PERSONAL PROTECTIVE EQUIPMENT OVERVIEW

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SUMMARY

Personal Protective Equipment

Respiratory Protective Equipment

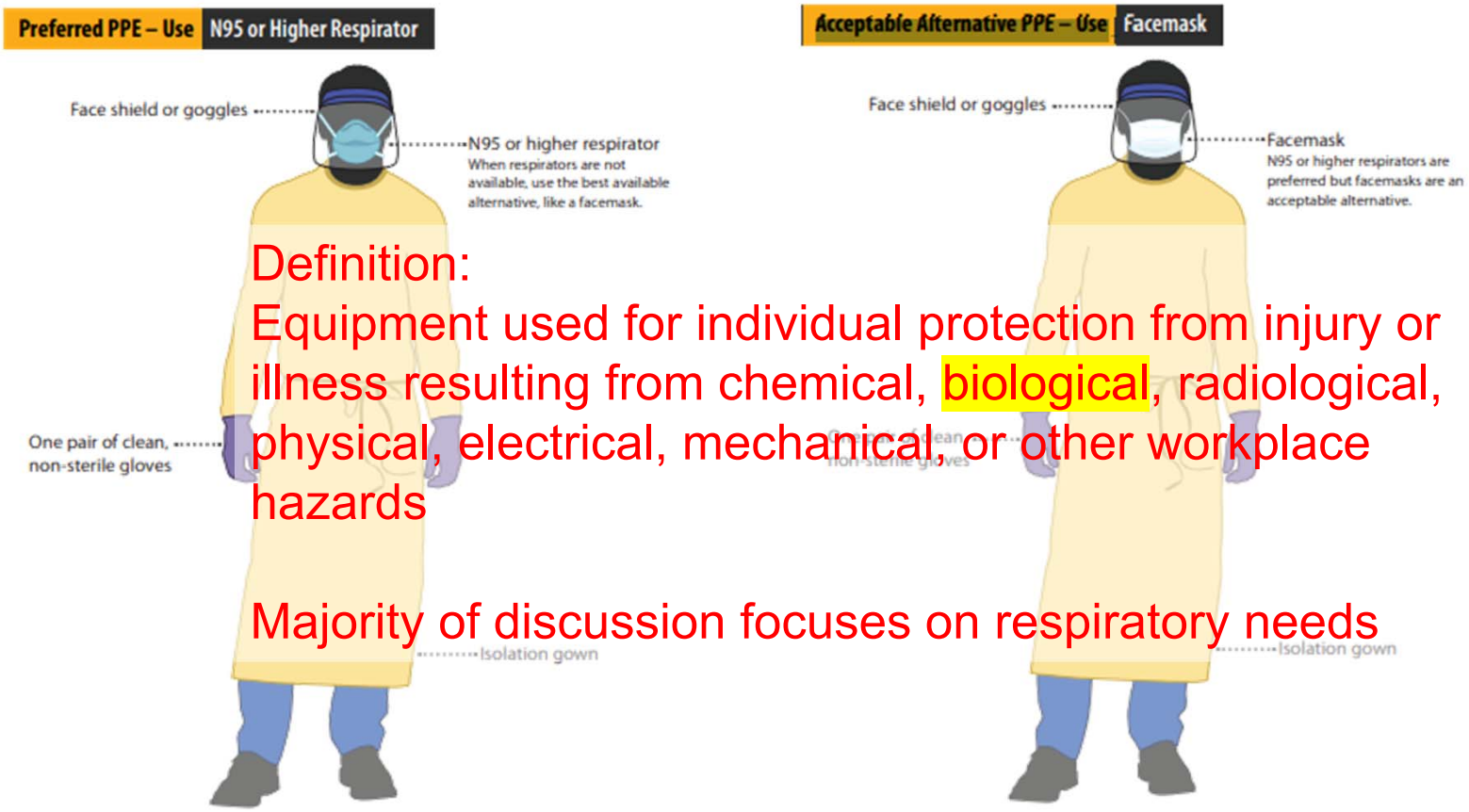
Filtering Respirators

What's Important?

- Filtration
- Fit
- Function

- Certification
- Selection
- Use
- Pandemic Crisis

Use Personal Protective Equipment (PPE) When Caring for Patients with Confirmed or Suspected COVID-19

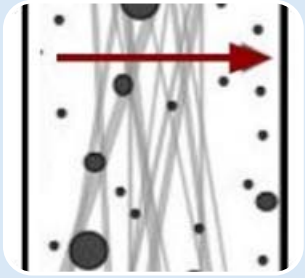


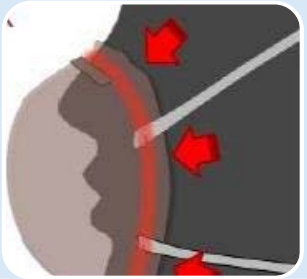
Definition:
Equipment used for individual protection from injury or illness resulting from chemical, biological, radiological, physical, electrical, mechanical, or other workplace hazards

Majority of discussion focuses on respiratory needs

https://www.cdc.gov/coronavirus/2019-ncov/downloads/A_FS_HCP_COVID19_PPE_11x17.pdf

KEY ASPECTS OF RESPIRATORY PROTECTION INFLUENCING EFFECTIVENESS ("3Fs")





	Filtration	Fit	Function
Key Question	How well does the material used remove particles from the air?	How much air leaks round the perimeter when the product is worn, affecting its protectiveness?	How much does the product affect the wearer's comfort and ability to do their job effectively?
Associated Factors	Media Efficiency or Penetration (%)	Quality of facial seal, fit testing, fit checking, Protection Factor	Airflow resistance, skin compatibility, balance, communication, physiological burden, CO_2, heat and moisture build-up

FACIAL BARRIERS, SURGICAL MASKS, RESPIRATORS ARE DIFFERENT

Microsoft Stock

3M Canada

Barrier Face Covering

- No performance requirements
- No seal to the face
- Any kind of filtration material may be used

Typical relevant capabilities
Filtration ★
Fit ★
Function ★★★
Splash Protection ★

Surgical Mask

- No seal to the face
- Filtration is material fluid and biological agent resistant

Typical relevant capabilities
Filtration ★★
Fit ★
Function ★★★
Splash Protection ★★+

Approved Respirator

- Governed by regulation and performance standards
- Good seal to the face
- Filtration material required to pass specifications

For filtering facepiece:
Filtration ★★★★
Fit ★★★★
Function ★★
Splash Protection ★★+

EXAMPLES OF RESPIRATORY PROTECTIVE EQUIPMENT

Respirator:
A component of Personal Protective Equipment (PPE), designed to protect the wearer's respiratory tract against inhalation of hazardous atmospheres

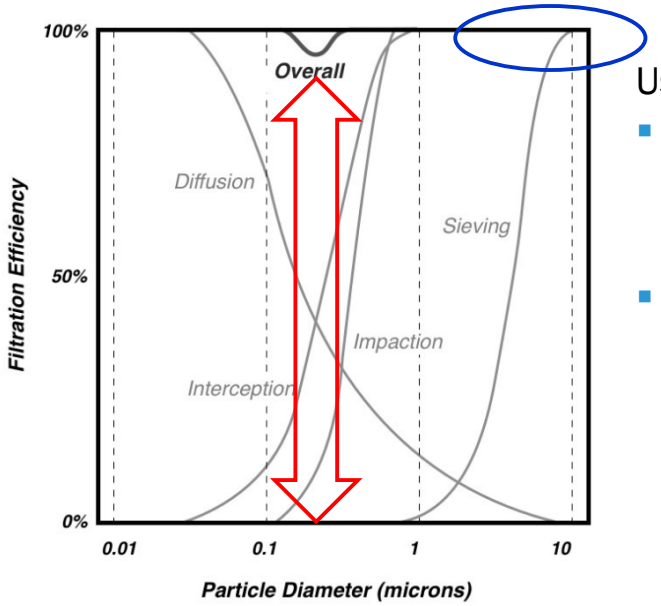
Selection includes balancing desired protection with other factors

Equipment	SCBA	PAPR (T)	FF-APR	PAPR (L)	HF-APR	FFP
Protection Hierarchy Level	5	4	3	2	1	1
Assigned Protection Factor	10,000	1,000	100	25/1,000	10	10
Comfort/Physiological Burden	★	★★★	★★	★★★★	★★	★★
Ease of Logistics and simplicity of training/ Maintenance	★	★★	★★★	★★	★★★	★★★★
Non-Stop Usage in typical environment	30 min (air supply limited)	~8 hours (battery limited)	>8 hours (filter limited)	~8 hours (battery limited)	>8 hours (filter limited)	~2-4 hours (filter limited)
Initial Cost Range	>$2,000	$1,000-1,500	$50 - $100	$1,000-1,500	$30 - $50	$2-3

Photos: 3M Company/BBC

FILTRATION OF PARTICULATE MATTER

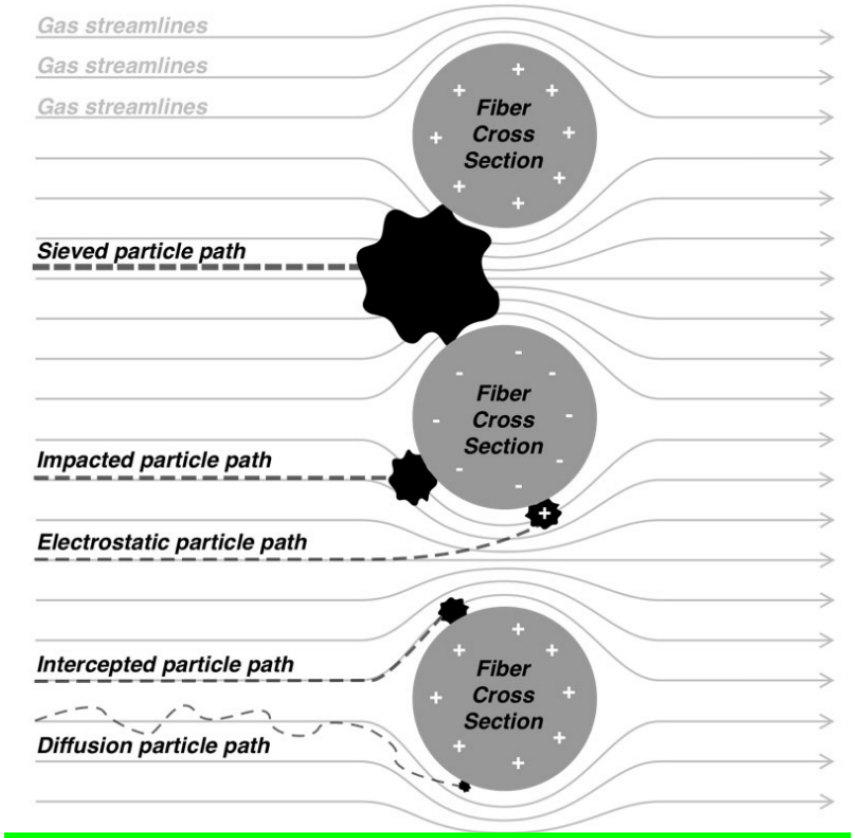
- Effective performance in respirator filters comes from a fibrous non-woven web (usually glass or polymer) with multiple mechanisms for particle removal
- Some ways are more effective for larger particles, others more effective for smaller particles
- Mechanisms combine so there is a "most penetrating particle size" - in the range 0.2 to 0.3 microns, at which respiratory protection filters are tested.

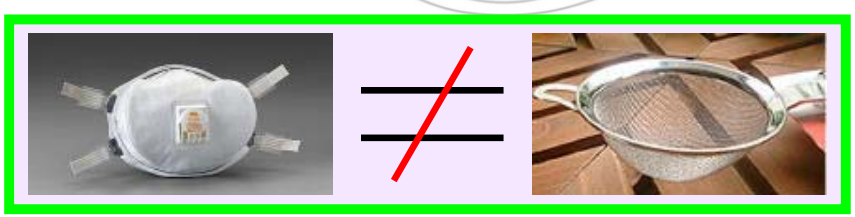


Useful to Note :

- The "95" in N95 represents 95% efficiency at this size
- Sizes of expelled respiratory fluid mean that filtration efficiency for them is close to 100% for a N95 filter

https://www.apsf.org/article/hepa-filters-do-we-really-know-enough-breathing-circuit-filters-in-the-era-of-covid-19/





Conclusion: NOT like a fishing net or tea strainer!

PRODUCT CLASSIFICATIONS

Respirators

- Respirators for workplace use in Canada must meet an approved performance level – the US National Institute for Occupational Health and Safety (NIOSH) is generally the accepted body
- NIOSH sets performance standards for all types of respirator – for particulate ones it established criteria with testing at the most penetrating particle size

Surgical Masks

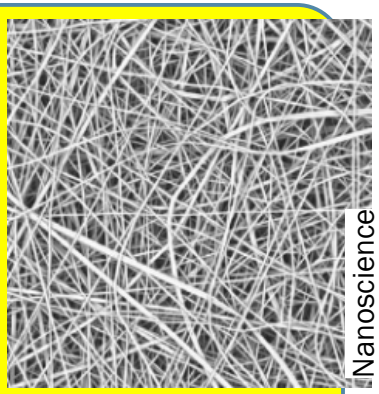
- Surgical mask "clearance" standard by the US FDA covering
  - Fluid resistance
  - Flammability
  - Biological filtration
- Filtration requirements are much lower than NIOSH

NIOSH Classifications

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 Air		100N	HE	100P

Why N, R and P?

- Polymer filter media are often treated to create dispersed electrostatic charge on fibres to improve removal of smaller particles while offering lower airflow resistance
- Oil can interfere with such treatments by coating the fibres, so either:
  - Both inorganic salt and oil-based aerosols are also used for approvals testing (e.g EN 149 FFP2)
  - There is distinction of classes for non-oil and oil-based aerosols (NIOSH N, R & P classes)



Nanoscience

FIT TESTING AND FIT CHECKING – TO MINIMIZE FILTER BY-PASS (PART OF A RESPIRATORY PROTECTION PROGRAMME)

Qualitative Fit Test

3M Company

For initial selection and routine re-testing

- Subject dons respirator as normal
- Hood over head
- Bitter or sweet aerosol introduced into hood
- Taste indicates leakage

Quantitative Fit Test

TSI Incorporated

- Subject wears respirator with probe to sample interior
- Sensitive particle analyser compares ratio of airborne dust outside to inside facepiece
- Ratio is measured during movement breathing and speech exercises

User Seal Check

Each donning

Harvard Medical School

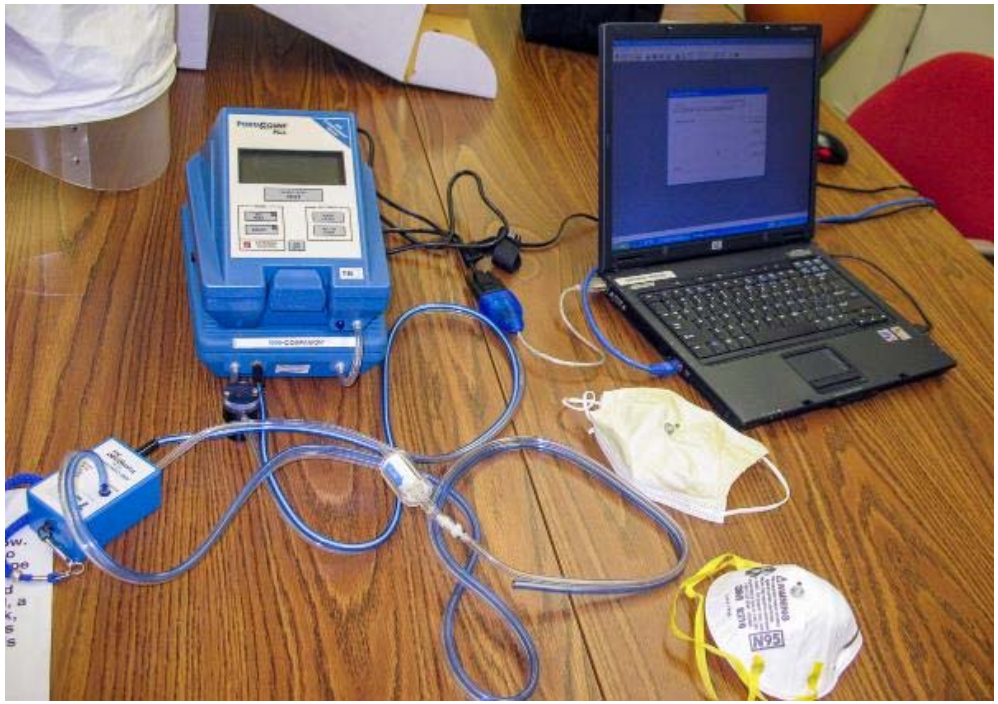
- Subject dons mask and blocks air paths
- Sharp inhalation and exhalation, feel for air leakage around face-seal

FIT: WHAT AFFECTS FIT OF A FILTERING FACEPIECE OR OTHER RESPIRATOR

- Design of mask (technology, standards and head-shape)
- Airflow resistance of filter media – higher resistance may exacerbate leakage
- Flexibility of facepiece
- Nose clip/cushioning or sealing materials
- Straps – adjustment, placement, effectiveness
- Proper donning and adjustment
- Facial hair growth

Additionally – changes over time:

- Loss of flexibility/seal due to heat, humidity and secretions
- Effects of decontamination for re-used equipment - on filtration, strength and flexibility
- Ageing of construction materials
- Studies on stockpiles show straps fail first



RECEPTOR'S TIME TO INFECTIOUS DOSE (WITH THANKS TO LISA BROSSEAU)

Sample calculation for time for a product wearer ("receptor") to receive an infections dose based on source control and facial protection levels

	Inward Leakage at the Respirator				
Outward Leakage from the Source	No Facepiece (100%)	Typical Face Covering (75%)	Better Face Covering (50%)	Respirator with Some Leakage (10%)	Well-Fitting Respirator (1%)
No Facepiece (100%)	15 min	20 min	30 min	2.5 h	25 h
Typical Face Covering (75%)	20 min	27 min	40 min	3.3 h	33 h
Better Face Covering (50%)	30 min	40 min	60 min	5 h	50 h
Respirator with Some Leakage (10%)	2.5 h	3.3 h	5 h	25 h	250 h
Well-Fitting Respirator (1%)	25 h	33 h	50 h	250 h	2500 h

Assumes that, for a dose with a high probability of infection, the time to infectious dose = 15 minutes (CDC contact tracing time) and contact is in a poorly ventilated area (1 air change/hour)
https://www.cdc.gov/coronavirus/2019-ncov/php/contact-tracing/contact-tracing-plan/contact-tracing.html#:~:text=Summary%20of%20COVID%2D19%20Specific%20Practices&text=Contact%20tracing%20will%20be%20conducted,or%20probable%20COVID%2D19%20patients.

HOW IS RESPIRATOR PERFORMANCE PROVEN?
STANDARDS AND CERTIFICATION

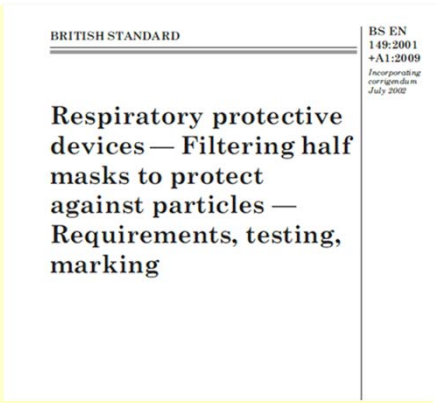
Across the world, there are national or multi-national standards addressing respirator performance and use

Performance Standards

- Set minimum performance criteria and cover the “3F”s
- Assure users that design is capable of providing a level of protection
- Promote quality consistency

But…

- May not be updated or out of sync with user needs


BRITISH STANDARD

BS EN 149:2001 +A1:2009

Incorporating corrigendum July 2002

Respiratory protective devices — Filtering half masks to protect against particles — Requirements, testing, marking

Certification Systems

- Manufacturers provide data and product samples which are tested and approved to criteria in standards
- Include manufacturing quality and audits
- Assure users individual models provide protection

The same standards for respiratory protection apply to healthcare as in general industry

Healthcare has some additional levels where surgical mask requirements are added to respirators – but most respirators meet those anyway

RESPIRATOR SELECTION GUIDANCE IN CANADA

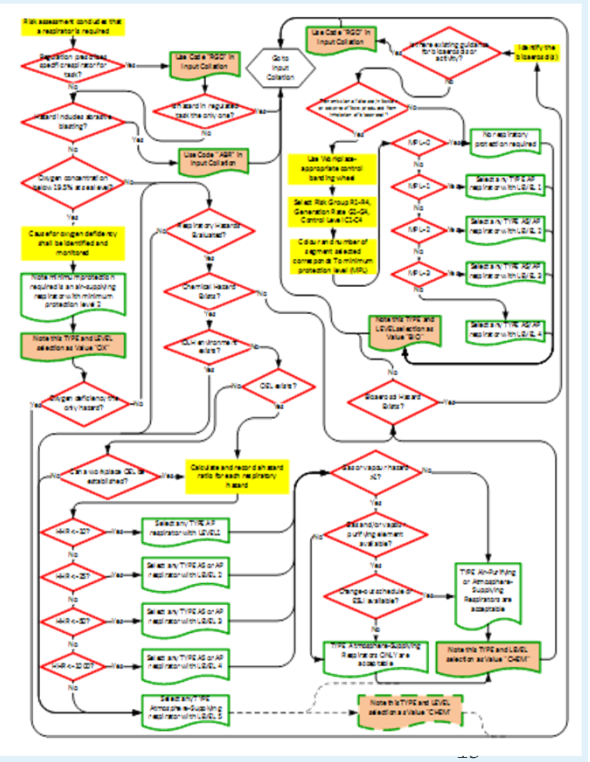
CANADIAN STANDARD CSA Z94.4-18

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

- Respirator use in workplaces is covered by Federal, Provincial or Territorial Regulation
- Canadian Standard CSA Z94.4 addresses selection, use and care and is considered a “best practice” for workplaces to follow

Areas included:

- 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
- Training and recordkeeping



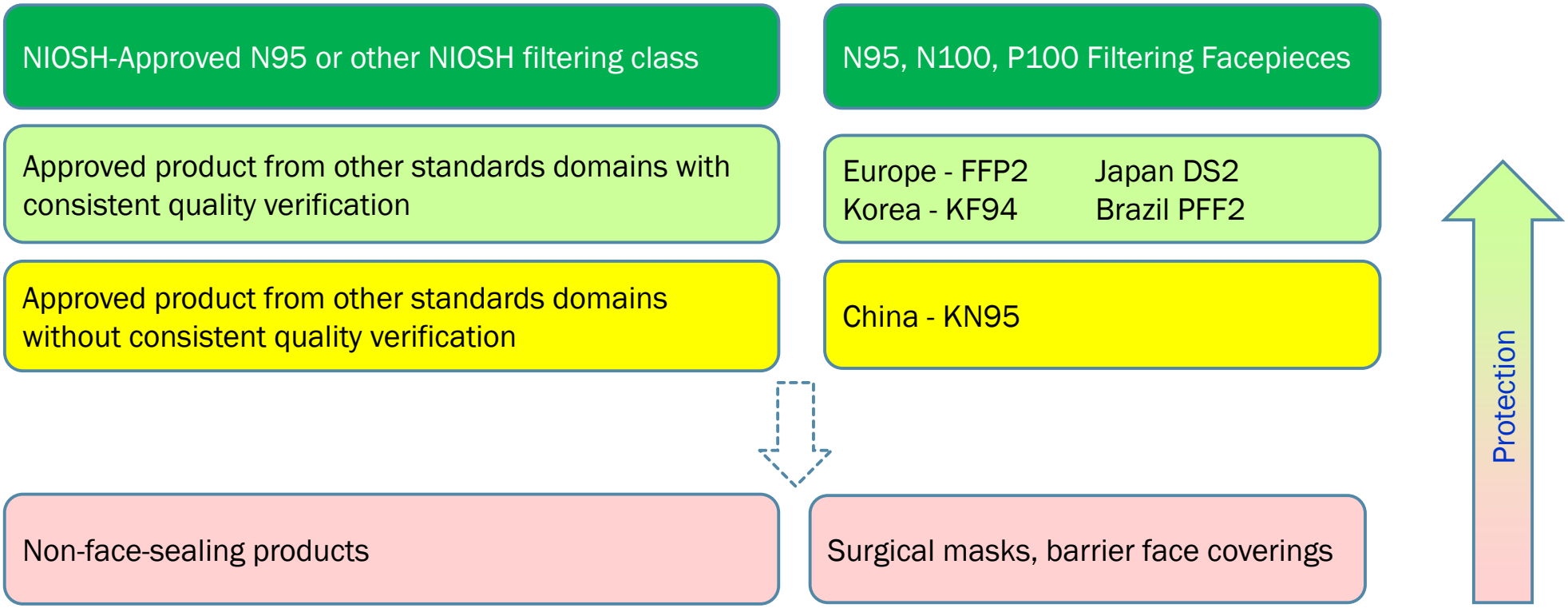
CSA Z94.4 was the first standard in the world (2011) to include a systematic guidance protocol for selection respirators for airborne biological hazards

IRSST in Quebec followed in 2012 https://www.irsst.qc.ca/bioaerosol/default.aspx?

CLEANING, RE-USE AND EXTENDED USE
QUESTIONS DRIVEN BY SUPPLY SHORTAGES

Question	Filtering Facepiece Respirators	Elastomeric/PAPRs
Re-use in normal times?	Normally disposable after usage period	Can be cleaned and re-used, filters can be changed out
Extended use?	Feasible, recognised bodies set requirements	Accepted as part of general usage
Cleaning and Disinfection	Not normally undertaken But for shortage, protocols have been defined for chemical or ultraviolet treatments to disinfect products	Cleaning well established, Disinfection a new concept but feasible methods issued
Impact on effectiveness	Noted impacts limit number of cleaning cycles to generally 5 or fewer	Manufacturers issue recommendations
“Out of Date” Product Usage	Has been studied, highest concerns are straps rather than filter capability	Likewise, elastomeric components must be checked for degradation

EFFECTIVE RESPIRATOR OPTIONS IN EVENT OF SHORTAGE



CONCLUSIONS FOR RESPIRATOR TYPES USEFUL IN HEALTHCARE IN PANDEMIC CIRCUMSTANCES

Filtering Facepiece

- Familiar to user community
- Basic-level of protection
- Industrial variants can be accepted (e.g. P100 types)
- Intended to be disposable, but re-use now in effect

Elastomeric Facepiece

- Half-mask (nose & mouth)
- Full-face with eye-protection
- Reusable mask after cleaning
- Longer duration filters
- Use with replaceable N95 or P100 filters

Powered Air Purifying Respirator

- Blower feeds air facepiece or head-top
- Exiting airflow provides effective protection
- Reusable after cleaning
- Requires battery charging and maintenance programme
- New NIOSH standards will lead to smaller, lighter and cheaper products than current offerings
- Belt, neck or head-mounted variants

Dräger

Dräger

3M

3M

Clean Space

Maxair

THANK YOU

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