REVISTA Ação Ergonômica

R. Ação Ergon., 15(1), 2021.
ISSN 2965-7318. doi: 10.4322/rae.v15e202105.en

EVALUATION OF THERMAL STRESS IN VEHICLES USED IN RADIO PATROL SERVICES IN OPERATION SUMMER IN THE MUNICIPALITIES OF CARAGUATATUBA AND SANTOS / SP

Ana Carolina Russo[1]*

Abstract

The work of police officers, during their work day, requires not only physical preparation, but also psychological and cognitive preparation. All of these factors negatively contribute to the physical and mental comfort of these professionals. Considering that in the summer the temperatures inside police vehicles can exceed the temperature range of between 20 and 23°C (thermal comfort condition), recommended by Regulatory Standard (NR) 17, and that police officers on patrol duty generally do not use air conditioning, this study aimed to analyze the thermal stress conditions to which military police officers in the state of São Paulo are subjected, in light of the current standards and procedures, when performing motorized patrol duty in Caraguatatuba (north coast) and Santos (south coast). The data obtained show that there is an imminent need to adapt the activity to improve the thermal comfort condition inside police vehicles.

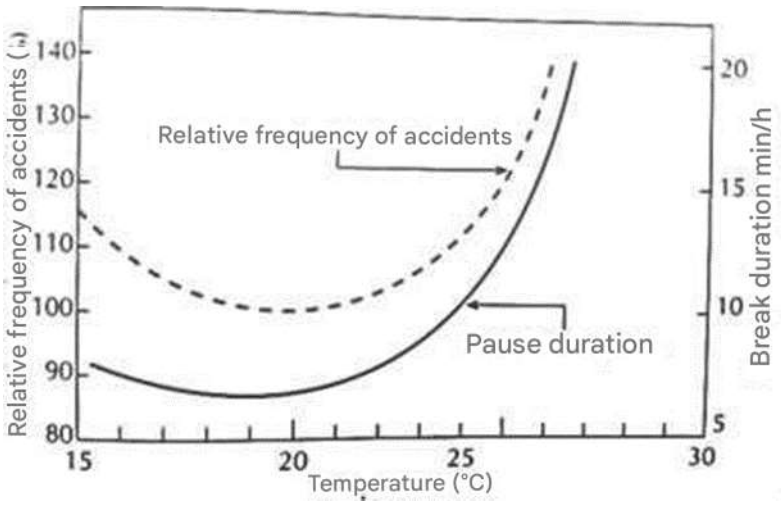
Keywords: Heat Stress. NR 17. Risk Analysis.

1. INTRODUCTION

The work environment, influenced by market demands, high productivity and high competitiveness, can trigger several negative effects on the health of rural workers, including those who work in viticulture. Unfavorable environmental conditions, such as excessive heat, are sources of stress at work, causing discomfort, increasing the risk of accidents, in addition to causing damage to health (IIDA and BUARQUE, 2016). Figure 1 shows the increase in the relative frequency of accidents as a function of the increase in temperature

[1] Jorge Duprat Figueiredo Foundation for Occupational Safety and Medicine.* ana.russo@fundacentro.gov.br.

Figure 1 – Influence of ambient temperature on a coal loading task



Source: (IIDA and BUARQUE, 2016)

The work should be carried out in the thermal comfort zone, which can be defined as the feeling of well-being experienced by a person, as a result of the satisfactory combination, in this environment, of variables such as: relative humidity (RH) and ambient temperature (TA) with the activity developed there and with the clothing worn by people (RUAS, 1999). Most of the studies available in the literature on thermal comfort focus on the issue of comfort linked to built environments (BERMEJO and colab., 2012; FILIPPÍN and FLORES LARSEN, 2012; KITOUS and colab., 2012). Thus, there is a need for research related to the thermal comfort of onboard workers (MEDEIROS, 2014).

One of the increasingly common work environments in the twenty-first century is the automobile, which is used by drivers, taxi drivers and even the armed forces, as in the case of radio patrol activities by the Military and Civil Police (MEDEIROS, 2014). The work of police officers, during their working hours, requires not only physical preparation, but also psychological and cognitive preparation (AÑEZ, 2003). In addition to the environmental issues of work, the police officer is generally equipped with instruments such as: weapons, handcuffs, batons, bulletproof vests, in addition to the uniform itself, significantly interfering in the thermal comfort of individuals, since it increases the level of thermal resistance (SIMÕES, 2003). All these factors contribute negatively to the physical and mental comfort of the agents of this type of work (MEDEIROS, 2014).

Annually from December to February, "Operation Summer" takes place, in which 16 municipalities on the south and north coast of São Paulo have reinforced policing. Considering that in the summer the temperatures inside the vehicles can exceed 25 °C, and that the police officers in radio patrol activity generally do not use air conditioning, because they remain with

the windows open, this work proposed to analyze the conditions of thermal stress to which the military police of the state of São Paulo are subjected, in the light of the rules and procedures in force (BRASIL, 1978a; FUNDACENTRO, 2001), when carrying out motorized radio patrol services in Caraguatatuba (north coast) and Santos (south coast) in the 20th and 6th Military Police Battalion of the Interior (BPMI), respectively.

2. MATERIALS AND METHODS

The collection of environmental variables (dry bulb temperature, wet bulb temperature, globe temperature, relative humidity and ambient temperature) was done through the installation of the HMTGD-1800 thermal stress meter (calibrated), HIGHMED brand (Figure 1) inside the vehicle so that it could collect thermal data while the radio patrol activity was carried out. This meter, in addition to measuring climatic variables, directly provides the values of the Wet Bulb Index and Globe Thermometer (IBUTG), as established in NR15 and Occupational Hygiene Standards (NHO) 6 (BRASIL, 1978a; FUNDACENTRO, 2001), and its range of action is between -20ºC and +70ºC.

Figure 2 - Heat stress meter

Source: Author himself

As can be seen in Figure 2, the equipment was positioned in the center of the vehicle's dashboard, in order to collect information (every one minute) in the most homogeneous way possible, uninterruptedly for 24 hours (day and night shifts) over 6 days in each municipality (Caraguatatuba and Santos).

For the calculation of the IBUTG (BRASIL, 1978a; FUNDACENTRO, 2001) the condition of internal environment was considered, that is, without incidence of direct solar load, since it was an evaluation carried out inside the vehicle, according to Equation 1.

$$IBUTG = 0.7tbn + 0.3ttt \quad (1)$$

Where:

- Tbn: natural wet bulb temperature ºC
- Tg: globe temperature ºC

The determination of the maximum allowed IBUTG is linked to the metabolic rate required in the work activity, which can be obtained in NHO 6 (FUNDACENTRO, 2001).

When the worker is exposed to two or more different thermal situations, the weighted average IBUTG, obtained from Equation 2, must be determined using the IBUTG values representative of the different thermal situations that make up the exposure cycle of the evaluated worker.

$$IBUTG = \frac{IBUTG_1 \times t_1 + IBUTG_2 \times t_2 + \cdots + IBUTG_{ii} \times t_{ii} + \cdots + IBUTG_n \times t_n}{60} \quad (2)$$

Where:

- IBUTG= Time-weighted average IBUTG in °C
- IBUTGi = IBUTG of thermal situation "i" in °C
- ti = total exposure time in thermal situation "i" in minutes, in the
- 60 consecutive minutes period more unfavorable
- i = ith thermal situation t1 + t2 + ... + ti + ... + tn = 60 minutes

The limit of occupational exposure to heat is the maximum permissible IBUTG value corresponding to the type of activity, determined from the value of the metabolic rate (M) for the exposure condition evaluated, as shown in Table 1. This limit is valid for healthy, acclimatized workers, fully dressed in light pants and shirt, and with adequate replacement of water and mineral salts.

It is worth noting that the values used in Equation 2 were those referring to the most unfavorable 60-minute period of the working day, as required by NHO 6 (FUNDACENTRO, 2001).

Table 1 - Maximum Mean IBUTG Value for Each Degree of Metabolism

Intermittent work regime with rest at the workplace (per hour)	Lightweight	Moderate	Heavy
Continuous work	Up to 30	Up to 26.7	Up to 25.0

45 minutes of work, 15 minutes of rest	30.1 to 30.6	26.8 to 28.0	25.1 to 25.9
30 minutes of work, 30 minutes of rest	30.7ºC to 31.4	28.1 to 29.4	26.0 to 27.9
15 minutes of work, 45 minutes of rest	31.5ºC to 32.2	29.5 to 31.1	28.0 to 30.0
Work is not allowed without the adoption of adequate control measures	Above 32.2ºC	Over 31.1	Above 30.0

Source: NR15 (BRASIL, 1978a)

In this article, the radio patrol activity was considered continuous and Moderate (Sitting, vigorous movements with arms and legs). Thus, the limit established for the IBUTG corresponds to a maximum value of 26.7 °C.

3. FINDINGS

Table 2 and Figure 3 show the data obtained in the analyses carried out in Caraguatatuba during the day (06:00 to 18:00).

Table 2 – Mean values of internal IBUTG, Ambient Temperature and Relative Humidity in the daytime shift in the municipality of Caraguatatuba (North Coast of SP)

Date	IBUTG (indoor) °C	Ambient temperature °C	UR %
06/01/2020	29,7	32,1	57,1
07/01/2020	34,6	40,5	35,3
08/01/2020	36,7	43,4	42,1
09/01/2020	34,6	39,5	43,9
10/01/2020	32,8	35,7	54,9
11/01/2020	41,1	47,9	40,5

Figure 3 - Mean values of internal IBUTG, Ambient Temperature and Relative Humidity in the daytime shift in the municipality of Caraguatatuba (North Coast of SP)

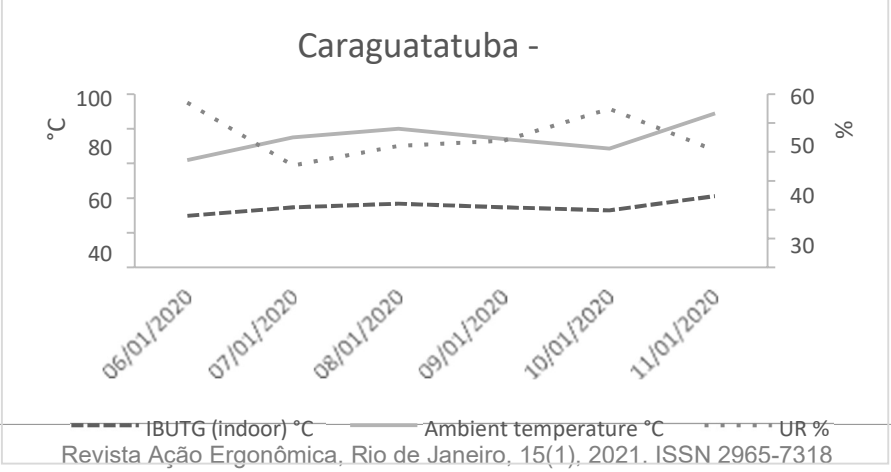
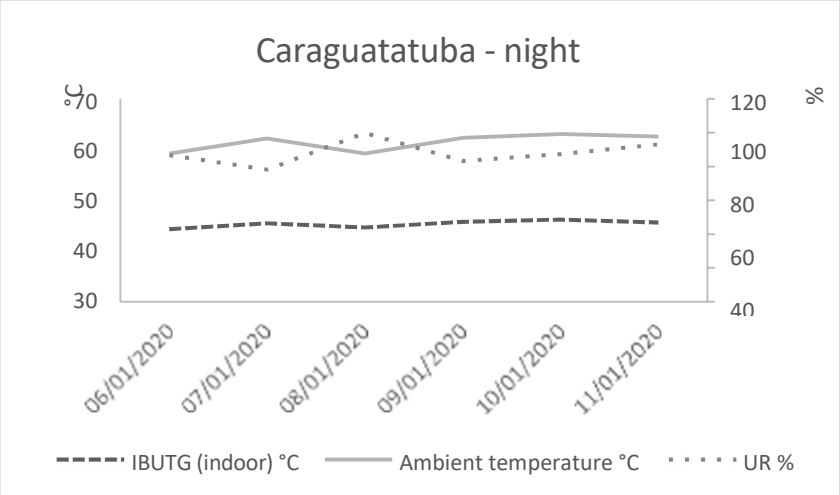


Table 3 and Figure 4 present the data obtained in the analyses carried out in Caraguatatuba at night (6:00 p.m. to 6:00 a.m.).

Table 3 – Mean values of internal IBUTG, Ambient Temperature and Relative Humidity in the night shift in the municipality of Caraguatatuba (North Coast of SP)

Date	IBUTG (indoor) °C	Ambient temperature °C	UR %
06/01/2020	25,0	26,1	86,6
07/01/2020	27,0	29,3	78,1
08/01/2020	25,6	25,5	99,7
09/01/2020	27,5	29,1	83,1
10/01/2020	28,3	29,5	87,2
11/01/2020	27,3	29,7	93,0

Figure 4 - Mean values of internal IBUTG, Ambient Temperature and Relative Humidity in the night shift in the municipality of Caraguatatuba (North Coast of SP)



As can be seen in Table 1, the maximum allowed IBUTG would be 26.7.6 °C. Thus, as can be seen in Table 2, all the days sampled (during the day) had the value exceeded when compared to what is allowed in the norm. And at night (Table 3), the IBUTG was exceeded in 4 of the 6 days of analysis and presents a high Relative Humidity, which hinders thermal exchange.

Table 4 and Figure 5 show the data obtained in the analyses carried out in Santos during the day (6:00 a.m. to 6:00 p.m.).

Table 4 – Mean values of internal IBUTG, Ambient Temperature and Relative Humidity in the daytime shift in the municipality of Santos (South Coast of SP)

Date	IBUTG (indoor) °C	Ambient temperature °C	UR %
16/01/2020	36,6	46,3	31,1
17/01/2020	26,8	29,2	69
18/01/2020	28,6	32,8	61,9
19/01/2020	25,8	29,5	63,9
20/01/2020	31,0	37,3	41,4
21/01/2020	34,2	43,0	28,3

Figure 5 - Mean values of internal IBUTG, Ambient Temperature and Relative Humidity in the day shift in the municipality of Santos (South Coast of SP)

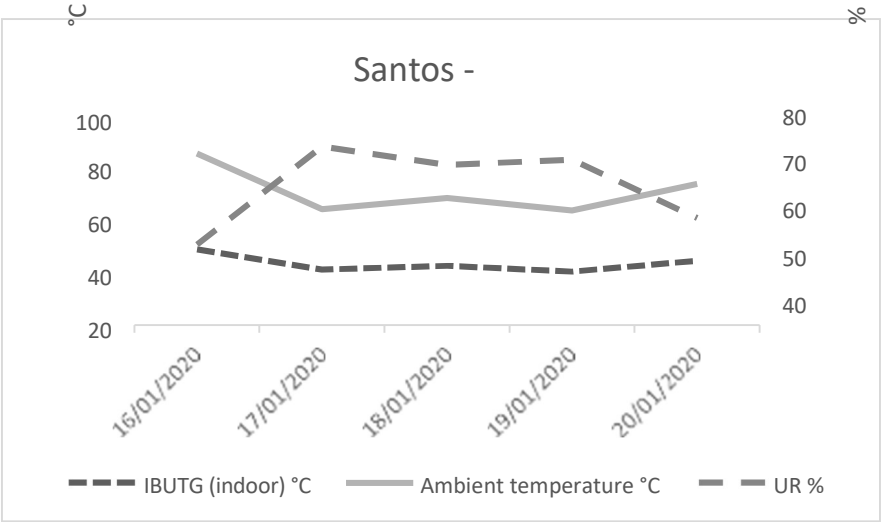


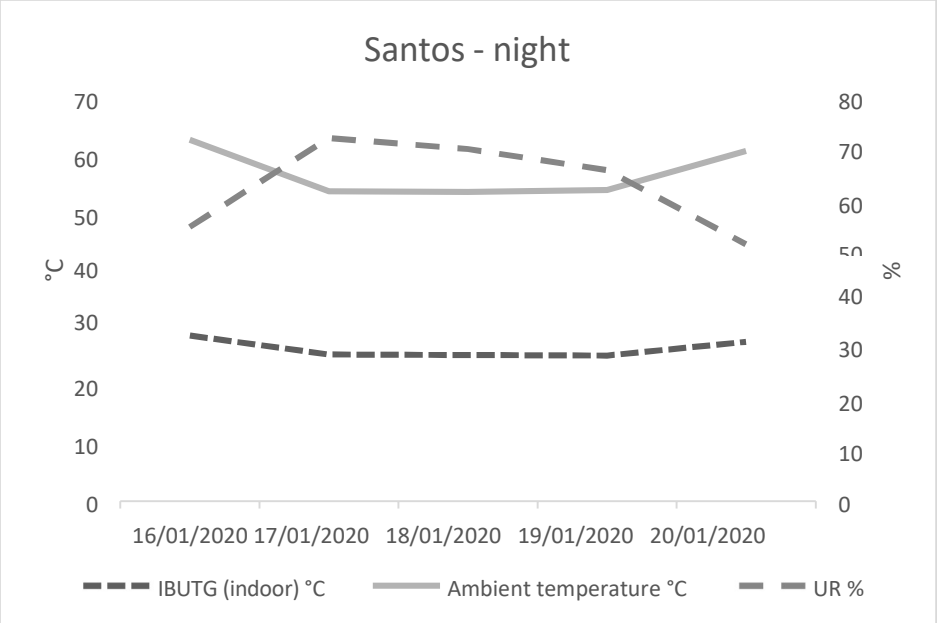
Table 5 and Figure 6 present the data obtained in the analyses carried out in Santos at night (6:00 p.m. to 6:00 a.m.).

Table 5 – Mean values of internal IBUTG, Ambient Temperature and Relative Humidity in the night shift in the municipality of Santos (South Coast of SP)

Date	IBUTG (indoor) °C	Ambient temperature °C	UR %
16/01/2020	28,8	34,1	54,5
17/01/2020	25,5	28,4	72,2
18/01/2020	25,4	28,4	70,0
19/01/2020	25,3	28,8	65,8

20/01/2020	27,7	33,2	51,1
21/01/2020	28,6	35,0	45,7

Figure 6 - Mean values of internal IBUTG, Ambient Temperature and Relative Humidity in the day shift in the municipality of Santos (South Coast of SP)



In Santos, only on 01/19/2020, during the day (Table 4), the IBUTG value did not exceed the allowed, and at night (Table 5), on 3 of the 6 days the limit was exceeded.

Regarding the Ambient Temperature, all the conditions analyzed exceed the limit of 25 °C established by NR17 (BRASIL, 1978b).

When considering the impact of clothing on the thermal comfort of police officers, it is necessary to make a correction on the value of the IBUTG limit. This correction is linked to the thermal insulation of the garment, as shown in Table 6.

Table 6 - Thermal insulation of police clothing

Thermal insulation (ICL)	
Underwear	0.03 clo
T-shirt	0.19 clo
Japona	0.69 clo
Trousers	0.28 clo
Socks	0.03 clo
Boots	0.10 clo
Beret	0.01 clo
Waistcoat	0.22 clo

Total	1,55 Clo

The total thermal insulation of the garments, according to data presented in Table 6, was obtained through the sums of the respective insulation for each item of the police uniforms (MEDEIROS, 2014).

The ORCBS - The Office of Radiation, Chemical and Biological Safety (THE OFFICE OF RADIATION, 1999) presents the correction values (Table 7).

Table 7 - Correction of IBUTG for different types of clothing

Type of clothing	Icl Value (clo)	IBUTG Correction (ºC)
Summer work uniform	0,6	0
Cotton cover	1,0	-2
Moisture protection, permeable	1,2	-4
Winter work uniform	1,4	-6

Source: ORCBS (THE OFFICE OF RADIATION, 1999)

Thus, considering that the thermal insulation established for the clothing used by the military police of São Paulo when carrying out the radio patrol was 1.55 clo (Table 6), in order to use the correction proposed by the aforementioned authors, the correction of the IBUTG was adopted at -6º C. Therefore, correcting the Limits of Exposure to Heat contained in NR-15, considering the correct thermal insulation, Table 8 is presented.

Table 8 - Heat exposure limits for radio patrol activity

Intermittent work regime with rest at the workplace (per hour)	Moderate
Continuous work	Up to 20.7
45 minutes of work, 15 minutes of rest	20.8 to 22.0
30 minutes of work, 30 minutes of rest	22.1 to 23.4
15 minutes of work, 45 minutes of rest	23.5 to 25.1
Work is not allowed without the adoption of adequate control measures	Over 25.1

Source: Adapted from Regulatory Standard – NR 15 (BRASIL, 1978a)

Thus, considering the impact of clothing on the activity, the new limit of 20.7 °C was exceeded in all conditions and environments analyzed in this study.

4. Conclusion

The results of the evaluations of the Wet Bulb Index Thermometer of Globo indicate the imminent need to adapt the radio patrol activity carried out during Operation Summer. Both the north and south coasts of the state of São Paulo presented values above those allowed by the norm in the period analyzed.

Thus, it is suggested to adjust the thermal insulation of the clothing (made of lighter materials, which allows a greater exchange of heat between the police officers and the thermal environment) and the use of air conditioning inside the vehicles.

References

AÑEZ, Ciro Romelio Rodriguez. Sistema de avaliação para a promoção e gestão do estilo de vida saudável e da aptidão física relacionada à saúde de policiais militares. 2003. Universidade Federal de Santa Catarina , Florianópolis, 2003. Disponível em: <https://repositorio.ufsc.br/xmlui/bitstream/handle/123456789/84715/194330.pdf?sequence= 1&isAllowed=y>. Acesso em: 13 fev 2020.

BERMEJO, Pablo e colab. Design and simulation of a thermal comfort adaptive system based on fuzzy logic and on-line learning. Energy and Buildings, v. 49, p. 367–379, Jun 2012.

BRASIL. Ministério do Trabalho e Emprego. Norma Regulamentadora no 15, de 08 de junho. . Brasil: [s.n.]. Disponível em: <http://trabalho.gov.br/images/Documentos/SST/NR/NR15/NR-15.pdf>. , 1978a4

BRASIL. Ministério do Trabalho e Emprego. Norma Regulamentadora no 17, de 08 de junho.. [S.l: s.n.]. Disponível em: <http://trabalho.gov.br/images/Documentos/SST/NR/NR17.pdf>. Acesso em: 17 nov 2017b. , 1978

FILIPPÍN, C. e FLORES LARSEN, S. Summer thermal behaviour of compact single family housing in a temperate climate in Argentina. Renewable and Sustainable Energy Reviews. [S.l: s.n.]. , Jun 2012

FUNDACENTRO. Normas de Higiene Ocupacional NHO 06 - Avaliação da Exposição Ocupacional ao Calor. 2001. São Paulo: [s.n.], 2001. Disponível em: <http://www.fundacentro.gov.br/biblioteca/normas-de-higiene-ocupacional/publicacao/detalhe/2012/9/nho-01-procedimento-tecnico-avaliacao-da-exposicao-ocupacional-ao-ruido>.

IIDA, Itiro e BUARQUE, Lia. Ergonomia: Projetos e Produção. São Pauo: Blucher, 2016.

KITOUS, Samia e BENSALEM, Rafik e ADOLPHE, Luc. Airflow patterns within a complex urban topography under hot and dry climate in the Algerian Sahara. Building and Environment, v. 56, p. 162–175, Out 2012.

MEDEIROS, ELAINE GONÇALVES SOARES DE. Estudo termoambiental em viaturas utilizadas nos serviços de radiopatrulhamento no estado da paraíba. 2014. 1–130 f. Universidade Federal da Paraíba, 2014.

RUAS, Álvaro César. Conforto térmico nos ambientes de trabalho. [S.l.]: FUNDACENTRO, 1999. Disponível em: <file:///C:/Users/russo/OneDrive - Instituto Maua de Tecnologia/Disciplinas/Conforto Térmico nos Ambientes de Trabalho-pdf.pdf>.

SIMÕES, Márcia Clara. Formulação de um repositor hidroeletrolítico para o trabalho físico ostensivo de policiais militares, adaptado as variações climáticas de Florianópolis. 2003. Universidade Federal De Santa Catarina, Florianópolis, 2003. Disponível em: <https://repositorio.ufsc.br/bitstream/handle/123456789/86571/191995.pdf?sequence=1&isAl lowed=y>. Acesso em: 13 fev 2020.

THE OFFICE OF RADIATION, Chemical and Biological Safety. Msu Employee Guidelines For Working In Hot Environments. [S.l: s.n.], 1999.

VERNON, H. M. e BEDFORD, T. The Relation of Atmospheric Conditions to the Working Capacity and the Accident Bate of Coal Miners. Industrial Fatigue Research Board Report. Medical Research Council, n. 39, 1927.