Finnish Institute of Occupational Health

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The Finnish Work Environment Fund

WELL-BEING THROUGH WORK

Protection of face against cooling while using powered respirators in the cold environment

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Introduction

- Respiratory protective equipment (RPE) is required in the Arctic conditions, e.g. in mining, steel and construction work
  - to protect airways from airborne particles and gases
  - may increase respiratory resistance, especially filtering RPE
- Powered air purifying respirators (PAPRs) decrease breathing resistance and thus psychophysiological strain, but increase facial cooling.
- Facial cooling causes respiratory contraction and increase of blood pressure.
- Use of PARPs is experienced uncomfortable at +5-0°C and unbearable at -10°C.

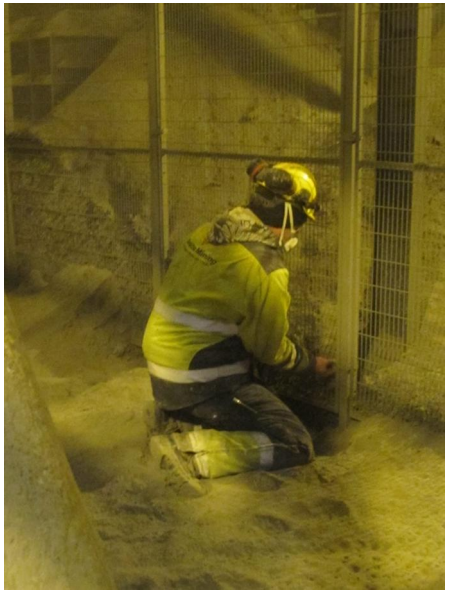

Photo: Sirkka Rissanen, FIOH

Objectives

Testing of certified personal protective equipment (PPE) cold environment is not taken into account.

- The objectives were:
  - to prevent facial cooling while using PARP in the cold
  - to determine the influence of the cold protection on protective efficiency of the PARPs.

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Studied powered respirators and balaclavas

- Powered air purifying respirators (PARPs) with helmet and face shield
  - Continuous air flow from the upper side
  - Air flow 175 and 190 l/min
- Reference respirators (filtering)
  - half face masks (disposable and reusable)
- Balaclavas for cold protection of face under PARPs
  - thin (1.0 mm), 100% CV
  - thick (3.0 mm), 100% PE

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Methods – Thermal insulation, skin temperatures and thermal sensations

- Thermal insulation (I_{cl}) was measured
  - by thermal head model
  - air temperature (T_{air}) of +10°C.
  - PARPs with and without air flow
  - PARPs with and without balaclavas

- Facial cooling was measured (N=7) at -20°C.
  - Face skin temperatures from 4 sites (forehead, nose, chin, cheek) and T_{air} inside the facemask.
  - Thermal sensation on face was asked (ISO 10551).
- Experimental protocol (40 min):
  - 15 min standing,
  - 10 min stepping on a 20-cm high step,
  - 5 min lifting a dumbbell,
  - 10 min standing.

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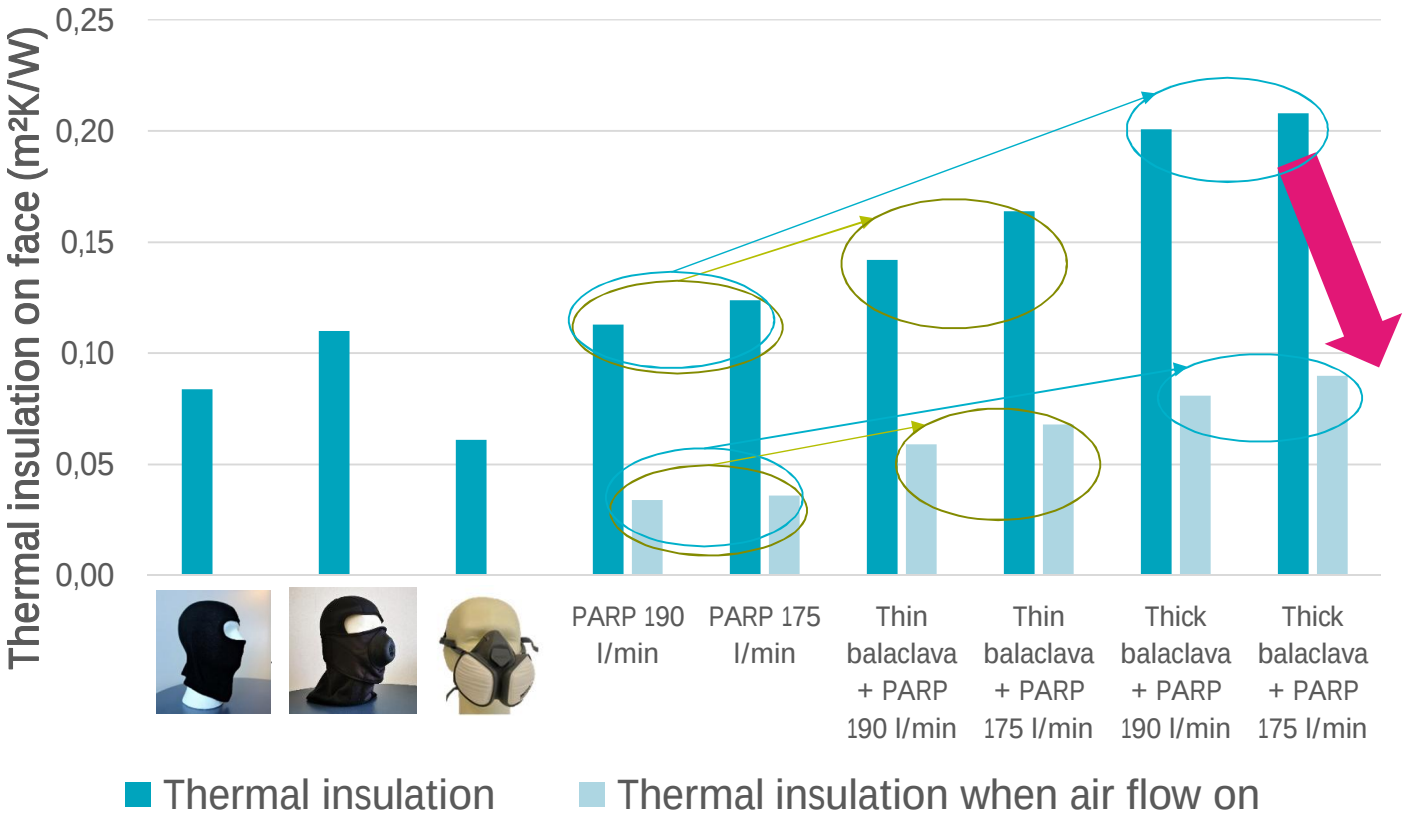
Methods – Fit test to measure protective efficiency of respirators

- Portacount 8020 Respirator Fit tester
  - based on HSE fit test method, modified with a step exercise
- Ambient temperatures +20 and -20 °C
  - preconditioning of the respirators for 15 min
- Subjects
  - Females and males
  - 2-3 subjects

Results – Thermal insulation

- Air flow in the mask dropped the I_{cl} on an average 62%.
- Thin balaclava increased the I_{cl}
  - by 29% without air flow
  - by 81% with air flow
- Thick balaclava increased the I_{cl}
  - by 73%without air flow
  - by 144% with air flow



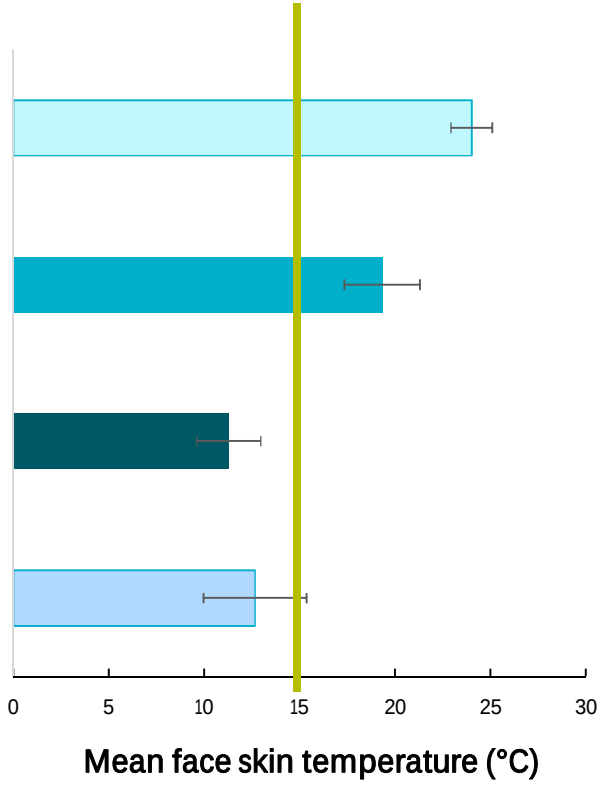
Results – Skin temperatures and thermal sensations without cold protection (at -20°C)

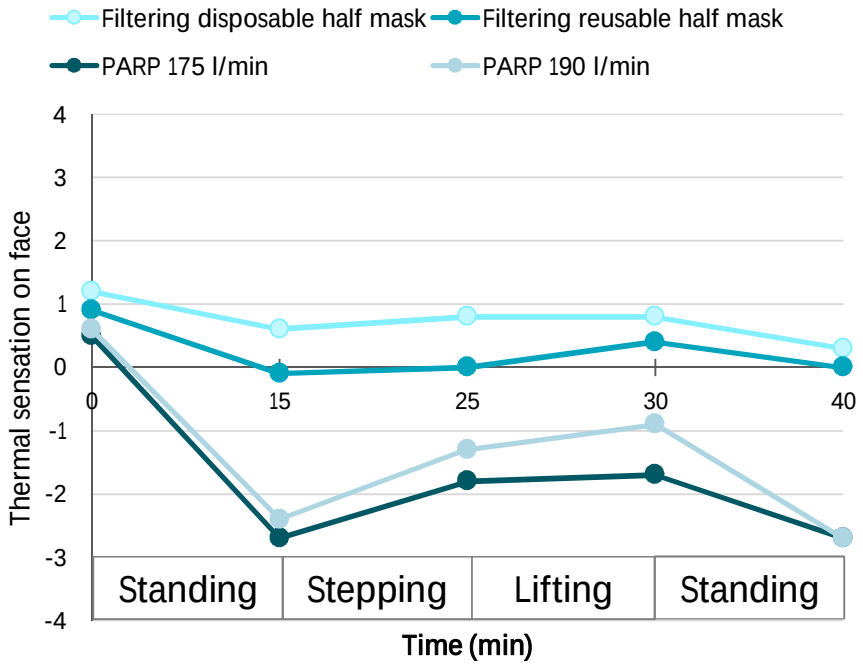
Filtering disposable half mask

Filtering reusable half mask

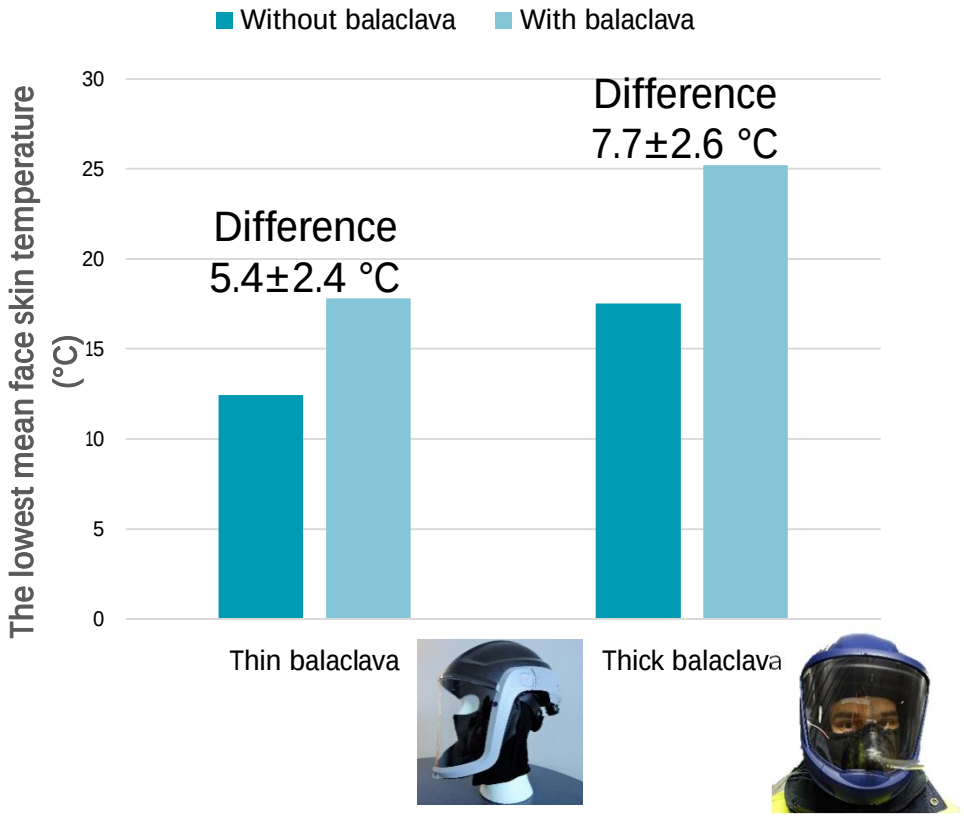
PARP 175 l/min

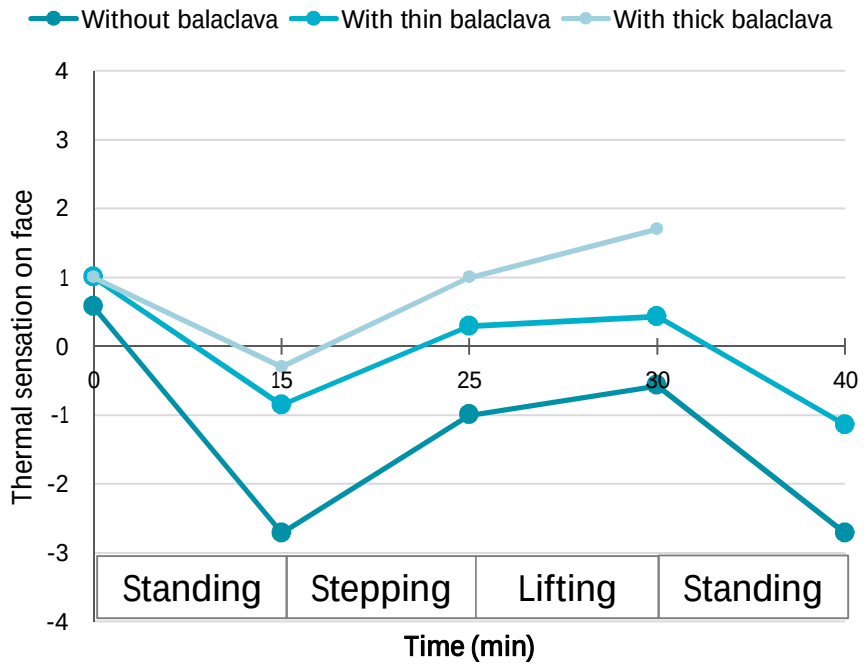
PARP 190 l/min





Results – Skin temperatures and thermal sensations with cold protection (at -20°C)





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Results – Balaclavas did not affect protective efficiency of PARPs

- Total protective efficiency of PARPs must be more than 500.

	Thin balaclava	Thick balaclava
PARP 190 l/min	45 000	26 300
PARP 175 l/min	82 400	97 700

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Conclusions

- Filtering respirators without powered air flow are protecting face against cold.
- Powered respirators can not be used in in very cold conditions (-20°C).
- Balaclava is recommended to use under PARPs with helmet and face shield in the cold (<-10°C).
- Balaclavas did not affect protective efficiency of PARPs with helmet and face shield.

Photo: Sirkka Rissanen, FIOH

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