Specific | Specific |
| | Warning devices | Specific | Specific |
| | Flow checking device | | Requirements |
| All Types Additional | Shelf life | | Requirements |
| | Cleaning of re-usable respirators | | Requirements |
| | Assessment of reliability | | Requirements |
| | Marking and Information supplied by the manufacturer | Requirements | Requirements |

Requirements – criteria defined for aspects which must be present which are general or with details set by the manufacturer

General – Statement about the feature with no measured criteria

Specific – sets a performance requirement measuring physical characteristics

Qualitative – test based on a subjective sensation by wearer

Quantitative – test based on measurement

| Aspect | Detail | NIOSH | CSA |
|---|---|---|---|
| All Types Performance | General and construction requirements | Requirements | Requirements |
| | | | Specific |
| | | | Specific |
| | | | General |
| | | | Specific |
| | | | Quantitative |
| | | | Specific |
| | | | Specific |
| | | | Specific |
| | | | General |
| Non-powered respirators | | | Specific |
| | | | Specific |
| | | | Specific |
| Powered air-purifying respirators | | | Specific |
| | | | Specific |
| | | | Specific |
| | | | Specific |
| | | | Specific |
| | Warning devices | Specific | Specific |
| | Flow checking device | | Requirements |
| All Types Additional | Shelf life | | Requirements |
| | Cleaning of re-usable respirators | | Requirements |
| | Assessment of reliability | | Requirements |
| | Marking and Information supplied by the manufacturer | Requirements | Requirements |

## Key Aspects for a Filtering Facepiece

NIOSH "Specifics" Highlighted

# Risk and Generation Band Changes

| Risk Level R | Starting Biosafety Risk Group | Base Description | Qualifying factors* |
|---|---|---|---|
| R1 | RG1 | Not associated with disease or serious adverse health effects in healthy adult humans | Use only if high probability of no adverse effects on exposed workers |
| R2L | RG2 | Associated with rarely serious occurrence of human disease or adverse health effects | Preventive/therapeutic intervention available, applied and effective<br>Low community spread |
| R2H | RG2 | Associated with rarely serious occurrence of human disease or adverse health effects | Preventive/therapeutic intervention inadequate or unavailable<br>Identified receiver sensitization<br>Medium/high community spread<br>Serious health effects noted in some cases in worker population |
| R3L | RG3 | Associated with serious or lethal human disease or adverse health effects | Preventive/therapeutic intervention available, applied and effective<br>Low community spread<br>No fatalities in hitherto healthy individuals |
| R3H | RG3 | Associated with serious or lethal human disease or adverse health effects | Preventive/therapeutic intervention inadequate or unavailable<br>Medium/high community spread<br>Fatalities reported in hitherto healthy individuals |
| R4 | RG4 | Causes serious or lethal human disease or adverse health effects | Preventive/therapeutic intervention inadequate or unavailable<br>High probability of infection<br>Frequent fatalities reported in hitherto healthy individuals |

*Any one of the qualifying factors listed should trigger “H” level assignment

| G | General Description | Contributors |
|---|---|---|
| G1 | Minimal aerosolization | Not close contact, local ventilation, low source density (i.e. small size or number of sources in volume) |
| G2 | Low aerosolization | Close contact, general ventilation only, low source density |
| G3 | Moderate aerosolization | Close contact, general ventilation only, high source density |
| G4 | High/Very High aerosolization | Close contact, general ventilation only, high source density |

## Examples provided for workplaces

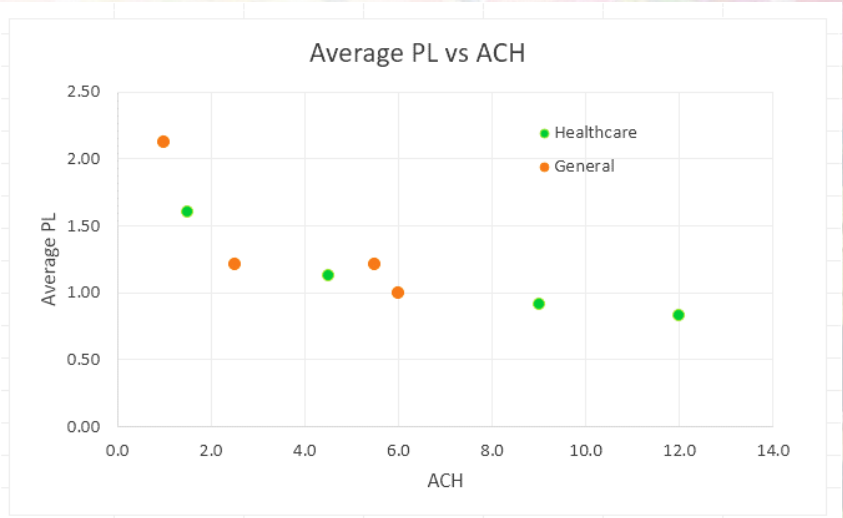
| G | General Description | Healthcare Example | Public Workplace Example | General Workplace Example |
|---|---|---|---|---|
| G2L | Low aerosolization | Single patient inactive with mouth covered<br>Non-patients not wearing effective source controls<br>Patient close to extraction ventilation<br>Far-field exposure | Low density of public /co-workers present generally using source controls | Open operations with minimal generation or disturbance and effective source extraction (e.g. a HEPA vacuum cleaner) |

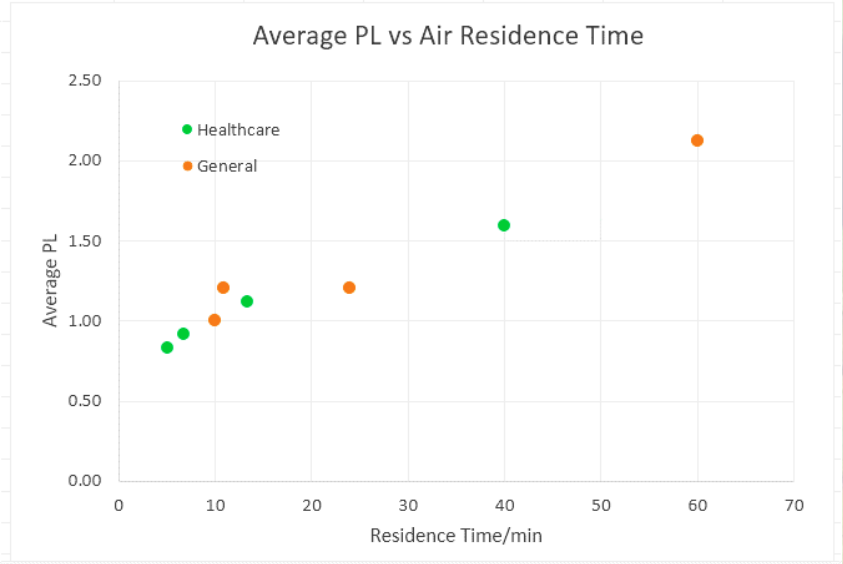
# Analysis of Existing Guidance

nterpretation current Healthcare wheel into Excel spreadsheet

| R/C | Agent Type | | CSA Z94.4-18 | | | |
|---|---|---|---|---|---|---|
| **R1** | **Not known to cause infection: may cause adverse effects** | **1** | G1 | G2 | G3 | G4 |
| C1 | Poorly Ventilated (<3 ACH) | 3 | 0 | 1 | 1 | 2 |
| C2 | Corridor/Patient room (3-6 ACH) | 6 | 0 | 1 | 1 | 1 |
| C3 | Negative Pressure/Laboratory/Autopsy (>6-12 ACH) | 12 | 0 | 0 | 0 | 1 |
| C4 | Surgery (>12 ACH) | 25 | 0 | 0 | 0 | 0 |
| | | | | | | |
| **R2** | **Rarely serious, prevention/therapy available** | **2** | | | | |
| C1 | Poorly Ventilated (<3 ACH) | 3 | 1 | 1 | 1 | 3 |
| C2 | Corridor/Patient room (3-6 ACH) | 6 | 1 | 1 | 1 | 1 |
| C3 | Negative Pressure/Laboratory/Autopsy (>6-12 ACH) | 12 | 1 | 1 | 1 | 1 |
| C4 | Surgery (>12 ACH) | 25 | 1 | 1 | 1 | 1 |
| | | | | | | |
| **R3** | **Serious/Lethal, prevention/therapy possible** | **3** | | | | |
| C1 | Poorly Ventilated (<3 ACH) | 3 | 1 | 1 | 2 | 4 |
| C2 | Corridor/Patient room (3-6 ACH) | 6 | 1 | 1 | 1 | 2 |
| C3 | Negative Pressure/Laboratory/Autopsy (>6-12 ACH) | 12 | 1 | 1 | 1 | 1 |
| C4 | Surgery (>12 ACH) | 25 | 1 | 1 | 1 | 1 |
| | | | | | | |
| **R4** | **Serious/Lethal, prevention/therapy not readily available** | **4** | | | | |
| C1 | Poorly Ventilated (<3 ACH) | 3 | 1 | 2 | 3 | 4 |
| C2 | Corridor/Patient room (3-6 ACH) | 6 | 1 | 2 | 2 | 3 |
| C3 | Negative Pressure/Laboratory/Autopsy (>6-12 ACH) | 12 | 1 | 1 | 1 | 2 |
| C4 | Surgery (>12 ACH) | 25 | 1 | 1 | 1 | 1 |

- Assign “average” flow to ventilation band (some arbitrariness)
- Average all protection levels outputs for the matrix of R/G combinations
- Upper plot – average protection level vs flow based on average ACH
- Lower plot – average protection level vs reciprocal of flow expressed as air “residence” time




eorganise by ventilation band, and add proposed R and G levels

| C/R | Agent Type | | CSA Z94.4-18 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **C1** | **Poorly Ventilated (<3 ACH)** | **1** | G1 | | G2 | | G3 | | G4 | |
| | | | L | H | L | H | L | H | L | H |
| R1 | Not known to cause infection: may cause adverse effects | R1 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 2 |
| R2 | Rarely serious, prevention/therapy available | R2L | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 |
| R2 | Rarely serious, prevention/therapy available, Extra Prec. | R2H | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 |
| R3 | Serious/Lethal, prevention/therapy possible | R3L | 1 | 1 | 1 | 1 | 2 | 2 | 4 | 4 |
| R3 | Serious/Lethal, prevention/therapy possible Extra Prec. | R3H | 1 | 1 | 1 | 1 | 2 | 2 | 4 | 4 |
| R4 | Serious/Lethal, prevention/therapy not readily available | R4 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| | | | | | | | | | | |
| **C2** | **Corridor/Patient room (3-6 ACH)** | **2** | | | | | | | | |
| R1 | Not known to cause infection: may cause adverse effects | R1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| R2 | Rarely serious, prevention/therapy available | R2L | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| R2 | Rarely serious, prevention/therapy available, Extra Prec. | R2H | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| R3 | Serious/Lethal, prevention/therapy possible | R3L | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| R3 | Serious/Lethal, prevention/therapy possible Extra Prec. | R3H | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| R4 | Serious/Lethal, prevention/therapy not readily available | R4 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 |

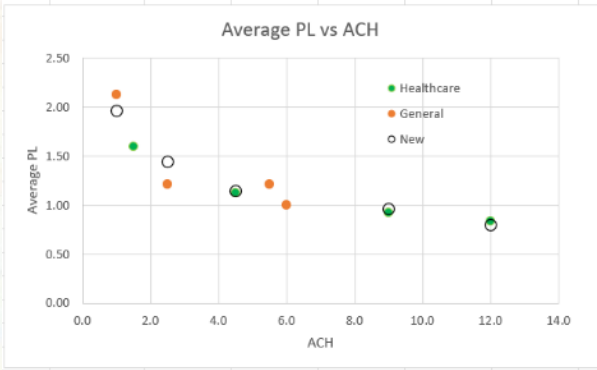
Observe that ranges in the two “wheels” appear on a common line, overlapping

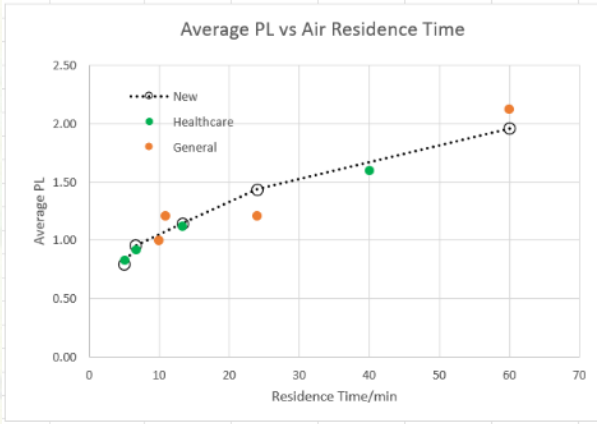
# Proposal for revised algorithm

- No separation of workplace type in tables, but applicable ventilation ranges provided in text
- Modify to PL allocations make an even pattern
  - Note this is a change from calculation method used earlier
- Use five ventilation bands to cover both former ranges
  - Can cover other workplace types as guidance needs only to interpret applicable C range
- Modified outputs in some cases to simplify selection in common healthcare scenarios
- New “average” line consistent with current inputs/outputs

| C1 | Unventilated Indoor Space | <=1 ACH | G1 | | G2 | | G3 | | G4 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | H | L | H | L | H | L | H |
| R1 | Not known to cause infection: may cause adverse effects | R1 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 2 |
| R2 | Rarely serious, prevention/therapy available | R2L | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 |
| R2 | Rarely serious, prevention/therapy available, Extra Precautions | R2H | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 3 |
| R3 | Serious/Lethal, prevention/therapy possible | R3L | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 4 |
| R3 | Serious/Lethal, prevention/therapy possible Extra Precautions | R3H | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| R4 | Serious/Lethal, prevention/therapy not readily available | R4 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 4 |
| C2 | Low | 1-3 ACH | | | | | | | | |
| R1 | Not known to cause infection: may cause adverse effects | R1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 2 |
| R2 | Rarely serious, prevention/therapy available | R2L | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| R2 | Rarely serious, prevention/therapy available, Extra Precautions | R2H | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| R3 | Serious/Lethal, prevention/therapy possible | R3L | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| R3 | Serious/Lethal, prevention/therapy possible Extra Precautions | R3H | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| R4 | Serious/Lethal, prevention/therapy not readily available | R4 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| C3 | Mid | 4-6 ACH | | | | | | | | |
| R1 | Not known to cause infection: may cause adverse effects | R1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| R2 | Rarely serious, prevention/therapy available | R2L | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| R2 | Rarely serious, prevention/therapy available, Extra Precautions | R2H | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| R3 | Serious/Lethal, prevention/therapy possible | R3L | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| R3 | Serious/Lethal, prevention/therapy possible Extra Precautions | R3H | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| R4 | Serious/Lethal, prevention/therapy not readily available | R4 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 |
| C4 | High | 6-12 ACH | | | | | | | | |
| R1 | Not known to cause infection: may cause adverse effects | R1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| R2 | Rarely serious, prevention/therapy available | R2L | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| R2 | Rarely serious, prevention/therapy available, Extra Precautions | R2H | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| R3 | Serious/Lethal, prevention/therapy possible | R3L | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| R3 | Serious/Lethal, prevention/therapy possible Extra Precautions | R3H | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| R4 | Serious/Lethal, prevention/therapy not readily available | R4 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| C5 | Very High | >12 ACH | | | | | | | | |
| R1 | Not known to cause infection: may cause adverse effects | R1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| R2 | Rarely serious, prevention/therapy available | R2L | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| R2 | Rarely serious, prevention/therapy available, Extra Precautions | R2H | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| R3 | Serious/Lethal, prevention/therapy possible | R3L | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| R3 | Serious/Lethal, prevention/therapy possible Extra Precautions | R3H | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| R4 | Serious/Lethal, prevention/therapy not readily available | R4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

## Proposal and Current Comparison




## Example Difference Analysis

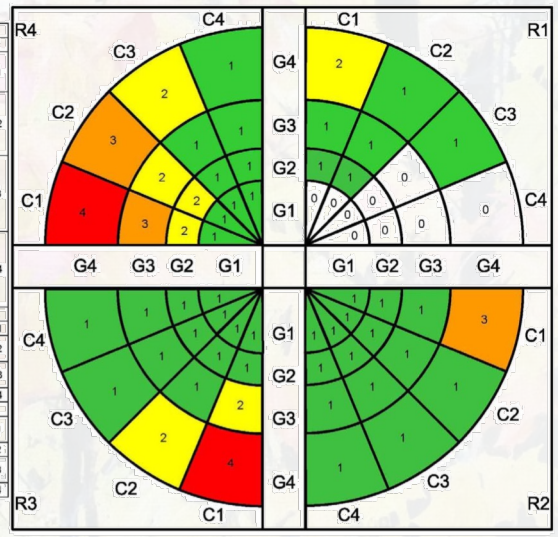
| C1 | Unventilated Indoor Space | <=1 ACH | Proposal G1 | | Proposal G2 | | Proposal G3 | | Proposal G4 | | Current G1 | | Current G2 | | Current G3 | | Current G4 | | Differences G1 | | Differences G2 | | Differences G3 | | Differences G4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | H | L | H | L | H | L | H | L | H | L | H | L | H | L | H | L | H | L | H | L | H | L | H |
| R1 | Not known to cause infection: may cause adverse effects | R1 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| R2 | Rarely serious, prevention/therapy available | R2L | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 0 | 0 | 0 | 0 | -1 | 0 | -1 | 0 |
| R2 | Rarely serious, prevention/therapy available, Extra Precautions | R2H | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| R3 | Serious/Lethal, prevention/therapy possible | R3L | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 0 | 0 | -1 | 0 | -1 | 0 | -1 | 0 |
| R3 | Serious/Lethal, prevention/therapy possible Extra Precautions | R3H | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| R4 | Serious/Lethal, prevention/therapy not readily available | R4 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 4 | 2 | 2 | 3 | 3 | 4 | 4 | 4 | 4 | -1 | 0 | -1 | 0 | -1 | 0 | 0 | 0 |

# Proposal Layout by Risk Group

## Current

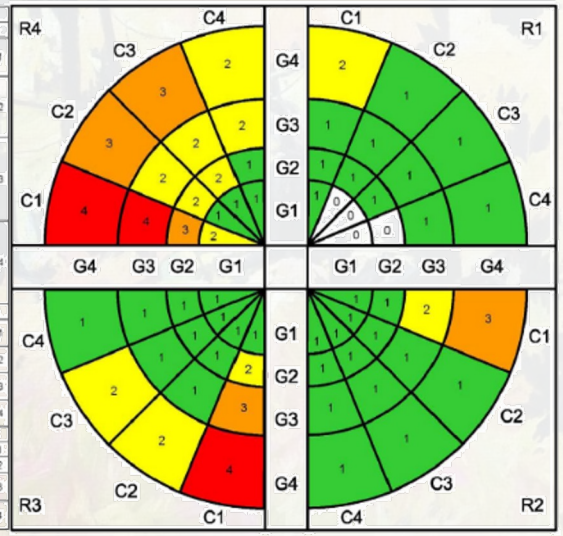
**Healthcare**

| Health Care Facilities | |
|---|---|
| **Risk Group** | |
| Agents that are not associated with disease or serious adverse health effects in healthy adult humans | R1 |
| Agents that are associated with human disease or adverse health effect which is rarely serious and for which preventive or therapeutic interventions are often available | R2 |
| Agents that are associated with serious or lethal human disease or adverse health effect for which preventive or therapeutic interventions may be available (high individual risk but low community risk) | R3 |
| Agents that are likely to cause serious or lethal human disease or adverse health effect for which preventive or therapeutic interventions are not usually available (high individual risk and high community risk) | R4 |
| **Generation Rate** | |
| Patient not coughing or sneezing | G1 |
| Patient coughing or sneezing with mouth covered | G2 |
| Patient coughing or sneezing with mouth uncovered | G3 |
| Aerosol generating procedures | G4 |
| **Control Level** | |
| Poorly Ventilated <3 air changes per hour (ACH) | C1 |
| Corridor or patient room, 3-6 ACH | C2 |
| Negative Pressure, Laboratory, Autopsy, 6-12 ACH | C3 |
| Surgery >12 ACH | C4 |




**General Workplace**

| General Workplace Environment | |
|---|---|
| **Risk Group** | |
| Agents that are not associated with disease or serious adverse health effects in healthy adult humans | R1 |
| Agents that are associated with human disease or adverse health effect which is rarely serious and for which preventive or therapeutic interventions are often available | R2 |
| Agents that are associated with serious or lethal human disease or adverse health effect for which preventive or therapeutic interventions may be available (high individual risk but low community risk) | R3 |
| Agents that are likely to cause serious or lethal human disease or adverse health effect for which preventive or therapeutic interventions are not usually available (high individual risk and high community risk) | R4 |
| **Generation Rate** | |
| Low release of bioaerosol / pathogen | G1 |
| Medium release of bioaerosol / pathogen | G2 |
| High release of bioaerosol / pathogen | G3 |
| Very High release of bioaerosol / pathogen | G4 |
| **Control Level** | |
| Indoor – poorly ventilated ACH ≤ 1 | C1 |
| Indoor – ventilation 1 < ACH < 4 | C2 |
| Indoor – ventilation 4 < ACH < 6 Outdoor - low wind | C3 |
| Indoor – ventilation ACH > 6 Outdoor - moderate wind | C4 |




## Approximate control level (C) conversion

| Current | | Proposal |
|---|---|---|
| HC | GW | |
| | C1 | C1 |
| C1 | C2 | C2 |
| C2 | C3 | C3 |
| C3 | C4 | C4 |
| C4 | | C5 |

## Proposal

| R Level | C | G1 | | G2 | | G3 | | G4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | L | H | L | H | L | H | L | H |
| **R1: Not known to cause infection: may cause adverse effects** | | | | | | | | | |
| Unventilated <=1 ACH | C1 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 2 |
| Low Ventilation 1-3 ACH | C2 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 2 |
| Medium Ventilation 4-6 ACH | C3 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| High Ventilation 6-12 ACH | C4 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Very High Ventilation (>12 ACH) | C5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **R2L: Rarely serious, prevention/therapy available** | | | | | | | | | |
| Unventilated <=1 ACH | C1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 |
| Low Ventilation 1-3 ACH | C2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| Medium Ventilation 4-6 ACH | C3 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| High Ventilation 6-12 ACH | C4 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| Very High Ventilation (>12 ACH) | C5 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| **R2H: Rarely serious, prevention/therapy available Extra Precautions** | | | | | | | | | |
| Unventilated <=1 ACH | C1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 3 |
| Low Ventilation 1-3 ACH | C2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| Medium Ventilation 4-6 ACH | C3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| High Ventilation 6-12 ACH | C4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Very High Ventilation (>12 ACH) | C5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **R3L: Serious/Lethal, prevention/therapy possible** | | | | | | | | | |
| Unventilated <=1 ACH | C1 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 4 |
| Low Ventilation 1-3 ACH | C2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| Medium Ventilation 4-6 ACH | C3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| High Ventilation 6-12 ACH | C4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| Very High Ventilation (>12 ACH) | C5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **R3H: Serious/Lethal, prevention/therapy possible Extra Precautions** | | | | | | | | | |
| Unventilated <=1 ACH | C1 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| Low Ventilation 1-3 ACH | C2 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| Medium Ventilation 4-6 ACH | C3 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| High Ventilation 6-12 ACH | C4 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| Very High Ventilation (>12 ACH) | C5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **R4: Serious/Lethal, prevention/therapy not readily available** | | | | | | | | | |
| Unventilated <=1 ACH | C1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 4 |
| Low Ventilation 1-3 ACH | C2 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| Medium Ventilation 4-6 ACH | C3 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 |
| High Ventilation 6-12 ACH | C4 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| Very High Ventilation (>12 ACH) | C5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

# Output: CSA Z94.4 Hierarchy of Respiratory Protection

For filtering respirators: algorithm output recommendation is a respirator at or above the Protection Level (PL) 0-4 for types as shown


**0**
Respiratory Protection not presumed necessary

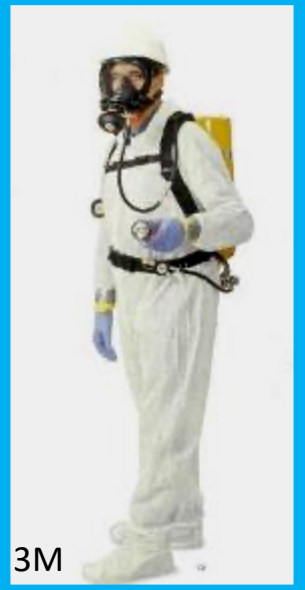

**1**
Fitted filtering facepiece


**1**
Half-facepiece air-purifying respirator


**2**
Loose-fitting powered air-purifying respirator


**3**
Full-facepiece air-purifying respirator


**4**
Tight-fitting powered air-purifying respirator




**5**
Self-Contained Breathing Apparatus