EFFECT OF HEAT STRESS TOWARDS JOB PERFORMANCE AMONG WORKERS IN PALM OIL MILL

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ABSTRAK

Komponen haba persekitaran atmosfera merupakan satu isu penting yang berkaitan dengan kesihatan manusia. Haba persekitaran termasuk kedua-dua syarat-syarat Pertukaran haba (tekanan) dan tindak balas fisiologi (tekanan). Tujuan kajian ini adalah untuk menentukan kesan haba tekanan di kalangan pekerja di kilang minyak sawit. Suhu persekitaran dan tindak balas fisiologi pekerja seperti kadar degupan jantung dan teras suhu badan diukur antara 28 pekerja dalam kajian ini. Suhu dunia mentol basah (WBGT) telah digunakan untuk mengukur pendedahan haba alam sekitar, WBGTin dan kelembapan. Kadar degupan jantung telah diukur dengan menggunakan alat BUA50 MEDISANA yang tekanan darah automatik. Manakala suhu teras badan ini diukur dengan menggunakan alat FLUKE termometer inframerah 572-2. Borang soal selidik telah digunakan untuk mendapatkan data demografi, gejala-gejala kesihatan dan haba berkaitan penyakit yang dialami oleh pekerja. Keputusan menunjukkan purata WBGTin bagi setiap stesen kerja; Bilik enjin (29.34 °C), pensterilan (29.03 °C), Bilik minyak (30.15 °C) dan Stesen dandang (28.88 °C) adalah sedikit di atas nilai had minimum (TLV) daripada ACGIH (27.5 °C). Di samping itu, purata kadar jantung diukur sebelum dan selepas 4 jam kerja adalah di bawah daripada kadar degupan jantung biasa dicadangkan (110 bpm). Sementara itu, purata suhu badan diukur sebelum dan selepas 4 jam kerja adalah di bawah had yang disarankan oleh ACGIH Time-Weighted purata (< 38°C). Tidak ada perbezaan kepentingan perubahan fisiologi sebelum kerja dan selepas empat jam kerja. Oleh yang demikian, tiada korelasi yang signifikan antara tekanan haba persekitaran dan tekanan haba peribadi. Tiada faktor-faktor yang ketara berkaitan dengan pembebasan haba peribadi. Walaupun pendedahan persekitaran haba telah melebihi nilai had ACGIH, tahap stres haba peribadi tidak sampai ke tahap tidak boleh diterima standard fisiologi. Ia mungkin proses senaman yang merupakan sebuah badan individu menyesuaikan diri secara beransur-ansur perubahan dalam persekitarannya, membolehkannya mengekalkan prestasi merentasi pelbagai keadaan persekitaran. Mengekalkan amalan-amalan kerja yang disyorkan untuk mengekalkan prestasi mereka dan meminimumkan risiko kesihatan pekerja.

ABSTRACT

Thermal component of the atmospheric environment is an important issue which is related to human's health. Thermal environment includes both heat exchange conditions (stress) and the physiological response (strain). The aim of this study is to determine the effect of heat stress among the workers in palm oil mill. Environmental temperature and physiological reactions of workers such as heart rate and core body temperature were measured among 28 workers in this study. Wet Bulb Globe Temperature (WBGT) were used to measure the environmental heat exposure, WBGTin and relative humidity. Heart rate were measured using an MEDISANA BUA50 Automatic Blood Pressure Monitor while body core temperature was measured using an FLUKE 572-2 Infrared Thermometer. A questionnaire was used to obtain the demographic data, health symptoms and heat related illness that experienced by the workers. Result shows the average of WBGTin for each workstation; engine room (29.34 °C), sterilization (29.03 °C), oil room (30.15 °C) and boiler station (28.88 °C) were slightly above the Threshold Limit Value (TLV) of ACGIH (27.5 °C). In addition, the average heart rate measured before and after 4 hours of work were below than the suggested normal heart rate (110 bpm). Meanwhile, the average of body temperature measured before and after 4 hours of work were below the limit that recommended by ACGIH Time-Weighted Average (<38 °C). There was no significance difference in physiological changes before work and after four hour of work. Therefore, there are no significant correlation between environmental heat stress and personal heat stress. None of the factors significantly associated with personal heat stress. Even though the environmental heat exposure were above the ACGIH's threshold limit value, the personal heat stress level did not reach unacceptable level of physiological standard. It maybe the process of acclimatization which is an individual body adjust to a gradual change in its environment, allowing it to maintain performance across range of environmental conditions. Maintain works practices are recommended to maintain their performance and minimize health risks of workers.

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LIST OF SYMBOLS

°C	Temperature
%	Percentage
bpm	Beat per minute

LIST OF ABBREVIATIONS

WBGT	Wet Bulb Globe Temperature
NWB	Nature Wet-Bulb
DB	Dry Bulb
GT	Globe Tempearture
Rh	Relative Humidity
HI	Heat Index
ACGIH	American Conference of Governmental Industrial Hygeniest
AL	Action Limit
TLV	Threshold Limit Value

CHAPTER 1

INTRODUCTION

1.1 Introduction

Heat stress includes a series of conditions where the body is under stress from overheating. Heat is one of the physical hazards that can cause health problems in the workplace (Kjellstrom,2009). The most important and common occupational health problems in workplaces is inappropriate thermal conditions that can impact the health and productivities of workers (Venugopal,2015). Daily heat exposure during the hot temperature is a problem particularly for people working in jobs that cannot be, or are not cooled by air conditioning or other technical methods. Workers who are exposed to extreme heat or work in hot environments may be at risk of heat stress. Exposure to extreme heat can result in occupational illnesses and injuries. Heat can also increase the risk of injuries in workers as it may result in sweaty palms, fogged-up safety glasses, and dizziness. Workers at risk of heat stress include outdoor workers and workers in hot environments such as firefighters, bakery workers, farmers, construction workers, miners, boiler room workers, factory workers, steel workers and others.

Since the internal body temperature should be kept around 37 °C, heat exchange between human body and surrounding environment seems to be essential (Parsons,2003). Body must reach thermal equilibrium by dissipating excess heat transferred to the body and produced in the body. Failure to remove excessive heat will cause an increase in the deep body temperature (Gonzalez,2010). Consequently, heat induced physiological strain may lead to health impairments such as heat stroke, heat exhaustion, heat cramps, heat collapse, heat rashes, and heat fatigue.

In other hand, different factors including type of task, duration of the exposure, intensity of the stressor, and operators' skill level are key variables influencing the extent that thermal conditions influence the performance. However, it had been shown that simple tasks are less affected by heat stress, comparing to the complex tasks such as tracking, monitoring, and multiple tasks.

1.2 Background of Study

Workers labouring in palm oil mill in tropical settings with high ambient temperatures are subjected to thermally stressful environments that can create risks of heat- related illnesses and cause to heat stress.

In palm oil mill, the working hours for the workers is 8 hours per day with some workers doing overtime of 1–2 hours on random days during peak production. A hot environment combined with physically demanding tasks in long period of time can subject workers to a higher risk of heat stress. Hence, most of worker could not avoid from suffering heat stress while doing their work in palm oil mill. Places such as loading ramp, sterilization, thresher, kernel, press, production room, engine room, boiler room and workshop in the palm oil mill are the locations that workers may suffer high level of heat stress (Karmegam, 2012). The process in the palm oil mill involved radiation heat which is the distance between workers with the source of heat are nearer. Therefore, the heat exposure among workers are high. High temperature has been found to be associated with lower productivity of work, raised in the frequency of accident and performance of workers are reduce (Kjellstrom&Dirks,2001).

This research is conducted to investigate the effect of heat stress among workers who work at hot environment in palm oil mill. Job performance of workers and their awareness that caused by hot environment was assessed by using a set of questionnaire. Meanwhile, Wet Bulb Globe Temperature(WBGT), blood pressure monitor, and thermometer was used to measure the heat in the hot thermal environment.

1.3 Problem Statement

In developing countries, palm oil mill is one of important economic industries. Workers in palm oil mill are more likely exposed to excessive heat stress during their working time. People working in various industries are exposed to excessive heat burden in addition to environmental temperature (Parsons,2002). In addition, worker in palm oil mill are more exposed of radiant heat source while their working. Outdoor temperatures are quite similar with indoors in agriculture sectors with process generated heat. Workers that exposed to heat stress was higher value than the threshold limit values recommended by the American Conference of Governmental Industrial Hygienists (ACGIH,2015). In palm oil mill, the heat stress of workers was higher than the standard level (Ansari,2014). Other than that, excessive heat stress of the workers in palm oil mill also involve indoor and outdoor activities. Lucas, (2014) stated that outdoor workers are exposed to sunlight and wind, indoor workers are exposure to radiant heat sources or without adequate ventilation, or those workers were not acclimatized can lead to heat stress and stroke in the workplace. (Kjellstrom, 2009; Hanna, 2011 and Xiang, 2014) found that, in high temperature, risk of heat- related illnesses and injuries were increasing in many types of indoor and outdoor worker's activities. Heat-generating sources at work, high external air temperatures, or a combination of both can causes workplace exposure to heat (Heat Stress in The Workplace,2008).

Currently, there is a lack of research about the effects of heat stress on the performance and productivity of humans. Moreover, the existing data on the real exposure of workers to high-temperature environments and reduced productivity and efficiency are rather ambiguous (Lin, 2009 and Behesti, 2016). If the necessary control measures are not taken, high workplace temperature may have considerable effects on productivity, occupational efficiency, and their related costs.

1.4 Research Objectives

The research objectives of this study are described generally and specifically.

1.4.1 General Objective

i. To evaluate the effect of heat stress towards job performance among workers in palm oil mill.

1.4.2 Specific Objectives

i. To determine the environmental heat stress level in several work stations of palm oil mill.

ii. To determine personal heat stress level among workers in palm oil mill.

iii. To determine the correlation between environmental heat stress and personal heat stress.

iv. To determine the prevalence of heat illness among palm oil mill.

v. To identify factors associated with heat illness due to heat exposure among workers.

1.5 Research Questions

i. What is the level of heat stress in several work stations of palm oil mill?

ii. What is the level of heat exposure among workers in palm oil mill?

iii. Is there any correlation between the environmental and personal heat stress level?

iv. What are the factors significantly associated with heat illness due to heat exposure among palm oil mill workers?

1.6 Research Hypothesis

Hypotheses for this study are:

i. There is no significance correlation between environmental and personal heat stress among palm oil mill workers.

ii. Factors such as occupational, environmental, and personal factor are not significantly associated with heat illness among workers.

1.7 Significance of Study

Physical activities in hot environment will affect the performance of the workers and the health status of the workers. Thus, this study is important to determine the heat stress level that exposed by the workers in the working environment. Findings on heat condition at the workplace will enable the employer to respond accordingly for prevention strategies towards heat stress exposure. Also, the employer can be able to take action on different control measure to ensure the environment of the workplace are in optimum condition.

In addition, the study on the factors that lead to heat stress among workers will enable the employer to understand and take action to minimize factors that create excessive heat exposure to workers. Moreover, the study on heat illness symptoms due to heat exposure among workers will able employer and themselves to recognize the symptoms and get medical surveillance to avoid further adverse health effect.

Finally, information gained in the study can be used as a baseline data in the future studies on the heat stress among the steel workers. This allows more studies to be conducted in order to increase the awareness level toward heat stress in palm oil mill.

1.8 Scope of Study

The aim of this study is to identify the effects of workers who exposed to heat while carrying out their work in palm oil mill. This study conducted in palm oil mill that located in Gambang, Pahang. The data collection was conducted through preliminary walk through survey to understand and identify nature of work in palm oil mill which related to heat stress problem. This data collection was done by using several instruments including questionnaire, interview, Wet Bulb Globe Temperature (WBGT), thermometer and blood pressure monitor.

For area monitoring, Wet Bulb Globe Temperature (WBGT) is used to measure air temperature, humidity, and radiant heat in several work stations of palm oil mill. While the personal monitoring was conducted using the infra-red thermometer and blood pressure monitor to determine the heat and blood pressure on the human body. The questionnaire was distributed to the employees to ascertain self-reported heat related health symptoms of workers and its effects on job performance.

1.9 Conceptual Framework

The conceptual framework as shown in Figure1.1 illustrates the effect of heat stress among workers at the hot environment in palm oil mill. Workers may exposed to heat which can cause them to suffer heat stress while they carrying out their work. Palm oil mill were divided in four divisions namely sterilization, engine room, boiler station and oil room. In addition, factors such as personal factors, occupational factors and environment factors may have induced workers to exposed heat stress while they do their work. Furthermore, workers may suffer heat related illness such as heat syncope, heat rash, heat cramps, heat exhaustion, heat stroke, and heat strain if they do not apply any prevention method to prevent themselves from suffering heat related illness.

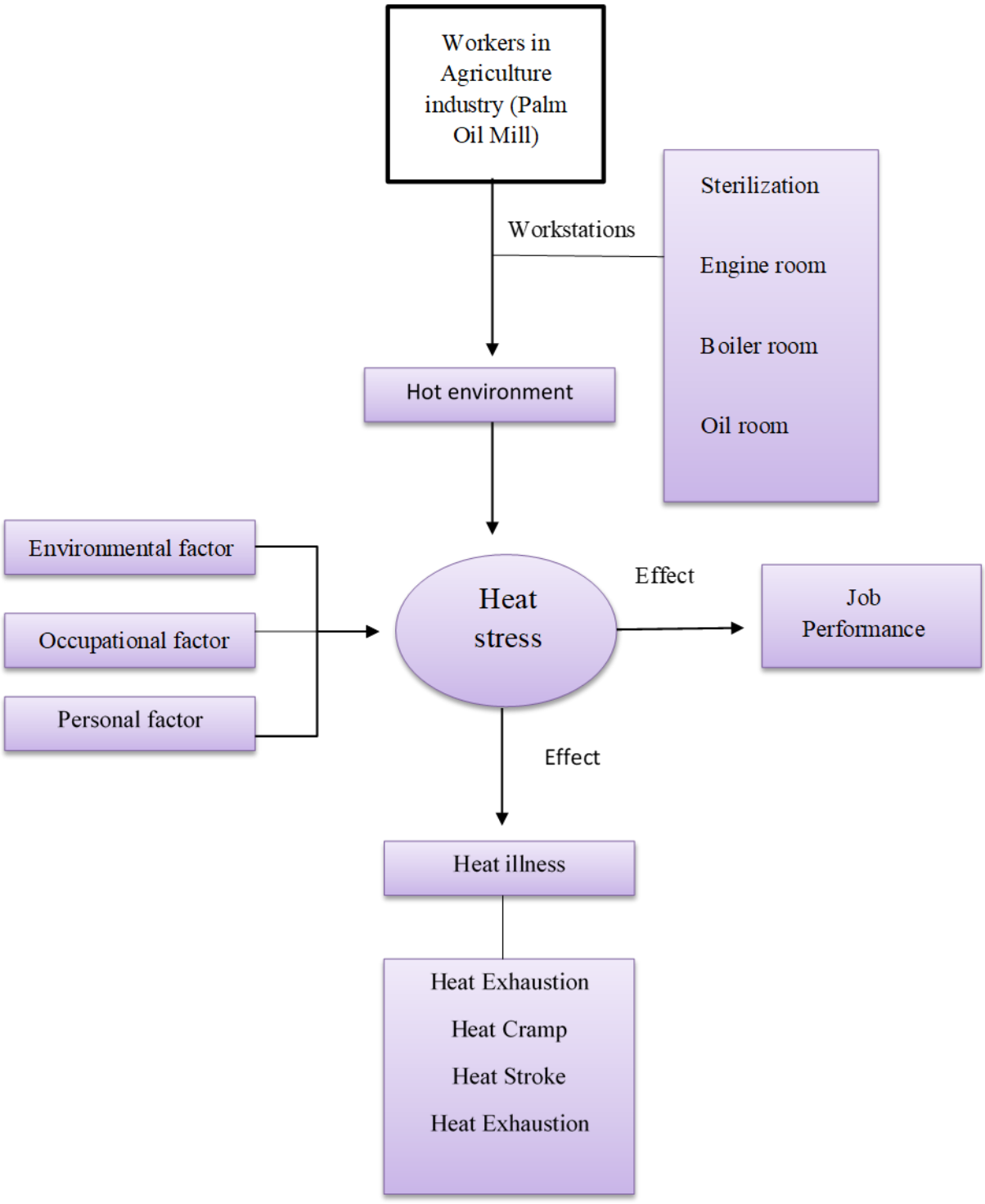

Figure 1.1 : The Conceptual Framework of Research Study

1.10 Definition of Variables

1.10.1 Heat Stress

Heat Stress happened when the body's means to control its internal temperature begins to fail. Factors that can cause such as air temperature work rate, humidity and clothing worn while working may lead to heat stress (Body, Hazards, & April, 2012).

1.10.2 Heat Related Illness

Adverse physical or mental condition from work activity or work related situation (EPA, 2011). It refers to the situation where people occur with symptom such as dizziness, fainting, nausea and other related symptoms.

1.10.3 Heat Stroke

It is the illness which core body temperature that raise above 105.1º F or 40 º C which accompanied by hot, dry skin and the abnormalities of central nervous system such as delirium, convulsions or coma (Alert, 2014). Workers who suffered Heat Stroke may face impairment of organ or even death. Most of the organs in the body such as nervous system, liver, kidney, muscle and heart can endure the damage of tissue on the workers who suffer heat stroke due to long hours exposed to the hot environment at palm oil mill.

1.10.4 Heat Exhaustion

It is the response to the body due to excessive loss of water and salt that contained in sweat (Moshab, 2007). It is an illness that results from the overexposure to heat at steel industry which can induce people to face excessive sweating, fatigue, nausea, and dizziness

1.10.5 Heat Cramp

A condition that is marked by sudden development of cramps in skeletal muscles and that results from prolonged work or exercise in high temperatures accompanied by profuse perspiration with loss of sodium chloride from the body (Bergeron, 2013).

1.10.6 Personal Factor

The ability of employees to perform physical tasks may vary because of difference in age, physical condition, strength, gender, stature, visual capabilities, and other condition of health. The level of physical fitness, weight, diet, habits, and lifestyle may influence the health of workers (Inspectorate et al., 2012).

1.10.7 Occupational Factor

Clothing and workload are the type of job factors that lead to the changes of the heat expose level. According to Havenith (2002) the clothing and workload factors can affect the amount of heat produced by the body and the amount of heat dissipated from the body.

1.10.8 Environmental Factor

Environmental factors in the hot environment of workplace have been shown to contribute to the development of fatigue (Moshab, 2007). Air temperature, humidity and movement of air can increase the probability of heat stress illness that may face by workers at hot and humid environment.

1.10.9 Heart Rate

The number of beats of heart per unit of time which is based on the number of contractions of the ventricles that located at the lower chambers of the heart (Arbogast, Belwadi, & Allison, 2012).

1.10.10 Core Body Temperature

It is controlled by a negative feedback system which is usually 37ºC no matters what the temperature of the surrounding or the activity of level of individual (Langworthy, 2002). The average core body temperature is 37ºC or 98.6°F which varies with the individual, time of day and fever of exertion.

CHAPTER 2

LITERATURE REVIEW

2.1 Heat

Heat is energy in transfer to or from a thermodynamic system, by mechanisms other than macroscopic work or transfer of matter (Bras, 2010). Heat can cause people to suffered thousands of fatalities in every year of the worldwide. Hence, it is earning the nickname of “killer of silence” Heat and the dangers of heat are often accepting more attention in the countries with climate of temperate due to lack of acclimatization (Bober, 2012). It is an air temperature above 36ºC of dry air or value of WBGT greater than 28ºC (Ramphal, 2012).

2.2 Heat Stress

There is an amalgamation of heat load individual and factors of environmental that impose on the bodies of workers which in turn have effects on the performance, safety and health of workers (Hemmatjo et al., 2013).

There are four climatic factors of environmental heat load which include air temperature, humidity, speeds of wind and mean radiant temperature. The effect of heat stress can create problem to the psychological and health. It also can influence the performance of workers while they carrying out their works (Changes, 2014).

Heat Stress is one of the physical harmful agents in many industries. It can make people to suffer fatigue and lethargy. Heat stress is the overall heat load to which an employee may be exposed from the combined contributions of metabolic heat, environmental factors (i.e. air temperature, humidity, air movement, and radiant heat), and clothing requirements (Guidelines of Heat Stress Management, 2016). Heat Stress

also can decrease productivity, increase error of humans and increase the number of accidents as well as heat-related diseases (Hemmatjo et al., 2013).

2.3 Heat Related Illness

Heat related illness can be developed with prolonged exposure to the hot environment when workers perform the physical demanding work or exercise. Heat related illness can be known as specific ailments that can cause workers to suffer body pain if they exposed to heat at hot environment. There are some of the examples of heat related illnesses which include heat rash, heat cramps, heat exhaustion and heat stroke. Heat rash is the least severe injury whereas heat stroke can make people to suffer the most severity injury if compare to others heat related illness (Hunt, 2011).

2.3.1 Heat Cramps

Heat cramps often occurs due to the imbalance of the sweating. It usually involves muscles that are fatigued by heavy work, such as calves, thighs, and shoulders. The symptom of heat cramps is muscle spasms which include painful, involuntary, brief, intermittent, and self-limited (Bergeron, 2013). Patients need to stop all the activities immediately and sit in a cool place if they suffered heat cramps while doing their work. Patients can rest and drink plenty of water or electrolytes fluids in order to treat this type of illness.

2.3.2 Heat Rash

Heat rash is common problem that can happen to the workers that work at the hot and humid working environment. People may suffer heat rash when they exposed to the high and humidity of environment that can cause them to sweat excessively. Heat rash can be known as Miliara. It also can know as acute inflammation of the skin and the clogging of the ducts of sweat. It is commonly pruritic and it is normally appearing papulovesicular. People who suffered heat rash can be caused by the infection of bacterial that can shut down the function of sweat glands (Hall, 2012). The heat related illness of heat rash can be prevented by cooling the surrounding of area and reduced the clothing coverage where the possible will help the resolution.

2.3.3 Heat Syncope

Heat Syncope occurs with the hypertension of orthostatic that result from the vasodilation of peripheral, depletion of volume, pooling of venos and bloods, and decreased in the tone of vasomotor when people exercising in the hot and humid environment with the consecutive loss of consciousness. Elderly individuals have the highest probability to suffer heat syncope than youngest individuals. Heat Syncope can influence mostly in the poorly acclimatization (Hall, 2012b). People who stand for a long time of hours after significant exertion and rapid change in the position of body after exertion such as from sitting to standing may suffer heat syncope (Howe & Boden, 2007).

Dehydration and lack of acclimatization are the factor that can caused workers to suffer heat syncope. Symptoms of heat syncope that may suffer by workers include light-headedness, dizziness and fainting. There are two ways to treat the heat syncope such as sitting or lying down in a cool place when the patient starts to feel the symptoms of heat syncope. Besides, patients also can drink water, clear juice or sports beverage slowly to treat the heat syncope that suffered by patients (Margaret, 2009).

2.3.4 Heat Exhaustion

Heat exhaustion is the most common heat related illness that can suffered by people and characterized by significant depletion of volume. Heat exhaustion is the response of body to the excessive loss of water and salt and it is usually through excessive of sweating. Most of the people with high age, high blood pressure and work in the hot environment have the highest probability to suffer heat exhaustion. The core body temperature for people who suffered heat exhaustion is normally in the range of 37º C and 40º C (Diego, 2008).

Depletion of water and depletion of salt are two types of Heat Exhaustion that people may suffer if they long time exposed to the hot and humid environment. People may suffer water depletion heat exhaustion if they work in a hot environment without sufficient replacement of water. Patients who faced the problem of heat exhaustion may have suffered some non-specific symptoms and signs such as fatigue, headache, nausea, vomiting, weakness, malaise, dizziness, nausea, myalgia, irritability, diaphoresis, fast

and shallow breathing and muscle cramps. Patient usually sweat a lot if they suffered heat exhaustion when exposed to the hot environment (Binkley et al,. 2002).

Workers that suffered heat exhaustion can be treated by giving them rest in a cool, shaded or air-conditioned area. Plenty of water or other cool and non-alcoholic beverages can be given to the patient who suffered heat exhaustion. Patients should take a cool shower, bath, or sponge bath in order to make sure them quickly recover forms heat exhaustion.

2.3.5 Heat Stroke

Heat Stroke is one type of medical emergency that happened when the body system is failed to regulate thermal temperature of human. It happened when the internal temperature of the body rises to the range of 104ºF. It can happen when your body gets too hot during strenuous exercise or when exposed to very hot temperatures, or it can happen after heat exhaustion isn't properly treated. Heatstroke is much more serious than heat exhaustion. Heat stroke can damage people's organ and brain. Heat stroke also can kill people silently without any sound (Howe & Boden, 2007). The primary sign of the heat stroke victim showed confusion, loss of conscious and abnormally high body temperature. This eventually can cause the person to death. Clinical studies have shown that death from heatstroke mostly occur soon after the onset of hyperthermia and associated cardiovascular failure (Bouchama, 2007).

2.4 Environmental Factors

There are six common environmental factors that can be used to determine the body heat balance which include air temperature, radiant temperature, movement of air, humidity, clothing and metabolic heat. Air temperature is the air surrounding the body which can be measured by using thermometer. Normally, symbol of Celsius (°C) or Fahrenheit (°F) are used to represent the air temperature surrounding the body.

Besides that, humidity is known as air's moisture content whereas relative humidity is the ratio between the actual amounts of the water vapour in the air and the maximum amount of the water vapour that the air can hold at the air temperature. There is more moisture is able to be carried in the air if the air is warmer. High humidity tends to make people feel hotter than low humidity. This is because environment with high

humidity have a lot of vapour in the air which can abstain the evaporation of sweat from the skin. Radiant heat is another environmental factor which is emitted from hot object that can cause people to suffer heat related illness. Radiant temperature has the higher possibility to influence people in gaining heat in the hot environment than air temperature. People may suffer radiant temperature at the radiant heat sources such as sun, fires, electric fires, furnaces, rollers and molten metal (Mohamed & Srinivas, 2009).

Movement of air is also one of the environmental factors. Movement of air can cool people in most of the condition. Hence, people can get some relief in the hot condition. In conversely, people can get extra chill in the cold condition. Clothing can abstain the heat that transfer from the body to the surrounding of environment. People need to wear clothes to help them dissipate heat at the hot environment. In conversely, clothes can help the wearer to prevent the transfer of heat at the cold environment. Lastly, metabolic heat is also another factor that we produce inside our body when we carry out the physical activity. There is more heat can produce when the quantity of physical works is increased. Hence, there is more heat that needs to be lost in order to make sure people do not overheat while they carrying out their works (Lundgren et al., 2013).

The exchange of heat among humans with the environment affected by acclimatization and status of hydration, posture of body, permeability of clothing and respiration. Processes such as radiation, conduction, convection, and evaporation at the surface of skin and the lungs can influence the tolerance of heat that may be gained through the processes of heat transference between the body and the macro environment (Lundgren et al., 2013).

2.4.1 Conduction

It is a process of transferring of heat to the body by directing the contact with the warm object when there is a difference in temperature or electrical potential between the regions of adjoining without the movement of material. This is a relatively insignificant source of heat when considering heat that gain in the body (Manitoba, 2007).

2.4.2 Convection

There is the exchange of heat in the body with the surrounding air. The air of moving can cool the body if it is cooler than the body temperature. The moving of air can raise the load of heat if it is warmer than the body temperature. Speed of air is an essential factor in heat loss or gain (Manitoba, 2007).

2.4.3 Radiation

There is a process of transferring heat to the body through air and from the sources of hot. Types of radiation include light, heat, furnaces, oven and sun. Heat can lose if the surrounding air is cooler than the body (Manitoba, 2007).

2.4.4 Evaporation

Evaporation of perspiration from the skin is the method to remove the heat from people who suffer heat stress when exposed to heat at hot environment. The rate of perspiration is occurred if there are the increases in temperature, humidity and work rate. Sweats that flow out from people who suffer heat stress do not evaporate as quickly at high humidity. High air speed and low humidity in the air can raise the evaporation. Excessive perspiration may lead to dehydration if the surrounding area of air is hot and dry (Manitoba, 2007).

2.5 Personal Factor

There are various personal factors that can induced people to be suffered for heat stress when they exposed to heat at hot environment. Copped the heat stress well than the unfit people. Age is also another factor that can affect the possibility of people to get heat related illness when they exposed to hot environment. Health issue may start to emerge when people are reached the middle age around 45 years old. People over the age of 60 have the highest probability to suffocating the hot conditions. This is due to the physiological differences in regulating the heat and restricted mobility that can lower down the ability to access the fluids when needed. Besides that, body mass, size, and composition in the changes in age may cause declined in the response of homeostatic and the regulation of blood pressure which can increase the risk of

thermoregulatory deficits. Hence, elderly people have higher possibility to suffer heat stress (Lundgren et al., 2013).

In addition, weight is one of the factors that can cause the possibility of people to suffer heat stress at hot environment. People who are obese or overweight have the highest probability to suffer heat stress in the hot environment due to the imbalance in the transfer of heat. People who are overweight or obese may suffer fatal heat stroke 3.5 times more frequently than those who have average weight when they exposed to heat at hot environment (Hall, 2012a).

On the other hands, level of fitness also can affect the possibility of the people to suffer heat related illness if they exposed to heat at hot environment. For example, people have well physically fitness will acclimatize better than unfit people. They copped the heat stress well than the unfit people.

2.6 Occupational Factor

There are various types of occupational factors that can cause people to suffer heat related illness when they exposed to extreme heat at hot environment. Workers who employed at the occupations of outdoor with the high physical loads have the higher probability to suffer severe heat exposure than workers who work at indoor. This is because works of outdoor are most problematic and fatalities due to stress of heat are associated with warm nights, hot days and hard physical work. Workers who wear semi- permeable or impermeable protective clothing can have severe obstruction exchange of heat through evaporation. Heat can make the workers to take off the protective clothing due to uncomfortable while they carrying out their work. Hence, workers have the higher probability to expose to dangerous and get injury when they take off their protective clothing (Lundgren et al., 2013).

2.7 Effect Heat Stress toward Job Performance

Job performance is a very considerable factor influencing profitability of any organization (Bevan, 2012). Performance is important for organizations as employees' performance leads to business success. Also, performance is important for individuals, as achieving tasks can be a source of satisfaction (Muchhal, 2014). Job performance can

be defined as behaviours or activities that are performed towards accomplishing the organization's objectives (Motowidlo, Borman and Schmit, 1999).

Besides, the physical environment at work is critical to employees' performance, satisfaction, social relations and health. High temperatures can affect employee's performance, particularly duties required on cognitive, physical, and perceptual duties. (Badayai, 2012). Chandrasekar (2011) state that high temperatures can have a direct impact on health and lead to heat stress and heat exhaustion.

Moreover, environmental heat influences the performance and productivity of humans through changing physiological parameters, such as blood flow and hormone release rate (Behesti, 2016). According to Nejad (2016), heat stress can be associated with psychological and physical effects such as irritability, nervousness, moodiness, depression (mental effects), cardiovascular complications, perspiration, water and electrolyte imbalance, and changes in blood flow rate (physical effects). A combination of mental and physical reactions is embodied in the form of low work efficiency, reduced labor skills, muscular fatigue, poor concentration, and thus, increased frequency of mistakes. In addition to its health related consequences, exposure to heat can deteriorate human performance under various conditions (Kjellstrom,2009).

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter focused on sampling area, research design, study sample and sampling strategies. Detail procedures for carrying out data collection using several instrument such as Wet Bulb Globe Temperature (WBGT) for area monitoring and thermometer and blood pressure monitor for personal monitoring. Procedure and methods of this research were conducted by sequences in order to make sure the whole research is executed successfully.

3.2 Study Area

The area of study is focused at palm oil mill located in Kuantan. Most of the workers who work at the palm oil mill has the higher probability to expose to the heat during the period of the work hours' time. The division of the study was according to several workstations in palm oil mill such as engine room, sterilization, boiler station, and oil room. The location that selected to carry out the research is the area around Gambang, Pahang. Selection is carried out by randomly choose to take part in this research.

3.3 Research Design

The study design used in this study is a cross-sectional study. This study design was easy to get information of workers at one specific point in time, less time consuming, inexpensive, and the data could be used for various type of research.

This cross-sectional study was conducted to evaluate the effect of heat stress towards job performance among workers in palm oil mill. This design was to determine the environmental heat stress level in several work station of palm oil mill and personal heat stress level among workers in palm oil mill. In addition, correlation between environmental heat stress and personal heat stress among steel workers is also evaluated in this research of study. Furthermore, the factors that associated with heat illness due to heat exposure among steel workers also be studied.

3.4 Study Sample

The population in this study is based on the workers who are working in agriculture process of palm oil at palm oil mill. Sample in this study is focused on the workers who work at palm oil mill in the area of Gambang, Pahang. The industrial area around Gambang, Pahang is selected due to the convenient of collecting data while the study is conducted. This is because there are a lot of industries at the industries area of Gambang which are qualified to conduct this study due to the environment and nature of work that required in this research project.

To determine the sample size of this study, Krejcie and Morgan (1970) formula is chosen. These formulas need knowledge of the variance or proportion in the population and a determination a to the maximum desirable error, as well as the acceptable risk of Type I error (Krejcie & Morgan, 1970). Based on Table 3.1, if the population for the research is 30, the number of respondents should be 28. Therefore, after considering 20% drop out, a total of 28 respondents were selected to be respondents in this study.

Workers who take alcohol, prescription and drug before the work time of hours were excluded from this study. This is because the consumption of alcohol can affect the result of the study. This may cause the inaccurate of the result in this research study.

Table 3.1 : Table for determine sample size for a given population

N	*S*	*N*	*S*	*N*	*S*
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

N=30 ,S=28

Source: Krejcie & Morgan (1970)

3.5 Data Collection Technique

Figure 3.1 shows the data collection was involving area monitoring, personal monitoring, and distribution of questionnaire. Besides, the identifications of the type of activities and workstation in palm oil mill such as activities of engine room, sterilization, boiler station, oil room are to be identified and studied. Area monitoring for the heat stress level was conducted by using WBGT. The sampling and collection of the heat stress level of the area was conducted. Then, personal monitoring on personal heat stress was conducted to measure the physiological effect among the respondent. The method that used to choose the respondent was random sampling. Workers who work at the area of Gambang's palm oil mill were chosen from the population to participate in this study. The respondents were selected randomly from each workstation. The personal monitoring on personal heat stress was conducted to measure the physiological effect of workers such as rate of heart and core body temperature among workers in palm oil mill. Next, the questionnaire was distributed to the respondent for surveying health symptoms due to exposure to heat, factor that associated and their job performance.

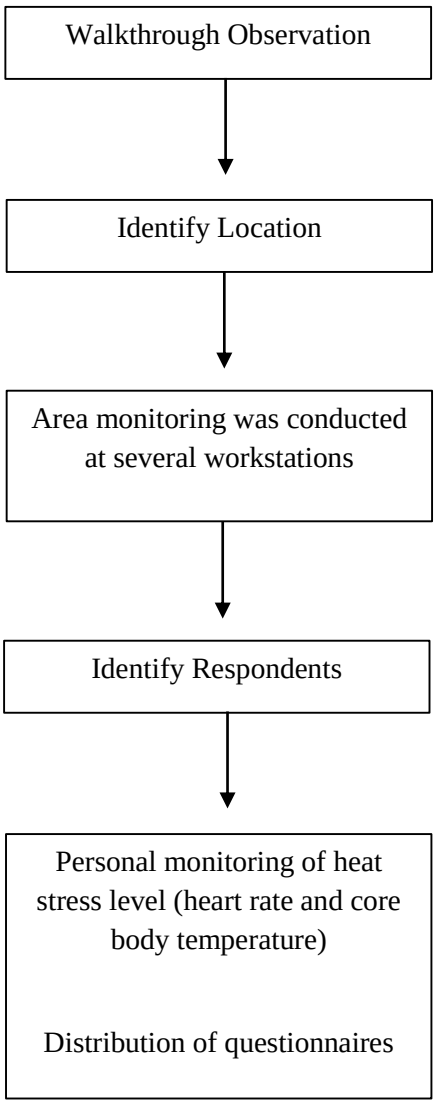

Figure 3.1 : Data Collection Process

3.5.1 Walkthrough Observation

Initially, a walkthrough survey is conducted to observe all the part of activities and workstation at palm oil mill during working hours before the start of the monitoring.

3.5.2 Area monitoring

Based on Figure 3.2, Wet Bulb Globe Temperature (WBGT) is used to measure the level of heat stress in several works station at palm oil mill. Globally, the WBGT index is the most commonly used heat index in heat stress assessments (Lundgrenand, 2014). The WBGT combines the effect of the four main thermal components included

environment, air temperature, humidity, air velocity, and radiation, as measured by the dry bulb, wet bulb, and globe temperatures (Kjellstrom, 2012). Wet Bulb Globe Temperature (WBGT) is assemble the probes of Dry bulb temperature (Ta), Natural Wet Bulb temperature (Tnwb), and Globe Temperature (Tg) for the electronic Wet Bulb Globe Temperature (WBGT). Types components and measurements that were done by WBGT shown in Table 3.3. The model used for the area monitoring of heat stress for this study is Model Questemp°34. This model was production from the Quest technologies for the monitoring of the area heat stress.

Table 3.2 : Measurement of WBGT

Component of WBGT	**Measurement**
Wet bulb temperature (Tnwb)	Air humidity
Globe temperature (Tg)	Radiant heat
Dry bulb temperature (Ta)	Ambient temperature

Source: Guidelines of Management Heat Stress at Workplace (2016)

Figure 3.2 : Wet Bulb Globe Temperature Meter

Subsequently, the Natural Wet Bulb reservoir was filled with distilled water and then switch ON. Afterwards, the Wet Bulb Globe Temperature (WBGT) is placed at the sites that selected to take the reading in the palm oil mill. The position of WBGT was placed at 1.1 meters from the floor level and supported by the standard photographic tripod. The equipment will be placed as near as possible to the source of heat. The individual temperatures (Dry Bulb Temperature, Natural Wet Bulb Temperature, Globe Temperature, Relative Humidity, and Heat Index) was manually recorded. In addition, based on Guideline of Heat Stress Management (2016), the measurement time is set to be taken at intervals of every five minutes for one hour. So, the total of samples that collected is twelve samples at specific areas. The reading obtained is recorded and will be compared to the standards.

The WBGT is a weighted average of the three temperature sensors that use the following formula: (E.q.3.1), (E.q.3.2) & (E.q.3.3)

For indoor conditions with no solar, the index of WBGT is calculated as shown in E.q.3.1

$$WBGT = 0.7\ NWB + 0.3\ GT \qquad 3.1$$

For outdoor environments with direct exposure to sunlight, the index of WBGT is calculated as in E.q. 3.2

$$WBGT = 0.7\ NWB + 0.2\ GT + 0.1\ DB \qquad 3.2$$

Average Wet Bulb Globe Temperature (WBGT) is calculated as Average WBGT

$$\frac{(WBGT1)(t1)+ (WBGT2)(t2)+...+(WBGTn)(tn)}{(t1) + (t2) +... (tn)} \qquad 3.3$$

Where:

WBGT : Wet Bulb temperature index

NWB : Nature Wet- Bulb Temperature

DB : Dry Bulb Temperature

GT : Globe Temperature

3.5.3 Personal Monitoring

Personal monitoring was measured based on oral temperature and heart rate among workers in palm oil mill.

3.5.3.1 Heart Rate

Heart rate was measured by measuring the pulse rate of workers in palm oil mill. The monitoring was conducted 2 times which is before they begin their work and after 4 hours their working at palm oil mill.

Heart rate is an effective way to measure the heat stress on the body of workers. Figure 3.3 shows the instrument was used to measure the pulse rate is blood pressure monitor (Model MEDISANA BUA50). The function of this instrument is used to measure the pulse rate of workers and it will show the result of blood pressure and pulse rate out digitally.

Figure 3.3 : MEDISANA BUA50

In addition, Baura (2012) carried out measurement taken of blood pressure must at around the same time of each day. Firstly, ensure the respondent was sit comfortably and relaxed. Then, the arm is supported on a tabletop at an even level with his heart. The cuff was placed on exposed arm at 2cm (approximately two finger-breadths) above the elbow. The tubing was placed at the centre of arm facing the front, and that the

sensor is correctly placed. During measurement, the respondents were stay relaxed, keeping still and quiet. The cuff was inflated, then slowly deflate. When the measurement was complete, readings of the systolic and diastolic blood pressures and pulse rate was displayed on the digital panel (Omboni, 2007). The reading was recorded.

Furthermore, factors that have been considered before taking the measurement, respondent are not allowed to smoke or consume foods or drinks containing caffeine (such as tea or coffee) at least 30 minutes before measurement. This is because it can have interrupted the real measurement (Chobanian, 2003). The respondent who have felt unwell, cold, anxious, stressed, in pain, or have a full bladder was excluded from this measurement.

3.5.3.2 Core Body Temperature

Oral temperature was measured to determine the core body temperature of workers. Figure 3.4 shows the instruments that was used to measure the core body temperature is thermometer (Model FLUKE 572-2 IR THERMOMETER). The measurement of temperature is measured before workers carry out their work and after they finished their work. Handheld IR thermometers are fast, accurate and convenient. This device was placed 1cm from the forehead of the respondents. The responsed time (detection to display) of an IR thermometer was typically about one-half second, then the reading of their body was recorded after the reading was display at screen of this device (Mahan, 2008 & Hamilton, 2013).

Figure 3.4 : FLUKE 572-2 IR THERMOMETER

3.5.3.3 Questionnaire

Questionnaires was adopted from Hunt (2011) and modified for this study. Random sampling was used to conduct this questionnaire. Using this technique, each individual within the chosen population is selected by chance and is equally as likely to be picked as anyone else. Questionnaires were distributed to the workers that work at the palm oil mill. Workers need to answer the questionnaires in order to provide information on characteristics, working environment, and heat illness symptoms. The assistances and guidance are given to workers while completing the questionnaire.

Specifically, the general characteristics questionnaire is to obtain information on the background characteristics of the respondent and personal information that included age, gender, race, BMI, work duration, and employment period. In addition, working environment questionnaire is to perceive temperature and air humidity of environment. The time spent in hot environment, the sweating rate, and frequency of respondent take drink during working hour were also included in the questionnaire. Furthermore, the questionnaire of heat illness symptom is going to be answer based on their belief that related to their heat exposure during work.

3.6 Quality Assurance

The calibration on instrument Wet Bulb Globe Temperature (WBGT), blood pressure monitor and infrared thermometer were done before carrying out the measurement. Guidance and explanations on questionnaire are given to the respondents to ensure their understanding and accuracy of the information given.

3.7 Study Ethics

There is few study ethics that need to be taking into consideration throughout conducting this study. The details of the respondents and the companies must always be kept into privacy and confidential. The information gather should be for study and academic purpose only.

3.8 Study Limitation

The limitation of this study was the sample size was particularly small. Findings were limited because this study was focused only on during day shift work of operation at palm oil mill instead of day-night shift work. This study also focus on exposed group which it involved the workers at the operation without involving administration workers at palm oil mill. Thus, it was difficult to find significant relationship from the data; as statistical test normally requires a larger sample size to ensure representatives distribution of the population and it could obtain more precise result.

3.9 Data Analysis

Statistical Package for the Social Science (SPSS) software is a program that used to analyse all the data that collected on this research of study. All the data include area monitoring and personal monitoring is analysed by using this software. Parametric test is used for the test of normal distribution whereas non-parametric test is used for non-normally distributed data in this research of study. Data obtained was statistically analysed using descriptive and inferential analysis.

3.9.1 Descriptive Analysis

This analysis uses the percentage, frequency, mean, standard deviation, minimum and maximum value to describe the demographic of the respondents. It helps in generalizing the data and details of the respondents.

3.9.2 Inferential Analysis

Inferential analysis utilizes a random sample of data in use from a population to describe and make inferences about the population. Spearman Rho's test was used to determine correlation between environmental heat stress and personal heat stress level. The correlation coefficient (r) is a measure of the strength of the relationship between two variables and the value of r is between +1.00 and -1.00. Besides, the paired sample t-test was used to determine the comparison of body temperature and heart rate before and after 4 hours of work. This test was observed the changes of the variables between before and after 4 hours work.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This discussion will present the data obtained from the study conducted. All the data attained are tabulated accordingly and suitable graphs are being used to illustrate the data.

4.2 Background Information of Respondent

In this study, descriptive analysis was used to analyze the socio demographic characteristic of respondents who took part in this research of study which consists of gender, age, race, body mass index (BMI) and job experiences. Table 4.1 shows the demographic data of 28 respondents who were all male workers from the palm oil mill located at Gambang, Pahang, Malaysia. Besides, the highest frequency of the age is 36 to 45 years old which is 13 workers. The older a person is the more likely they are to suffer from the effect of heat (Parameswarappa,2014). Based on Table 4.1, it shows two races of workers in this palm oil mill which are local workers and foreign workers. The most of the workers are Malay which comprises 53.6%. Whereas the percentage of the local workers is differed by only 7.2% from the percentage of foreigner workers which is 46.4%. Furthermore, the Body Mass Index was divided into five categories which are < 18.5 (Underweight), 18.5 – 24.9 (Normal), 25.0 – 29.9 (Overweight), and >30 (Obese). The majority of the worker's BMI which is at ranges 18.5 – 24.9 (Normal) with represent 64.3%. Most of respondents worked 8 hours a day. The highest percentage of the job experience is 1-3 years which is 35.7%.

Table 4.1 : Demographic data of workers

Variables	Frequency	Percentage (%)
Age (years)		
< 25	5	17.9
25-35	10	35.7
36-45	13	46.4
Race		
Local	15	53.6
Foreigner	13	46.4
Body Mass Index		
Underweight	4	14.3
Normal	18	64.3
Overweight	5	17.9
Obese	1	3.6
Employment Period		
1-3 years	10	35.7
4-6 years	8	28.6
7-9 years	6	21.4
>10 years	4	14.3

N = 28

4.3 Environmental Heat Stress Assessment

Environmental heat stress assessment was carried out based on the Wet Bulb Globe Indoor Temperature (WBGTin), humidity and air velocity. The result will be compared with international standard such as ACGIH TLV and OSHA technical manual (1992). Besides, the ability to work in a hot and humid environment is directly related to environmental heat stress level (Liang et al.,2011). OSHA 1992 stated environmental factors such as temperature, relative humidity and work process can cause heat stress problems to the workers in hot workplace.

4.3.1 Heat Stress Assessment at Engine Room

Table 4.2 shows the result of WBGT at Engine Room of Palm Oil Mill. The globe temperature is the most obvious increasing dynamic parameters if compared to others parameters. The highest indices of globe temperature can reach up to 33.5 °C. Hence, air and radiant temperature are very high during the evaluation of environmental parameters in this section study.

Besides, wet bulb temperature is the lowest indices of environmental parameters if compared to others environmental parameters. The maximum level of the wet bulb's indices is 28.9 °C whereas the minimum level of wet bulb's indices is 27.6 °C. A wet bulb thermometer is functioning to estimate the extent cooling as moisture dries from a surface of evaporative cooling. This thermometer can represent the integrated effect of humidity, wind and radiation (Willett & Sherwood, 2012). Hence, it can say that the composition of humidity, wind and radiation is low in the engine room of this study.

In addition, the indices of dry bulb thermometer is higher than wet bulb thermometer in the engine room of this study. There is only a little bit difference which is 1.2 °C between the maximum level and minimum level of the indices of dry bulb temperature.

Table 4.2 : The Environmental Heat Stress Level of Engine Room

Environmental Parameter	Minimum	Maximum	Average
Wet Bulb Temperature (°C)	27.6	28.9	27.93
Dry Bulb Temperature (°C)	29.7	30.9	30.37
Globe Temperature (°C)	31.5	33.5	32.81
Humidity (%)	78	89	83.67
WBGT (In) (°C)	29.1	29.8	29.34
Heat Index (°C)	38	40	38.67

4.3.2 Heat Stress Assessment at Sterilization

Table 4.3 shows the result of environmental parameters at the sterilization station at palm oil mill. It is clearly to show all the indices of environmental parameters are increase. However, the indices of humidity at sterilization station slightly lower than the percentage at engine room.

Furthermore, the maximum of temperature during this evaluation is about 36.3 °C which is stated by globe temperature. The minimum of globe temperature can be dropped to 34.2 °C in this evaluation. The wet bulb temperature, dry bulb temperature, and globe temperature is increasing slowly in this evaluation at boiler station of palm oil mill.

Table 4.3 : The Environmental Heat Stress Level of Sterilization Station

Environmental Parameter	Minimum	Maximum	Average
Wet Bulb Temperature (°C)	26.2	27.7	26.85
Dry Bulb Temperature (°C)	31	32.8	31.98
Globe Temperature	33.4	35.6	34.38
Humidity (%)	67	74	70.58
WBGT (In) (°C)	28.3	29.8	29.03
Heat Index (°C)	38	42	40.08

4.3.3 Heat Stress Assessment at Boiler Station

Table 4.4 below shows the result of environmental parameters at the boiler station of palm oil mill. It is clearly to show that all the indices of environmental parameter are increases.

Moreover, the smallest value of dry bulb temperature was 31.5°C whereas the largest value was 33.4°C according to the Table 4.3 above. Hence, the average value of that day temperature was 32.56 °C. The environment temperature of working area is considered as extreme hot temperature if the temperature is above 32° C (Bradshaw, 2006). Hence, it can be concluded that the environment temperature of the boiler station has reached the level of the range extreme hot environment according to the dry bulb temperature of this assessment. People who carry out work at the extreme heat of environment have the highest probability to suffer heat related disorder such as heat stroke, heat exhaustion, heat rash, heat cramps and heat syncope. Thus, prevention of heat stress activities should be strongly recommended in order to reduce the risk of heat related disorders occur among all the workers who work at palm oil mill.

Table 4.4 : The Environmental Heat Stress Level of Boiler Station

Environmental Parameter	Minimum	Maximum	Average
Wet Bulb Temperature (°C)	27.1	28.3	27.8
Dry Bulb Temperature (°C)	31.5	33.4	32.56
Globe Temperature (°C)	34.2	36.3	35.73
Humidity (%)	69	75	72.5
WBGT (In) (°C)	29.2	30.7	30.15
Heat Index (°C)	40	45	42.33

4.3.4 Heat Stress Assessment at Oil Room

Table 4.5 shows the environmental parameters at oil room of palm oil mill. Relative humidity is the environmental indices that changed all along in the duration of this assessment. The highest value of relative humidity can reach 70%. This is the smallest percentage if compare to other's workstation.

Globe temperature that used to indicate the air temperature and radiant heat temperature in this study is obtain higher indices if compare to the dry bulb temperature. The globe temperature is rocketed steadily at the beginning of the assessment until the end time slot of the assessment. The maximum value of globe temperature is 35.1°C. Then, the globe temperature started to decline gradually and reached the minimum point which is 33.8°C in this assessment. The globe temperature started to rose gently after reach the minimum point. Hence, it can be concluded that the globe temperature is dynamic during the assessment at palm oil mill.

Table 4.5 : The Environmental Heat Stress Level of Oil Room

Environmental Parameter	Minimum	Maximum	Average
Wet Bulb Temperature (°C)	25.8	27.4	26.63
Dry Bulb Temperature (°C)	31.9	32.9	32.43
Globe Temperature (°C)	33.8	35.1	34.32
Humidity (%)	66	70	67.42
WBGT (In) (°C)	28.4	29.5	28.88
Heat Index (°C)	38	42	40.5

4.3.5 The Comparison of Heat Index between four Department

Heat index is mainly based on two things which are the actual temperature and humidity. Humidity is a general term that used for the amount of moisture in the air. This is usually expressed in terms of relative humidity or as percentage. Besides, the comparison of heat index among four department of palm oil mill was used Fahrenheit unit for temperature. The degree Celsius (°C) of the temperature of the departments' heat index is converted to Fahrenheit by using the equation, °C x 9/5 + 32 = °F.

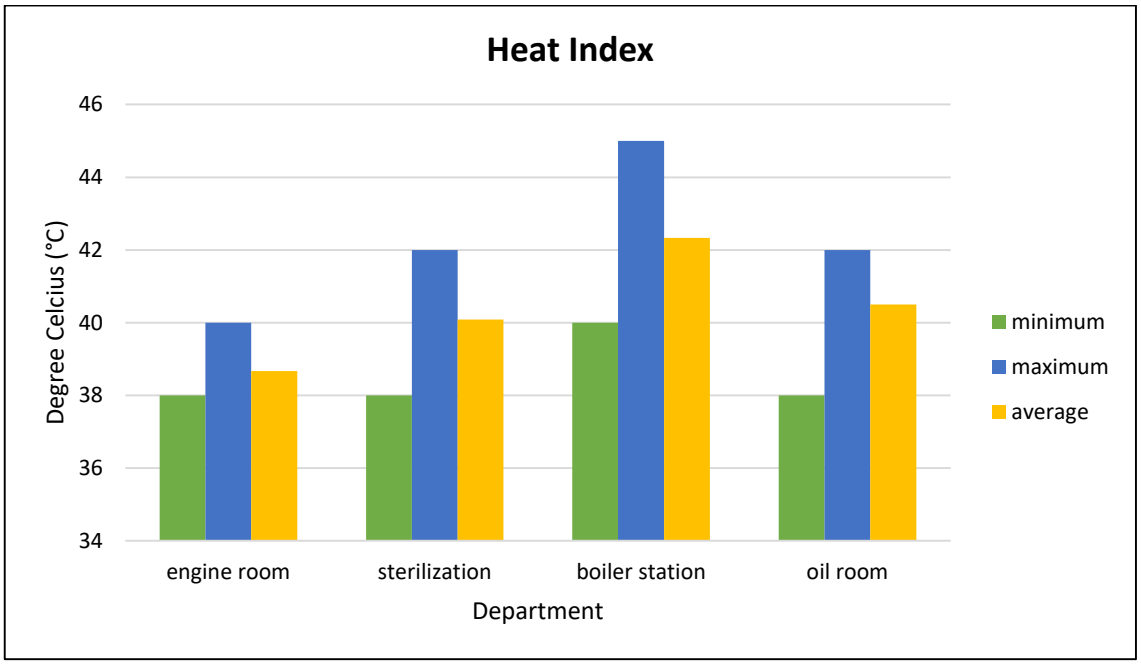

Figure 4.1 : Comparison of Heat Index among the departments at Palm Oil Mill

Figure 4.1 above shows the comparison of heat index among four departments at palm oil mill. It includes the minimum, maximum and average of temperature in term of heat index for each department at pam oil mill. Furthermore, boiler station is the department that shows the highest heat index which is 45°C among the four of departments. This is because boiler station is the department that generates steam which drives a steam turbine to produce electricity and workers need to expose to heat while at work. The lowest heat index was engine room if compared to other departments. Hence, at engine room, workers do not have higher chance to contact with heat while doing their work. Whereas the second higher of heat index is differed by only 2°C from the lowest heat index which is 40°C for both of department of sterilization and oil room.

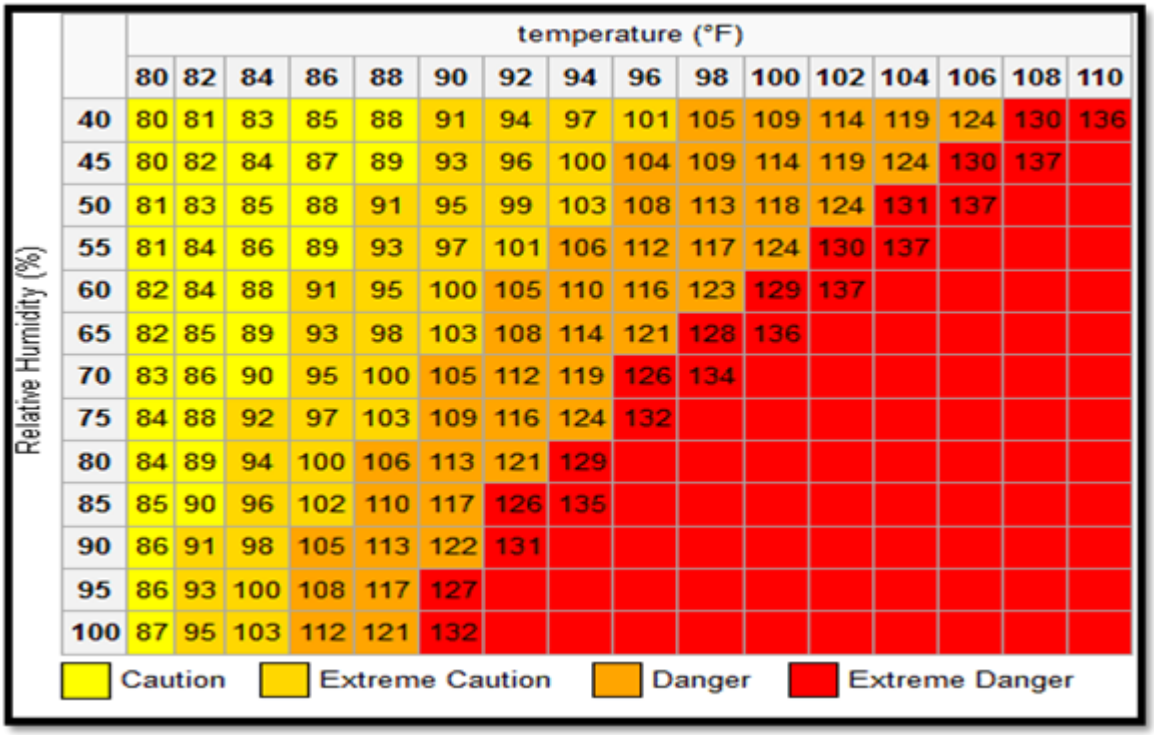

Figure 4.2 : Heat Index Chart

Source: Grant (2013).

Heat Index	Risk Level	Protective Measures
Less than 91°F	Lower (Caution)	Basic heat safety and planning
91°F to 103°F	Moderate	Implement precautions and heighten awareness
103°F to 115°F	High	Additional precautions to protect workers
Greater than 115°F	Very High to Extreme	Triggers even more aggressive protective measures

Figure 4.3 : Protective Measures for different level of risk level

Source: Osha (2016).

Figure 4.2 above shows the heat index chart that can be used to indicate the risk level of the surrounding temperature. Besides, Figure 4.3 shows the protective measures for the risk for heat-related illness that range from lower to very high to extreme. As the heat index value goes up, more preventive measures are needed to protect workers. The maximum point of heat indices for boiler department is 113.0°F which can be classify as high risk level. Meanwhile, the maximum heat indices of sterilization department can

reach 107.6 °F which is same risk level with oil room. Based on Figure 4.6, the risk level for aluminium department also in danger state which is at high risk level. Hence, it can be said that workers who work at sterilization also have the risk to suffer heat related illness because they have contact with heat in the production of palm oil. In addition, the maximum point of heat indices for engine room is 104.0 °F which can be classified also at high risk level. In conclusion, all department in this research study were at high risk level. Therefore, additional precautions that list in Figure 4.7 can be implemented in order to determine when extra precautions are needed at a worksite to protect workers from environmental contributions to heat-related illness at palm oil mill.

4.4 Personal Heat Stress Monitoring

Personal heat stress level among workers was measured based on core body temperature and heart rate among workers in palm oil mill.

4.4.1 Heart Rate

Heart rate was being considered as an effective measure of heat stress level. Heart rates were measured for 2 times to indicate in the change of the heart rate. The repeat measures of heart rate were done for before work and after 4 hours of their working. The analyses were conducted among workers in palm oil mill to indicate the heat stress level of the workers.

Table 4.6 shows the result of pulse rate before and after four hours of work between all 28 respondents. According to OSHA Technical Manual, 1992 stated that normal pulse rate is always below 110 bpm. For measurement of pulse rate before work, the minimum and maximum are 67 bpm and 114 bpm respectively. Meanwhile, for measurement of pulse rate after 4 hours of work, the highest and the lower are 69 bpm and 119 bpm. However, the maximum pulse rate for both time of their work are exceeds the standard. The highest value of average measured were 89 bpm and 88.21 bpm respectively before and after 4 hours working which was below than suggested by OSHA Technical Manual (1992). The data was supported by the study of Zailina (2017) that stated the average heart rate was below the suggested standard.

Table 4.6 : Statistics of physiological parameters of pulse rate

	Pulse rate before work (bpm)	Pulse rate 4 hours after work (bpm)
Min	67	69
Max	114	119
Mean	89.00	88.21
S.D	14.42	14.28

N=28

4.4.2 Core Body Temperature

Table 4.7 shows core body temperature of workers before start of work which was in the range of 34.3 °C - 37.1 °C (Mean 35.78 and standard deviation: 0.64). The core body temperature measured soon after work was in range of 34.3 °C to 37.30 °C (Mean 35.99 and Standard Deviation: 0.78). The rate of increase in core body temperature is a potential factor to expose of heat related illness. Besides, the threshold limit value for body temperature which is 37.5 °C (ACGIH,2008). In this study, it is found that the core body temperature of workers are not more than the standard value. Therefore, it indicates the safe range for normal body temperature, so that they can work safely. The previous study was revealed that core body temperature threshold was in safe level which is the body temperature was below than 38°C (Shamsul et al.,2014 & Logan, 1999).

Table 4.7 : The statistics of physiological parameters of core body temperature

	Body Temperature before work (°C)	Body temperature after work (°C)
Min	34.30	34.30
Max	37.10	37.30
Mean	35.78	35.99
S.D	0.64	0.78

N=28

4.4.3 Comparison of heart rate and body temperature

Table 4.8 shows the comparison of heart rate and body temperature among workers before and after work. The mean difference of heart rate for before work and after 4 hours of work was 0.79±10.63 bpm. Paired t-test analysis shows there are no significance difference of body temperatures before work and after 4 hours of work ($p > 0.05$). It shows that there are no changes of body temperature happened due to drinking water freely accessible at the workplace and rest sufficiently.

Comparisons of body temperature before work and after 4 hours of work are stated in the table. The mean difference of body temperature for before and after 4 hours of work was -0.21±0.68 °C. The test also gave no significance difference for before and after 4 hours of work. Hasan (2014) found on his study that there were also had no significance difference of body core temperature before work and after work.

Table 4.8 : The comparison of heart rate and body temperature among workers before and after work

Variables	Mean Difference (SD)	P-value
Heart rate (bpm)		
Before – After 4 hours	0.79 (10.63)	0.70
Body temperature (°C)		
Before – After 4 hours	-0.21 (0.68)	0.10

N = 28; Paired t-test

4.5 Relationship between environmental heat stress and personal heat stress

Based on Table 4.9, it shows the relationship between WBGT indoor temperature of the workplaces with pulse rate and core body temperature. The Spearman Rho was used to determine the correlation between environmental and personal heat stress. Table 4.8 shows WBGT value and heart rate for before work and after 4 hours of work had a fair correlation of ($r = -0.10$, p-value = 0.62) and ($r = 0.0012$, p-value = 0.99). In addition, there is no significance difference between WBGT value with body temperature for before work ($r = -0.07$, p-value = 0.74) and after 4 hours of work ($r = 0.16$, p value = 0.43).

In this study, the hypothesis (there was no significance correlation between the and personal heat stress was accepted. The data was supported by the study from Hasan (2014) and Vibol Sao et.al. (2017), they also stated that there was no significant relationship between WBGT indoor temperature with body temperature and pulse rate before and after work. This situation happens due to not enough environmental high temperature to cause directly towards workers.

Table 4.9 : The correlation between heat stress index (WBGTin) of each workstations with physiological parameters

Main Variable	Related Variable	r	P-value
WBGT indoor temperature	Heart rate		
	Before work	-0.10	0.62
	After 4 hours of work	0.00	0.99
	Body Temperature		
	Before work	-0.07	0.74
	After 4 hours of work	0.16	0.43

N=28:Spearman Rho Correlation

4.6 The prevalence of heat illness among workers based on individual perception

In this study, there are six types of symptoms that were asked to the workers which are fatigue, dizziness, headache, fainting, nausea, muscle cramps. Table 4.10 shows the prevalence of heat related symptoms according to the workstations. The most frequent health effect based on the individual perception is fatigue with 7 complains (25%) for each workstation and only 6 complains (21.4%) at boiler station. Fatigue is the symptoms of heat stress that can lead to workplace accident (Rowlinson et.al., 2014). Previous study by Shamsul (2014) reported that the most prevalence effect of heat stress in the present study was fatigue. In addition, dizziness and headache was experienced by workers for each workstation which are 2 complains (7.1%) and 3 complains (10.7%).

Besides, there is no fainting being complain by the workers in each workstation. Fainting also known as heat syncope, which is can occurs with prolonged standing or sudden rising from a sitting or lying position. Based on table 4.9, there are complains of muscle cramps by the workers for each workstation except workers at engine room. This is because metabolic workload at this workstation was less copared to thers workstations. Seichi, 2013 stated that heat cramps usually affect the major muscles that are being stressed in a hot environment. Symptoms of muscles cramps include profuse sweating with involuntary spasms of the large muscles in the body.

Table 4.10 : The prevalence of heat related symptoms of the workers

Health symptoms	Engine room	Sterilization	Oil room	Boiler station
	Freq. (%)	Freq. (%)	Freq. (%)	Freq. (%)
Fatigue	7 (25)	7 (25)	7 (25)	6 (21.4)
Dizziness	2 (7.1)	2 (7.1)	3 (10.7)	2 (7.1)
Headache	3 (10.7)	3 (10.7)	2 (7.1)	2 (7.1)
Fainting	-	-	-	-
Nausea	1 (3.6)	-	-	2 (7.1)
Muscle cramps	-	1 (3.6)	2 (7.1)	1 (3.6)

n=7 , Freq. = Frequency

4.7 Factors associated with personal heat stress among workers

Personal, occupational factors and area heat stress level were used to determine the relationship toward personal heat stress level of oral temperature and heart rate of the respondents. Table shows the relationship between factors associated (age, body mass index, employment period, WBGTin) with personal heat stress (heart rate and body temperature after 4 hours of work). The result of relationship between selected factors and personal heat stress were measures by using simple linear regression and multiple linear regression.

Based on table 4.11, measurement on simple regression of heart rate for 4 hours after work showed a not significant for each of the factors. Meanwhile, multiple linear regression measurement also showed a not significant for each of the factors in 4 hours

after work of heart rate. Besides, factors of age, body mass index, employment period, and WBGTin showed there are no significance on the body temperature after 4 hours of work with $p = 0.90$, $p = 0.80$, $p = 0.11$, $p = 0.41$ respectively. Similarly, previous study by (Bahri et al., 2015) in palm oil mill reported that there wasno significant difference in the relationship between body core temperature after 2 hours and 8 hours of work. Meanwhile, multiple linear regression measurement also showed a not significant for each of the factor in 4 hours after work of body temperature.

In this study, hypothesis (Factors such as personal, occupational and environmental factor significantly associated with personal heat stress) was rejected. This result was supported by Karmegam et.al., (2012) where age, BMI, employment period, WBGTin are not influence the personal heat stress. Respondents had a short break for water intake during working hour. Maintaining constant water intake may reduce body water loss and maintain body core temperature and fluid balance in body (Gupta, 2006).

Table 4.11 : The relationship between selected factors with personal heat stress

Variables	Simple linear regression		Multiple linear regression		
	Beta	**P-value**	**Beta**	**P-value**	**R^2**
Heart Rate After 4 Hours of Work					
Age	0.37	0.06	0.33	0.16	0.19
BMI	0.26	0.18	0.20	0.31	
Employment period	0.27	0.17	0.02	0.95	
WBGTin	0.07	0.71	0.07	0.70	
Body Temperature After 4 Hours of Work					
Age	-0.03	0.90	0.24	0.31	0.18
BMI	0.05	0.80	0.15	0.45	
Employment period	-0.31	0.11	-0.50	0.06	
WBGTin	0.16	0.41	0.19	0.35	

N=28; Simple and Multiple Linear Regression

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In this study, the aim of this research was to monitor the environmental area and personal heat stress level of several workstations in palm oil mill and their heat related health symptoms complaint. The area monitoring WBGTin for four workstations of this evaluation of this study were above the recommended ACGIH permissible heat exposure threshold limit value. Meanwhile, the heat indices for all workstations that included in this study were at high risk level. Hence, additional precaution was needed to protect workers from environmental contributions to heat-related illness.

The personal heat stress level was measured based on core body temperature and heart rate among the workers. Finding showed that there are no significance difference between before and after four hours of work in body temperature and heart rate. This indicates that body temperature and heart rate were slightly changing from before and after four hours of work. In addition, the average heart rate measured before and after 4 hours of work were below than the suggested the normal heart rate which is below than 110 bpm (OSHA Technical Manual 1999). Meanwhile, the average of body temperature measured before and after 4 hours of work were below the limit that recommended by ACGIH Time-Weighted Average which is below 38 °C (ACGIH,1992).

Besides, there are no significant correlation between the WBGTin and heart rate. The study also showed that no correlation between WBGTin and heart rate. This indicates the personal heat stress was not affected by the environment heat.

Furthermore, there are no significant relationship between factors that selected (age, body mass index, employment period, WBGTin) with personal heat stress (heart rate and body temperature after 4 hours of work) for simple linear regression and multiple linear regression. . Even though the environmental heat exposure were above the ACGIH's threshold limit value, the personal heat stress level did not reach unacceptable level of physiological standard. It maybe the process of acclimatization which is an individual body adjust to a gradual change in its environment, allowing it to maintain performance across range of environmental conditions.

5.2 Recommendation

Several recommendations are made from this research for the industry as well as future study.

5.2.1 Industry level

Recommendation for industry level are maintained work practices as it is applicable to palm oil mill industry to prevent excessive heat exposures which can cause heat related illness to the workers. It must be addressed by each of the palm oil mill's management in order to sustained productive and healthy workers.

5.2.2 Future Research

There are several recommendations to improve the findings and validity of the results for future research.

5.2.2.1 Sample size

The sample size is particularly small in this study compared to previous study on heat stress. Findings were limited because this study was focused only on during day shift work of operation at palm oil mill instead of day-night shift work. This study also focus on exposed group which it involved the workers at the operation without involving administration workers at palm oil mill. It is suggested that include a larger sample size. This is because different human body could have different heat stress acceptable level and it could obtain more precise result by looking into larger population of sample.

5.2.2.2 Control group

Study should well include control group which workers who have been not been exposed to heat stress, for example workers that work in office that provided with air conditioning. It could to see he differences between exposed and unexposed workers to heat stress. Personal heat stress also should be conducted for the unexposed group.

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APPENDIX A
WORKSTATIONS THAT INVOLVE IN THIS STUDY

Boiler Station

Sterilization

Engine Room

Oil Room

Personal monitoring

Environmental monitoring

APPENDIX B
GANTT CHART

TASK	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN
PREPARING TITLE PROPOSAL IDENTIFY												
APPRORIATE METHODOLOGY FINALIZE												
METHOD												
IDENTIFY LOCATION												
WALKTHROUGH OBSERVATION												
IDENTIFY RESPONDENT												
GET PERMISSION TO DO ASSESSMENT IN INDUSTRY												
DATA COLLECTION ADMINISTRATIVE												
QUESTIONNAIRE AMONG RESPONDENT												
ENVIRONMENTAL HEAT STRESS MONITORING												
PERSONAL HEAT STRESS MONITORING												
DATA ANALYSIS												
PREPARE DRAFT FINAL REPORT												
FINAL DRAFT SUBMISSION												
FYP PRESENTATION												

APPENDIX A

QUESTIONNAIRE

GENERAL CHARACTERISTICS

1. Age (**Umur**) :

☐ Under 25 ☐ 25-35 ☐ 36-45
☐ 46-55 ☐ Above 55

2. Gender (**Jantina)**

☐ **Lelaki** ☐ **Perempuan**

3. Race (**Bangsa**) :

☐ Malay ☐ Chinese ☐ Indian ☐ Others :

4. Height (**Ketinggian) :**

5. Weight (**Berat Badan) :**

6. BMI:

7. What the job activities involve :
Jenis aktiviti yang anda lakukan dalam kerja

8. How many years have you worked at this task :
Sudah berapa lama anda bekerja di sektor ini

☐ 1-3 ☐ 7-9
☐ 4-6 ☐ More than 10

9. How many hours do you work in a day :
Berapa lama anda bekerja dalam satu hari

☐ 5 hrs ☐ 6 hrs ☐ 7hrs ☐ 8hrs

WORK ENVIRONMENT

1. How do you describe the temperature of your work environment:
   Bagaimanakah anda menggambarkan suhu di persekitaran tempat kerja anda

   ☐ Very hot ☐ Hot ☐ Warm ☐ Neutral

2. Do you feel dry or humid in your workplace:
   Adakah anda rasa kering atau lembap di tempat kerja anda

   ☐ Dry ☐ Humid

3. How much time do you spend working at hot environment:
   Berapa lama anda menggunakan masa berada di tempat panas

   ☐ None ☐ Some of time ☐ Half of time ☐ Most of time ☐ All of time

4. How often do you sweat at work:
   Kekerapan anda berpeluh adalah

   ☐ None ☐ Some of time ☐ Half of time ☐ Most of time ☐ All of time

5. Is drinking water freely accessible during work
   Adakah air minuman boleh didapati di tempat kerja anda dengan percuma

   ☐ Yes ☐ No

6. How often do you drink during working hour:
   Berapa kali anda minum dalam waktu kerja anda

   _____time

7. How much of water consume each time you drink:
   Berapa banyak air yang anda ambil setiap kali minum

   ☐ <330ml ☐ 330ml-500ml ☐ 500ml-1500ml ☐ >1500ml

8. How often do you urinate during working hour:
   Berapa kali anda membuang air kencing dalam waktu kerja anda

   _____time

HEAT ILLNESS SYMPTOMS

Have you experienced these symptoms or health effect while carry out your work ?

Adakah anda pernah mengalami simpton atau penyakit ini semasa bekerja ?

Symptoms	Occurred	
	Yes	No
Fatigue **Keletihan**		
Dizziness **Pening**		
Headache **Sakit Kepala**		
Muscle Cramps **Kejang Otot**		
Fainting **Pengsan**		

Source: Hunt (2011)