

# Oljearbeideren i kalde omgivelser

## *Kulde som risikofaktor på arbeidsplassen*

HMS utfordringer I Nordområdene  
Norsk Olje og Gass  
Arbeidsseminar 2: Helse og Arbeidsmiljø  
Solstrand Fjordhotell, Os

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SINTEF Teknologi og samfunn



# Agenda

Hvordan håndtere risiko forbundet med arbeid i kaldt klima?

- Kritiske faktorer ved arbeid i kaldt klima
  - Effekt av kulde på helse: skader og sykdommer
  - Effekt av kulde på ytelse: fysisk, manuell og kognitiv
- Standarder og metoder for å vurdere risiko ved arbeid i kaldt klima

Anbefalinger



Kald luft

Kald sjø

Sterk vind

Mørketid

Lange  
avstander

Begrenset  
infrastruktur

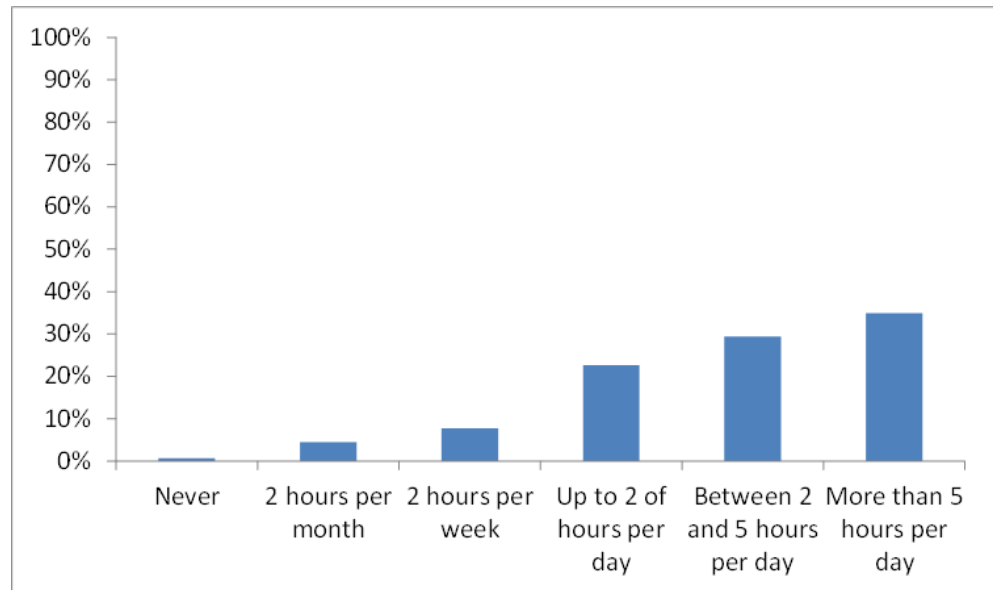
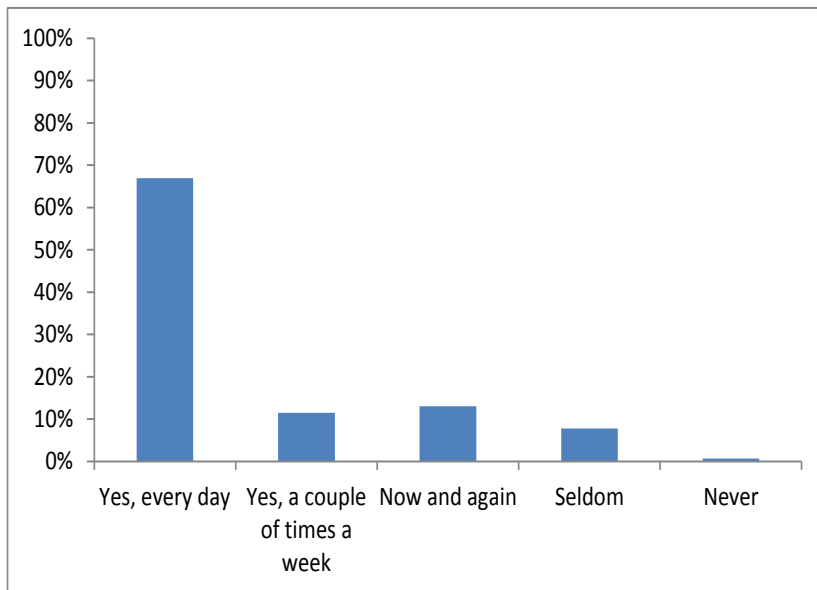
Polare  
lavtrykk



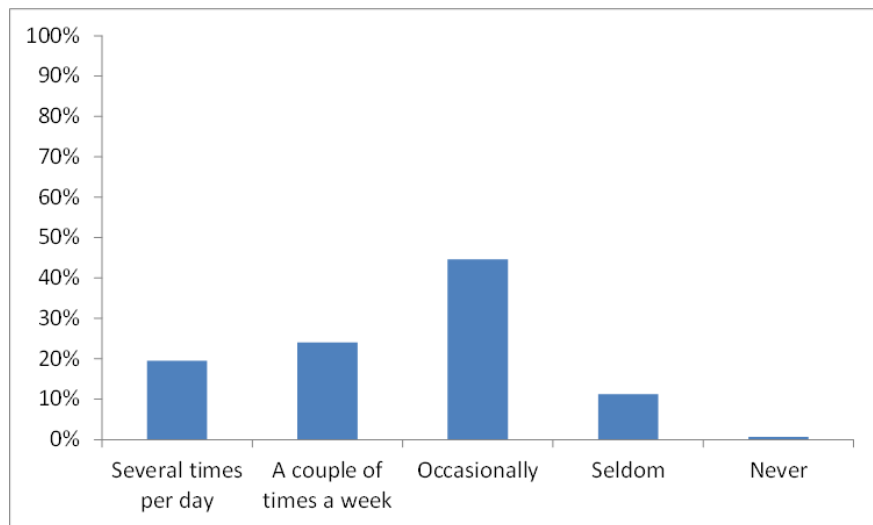
# Spørreundersøkelsen ColdWear 2012 (n=269)

Melkøya, Heidrun, Åsgard , Snorre and Sleipner

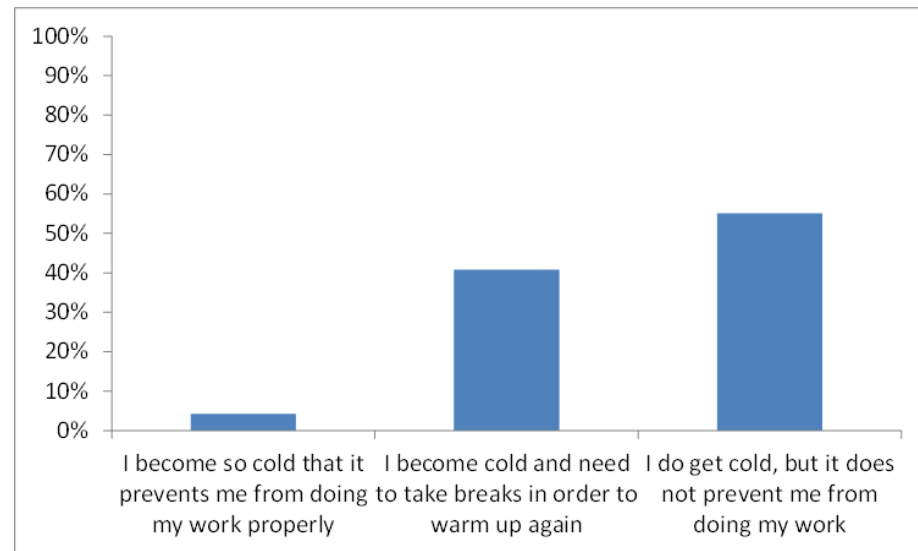
- Do you work outdoors in areas exposed to severe weather conditions?
- How much do you work outdoors?



How often do you feel cold when you are working?



How does feeling cold affect you?





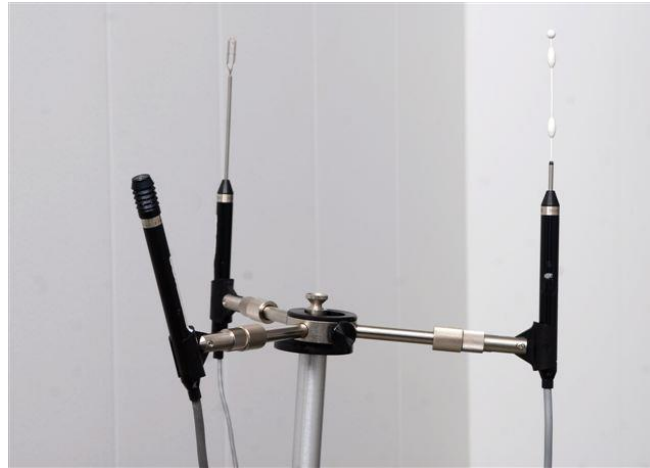


## ***COLD ENVIRONMENT***

***"An environment with a air temperature of 5° C may be described as "cold", however an active, heavily clothed person in that environment maybe hot and sweating in an attempt to loose heat"***

# Det termiske miljø – seks faktorer

- Luft temperatur
- Fuktighet
- Stråling
- Luft bevegelse/vind
- Metabolsk varmeproduksjon
- Bekledning



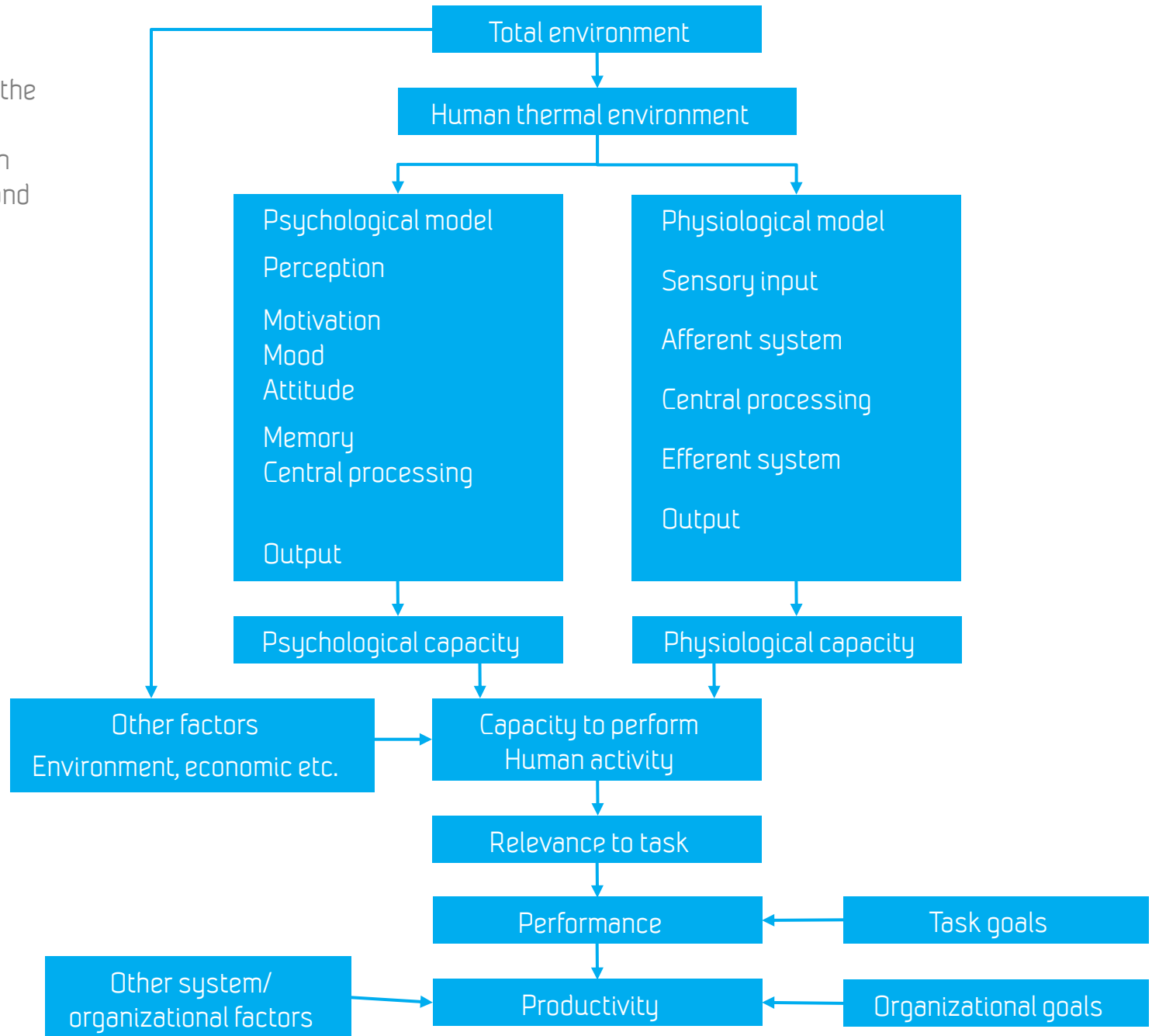
Bruel and Kjaer indoor climate analyzer

# Arbeidsmiljø

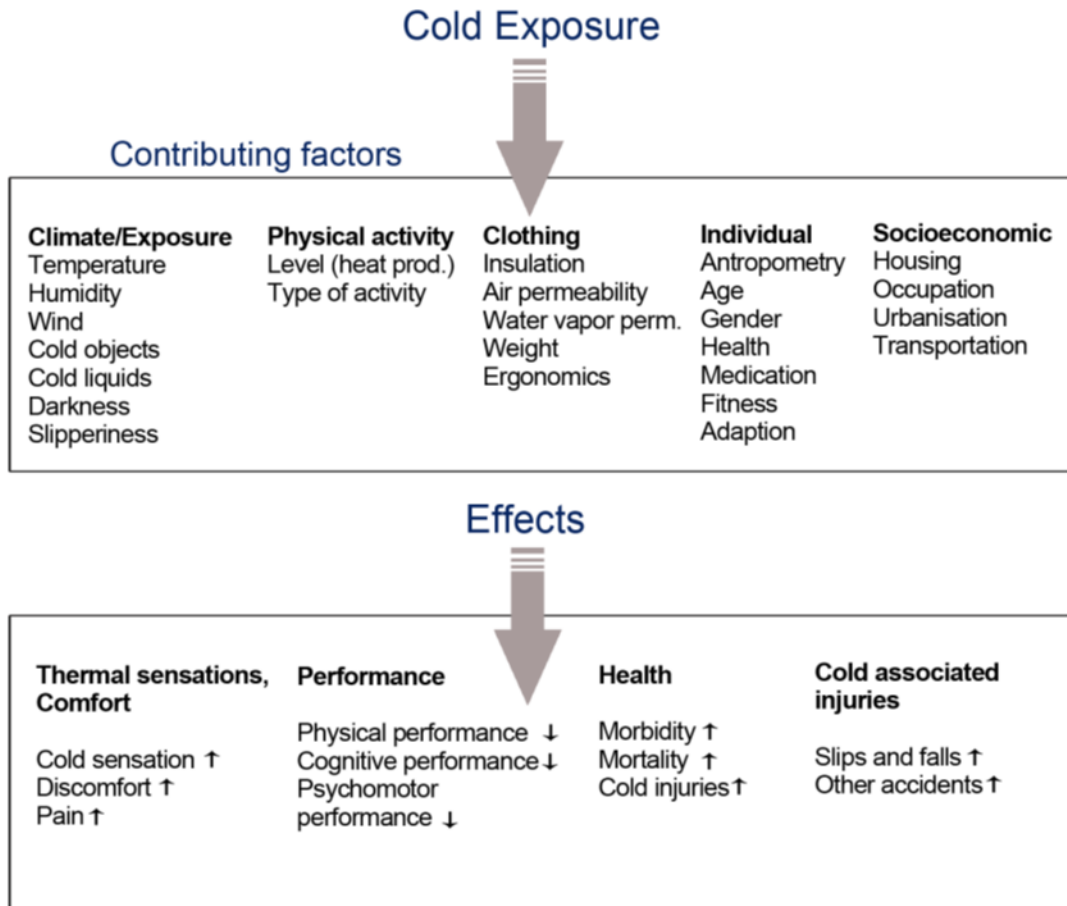
- Fysisk arbeidsmiljø:
  - Klimatisk arbeidsmiljø
  - Ergonomisk arbeidsmiljø
  - Innemiljø
  - Støy og vibrasjoner
  - Kjemiske stoffer
- Organisatorisk arbeidsmiljø:
  - Stress
  - Selvstyring
  - Variasjon
  - Konsentrasjon
  - Arbeidsmengde
  - Samarbeidsrelasjoner
  - Vold og trakassering



Model for considering the effects of the thermal environment on human activity performance and productivity



# Faktorer som påvirker risiko ved arbeid i kaldt klima



Report nr. SINTEF F24656 - Restricted

## Report

Arctic weather protection, health effects, monitoring systems and risk assessment

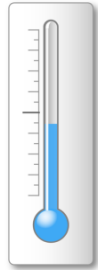
**Authors**  
 Hilde Færevik  
 Mariann Sandsund, Øystein Wiggen, Julie Renberg



The effects of cold (adopted from Mäkinen et al. 2007).

SINTEF Technology and Society  
 Department of Health Research, Work Physiology  
 2013-09-26

# Cold stress



Discomfort

Performance degradation

- Physical
- Manual
- Cognitive

Ambient temperature ( $T_a$ )  
WCT

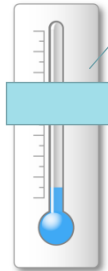
Risk of unsafe  
behaviour of  
workers

NORSOK S002  
ISO 11079  
WCI

Slip and fall accidents  
Contact cooling

Cold injuries

Whole body cooling –  
hypothermia  $T_c < 35^\circ\text{C}$



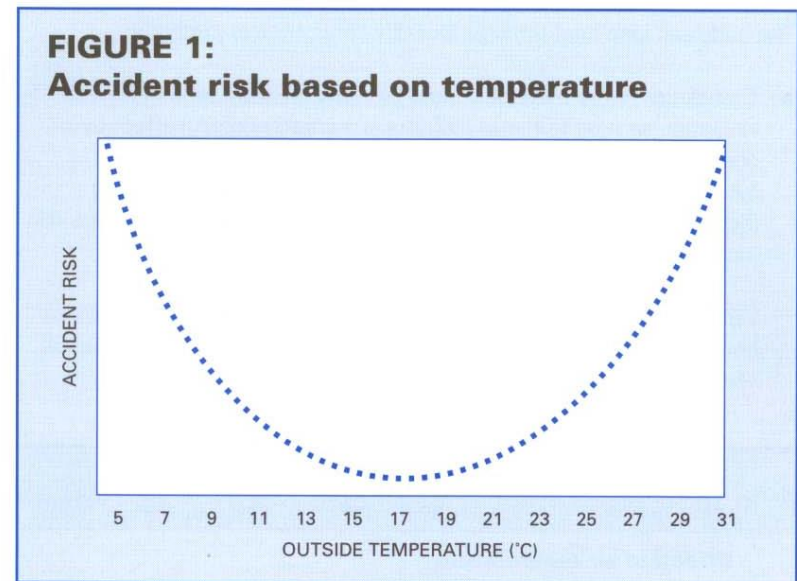
# Risiko forbundet med arbeid i kulde

## Eksposering:

- Lave temperaturer, vind, nedbør
- Kalde overflater, materialer, utstyr
- Kaldt vann, kalde væsker

## Risiko forbundet med eksponering:

- Lokal nedkjøling
  - Hud
  - Ekstremiteter
  - Kontakt med kalde flater (konduktiv)
  - Konvektiv (vind, trekk)
  - Respiratorisk nedkjøling
- Generell nedkjøling (hele kroppen)



Adapted from: Ramsey J.D. *et al.*, 1983. *Journal of Safety Research* No. 14, pp. 105-114. Effect of the workplace thermal condition on safe work behaviour.

**Risiko for ulykker øker når temperaturen synker**

# Effekt av kulde på ytelse



# Mennesket i kaldt klima



- Dårlig tilpasset kulden
- Homeoterm organisme;  
Termoregulatorisk system  
optimalisert for å opprettholde  
en dyp kjerne temperatur på 37°C
- Endringer i dyp kjernetemperatur  
vil påvirke kjemiske prosesser,  
enzym- systemer, cellestrukturer  
m.m

# Effekt av kulde på kognitiv yteevne

- Mest påvirket av kulde er årvåkenhet og motoriske ferdigheter
- Kulde reduserer, øker eller har ingen effekt på kognitiv yteevne
- Ubehag ved lokal nedkjøling kan påvirke konsentrasjonen
- Avhengig av kompleksiteten på oppgaven
  - Komplekse oppgaver påvirkes av mer av kulde
  - Kulde kan også skjerpe konsentrasjonen inntil et visst nivå
- Effekten kan kompenseres med en økt innsats inntil et visst nivå



Statoils LNG terminal Melkøya, Foto: SINTEF

# Effekt av hudtemperatur på manuell ytelse, funksjon og følsomhet

32-36°C:	Optimal temperatur
Under 32°C:	Reduksjon i følsomhet for ujevnheter i kontaktoverflate
28°C (muskel):	Reduksjon i muskelkraft
20-27°C:	Reduksjon i nøyaktighet og utholdenhet
12-16°C:	Reduksjon i manuell ferdighet
16°C:	Smerte (for avkjøling av hele handa)
8°C:	Tap av sensitivitet
6°C:	Nerveblokkade
6-7°C:	Tap av følelse



# Study IV (2011) ColdWear project

Industrial Health 2011, 49, 443–451

Original Article

## Effect of Cold Conditions on Manual Performance while Wearing Petroleum Industry Protective Clothing

Øystein Nordrum WIGGEN<sup>1, 2\*</sup>, Sigrì HEEN<sup>1</sup>, Hilde FÆREVIK<sup>2</sup> and Randi Eidsmo REINERTSEN<sup>2</sup>

<sup>1</sup>Department of Biology, Norwegian University of Science and Technology, Faculty of Natural Sciences and Technology, Trondheim, Norway

<sup>2</sup>SINTEF Technology and Society, Preventive Health Research, Trondheim, Norway



- The purpose of this study was to investigate manual performance and thermal responses during low work intensity in persons wearing standard protective clothing in the petroleum industry when they were exposed to a range of temperatures (5, -5, -15 and -25 °C).
- Exposure to -5 °C or colder lowered skin and body temperatures and resulted in reduced manual performance during low work intensity.
- Current protective clothing at a given cold exposure is not adequate to maintain manual performance and thermal balance for petroleum workers in the high north.

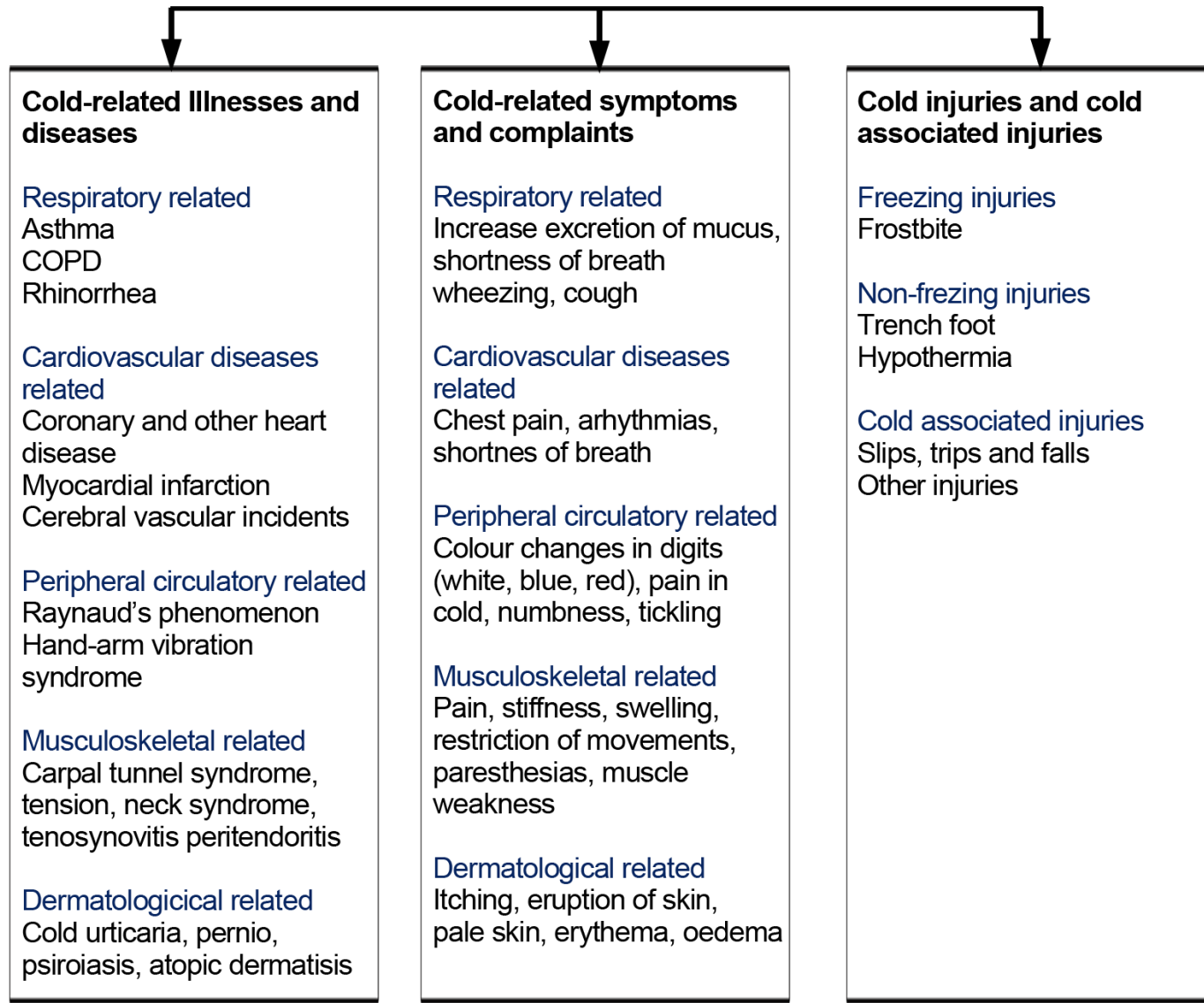
# Effekt av kulde på helse



# Kulderelaterte sykdommer

- Kan være sykdommer som forårsakes av kulde, eller sykdommer hvor forløp eller symptombilde påvirkes av kuldeeksponering
- Personer med påvist hjerte/karsykdommer reagerer uheldig på arbeid i kulde- økt risiko for høyt blodtrykk
- Personer med Raynauds tilstand - forstyrrelser i perifer sirkulasjon
  - Raynauds fenomen – økt forekomst av "hvite fingre" ved lagnvarig eksponering til kulde og/eller vibrasjon
- Lunge-/luftveissykdommer
- Muskel-/skjelettsykdommer
- Hudsykdommer
- Allergier (hypersensitivitet)

# Cold Exposure



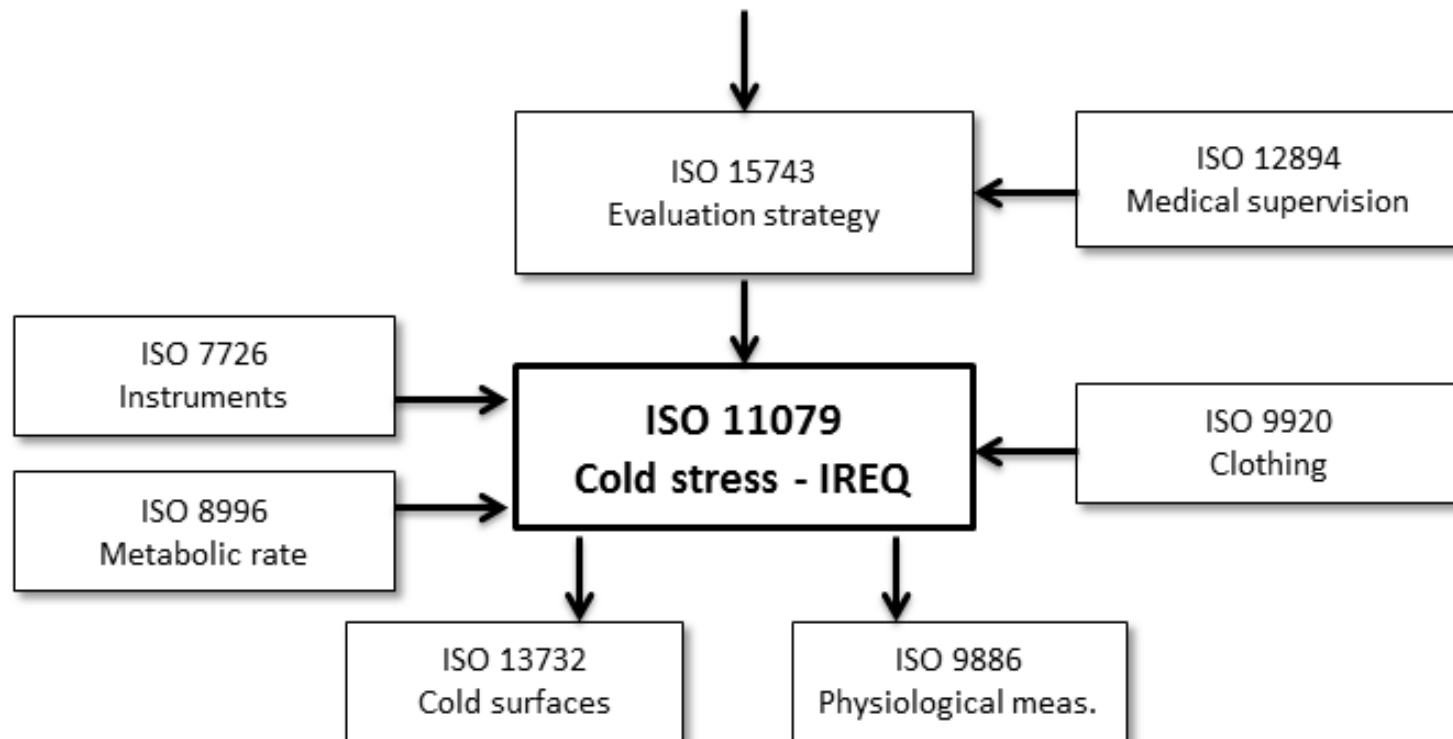
Mäkinen and Hassi, 2009

# Håndtering av risiko ved arbeid i kaldt klima standarder og testmetoder

# Standarder og retningslinjer

- ISO 15743:2008. Ergonomics of the thermal environment - Cold workplaces - Risk assessment and management
- ISO 12894: 2001. Ergonomics of the thermal environment - Medical supervision of individuals exposed to extreme hot or cold environments.
- ISO 19906: 2010. Petroleum and natural gas industries — Arctic offshore structures.
- NORSOK STANDARD S-002 (Rev. 4 August 2004). Working environment.
- OGP report no. 488. Performance indicators for fatigue risk management systems, Guidance document for the oil and gas industry (2012).
- OGP report no. 343. Managing health for field operations in oil and gas activities (2011).
- OGP report no. 398. Health aspects of work in extreme climates. A guide for oil and gas industry managers and supervisors (2008).
- Barents 2020 RN05 Working Environment – Barents Sea - stage 4 (Veritas, 2010)

# ISO standarder for risikovurdering i kulde





# ISO 15743 – Cold risk assessment

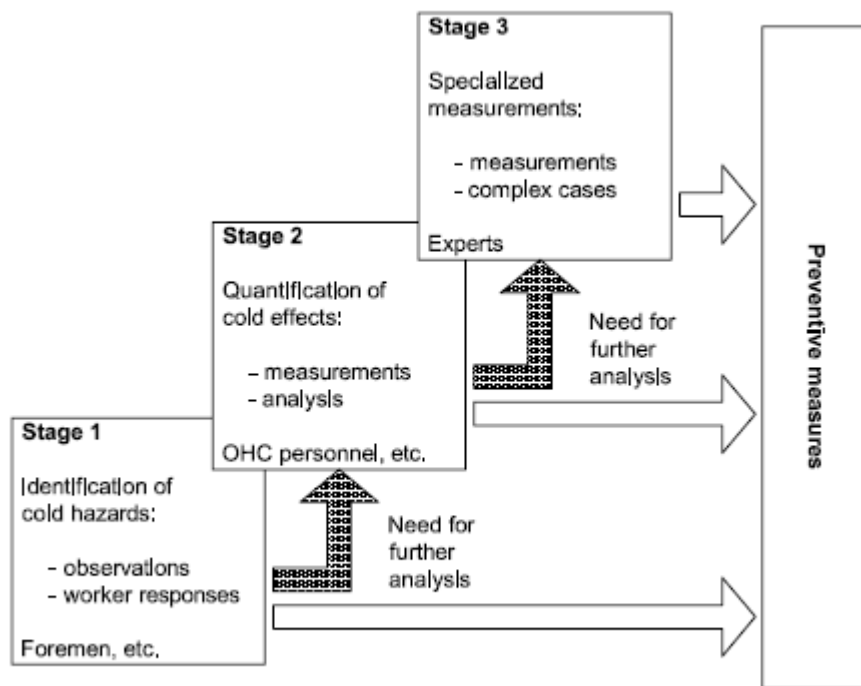


Figure 1 — Model for cold risk assessment in the workplace

INTERNATIONAL  
STANDARD

**ISO  
15743**

First edition  
2008-07-01

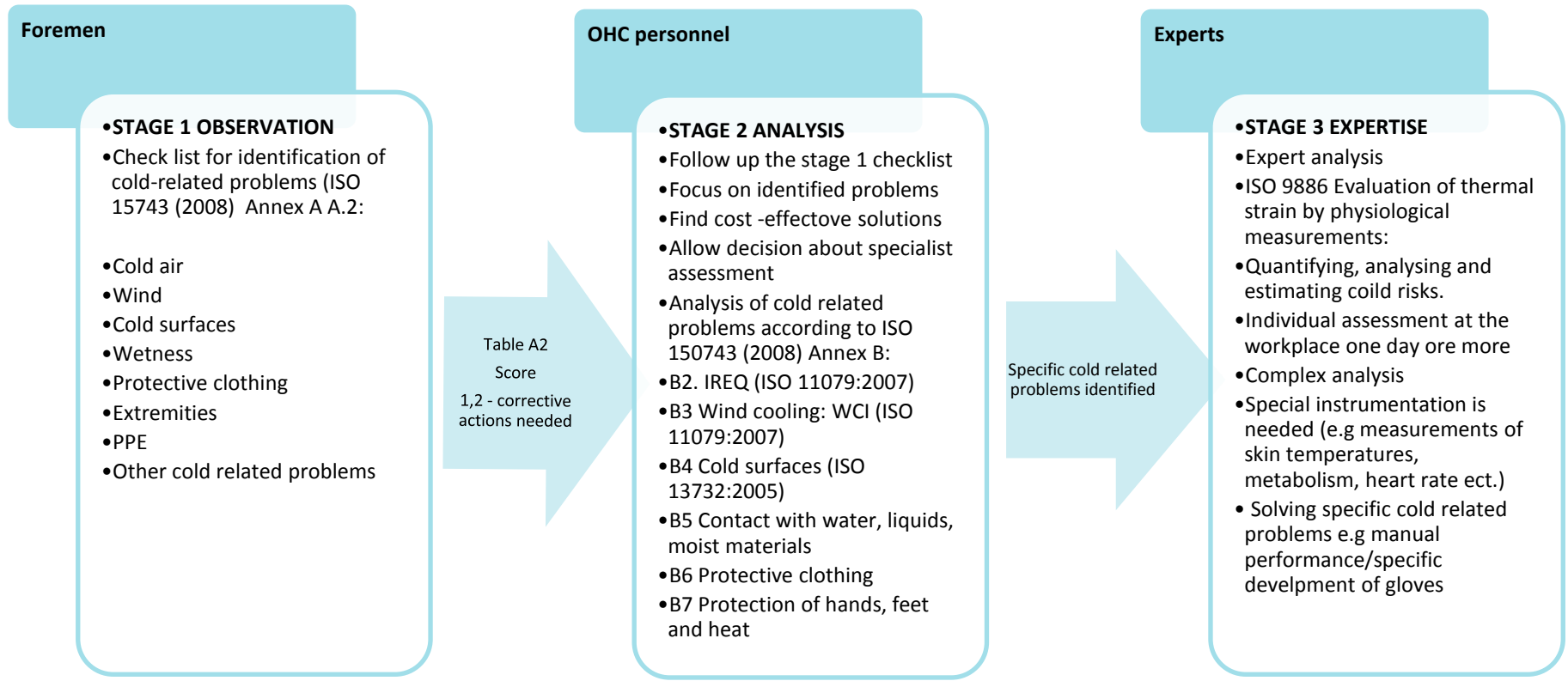
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**Ergonomics of the thermal  
environment — Cold workplaces — Risk  
assessment and management**

*Ergonomie des ambiances thermiques — Lieux de travail dans le  
froid — Évaluation et management des risques*

# ISO 15743 - Cold risk assessment model

- Stage 1 Observation, Stage 2 Analysis, Stage 3 Expertise
- Preventive measures, cold risk management plan



# ISO 15743:2008(E) Cold work check list

Are these conditions causing problems with cold?

(No, Yes - slight problem/ Yes – severe problems):

- exposure to cold air
- degree of contact with cold materials
- degree of exposure to wetness
- problems related to the cold protective clothing ensemble
- problems related to protecting the extremities (hands, feet and head)
- problems related to using personal protective equipment (e.g. hearing equipment) together with cold protective clothing
- slipperiness
- icing/falling ice
- snow drift
- other problems related to cold (e.g. insufficient lighting, varying thermal environments, varying workload)

A.2 Checklist for identification of cold-related problems

Name of company: ..... Date: .....

Observed task: ..... Temperature: .....°C  
Wind speed: .....m/s

Scoring:

0 No need for preventive actions     1 Corrective actions are recommended in the long run     2 Immediate need for corrective actions

1. Cold air

0 Air temperature does not cause any problem  
 1 Air temperature causes some problems  
 2 Air temperature clearly causes problems

Remarks: .....

2. Wind/air movements

0 No air movements  
 1 Light cold air movements (e.g. sensation of draught, light wind)  
 2 Strong cold air movements (e.g. strong wind blowing occasionally or repeatedly)

Remarks: .....

3. Contact with cold surfaces while handling tools/materials or when sitting, kneeling or lying on cold surfaces

0 Minimal risk  
 1 Working for short periods with thin gloves, sitting, kneeling or lying on cold surfaces  
 2 Working with bare or insufficiently protected hands or for longer periods sitting, kneeling, standing or lying on cold surfaces

Remarks: .....

4. Exposure to water/liquids/wetness

0 No exposure  
 1 Short periods of exposure (e.g. when handling cold materials, raining, snowing)  
 2 Long periods of exposure (e.g. continuously handling cold fluids or wet materials)

Remarks: .....

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# Cold risk management

- Establish a cold workplace team that should be responsible for the design and implementation stages and for continuous follow-up of cold-related issues.
- The management system should consider human factors such as experience, training, night-time operations (year-round in some cases), etc.
- For new operations, temporarily reduced performance should be considered, in the expectation that performance will improve.
- Achievement targets should be established and seasonal evaluations of performance should be carried out.
- A cold-risk management plan should be developed as a part of the general occupational safety plan of the individual workplace (this depends on the circumstances – offshore/land based etc), the plan should at a minimum include:

# Cold risk management plan

- Cold-risk assessment checklist
- Organizational cold protective measures
  - Duration and intensity of exposure
  - Time for recovery
  - Extra manpower
  - Planning of some activities to the summer
  - Monitoring system (buddy system/WCI)
- Technical preventive measures
  - Shelter
  - Tools and machinery
  - Reduction of slippery areas
  - Lighting
  - Insulation of work area
- Protective clothing and PPE
  - Need for thermal insulation (IREQ)
  - Clothing for cold and foul weather
  - Hand, foot, head, face protection
- Information and training
- Occupational health care

# Helsekriterier for arbeid i kaldt klima – standarder og retningslinjer

- Lovdata: FOR 2010-12-20 nr 1780: Forskrift om helsekrav for personer i arbeid på innretninger i petroleumsvirksomheten til havs
- Veileder til Forskrift om helsekrav for arbeidstakere på petroleumfeltet. Helsedirektoratet. IS-1879. 2011/
- ISO 12894:2001. Ergonomics of the thermal environment - Medical supervision of individuals exposed to extreme hot or cold environments.
- ISO 15743:2008(E). Ergonomics of the thermal environment — Cold workplaces —Risk assessment and management.
- ISO 11079: 2007 (Annex B). Ergonomics of the thermal environment — Determination and interpretation of cold stress when using required clothing insulation (IREQ) and local cooling effects.
- NORSOK STANDARD S-002:2004. Working environment.
- OGP report no. 398. Health aspects of work in extreme climates. A guide for oil and gas industry managers and supervisors. IPIECA 2008.
- OGP report no. 343. Managing health for field operations in oil and gas activities.

# ISO 12894 Medical supervision of individuals

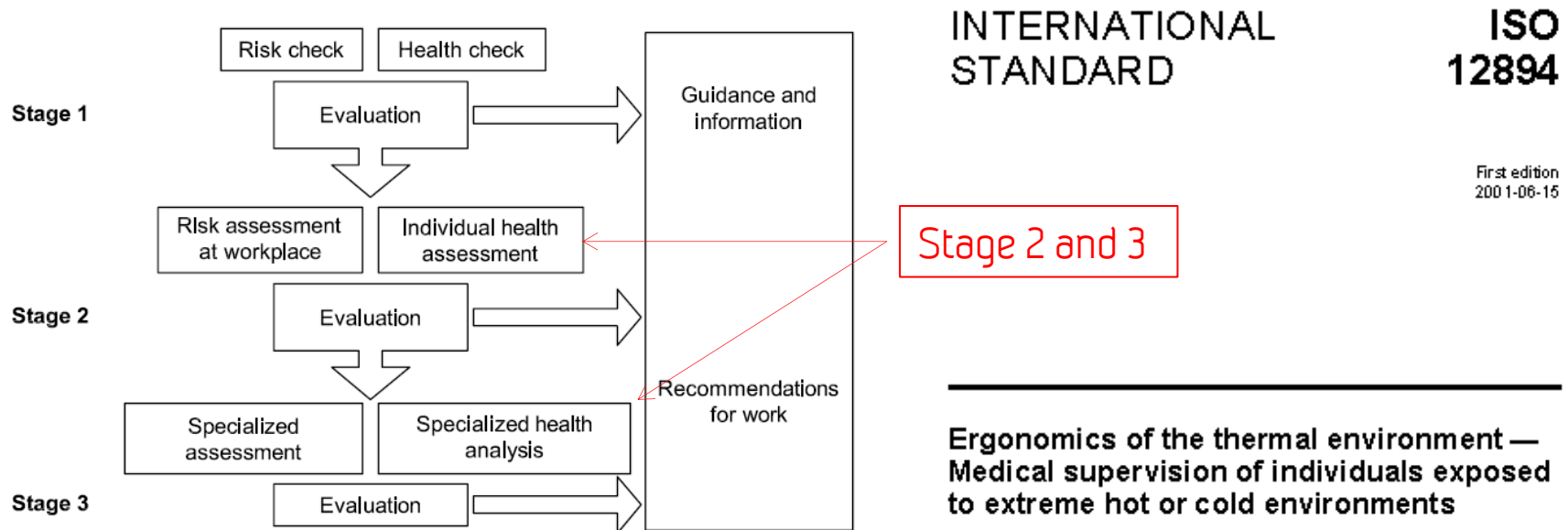
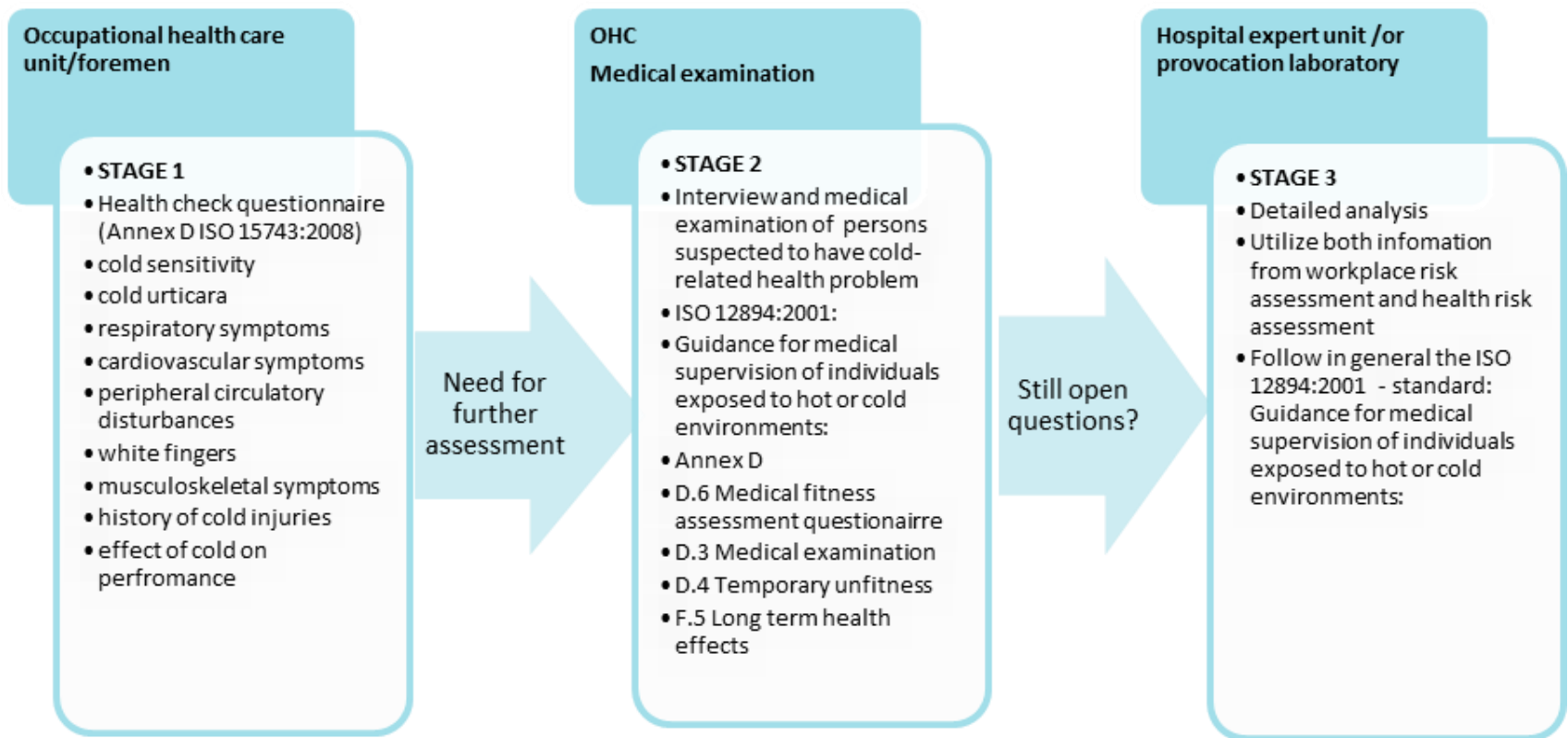


Figure 2 — Relationship between cold risk assessment and health assessment



# Helsevurdering for arbeid i kaldt klima



## ISO 15743 Annex D

## Cold urticaria

3. Do you experience an intense itching of the skin in the cold or after cold exposure, related to a superficial inflammation (eczema) or like a rash (urticaria)?

- a) 1 No  
b) 2 Yes

Detailed interview of cold urticaria.

## Respiratory symptoms

4. Do you experience...

	In warm	In cold	In cold during exertion	Not at all
a) Shortness of breath?	1	2	3	4
b) Extended coughing or coughing fits?	1	2	3	4
c) Wheezing?	1	2	3	4
d) Increased excretion of mucus from the lungs?	1	2	3	4
e) Very profound rhinitis?	1	2	3	4

Detailed interview of respiratory function.

## Cardiovascular symptoms

5. Do you experience...

	In warm	In cold	In cold during exertion	Not at all
a) Chest pain?	1	2	3	4
b) Cardiac arrhythmias?	1	2	3	4
c) High blood pressure?	1	2	3	4

Detailed interview of cardiovascular function.

## Symptoms related to peripheral circulatory disturbances

6. Do you experience episodic...

	In warm	In cold	Not at all
a) Circulatory disturbances in hands and/or feet	1	2	3
b) Blurring of vision	1	2	3
c) Headache named migraine	1	2	3

## D6 Medical Fitness Assessment

### Other factors that should be considered:

- physical and chemical factors
- ergonomic factors
- psychosocial factors
- individual health and performance
- isolation, low temperatures, darkness,
- organisation of work, noise and vibratic
- personal factors :
- (age, gender, place of residence, ethnici
- work organization: shift work, exercise

### D.6 Medical fitness assessment questionnaire prior to cold exposure

#### IN CONFIDENCE

This questionnaire should be completed prior to exposure to cold conditions. It is recommended that it is administered by someone with appropriate knowledge, for example, a nurse or trained laboratory scientist.

Please circle the appropriate response.

Name ..... Date...../...../.....

Age ..... years Sex: Male/Female

Present occupation .....

1. Have you ever experienced episodes of fits or faints, or loss of consciousness (apart from concussion)? Yes/No
2. Do you suffer from thyroid or other general medical disease, for example, diabetes mellitus? Yes/No
3. Do you suffer from any disease of the heart or blood vessels, including high blood pressure? Yes/No
4. Do you suffer from Raynaud's phenomenon, or other peripheral vascular disease? Yes/No
5. Do you suffer from any chest disease, e.g. asthma or chronic bronchitis? Yes/No
6. Have you been treated for any serious mental ill health, or do you suffer from anxiety or depression? Yes/No
7. Do you suffer from any disease of the skin? If yes, please specify  
..... Yes/No
8. Do you suffer from any rheumatism or diseases of the joints? Yes/No
9. Do you currently take any medication? Yes/No  
If yes, please specify .....
10. Have you ever experienced any general or local allergic reaction to cold? Yes/No  
If yes, please specify .....
11. Have you ever suffered from any freezing or non-freezing cold injury? Yes/No  
If yes, please specify .....

# ISO 11079 - Determination of wind cooling

**Table D.1 — Cooling power of wind on exposed flesh expressed as a comparative wind chill temperature ( $t_{WC}$ ) at a defined wind speed of  $4,2 \text{ km} \cdot \text{h}^{-1}$**

$v_{10}$		$t_a$ °C										
$\text{km} \cdot \text{h}^{-1}$	$\text{m} \cdot \text{s}^{-1}$	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50

**Table D.2 — Wind chill temperature ( $t_{WC}$ ) and freezing time of exposed skin**

Classification of risk	$t_{WC}$ °C	Effect
1	-10 to -24	Uncomfortably cold
2	-25 to -34	Very cold, risk of skin freezing
3	-35 to -59	Bitterly cold, exposed skin may freeze in 10 min
4	-60 and colder	Extremely cold, exposed skin may freeze within 2 min

60	16,7	-9	-16	-23	-30	-37	-43	-50	-57	-64	-71	-78
65	18,1	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79
70	19,4	-9	-16	-23	-30	-37	-44	-51	-59	-66	-73	-80
75	20,8	-10	-17	-24	-31	-38	-45	-52	-59	-66	-73	-80
80	22,2	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81

The shaded areas refer to the different classes of risk according to Table D.2.

$$t_{WC} = 13,12 + 0,6215 \cdot t_a - 11,37 \cdot v_{10}^{0,16} + 0,3965 \cdot t_a \cdot v_{10}^{0,16}$$

INTERNATIONAL  
STANDARD

ISO  
11079

First edition  
2007-12-15

**Ergonomics of the thermal environment — Determination and interpretation of cold stress when using required clothing insulation (IREQ) and local cooling effects**

*Ergonomie des ambiances thermiques — Détermination et interprétation de la contrainte liée au froid en utilisant l'isolement thermique requis du vêtement (IREQ) et les effets du refroidissement local*

Classification of risk	Wind chill temperature°C	Risk	Recommended limits for work
0	<-9	Low risk, < 5% chance of frostbite for most people	Normal work; emergency work; planned maintenance
1	-10 to -24	Low risk, < 5% chance of frostbite for most people, uncomfortable cold	Normal work (reduced work periods); emergency work
2	-25 to -34	Moderate risk, increasing risk of frostbite for most people in 10- 30 minutes*, very cold	Normal work (reduced work periods); emergency work
3	-35 to -59	High risk, risk of frostbite for most people in 2-10 min*, bitterly cold	Emergency work only
4	-60 and colder	Extreme risk, risk of frostbite for most people in 2 minutes or less*, extremely cold	No work outside

Færevik H., Sansund M., Wiggen Ø., Renberg J. (2013)

Sintef report F24656 Arctic Weather Protection, health effects, monitoring systems and risk assessment

Wind scale	Wind speed		Ambient temperature (°C)										
	Km·h <sup>-1</sup>	m·s <sup>-1</sup>	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50
Light breeze (1.6-3.3)	5	1.4	-2	-7	-13	-19	-24	-30	-36	-41	-47	-53	-58
	10	2.8	-3	-9	-15	-21	-27	-33	-39	-45	-51	-57	-63
Gentle breeze (3.4-5.4)	15	4.2	-4	-11	-17	-23	-29	-35	-41	-48	-54	-60	-66
	20	5.6	-5	-12	-18	-24	-31	-37	-43	-49	-56	-62	-68
Moderate breeze (5.5-7.9)	25	6.9	-6	-12	-19	-25	-32	-38	-45	-51	-57	-64	-70
	30	8.3	-7	-13	-20	-26	-33	-39	-46	-52	-59	-65	-72
Fresh breeze (8.0-10.7)	35	9.7	-7	-14	-20	-27	-33	-40	-47	-53	-60	-66	-73
	40	11.1	-7	-14	-21	-27	-34	-41	-48	-54	-61	-68	-74
Strong breeze (10.8-13.8)	45	12.5	-8	-15	-21	-28	-35	-42	-48	-55	-62	-69	-75
	50	13.9	-8	-15	-22	-29	-35	-42	-49	-56	-63	-70	-76
Near gale (13.9-17.1)	55	15.3	-9	-15	-22	-29	-36	-43	-50	-57	-63	-70	-77
	60	16.7	-9	-16	-23	-30	-37	-43	-50	-57	-64	-71	-78
	65	18.1	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79
Gale to hurricane (> 17.2)	70	19.4	-9	-16	-23	-30	-37	-44	-51	-59	-66	-73	-80
	75	20.8	-10	-17	-24	-31	-38	-45	-52	-59	-66	-73	-80
	80	22.2	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81

WCT	Risk of frostbite	Duration of cold exposure	Preventive measures
10 to -9	0: Low risk  < 5% chance of frostbite for most people	Unlimited	<ul style="list-style-type: none"> <li>• Dress warmly</li> <li>• Stay dry</li> <li>• Awareness if manual operations with bare hands has to be performed outdoors</li> </ul>
-10 to -24	1: Low risk  < 5% chance of frostbite for most people Uncomfortable cold	40-120 minutes	<ul style="list-style-type: none"> <li>• Dress in layers of warm clothing, with an outer layer that is wind-resistant.</li> <li>• Wear a hat, mittens or insulated gloves, a scarf and insulated, waterproof footwear.</li> <li>• Stay dry.</li> <li>• Keep active</li> <li>• Awareness if manual operations with bare hands has to be performed</li> </ul>
-25 to -34	2: Moderate risk  Increasing risk of frostbite for most people in 10- 30 minutes  Very cold,	10-30 minutes*	<ul style="list-style-type: none"> <li>• Dress in layers of warm clothing, with an outer layer that is wind-resistant</li> <li>• Minimize exposed skin (facemask and goggles)</li> <li>• Wear a hat, mittens or insulated gloves, a scarf, neck tube or face mask and insulated, waterproof footwear</li> <li>• Stay dry</li> <li>• Keep active</li> <li>• Take brakes and drink warm drinks</li> <li>• Check face and extremities for numbness or whiteness – buddy control</li> </ul>
-35 to -59	3: High  Bitterly cold, High risk of frostbite for most people in 2-10 min	0-10 minutes*	<ul style="list-style-type: none"> <li>• Dress in layers of warm clothing, with an outer layer that is wind-resistant.</li> <li>• Cover all exposed skin (facemask and goggles)</li> <li>• Wear a hat, mittens or insulated gloves, a scarf, neck tube or face mask and insulated, waterproof footwear.</li> <li>• Be ready to cut short or cancel outdoor activities.</li> <li>• Stay dry</li> <li>• Keep active.</li> <li>• Take brakes and drink warm drinks</li> <li>• Check face and extremities for numbness or whiteness – buddy control.</li> <li>• Perform risk assessment before each work task</li> </ul>
-60 and colder	4: Extreme  Extremely cold. High risk of frostbite in most people in 2 minutes or less	Extreme risk, risk of frostbite for most people in 2 minutes or less*, extremely cold	<ul style="list-style-type: none"> <li>• No work outside</li> </ul>



# Wind Chill Temperatur

- $-4.8^{\circ}\text{C}$  hudtemperatur er satt som kritisk grense for utvikling av frostskaeder (Danielsson, 1996)
- Forsøk med termisk sylinder (konvektivt varmetap) har demonstrert at  $-4.8^{\circ}\text{C}$  nåes ved en WCT på  $-27^{\circ}\text{C}$  (under stabile forhold)
- Forsøk med mennesker viser at en WCT på  $-27$  representerer moderat risiko for utvikling av frostskaeder (Ducharme og Brajkovic, 2005)

# Advances and shortcomings of the Canadian WCI

Knowing the risk and the time it will take to develop frostbite are both useful in helping people decide what to wear in the cold and in providing a framework for management of cold work (Ducharme and Brajkovic, 2005).

Risk of frostbite is dependent on several factors:

- Temperature and wind
- Duration of exposure
- Individual factors
- Regions of skin cooling (nose, cheek, finger)

How to define WCT threshold values for risk associated with cooling of exposed skin ?

# Shortcomings of the current WCI (Shitzer and Tikuisis, 2012)

- Bare skin will cool faster under higher wind conditions (asymmetrical cooling) – the current WCI is based on steady state cooling.
- Narrow regions of the body (finger and nose) will cool faster compared to the cheek – the current WCI is based on cheek temperatures.
- Prediction of times to skin freezing (in essence, safe exposure limits) would be more meaningful and easier to interpret than the WCT
- Cooling time would also enable direct measures of **degraded function** (e.g loss of finger dexterity) under moderate conditions and the **risk of cold injury** (e.g frostbite under more serious conditions) to be included

Combinations of WCT and exposure duration that correspond to estimated finger skin temperature of 14°C (Daanen, 2009)

Wind chill temperature (WCT)	Exposure duration wearing gloves (min)
-10	>60
-20	37
-30	15
-40	9
-50	5

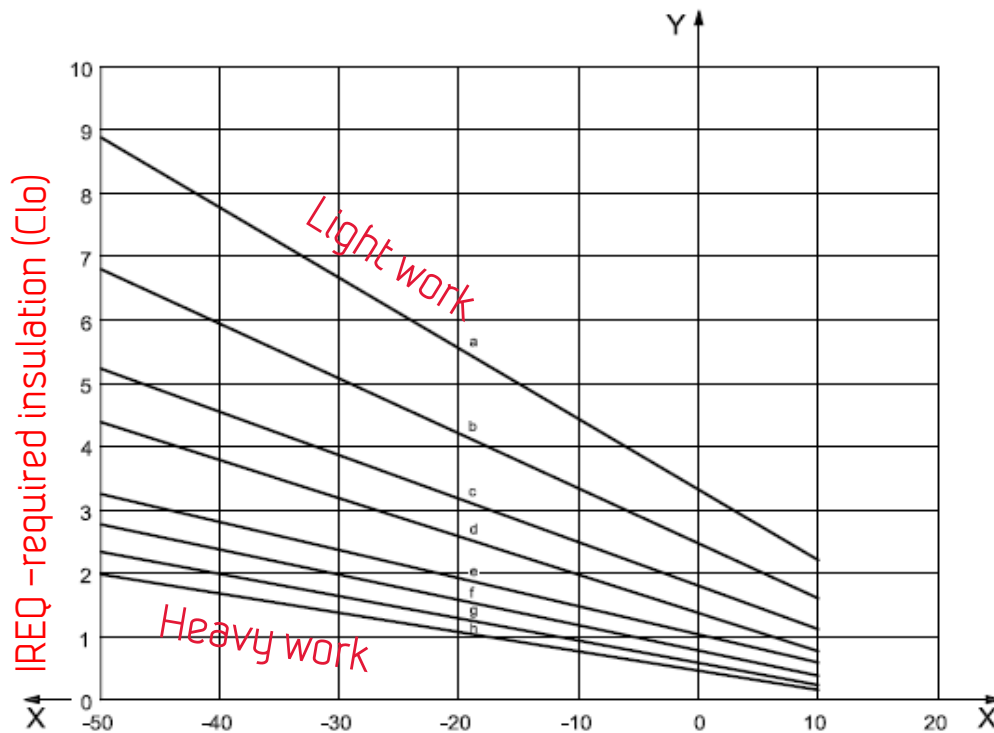
# ISO 11079 Evaluate cold stress using IREQ

- Evaluate cold stress using IREQ (required insulation and clothing effects):
  - a) measure or estimate air temperature (see ISO 7726);
  - b) measure or estimate air velocity (see ISO 7726);
  - c) determine exposure times;
  - d) estimate activity level for the calculation of metabolic heat production (see ISO 8996);
  - e) estimate thermal insulation of clothing (see ISO 9920);
  - f) calculate  $IREQ_{neutral}$  and  $IREQ_{min}$  using
    - ↓ a computer program (see ISO 11079:2007, Annex F), or ↓ graphs
  - g) compare IREQ with the actual clothing insulation;
  - h) if clothing insulation is lower than  $IREQ_{min}$ , calculate the DLE (duration limited exposure) time.

# IREQ - required thermal insulation

Human thermal balance:

Environmental cold stress – metabolic heat production – thermal insulation of clothing



INTERNATIONAL  
STANDARD

ISO  
11079

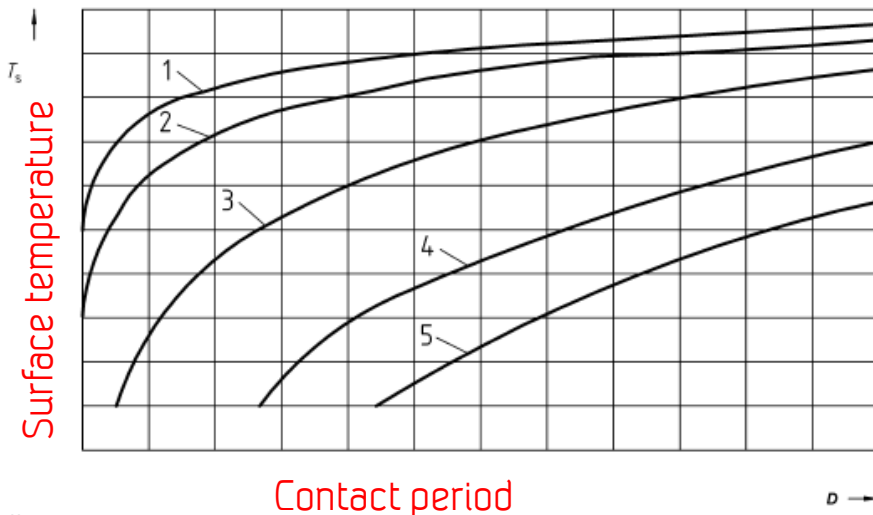
First edition  
2007-12-15

**Ergonomics of the thermal environment — Determination and interpretation of cold stress when using required clothing insulation (IREQ) and local cooling effects**

*Ergonomie des ambiances thermiques — Détermination et interprétation de la contrainte liée au froid en utilisant l'isolement thermique requis du vêtement (IREQ) et les effets du refroidissement local*

[http://wwwold.eat.lth.se/Forskning/Termisk/Termisk\\_HP/Klimatfiler/IREQ2002alfa.htm](http://wwwold.eat.lth.se/Forskning/Termisk/Termisk_HP/Klimatfiler/IREQ2002alfa.htm)

# ISO 13732-3 Prediction of local cooling



Key					
1	Aluminium	3	Stone	5	Wood
2	Steel	4	Nylon		
$D$	Contact period	$T_s$	Surface temperature		

Figure 1 — Principal relationship between material, duration and temperature for skin in contact with a cold surface

INTERNATIONAL  
STANDARD

ISO  
13732-3

First edition  
2005-12-01

**Ergonomics of the thermal environment — Methods for the assessment of human responses to contact with surfaces —**

Part 3:  
**Cold surfaces**

*Ergonomie des ambiances thermiques — Méthodes d'évaluation de la réponse humaine au contact avec des surfaces —*

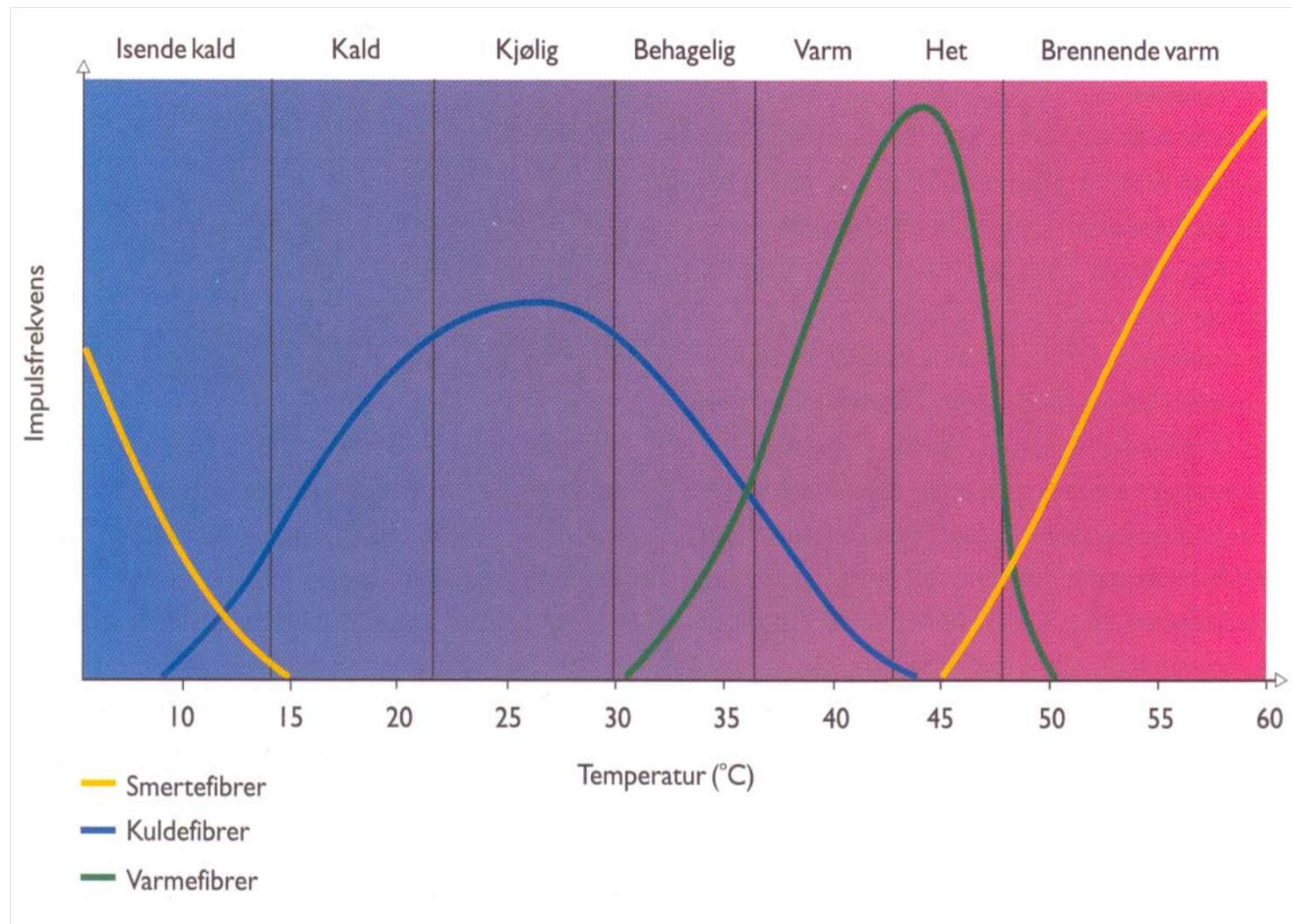
*Partie 3: Surfaces froides*

Determination of pain, frostbite and numbness threshold – large individual variation

Pain : Time to reach a contact temperature (skin) of 15 C



# Thermoreceptors in the skin



Maximum time (sec) for cooling of hands until pain sets in (15 °C) when gripping cold materials with the whole hand without insulating gloves (from ISO 13732-3).

Material type	Surface temperature of material/tool							
	°C							
	5	0	-5	-10	-15	-20	-25	-30
Aluminium	>15	7	<1	<1	<1	<1	<1	<1
Steel	>15	6	2	<1	<1	<1	<1	<1
Rock	>15	10	5	3	1	<1	<1	<1
Nylon	>15	13	10	7	5	4	3	2
Wood	>15	15	11	9	7	5	4	3

# Forebygging av kulde som risikofaktor på arbeidsplassen

- Planlegg aktivitetene i forhold til klimaforhold
  - Hvis mulig planlegg utendørsarbeid til varmere årstider
  - Undersøk om deler av arbeidet kan gjennomføres innendørs
  - Tillat mer tid til arbeidsoppgavene i kalde omgivelser
  - Utvid arbeidstokken
  - Planlegg regimer for arbeid / hvile
  - Sørg for fleksibilitet med tanke på intensitet og varighet av arbeidet
- Kle deg riktig, bruk gjerne godkjent vernebekledning mot kulde (snømerket, ENV 342)
- Velg verktøy som er tilpasset kulde, unngå varmetap til kalde flater
- Sørg for tilstrekkelig varm mat og drikke
- Pass på å få gjenoppvarming ved spesielt kalde eksponeringer
- Overvåk subjektive reaksjoner hvis du jobber sammen med flere
- Rapportert til formann eller foresatt via kommunikasjonssystem
- Informasjon og opplæring!

# Tekniske tiltak/vinterisering

- Vinterisering/tilpasning av innretninger, utstyr og bekledning
- Bygge inn/klima avskjerming
- Varme opp
- Forebygge skli og fallulykker på islagte underlag
- Forebygge fallende is
- Alarmering/varsling

# Bekledning og personlig verneutstyr

- Bekledning
  - Undertøy
    - Absorbere og transportere svette bort fra kroppen
    - (Isolere)
  - Mellombekledning
    - Isolere
    - Transportere svette videre ut
  - Yttertøy (skall bekledning)
    - Beskytte mot omgivelsene
    - Redusere fuktighet inne i bekledningen
- Fottøy: skosåler med friksjon som motvirker skliulykker/ lufting og isolasjon/
- Vernehjelm/hansker/briller/hørselsvern som er kompatibelt med annet utstyr og fungerer i kulde

# Europeiske standarder relatert til bekledning

- EN 511 Protective gloves against cold. CEN, European Committee for Standardization
- ENV 342 Protective clothing. Ensembles for protection against cold. CEN, European Committee for Standardization.
- EN 342 Protective clothing - Ensembles and garments for protection against cold
- EN 14058 Protective clothing - Garments for protection against cool environments
- ENV 343 Protective clothing. Protection against foul weather. CEN, European Committee for Standardization
- EN 343 Protective clothing - Garments for protection against rain
- EN 13921-4 Personal protective equipment. Ergonomic principles. Part 4: Thermal characteristics. CEN, European Committee for Standardization
- EN ISO 15831 Clothing - Physiological effects - Measurement of thermal insulation by means of a thermal manikin

# Oppsummering: risikovurdering i kulde

## Tekniske krav (WCI/IREQ):

- Planlegg for kuldeeksponering i tidlig designfase (Met-Ocean data/ISO 19906)
- Designfase: NORSOK S-002 bør styrkes på kulde problematikk
- ISO 11079 (WCI) anbefales som basis for utvikling av retningslinjer for arbeid i kaldt klima

## Operasjonelle krav:

- ISO 15743 anbefales som et verktøy for risikovurdering av arbeid i kaldt klima
- Metodene beskrevet i ISO 15743 bør implementeres og tilpasses eksisterende rutiner som en del av bedriftens HMS retningslinjer og systemer (eks JHA - NORSOK S-002, § 4.4.3)
- ISO12894 anbefales som verktøy for tidlig identifisering av mulig helserisiko forbundet med arbeid i kaldt klima og eventuell medisinsk oppfølging
- Videre utvikling av WCT som et verktøy for mer enn vurdering av risiko for frost skader



# Oppsummering: helsekriterier for arbeid i kulde

1. Generelle helsekrav skal følges også i kaldt klima:
  - Helsekrav definert i FOR 2010-12-20 nr 1780: Forskrift om helsekrav for personer i arbeid på innretninger i petroleumsvirksomheten til havs
  - Veileder til Forskrift om helsekrav for arbeidstakere på petroleumsfeltet. Helsedirektoratet. IS-1879. 2011/
2. Vurdering av helserelaterte plager bør følge metodikk som er beskrevet i ISO 15743 og ISO 12894
3. Vurdering av medisinsk skikkethet for arbeid i kulde bør inneholde kulde relaterte symptomer og plager, vurdering av fysisk belastning, oppgaver og varighet av arbeidet
4. Kulde relaterte symptomer og sykdommer bør identifiseres gjennom helsesjekk skjema (ISO 12894)
5. Kunnskap og opplæring om risikofaktorene hos både arbeidere og helsepersonell
6. Helseeksklusjonskriterier må vurderes i hvert enkelt individuelle tilfelle

# Fremtiden?

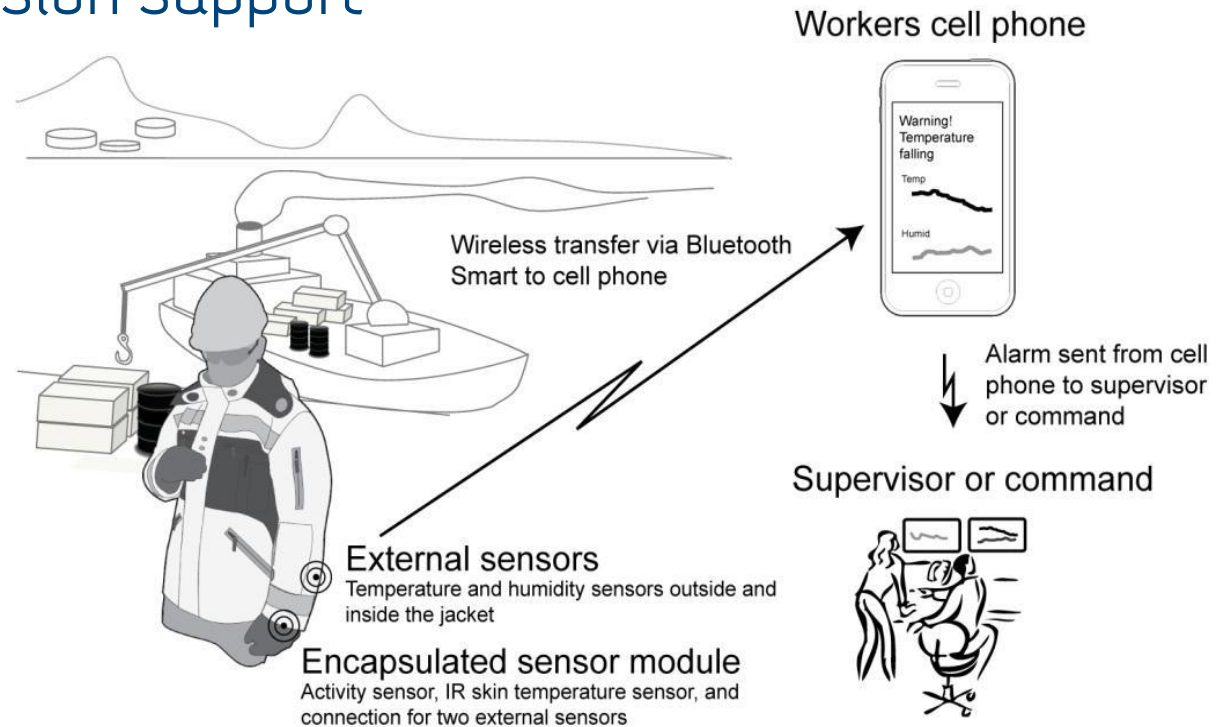
## Smart jacket for decision support

The most widely used index for workers in the cold:

- wind chill index (WCI), assess the risk of freezing of the unprotected human skin

High cost attended with temporary shutting down e.g. a plant due to rough climate.

Need for using the right criteria to abort work is essential.



Hypothesis : Sensors can be integrated in clothing to provide information about ambient conditions, physiological parameters and activity and thereby be used as a tool to set threshold limits for safe performance in the cold - (without disturbing the user).

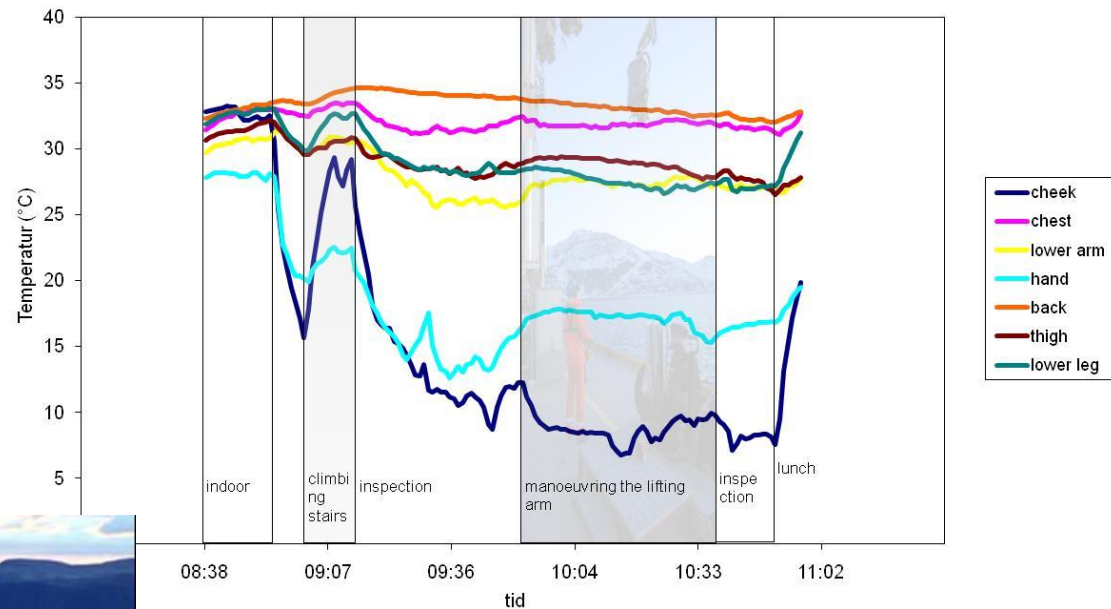
# Requirements for improved decision support

Field studies at Melkøya have shown that

- The operators get too cold on their hands, fingers and cheek
- Activity level and environment varies through the day, both inside and outside assignments



## Field studies at Melkøya, Operator 3



## Measure temperature and humidity outside and inside the jacket

-> **IsenseU: External sensors**

*Sensiron SH21 - Combined temperature and humidity sensor. Attached to textile by vacuum molding*

## Transmit signals between external sensors and mother board

-> **Flexible conductors**

*Conductive yarn coated with silicone*

## Transmitting data wirelessly

-> **IsenseU : Bluetooth Smart**

## Measure Activity

-> **IsenseU: accelerometer, gyroscope, magnetometer**  
*Measures the movement of the hand*

## Measure skin temperature on hand

-> **IsenseU: IR-sensor**



**Wearable Wireless Multi-parameter Sensor Module for Physiological Monitoring**, Anders E. Liverud, Jon Vedum, Franck Fleurey and Trine M. Seeberg. pHealth, Portugal 26-28 June 2012.

# Summary

- A demonstrator for workers in cold climate have been built and tested on 6 persons in cold and warm environment.
- The demonstrator provided information about
  - Thermal conditions at the site of the worker
  - Local cooling effects of extremities.
  - Microclimate in the jacket
  - Activity of the worker
  - Sweat



**All this information can be used in an enhanced safety perspective, as an improved tool to advice outdoor work control for workers in cold climate and thereby represent an improvement compared to existing current international standards.**

# Takk for oppmerksomheten

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Avdeling Helse

