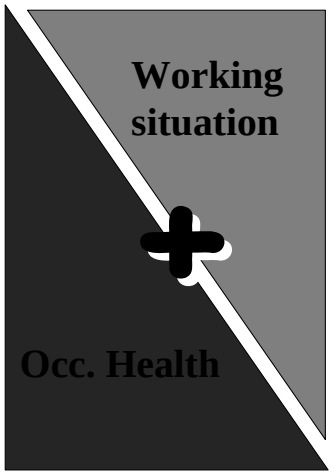
Strategy for the management of the thermal working conditions

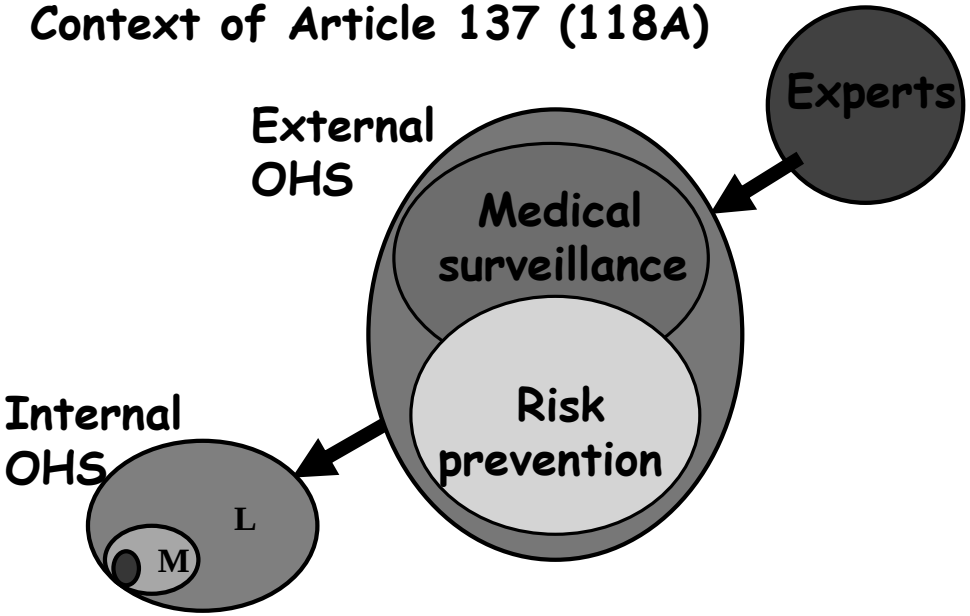
Jacques Malchaire
Catholic University of Louvain
Belgium

OH partners

- Employees
- Management
- Safety officers
- Occ. physicians
- Occ. hygienists
- Ergonomists
- Experts



Context of Article 137 (118A)

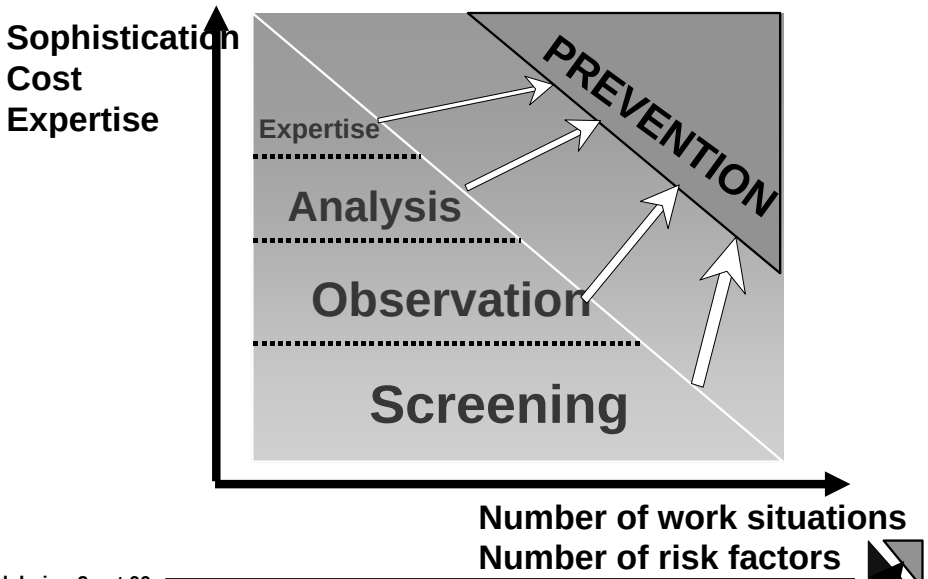


Occupational Health Services structure

Objectives

- Coordination of all actors
- « We need valid and useable standards with sufficient scope for practical application »
- « Evaluation » vs « Measurements »
- Cost-effectiveness
- Prevention vs assessment
- Qualitative vs quantitative
- Methods applicable by SMEs

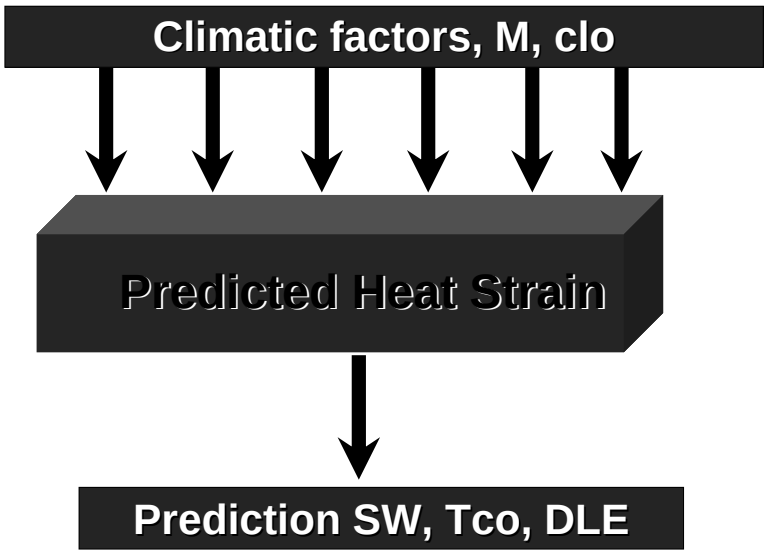
Prevention Strategy



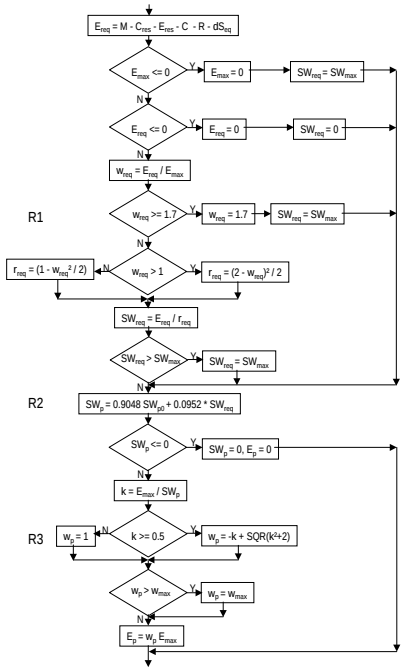
	Stage 1 *"Screening"*	Stage 2 *"Observation"*	Stage 3 *"Analysis"*	Stage 4 *"Expertise"*
• When?	Systematically	When a "problem" is detected	More complicated Cases	Very complex cases
• How?	Opinions	Qualitative observations	Ordinary measurements	Specialised measurements
• Cost?	Very low	Low	Average	High
• Duration (order of magnitude)	10 min	2 hours	1 day	A few days
• By whom?	Workers + company management	Workers + company management	Same + specialists	Same + specialists + experts
• Knowledge - working conditions - ergonomics	Very high Low	High Average	Average High	Low Specialised

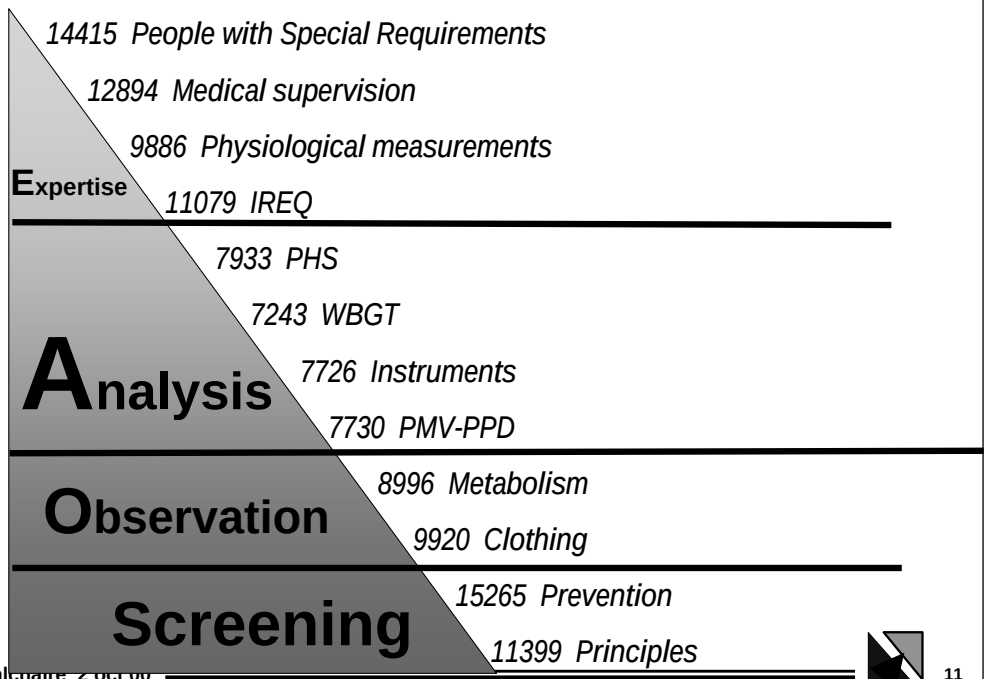
Characteristics

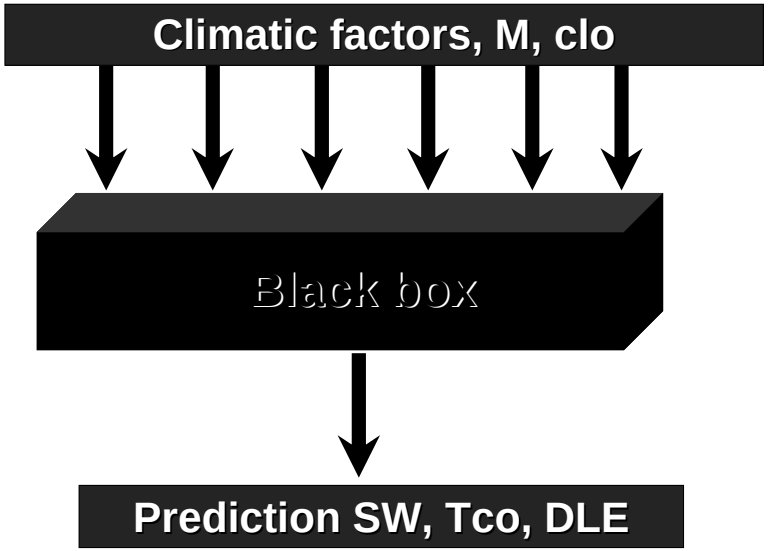
- Participative
  - Workers play the essential role in the dynamics of improvement
  - Occupational health specialists and experts are helping
- Structured in 4 complementary stages
  - Requiring complementary knowledge and competencies



Symbol	Term	Unit	Symbol in the program
-	code =1 if walking speed entered, 0 otherwise	-	defspeed
-	code =1 if walking direction entered, 0 otherwise	-	defdir
α	fraction of the body mass at the skin temperature	dimensionless	-
α_i	skin-core weighting at time i	dimensionless	TskTcrwg
α_{i-1}	skin-core weighting at time (i-1)	dimensionless	TskTcrwg0
ε	emissivity of the bare skin	dimensionless	-
τ	time constant	min	-
θ	angle between walking direction and wind direction	degrees	Theta
A_{Du}	Dubois body surface area	square metre	Adu
A_p	fraction of the body surface covered by the clothing	dimensionless	Ap
A_r	effective radiating area of the body	dimensionless	Ardu
C	heat flow by convection at the skin surface	Watts per square metre	Conv
c_e	water latent heat of evaporation	Joules per kilogram	-
$C_{orr,cl}$	correction for the dynamic clothing insulation for totally clothed subjects	dimensionless	CORcl
$C_{orr,Ia}$	correction for the dynamic boundary layer insulation	dimensionless	CORia
$C_{orr,tot}$	correction for the dynamic clothing insulation as a function of the actual clothing	dimensionless	CORtot
$C_{orr\ E}$	correction for the dynamic permeation rate	dimensionless	CORe
c_p	specific heat of dry air at constant pressure	Joules per kilogram of dry air	-
C_{res}	heat flow by respiratory convection	Watts per square metre	Cres
c_{sp}	specific heat of the body	Watts per square meter per degree celsius	spHeat
D_{lim}	allowable exposure duration	min	Dlim
$D_{lim\ tre}$	allowable exposure duration for heat storage	min	Dlimtre
$D_{limloss50}$	allowable exposure duration for water loss, mean subject	min	Dlimloss50
$D_{limloss95}$	allowable exposure duration for water loss, 95% of the working population	min	Dlimloss95
D_{max}	maximum water loss	grams	Dmax
D_{max50}	maximum water loss to protect a mean subject	grams	Dmax50
D_{max95}	maximum water loss to protect 95% of the working population	grams	Dmax95
dS_i	heat stored during the last time increment	Watts per square metre	dStorage
dS_{eq}	body heat storage rate for increase of core temperature associated with the metabolic rate	Watts per square meter	dStoreq







Methodology

Stage 1: SCREENING

First stage: SCREENING

- To get an overview of the working conditions
  - for the main factors related to safety, health and well being
- Conclusions:
  - Are there complaints related to the climatic conditions?

Stage 1: SCREENING

Collect information about the work situation, in general:

- the working conditions
- the physical conditions: heat, noise, pollution,...
- the psychosocial factors
- ....

Define what is determinant for the workers health and well being

Stage 2 : OBSERVATION

OBSERVATION designed to:

- Identify particular circumstances, specific tasks, unusual working conditions where a "problem" exists
- Determine what to do to reduce or eliminate these problems: straightforward solutions
- By or with the help of the workers themselves.

Conclusion:

- Is the "problem" satisfactorily controlled or not?
- If not, the assistance of specialists is needed.

Criteria for OBSERVATION

Designed for the workers and their management

- Simple to understand by untrained people
- Avoid concepts or terms not readily understood
- Easy to use, maximum 1 hour for a specific circumstance of work
- Based on simple OBSERVATIONS (no measurement)
- Oriented towards prevention

Procedure

Discussion of

- The working conditions
- The technical process
- The characteristics of the heat or cold sources
- The possibilities of control measures.

Stage 2: OBSERVATION

Describe the working condition known to or likely to raise a thermal problem

Evaluate the situation for each of the six parameters separately:

Stage 2: OBSERVATION

AIR TEMPERATURE	
-3	• Generally freezing
-2	• Generally between 0 and 10°C.
-1	• Generally between 10 and 18°C
0	• Generally between 18 and 25°C
1	• Generally between 25 and 32°C
2	• Generally between 32 and 40°C
3	• Generally greater than 40°C

Stage 2: OBSERVATION

HUMIDITY	
-1	- Dry throat/eyes after 2-3 hours
0	- Normal
1	- Moist skin
2	- Skin completely wet
THERMAL RADIATION	
-1	- Cold on the face after 2-3 minutes
0	- No radiation discernible
1	- Warm on the face after 2-3 minutes
2	- Unbearable on the face after > 2 minutes
3	- Immediate burning sensation

Stage 2: OBSERVATION

AIR MOVEMENTS	
-2	. cold strong air movements
-1	. cold light air movements
0	. no air movements
1	. warm light air movements
2	. warm strong air movements
WORK LOAD	
0	. office work: easy low muscular constraints,
1	occasional movements at normal speed.
2	. Moderate work with arms or legs
	. Intense work with arms and trunk
3	. very intense work at high speed: stairs, ladders

Stage 2: OBSERVATION

CLOTHING	
0	- light, flexible, not interfering with the work
1	- long, heavier, interfering slightly with the work
2	- clumsy, heavy, special for radiation, humidity
3	- special overalls with gloves, hoods, shoes
OPINION OF THE WORKERS	
-3	- shivering, strong discomfort for the whole body
-2	- strong local discomfort overall sensation coolness
-1	- slight local cool discomfort
0	- no discomfort
1	- slight sweating and discomfort thirst
2	- heavy sweating, work pace modified
3	- excessive sweating, special clothing

OBSERVATION: Synthesis

Summary of the results

	-3	-2	-1	0	1	2	3
Air temperature							O
Humidity						O	
Radiation					O		
Air movements				O			
Work Load						O	
Clothing							O

OBSERVATION: Solutions

AIR TEMPERATURE

- Locate the sources of heat or cold in the periphery
- Eliminate the sources of hot or cold air
- Insulate the hot surfaces
- Exhaust hot or cold air locally
- Ventilate without draughts
- Use clothes with lower or higher insulation
- ...

Stage 2: OBSERVATION

HUMIDITY

- Eliminate the leaks of vapour and water
- Enclose all evaporating surface
- Use clothes waterproof but permeable to vapour
- ...

THERMAL RADIATION

- Reduce the radiating surfaces
- Use reflecting screens
- Insulate or treat the radiating surface
- Locate workstations away from radiating surfaces
- Use special protective clothes reflecting radiation
- ...

Stage 2: OBSERVATION

AIR MOVEMENTS
Reduce or eliminate air draughts
Use screens to protect locally against draughts
Locate workstations away from air draughts
...

WORK LOAD
Reduce the movements during work
Reduce displacements
Reduce the speed of movements
Reduce the efforts, use mechanical assistance...
Improve the postures...

Stage 2: OBSERVATION

CLOTHING

- Improve the design of the clothing
- Select more suitable materials
- Look for lighter materials
- ...

OBSERVATION: Synthesis

Estimate what the situation will be after improvement

	-3	-2	-1	0	1	2	3
Air temperature						X	O
Humidity					X	O	
Radiation					=		
Air movements				=			
Work Load					X	O	
Clothing					X		O

Stage 2: OBSERVATION

Determine, if necessary, the measures to be taken in the short-term:

- Hot or cold drinks
- Recovery periods
- Work organisation
- Clothing....

OBSERVATION: Conclusions

- Decide whether a more detailed ANALYSIS is needed to quantify and to solve the problem.
- Determine the measures to be taken in the short-term if needed:
  - Drinks, Recovery periods,Work organisation
  - Clothing....

Stage 3: ANALYSIS

Stage 3: ANALYSIS

- Deal with specific conditions
- Usually involve measurements

Conducted with the help of OH services with adequate training

- To find technical solutions
- To define organisational solutions and short-term protection measures

Conclusions

- Is the assistance of an expert required?

Criteria for ANALYSIS

Designed for OH specialists

- Use common concepts and techniques
- If necessary simple, measurements
  - To identify the causes of the problems
  - And the means to solve them
- Useable in less than one day
- Oriented towards prevention

ANALYSIS: Objectives

For the conditions selected during stage 2:

OBSERVATION

To quantify the risk of thermal discomfort or

- To Identify more elaborated solutions
- To determine the optimum work organisation.
- To determine whether an EXPERTISE (stage 4) is needed.

ANALYSIS: Procedure

Analyse the sequence of activities:

- Description of the activities.
- Mean and maximum durations.
- Period concerned by the working situation.
- Exposed workers

ANALYSIS: Procedure

ANALYSIS of the working situation during representative period(s) of time

- Measurement or estimation of the mean and maximum values
- Computation of the indices (PMV/PPD, PHS)

ANALYSIS: Synthesis

	Activity ...		Activity ...	
	mean	Max	mean	max
t_a RH t_g v_a M Clo				
PMV PPD WBGT PHS / DLE				

ANALYSIS:Interpretation

Risk in the present situation

cold constraint	PMV < -2
cold discomfort	-2 < PMV < -0,5
comfort	-0,5 < PMV < 0,5
warm discomfort	0,5 < PMV < 2
constraint in the long term	DLE < 480 min
constraint in the short term	DLE < 120 min
immediate constraint	DLE < 30 min

ANALYSIS: Procedure

- Determine the acceptability of the working condition by comparing:
  - mean-maximum duration of each activity
  - the DLEs.
- Define prevention/control techniques
- Define the optimum work organisation.
- Determine the residual risk after implementation of these prevention/control measures.

ANALYSIS: synthesis

	Activity ...	Activity

3. RISK
• Class of risk
• If heat stress
  • Sweating rate
  • Water loss per day
  • DLE		

4. ACCEPTABILITY		
5. PREVENTION/CONTROL MEASURES		
6. RESIDUAL RISK		
7. NEED FOR AN EXPERTISE		
8. SHORT TERM MEASURES		
9. MEDICAL SURVEILLANCE		

Stage 4: EXPERTISE

Stage 4: EXPERTISE

Better characterise some heat or cold sources and/or some unusual circumstances

- Specific measurements
- Specific investigation techniques

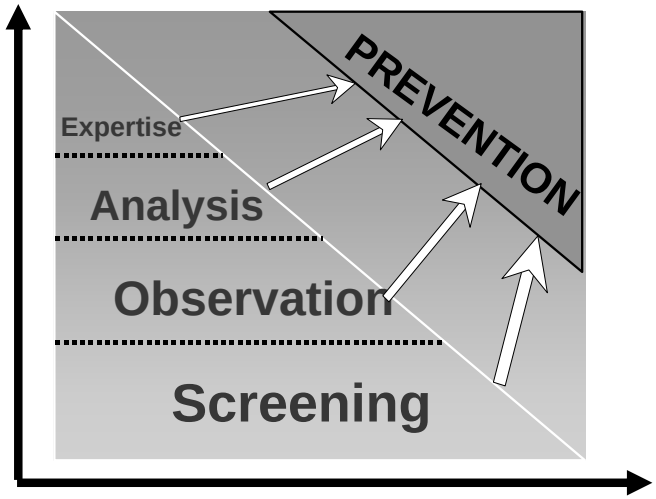
Characterise the overall exposure of the workers

Look for sophisticated prevention/control measures

Stage 4: EXPERTISE

- Sequence of activities:
- Specialised measurements:
  - Radiation, air circulation,...
  - Metabolic rate: Oxygen consumption, HR
  - Clothing insulation
  - Time variations
- Computation of indices according to time: PMV - PPD, Predicted Heat Strain

Prevention Strategy



Thank you