Gezondheidsraad
Health Council of the Netherlands

To the State Secretary of Social Affairs and Employment

Subject	: Advisory letter *Heat stress*
Your reference	: G&VW/GW/2011/2388
Our reference	: I-762/11/AvdB/fs/832-G2 Publication no. 2011/31E
Enclosure(s)	: 1
Date	: November 16, 2011

Dear State Secretary,

On 24 March 2008, the Health Council of the Netherlands sent you the advisory report entitled *Heat stress in the workplace*. Your Ministry subsequently submitted a written request to the Health Council, on 23 February 2011, requesting a recommendation concerning "practically manageable occupational exposure limits" for heat stress (in terms of body core temperature; see Annex A). In its advisory letter, the Council's Committee on the Identification of Workplace Risks (see Annex B) reports its findings on health-based and safety-based occupational exposure limits (OELs) for heat stress. The advisory letter was reviewed by the Council's Standing Committee on Health and Environment.

Conclusions from the foregoing report

The previous report, which was published in 2008, focused on a question posed by the then Minister of Social Affairs and Employment. The question concerned (international) scientific insights at the present time, or expected in due course, with regard to health-based or safety-based OELs for heat stress in the workplace.[1] In other words, this involved the options for setting OELs for heat stress, rather than making recommendations for specific values. In 2008, the Committee formulated three conclusions with regard to this question:

P.O. Box 16052
NL-2500 BB The Hague
Telephone +31 (70) 340 70 17
Telefax +31 (70) 340 75 23
E-mail: a.vander.burght@gr.nl

Visiting Address
Parnassusplein 5
NL-2511 VX The Hague
The Netherlands
www.gr.nl

- There are health-based, scientifically based OELs for the prevention of short-term adverse physical effects resulting from heat stress. Some examples of these OELs are the reference values for ambient heat, expressed as Wet Bulb Globe Temperature (WBGT) [a], in ISO standard 7243:1989 and the Recommended Alert Limits (RAL) and Recommended Effect Limits (REL; which are also expressed as WBGT) of the American National Institute for Occupational Safety and Health (NIOSH).[2,3] On the basis of current scientific insights, there is no reason to revise the OELs for short-term adverse physical effects.
- The OELs in question do not account for the short-term adverse mental effects of heat stress. Two such effects, highlighted in the scientific literature, are decreased vigilance and impaired judgment under the influence of heat stress. These can increase the risk of making mistakes, which can give rise to unsafe work situations. It also emerged that vigilance is affected by levels of heat stress before any physical effects occur. The scientific literature appears to hold out the prospect of safety-based OELs associated with mental performance.
- As yet, too little is known about the long-term effects of heat stress, both physical and mental, to support specific recommendations for health-based or safety-based OELs.

The scientific data

In response to this report, you requested recommendations for "practically manageable" health-based OELs. This requires a review of the scientific literature. The Committee accordingly conducted a literature survey in the online databases PubMed, PsycINFO, and Web of Science using a series of key words derived from the references cited in the previous report. Further details of this literature survey are set out in Annex C.

Previous scientific studies have already been summarised in good-quality reviews. The Committee has therefore focused on primary research articles published during the past ten years.[3-5] For the purposes of this advisory letter it has used a selection of reviews and recent primary publications that are relevant to this document.

[a] Wet bulb globe temperature (WBGT) is an index unit for environmental warmth, that combines measurements of air temperature (dry-bulb temperature), air humidity and air speed (natural wet bulb temperature) and radiant temperature (black globe temperature) according to one of the following formulae: $WBGT_{outside} = 0.7T_{wet} + 0.1T_{dry} + 0.2T_{black}$ (outside in direct sunlight) or $WBGT_{inside} = 0.7T_{wet} + 0.3T_{black}$ (inside or outside with no direct sunlight).

P.O Box 16052
NL-2500 BB The Hague
Telephone +31 (70)340 70 17
Telefax +31 (70)340 75 23
E-mail: a.vander.burght@gr.nl

Visiting Address
Parnassusplein 5
NL-2511 BX The Hague
The Netherlands
www.gr.nl

In addition to its survey of scientific literature, the Committee assessed the extent to which publications by national and international research institutes or organisations that had been important sources of information in the foregoing report had been revised since 2008. After consulting their websites, the Committee found that the institutes and organisations had not amended or replaced their documents in recent years. The bodies in question were the World Health Organization (WHO), the International Organization for Standardization (ISO), the American National Institute for Occupational Safety and Health (NIOSH), the American Conference of Governmental Industrial Hygienists (ACGIH), and the American Occupational Safety and Health Administration (OSHA).[3,6-9]

The short-term physical effects of heat stress

As described in the previous report, the main adverse short-term effects of heat stress (in work situations) relate to acute heat illnesses. These range from relatively harmless itchy skin and blistering, muscle cramps and fainting (heat syncope), to health-threatening heat exhaustion and heat-stroke.[1] Heat exhaustion involves an increase in the body core temperature[b], to between 38°C and 39°C; with heat-stroke the body core temperature exceeds 40.5°C.

Other short-term effects of heat stress may include reduced fertility in men who are exposed to heat stress in the course of their work, such as welders and metal workers, as well as those working in the ceramics industry and in bakeries. However, it was not possible to derive the associated levels of heat stress from these epidemiological studies.

More recent scientific literature (i.e. published since 2008), sheds no new light on the effects in question.

At international level there are a range of different OELs aimed at protecting workers against the short-term effects of heat stress. These existing OELs are intended to prevent body core temperature from rising above 38°C. That limit of 38°C is based on a 1969 WHO recommendation which stated that “it is considered inadvisable for the deep body temperature to exceed 38°C for prolonged daily exposures in heavy work”.[9] This recommendation was upheld by experts

[b] Body core temperature: the temperature inside the trunk and brain; the temperature of the blood in the lung artery being its standard.

P.O Box 16052
NL-2500 BB The Hague
Telephone +31 (70)340 70 17
Telefax +31 (70)340 75 23
E-mail: a.vander.burght@gr.nl

Visiting Address
Parnassusplein 5
NL-2511 BX The Hague
The Netherlands
www.gr.nl

participating in the 2002 WHO workshop "Adverse temperature levels in the human body".[10] That workshop involved an evaluation of scientific data on the effects of hyperthermia on the human body. Its objective was to establish limit values for radio-frequency electromagnetic fields.

Body core temperature as a biological OEL for heat stress

The Minister of Social Affairs and Employment has asked the Health Council if a body core temperature of 38°C could serve as a health-based OEL to prevent the short-term effects of heat stress. This is because current OELs (e.g. NIOSH's reference values or the ISO standard) are intended to prevent the body core temperature from rising above 38°C.[10] However, the scientific literature shows that the body core temperature can fluctuate.[11] At population level, the mean body core temperature for both men and women is 37.0°C, with a slight difference in distribution between genders.[12]

An individual's core temperature follows a 24-hour cycle, or circadian rhythm. The lowest value occurs early in the morning and the highest value in the late afternoon or early evening.[13] Within any given 24-hour period, the highest and lowest values differ by approximately one degree Celsius. As a result, some individuals will reach and exceed the 38°C "limit" during their normal 24-hour rhythm. In women who are ovulating or using hormone-based contraceptives, the entire 24-hour body-core-temperature curve shifts upwards by about half a degree Celsius.[13]

The body core temperature also varies from one individual to another. This is because the core temperature is influenced by an individual's age and fitness level. In the young, and those who are physically fit, the difference between the highest and lowest 24-hour value is greater than in older people, and those who are unfit or chronically ill.[13] The healthier the individual, the greater the daily range of body core temperature and the greater the chance that they will exceed the 38°C "limit". Accordingly, those who exceed this limit are not always at risk. Body core temperatures (well) in excess of 38°C have been recorded in athletes or experienced workers in physically demanding occupations, such as fire fighters, soldiers, or miners. Yet the individuals in question exhibited no symptoms of acute heat illnesses.[14-18]

In the light of the individual fluctuations in body core temperature described above, the Committee concludes that this parameter is not a suitable basis for a health-based OEL. The Committee also points out that there are certain practical objections to an OEL based on body core temperature. Temperature measurements in the rectum, oesophagus, and gastrointestinal tract correspond most closely to body core temperature and are preferable to measurements taken under the tongue, in

P.O Box 16052
NL-2500 BB The Hague
Telephone +31 (70)340 70 17
Telefax +31 (70)340 75 23
E-mail: a.vander.burght@gr.nl

Visiting Address
Parnassusplein 5
NL-2511 BX The Hague
The Netherlands
www.gr.nl

the armpits, or in the ear.[11] However, measurements in these areas of the body are difficult to make, are sensitive to the ingestion of cold or hot drinks, and involve a degree of discomfort for the worker in question.

Health-based recommended OEL for short-term physical effects

Is the Committee aware of any other options for a health-based recommended OEL that can protect workers from the short-term effects of heat stress? How relevant are the OELs developed by two different institutions i.e., the reference values for the WBGT from ISO 7243:1989, and NIOSH's Recommended Effect Limits (RELs) and Recommended Alert Limits (RALs), also in WBGT.[2,3,19] After all, both OELs aim to prevent the body core temperature from rising above 38°C.

While the Committee takes the view that an OEL based on body core temperature is not worthwhile, it does see OELs for ambient heat that prevent body core temperature (at group level) from exceeding 38°C as a useful way of protecting workers against the short-term health effects of heat stress.

Scientists see the reference values for ambient heat, expressed as the WBGT, as a good indicator of heat stress, albeit with some limitations.[20] The Committee considers the OELs recommended by NIOSH to be important because of the available health-based evidence which, unlike the ISO standards, is well documented in the report itself.[1,3] NIOSH's WBGT values can be derived from two graphs, one for acclimatised individuals (REL) and one for unacclimatised individuals (RAL). The WBGT values for ISO 7243:1989 are documented in table format. They have been published by various parties, including Parsons in 2006 (Table 1).[21] Although NIOSH was involved in the development of ISO 7243:1989, the reference values of both institutions are not an exact match. For light and moderate levels of physical exertion (up to 200 Watts/m^2 or 360 watts for total skin surface), the ISO standard and NIOSH have the same WBGT values. The ISO values for high and very high levels of physical exertion are a few degrees lower than those developed by NIOSH. This is because the ISO values take "sensible air movement" into account. In case a workplace lacks "sensible air movement", the ISO standard at high levels of physical exertion is lower than the NIOSH standard. However, the Committee points out that the ISO standard does not provide a clear definition of "sensible air movement", which tends to undermine any attempt to distinguish between these OELs.

P.O Box 16052
NL-2500 BB The Hague
Telephone +31 (70)340 70 17
Telefax +31 (70)340 75 23
E-mail: a.vander.burght@gr.nl

Visiting Address
Parnassusplein 5
NL-2511 BX The Hague
The Netherlands
www.gr.nl

Table 1 ISO 7243: Reference values for the WBGT index for external heat stress (according to Parsons 2006).

Metabolism (M)	WBGT reference value	
	Acclimatised individual	Unacclimatised individual
watt/m^2	°C	°C
At rest M ≤ 65	33	32
65 < M ≤ 130	30	29
130 < M ≤ 200	28	26
200 < M ≤ 260	25 (26)*	22 (23)*
M > 260	23 (25)*	18 (20)*

* Figures in parentheses apply to the situation with sensible air movement and correspond to the NIOSH standards.

When all of the available scientific information is taken into consideration, the Committee sees no reason to revise its conclusion in the previous report, which was that there are health-based, scientifically supported OELs available that can prevent the short-term adverse physical effects of heat stress.

Short-term mental effects cannot be quantified

In its 2008 report, the Committee wrote that heat stress can also adversely affect various mental functions.[1] An increase in ambient temperature causes a decline in vigilance, more mistakes and accidents, as well as reduced short-term memory and concentration, and greater psychological distress.

Following an exhaustive examination of the scientific literature, the Committee concludes that, since the end of the 20th century (when the reviews by Ramsey, Hancock, Vasmatzidis, and Pilcher et al. were published), little progress has been made in terms of clarifying the adverse mental effects of heat stress.[4,5,22] In a recent publication, Gaoua summarised the current level of knowledge in this field and confounding factors in the existing body of research, in addition to making recommendations for future research.[23] She hypothesised that the mental effects result from the brain's inability to curb the physical effects of heat stress while simultaneously performing mental tasks.

The Committee endorses the existence of the confounding factors cited by Gaoua in the available scientific studies. The studies differ in the way that heat stress was generated. This was either done

P.O Box 16052
NL-2500 BB The Hague
Telephone +31 (70)340 70 17
Telefax +31 (70)340 75 23
E-mail: a.vander.burght@gr.nl

Visiting Address
Parnassusplein 5
NL-2511 BX The Hague
The Netherlands
www.gr.nl

passively or by means of physical exertion. They also used different index units for ambient heat. In many cases, there is no data on the test subjects' level of hydration/dehydration (the body's water balance), their degree of acclimatisation (habituation), and their body core temperature.[1] Another noteworthy point is that experimental research on heat stress often involves just two or three different, widely varying ambient temperatures.[24] Given these differences, the Committee is unable to indicate a threshold level below which no adverse, heat-stress-related mental effects would occur.[22,25]

On several points there is scientific consensus, that vigilance is affected most by heat stress, followed by dual tasking, then tracking a moving target on a computer. The least affected is simple mental performance.[4,10] In other words, the more complex the mental task, the more sensitive it is to the effects of heat stress. It is also scientifically accepted that mental effects occur at levels of heat stress where physical effects are not yet observed.[10] Based on Ramsey's work, and their own research, Hancock and Vasmatzidis calculated that a body core temperature rise of 0.055°C results in diminished vigilance, while physical effects occur at an increase of 1.65°C.[4] The calculations omitted details of the test subjects' age or gender, as there was insufficient data on these individual factors. A recent study found a relationship between daily fluctuations in skin temperature and vigilance. At constant ambient temperature, a rise of 1°C in skin temperature (measured on the chest) equated to a 7% reduction in test reaction speed.[26] It is not clear whether the skin temperature measurements in this study reflected fluctuations in body core temperature. In an earlier study, in which both skin and core temperatures were measured, no relationship between skin temperature and mental performance were found.[27]

As yet, little research has been carried out into the mental effects of heat stress in work situations. In addition to the studies reported in the 2008 report, the Committee came across a recent study of 40,000 Thai workers.[28] In their responses to a questionnaire, 18% of these workers (prevalence) indicated that they had often been exposed to high temperatures in the course of their work, during the preceding twelve months. The frequency of cases of psychological distress and poor health reported by this group of workers was significantly greater than in the other workers, who had not been exposed to high temperatures. Psychological distress was mainly reported by men aged from 15 to 29, and poor health in women above the age of 45. The effects under investigation, which were reported by the workers themselves, spanned a period of four weeks prior to the study. No definition of "poor health" was given, and the result was based on a single question in the questionnaire. Psychological distress was the result of three questions. No objective measures of health effects were made.

P.O Box 16052
NL-2500 BB The Hague
Telephone +31 (70)340 70 17
Telefax +31 (70)340 75 23
E-mail: a.vander.burght@gr.nl

Visiting Address
Parnassusplein 5
NL-2511 BX The Hague
The Netherlands
www.gr.nl

Based on the scientific literature studied, the Committee has determined that a rising ambient temperature involves a greater risk of making mistakes, possibly resulting in health impairment for those involved, or others. Although the Committee's previous report (2008) indicated that safety-based OELs for such effects were a realistic prospect, the data turn out to be insufficient for the effects to be quantified. Reviews and recent studies show that there are still many scientific issues surrounding the effects of heat stress on mental performance. Moreover, it appears that even minimal increases in body core temperature can have an effect on vigilance. Accordingly, it is by no means certain that it will be possible ever to establish safety-based OELs for the mental effects in question.

There is still insufficient data on the long-term effects of heat stress

In its previous report, the Committee stated that there has been little or no research into the long-term physical effects of heat stress. There have been reports of kidney stones and possible effects on renal function. There is also tentative evidence that heat stress can boost the development of skin cancer caused by ultraviolet radiation (when working outdoors).[1] No new studies into any of these effects have been published since 2008. The Committee did manage to find another three studies dating from an even earlier period. However, there is still insufficient scientific evidence on long-term effects of heat stress to provide the basis for a health-based OEL.

According to the experts in the 2002 WHO working group, heat stress can boost the effects of known carcinogens such as radiation or chemicals, but there is insufficient scientific evidence that heat stress itself can give rise to tumours.[10]

Some workers are at greater risk of heat stress than others

As the Committee stated in its previous report, workers differ in their degree of susceptibility to heat stress. This is a reflection of the nature of their work, the environmental conditions involved, and their own personal traits.[1]

The Committee would like to draw attention, once again, to two of these personal traits in particular – acclimatisation and hydration. The scientific literature shows that worker habituation to heat stress, and drinking to restrict fluid lost when sweating, can both ameliorate the effects of heat stress.[29,30] The process of acclimatisation takes seven to ten days. Experienced workers who perform physically demanding work or who work in a high-temperature environment are therefore acclimatised and more resistant to the effects of heat stress.[31] This is conditional on the restriction

P.O Box 16052
NL-2500 BB The Hague
Telephone +31 (70)340 70 17
Telefax +31 (70)340 75 23
E-mail: a.vander.burght@gr.nl

Visiting Address
Parnassusplein 5
NL-2511 BX The Hague
The Netherlands
www.gr.nl

of water loss through sweating to no more than two percent of body weight.[32] New, inexperienced workers, employees who return from an absence of more than one week, or workers facing heat stress on hot summer days may be more at risk of making mistakes. They may also run a greater risk of acute heat illnesses due to heat stress, especially in workplaces where concentration and alertness are called for or where high levels of physical exertion are required.

There is no data on heat stress in the Dutch working situation

As in the previous report, the Committee notes that no data is available on the number of workers in the Netherlands who are exposed to heat stress at work. It reached this conclusion after consulting the 2009 Arbobalans, the 2009 Netherlands Working Conditions Survey (NEA), and Statistics Netherlands.[33-35] Also the Committee is not aware of any data on the frequency, level and duration of heat stress in Dutch workplaces. In view of the adverse mental effects and potential safety risks associated with heat stress, the Committee considers it important to point out that 58 percent of the 20,000 employees surveyed in the NEA reported that their work required intense cognitive effort, 84 percent said that their work required a sustained mental focus, and 75 percent indicated that their work required considerable attention.[35] Those working in the areas of education, financial services, public administration, the health service, welfare, and business services in particular have experienced an upward trend in cognitive load compared to previous years.

Recommendation

To protect against the short-term adverse physical effects of heat stress, the Committee upholds the conclusion, given in its previous report, that health-based OELs for ambient heat (in WBGT) are already available and prevent the average body core temperature (at group level) from exceeding 38°C. In this way, these OELs ensure that the risk of severe acute heat illnesses remains negligibly small. The Committee prefers the health-based, scientifically supported OELs developed by NIOSH. One drawback of the REL and RAL values recommended by NIOSH is that these WBGT values have to be read-off from a diagram. Accordingly, for the sake of completeness, the Committee points out that, in the case of light and moderate levels of exertion, the WBGT values of ISO 7243:1989 match those given by NIOSH and have been documented, in table form, in Parsons' 2006 publication (Table 1).[21] At high levels of effort, NIOSH's WBGT values can also be derived from Parsons' publication.

P.O Box 16052
NL-2500 BB The Hague
Telephone +31 (70)340 70 17
Telefax +31 (70)340 75 23
E-mail: a.vander.burght@gr.nl

Visiting Address
Parnassusplein 5
NL-2511 BX The Hague
The Netherlands
www.gr.nl

Gezondheidsraad
Health Council of the Netherlands

It is not possible to derive a health-based OEL based on body core temperature at individual level. This is because any given individual's body core temperature fluctuates too widely.

Regarding the short-term adverse mental effects of heat stress, the Committee concludes that the risk of making mistakes increases as the ambient temperature and/or body core temperature rises. However, there is still insufficient scientific data for this to be quantified.

Regarding the adverse, long-term effects of heat stress, the Committee upholds its conclusion that the scientific data are inadequate to serve as a basis for health-based or safety-based OELs.

Yours sincerely,
(signed)
Professor L.J. Gunning-Schepers
President

P.O Box 16052
NL-2500 BB The Hague
Telephone +31 (70)340 70 17
Telefax +31 (70)340 75 23
E-mail: a.vander.burght@gr.nl

Visiting Address
Parnassusplein 5
NL-2511 BX The Hague
The Netherlands
www.gr.nl

Literature

1 Health Council of the Netherlands. Heat stress in the workplace. The Hague: Health Council of the Netherlands, 2008; publication no. 2008/24.
2 NEN-ISO 7243:1989. Nederlands Normalisatie Instituut; 1989.
3 National Institute for Occupational Safety and Health. Criteria for a recommended standard Occupational exposure to hot environments. Revised criteria 1986. 1986: 86-113.
4 Hancock PA, Vasmatzidis I. Effects of heat stress on cognitive performance: the current state of knowledge. Int J Hyperthermia 2003; 19(3): 355-372.
5 Pilcher JJ, Nadler E, Busch C. Effects of hot and cold temperature exposure on performance: a metaanalytic review. Ergonomics 2002; 45(10): 682-698.
6 American Conference of Governmental Industrial Hygienists. TLVs and BEIs. 2010.
7 International Organization for Standardization. www.iso.org.
8 Occupational Safety & Health Administration. OSHA Technical Manual Section III: Chapter 4. www.osha.gov/dts/osta/otm/otm_iii/otm_iii_4.html.
9 World Health Organization. Health factors involved in working under conditions of heat stress. Report of a WHO Scientific Group. World Health Organ Tech Rep Ser 1969; 412: 1-32.
10 Goldstein LS, Dewhirst MW, Repacholi M, Kheifets L. Summary, conclusions and recommendations: adverse temperature levels in the human body. Int J Hyperthermia 2003; 19(3): 373-384.
11 Lim CL, Byrne C, Lee JK. Human thermoregulation and measurement of body temperature in exercise and clinical settings. Ann Acad Med Singapore 2008; 37(4): 347-353.
12 Sund-Levander M, Forsberg C, Wahren LK. Normal oral, rectal, tympanic and axillary body temperature in adult men and women: a systematic literature review. Scand J Caring Sci 2002; 16(2): 122-128.
13 Kelly G. Body temperature variability (Part 1): a review of the history of body temperature and its variability due to site selection, biological rhythms, fitness, and aging. Altern Med Rev 2006; 11(4): 278-293.
14 Brake DJ, Bates GP. Deep body core temperatures in industrial workers under thermal stress. J Occup Environ Med 2002; 44(2): 125-135.
15 Ely BR, Ely MR, Cheuvront SN, Kenefick RW, DeGroot DW, Montain SJ. Evidence against a 40 degrees Celsius core temperature threshold for fatigue in humans. J Appl Phys 2009; 107: 1519-1525.

P.O Box 16052
NL-2500 BB The Hague
Telephone +31 (70)340 70 17
Telefax +31 (70)340 75 23
E-mail: a.vander.burght@gr.nl

Visiting Address
Parnassusplein 5
NL-2511 BX The Hague
The Netherlands
www.gr.nl

16 McLellan TM, Selkirk GA. The management of heat stress for the firefighter: a review of work conducted on behalf of the Toronto fire service. Ind Health 2006; 44: 414-426.
17 Tippet MLSJR, Lacambra M, Horswill CA. Core temperature and sweat responses in professional women's tennis players during tournament play in the heat. J Athlet Training 2011; 46(1): 55-60.
18 Amos D, Hansen R, Lau WM, Michalski JT. Physiological and cognitive performance of soldiers conducting routine patrol and reconnaissance operations in the tropics. Mil Med 2000; 165(12): 961-966.
19 NEN-ISO 7933:2004. Nederlands Normalisatie Instituut; 2004.
20 Budd GM. Wet-bulb globe temperature (WBGT)--its history and its limitations. J Sci Med Sport 2008; 11(1): 20-32.
21 Parsons K. Heat stress standard ISO 7243 and its global application. Ind Health 2006; 44: 368-379.
22 Ramsey JD. Task performance in heat: a review. Ergonomics 1995; 38(1): 154-165.
23 Gaoua N. Cognitive function in hot environments: a question of methodology. Scand J Med Sci Sports 2010; 20 Suppl 3: 60-70.
24 Gaoua N, Racinais S, Grantham J, El MF. Alterations in cognitive performance during passive hyperthermia are task dependent. Int J Hyperthermia 2011; 27(1): 1-9.
25 Hancock PA, Ross JM, Szalma JL. A meta-analysis of performance response under thermal stressors. Hum Factors 2007; 49(5): 851-877.
26 Romeijn N, Van Someren EJW. Correlated fluctuations of daytime skin temperature and vigilance. J Biol Rhythms 2011; 26(1): 68-77.
27 Simmons SE, Saxby BK, McGlone FP, Jones DA. The effect of passive heating and head cooling on perception, cardiovascular function and cognitive performance in the heat. Eur J Appl Physiol 2008; 104(2): 271-280.
28 Tawatsupa B, Lim LLY, Kjellstrom T, Seubsman S, Sleigh ATCSt. The association between overall health, psychological distress, and occupational heat stress among a large national cohort of 40,913 Thai workers. Gobal Health Action 2010; 3(5034 - doi:10.3402/gha.v3i0.5034).
29 Garrett AT, Goosens NG, Rehrer NG, Patterson MJ, Cotter JD. Induction and decay of short-term heat acclimation. Eur J Appl Physiol 2009; 107: 659-670.
30 Ishikawa T, Tamura H, Ishiguro H, Yamaguchi K, Minami K. Effect of oral rehydration solution on fatigue during outdoor work in a hot environment: a randomized crossover study. J Occup Health 2010; 52: 209-215.
31 Maeda T, Kaneko S, Ohta M, Tanaka K, Sasaki A, Fukushima T. Risk factors for heatstroke among Japanese forestry workers. J Occup Health 2006; 48: 223-229.
32 Kenefick RW, Sawka MN. Hydration at the work site. J Am Coll Nutr 2007; 26(5): 597S-603S.

P.O Box 16052
NL-2500 BB The Hague
Telephone +31 (70)340 70 17
Telefax +31 (70)340 75 23
E-mail: a.vander.burght@gr.nl

Visiting Address
Parnassusplein 5
NL-2511 BX The Hague
The Netherlands
www.gr.nl

33 Centraal Bureau voor de Statistiek. www.cbs.nl.

34 Klein Hesselink J, Houtman I, Hooftman W, Bakhuys Roozeboom M. Arbobalans 2009 Kwaliteit van de arbeid, effecten en maatregelen in Nederland. www.arboportaal.nl.

35 Koppes L, De Vroome E, Mol M, Janssen B, Van den Bossche S. Nationale Enquête Arbeidsomstandigheden 2009 Methodologie en globale resultaten. www.tno.nl/nea.

P.O Box 16052
NL-2500 BB The Hague
Telephone +31 (70)340 70 17
Telefax +31 (70)340 75 23
E-mail: a.vander.burght@gr.nl

Visiting Address
Parnassusplein 5
NL-2511 BX The Hague
The Netherlands
www.gr.nl

Annex **A**

Request for advice

On 23 February 2011, the Executive Director of the Health Council received a request from the State Secretary for Social Affairs and Employment for an advisory report on heat stress. The State Secretary wrote (letter G & VW/GW/2011/2388):

On 2 February, I received your letter in response to my request for a statement, in the very near future, on a health-based occupational exposure limit for the short-term physical effects of heat stress.

In this letter, you indicated that the Committee on the Identification of Workplace Risks is of the opinion that, in addition to the short-term physical effects of heat stress, consideration should be given to the short-term mental effects when determining a health-based or safety-based occupational exposure limit. The Committee indicated that it expects to be able to publish recommended occupational exposure limits for both effects around the summer of 2011.

Meanwhile, the proposal concerning these occupational exposure limits has been subject to the inevitable delays. The Ministry of Social Affairs and Employment concurs with your proposal and is confident that the Committee will be able to deliver a draft recommendation for practically manageable occupational exposure limits as a function of body core temperature timely.

I look forward to receiving your recommendation.
(signed)
drs. H.E.M. Seerden

Annex **B**

The Committee

- Professor T. Smid, *chairman*
  Endowed Professor of Working Conditions, VU University Medical Center, Amsterdam and working conditions advisor, KLM Health Services, Schiphol-East
- Professor A.J. van der Beek
  Professor of Epidemiology of Work and Health, EMGO Institute, VU University Medical Center, Amsterdam
- Professor A. Burdorf
  Professor of Occupational Epidemiology, Erasmus Medical Center, Rotterdam
- H.J. van der Brugge, *observer*
  Ministry of Social Affairs and Employment, Den Haag
- Professor M.H.W. Frings-Dresen
  Professor of Occupational Health, Coronel Institute for Work and Health, Academic Medical Center, Amsterdam
- Professor D.J.J. Heederik
  Professor of Health Risk Analysis, Institute for Risk Assessment Sciences, Utrecht
- Professor J.J.L. van der Klink
  Professor of Social Medicine, Work and Health, University Medical Center, Groningen
- Dr. P.C. Noordam, *observer*
  senior advisor, Labour inspectorate, Den Haag
- Dr. T. Spee
  Occupational Hygiene policy advisor, the Arbouw Foundation, Amsterdam

- J. van der Wal
  Head of Safety, Shell Europa Exploration and Production, Nederlandse Aardolie Maatschappij (NAM), Assen
- Dr. A.S.A.M. van der Burght, *scientific secretary*
  Health Council, Den Haag

The Health Council and interests

Members of Health Council Committees are appointed in a personal capacity because of their special expertise in the matters to be addressed. Nonetheless, it is precisely because of this expertise that they may also have interests. This in itself does not necessarily present an obstacle for membership of a Health Council Committee. Transparency regarding possible conflicts of interest is nonetheless important, both for the chairperson and members of a Committee and for the President of the Health Council. On being invited to join a Committee, members are asked to submit a form detailing the functions they hold and any other material and immaterial interests which could be relevant for the Committee's work. It is the responsibility of the President of the Health Council to assess whether the interests indicated constitute grounds for non-appointment. An advisorship will then sometimes make it possible to exploit the expertise of the specialist involved. During the inaugural meeting the declarations issued are discussed, so that all members of the Committee are aware of each other's possible interests.

Annex **C**

Literature survey

As a first step the reference values and OELs mentioned in the advisory report were checked for revisions and adaptations by consulting the websites of the World Health Organization (WHO), the International Organization for Standardization (ISO), the American National Institute for Occupational Safety and Health (NIOSH), the American Conference of Governmental Industrial Hygienists (ACGIH) and the American Occupational Safety and Health Administration (OSHA).

Next, the websites of the Dutch Labour Inspectorate, the British Health and Safety Executive (HSE), the French Agency for Food, Environmental and Occupational Health & Safety (ANSES), the Finnish Institute of Occupational Health (FIOH), the European Agency for Safety and Health at Work and the Canadian Occupational Safety were consulted on heat stress guidelines. These websites did not provide new information.

The websites of the National Guideline Clearinghouse, Clinical Evidence and the Cochrane Library were searched for information on ‘heat’ or ‘fever’. No useful information was retrieved.

The following concepts served as a starting point for the systematic literature review on heat stress as an occupational risk:

- heat (stress), work-related, and health effects (both physical and mental)
- core temperature and health effects (both physical and mental)

Series of key words and MeSH-terms were composed based on the references listed in the advisory report. Combinations of the series were used to obtain scientific publications on heat stress from the online databases PubMed, PsycInfo and Web of Science.

PubMed

In April 2011 PubMed was searched with the following combinations:

- #1 and #2 and #4
- #1 and #2 and #3

#1 = heat[tiab] or hot[tiab] or high temperature[tiab] or thermal[tiab] or climate [tiab] or environment[tiab] or WBGT[tiab] or hot temperature[MeSH]

#2 = core temperature[tiab] or body temperature[tiab] or hyperthermia[tiab] or critical internal temperature[tiab] or thermal dosimetry[tiab] or normal tissue tolerance[tiab] or physiological limits[tiab] or damage threshold[tiab] or dehydration[tiab] or body temperature regulation[MeSH] or body temperature changes[MeSH] or fever[MeSH] or heat stress disorders[MeSH]

#3 = mental[tiab] or percept*[tiab] or cognitive[tiab] or psychomotor[tiab] or vigilance[tiab] or performance[tiab] or attention[tiab] or memory[tiab] or reaction time[tiab] or tracking[tiab] or fatigue[tiab] or exhaustion[tiab] or psychological strain[tiab] or fatigue[MeSH] or psychological stress[MeSH] or neurobehavioral manifestations[MeSH] or psychological phenomena and processes[MeSH]

#4 = “health effects”[tiab] OR occupational health[MeSH] OR occupational diseases[MeSH] OR “occupational risk factor”[tiab] OR safety[MeSH] OR safet*[tiab] OR safety management[MeSH] OR risk management[MeSH] OR sprains and strains[MeSH] OR wounds and injuries[MeSH] OR health[tiab] OR disorder[tiab] OR disorders[tiab] OR syndrome[tiab] OR disease[tiab] OR diseases[tiab] OR wounds[tiab] OR injuries[tiab] OR injury[tiab] OR sprains[tiab] OR strains[tiab] OR pain[tiab] OR discomfort[tiab] OR risk[MeSH]

Due to the large number of references (approximately 10,000) from the initial survey, the systematic literature review was restricted to the last ten years. For the period January 2002 until April 2011 over 4,000 publications were retrieved. Based on the title and subsequently the executive summary, approximately 275 publications were selected that related to physical or mental effects of heat stress in humans; index units of heat stress;

physical or mental effects of dehydration in humans; heat stress in occupational situations; or the physiology of body core temperature.

PsycInfo

A similar strategy was used for a systematic literature survey in PsycInfo. The survey was conducted in May 2011 and for the period January 2002 until May 2011 approximately 200 publications were retrieved.

Web of Science

Web of Science was searched with a similar strategy. For the period January 2002 until May 2011 approximately 120 publications were retrieved.