The floor of the Ooms Room has an area of 136 square metres. What mass of **ACTIVATED CARBON** has the same surface area?

HINTS

The vial on the table in front of you contains **3 g** of activated carbon powder.

Surface area is all the parts of a material, inside and out, that touch the air.

Activated Carbon Powder

The Layers Between Life and Death:

Personal Protective Equipment (PPE)

1. Introduction to PPE
2. OPCW protective clothing levels
3. Be an OPCW inspector!
4. Limitations and future PPE
5. Q&A

OPCW inspectors face chemical threats

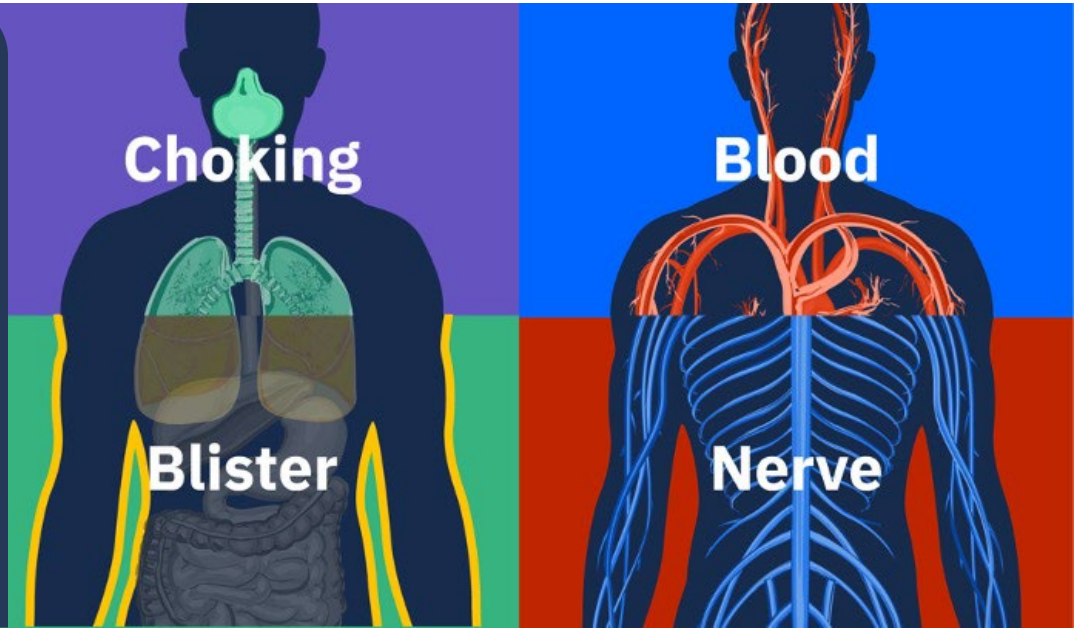
- Industry
- Schedule 1
- OCW
- ACW
- CWDFs
- CWPFs
- TAVs

The chemical threat spectrum is broad

Chemical warfare agents

The chemical threat spectrum is broad

Chemical warfare agents



The chemical threat spectrum is broad

Chemical warfare agents

Toxic industrial chemicals

The chemical threat spectrum is broad

Chemical warfare agents

Toxic industrial chemicals

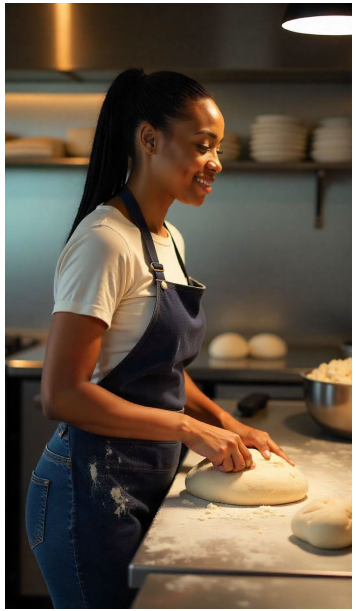
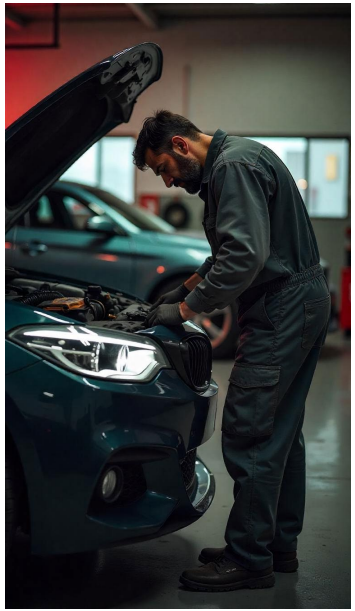
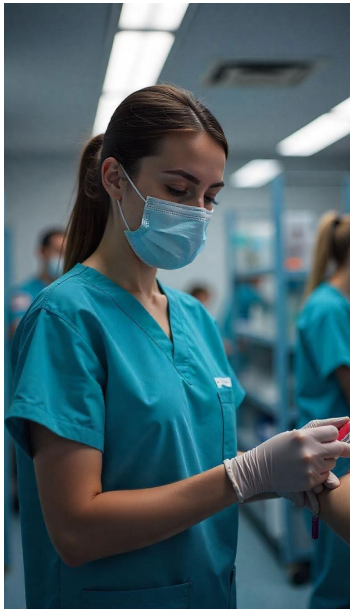
- Solids
- Liquids
- Aerosols
- Gases
- Vapours

How do inspectors stay safe in hazardous environments?


By wearing
personal
protective
equipment (PPE)

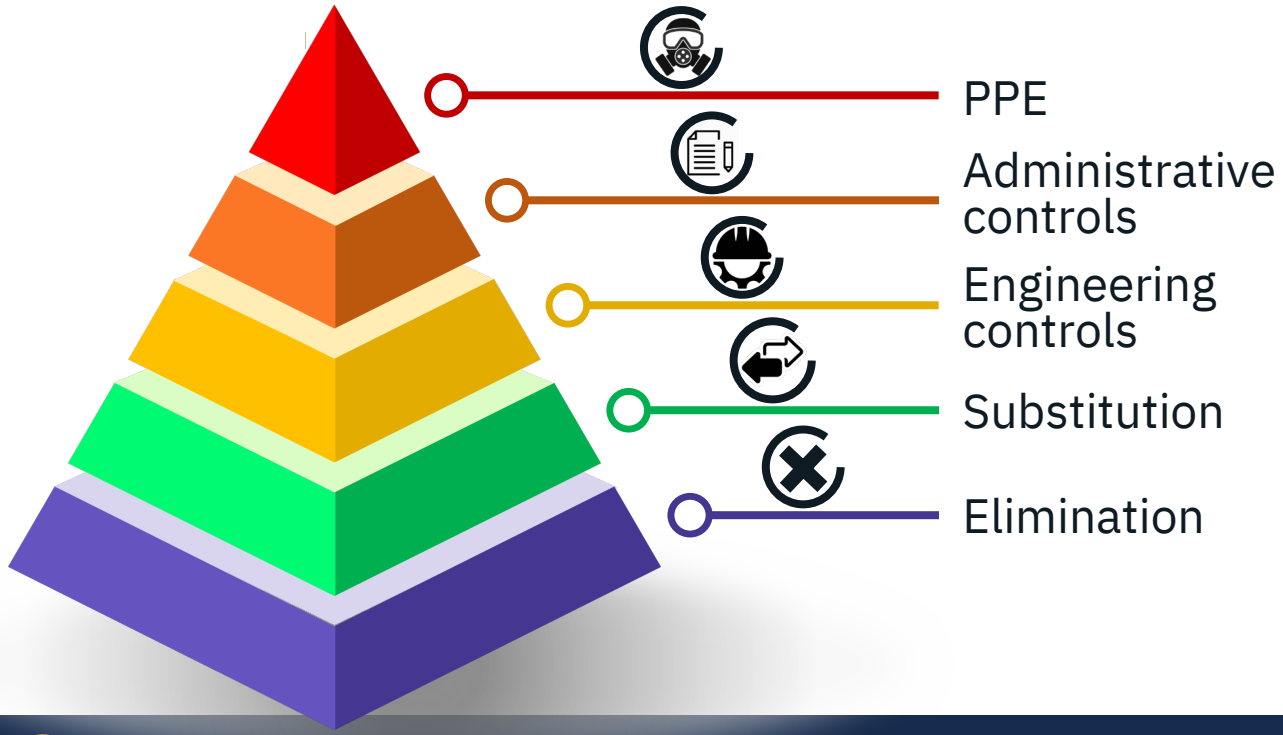
Everyday PPE

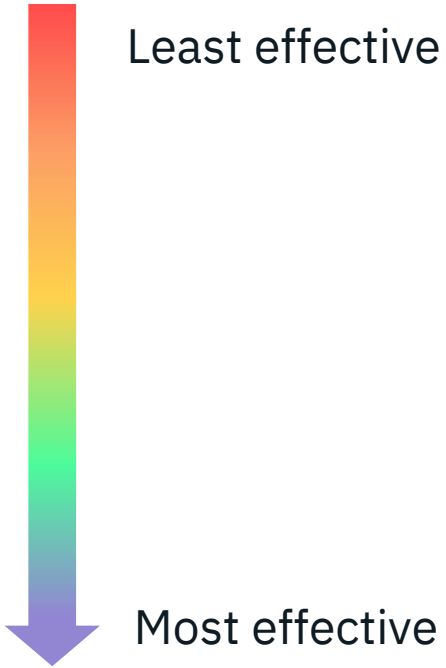


Providing protection by **reducing the risk of injury or exposure**

PPE: the last line of protection





PPE: the last line of protection

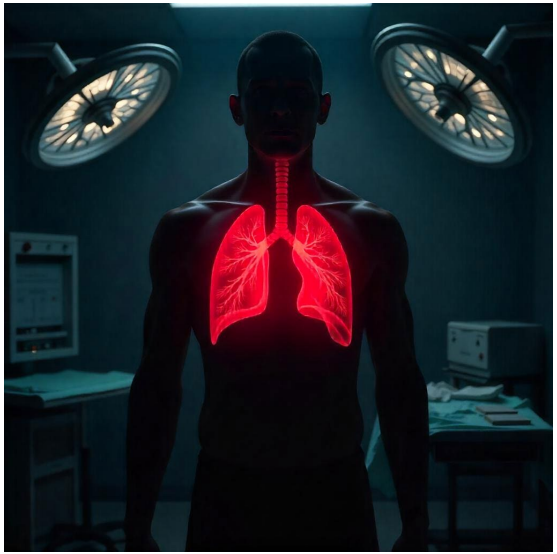
PPE	Sunglasses
Administrative controls	Training on UV exposure
Engineering controls	Install shade and films
Substitution	Go out at night
Elimination	Avoid going outside

Chemical PPE

Provides protection by **reducing the risk of injury or exposure**

Acts as a **shield** between the operator and the hazardous chemical environment

Critical areas to protect



Lungs

Skin

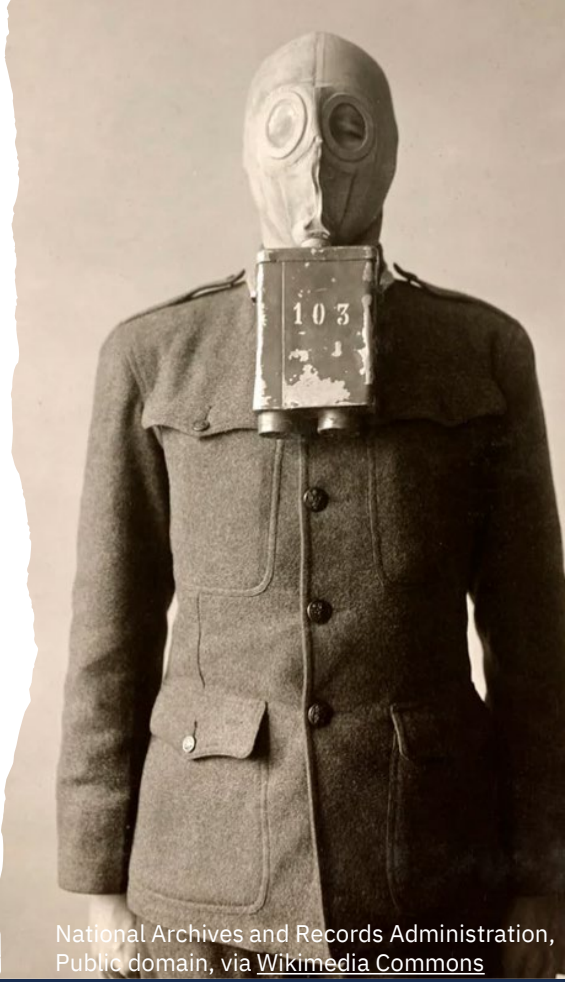
Eyes/face

Evolution of PPE

23–79 AD
Pliny the Elder

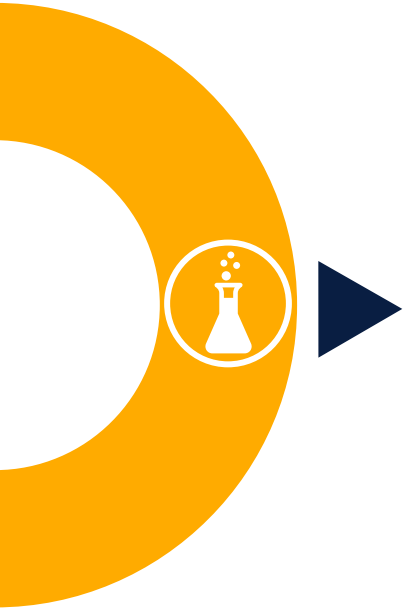
1600s
Plague doctor

1915
WWI



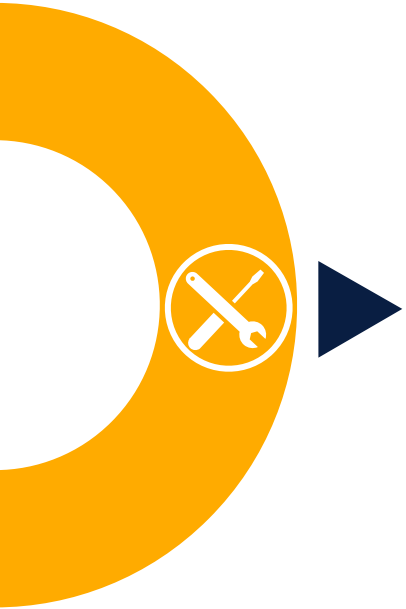
National Archives and Records Administration, Public domain, via Wikimedia Commons

PPE requirements



- High breakthrough time
- Repels a wide range of liquids
- Resistance to specific chemical agents
- Sealed seams and covered zippers

PPE requirements



- Tear, puncture, and abrasion resistant
- Effective enclosures (e.g. zippers and seams)
- Strong seam construction
- Flexible

PPE requirements

- Comfortable
- Lightweight
- Allows body heat to dissipate
- Ergonomic design and mobility
- Ease of donning and doffing
- Compatible with other PPE
- Durable

Donning = putting on

Doffing = removing

No universal PPE solution exists

No one-size-fits-all approach as there is **no single protective material that can fulfil all the requirements of protection** against all types of chemicals

Wearing protective clothing always involves a **balance between maximising protection and minimising the physical and practical challenges** it creates for the user

Examples of respiratory protection

Air-purifying respirators
(“gas masks”)

Supplied-air respirators

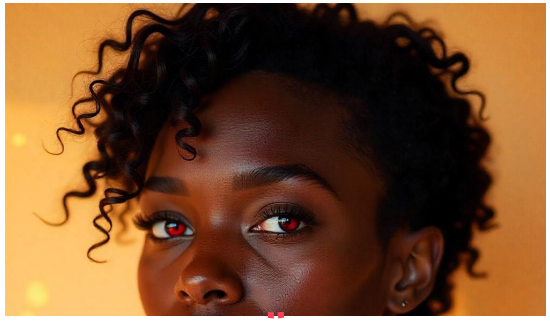
Self-contained breathing apparatus (SCBA)

Examples of skin protection

Lab coat, gloves

Chemically resistant suit, gloves

Examples of eye protection



Safety glasses

Face shield

OPCW protective clothing levels

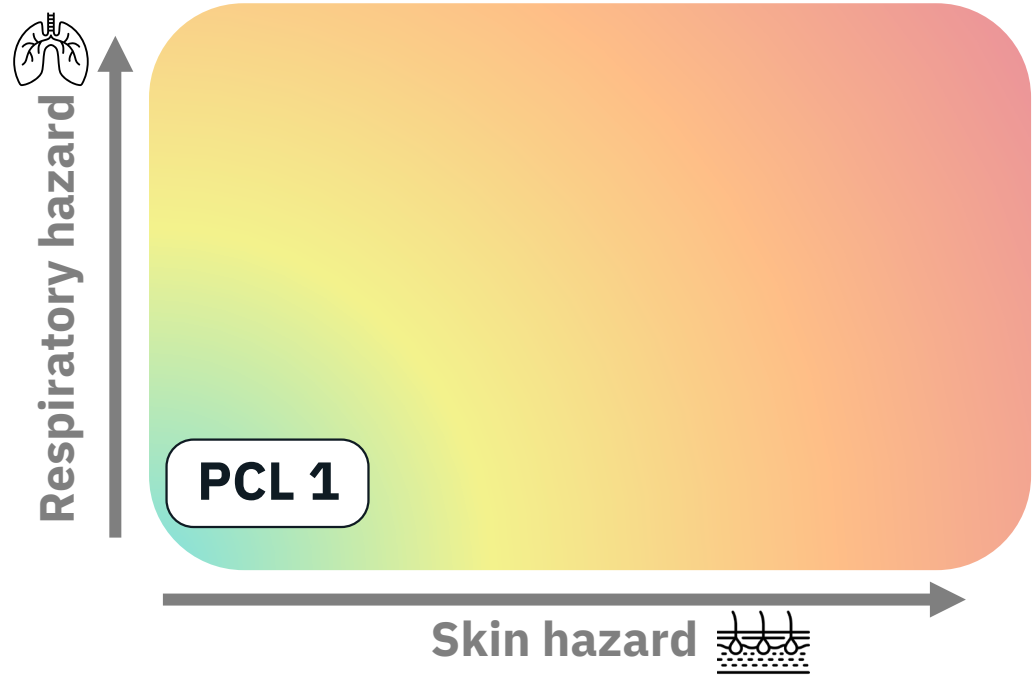
- 8 protective clothing levels (PCLs)
- Selection driven by respiratory and skin hazards present
- Protection comes from multiple PPE elements combined

OPCW protective clothing levels

- 8 protective clothing levels (PCLs)
- Selection driven by respiratory and skin hazards present
- Protection comes from multiple PPE elements combined

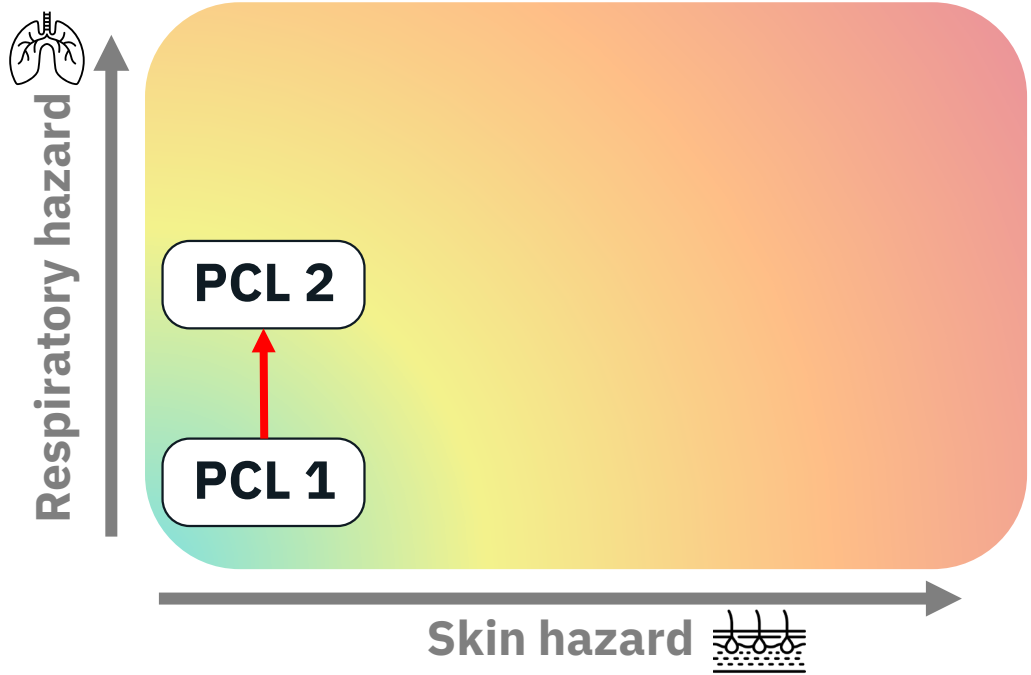
PCL 1: no chemical hazards

- Standard clothing / coverall
- Safety shoes
- Safety glasses
- Safety helmet
- Air-purifying respirator for escape purposes (if needed)



PCL 2

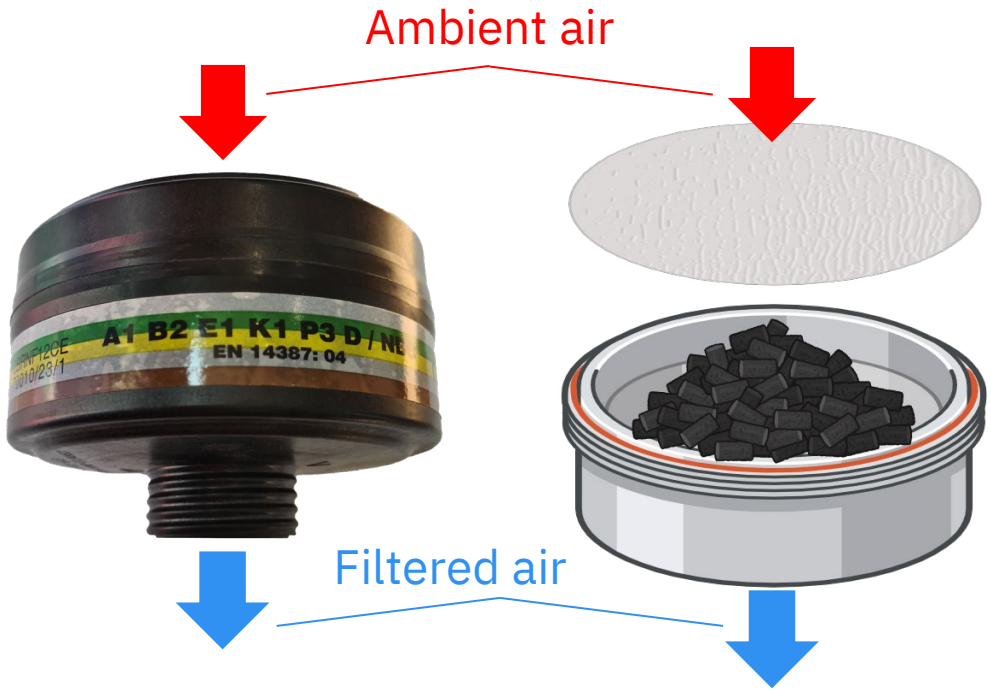
- Coverall
- Safety shoes
- Safety glasses
- Safety helmet
- **Air-purifying respirator**



Air-purifying respirators

Air-purifying respirators

Canister: a multi-stage purification system



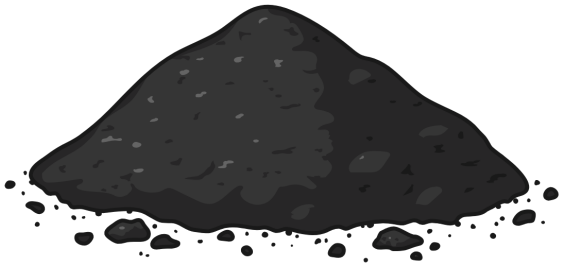
Particulate filter

Activated carbon layer

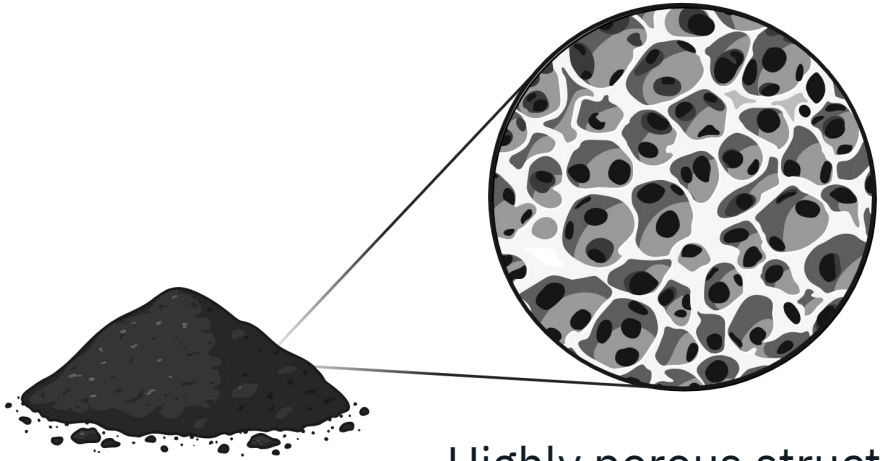
Activated carbon: the life-saving powder

Treated (*activated*) carbon

- Powder
- Granular
- Spheres
- Fibre



Activated carbon: the life-saving powder



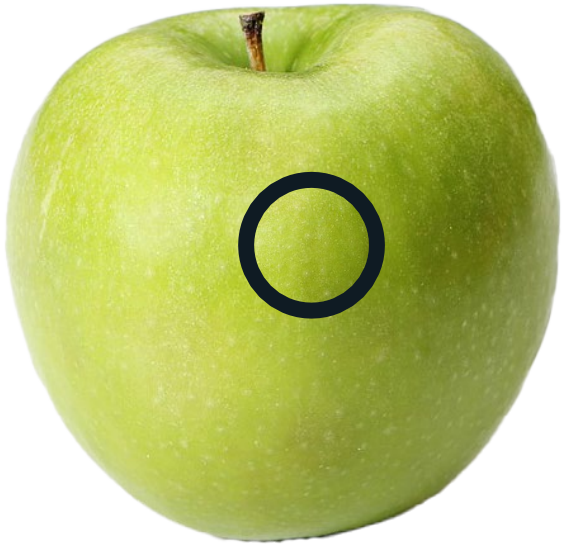
Extremely high **surface area**

Highly porous structure

Surface area
EXPLAINER

Surface area

Surface area is **all the parts** of a material, inside and out, **that touch the air**



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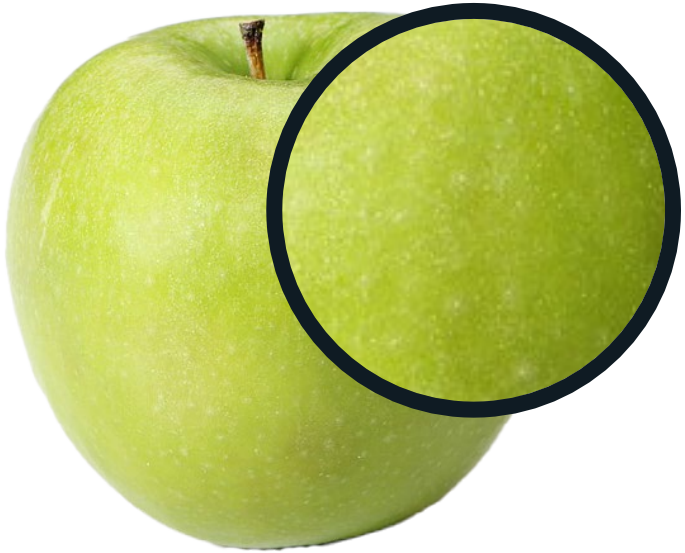

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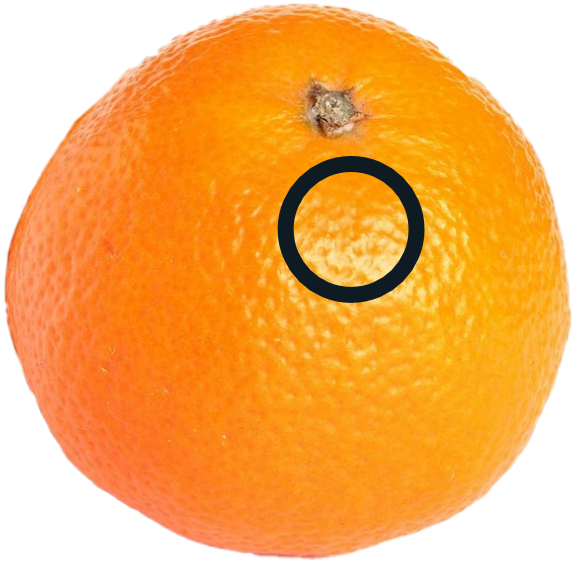

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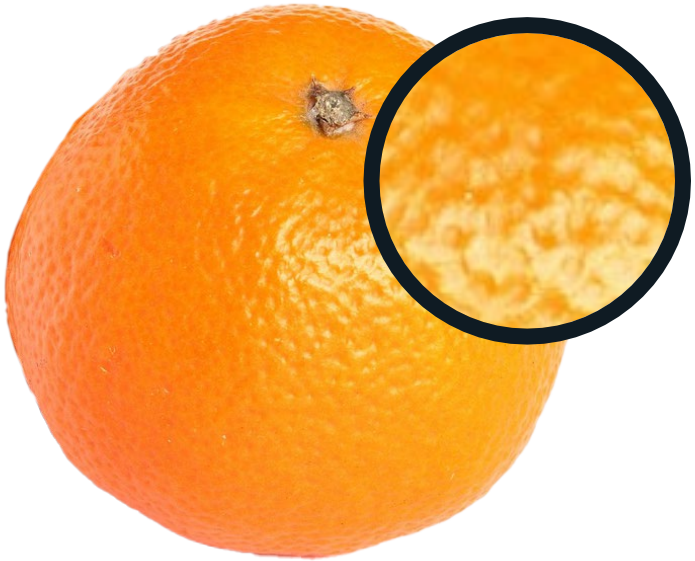
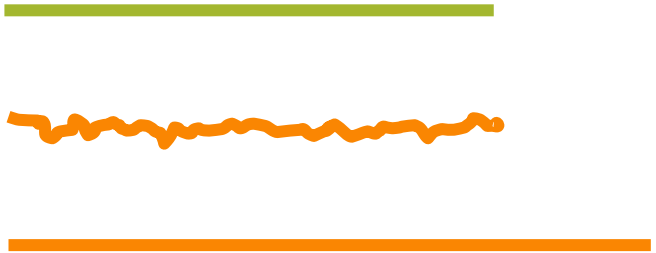
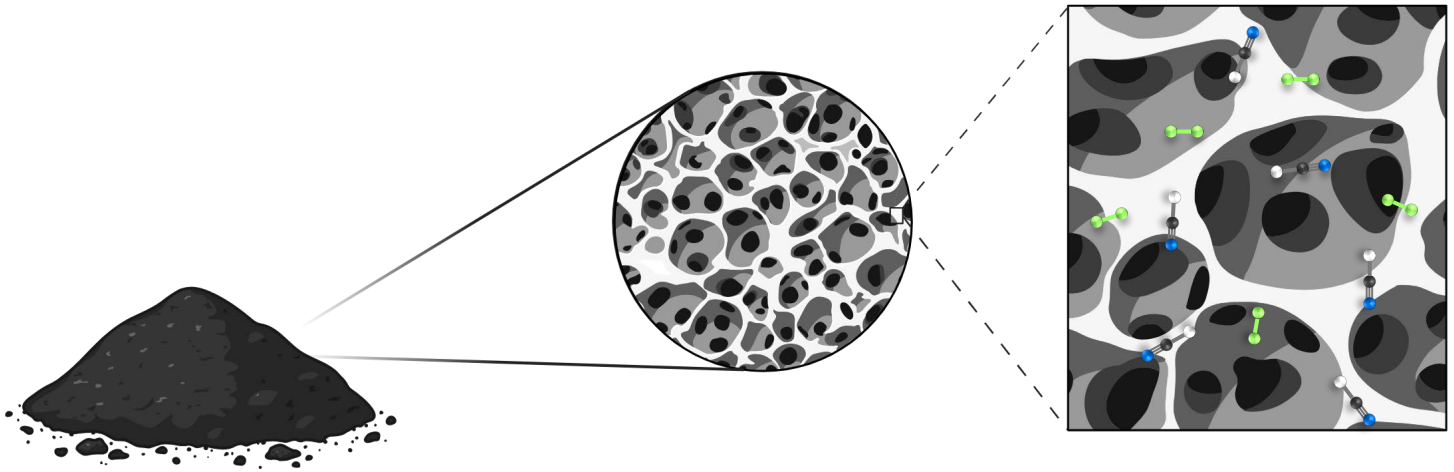




Activated carbon: the life-saving powder



Adsorption NOT **ab**sorption

The greater the surface area, the more space to trap chemicals

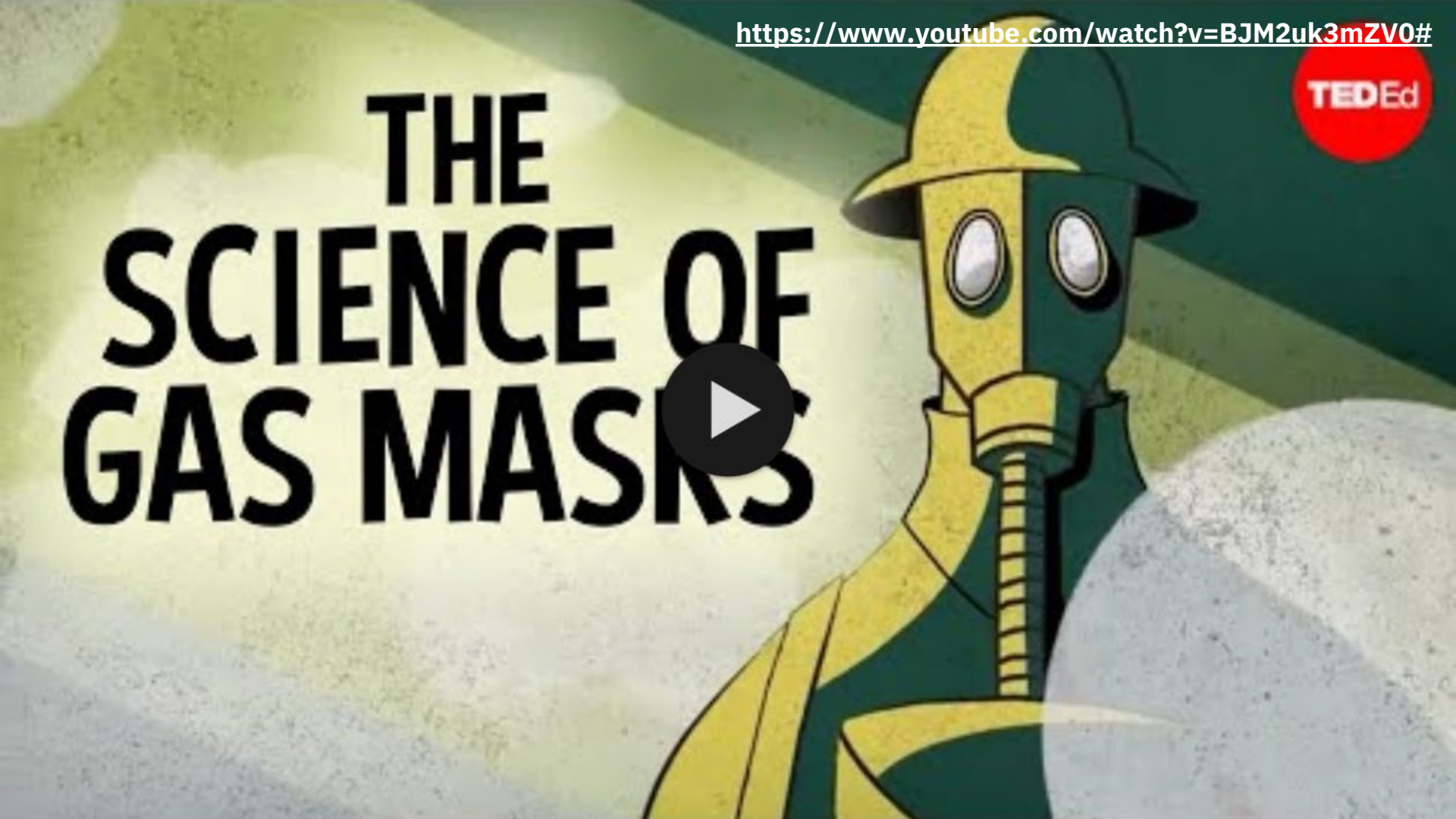
The floor of the Ooms Room has an area of 136 square metres. What mass of **ACTIVATED CARBON** has the same surface area?

Activated Carbon Powder

ANSWER:

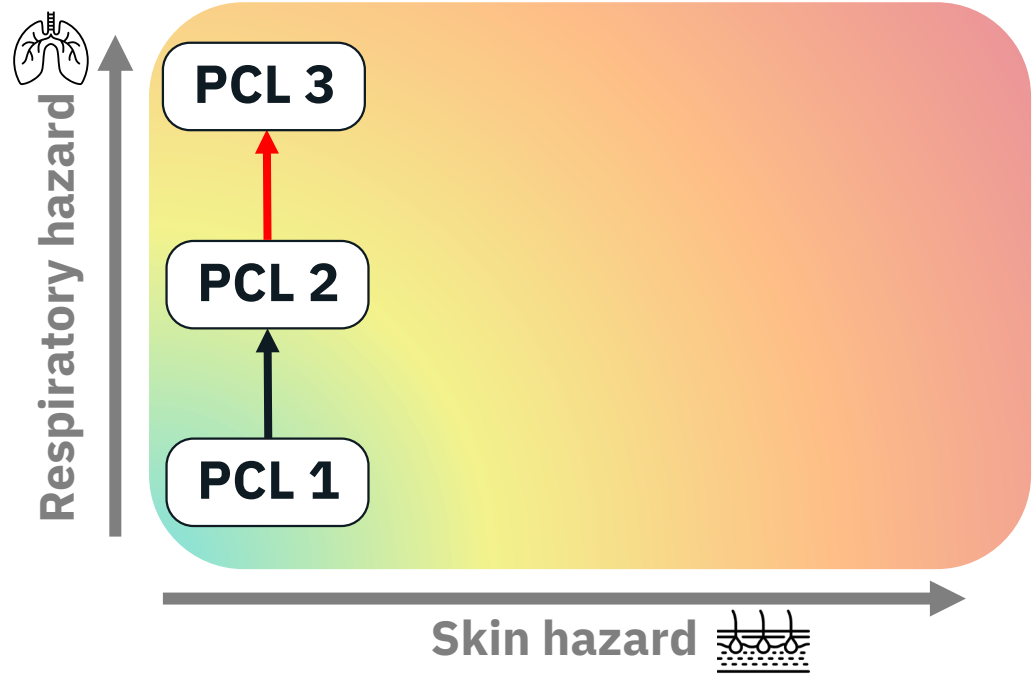
0.14 g

https://www.youtube.com/watch?v=BJM2uk3mZV0#



PCL 3

- Coverall
- Safety shoes
- Safety glasses
- Safety helmet
- **Supplied air system**



Supplied-air respirators

Self-contained breathing apparatus (SCBA)

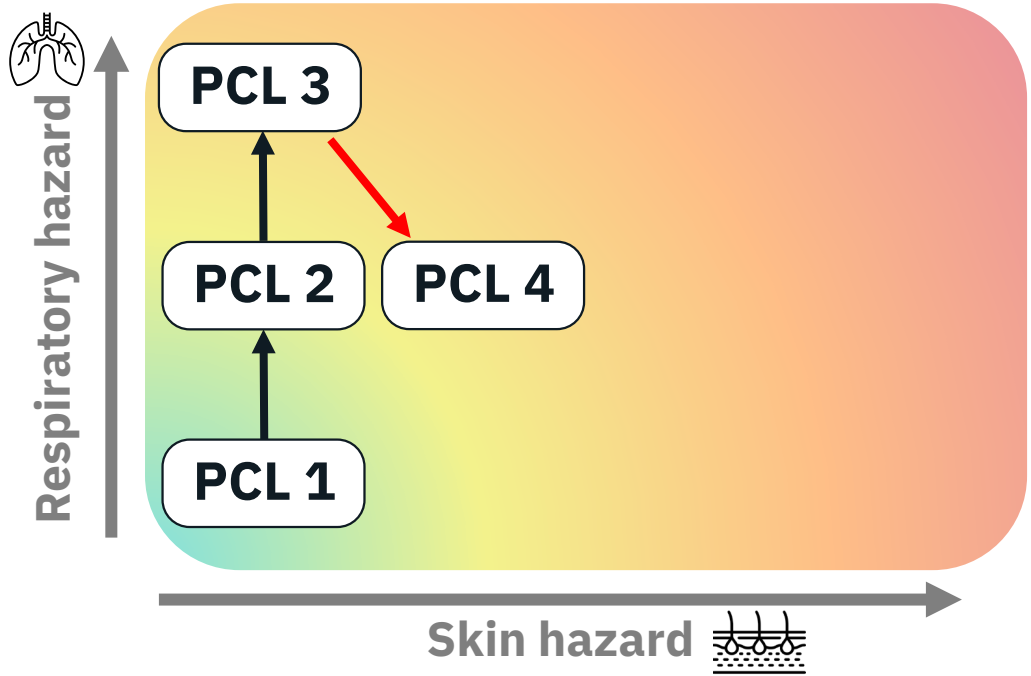
OR

Airline respirator

Avon ST53 (SCBA)

PCL 4

Air-permeable chemical protective suit (**Saratoga**®)

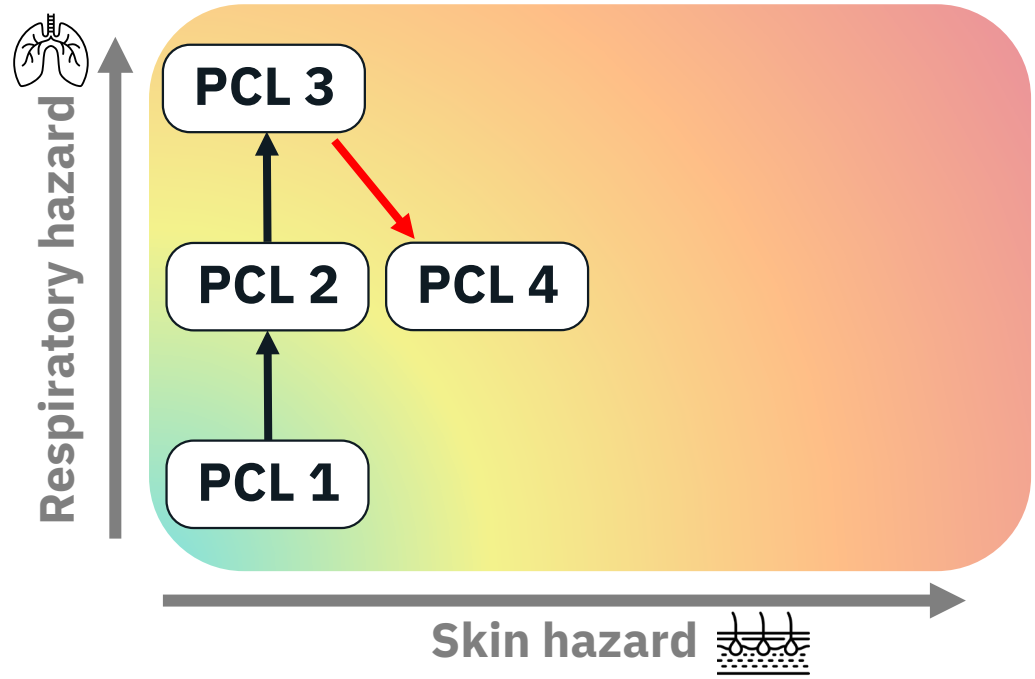


PCL 4

Air-purifying respirator

Butyl (black) and nitrile (blue) rubber gloves

Safety shoes and butyl rubber overboots



Saratoga: design features

- One-piece suit
  - No gap between jacket and trousers
  - Increased flexibility
  - Simplified donning and doffing
- Diagonal front zipper
- Rescue strap
- Three-layer design

Saratoga: design features

1. **Outer layer – protective fabric**
   - First barrier against droplets and solids
   - Hydrophobic fabric to repel liquid droplets
   - Durable, abrasion-resistant fabric

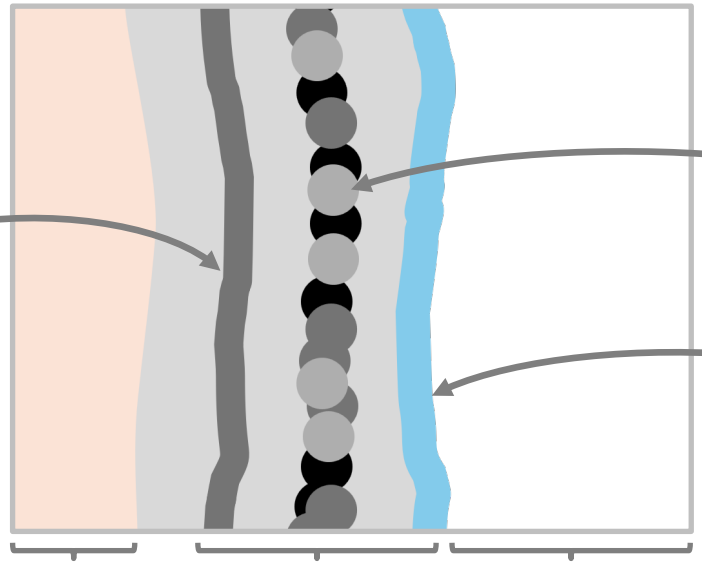
Saratoga: design features

2. **Middle layer – adsorbtive layer**
   - Core chemical protective layer
   - Activated carbon beads
   - Traps toxic vapours and gases
   - Air and moisture can pass through

Saratoga: design features

3. **Inner layer – comfort liner**
   - Soft, breathable fabric
   - Reduces heat stress, chafing, and irritation

Saratoga layers



Middle layer (adsorbtive layer – activated carbon spheres)

Inner layer (comfort liner)

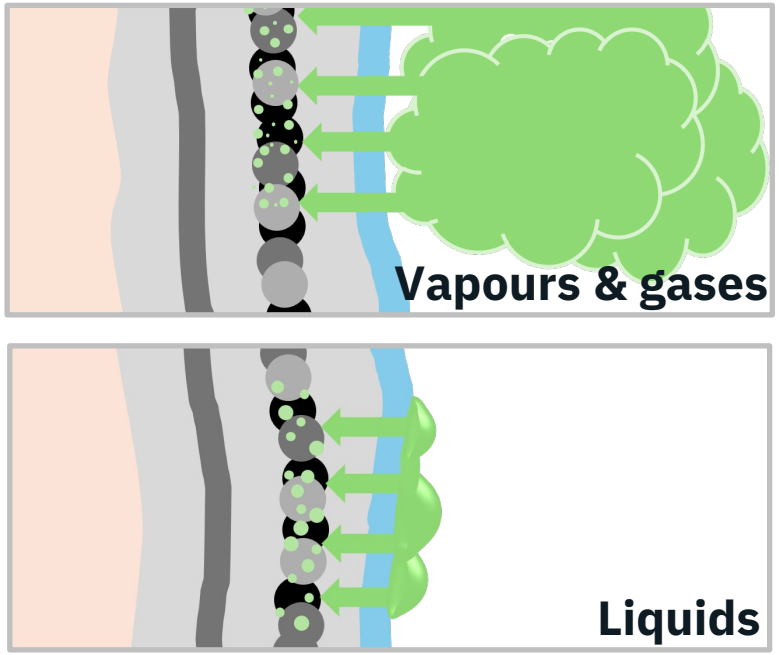
Outer layer (protective fabric)

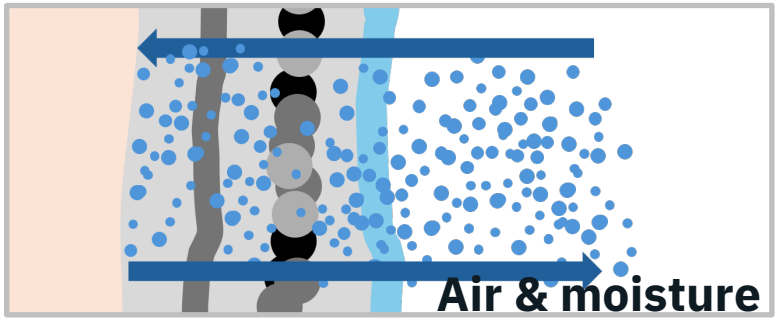
Skin

Suit fabric

External hazards

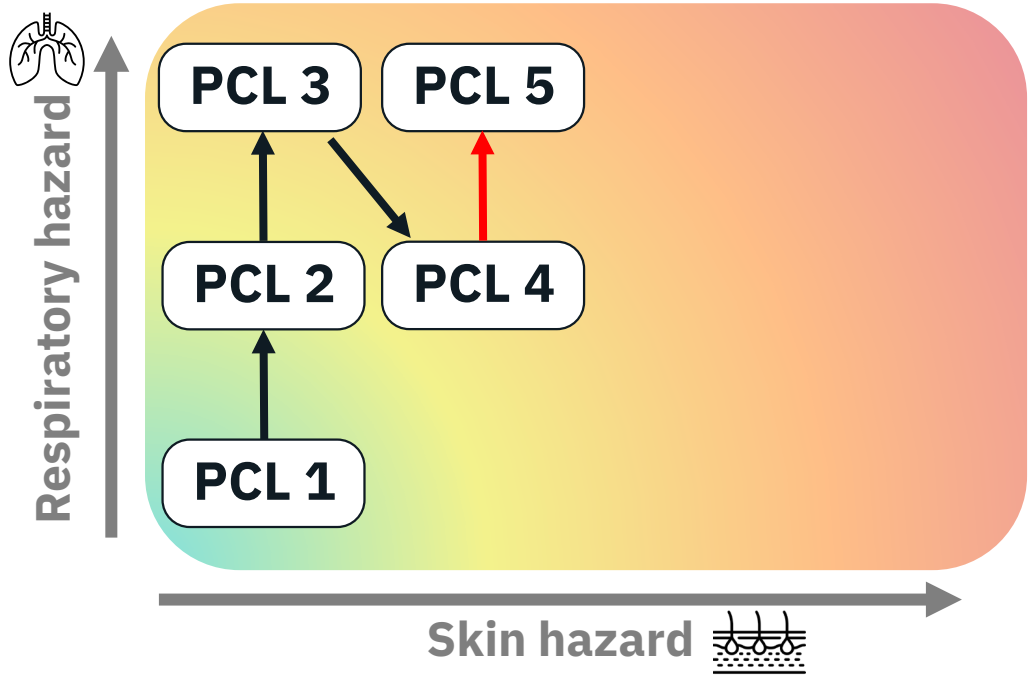
Saratoga layers





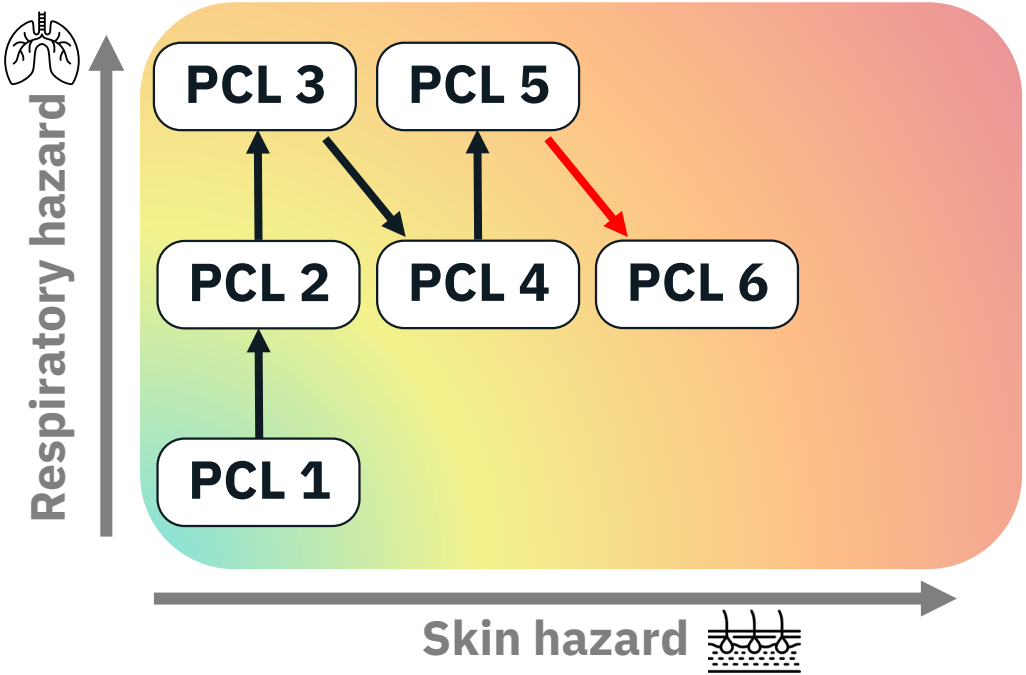
PCL 5

Identical to PCL 4 except that a **supplied-air system is used** rather than an air-purifying respirator



PCL 6: liquid/splash hazard

Impermeable chemical protective suit

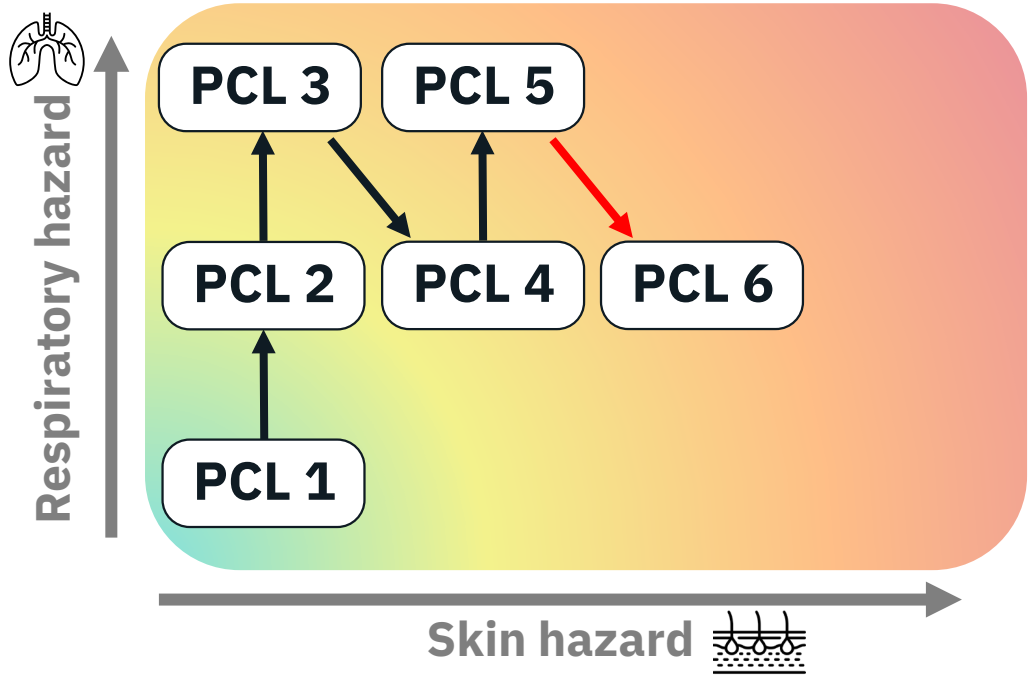


PCL 6: liquid/splash hazard

Air-purifying respirator

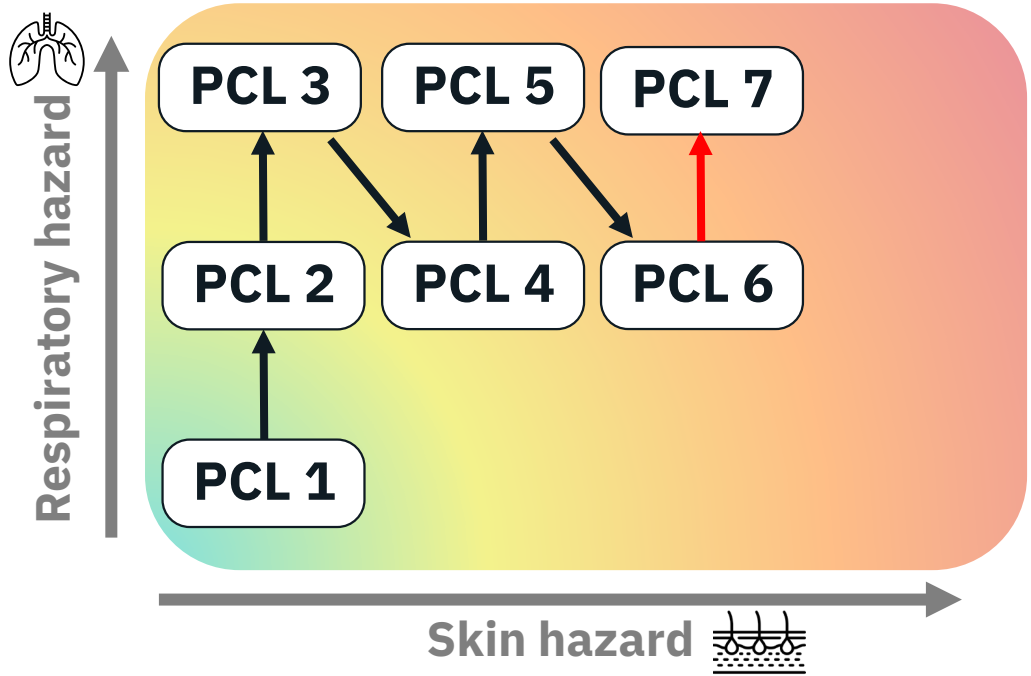
Butyl and nitrile rubber gloves

Safety shoes and butyl rubber overboots



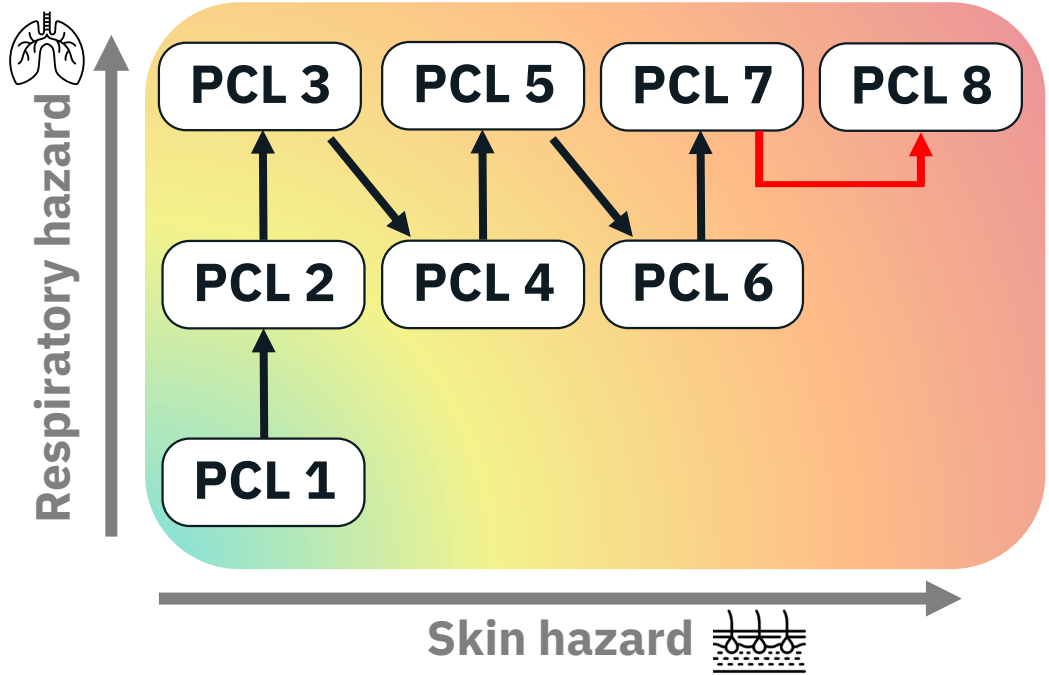
PCL 7

Identical to PCL 6 except that a **supplied-air system is used** rather than an air-purifying respirator



PCL 8

DuPont™ Tychem® TK Suit
Fully encapsulated gas-tight chemical protective suit

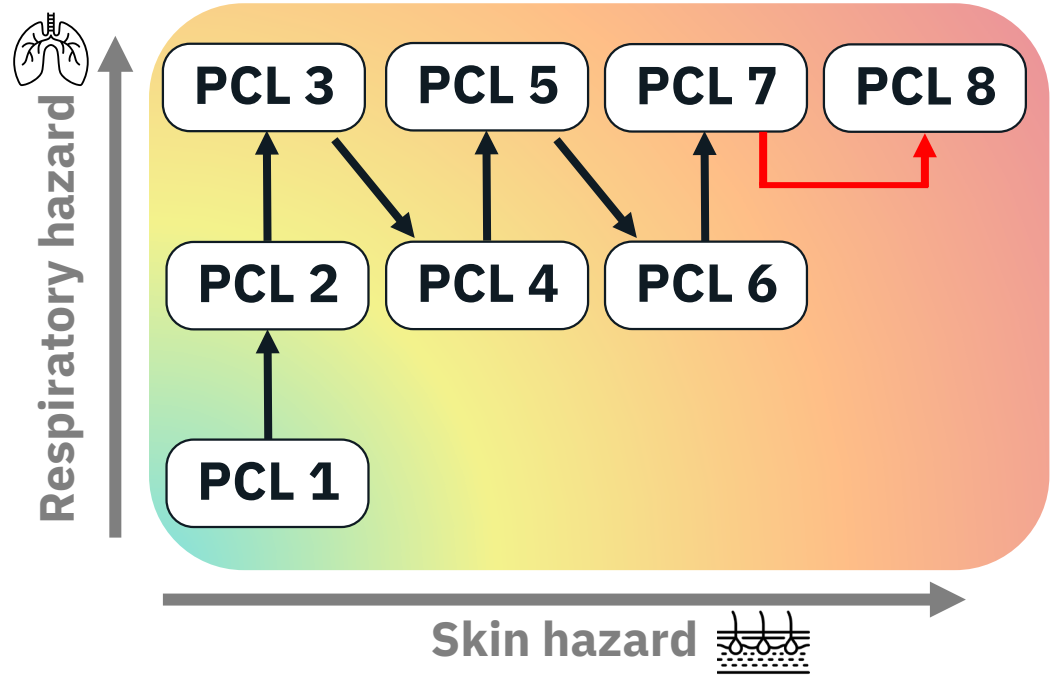


PCL 8

Supplied-air system

Butyl and nitrile rubber gloves

Chemical protective boots



Tychem TK suit: design features

- Robust and lightweight
- Wide visor for panoramic visibility
- Puncture- and tear-resistant fabric
- Impermeable seams
- Extra-long gas-tight zipper

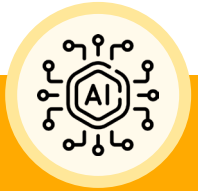

DEMO

Limitations of PPE

- Reduced mobility and dexterity
- Reduced field of vision
- Impaired situational awareness
- Muffled voice
- Visor fogging
- Increased heat stress
- Increased sweating
- Limited wear time

PPE in the future

Integration of nanofibres and metal-organic frameworks



Smart materials, integrated sensors, and connected devices

Lighter and more durable materials

Drones equipped with cameras and sensors

Summary

1. There is no one-size-fits-all approach to PPE: selection is made according to hazard
2. Trade-off between maximising protection and minimising the physical and practical challenges
3. Limitations and constraints remain but future developments may overcome them

Acknowledgements

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Peter Hotchkiss

Technology & Training Hub

...and all helpers present today

Questions