



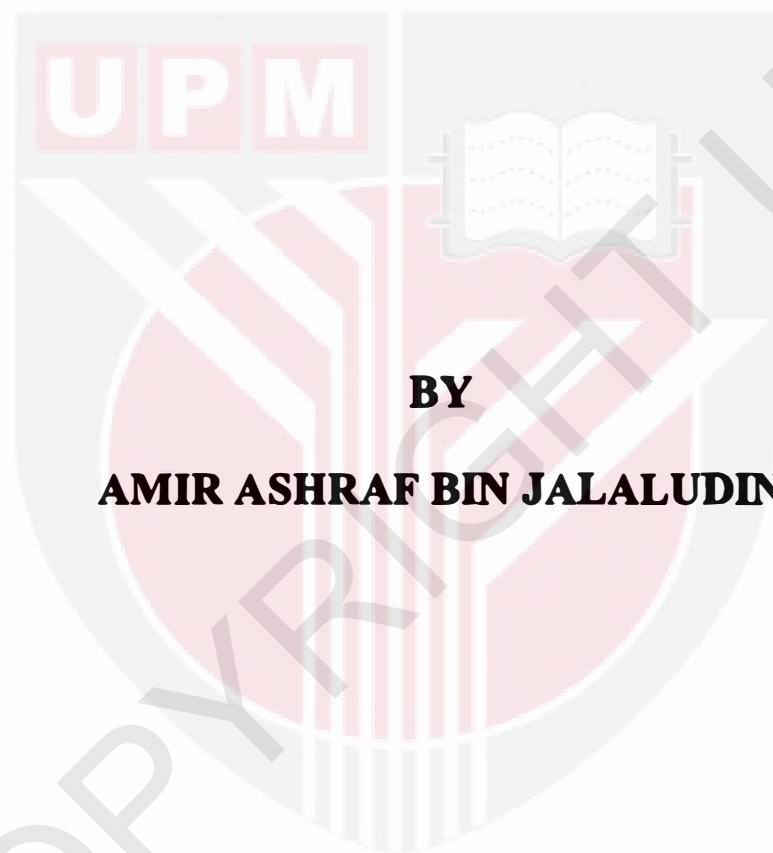
UNIVERSITI PUTRA MALAYSIA

***EFFECT OF OCCUPATIONAL HEAT STRESS ON PHYSIOLOGICAL
CHANGES AND HEAT RELATED ILLNESS AMONG WORKERS
FROM LATEX GLOVES MANUFACTURING INDUSTRY, NEGERI
SEMBILAN***

AMIR ASHRAF BIN JALALUDIN

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LATEX GLOVE MANUFACTURING INDUSTRY,
NEGERI SEMBILAN**



**BY
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**Thesis submitted in fulfilment of the requirement for the degree of Bachelor
Science (Environmental and Occupational Health) from the Faculty of Medicine
and Health Sciences, Universiti Putra Malaysia**

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ABSTRACT

EFFECT OF OCCUPATIONAL HEAT STRESS ON PHYSIOLOGICAL CHANGES AND HEAT RELATED ILLNESS AMONG WORKERS FROM LATEX GLOVES MANUFACTURING INDUSTRY, NEGERI SEMBILAN

AMIR ASHRAF BIN JALALUDIN

Background: Latex gloves production workers have exposed to high level of temperature due to the nature of their work process. However, limited study has been conducted on potential health hazards of high temperature among these industrial workers. **Objective:** This study was conducted to determine the effect of occupational heat stress on physiological changes and heat related illness among workers from latex gloves manufacturing industry. **Methodology:** This cross-sectional study was conducted at one specific latex gloves industry in Senawang, Negeri Sembilan. Total of workers (n=88) participated in this study. Adapted questionnaire, QUESTTemp[®] 36 Thermal Environmental Monitor (measure heat stress assessment (WBGT_{in})) and TSI Velocicalc[®] Air Velocity Meters (measure level of air velocity) were used. Meanwhile, OMRON MC-510 Gentle Temperature ear thermometer (measure core body temperature), POLAR Heart Rate FT60 (measure heart rate) and OMRON T3 Automatic Blood Pressure Monitor (measure blood pressure) were used in the physiological measurement. All these physiological parameters were taken in three different work shifts; before shift, after two hours working and after eight hours working. **Results and Discussion:** The average of WBGT_{in} in latex gloves production was 33.7 °C, which has exceeded the Threshold Limit Value (TLV, >26 °C). There was no significant correlation between WBGT_{in} and air velocity ($r=-0.013$, $p>0.05$). The highest symptoms for prevalence of heat related illness among respondents were fatigue, dizziness and confusion (81.8%), followed by nausea, thirst, moist skin and felt cold and excessive sweating (80.7%), rash and reddish skin after heat exposure, muscle cramp, legs and hand discomfort (26.1%), dry skin, high body temperature, stroke (9.1%) and faint (6.8%). There were significantly difference in physiological changes (core body temperature, $F=74.87$, $p<0.001$); (blood pressure, $F=37.47$, $p<0.001$); (heart rate, $F=25.17$, $p<0.001$) between three different work shifts. **Conclusions:** The workers in latex gloves production were exposed to high level of heat stress. All three physiological parameters of respondents were significantly difference between three periods of time. The air velocity at most of work sections in production area were inadequate; however the results has shown that there was no significant correlation between WBGT_{in} and air velocity. Measures such as engineering controls, administrative controls, training and monitoring of work should be emphasized in order to reduce the risk of heat stress at the workplace.

Keywords: Occupational heat stress, latex gloves manufacturing industry, physiological changes

ABSTRAK

KESAN TEKANAN HABA PEKERJAAN TERHADAP PERUBAHAN FISILOGI DAN PENYAKIT BERKAITAN HABA DALAM KALANGAN PEKERJA PERINDUSTRIAN SARUNG TANGAN LATEKS, NEGERI SEMBILAN

AMIR ASHRAF BIN JALALUDIN

Latar Belakang: Pekerja pengeluaran sarung tangan lateks telah terdedah kepada suhu yang tinggi disebabkan sifat proses kerja mereka. Walau bagaimanapun, masih kurang kajian telah dijalankan mengenai bahaya suhu tinggi dalam kalangan pekerja industri ini. **Objectif:** Kajian ini dijalankan untuk menentukan kesan tekanan haba pekerjaan terhadap perubahan fisiologi dan penyakit berkaitan haba dalam kalangan pekerja perindustrian sarung tangan lateks. **Metodologi:** Kajian keratan rentas ini dijalankan di sebuah industri sarung tangan lateks khusus di Senawang, Negeri Sembilan. Jumlah pekerja ($n=88$) telah mengambil bahagian dalam kajian ini. Borang soal selidik kajian lepas yang disesuaikan dengan kajian semasa, QUESTTemp[®] 36 Pemantauan Suhu Persekitaran (mengukur penilaian tekanan haba ($WBGT_{in}$)) dan TSI Velocicalc[®] Pengukur Halaju Udara (mengukur tahap halaju udara) telah digunakan. Sementara itu, termometer telinga OMRON MC-510 Gentle Temperature (mengukur teras suhu badan), Kadar Jantung POLAR FT60 (mengukur kadar dengupan jantung) dan Monitor Tekanan Darah Automatik OMRON T3 (mengukur tekanan darah) telah digunakan semasa pengukuran fisiologi. Semua parameter fisiologi ini diambil dalam waktu giliran kerja yang berbeza; sebelum bekerja, selepas dua jam bekerja and selepas lapan jam bekerja. **Keputusan dan Pembincangan:** Purata bagi $WBGT_{in}$ dalam pengeluaran sarung tangan lateks adalah 33.7°C , yang telah melebihi Nilai Had Ambang (NHA, $>26^{\circ}\text{C}$). Nilai $WBGT_{in}$ tiada korelasi dengan bacaan halaju udara ($r=-0.013$, $p>0.05$). Simptom bagi prevalen paling tinggi bagi penyakit berkaitan haba adalah keletihan, pening kepala, kekeliruan (81.8%), diikuti oleh loya, dahaga, kulit lembap dan terasa sejuk dan peluh berlebihan (80.7%), ruam dan kulit kemerahan selepas terdedah kepada haba, kekejangan otot, lenguh pada tangan dan kaki (26.1%), kulit kering, suhu badan yang tinggi dan strok (9.1%) and pengsan (6.8%). Terdapat perbezaan yang signifikan dalam perubahan fisiologi (suhu badan teras, $F=74.87$, $p<0.001$); (tekanan darah, $F=37.47$, $p<0.001$); (kadar dengupan jantung, $F=25.17$, $p<0.001$) antara tiga waktu kerja yang berbeza. **Kesimpulan:** Pekerja dalam produksi sarung tangan lateks telah terdedah kepada haba yang tinggi. Ketiga-tiga parameter fisiologi responden mempunyai perbezaan yang signifikan antara tiga tempoh masa. Halaju udara di kebanyakan bahagian kerja produksi tidak mencukupi; walau bagaimanapun keputusan menunjukkan bahawa tiada korelasi yang signifikan antara $WBGT_{in}$ dan halaju udara. Langkah-langkah seperti kawalan kejuteraan, kawalan pentadbiran, latihan dan pemantauan kerja harus ditekankan untuk mengurangkan risiko tekanan haba di tempat kerja.

Kata Kunci: Tekanan haba pekerjaan, perindustrian sarung tangan lateks, perubahan fisiolo

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LIST OF ABBREVIATIONS

<	Less than
>	More than
°C	Degree Celcius
AL	Action Limit
BMI	Body Mass Index
bpm	beats per minute
CCBA	closed-circuit breathing apparatus
DOSH	Department of Occupational Safety and Health
DPNR	deproteinised natural rubber
ENR	epoxidized natural rubber
GDP	Gross Domestic Product
ISO	International Organization for Standardization
LSD	lysergic acid diethylamide
m/s	meter per second
mL	militre
mmHg	milimeter per mercury
MREPC	Malaysia Rubber Export Promotion Council
OSHA	Occupational Safety and Health Administration
PCP	phencyclidine hydrochloride
PPE	personal protective equipment
SMR	Standard Malaysian Rubber
SOCISO	Social Security Organization
T_{db}	dry-bulb temperature
T_g	globe temperature
T_{nwb}	Natural wet-bulb temperature
TLV	Threshold Limit Value

TPENR **thermoplastic elastomers natural rubber**

WGBT_{in} **Wet Bulb Globe Temperature Indoor**



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CHAPTER 1

INTRODUCTION

1.1 Background

Malaysia has a rapid economic growth via industrialization has given a significant impacts on income distribution and quality of life. The listed type of industries in the First Schedule of Occupational Safety and Health Act (OSHA) 1994, have contributed comprehensively to this rapid economic growth. Among all of these sectors, occupational health problems has been arising those days due to the occupational heat exposure at different work environmental setting (Srinivasan et al, 2016). An epidemiologic study has differentiated several type of industries generally based on their characteristics of workplace heat exposure (Xiang et al, 2013). The differences have been summarized and discussed as below.

Manufacturing Industries

In manufacturing industry, most of the workers were mostly surrounded by hot machines, furnaces, ovens, boilers and molten metals. Naturally, all those machineries and equipments come with processes with high and extreme temperature. These were the main source of heat exposure at the workplace that increases level of heat stress among workers. A poor thermal indoor environment is one of the conditions that affecting workers' health and lead to occupational heat stress (Chowdhury et al, 2017). Hot days due to climate change nowadays may be

worsening the extent of heat stress for them that working nearby heat generating sources and processes.

Agricultural Industries

Agriculture also was one of the industries at highest risk of heat-related illness and injury. Mainly, harvesters and farmers were exposed to outdoor heat extremes for long period of time. According to Spector et al (2017), there were several epidemiologic studies have reported an association between ambient heat exposure and injuries in agriculture. Plus, there was still a lack of occupational health and safety programmes. This induced more to increase accidents due to heat exposure. For instance, in United States, this sector has contributed with mortality rate approximately 20 times greater than for all civilian workers.

Construction Industries

As for construction, it has a few contributing factors that escalated the risk of heat-related health impact and injury among its workers. For example, constant use of machinery and powered tools, working on elevated surfaces, heavy workload and lack of appropriate condition and accommodation near work sites and constant direct exposure to sunlight. Such symptoms as headache, dizziness, easy to get fatigue, impatient and waking up early due to hot condition normally has risen among them and this could strengthen that heat exposure may increase the risk of occupational accidents and injuries (Xiang et al, 2013).

Mining Industries

Commonly, workers in mining industries have been facing a hot working condition. Most of the heat stress problems have reported from underground mines as additional

heat from virgin rock and mines increased with depth (Xiang et al, 2013). Moreover, mine workers also facing extreme heat load when they were wearing their personal protective equipment (PPE) such as breathing apparatus like a closed-circuit breathing apparatus (CCBA) and of course entering hot and poorly ventilated environment (Varley, 2004). This also put burden to them as they have inability to drink any fluids for extended period of time. Therefore, without preventive and control measures taken, mining workers also at high risk to get occupational heat stress.

This study intended to focus more the effect of occupational heat stress among workers from latex glove manufacturing industry. Azer et al (2016) have stated that manufacturing industries was significantly related to real Gross Domestic Product (GDP) per capita, which indicated positive contribution to Malaysia economic growth as compared to other sectors. In fact, Malaysia Rubber Export Promotion Council (2017) has stated that Malaysia is the world's fifth largest producer of natural rubber. Specifically, rubber gloves under the latex goods category continued to contribute significantly to total exports of rubber products by reaching RM13.3 billion in export value of all rubber products exported. Since that, clearly, Malaysia has quite numbers of latex gloves manufacturing industries to meet the export demand. All of these required production process with extreme heat and involved a large number of workers in long duration of time of heat exposure. Most of the latex glove production or even other production as well, was non-stop with twenty-hour production which mainly involve the use of heat productivity machinery and process that include upstream, midstream and downstream sectors (Mohd Kassim, 2016).

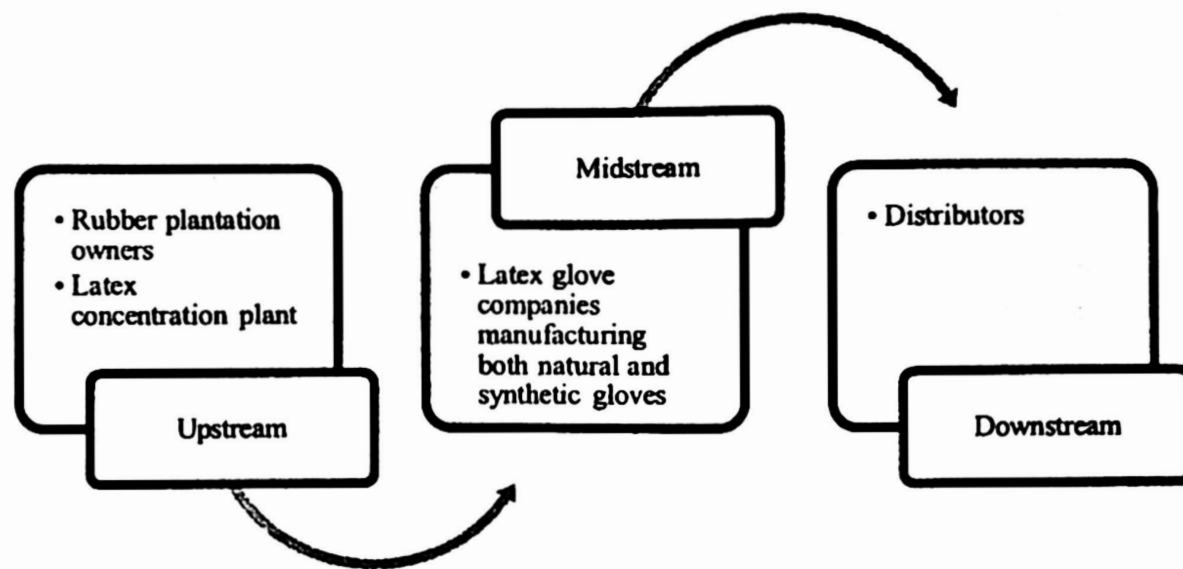


Figure 1.1 Flow of three sectors involved in a latex glove industry.

A worker that has exposed to extreme heat or high air temperature in work environment was considered underwent a physical occupational hazard. Due to long term of this exposure, the worker might result in suffering from occupational heat stress. The Guidelines on Heat Stress Management at Workplace (2016) defined heat stress was the overall heat load to which an employee may be exposed from a combined contribution of metabolic rate, environmental factors – air temperature, humidity, air movement and radiant heat, clothing requirements. Heat stress occurred when a body's mean of controlling its internal temperature started to fail. Rahman et al (2016) stated that heat stress could cause discomfort, fatigue, exhaustion, heat cramps and heat stroke in human. This also would induce to occupational injuries and fatalities. Study has shown that heat exposure has been considered as a threat to workers' safety (Chang et al, 2015). The research has demonstrated a linkage between heat exposures to increased rate of unsafe behaviours. For instance, the slipperiness of sweaty palms, the fogging of safety equipment due to heat and impaired physical performance were often blamed for such increases.

According to Yusof et al (2015), heat stress could be affected by high temperature working environment which could affect physiological changes of blood pressure, heart rate and core body temperature. Thus, this led to various heat-related illnesses that could have affects workers such as listed in Guidelines (2016) like heat rash, heat cramps, heat exhaustion, heat syncope and heat stroke. There were many factors that contribute to heat stress and these included environmental and non-environmental factors (Guidelines, 2016). The factors were listed as below;

Table 1.1 Contributing factors that led to heat stress

Environmental factors	Non-environmental factors
• Air temperature • Air velocity • Radiant temperature • Relative humidity	• Personal factors (e.g. clothing, health condition, acclimatisation and hydration) • Work factors (e.g. metabolic rate and work rate such as light/moderate/heavy)

(Source: Guidelines on Heat Stress Management at Workplace, 2016)

Therefore, as for this study, the environmental factors that have been the most significant contributor to heat stress should be measured and follows by the non-environmental factors that would also identified.

1.2 Problem Statement

Previous studies have shown a significant effect between high environmental temperature and negatively impact mainly to workers' health, which could lead them to get any heat-related illness or any occupational injury and accident. For instance, Monazzam et al (2014) has found that in one particular Iran's petrochemical industry, there was a significant effect on physiological parameters due to exposure of extreme heat at work site for both acclimated and unacclimated subjects. It showed that WBGT index and discomfort indexed has the highest relationship with heart rate among workers. Shamsul and Dubashini (2014) also found that there was significant correlation between core body temperature and pulse rate after 8 hours of working periods in steel plant factory, Johor. Another study conducted in rubber glove industry previously and discovered the workers in rubber glove industry at Selangor, were exposed to high level of heat stress over time. The physiological parameters such as blood pressure, heart rate and core body temperature among workers have shown significant difference between three period of time – before shift, after 2 hours of working and after 8 hours of working (Mohd Kassim, 2016).

Occupational heat exposure may affect both outdoor and indoor workers who performed activities in hot environment such as near furnaces, ovens and boilers (Fabiana et al, 2017). This has proven that workers in manufacturing industry have high potential involved in occupational heat stress due to availability of several contributing factors mentioned earlier, specifically in latex glove industry. According to Social Security Organization (SOCSO) (2015), statistics has revealed that there were high number heat-related accidents among workers in Malaysia's manufacture of rubber products. In that particular year, the total accidents reported in rubber products manufacturing industry were 386 accident cases. As for heat-related

accidents, 126 (32.64%) of them were reported as accident caused by exposure to heat and 253 (65.54%) accident cases were classified under caused of contact with hot object/substance. As calculated, majority of accidents reported in manufacture of rubber products by SOCSO (2015) were heat-related accidents.

As mentioned earlier on, workers in manufacturing industry were mostly surrounded by heat-releasing machinery equipments, boilers, furnaces and ovens. Same goes to latex glove industry, it involved quite number of machinery – particularly ovens/main ovens, and naturally followed by processes that required high temperature in its production. Since that, high level of heat has been produced from each capacity and the workers in latex glove production area are directly at high risk of heat stress. Generally, the processes involved in latex glove industry including at study location, were involving coagulant and latex dipping, drying, leaching, beading, vulcanization and others (UKEssays, 2015). Basically, all of those processes were needed of high temperature condition and this required several types of oven such as main oven, coagulant oven and drying oven as well. In fact, the temperature has been identified and it was in range of 90°C – 160°C and the highest was a main oven 1 (156.4°C).

Consequently, this study was to determine the effect of occupational heat stress and evaluate the physiological changes involved – blood pressure, heart rate and core body temperature, and also heat related illness among workers in latex glove manufacturing industry in Senawang, Negeri Sembilan. Based on Guidelines (2016), contributing factors needed to be measured and identified while conducting the study, especially the environmental factors that involved air temperature, air velocity, radiant heat and relative humidity. Based on Mohd Kassim (2016), when the glove production workers were exposed to high level of heat, the physiological

parameters mentioned previously tended to increase. For instance, as for core body temperature, the threshold level associated with loss of judgement and reaction time was 38° C. If it achieved 38.6° C and above, physical heat strain begun and if not treated, would progress to acute heat related illness. Meanwhile, the other reference limit to be referred, 110 bpm and between range of systolic and diastolic of 100 and 120 mmHg and 60 to 90 mmHg, were for heart rate and blood pressure, respectively (Shamsul & Dubashini, 2014). The consequences or effect of these physiological changes shows that they may lead to heat-related illness that could be conveyed in diagram below;

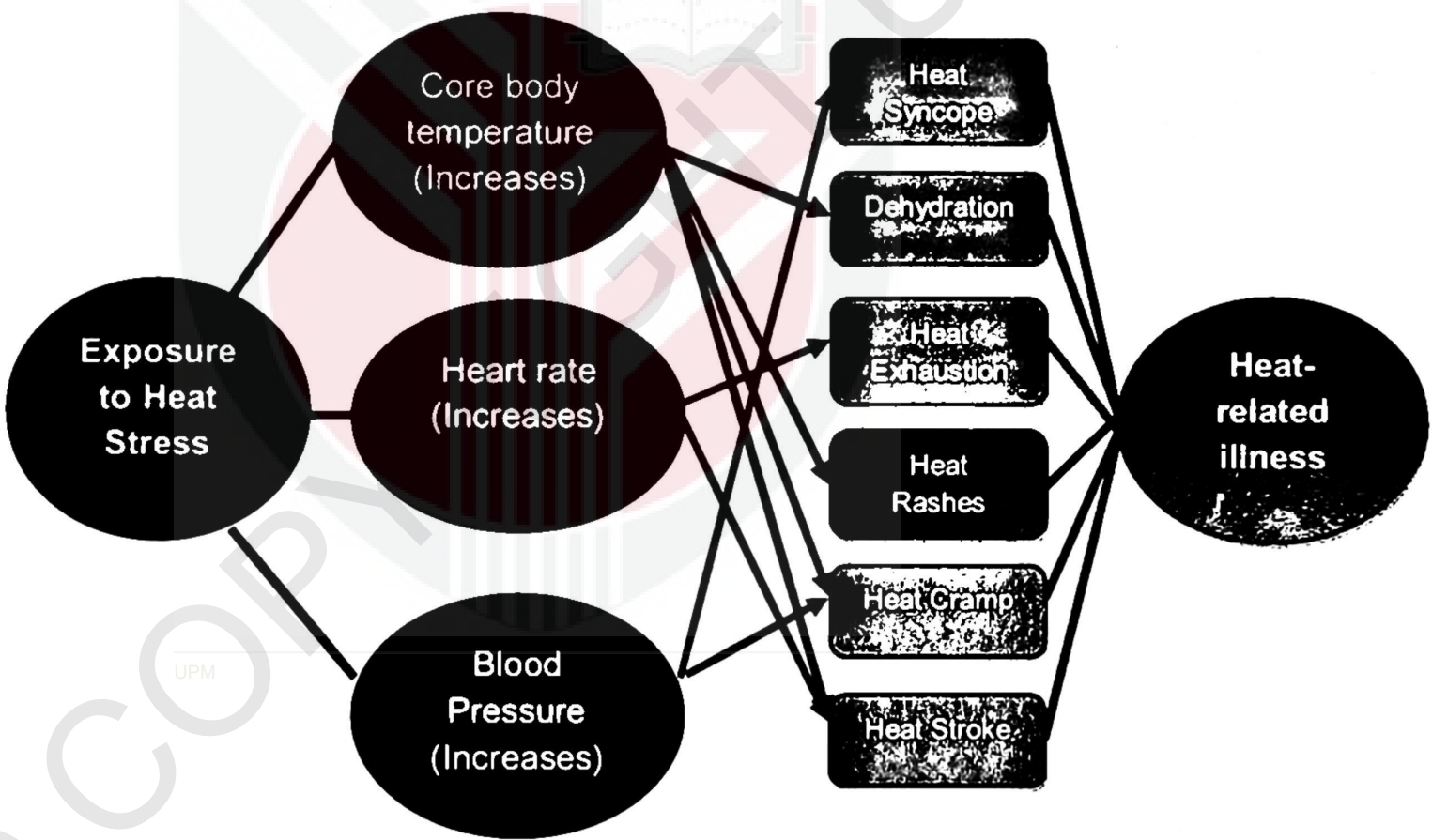


Figure 1.2 Relationship between physiological changes among workers exposed to heat stress and Heat-Related Illness (Yusof et al, 2015; Mohd Kassim, 2016)

1.3 Study Justification

Since 2011, Malaysia has been acquired leadership in production capacity of latex products although the country no longer the biggest source of commodity. For the last 15 years, the country has been the source of rubber gloves, exporting about 100 billion pieces of products to meet two-third of global demand (Rubber Journal Asia, 2011). Recently, according to Plantation Industries & Commodities Minister, Dato' Seri Mah Siew Keong, Malaysia's rubber exports were set to surpass RM 27 billion in 2017, 10% more than 2016, RM 24.79 billion (Ching, 2017). This obviously shows that manufacture of rubber products did contribute significantly to Malaysia's economic growth. If this heat stress issue still arise and not been controlled well, it may affect the industry's production negatively aside from the workers' health themselves.

Research regarding heat stress at workplace among workers has been commonly conducted and published globally. This has proven that there were many countries were taken seriously about this matter. According to an epidemiologic study, heat stress research from South and Southeast Asia only has covered more than 23% and there still more to be progressed (Xiang et al, 2013). Unfortunately, there was still an inadequate number of study conduct in Malaysia, specifically in latex glove manufacturing industry. One of the main reasons was may due to the fact that every production plant has different work environment setting include both environmental and non-environmental condition.

Malaysia's Department of Safety and Health (DOSH) under Ministry of Human Resources, has established a comprehensive guideline regarding Heat Stress Management at Workplace in 2016. The general purpose of this guidelin was to

provide guidance on how to recognize, estimates, prevents and treat heat stress at work. With this, the study could follow and refer the criteria and requirement that has been stipulated in the guidelines itself. As being the main reference, the study could provide more stable and suitable data by following the country's own standard and requirement.

In view of this study aims to measure the environmental factors by using proper method and standard operating procedures (SOP) such as Wet Bulb Globe Temperature (WBGT) and Air Velocity Meter. As for that, this study practically to measure the effect of heat stress and physiological changes (blood pressure, heart rate and core body temperature) and heat related illness to workers that exposed to extreme heat at latex glove manufacturing industry. Therefore, this study needed to be conducted in order to develop and provide fundamental data regarding heat stress among latex glove manufacturing industry workers. This could help to increase the heat stress management at workplace.

1.4 Objectives

1.4.1 General Objective:

To determine the effect of occupational heat stress on physiological changes (core body temperature, heart rate and blood pressure) and heat related illness among workers from latex glove manufacturing industry in Senawang, Negeri Sembilan.

1.4.2 Specific Objectives:

- I. To determine socio-demographic data of respondents
- II. To determine the WBGT index and the metabolic workload at latex glove production.
- III. To determine air velocity and relative humidity at latex glove production area.
- IV. To determine the prevalence of heat related illness among workers while exposed to heat.
- V. To determine physiological parameter (**core body temperature, heart rate and blood pressure**) between before shift, after 2 hours working and after 8 hours working among respondents.
- VI. To determine the correlation between WBGT index and air velocity in latex glove production area.
- VII. To compare the differences of physiological changes (**core body temperature, heart rate and blood pressure**) with three different work shifts among respondents that exposed to heat (before shift, after 2 hours working and after 8 hours working).

1.5 Hypothesis

H₁: There is a significant correlation between WBGT index and air velocity in latex glove production area.

H₂: There is a significant difference in core body temperature between before shift, after 2 hours working and after 8 hours working among respondents that exposed to heat.

H₃: There is a significant difference in heart rate between before shift, after 2 hours working and after 8 hours working among respondents that exposed to heat.

H₃: There is a significant difference in blood pressure between before shift, after 2 hours working and after 8 hours working among respondents that exposed to heat.

1.6 Definition of Terms

1.6.1 Conceptual Definition

1.6.1.1 Heat Stress

Heat stress could be defined as the sum of environmental and metabolic heat loads which increased the core body temperature of an individual that may potentially cause physiological decrements (Srinivasan et.al, 2016).

1.6.1.2 Physiological Changes

Physiological changes was well-known as physiological adaptations when the body tend to increase the temperature, heart rate, and blood pressure when exposed to high level of temperature (Mohd Kassim, 2016).

1.6.1.3 Heat Related Illness

Heat related illness was a physiologic insult to the body from the exposure to elevated temperature, which could lead to elevation of core body temperature that surpassed the compensatory limits of thermoregulation (Atha, 2013). It also defined when a person has symptoms including headache, nausea and fatigue after exposure to the heat (MedicineNet.com, 2013).

1.6.1.4 Natural Wet Bulb Temperature

Natural wet bulb temperature was which air was allowed to flow over the sensor naturally rather than being forced. When air flow was less

than 3 m/s, the temperature reduction was less than psychometric wet bulb for same humidity air movement (Plog & Quinland, 2002).

1.6.1.5 Globe Bulb Temperature

Globe bulb temperature was responded to radiant heat from solid surroundings and convective heat with the ambient air. It was to estimate the average wall temperature of surroundings (Plog & Quinland, 2002).

1.6.1.6 Dry Bulb Temperature

Dry bulb temperature was direct measurement of air temperature. The temperature sensor was surrounded by air, which was allowed to freely flow around the sensor and it may influence by radiant heat sources. Therefore, it should be shielded from them (Plog & Quinland, 2002).

1.6.2 Operational Definition

1.6.2.1 Heat Stress

Heat stress level was determined by using QuestTemp° 36 Thermal Environmental Monitor in order to measure environmental temperature in Degree Celsius (°C).

1.6.2.2 Physiological Changes

Core body temperature was measured by using OMRON MC-510 Gentle Temperature Ear Temperature. Meanwhile, as for heart rate, POLAR Heart Rate Monitor has been applied and also OMRON

Blood Pressure Monitor Model T3 was used for measuring blood pressure.

1.6.2.3 Heat Related Illness

Heat-related illness was measured by using adapted questionnaire. The questionnaire consisted of all symptoms related to health effect after exposed to high level of temperature.

1.6.2.4 Natural Wet Bulb Temperature

Wet bulb temperature was measured by exposing a wet sensor, such as wet cotton wick fitted over the bulb of a thermometer, to the effects of evaporation and convection. The term natural referred to air movement around sensor (Guidelines, 2016).

1.6.2.5 Globe Bulb Temperature

The temperature was measured inside a blackened, hollow and thin copper globe (Guidelines, 2016).

1.6.2.6 Dry Bulb Temperature

It was measured by a thermal sensor, such as ordinary mercury in glass thermometer that was shielded from direct radiant energy sources (Guidelines, 2016).

1.7 Conceptual Framework

Heat stress was classified under one of the main occupational physical hazard in production of latex glove industry. The workers in production area were exposed to high temperature which has caused some physiological changes. In this conceptual framework, the heat source was the main oven. The concerned variables were relative humidity, air velocity, air temperature and radiant heat. Meanwhile, as for individual activity is consisting of metabolic rates and workload. The conceptual framework was as below.



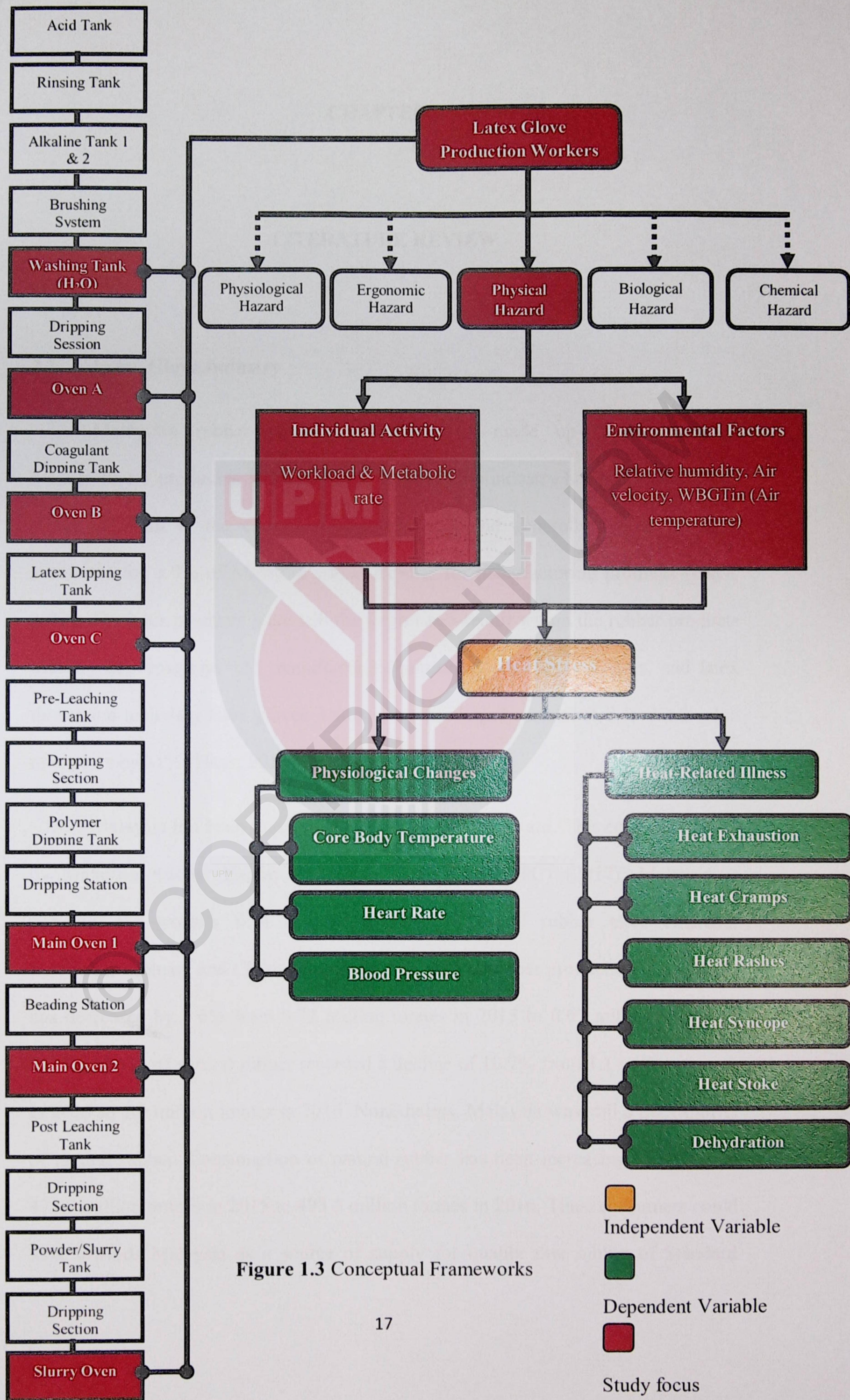


Figure 1.3 Conceptual Frameworks

CHAPTER 2

LITERATURE REVIEW

2.1 Latex Glove Industry

Malaysian rubber products industry was made up more than 500 manufacturers producing latex products. In 2011, the industry has been contributed RM18.1 billion to the country's export earning and generally rubber products accounted for 3.9% of Malaysia's total exports for manufacturing products (Hays, 2013). The latex products were still the largest sub-sector within the rubber products industry and comprise 125 manufacturers producing condom, catheters, and latex thread and including latex gloves. Latex glove has largely contributed for total value of exports by 81% (Hays, 2013).

Malaysia has been improving records by times forward. This could be proven by Malaysia Rubber Export Promotion Council (MREPC) (2017), Malaysia is currently the world's fifth largest producer of natural rubber after Thailand, Indonesia, Vietnam and China. In spite of that, natural rubber production in Malaysia has decreased by 6.6% from 0.72 million tonnes in 2015 to 0.67 million tonnes in 2016. Exports of natural rubber recorded a decline of 10.7% from 1.1 million tonnes in 2015 to 1.0 million tonnes in 2016. Nonetheless, Malaysia was still a net exporter of natural rubber. Consumption of natural rubber has been increasing by 4% from 474.7 million tonnes in 2015 to 493.5 million tonnes in 2016. Thus, consumers could look towards Malaysia as a source of supply for quality raw rubber of Standard

Malaysian Rubber (SMR) grades, specialty rubber such as epoxidized natural rubber (ENR), deproteinised natural rubber (DPNR), thermoplastic elastomers natural rubber (TPENR) and latex concentrates including Low Protein Latex. Meanwhile, for synthetic rubber, the production in Malaysia also has been increasing by 23% from 0.10 million tonnes in 2015 to 0.12 million tonnes in 2016. Anyhow, Malaysia was still a net importer of synthetic rubber. As for latex goods, it remained the largest contributor to Malaysian exports of rubber products, by reaching RM14.6 billion in 2016. It accounted for 80.7% of the total exports of rubber products in the year. Rubber gloves under the latex goods category continued to contribute significantly to total exports of rubber products by reaching RM13.3 billion in export value or 73.2% of the total value of all rubber products exported (MREPC, 2017).

One of Malaysia's top producers of latex gloves was established in 1980 and has continually broken into new markets all over the world. This could be proven when it has exported products to more than 30 countries. Mohd Kassim (2016) has stated that Malaysia's top producer was the world's largest rubber glove manufacturer, with 20 factories and 379 production lines. Some of the factories are located in other countries and to be exact, four of them were in Thailand and two in China. The particular company has a total capacity of 33.75 billion pieces of gloves/year, sells to 180 countries and has a 23% share of global market. The latex glove manufacturing industry was building four more plants costing about RM160 million and this would add 80 production lines more to raise the company's capacity by 7.5 billion pieces to 41.24 billion pieces/year. It made 13 types of gloves including latex (powdered), latex (powder-free), vinyl and nitrile that designed to meet a whole range of requirements (Rubber Journal Asia, 2011).

In latex glove industry involved processes including dipping chemical process, machinery process and burning process by using oven (Mohd Kassim, 2016). The heating process involved in latex glove industry production line were using natural gas, steam and heat conduction oil. Clearly, the heat produced for each production line was high and the workers would highly exposed. Eventually, this would lead to heat stress and contribute to physiological changes and heat-related illness. The Figure 2.1 and Table 2.1 showed the process flow chart and temperature involved respectively of latex glove production as below discussed;



Figure 2.1 Process Flow Chart of Latex Glove productions

Table 2.1 The process of latex glove production and temperature involved

Process	Temperature	Work Task
1) Acid Tank (Nitric Acid)	Below 50 °C	To remove the powder and dirt from the formers
2) Rinsing Tank	Below 50 °C	To rinse the former
3) Alkaline Tank 1 (KOH)	Below 50 °C	To neutralize any acidic solution carried on the formers
4) Alkaline Tank 2	Below 50 °C	To use for rinsing purpose
5) Brushing System	Below 50 °C	Circular Brush and Horizon Brush
6) Washing Tank (H ₂ O)	50 °C	To wash/rinse the formers
7) Dripping Session	Below 50 °C	To drip chemicals after dipping process
8) Oven A	99 °C	Former dryer
9) Coagulant Dipping Tank	70.4 °C	To form film of coagulant
10) Oven B	103.1 °C	Drying the mold
11) Latex Dipping Tank	36.6 °C	To form latex film on formers
12) Oven C	133.2 °C	Gelling process for the latex film
13) Pre Leaching Tank	75.5 °C	To reduce the chemical

		residue Tank 1,2 and 3
14) Dripping Session	Below 50 °C	To drip chemicals after dipping process
15) Polymer Dipping Tank	33.2 °C	Acrylic based polymer to coat inside glove and act as barrier to use's skin have allergy
16) Main Oven 1	156.4 °C	Drying process
17) Beading Station	Below 50 °C	To remove beads from latex gloves
18) Main Oven 2	112 °C	Vulcanization process
19) Post Leaching Tank	90 °C	To extract the protein residue Tank 4,5 and 6
20) Dripping Section	Below 50 °C	To drip chemicals after dipping process
21) Powder/Slurry Tank	Below 50 °C	To use for powder glove only
22) Dripping Section	Below 50 °C	To drip chemicals after dipping process
23) Slurry Oven	87 °C	To use for powder glove only
24) Beading Brush Station	Below 50 °C	To brush beading
25) Stripping Station		The finished gloves ready to be stripped

2.2 Heat Stress

Heat stress could happen when the body of an individual reacted to heat by increasing the blood flow to the skin's surface and by sweating. This results in cooling as sweats evaporates from the body surface and heat was carried to the surface of the body by the increased of blood flow. Heat could also be lost by radiation and convection from the body's surface (Guidelines, 2016). The heat stress situation that generally needed to be acknowledged are when workers wearing protective clothing and performing heavy work in hot and humid conditions. These workers were at high risk because sweat evaporation was restricted by the type of clothing and humidity of the environment. Heat would be produced within the body due to the work rate and of insufficient heat lost, core body temperature would rise. As the core body temperature rised, the body will reacted by increasing the amount of sweat produced which may lead to any heat-related illness such as dehydration. Another physiological changes occur which was heart rate also may increase which put additional strain to the body as well.

Heat was continuously generated in the human body by metabolic processes and exchanged with the environment and among internal organs by conduction, convection, evaporation and radiation (Thermopedia, 2011). Conduction was when the heat transfer directly from the molecules to other solid, liquid or gas. Plog and Quinlan (2002) has stated that the variance of temperature between skin and the solid surface, the thermal conductivity of solid body that the person contacts and clothing that maybe separate the person from the body surface were depending factors of heat transfer rate. As for convection, the cooling of the air around the body by the cooler air passing over the warm skin that are exposed. Radiation was a method of heat transfer that does not rely upon any contact between the heat source and heated

object as was the case with conduction and convection. The evaporation was from liquid surface was very effective cooling mechanism. The human body made use of evaporative cooling by perspiration or sweating to give off energy when surrounded by a temperature higher than body temperature. The cooling process was an example of the approach of thermal equilibrium.

According to Plog and Quinlan (2002), the rate of convection depended on the magnitude of the temperature differences, the amount of air motion and the clothing. Guidelines (2016) has emphasised that radiant heat may be presented if there were heat sources in the environment. Radiant heat could affect people who were exposed to direct sunlight or close to process area which emitted heat. With that, it also affected the surrounding solid surface of average temperature, skin temperature and clothing. The exchange rate of heat gradient of certain environmental condition could inhibit appropriate thermoregulation (Mohd Kassim, 2016).

The main instrument that would use in this study was wet bulb globe temperature (WBGT). It was a common equipment to measure heat stress level and the parameters involved were relative humidity, globe temperature, natural-bulb temperature and dry temperature (Monazzam et al, 2014). WBGT also has been proposed in ISO7243 for estimating the heat stress among workers in hot work environment. With that, it was the most suitable and reliable instrument to indicate the heat stress level. The calculation would be involving $WBGT_{in}$ and $WBGT_{out}$. As for $WBGT_{in}$, it would calculate in shaded areas where as the $WBGT_{out}$ would calculate under condition of direct sunlight. The calculation were as follows:

For indoor and outdoor conditions with no solar load, $WBGT_{in}$ was calculated as:

$$WBGT_{in} = 0.7 T_{nwb} + 0.3 T_g$$

For outdoor with solar load, $WBGT_{out}$ was calculated as:

$$WBGT_{out} = 0.7 T_{nwb} + 0.2 T_g + 0.1 T_{db}$$

Where;

T_{nwb} = Natural Wet-Bulb Temperature

T_g = Globe Temperature

T_{db} = Dry-Bulb Temperature

Natural wet-bulb temperature (T_{nwb}) was the temperature of air flow over sensor naturally which was very sensitive to relative humidity and air movement. It would measure inside the a water wetted small cloth sock, which stimulated the heat exchange effect of evaporation from sweat covered skin. The globe temperature (T_g) would be measured radiant heat from solid surroundings and convective heat with ambient air. The measurement took place inside a black globe, which stimulated the uptake of heat on skin from heat radiation. As for dry-bulb temperature (T_{db}) was measuring air temperature directly from the environment (Srinivasan, 2016).

The Guidelines (2016) has stated that metabolic rate was influenced by workers' job scope and duration of heat exposure at workplace. The job scope consisted of four categories of physical work. The metabolic rate needed to determine in order to acknowledge the rate of internal heat generated from the body to maintain thermal equilibrium with the surrounding (Plog and Quinlan, 2002). These metabolic rates could be determined by estimation of Guidelines has created

the Threshold Limit Value (TLV) which included an empirically-derived table of work category and metabolic rate (Watt, W). The goal of TLV was to maintain the core body temperature within 1 °C of normal (37 °C), without exceeding 38 °C. When the level of physical work increased in hot working environment, workers were at high risk as the core body temperature would increase upper 38 °C. According to Shamsul and Dubashini (2014), the threshold level of core body temperature associated with loss of judgement and reaction time was 38 °C. After reaching at 38.6 °C, physical heat strain would begin and if not treated immediately, the heat stroke would occur. Table 2.2 as shown below has described the four categories mentioned earlier.

Table 2.2 Metabolic rate of Workers by Job Category

Work Category	Metabolic Rate	Examples of physical work
Rest	115 W	Sitting
Light	180 W	Sitting with manual work with hands or hands and arms and driving
		Standing with some light arm work and occasional walking
Moderate	300 W	Sustained moderate hand and arm work, moderate arm and leg work, moderate arm and trunk work, or light pushing and pulling. Normal walking Moderate lifting
Heavy	415 W	Intense arm and trunk work, carrying, shoveling, manual sawing, pushing and pulling heavy loads and walking at a fast pace.

Heavy metal handling

Very Heavy 520 W Very intense activity at fast to maximum pace.

Source: Guidelines on Heat Stress Management at Workplace 2016, DOSH Malaysia

TLV and Action Limit (AL) were also applied and the values were represented conditions which was believed that nearly all heat acclimatized, adequately hydrated, unmediated and healthy workers maybe repeatedly exposed to without adverse health effects. Table 2.3 has shown the screening criteria for allocations of work and rest with TLV and AL.

Table 2.3 Screening Criteria for TLV and AL based on ACGIH TLV

SCREENING TLV					SCREENING AL			
% WORK	LIGHT	MODERATE	HEAVY	VERY HEAVY	LIGHT	MODERATE	HEAVY	VERY HEAVY
75-100	31.0	28.0	-	-	28.0	25.0	-	-
50-75	31.0	29.0	27.5	-	28.5	26.0	24.0	-
25-50	32.0	30.0	29.0	28.0	29.5	27.0	25.5	24.5
0-25	32.5	31.5	30.5	30.0	30.0	29.0	28.0	27.0

Source: Guidelines on Heat Stress Management at Workplace 2016, DOSH Malaysia

2.3 Physiological changes

A study in Malaysia has found that the average comfortable temperature for normal population was between 24°C to 28°C and if ambient temperature was above of 28°C, it raised the risk of heat stress (Shamsul and Dubashini, 2014). In this study, three physiological changes were needed to be determined and they were discussed as below.

Kenny et al (2017) has stated that human live their entire lives within a very small, fiercely protected range of internal body temperature. Human could tolerate internal temperature below 35° C or above 41° C for only very brief of periods of time. In order to maintain internal temperature within this limits, human have developed very effective and in some instances specialize physiological responses to acute thermal stresses. Core body temperature represented internal or deep body temperature and could be measured orally, rectally, in laboratory settings, in oesophagus or on the tympanic membrane which was at ear. According to Childs et al (1999), the uses of ear to measure core body temperature has become well-known and some hospitals trusts have recommended that ear thermometers replace all previously used electronic thermometers. This was because by measuring core body temperature through ear could determine the brain temperature at a site close to the temperature regulating centre, the hypothalamus. The tympanic membrane has a good blood supply so the temperature at the tympanum was probably about the best one could get as an indirect measure of brain temperature. Physically, the modern ear thermometers were user-friendly and very popular.

According to Human Kinetics (2017), temperature could be an extremely important factors that affecting heart rate. The higher the temperature could cause the heart to beat faster and place considerable strain on the body. Especially, when in hot work environment, the body must move more blood to the skin to cool it while also maintaining blood flow to the muscles. In order to complete this function, the blood flow level must be increased which means the heart rate in faster beat. Fluid intake was very important if an individual under these conditions. Sweat changes blood volume, which eventually could cause any heat related illness and also cardiac problems. According to Plog and Quinlan (2002), for effective heat stress control, the

recovery of heart rate should be less than 100 beats per minute (bpm) at one minute (HRR1). In addition, the heart rate at three minutes (HRR3) should be less than 90 bpm or the value between HRR1 and HRR3 should be less than 10 bpm. If the average daily heart rate exceeds 110 bpm, this would lead to heat stress.

Heat stress impaired baroreflex responsiveness perhaps due to the reduced range by which baroreflexes could increase heart rate, cardiac output, sympathetic activity and vascular resistance during a hypotensive challenge. A dynamic exercise also has the potential to cause large increases in internal temperature, component of the response of exercise with respect to baroreflex control of blood pressure. This may affect thermal load during exercise bout (Crandall, 2008). Yusuf et al (2015) stated that as for short term of heat exposure, blood pressure at exercising muscle area would increase while the blood circulation at renal, splanchnic and non-exercising muscle would decrease. It also would increase to skin to lose the excess heat in order to maintain body homeostasis with the environment since the body has achieved over from the heat exposure. The warm blood from the core body temperature would be cooler and act as radiator (Mohd Kassim, 2016). As the body temperature increases, it would form stress that triggered the sympathetic nervous system and induced physiological change which most obvious in cardiovascular response. Previous study also has shown that heat stress significantly reduced the peripheral vascular resistance and blood volume shifts from central body to periphery to facilitate heat exchange. The reference limit for blood pressure was in range of systolic and diastolic between 100 and 120 mmHg and 60 to 90 mmHg (Shamsul and Dubashini, 2014).

2.4 Heat-Related Illness

United States Department of Labour (2016) discovered that heat-related illness occurred when there was an increase in workers' core body temperature healthy level (less than 38° C). As core body temperature increased, the body was less able to perform normal functions. If this continued, the body released inflammatory agents associated with damage to liver and muscle, specifically. The process may become self-sustaining and generate a run-away inflammatory response, the “systemic inflammatory response” syndrome that often leads to death, normally when the body temperature reaches 41° C. Same goes to Guidelines (2016), it stated that workers could get heat-related illness when exposed to abnormal or prolonged amounts of heat and humidity without relief or adequate fluid intake. Figure 2.2 would describe the normal responses to the heat stress in body and how it can lead to heat-related illness.

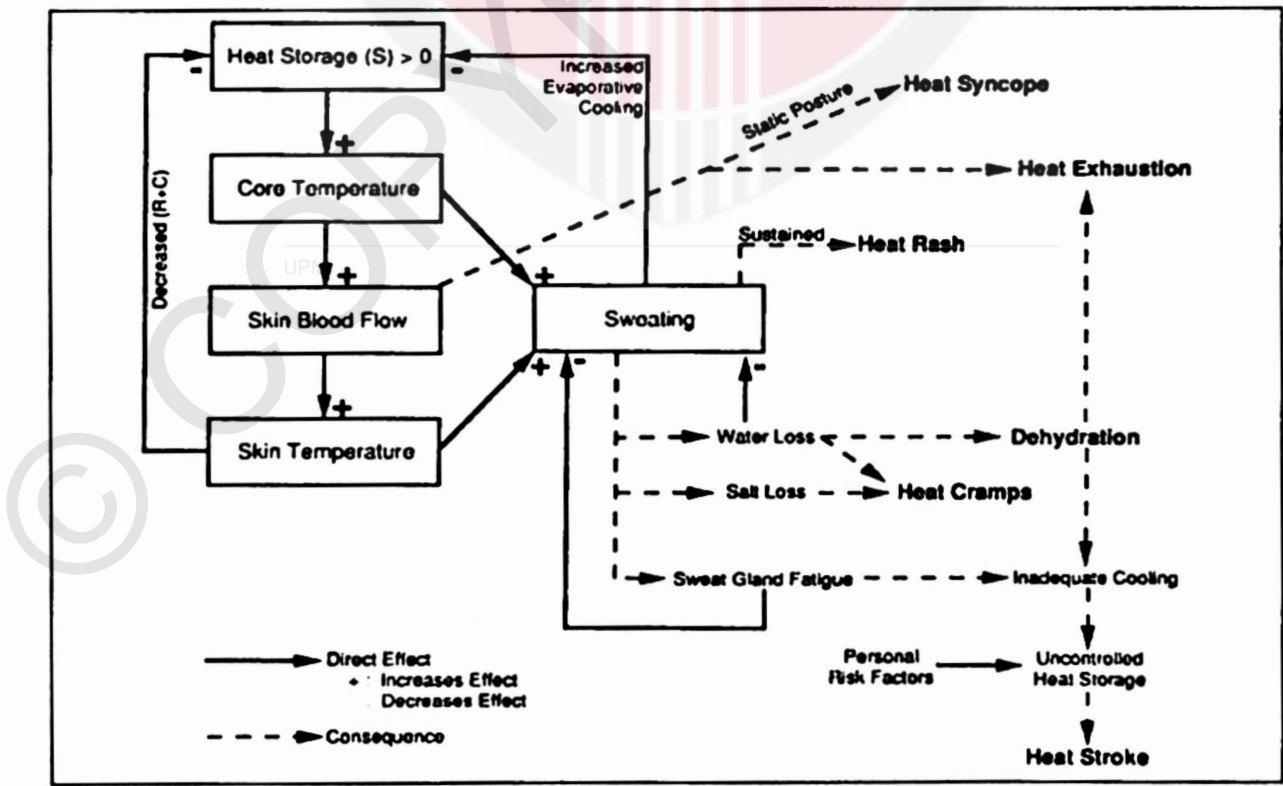


Figure 2.2 Normal response to heat stress exposure and how it lead to heat-related illness

(Source: Plog and Quinlan, 2002)

As listed in Guidelines (2016), first heat-related illness was heat rash which was the most common problem in hot work environment. It caused discomfort and itchiness. Heat rash was caused by sweating and looks like a red cluster of pimples or small blisters and it may appear on the neck, upper chest, groin, under breasts and elbow creases. In order to treat heat rash, skin needed to be kept clean, dry and reduce heat exposure (Plog and Quinlan, 2002).

Heat exhaustion was the next most serious heat-related health problems. Heat exhaustion was the body's response to an excessive loss of the water and salt, usually through excessive sweating. The signs and symptoms of heat exhaustion were headache, nausea, dizziness, weakness, irritability, confusion, thirst, heavy sweating and a body temperature greater than 38° C (100.4° F) (Guidelines, 2016). First aid that could be taken for treating heat exhaustion was by lying down flat on back in cool environment, drink a lot of water and loosen clothing (Plog and Quinlan, 2002).

As for heat syncope, it usually occurs after prolonged standing or sudden rising from a sitting or supine position. Heat syncope symptoms include light-headedness, dizziness and fainting. Dehydration and inadequate acclimatization often contributed to heat syncope (US Department of Labour, 2017). The actions could be taken to treat heat syncope were slightly the same with heat exhaustion which are lying on cool environment and drink plenty of water (Plog and Quinlan, 2002).

The most severe illness in heat stress issue was heat stroke and it should be treated as a medical emergency. Heat stroke occurred when the body becomes unable to adequately dissipate heat, losing the ability to regulate core body temperature. As core body temperature rised, the sweating mechanism may fail and the body was unable to cool down. This could lead to heat stroke to occur and the body

temperature could rise to 41° C (106° F) or higher within 10 to 15 minutes. Heat stroke could cause death or permanently disable if emergency medical treatment was not given. The symptoms include confusion, clumsiness, slurred speech, fainting, hot dry skin, profuse sweating, seizures and high body temperature (US Department of Labour, 2017). The first aid can be taken are immediate, aggressive and effective cooling. It needed to transport to hospital and take the body temperature (Plog and Quinlan, 2002).

2.5 Other Factors

This study will relate heat stress to core body temperature, heart rate and blood pressure which each of them has shown significantly affected and differentiates the individual exposed to heat. According Mohd Kassim (2016), there are several personal factors that can influence and affect workers towards heat stress. There are acclimatisation, prescription of drugs, illness or disease, age and diet can give significantly negative impact to an individual's thermoregulation. This will directly change the degree of heat strain experienced.

Firstly, acclimatisation was a process in which an individual body adjusted to a gradual change in its environment such as change in temperature, humidity, photoperiod or pH, allowing it to maintain performances across a range of environmental conditions (Guidelines, 2016). Generally, complete heat acclimatisation took seven to fourteen days. Meanwhile, loss of acclimatisation occurred gradually when a person was moved permanently away from a hot environment. Nonetheless, there would be a decreased in heat tolerance occurred although after taking a long weekend. As a result of reduced heat tolerance, it was often not advisable for anyone to work under very hot conditions on first day of the

week. For new workers, they should acclimatise before assuming a full workload. It was advisable that the workers should be assigned about half of normal workload and gradually increased on the next day as continues. Even for fit and well-trained workers, they should be tolerating with heat better compared to people in poor physical condition (Guidelines, 2016).

Drugs could give effect to workers' thermoregulatory process in body. The drugs were mostly illegal such as methamphetamine, amphetamines, cocaine, heroin, phencyclidine hydrochloride (PCP) and lysergic acid diethylamide (LSD). These drugs could cause problems and including lead to dehydration and eventually to any heat-related illness (WebMD, 2017). Some of the drugs for treating heart and blood pressure such as beta blockers could reduce the blood flow (Mohd Kassim, 2016).

If workers were suffering from cardiovascular disease, respiratory disease and uncontrolled diabetes, their physiological changes maybe affected and put them into at high risk to heat-related illness compared to healthy person (Guidelines, 2016). They should be taken special precaution as they also immune compromised and susceptible to any disease and illness including heat-related disease since they already suffered in specific disease. People with skin disease and rash are also receptive to heat.

Larose et al (2014) has stated that for both dry and humid heat stress conditions created a greater thermoregulatory challenge for middle-aged and older adults. The range of age was 50-54 and 55-70 years. Many studies also have been conducted on the effect of aging on heat tolerance by comparing difference groups of ages for their blood flow and sweating rate response when exposed to heat. The result have shown that for over 55 years old group has lower response in blood flow

to skin compare to the group that less than 30 years old (Mohd Kassim, 2016). Generally, for 50 years old and above have poor general health and low level of fitness will make them more susceptible to feeling the heat extreme (Guidelines, 2016).

Diet also could be one of the factors that could affect physiological change of individual's body, specifically consumption of caffeine. Ely et al (2011) has found that excessive of caffeine consumption in conjunction with exercise in hot environment may predispose individuals to heat related illness. This could proven as caffeine intake can increase heart rate of individuals and also induced an increases of systolic reading between range 5 to 55 mmHg and 5 to 10 mmHg for diastolic blood pressure reading (Mohd Kassim, 2016).

CHAPTER 3

METHODOLOGY

3.1 Study Design

This was a cross-sectional study where the exposure and health effects were measured and observed in November, 6th to 10th 2017 (a week).

3.2 Study Location

This study conducted at one Latex Glove Manufacturing factory of specific company in Senawang, Negeri Sembilan.

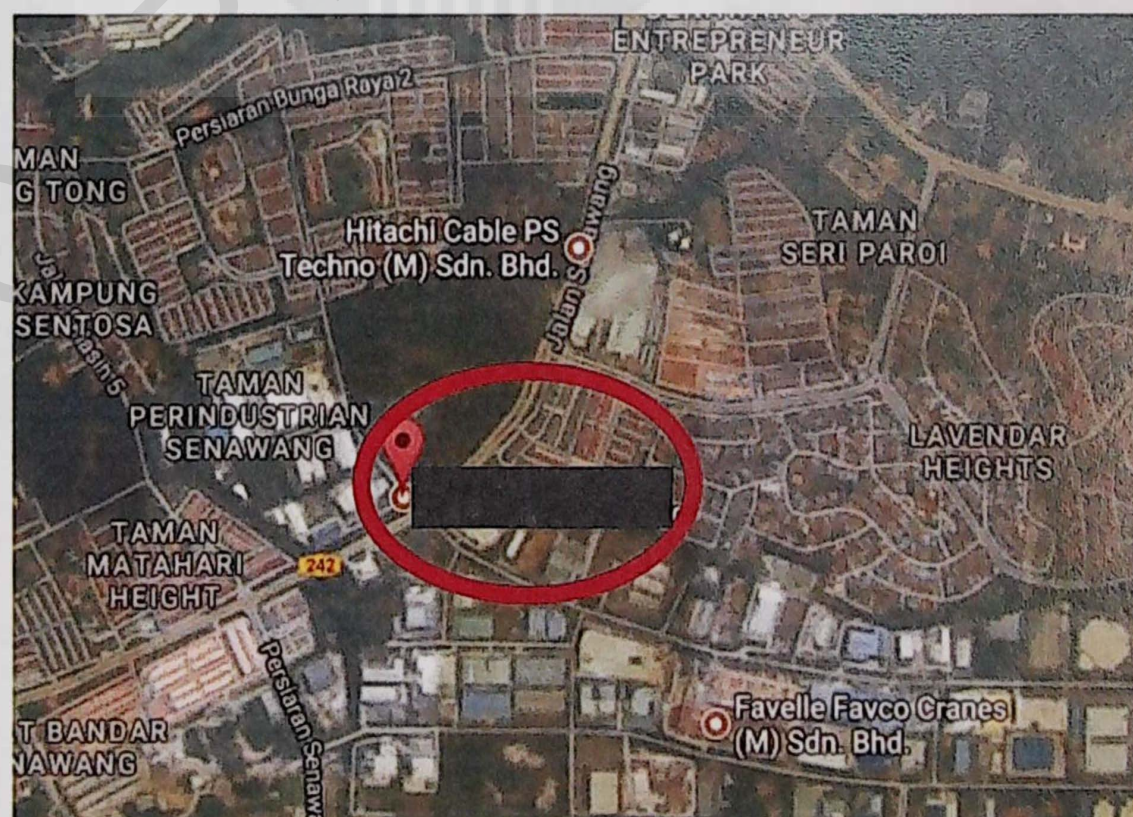


Figure 3.1 Mapping of study location

3.3 Study Population

The study population has involved workers in the production area of the factory which were exposed to heat from the main oven at work area.

3.4 Sampling

3.4.1 Sampling Frame

The sampling frame has referred to the name list of all employees' working at the production area of factory. The name list was taken from the Human Resource Department of factory. Figure 3.1 showed the production layout for each work section of workers that exposed to heat from main oven.

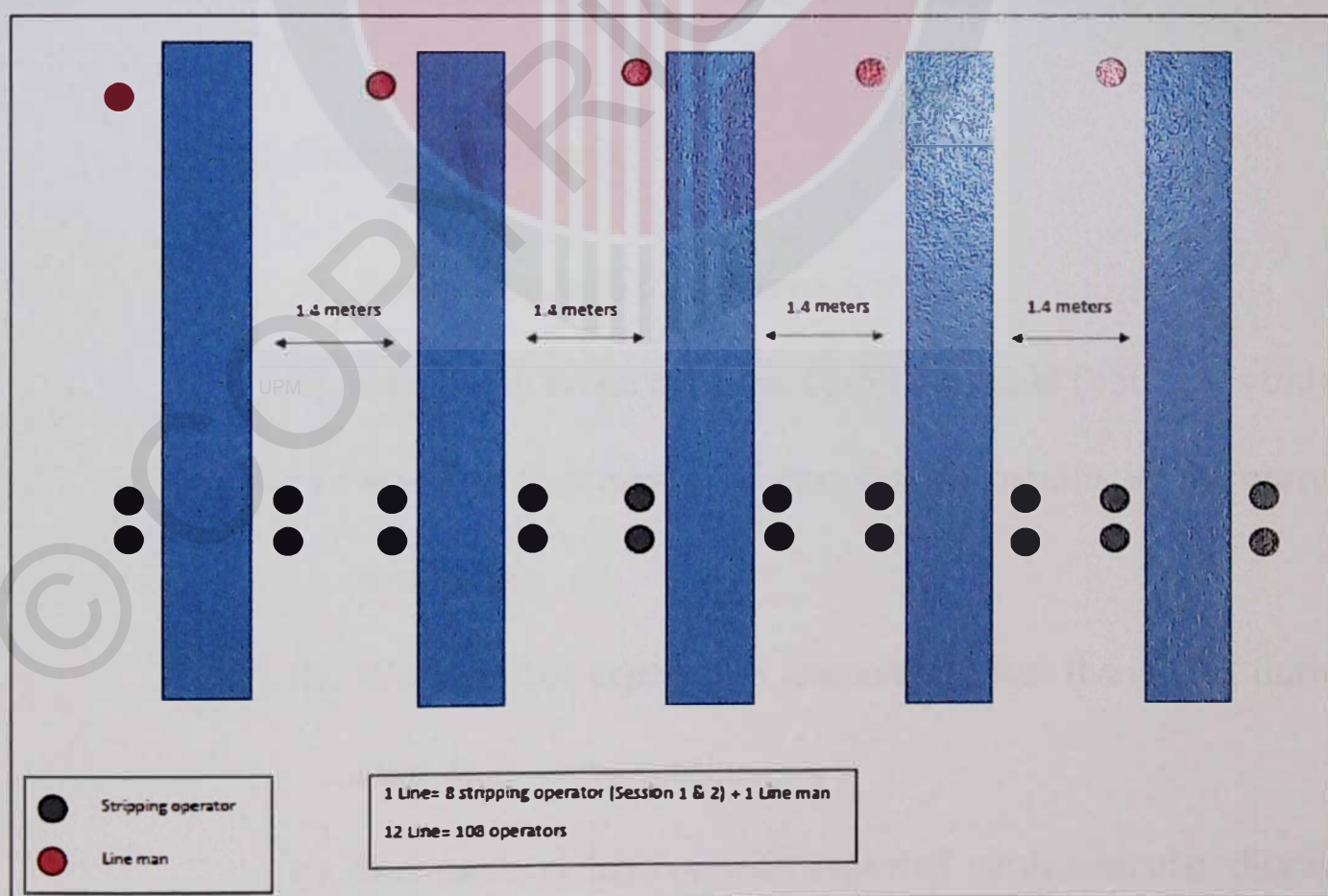


Figure 3.2 The production layout for each work section which involved workers that exposed to heat.

3.4.2. Selection Criteria

3.4.2.1 Inclusion Criteria:

- a) Male workers (Guideline, 2016)
- b) Age range between 18-50 years old (Larose et al, 2014)
- c) Workers that employed more than 3 months at the current workplace.(Mohd Kassim, 2016)
- d) Workers that exposed to high temperature during their daily work routine ($> 28^{\circ}\text{C}$)
- e) No medical history such as cardiovascular disease, respiratory disease and uncontrolled diabetes. (Guidelines,2016)

3.4.2.2 Exclusion Criteria

- a) Female workers (Guidelines, 2016)
- b) Age not in range between 18-50 years old (>50 years old)
- c) Workers that employed less than 3 months at the current workplace.
- d) Workers that exposed to temperature less than 28°C during their daily work routine.
- e) Has medical history with reported cardiovascular disease, respiratory disease and uncontrolled diabetes. (Guidelines, 2016).

3.4.3 Sampling Unit

The worker in the production area, who fulfilled the following inclusion and exclusion criteria, has been selected as sampling unit.

3.4.4 Sampling Size

The sample size was calculated to estimate the minimum number of participants to recruit in this study. This was done by for comparing two means with the aid of Openepi.com application (Kevin et al., 2017). It requires a desired confidence interval, power, ratio of sample size of group 2 to group 1, mean difference and standard deviation. Thus, sample size was estimated for each study group. The samples that involved in this sample size calculation are based on previous studies (Mohd Kassim, 2016).

Table 3.1 Descriptive profile of physiological changes (core body temperature, blood pressure and heart rate) during three different work shifts (before shifts, after 2 hours working and after 8 hours working.

Type of Variable	Mean±S.D.
Core body temperature	
Before shift	35.58± 0.39° C
After 2 hours working	35.88 ± 0.26° C
After 8 hours of working	36.20 ± 0.34° C
Blood Pressure	
Before shift	122.68± 7.17 mmHg
After 2 hours working	126.93 ± 5.20 mmHg
After 8 hours of working	130.72 ± 6.61 mmHg
Heart Rate	
Before shift	75.25 ± 7.01 bpm
After 2 hours working	82.32 ± 5.03 bpm
After 8 hours of working	88.45 ± 4.48 bpm

Source Mohd Kassim, 2016

The formula used in this sample size calculation was as follows:

$$n_1 = \frac{(\sigma_1^2 + \sigma_2^2 / \kappa)(z_{1-\alpha/2} + z_{1-\beta})^2}{\Delta^2}$$

$$n_2 = \frac{(\kappa * \sigma_1^2 + \sigma_2^2)(z_{1-\alpha/2} + z_{1-\beta})^2}{\Delta^2}$$

Where;

n_1 = sample size of Group 1

n_2 = sample size of Group 2

δ_1 = standard deviation of Group 1

δ_2 = standard deviation of Group 2

Δ = difference in group means

k = ratio = n_2/n_1

$Z_{1-\alpha/2}$ = two-sided Z value (e.g. Z = 1.96 for 95% confidence interval)

$Z_{1-\beta}$ = power (usually 80%)

Sample Size For Comparing Two Means

Input Data			
Confidence Interval (2-sided)	95%		
Power	80%		
Ratio of sample size (Group 2/Group 1)	1		
	Group 1	Group 2	Difference*
Mean	126.93	130.72	-3.79
Standard deviation	5.2	6.61	
Variance	27.04	43.6921	
Sample size of Group 1	39		
Sample size of Group 2	39		
Total sample size	78		

*Difference between the means

Figure 3.3 Sample size calculations at Openepi.com (2017)

Table 3.2 Summary of sample size calculation

Type of Variable	Sample Size Calculation	Sample Size
Core body temperature		
Before shift vs. After 2 hours working	$\frac{((0.39)_1^2 + (0.26)_2^2/k)(z_{1-\alpha/2} + z_{1-\beta})^2}{\Delta^2}$ $\frac{(k * (0.39)_1^2 + (0.26)_2^2)(z_{1-\alpha/2} + z_{1-\beta})}{\Delta^2}$	40
Before shift vs. After 8 hours working	$\frac{((0.39)_1^2 + (0.34)_2^2/k)(z_{1-\alpha/2} + z_{1-\beta})^2}{\Delta^2}$ $\frac{(k * (0.39)_1^2 + (0.34)_2^2)(z_{1-\alpha/2} + z_{1-\beta})}{\Delta^2}$	12
After 2 hours working vs. After 8 hours working	$\frac{((0.26)_1^2 + (0.34)_2^2/k)(z_{1-\alpha/2} + z_{1-\beta})^2}{\Delta^2}$ $\frac{(k * (0.26)_1^2 + (0.34)_2^2)(z_{1-\alpha/2} + z_{1-\beta})}{\Delta^2}$	30
Blood Pressure		
Before shift vs. After 2 hours working	$\frac{((7.17)_1^2 + (5.20)_2^2/k)(z_{1-\alpha/2} + z_{1-\beta})^2}{\Delta^2}$ $\frac{(k * (7.17)_1^2 + (5.20)_2^2)(z_{1-\alpha/2} + z_{1-\beta})}{\Delta^2}$	70

Before shift vs. After 8 hours working	$\frac{((7.17)_1^2 + (6.61)_2^2/k)(z_{1-\alpha/2} + z_{1-\beta})^2}{\Delta^2}$ $\frac{(k * (7.17)_1^2 + (6.61)_2^2)(z_{1-\alpha/2} + z_{1-\beta})}{\Delta^2}$	24
After 2 hours working vs. After 8 hours working	$\frac{((5.20)_1^2 + (6.61)_2^2/k)(z_{1-\alpha/2} + z_{1-\beta})^2}{\Delta^2}$ $\frac{(k * (5.20)_1^2 + (6.61)_2^2)(z_{1-\alpha/2} + z_{1-\beta})}{\Delta^2}$	78

Heart Rate

Before shift vs. After 2 hours working	$\frac{((7.01)_1^2 + (5.03)_2^2/k)(z_{1-\alpha/2} + z_{1-\beta})^2}{\Delta^2}$ $\frac{(k * (7.01)_1^2 + (5.03)_2^2)(z_{1-\alpha/2} + z_{1-\beta})}{\Delta^2}$	24
Before shift vs. After 8 hours working	$\frac{((7.01)_1^2 + (4.48)_2^2/k)(z_{1-\alpha/2} + z_{1-\beta})^2}{\Delta^2}$ $\frac{(k * (7.01)_1^2 + (4.48)_2^2)(z_{1-\alpha/2} + z_{1-\beta})}{\Delta^2}$	8
After 2 hours working vs. After 8 hours working	$\frac{((5.03)_1^2 + (4.48)_2^2/k)(z_{1-\alpha/2} + z_{1-\beta})^2}{\Delta^2}$ $\frac{(k * (5.03)_1^2 + (4.48)_2^2)(z_{1-\alpha/2} + z_{1-\beta})}{\Delta^2}$	20

Based on the calculation output from the formula, the blood pressure reading between two groups (after 2 hours working and after 8 hours working) generated among the highest sample size value based on the comparison of the mean difference. Therefore, a minimum of 78 participants was necessary to represent the general population count in this particular work environment.

3.4.5 Sampling method

This study has applied stratified random sampling method was applied in this study. By using this method, selection of respondents has begun from the whole total number of workers from production area of the factory. The respondents complied with study criteria were recruited. Thus, a new total number of populations was obtained. From that, a true sample size to represent this study were randomly selected as calculated in sampling size, 78.

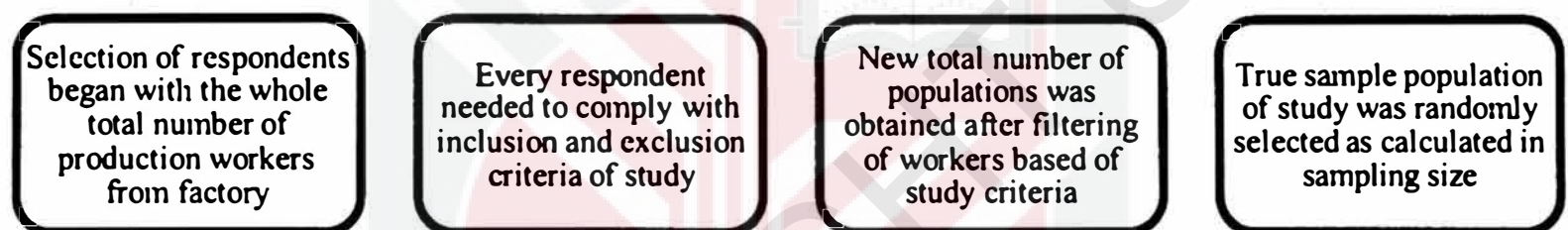


Figure 3.4 Stratified Random Sampling

3.5 Instrumentation

3.5.1 Questionnaires

An adapted questionnaire from previous studies (Yusof et al, 2015; Mohd Kassim, 2016) were used in this study which consisted of five parts:

- a) Part A: Socio-Demographic
- b) Part B: Occupational Information
- c) Part C: Health Information
- d) Part D: Lifestyle Information
- e) Part E: Heat Related Illness Complaints

3.5.2 Thermal Environment Monitor

The environmental temperature was measured by using QUESTemp° 36 Thermal Environmental Monitor which also calculate the wet bulb globe temperature (WBGTin). This instrument was placed between the potential heat source and workers of identified spot for eight hours period monitoring.



Figure 3.5 QUESTemp° 36 Thermal Environment Monitor

3.5.3 Air Velocity Meter

TSI Velocicalc ® Air Velocity Meter was used to measure the level of air velocity at production area. The measurement was taken for three sessions which involving morning, afternoon and evening sessions.



Figure 3.6 TSI Velocicalc ® Air Velocity Meter

3.5.4 Personal Body Core Meter

OMRON MC-510 Gentle Temperature Ear Thermometer was used to measure respondent's core body temperature. Measurement of core body temperature was taken for before shift, after 2 hours of working and after 8 hours of working where the sensor has inserted into respondents' ear during obtaining temperature reading.



Figure 3.7 OMRON MC-510 Gentle Temperature Ear Thermometer

3.5.5 Heart Rate Monitor Watch

POLAR Heart Rate FT60 was used in this study in order to measure heart rate of respondents in beat per minute (bpm). The measurement was obtained before shift, after 2 hours of working and after 8 hours of working.



Figure 3.8 POLAR Heart Rate FT60

3.5.6 Blood Pressure Monitor

OMRON T3 Automatic Blood Pressure Monitor was used to measure blood pressure of respondents. The cuff has been fastened onto the left arm during obtaining the blood pressure measurement. The workers also has been reminded for not eating and drinking 15 minutes before starting the measurement process.



Figure 3.9 OMRON T3 Automatic Blood Pressure Monitor

3.5.7 Weighing Scale and Height Meter

The SECA Body Meter has been using to measure the height of respondents. Meanwhile, for measuring weight of respondents, SECA Body Weighting was used. These two devices have provided data to calculate the Body Mass Index (BMI) of the respondents.



Figure 3.10 SECA Body Weighting

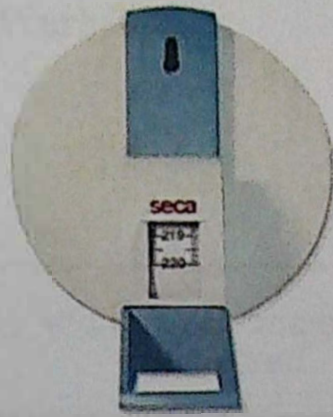


Figure 3.11 SECA Body Meter



3.6 Data Collection Workflow

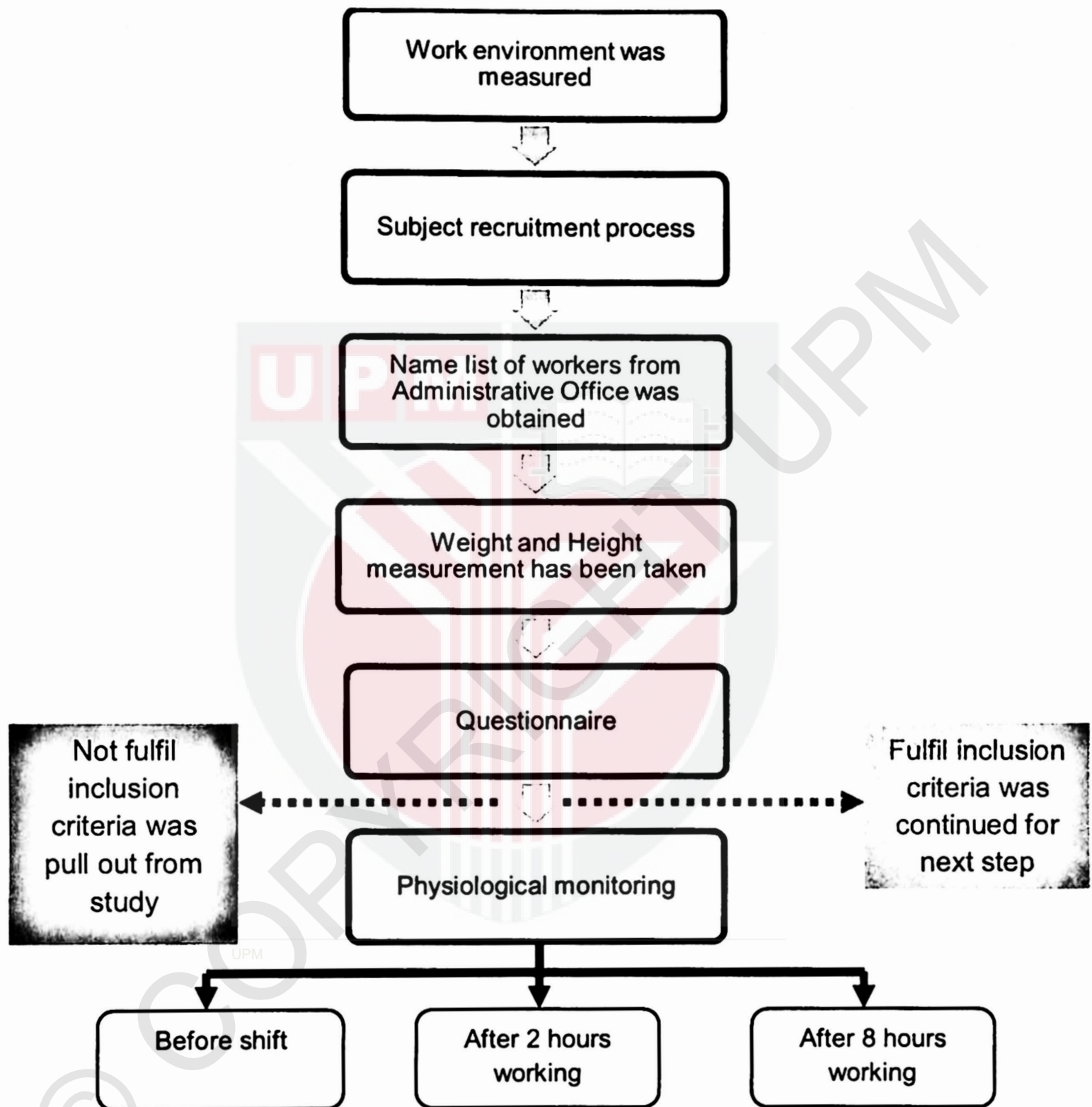


Figure 3.12 Data Collection Flowchart

3.7 Quality Control

3.7.1 Pre-Test Study

A pre-test was conducted before the real data collection of the research began. The respondent has undergone test on adapted questionnaire to observe and evaluate their knowledge level of the questionnaire. The pre-test has been involving 10 workers at study location that complied with study inclusion criteria.

3.7.2 Calibration

All the instruments have calibrated before starting the data collection process in order to ensure all of them is in good condition and minimize any data error. This also has enhanced accuracy of the result. The calibration process has referred the standard procedure given.

3.8 Data Analysis

All the collected data from questionnaire and measurement has been analyzed by using IBM SPSS Version 23 Software. The assumption of normality for significant was ($p>0.05$).

Table 3.3 Table of data analysis

Variable	Type of Analysis
1. To determine socio-demographic data of respondents	Descriptive analysis
2. To determine the WBGT index and metabolic workload at latex glove production area	Descriptive analysis
3. To determine air velocity and relative humidity at latex glove production area	Descriptive analysis
4. To determine the prevalence of heat related illness among workers while exposed to heat	Descriptive analysis
5. To determine physiological parameter (heart rate, core body temperature & blood pressure) between before shift, after 2 hours working and 8 hours working among respondents.	Descriptive analysis
6. To determine the correlation between WBGT index and air velocity in latex glove production area.	Used Pearson Correlation test
7. To compare the differences of physiological changes (heart rate, core body temperature and blood pressure) with three different work shift among respondents (before shift, after 2 hours working and after 8 hours working)	Used One- way ANOVA (3 different groups and above)

CHAPTER 4

RESULTS

4.1 Socio-Demographic Data of Respondents

Table 4.1 shows the socio-demographic information of the respondents. All of the respondents were male in age groups of 18 to 50 years old. From 88 workers that have participated in this study, majority of them were in range of 18 to 29 years old was 64 (72.7%), followed by in range of 30 to 38 years old was 17 (19.3%), in range of 39 to 39 years old was 6 (6.8%) and above 47 years old but less than 50 years old (inclusion and exclusion criteria) was only 1 (1.1%). As for ethnicity among respondents, most of them were Indians, 55 (62.5%), Malays was 22 (25.0%), Others were 8 (9.1%) and Chinese was 3 (3.4%).

In terms of body mass index (BMI), it has shown that more than half of involved respondents were normal, which in a range of 18.5 – 24.9 kg/m² is 74 (84.1%), followed by Overweight category which in range of 25.0 – 29.9 kg/m² is 11 (12.5%), Underweight, which less than 18.5 kg/m² was 2 (2.3%) and Obese, which is more than 30.0 kg/m² was only 1 (1.1%). Meanwhile, as for educational level of respondents, this study has found that, predominately the respondents were in secondary level, 51 (58.0%) and primary level, 22 (25.0%). Some of them were also not attending school (9.0%) and even received their Diploma/Degree/Certificates level (8.0%).

All the respondents were confirmed that have been working for more than 3 months (Guidelines, 2016), which fulfilled inclusion and exclusion criteria. The results has shown that most of the respondents have worked for less than 3 years, 63 (71.6%), followed by in range of 4 to 10 years, 23 (26.1%) and more than 10 years, 2 workers (2.3%). In terms of respondents' income per month, the study has found that majority of them were in low income category, less than RM 1,000 which was 63 of them (71.6%), followed by in middle income category, in range of RM1,000 to RM 2,000 was 16 workers (18.2%) and lastly 9 (10.2%) of them only in high income category, which is more than RM 2,000 per months.

Besides that, this study found that all of the workers (100%) in the production area wore specific personal protective equipment (PPE) such as safety shoes, safety helmet and safety goggles during their daily work routine as stipulated in company's requirement to be in the production area. Training on PPE has been given among the workers before they starting their work. In terms of health information, for any workers who have been verified by doctor having certain diseases (hypertension, diabetes and cardiovascular disease) was excluded (100%) from this study. In fact, the study has controlled several potential cofounding variables (alcohol consumption, smoking and drugs) before recruting them (100%) to proceed in the study.

Table 4.1 Socio-demography of respondents

Variables	Frequency (n)	Percentage (%)
Age Group (Years)		
Less than 30, (<30)	64	72.7
In range of 30 – 38	17	19.3
In range of 39 – 39	6	6.8
More than 47, (>47)	1	1.1
Ethnics		
Malays	22	25.0
Chinese	3	3.4
Indian	55	62.5
Others	8	9.1
Body Mass Index (BMI, kg/m²)		
Underweight (< 18.5)	2	2.3
Normal (18.5 – 24.9)	74	84.1
Overweight (25.0 – 29.9)	11	12.5
Obese (>30)	1	1.1
Educational Level		
None	8	9.0
Primary	22	25.0
Secondary	51	58.0
Diploma/Degree/Certificates	7	8.0
Duration of Employment (Years)		
Less than 3 years, (< 3)	63	71.6
In range of 4 – 10 years	23	26.1
More than 10 years, (>10)	2	2.3
Income per months (RM)		
Low, (< RM 1000)	63	71.6
Middle, (RM 1000 – RM 2000)	16	18.2
High, (> RM 2000)	9	10.2
N= 88 (100%)		

4.2 WBGT_{in} and Metabolic Workload of Workers in Latex Glove Production

Table 4.2 represents the Heat Stress Index value (WBGT_{in}) and it only focused on a few specific work sections in latex glove production area which are Line Operation, Stripping, Former Operation, Online Packing and Quality Control. Generally, results have shown that the temperature was in range of 32.92 °C to 35.06 °C. Specifically; the work section which has the highest WBGT_{in} recorded was in stripping area, 35.06 °C, followed by line operation area (34.40 °C), quality control area (33.8 °C), online packing area (32.92 °C) and the lowest WBGT_{in} is in former operation area (32.24 °C). From this study, the mean of WBGT_{in} was 33.7 °C.

According to Guidelines (2016), the respondents' metabolic workload category has been determined by identifying their work rate for every work sections involved. Most of the workers in every section were exposed to high temperature from main oven which in range of 90 °C – 160 °C. From this study, the workers were in moderate category of metabolic workload (300W) due to their work rate was also moderate. Moderate work rate was consisting of several types of work such as hand and arm work, carrying, lifting, pulling and pushing light loads and walking at every work sections, specifically.

Table 4.2 Exposure profile for WBGT_{in} and metabolic workload at several work sections

Work Section	Metabolic Workload Category	Metabolic Workload (W)	Work Rate	Wet Bulb Globe Temperature (WBGT _{in}), (° C) (Mean ± S.D)
Line Operation	Moderate	300	Moderate	34.40 ± 0.35
Stripping			(Hand and arm	35.06 ± 0.59
Former			work, carrying,	32.24 ± 0.32
Operation			lifting, pulling	
Online Packing			and pushing,	32.92 ± 0.62
Quality Control			walking)	33.88 ± 0.41
Average WBGT _{in} (° C)				33.7

*Metabolic workload has been referred Guidelines on Heat Stress Management at Workplace 2016.

4.3 Air Velocity and Relative Humidity in Each Work Section

The air velocity (m/s) and relative humidity (%) distribution are shown in Table 4.3. As for air velocity, the range was between 0.76 m/s to 1.31 m/s. The highest air velocity recorded was among workers in online packing area by 1.31 m/s, followed by former operation (1.06 m/s), line operation (0.86 m/s), quality control (0.83 m/s) and lastly, stripping by 0.76 m/s. With that, the mean of air velocity for this study was 0.96 m/s.

Meanwhile, as for relative humidity, the range was in between 43.58% to 50.02%. The highest relative humidity achieved was at former operation area by 50.02%, followed by stripping (47.82%), quality control (47.28%), line operation (45.22%) and lastly, online packing was the lowest in relative humidity which was 43.58%. From this study, the mean for relative humidity was 46.78%.

Table 4.3 Exposure profile for air velocity and relative humidity at specific work sections

Work Section	Air Velocity (m/s) (Mean ± S.D)	Relative Humidity (%) (Mean ± S.D)
Line Operation	0.86 ± 0.93	45.22 ± 1.61
Stripping	0.76 ± 0.42	47.82 ± 3.07
Former Operation	1.06 ± 0.70	50.02 ± 5.63
Online Packing	1.31 ± 0.81	43.58 ± 0.80
Quality Control	0.83 ± 0.83	47.28 ± 3.95
Average		
Air Velocity (m/s) & Relative Humidity (%)	0.96	46.78

4.4 Prevalence of Heat Related Illness

Table 4.4 showed the symptoms for prevalence of heat related illness among workers when exposed to occupational heat stress at their workplace. Seventy two respondents (81.8%) had experienced fatigue, dizziness and confusion which could lead to dehydration, followed by 71 respondents (80.7%) had moist and cold skin, excessive or heavy sweating, thirst and nausea which could lead to heat exhaustion, 23 respondents (26.1%) had muscle cramp, leg and hand discomfort which could lead to heat cramps and same goes to symptom of rashes and reddish skin after heat exposure , 23 (26.1%) which could lead to heat rashes, 8 of them (9.1%) had experienced stroke, dry skin and high core body temperature which lead them to heat stroke and lastly, 6 respondents (6.8%) had experienced previously after heat exposure which could lead them to heat syncope.

Table 4.4 Symptoms for prevalence of heat related illness complaints among workers

Symptom	Frequency (n)	Percentage (%)
Fatigue	72	81.8
Dizziness	72	81.8
Pale	0	0
Shortness of breath and weak pulse	0	0
Palpitation	0	0
Rash and reddish skin after exposure to heat	23	26.1
Nausea	71	80.7
Vomit	0	0
Muscle cramp	23	26.1
Legs and hand discomforts	23	26.1
Stroke	8	9.1
Faint	6	6.8
Convulsion	0	0
Confusion	72	81.8
Thirst	71	80.7
Dry skin	8	9.1
Moist skin and felt cold	71	80.7
Excessive sweating	71	80.7
Increased heart rate	0	0
High body temperature	8	9.1
N=88 (100%)		

4.5 Physiological Changes among Workers from Latex Glove Production

A physiological monitoring has been conducted in this study to record the three physiological changes among 88 respondents after exposed to occupational heat stress at workplace. The physiological changes that have been determined were core body temperature, blood pressure (systolic and diastolic) and heart rate. The monitoring has been taken three times which were before workers starting their shift, after 2 hours working and after 8 hours working (after work).

The mean for core body temperature for after 8 hours working was the highest which was 36.66° C compared to before shift and after 2 hours working which were 36.10° C and 36.39° C, respectively. As for systolic blood pressure, the workers have achieved the highest mean was when exposed to heat stress after 8 hours of working which was 130.93 mmHg compared to before shift and after 2 hours working which were 118.82 mmHg and 125.47 mmHg, respectively. Similarly, the highest mean for diastolic blood pressure was also after the workers exposed to high temperature for 8 hours of working which was 81.38 mmHg compared to before shift (72.17 mmHg) and after 2 hours of working (76.56 mmHg). For heart rate, the results also shows increment among respondents from before shift (77.67 bpm), after 2 hours working (82.38 bpm) and the highest was after 8 hours of working (87.47 bpm).

Overall, from this study, the physiological changes (core body temperature, blood pressure and heart rate) has shown that, after 8 hours of working, the respondents tempted to have significant increment compared from before shift and after 2 hours of working at latex glove production.

Table 4.5 Description information of core body temperature, blood pressure and heart rate between before shift, after 2 hours working and after 8 hours working

Variables	Mean ± S.D
Core Body Temperature (°C)	
Before Shift	36.10 ± 0.33
After 2 hours working	36.39 ± 0.27
After 8 hours working	36.66 ± 0.29
Blood Pressure, Systolic (mmHg)	
Before Shift	118.82 ± 10.82
After 2 hours working	125.47 ± 9.14
After 8 hours working	130.93 ± 7.67
Blood Pressure, Diastolic (mmHg)	
Before Shift	72.17 ± 8.27
After 2 hours working	76.56 ± 7.76
After 8 hours working	81.38 ± 7.53
Heart Rate (bpm)	
Before Shift	77.67 ± 9.43
After 2 hours working	82.38 ± 8.69
After 8 hours working	87.47 ± 9.35
N= 88 (100%)	

4.6 Correlation between WBGT_{in} and Air Velocity

In this study, a Pearson Correlation test has been tested between environmental heat (WBGT_{in}, °C) and air velocity (m/s) and it has been shown in Table 4.6. Based on the results, the *p*-value was more than 0.05 (*p*>0.05), therefore, there was no significance difference between WBGT_{in} and air velocity. This was because there was a poor negative correlation between WBGT_{in} and air velocity (*r*= -0.013).

Table 4.6 Pearson correlation between air velocity and WBGT_{in}

Variable	Mean ± S.D	Coefficient Correlation, <i>r</i>	* <i>p</i> -value
WBGT _{in} (°C)	33.7 ± 1.12		
Air Velocity (m/s)	0.96 ± 0.72	-0.013	>0.05

**p*-value is not significant at *p*>0.05

^a Pearson Correlation

4.7 Physiological Changes with Three Different Work Shifts

In this section, One-Way ANOVA has been used to compare the physiological changes (core body temperature, blood pressure and heart rate) involved with three different work shifts (before shift, after 2 hours working and after 8 hours working) among respondents in latex glove manufacturing industry. The results of comparative One-Way ANOVA in Table 4.7 has shown that there are significant differences between all physiological changes at three different work shifts (*p*<0.001).

Thus, a Bonferroni correction post-hoc test has carried out in order to confirm where the differences occurred between the variable groups involved in Table 4.8. The post-hoc results also showed that the physiological changes (core body temperature, blood pressure and heart rate) have significant differences (*p*<0.001) between three different work shifts (before shift, after 2 hours working and after 8 hours working). For every physiological change have significant differences from before shift to after 2 hours working and also after 8 hours working.

Overall, the results showed that all physiological changes among workers have increased by time of exposure to occupational heat stress in latex glove manufacturing industry also increased.

Table 4.7 The differences of Physiological Changes (Core Body Temperature, Blood Pressure & Heart Rate) with three different work shifts (before shifts, after 2 hours working & after 8 hours working).

Variables	Mean ± S.D	F-statistics (df)	*p-value
Core Body Temperature (° C)			
Before Shift	36.10 ± 0.33	74.87 (2, 261)	< 0.001***
After 2 hours working	36.39 ± 0.27		
After 8 hours working	36.66 ± 0.29		
Blood Pressure, Systolic (mmHg)			
Before Shift	118.82 ± 10.82	37.47 (2, 261)	< 0.001***
After 2 hours working	125.47 ± 9.14		
After 8 hours working	130.93 ± 7.67		
Blood Pressure, Diastolic (mmHg)			
Before Shift	72.17 ± 8.27	30.29 (2, 261)	< 0.001***
After 2 hours working	76.56 ± 7.76		
After 8 hours working	81.38 ± 7.53		
Heart Rate (bpm)			
Before Shift	77.67 ± 9.43	25.17 (2, 261)	< 0.001***
After 2 hours working	82.38 ± 8.69		
After 8 hours working	87.47 ± 9.35		

N= 88 (100%)

One-Way ANOVA

*p-value is significant < 0.05, highly significant difference, p<0.001

Table 4.8 Post Hoc Test (Bonferroni Correction) of Physiological Changes at three different work shifts (before shift, after 2 hours working & after 8 hours working)

Physiological Changes	Work shifts		<i>*p-value</i>
	Work Shifts (A)	Work Shifts (B)	
Core Body Temperature (°C)	Before Shift	After 2 hours working	<0.001***
		After 8 hours working	<0.001***
	After 2 hours working	Before Shift	<0.001***
		After 8 hours working	<0.001***
	After 8 hours working	Before Shift	<0.001***
		After 2 hours working	<0.001***
Blood Pressure, Systolic (mmHg)	Before Shift	After 2 hours working	<0.001***
		After 8 hours working	<0.001***
	After 2 hours working	Before Shift	<0.001***
		After 8 hours working	<0.001***
	After 8 hours working	Before Shift	<0.001***
		After 2 hours working	<0.001***
Blood Pressure, Diastolic (mmHg)	Before Shift	After 2 hours working	0.001***
		After 8 hours working	<0.001***
	After 2 hours working	Before Shift	0.001***
		After 8 hours working	<0.001***
	After 8 hours working	Before Shift	<0.001***
		After 2 hours working	<0.001***
Heart Rate (bpm)	Before Shift	After 2 hours working	0.002***
		After 8 hours working	<0.001***
	After 2 hours working	Before Shift	0.002***
		After 8 hours working	<0.001***

working	After 8 hours working	0.001***
After 8 hours working	Before Shift	<0.001***
	After 2 hours working	0.001***

N= 88 (100%)

*The mean difference is significant at the 0.05 level



CHAPTER 5

DISCUSSION

5.1 Socio-demographics of respondents

A total of 88 out of 173 workers have been participated in this study and they also have followed the inclusion and exclusion criteria. Similarly, total numbers of questionnaires (n = 88) has distributed. In order to get optimum response rate (>80%), the sample size has increased instead of using as calculated by Openepi.com (Kevin et al, 2017) which the minimum requirement for this study was only 78 respondents. Therefore, it has directly increased the power of study.

From 88 respondents involved in this study, sixty-four (72.7%) of them are less than 30 years old. The mean age of respondents was 28 years old. According to Analysis of Labour in Malaysia (2016), there were 92% of workers who age above 25 years and older (male) which clearly showed that the average age of respondents in this study were well with this respondent population (Department of Statistics Malaysia, 2016). However, as for respondents that exceeded 55 years old, have been excluded from this study. This is due to individual who age more than 55 years old and above had lower response from blood flow to the skin compared to the age group which less than that age (Larose et al, 2014). Fifty-five (62.5%) of them were Indians and seventy-four (84.1%) of them are normal (18.5 – 24.9 kg/m²) in Body Mass Index (BMI). Ely et al (2011) has stated previously that people with obese tend to have a high risk of disease including heat related illness due to the fat layer

composition and lower density of sweat gland which could decrease to heat loss. Next, in this study, there were fifty-one (68.0%) of them has secondary level in education. Moreover, sixty-three (71.6%) of them have worked less than 3 years and sixty-three (71.6%) of them have low income, which is less RM 1,000.

Previously have been reported in several similar studies, most of the respondents have a few similarities and differences of their socio-demographics. For instance, Muhd Kassim (2016) has reported that there were sixty-four (72.7%) of them are less than 30 years and sixty-four (72.7%) of them are normal in Body Mass Index (BMI). Meanwhile, there were fifty (56.8%) of them have worked less than 3 years and sixty-four (72.7%) of them has low income which was less than RM 1,000. As for Shamsul and Dubashini (2014), it has reported that the average of age of respondents involved were 32.4 years (more than 30 years old) and average of BMI among respondents were 23.18 kg/m² (normal range). In addition, fifty-two (86.6%) of them were Malays and forty-three (71.6%) had an education level of high school. Thus, results clearly has shown that most of the workers which have been exposed to occupational heat stress at workplace mostly have similar characteristics in terms of socio-demographics despite in different type of industries.

5.2 WBGT_{in} and Metabolic Workload of Workers in Latex Glove Production

The minimum reading of air temperature in this study was 32.92° C (Former Operation) meanwhile the maximum reading of air temperature was 35.06° C (Stripping). The average of air temperature (WBGT_{in}) in latex gloves manufacturing industry was 33.7° C with no clothing factor which the respondents' attire at workplace were only work clothes which consisting of shirt and pants. According to Guidelines (2016), the Threshold Limit Value (TLV) for metabolic rate moderate category is 29.0° C. Meanwhile, for action limit (AL) for same category of metabolic rate is 26.0° C. Most of the work sections involved in latex gloves manufacturing industry have exceeded the TLV and AL which has outlined in the national's standards and requirement (Guidelines, 2016). Overall, WBGT_{in} in this study has exceeded the AL and TLV from the standards and requirement which also categorized the latex gloves manufacturing industry under high risk due to followed the criteria that had been outlined in Guidelines (2016).

Table 5.1 Risk Decision

Risk Decision	
Adjusted WBGT Value	Decision
WBGT adjusted < Action Limit	Low Risk
Action Limit < WBGT adjusted < Threshold Limit Value	Medium Risk
WBGT adjusted > Threshold Limit Value	High Risk

Source: Guidelines on Heat Stress Management at Workplace, 2016

Although it had exceeded the AL and TLV, the Guidelines (2016) also has recommended that measurement of WBGT in rubber industries should be in range of 30.4°C to 35.3°C. Thus, the air temperature of latex gloves manufacturing industry in this study is still under acceptable limit. Allocation of work in a work/rest cycle was 66.67% which allocated in a range of 50-75%. The duration of working hour for respondents were 12 hours but the total duration of exposure to high temperature were only 8 hours. Basically, the workers would start their shift at 7.00 a.m and end at 7.00 p.m. In Figure 5.1, it showed the daily routines for their shift and the time when they exposed (working hour) and non-exposed to heat (morning session, break time, lunch hour and tea break) specifically outlined by management.

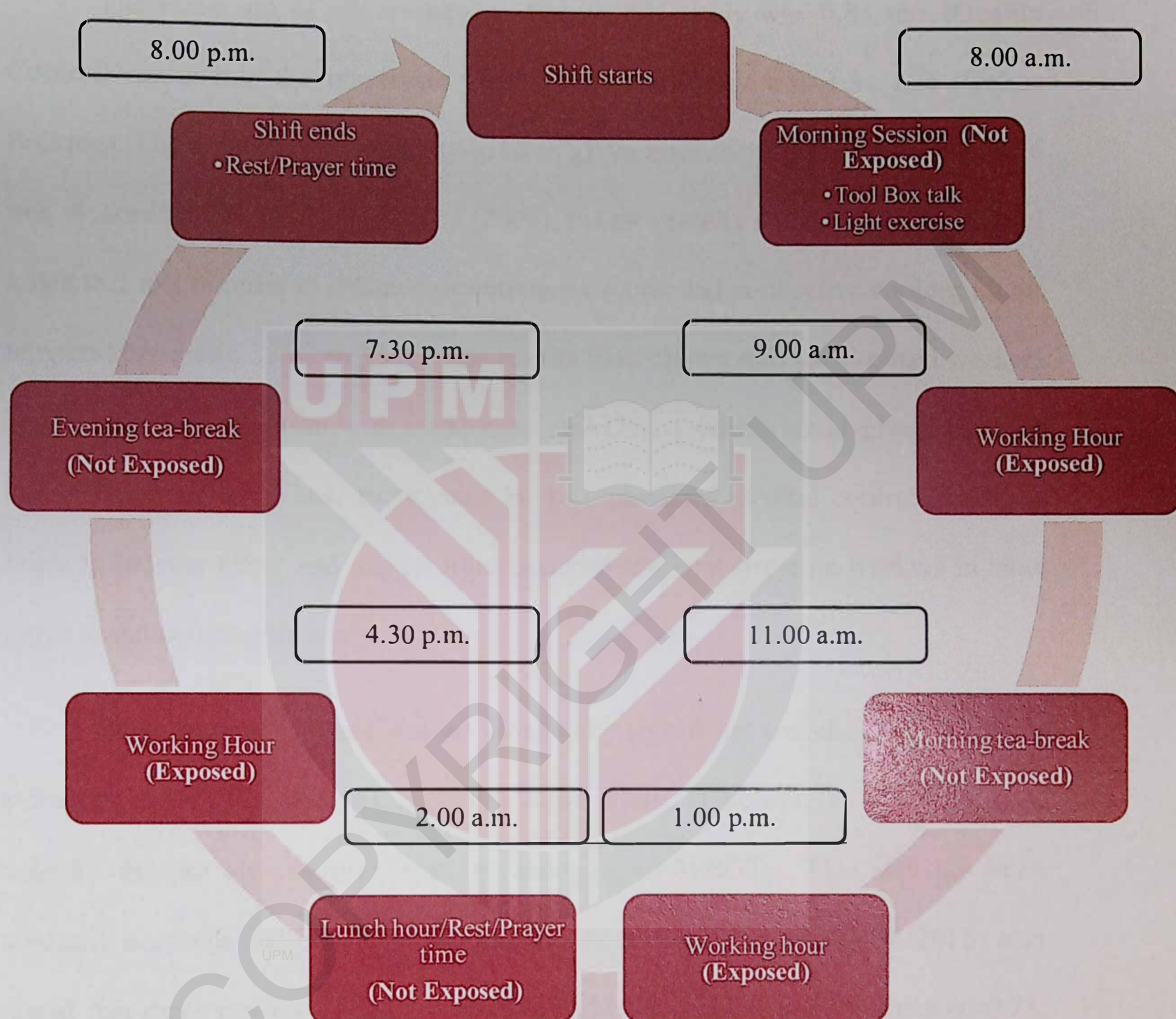


Figure 5.1 Work/Rest Cycle of workers at latex gloves manufacturing industry

5.3 Air Velocity, Relative Humidity and Correlation between WBGT_{in} and Air Velocity in Latex Gloves Production

The minimum of air velocity reading in this study was 0.83 m/s (Quality Control) meanwhile the maximum reading of air velocity was 1.31 m/s (Online Packing). The average of air velocity in latex glove manufacturing industry was 0.96 m/s. According to Plog and Quinland (2002), the air velocity should be in between of 1 m/s to 2 m/s in order to enhance evaporative cooling and convective cooling for air temperature within 30°C to 35°C. The results have shown that the exposed workers have worked in condition with inadequate air velocity which could give them heat stress at workplace. Thus, there must be recommended several control measures taken to prevent effect and impact from occupational heat stress on workers in latex glove manufacturing industry.

Based on results, there was no statistically significant correlation between air velocity and WBGT_{in} ($r=-0.013$, $p>0.05$) in this study. Therefore, the changing of air velocity did not significantly relate to changing of WBGT_{in}. This also has been similarly occurred and proven in previous study whereas Muhd Kassim (2016) also stated that there was no significant correlation between these two variables ($r=0.73$, $p=0.07$). For instance, the highest reading of air velocity in this study was 1.31 ± 0.81 m/s (Online Packing) but not for its air temperature which was 32.92 ± 0.62 °C, the lowest air temperature compared to other work sections in latex gloves manufacturing industry of this study. Meanwhile, as for the highest air temperature was 35.06 ± 0.59 °C (Stripping) with the lowest reading of air velocity 0.76 ± 0.42 m/s. The different of air flow may also affected by the existed control measures in this industry such as the number of fans used for each work sections. As for different reading of air temperature, it may influence by the distance of each work section

from the main source of heat in this study which was main oven. This may lead to poor air circulation and produce inconsistency in the WBGT_{in} results from level of air velocity in every work section.

The minimum for relative humidity was 43.58% (Online Packing) meanwhile the maximum reading for relative humidity of this study was 50.02% (Former Operation). The average of relative humidity for this latex gloves manufacturing industry was 46.78%. As previously stated, the air temperature was 33.7° C. According to following standards and requirement by Environment Canada (as non-available in Malaysia), the humidex range could be determined as below in Figure 5.2;

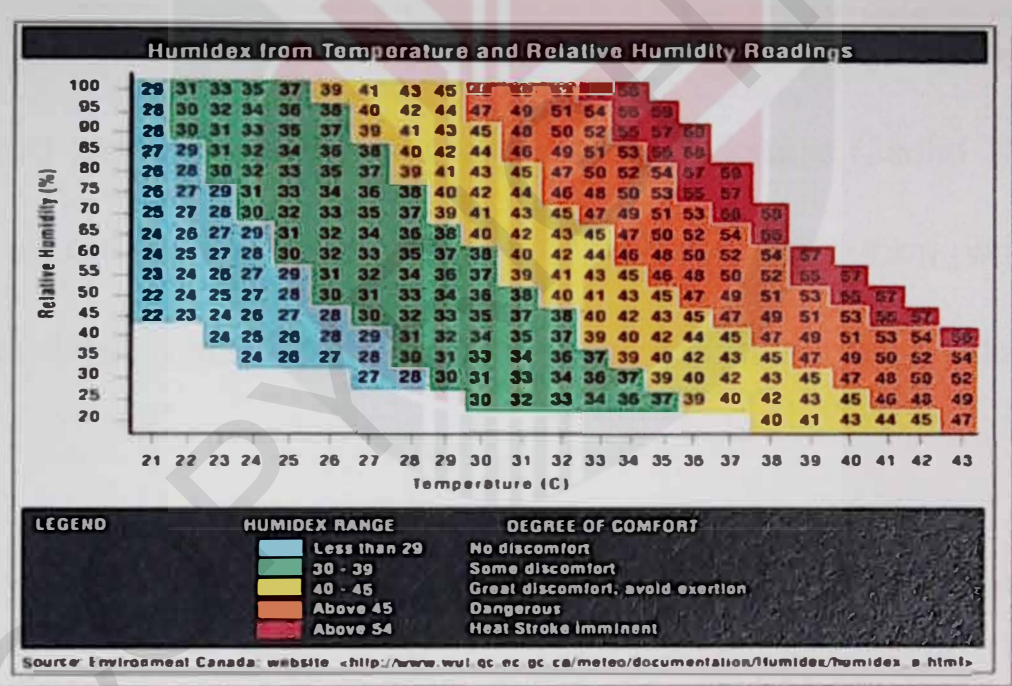


Figure 5.2 Humidex Range by Environment Canada

The result has shown that the humidex was in range of 40 – 45 which categorized as a great discomfort and must avoid exertion to workers. However, the result has shown differently as the measurement of humidex taken by QuesTemp 36° was 50.7 which categorized as dangerous to the workers (above 45). Muhd Kassim (2016) has mentioned previously that high level of relative humidity will cause heat more dangerous to the workers who exposed to high temperature. This would slow

the evaporation of perspiration in human body. Since the majority of the workers were exposed to temperature at 33.7° C and the relative humidity at 46.78%, this means that all workers are exposed to heat stress with discomfort and dangerous zone for them. However, the standard and requirement used would not suit local condition due to it only applicable to refer in cooler climates. A revision of these standards to suit tropical and sub-tropical conditions would be in order.

5.4 Prevalence of Heat Related Illness

Results of symptoms for prevalence of heat related illness in this study has shown that majority of the workers were leading to dehydration (81.8%) as the highest. Secondly, the workers also would suffer heat exhaustion (80.7%). Based on previous study, similarly, the dehydration was also the highest numbers of workers that dehydrated and suffered heat exhaustion at workplace (Muhd Kassim, 2016). Meanwhile, according to Yusof et al (2015), heat exhaustion was the highest recorded prevalence compared to dehydration and other heat related illness at workplace.

According to Mayo Clinic (2018), dehydration occurs simply when an individual use or lose more fluid than she/he take in, and the body does not have enough water and others fluid to carry out its normal functions. If it does not been replaced the lost fluids, the person will get dehydrated. The symptoms are extreme thirst, less frequent urination, dark-colored urine, fatigue, dizziness and confusions. In a previous study, several acute health complaints had been made which majority of the workers experienced fatigue (65%) and dizziness (33.3%) (Shamsul & Dubashini, 2014). This has proven that these symptoms could lead to dehydration and other heat related illness among workers. Risk of dehydration among workers

was when they were always in hot and humid condition. The humid air caused sweat could not be evaporated and cooled off as quickly it normally does. Thus, it leads to an increased body temperature and also other heat related illness including the as severe as heat syncope and heat stroke. This study has found out that the exposed workers also drink less amount of water. Based on survey, majority of the workers (more than 50%) in latex gloves manufacturing industry drank only 50 mL of water for every 30 minutes. Thus, the total amount of water that the respondents have approximately was 2.4 litres for 12 hours shift. Thus, it would lead the respondents more prone to overheating because it would decrease sweating and could progress to heat stroke. According to Brake and Bates (2003), the workers should be drinking at least 6 to 7 litres of water per shift (including 12 hours of working shift) under hot condition. Plus, based on Australia's Safety in Action (2014), it recommended that the workers exposed to high temperatures should drink 200 to 250 mL for every 15 to 20 minutes.

Meanwhile, as for heat exhaustion, according to United States' Department of Labor (US Department of Labour) (2018), it is the body's response to loss of water and salt from heavy sweating. One of the main contributors of heat exhaustion was dehydration which the respondents had drunk less amount of water. The signs and symptoms are headache, nausea, dizziness, weakness, irritability, thirst and heavy sweating. With heavy sweating, the workers were recommended to consume any sports drinks, salt water or any rehydration solution. This is due to human's sweating does not only losing water but also essential salts known as electrolytes (Australia's Safety in Action, 2014). Electrolytes conduct electrical impulses across cell membranes and which the body uses to make muscles contract. Electrolytes also regulate pH levels, blood pressure and play a key role in water retention. For instance,

with low sodium level in blood, the kidneys produce urine to lower the amount of water in the blood and maintain the required fluid; electrolyte balance. The lower blood plasma volume means the heart must pump harder the blood and oxygen to the working body muscles, increasing heart rate and perceived effort. Thus, the exposed workers under hot condition only made the condition worsen and experienced heat exhaustion and lead to even severe heat related illnesses which were heat syncope and heat stroke. Previously has been proven that, the exposed workers to high temperatures condition should consume one to two cups of 0.1% to 0.2% salt water, sport drinks containing 40 to 80 mg of sodium per 100 mL or oral rehydration solutions every 20 to 30 minutes (Mohd Kassim, 2016). It also stated that heat exhaustion is most often preceded by dehydration and it was usually associated with unacclimatized workers. However, untreated heat exhaustion may lead to heat stroke causing by central nervous system (CNS) dysfunctional such as coma and even death.

As for severe cases, from this study, symptoms like stroke, high body temperature and dry skin reported were 9.1% which could lead to have heat stroke. Meanwhile, as for faint was 6.8% which also could lead to one of the severe heat related illness, heat syncope. The symptoms occurred despite the all the workers were acclimatized. By comparison, these cases were higher number of percentage from several studies have reported previously. For instance, there were only 5.6% (heat stroke) and 4.4% (heat syncope) (Muhd Kassim, 2016). As for Yusof et al (2015), there was only 4.6% cases of heat stroke has been reported. It also has been supported which it stated that there is no relationship between heat acclimatization and incidence of heat stroke. This is due to there were other contributing factors which might lead respondents to heat stroke or other heat related illness such as environmental and non-environmental factors (Guidelines, 2016). With all these heat

related illnesses, they could reduce and influence workers' mental, physical and cognitive performance (Brake & Bates, 2003). Therefore, preventive and control measures must be taken to overcome this problem for this study.

5.5 Physiological Changes among Workers from Latex Gloves Production

The physiological parameters involved in this study were core body temperature, blood pressure (systolic and diastolic) and heart rate. The results have shown that for every physiological change occurred were gradually increased by measurement at three different work shifts which were before shift, after two hours working and after eight hours working with condition that had 33.7° C for air temperature, 0.96 m/s for air velocity, 46.78% for relative humidity and humidex range was in 40 to 45 which categorized as great discomfort condition for workers (by measurement; more than 45 which categorized as dangerous zone for workers).

In this study, for core body temperature, the results have shown that there were significant differences ($F=74.87$, $p<0.001$) between three different work shifts which were before shift, after two hours of working and after eight hours of working. This also has been supported by a Bonferroni Correction post hoc test and clearly showed that core body temperature before shift ($36.10 \pm 0.33^{\circ}\text{C}$) was significantly difference ($p<0.001$) between after two hours of working ($36.39 \pm 0.27^{\circ}\text{C}$) and after eight hours of working ($36.66 \pm 0.29^{\circ}\text{C}$). This case is commonly occurred that had been proven in several previous studies such as Muhd Kassim (2016) showed that core body temperature for before shift was significantly difference ($p<0.001$) between after two and eight hours of working. Same goes to Yusof et al (2015) which also showed that there was a significant difference ($p<0.05$) between after two and eight hours of working. Therefore, the physiological change pattern in

industry were significantly different for each work shift. Moreover, according to Brake and Bates (2003) and Shamsul and Dubashini (2014), core body temperature which exceeds 38°C would cause severe physiological strain and unacceptable for an average industrial workforce in an eight hours working period. Fortunately, in this study, the core body temperature among workers in latex gloves manufacturing industry was in range of 35.10°C to 37.90°C. Even though the core body temperature among workers increased gradually from before shift to after eight hours of working, it was still under acceptable limit but required preventive and control measures to minimize heat stress cases at workplace.

As for blood pressure (systolic and diastolic), this study has shown that both mean were significantly difference as for systolic blood pressure ($F=37.47, p<0.001$) and diastolic blood pressure ($F=30.29, p<0.001$) between before shift, after two hours working and after eight hours working. Bonferroni Correction post hoc test showed that the systolic blood pressure of respondents for before shift (118.82 ± 10.82 mmHg) has significant difference ($p<0.001$) between after two hours of working (125.47 ± 9.14 mmHg) and after eight hours of working (130.93 ± 7.67 mmHg). Similarly, it occurred to diastolic blood pressure of respondents for before shift (72.17 ± 8.27 mmHg) also has significant difference ($p<0.001$) between diastolic blood pressure for after two hours working (76.56 ± 7.76 mmHg) and after eight hours working (81.38 ± 7.53 mmHg). Moreover, the range of systolic blood pressure among respondents was in 92 to 155 mmHg meanwhile as for range of diastolic blood pressure was in range of 54 to 96 mmHg. The results were slightly exceeded from the normal range for human blood pressure which is in range of 100 to 120 mmHg (systolic blood pressure) and 60 to 90 mmHg (diastolic blood pressure) (Crandall, 2008). This was due the workers were exposed to high temperature of

working environment with availability of main source of heat in latex gloves manufacturing industry, main oven, which contributed in producing high level of heat stress condition, 90 to 160° C. In addition, with the exceeded blood pressure among workers, it would lead them to experience heat related illness such as heat exhaustion and heat syncope, specifically (Muhd Kassim, 2016).

The last physiological parameter involved in this study was heart rate. Previously, it has been proven that heart rate is significantly affected by high level of air temperature (Australia's Safety in Action, 2014). Due to exposure to heat stress condition, it caused to lose water and electrolyte from the human body. Thus, it leads the heart to work harder to pump all the blood and oxygen to all muscles in order to function normally. Therefore, it would directly increase the heart rate of individual. Increment of heart rate until exceeding 110 bpm, it leads to heat related illness including heat stroke (Human Kinetics, 2017). In this study, the results showed that there was a significant difference in the mean of heart rate between these three different work shifts ($F=25.17$, $p<0.001$). Bonferroni Correction post hoc test has indicated that heart rate among workers also had been significantly different ($p<0.001$) between before shift (77.67 ± 9.43 bpm) to after two hours working (82.38 ± 8.69 bpm) and after eight hours working (87.47 ± 9.35 bpm). Therefore, the mean of heart rate of respondents did not exceed 110 bpm which is under acceptable limit for workers in latex gloves manufacturing industry.

CHAPTER 6

CONCLUSION & RECOMMENDATION

6.1 Conclusion

The average of air temperature ($WBGT_{in}$) at the latex gloves manufacturing industry was 33.7°C which has exceeded the Action Limit (AL) and Threshold Limit Value (TLV) under metabolic workload moderate category (300 W) with allocation of work/rest cycle in range of 50 to 75% and also risk has decided under high risk criteria. However, the $WBGT_{in}$ was still classified in acceptable limit which recommended by the guidelines for rubber industries commonly in range of 30.4 to 35.3°C . Most of the work sections were inadequate of air velocity which made the workers highly exposed to heat stress; however the results indicated there was no significant correlation between environmental heat and air velocity. This continuous heat exposure to workers could affect the physiology of the body such as core body temperature, blood pressure and heart rate. However, the results most of them were still in acceptable range and all these physiological changes were significantly difference ($p < 0.001$) between three different work shifts which were before shift, after two hours working and after eight hours working. The highest symptoms for prevalence of heat related illness on respondents were confusion, fatigue and dizziness (81.8%) which could lead to dehydration. Measures such as engineering controls, administrative controls; training and monitoring of work should be emphasized in order to reduce the risk of heat stress.

6.2 Study Limitation

There were several limitations in this study and methods to overcome those that have been enumerated below.

i. Improper and inadequate record of heat related occupational injury/disease by the employer or worker

The respondent may not remember some important information regarding health history throughout the employment period at the workplace (information bias). The medical details of each worker should be monitored periodically and should be documented properly. Documented medical records can be used for interventions and surveillance purposes. Proper medical attention should be provided for the workers during the necessary period. Therefore, health education should be provided to the management highlighting the benefits of record keeping which can save money, manpower and time (Srinivasan et al, 2016).

ii. Health indicators

Core body temperature, blood pressure and heart rate were commonly used to determine the exposure of heat stress at workplace in a heat stress research. Thus, there were several confounding factors that may influence the health indicators which could give effect to results. For instance, smoking would temporarily increase the blood pressure and heart rate (Crandall, 2008). Diet also could influence the reading of physiological changes especially involving caffeine which also could increase heart rate and directly lead to heat related illness (Ely et al, 2011). Anxiety also could contribute to influencing the reading of physiological monitoring among workers due to the respondent

may feel uncomfortable when their physiological measurement was being taken. A proper study design with good planning of measurement and periodic monitoring could help to sort out these confounding factors.

iii. Lack of number of previous similar study as reference

This study was conducted in latex gloves manufacturing industry which was categorized under one of the rubber manufacturer industry. There was still paucity in number of similar study although there a few occupational heat stress study conducted at several type of industries. Nevertheless, different industry was still has different hazards and condition. Moreover, according to Srinivasan et al (2014), there were a few studies conducted regarding field of occupational heat stress study; however, the exact hypothesis between heat exposure and specific health outcome is yet to be answered clearly. Hence, more studies should be required in this research area to examine the effects of occupational heat stress especially in rubber manufacturer industry, as general.

6.3 Recommendations

From this study, the air temperature at most of the work sections involved from latex gloves manufacturing industry have exceeded the standard value (AL and TLV) in Guidelines on Heat Stress Management at Workplace 2016 by Malaysia’s Department of Occupational Safety and Health (DOSH). The guidelines also have outlined several preventive and control measures of heat stress according to risk decision which has been determined previously which was in high risk category. The recommended control measures have shown in Table 6.1 below.

Table 6.1 Recommended Control Measures According to Risk Decision

Low Risk (WBGT Adjusted < Action Limit)	Medium Risk (Action Limit < WBGT Adjusted < Threshold Limit Value)	High Risk (WBGT Adjusted > Threshold Limit Value)
• Continue work • Monitor	• General Controls	• Implement all general controls and applicable job specific control
	• Information, instructions and training • Regular drinks of water • Self-limitation to heat exposure • Health screening and surveillance ➢ Pre placement medical screening • Encourage reporting symptoms to management	• Applicable Job Specific Control ➢ Engineering Controls ○ Reduce workers activity by providing mechanical aids ○ Enclose or insulate hot surfaces ○ Shield workers from radiant heat ○ Provide adequate ventilation ○ Reduce humidity where applicable ○ Rapid cooling area ➢ Administrative Controls ○ Acclimatize workers ○ Supervision of workers

- Encourage healthy life style
- Monitor employees with existing medical condition
- Personal protective equipment
- Cool work rest area
- Establish work-rest regime to minimize heat exposure
- Provide and encourage regular intake of fluid/oral rehydration salt drinks
- Dress appropriately
- Changing the way of work is done
- Regular health screening
- Specific personal protective equipment (PPE)

Source: Guidelines on Heat Stress Management at Workplace 2016, DOSH Malaysia

However, the recommendations needed to be suitable and applicable for this study location which can solve heat related issues in the industry. This continuous of heat stress exposure could result in heat related illness among workers. Thus, there were a few control measures that should be taken as consideration in order to minimize the heat stress exposure among latex gloves manufacturing workers.

i. Engineering Control

Based on the results, workers have worked in a condition with inadequate air velocity due to average of reading of air velocity was 0.96 m/s. The optimum air velocity should be in range of 1 to 2 m/s for air temperature of surrounding in range of 30.0 to 35.0° C (Plog & Quinsland, 2002). Thus, number of fans at each work sections should be increased, especially at Stripping which has the lowest reading of air velocity (0.76 ± 0.42 m/s) with the highest reading of air temperature ($35.06 \pm 0.59^\circ$ C). There should be at least two fans at each work section to increase air velocity in that particular area and reduce heat respectively. The current

fan should be inspected to ensure effectiveness of air flow from each fan could reduce the environmental heat. In addition, the air-conditioned rest room should be provided in order to help workers in cooling down their body temperature at necessary time.

ii. Administrative Controls

The employers were recommended to provide adequate and suitable training on heat stress. The training programme could help the management in educating and creating awareness among workers especially on symptoms of heat related illness. This could prevent any worst case of heat stress to be occurred. The training programme also may cover with the description of heat stress, including signs and symptoms of heat related illness and first aid measures for each disorder. In addition, the study also found that the exposed workers have drunk less amount of water. Thus, the management should provide adequate number of water station to ensure the workers have enough drinking water. Mohd Kassim (2016) also stated that these industrial workers should consume one to two cups of 0.1 to 0.2% of salt water, sport drink containing 40 to 80 mg sodium per 100 mL, or oral rehydration solutions every 20 to 30 minutes.

The workers in latex gloves manufacturing industry needed to participate in medical surveillance on heat stress provided by management and the employers should be strict and ensure all workers are involved. This important matter is to screen and indentify the individual risk as they have exposed to high level of air temperature. The treatment should be included as to reduce any significant effect from that heat exposure. This surveillance should be conducted at least once a year by licensed

physicians. Furthermore, the signage of high level of heat should be put with high visibility location in order to alert workers when entering at each work sections.

Heat stress hygiene practices are the actions taken to reduce the risk of heat disorder. Each worker must be responsible in practicing good heat stress hygiene practices such as drinking enough amount of water in order to replace the water loss from the body. For instance, the management could have a programmed drinking which involving drinking small amount of water frequently over set periods of time rather than drinking ad lib (Australia's Safety in Action, 2014). This is due to when working in hot environment, each worker should be encouraged to quench their thirst all the time and consume at least to 500 mL of water every hour (Muhd Kassim, 2016). Besides that, the employees were highly advised to have balance diet without skipping any meal to replace minerals lost in sweat as well as calories.

Healthy lifestyle should be practiced by all workers in order to reduce the risk of any heat related illness. The workers need to have adequate of rest and sleep for increasing their job quality and efficiency. The management should highly recommend to the workers to avoid alcohol intake due to it could increase the risk of the most severe heat related illness, heat stroke. Lastly, the management itself should be a good role model to the workers. The commitment and support from the management and also participation from the workers are significantly required to maintain a productive and good health of workers from the excessively exposure to heat at workplace.

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APPENDICES

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**ETHICS COMMITTEE FOR RESEARCH INVOLVING HUMAN SUBJECTS
(JKEUPM)
UNIVERSITI PUTRA MALAYSIA**

Research title	: Effect of Occupational Heat Stress on Physiological Changes and Heat Related Illness Among Workers in Latex Glove Manufacturing Industry, Negeri Sembilan
Study Site	: Negeri Sembilan
JKEUPM Ref No.	: JKEUPM-2017-201
Researcher	: Amir Ashraf bin Jalaludin
Supervisor	: Dr. Karmegam Karuppiah

Documents received and reviewed with reference to the above study:

1. Ethics Application Form, Version 1 dated 31/10/2017
2. Respondent Information Sheet & Consent (English), Version 2 dated 22/12/2017
3. Respondent Information Sheet & Consent (Malay), Version 2 dated 22/12/2017
4. Proposal (English), Version 2 dated 22/12/2017
5. Questionnaire (Malay), Version 1 dated 31/10/2017
6. Curriculum Vitae of:
 - a. Dr.Karmegam Karuppiah

The University Research Ethics Committee, Universiti Putra Malaysia (JKEUPM) operates in accordance to the ICH-GCP Guidelines.

Decision by JKEUPM:

☒

Approved

☒

Permission MUST BE OBTAINED from the respective hospitals/ institutions before conducting the research

☐

Disapproved

Please note that the approval is **VALID UNTIL 5 JANUARY 2019**

Researchers should comply with the following:

- I. Complete a Study Final Report upon study completion (Form 3.2).
- II. Ethical approval is required in the case of amendments/ changes to the study documents/ study sites/ study team.



**JAWATANKUASA ETIKA UNIVERSITI UNTUK
PENYELIDIKAN MELIBATKAN MANUSIA (JKEUPM)
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,
SELANGOR, MALAYSIA**

BORANG 2.4: PENERANGAN DAN PERSETUJUAN RESPONDEN

Sila baca maklumat berikut dengan teliti. Sekiranya anda mempunyai sebarang pertanyaan, sila kemukakan kepada penyelidik.

1.TAJUK KAJIAN

Kesan Tekanan Haba Pekerjaan Terhadap Perubahan Fisiologi dan Penyakit Berkaitan Haba dalam kalangan Pekerja Industri Pembuatan Sarung Tangan Getah, Negeri Sembilan

2. PENGENALAN

Kajian ini bertujuan untuk mengenal pasti kesan tekanan haba pekerjaan terhadap perubahan fisiologi dan penyakit berkaitan haba dalam kalangan pekerja industri pembuatan sarung tangan getah. Pekerja yang terdedah kepada tahap tekanan haba yang melampau boleh mengatasi mekanisme di dalam badan yang boleh menyebabkan keadaan yang berbahaya seperti strok haba dan hal ini boleh membawa maut. Secara amnya, jika manusia gagal mengawal dan mengekalkan suhu boleh menyebabkan berlakunya seseorang mendapat tekanan haba. Impaknya, hal ini boleh menyebabkan penyakit berkaitan haba seperti kelesuan haba, kekejangan haba, pengsan haba dan juga strok haba. Sehubungan dengan itu, bagi memastikan keselamatan dan kesihatan pekerja, kajian ini perlu dijalankan bagi memastikan status kesihatan pekerja dapat ditingkatkan dan dilindungi daripada tekanan haba.

3. APAKAH YANG PERLU ANDA LAKUKAN?

Anda dikehendaki menandatangani borang penyertaan ini yang menyatakan anda berminat untuk menyertai kajian ini selepas anda membaca dan memahami segala penerangan yang diberikan. Anda diminta untuk menjawab soal selidik untuk mendapatkan maklumat mengenai kajian ini. Borang penyertaan dan borang soal selidik perlu dikembalikan kepada penyelidik sebelum ujian tekanan darah, kadar dengupan jantung dan suhu badan dijalankan. Ujian tekanan darah, kadar dengupan jantung dan suhu badan dijalankan sebanyak tiga kali iaitu pada sebelum waktu bekerja, dua jam selepas bekerja dan setelah tamat waktu bekerja.

4. SIAPA YANG TIDAK BOLEH MENYERTAI KAJIAN INI?

Pekerja yang bekerja kurang dari 3 bulan dan telah disahkan menghidap tekanan darah tinggi dan penyakit jantung.

5. APAKAH FAEDAH MENYERTAI KAJIAN INI?

a) KEPADA ANDA SEBAGAI PESERTA?

Melalui kajian ini, peserta akan dapat menjalani ujian kesihatan dan mengetahui status kesihatan diri secara percuma.

b) KEPADA PENYELIDIK?

Membantu penyelidik untuk menentukan tekanan haba dan kesannya dalam kalangan pekerja di industri pembuatan sarung tangan getah.

6. ADAKAH IA BERISIKO?

Tiada risiko di dalam kajian ini.

7. ADAKAH MAKLUMAT DAN IDENTITI SAYA KEKAL RAHSIA?

Maklumat dan identiti yang digunakan dalam kajian ini akan kekal sulit.

8. SIAPA YANG SAYA PERLU HUBUNGI SEKIRANYA SAYA MEMPUNYAI SOALAN TAMBAHAN SEMASA MENGIKUTI PENYELIDIKAN INI?

Jika anda mempunyai sebarang soalan tambahan, anda boleh menghubungi Dr Karmegam Karuppiah, penyelia kajian penyelidikan di 013-5818331 atau Amir Ashraf bin Jalaludin, penyelidik di 014-8456250.

Sila tandatangan di sini sekiranya anda telah membaca dan memahami kandungan halaman ini

9. PERSETUJUAN

Saya..... No Kad Pengenalan.
beralamat.....
.....dengan ini bersetuju untuk mengambil bahagian secara sukarela
dalam penyelidikan yang tersebut di atas *(kajian klinikal/percubaan ubat-ubatan/rakaman
video/kumpulan sasaran/temuduga/ soal selidik).

Saya telah diberi penjelasan secara menyeluruh mengenai penyelidikan ini dari segi metodologi,
risiko dan komplikasi (seperti tertulis pada Helaian Penerangan Responden). Saya memahami
bahawa saya berhak menarik diri dari penyelidikan ini pada bila-bila masa tanpa memberi
sebarang alasan.Saya juga memahami bahawa sebarang maklumat yang berkaitan identiti saya
akan dirahsiakan.

Saya* berminat / tidak berminat untuk mengetahui keputusan kajian yang melibatkan saya.

Saya* setuju/tidak bersetuju untuk imei/gambar/rakaman video/ rakaman suara digunakan
dalam apa jua bentuk penerbitan atau pembentangan. (sekiranya berkaitan).

*potong yang tidak berkenaan

Tandatangan Tandatangan
(Responden) (Saksi)

Tarikh : Nama :

No. K/P:

Saya mengesahkan bahawa saya telah menerangkan kepada responden ini sifat dan tujuan
penyelidikan yang tersebut di atas.

Tarikh Tandatangan
(Penyelidik)



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UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,
SELANGOR, MALAYSIA**

FORM 2.4: RESPONDENT'S INFORMATION SHEET AND INFORMED CONSENT FORM

Please read the following information carefully and do not hesitate to discuss any questions you may have with the researcher.

1. STUDY TITLE :

Effect of Occupational Heat Stress on Physiological Changes and Heat Related Illness among Workers in Latex Glove Manufacturing Industry, Negeri Sembilan.

2. INTRODUCTION:

The purpose of this study is to determine the effect of occupational heat stress on physiological changes and heat related illness among workers from latex glove manufacturing industry. This is because exposure to extreme heat stress level can overwhelm the body's coping mechanism leading to a serious condition such as heat stroke and possibly fatal. Heat stress can happen when the body failed in controlling and maintaining its internal temperature which lead to increase of core body temperature, heart rate and blood pressure of the exposed individual. These changes can result in heat related illness such as heat exhaustion, heat cramps, heat syncope and also heat stroke. Therefore, this study need to be conducted so, it can improve the safety and health status.

3. WHAT WILL YOU HAVE TO DO?

You must sign consent form which is stated that you are interested to participate in this study after you have read and understood all the explanation given. You will need to answer a questionnaire for obtaining information regarding this study. Then, consent form and questionnaires should be returned to researcher before blood pressure, heart rate and core body temperature test that will be carried out 3 times which are before shift, after 2 hours working and after 8 hours working.

4. WHO SHOULD NOT PARTICIPATE IN THE STUDY?

Workers who work less than 3 months and has been diagnosed with hypertension and heart disease.

5. WHAT WILL BE THE BENEFITS OF THE STUDY:

(a) TO YOU AS THE SUBJECT?

Through this participation, the subjects will be able to undergo a health test and find out the health status for free.

(b) TO THE INVESTIGATOR?

It will help the investigator to determine the heat stress and its effect among workers from latex glove manufacturing industry.

6. WHAT ARE THE POSSIBLE RISKS?

There is no risk available in this study.

7. WILL THE INFORMATION THAT YOU PROVIDE AND YOUR IDENTITY REMAIN CONFIDENTIAL?

The information and identity used in this study will remain confidential.

8. WHO SHOULD YOU CONTACT IF YOU HAVE ADDITIONAL QUESTIONS DURING THE COURSE OF THE RESEARCH?

If you have any further questions, you may contact Dr Karmegam A/L Karuppiah, Supervisor of this research at 013-5818331 or Amir Ashraf bin Jalaludin, the researcher at 014-8456250.

Please initial here if you have read and understood the contents of this page_____

9. CONSENT

I Identity Card No.
address.....
... ..hereby voluntarily agree to take part in the
research stated above *(clinical /drug trial/video recording/ focus group/interview-based/
questionnaire-based).

I have been informed about the nature of the research in terms of methodology, possible
adverse
effects and complications (as written in the Respondent's Information Sheet). I understand that
I have the right to withdraw from this research at any time without giving any reason
whatsoever. I also understand that this study is confidential and all information provided with
regard to my identity will remain private and confidential.

I* wish / do not wish to know the results related to my participation in the research

I agree/do not agree that the images/photos/video recordings/voice recordings related to me be
used in any form of publication or presentation (if applicable)

* delete where necessary

Signature Signature
(Respondent) (Witness)

Date : Name :

I/C No. :

I confirm that I have explained to the respondent the nature and purpose of the above-
mentioned research.

Date Signature
(Researcher)



PROJEK PENYELIDIKAN TAHUN AKHIR
B.S. KESIHATAN PERSEKITARAN DAN PEKERJAAN
FAKULTI PERUBATAN DAN SAINS KESIHATAN
UNIVERSITI PUTRA MALAYSIA
SERDANG, SELANGOR

***“BORANG SOAL SELIDIK BAGI KAJIAN TEGASAN HABA DAN KESANNYA
TERHADAP PEKERJA DI KILANG SARUNG TANGAN”***

ARAHAN SOALAN:

1. Borang soal selidik ini mengandungi empat (5) bahagian iaitu:

- BAHAGIAN A: MAKLUMAT DIRI
- BAHAGIAN B: MAKLUMAT PEKERJAAN
- BAHAGIAN C: MAKLUMAT KESIHATAN
- BAHAGIAN D: MAKLUMAT GAYA HIDUP
- BAHAGIAN E: MAKLUMAT SIMPTOM PENDEDAHAN HABA

- 2. Anda diminta untuk menjawab semua soalan yang ada di dalam buku ini
- 3. Untuk menjawab, sila tandakan jawapan di bahagian jawapan yang telah disediakan
- 4. Borang soal selidik hendaklah dikembalikan kepada pengkaji setelah selesai menjawab semua soalan
- 5. Semua maklumat yang diperolehi di dalam kajian ini adalah rahsia dan hanya digunakan untuk tujuan pembelajaran semata-mata.

Sekian, terima kasih

BAHAGIAN A: MAKLUMAT DIRI

1.1	Tarikh lahir	<table><tr><td></td><td></td><td>Tarikh</td><td></td><td></td><td>Bulan</td><td></td><td></td><td></td><td></td><td>Tahun</td></tr></table>			Tarikh			Bulan					Tahun					
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1.9	Gaji	RM <table><tr><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>																
1.10	Tinggi	<table><tr><td></td><td></td><td></td></tr></table> cm																
1.11	Berat	<table><tr><td></td><td></td><td></td></tr></table> kg																
1.12	Isi rumah	<table><tr><td></td><td></td></tr></table> orang																

code

A.1.1
A.1.2
A.1.3
A.1.4
A.1.5
A.1.6
A.1.7
A.1.8
A.1.9
A.1.10
A.1.11
A.1.12

BAHAGIAN B: MAKLUMAT PEKERJAAN

2.1. Apakah jawatan anda sekarang?

2.2. Di bahagian mana anda bekerja sekarang?

1. Online Packing

2. Line Boy

3. Former

4. Stripping

5. Roboting Arm

6. Housekeeping

7. Supervisor

8. Lain-lain

Nyatakan:

2.3. Berapa lamakah anda telah bekerja sebagai (pekerjaan seperti di atas)?

tahun

2.4. Berapa lamakah anda bekerja di kilang ini?

tahun

2.5. Shift kerja:

1. Normal

2. Shift

2.6. Berapa hari anda bekerja dalam sehari?

hari

2.7. Adakah anda bekerja lebih masa (OT)?

1. Ya

2. Tidak

2.8. Secara purata, berapa kerap anda bekerja lebih masa?

1. Tiada

2. 1-3 kali sebulan

3. 3-5 kali sebulan

4. Lebih daripada 5 kali sebulan

B.2.1

B.2.2

B.2.3

B.2.4

B.2.5

B.2.6

B.2.7

B.2.8

2.9. Berapa jamkah anda bekerja dalam sehari? _____ jam

B.2.9

2.10. Adakah anda menggunakan sebarang Peralatan Perlindungan Diri (PPE)?

1. Ya

2. Tidak

B.2.10

2.11. Tandakan jenis PPE yang digunakan:

1 Kasut keselamatan

2 Topi keselamatan

3 Cermin mata keselamatan

4 Sarung tangan

5 Pakaian perlindungan diri

6 Respirator

7 Lain-lain

Nyatakan: _____

B.2.11

2.12. Adakah latihan penggunaan PPE diberikan?

1. Ya

2. Tidak

B.2.12

2.13. Adakah anda terdedah kepada sebarang hazard seperti berikut:

1. Bahan kimia

2. Panas melampau

3. Habuk

4. Bunyi bising

5. Binatang berbisa

6. Lain-lain:

B.2.13

BAHAGIAN C: MAKLUMAT KESIHATAN

3.1. Adakah anda menghidap penyakit berikut dan telah disahkan oleh doctor?

Penyakit (a)	1. Ya (b)	2. Tidak (c)	Adakah anda pernah mengambil sebarang ubat-ubatan untuk penyakit tersebut	
			1. Ya (d)	2. Tidak (e)
3.1.1 Darah Tinggi				
3.1.2 Kencing Manis				
3.1.3 Jantung				

C.3.1
a-e

BAHAGIAN D: MAKLUMAT GAYA HIDUP

- 4.1 Adakah anda mengambil sebarang jenis dadah

1. Ya
2. Tidak

☐
☐
- 4.2 Adakah anda merokok?
Jika ya, _____ batang sehari

1. Ya
2. Tidak

☐
☐
- 4.3 Adakah anda mengambil minuman beralkohol?

1. Ya
2. Tidak

☐
☐

D.4.1

D.4.2

D.4.3

BAHAGIAN E: MAKLUMAT SIMPTOM-SIMPTOM PENDEDAHAN HABA

5.1 Adakah anda mengalami sebarang symptom-simptom atau tanda-tanda seperti yang di bawah semasa atau selepas terdedah kepada suhu /haba yang tinggi (panas)? Tandakan.

	Simptom	1. Ya	2. Tidak
E 5.1.1	Keletihan		
E 5.1.2	Pening kepala		
E 5.1.3	Kelihatan pucat		
E 5.1.4	Sesak nafas dan nadi lemah		
E 5.1.5	Berdebar-debar		
E 5.1.6	Ruam dan kulit kemerah-merahan selepas terdedah kepada panas		
E 5.1.7	Loya		
E 5.1.8	Muntah		
E 5.1.9	Kekejangan otot		
E 5.1.10	Terasa lenguh dibahagikan kaki atau tangan		
E 5.1.11	Strok		
E 5.1.12	Pitam		
E 5.1.13	Sawan		
E 5.1.14	Kekeliruan		
E 5.1.15	Pengsan		
E 5.1.16	Dahaga		
E 5.1.17	Kulit kering		
E 5.1.18	Kulit lembap dan terasa sejuk		
E 5.1.19	Peluh berlebihan		
E 5.1.20	Kadar degupan jantung meningkat		
E 5.1.21	Suhu badan yang sangat tinggi		

5.2 Kategori waktu bekerja anda

- 1. Bekerja berterusan bagi setiap jam
- 2. 75% bekerja, 25% rehat
- 3. 50% bekerja, 50% rehat
- 4. 25% bekerja, 75% rehat

E.5.2

5.3 Berapa lama anda terdedah kepada haba dalam pekerjaan seharian

- 1. Kurang daripada 2 jam
- 2. 2-4 jam
- 3. 4-6 jam
- 4. 6-8 jam
- 5. Lebih daripada 8 jam

E.5.3

-TERIMA KASIH ATAS KERJASAMA ANDA DALAM MENJAYAKAN KAJIAN INI-



CALIBRATION CERTIFICATE

CERTIFICATE NUMBER : VNA/A9512/16

PAGE : 2 OF 3

CALIBRATION RESULTS

Instrument Calibrated : Thermal Environment Monitor
ID. Number : V40413

Calibrated Range : (15 to 35) °C Specification : ± 0.5 °C

Readability : 0.1 °C

WET					
REFERENCE READ	RELATIVE HUMIDITY DURING CALIBRATION	PUT READ BEFORE ADJUST	CORRECTION		UNCERTAINTY, ± k = 2
			BEFORE ADJUST	AFTER ADJUST	
°C	%RH	°C	°C	°C	°C
15.0	54.9	15.1	-0.1	N/A	0.3
20.0	54.5	20.1	-0.1	N/A	0.3
25.0	54.0	25.0	0.0	N/A	0.3
30.0	53.7	30.0	0.0	N/A	0.3
35.0	53.2	35.0	0.0	N/A	0.3

DRY					
REFERENCE READ	RELATIVE HUMIDITY DURING CALIBRATION	PUT READ BEFORE ADJUST	CORRECTION		UNCERTAINTY, ± k = 2
			BEFORE ADJUST	AFTER ADJUST	
°C	%RH	°C	°C	°C	°C
15.0	54.9	15.1	-0.1	N/A	0.3
20.0	54.5	20.1	-0.1	N/A	0.3
25.0	54.0	25.0	0.0	N/A	0.3
30.0	53.7	30.0	0.0	N/A	0.3
35.0	53.2	35.0	0.0	N/A	0.3

The uncertainty calculation is based on ISO Guide to Expression of Uncertainty in measurement.

Note

1. Set Temperature at 33°C during humidity measurement.
2. Set Humidity at 55 %RH during temperature measurement.
3. IRT - Unit Under Test
4. To derive True Value - Use Instrument Reading - Correction
5. Interpolation - Reading between 2 test point may be derive by interpolation and plot a straight line graph where Reference (x-axis) is Correction (y-axis)
6. Correction can be ignore if smaller than user specification, unless otherwise user shall apply correction to derive true value.
7. If no adjustment done refer to "Correction Before Adjust" - If adjustment was done refer to "Correction After Adjust" to derive the true value
8. N/A - No Adjustment done
9. Uncertainty - Parameter associated with the result of measurement that characterizes the dispersion of the value that could reasonably be attributed to the measurand
10. Calibration was perform according to international reference standard JIS B*304, JIS B*920, JIS Z3406, BS 1339

The expanded uncertainties are based on an estimated confidence probability of not less than 95% and have a coverage factor of k=2 unless stated otherwise

This certificate is issued in accordance with the conditions of accreditation granted by the SAMM which has assessed the measurement capability of the laboratory and its traceability to recognised national standards and to the units of measurement realised at the corresponding national standards laboratory. Copy write of this certificate is owned by the issuing laboratory and may not be reproduced other than in full except with the prior written approval from VNA Engineering Sdn Bhd.

CALIBRATION CERTIFICATE

CERTIFICATE NUMBER : VNA/A9512/16

PAGE : 3 OF 3

CALIBRATION RESULTS

Instrument Calibrated : Thermal Environment Monitor

ID. Number : V40413

Calibrated Range : (30 to 90) %RH

(15 to 35) °C

Readability : 1 %RH

0.1 °C

Specification : ± 5 %RH

± 0.5 °C

GLOBE					
REFERENCE READ	RELATIVE HUMIDITY DURING CALIBRATION	UUT READ BEFORE ADJUST	CORRECTION		UNCERTAINTY, ± k = 2
			BEFORE ADJUST	AFTER ADJUST	
°C	%RH	°C	°C	°C	°C
15.0	54.9	15.1	-0.1	N/A	0.3
20.0	54.5	20.1	-0.1	N/A	0.3
25.0	54.0	25.0	0.0	N/A	0.3
30.0	53.7	30.0	0.0	N/A	0.3
35.0	53.2	35.0	0.0	N/A	0.3

RELATIVE HUMIDITY					
REFERENCE READ	TEMPERATURE DURING CALIBRATION	UUT READ BEFORE ADJUST	CORRECTION		UNCERTAINTY, ± k = 2
			BEFORE ADJUST	AFTER ADJUST	
%RH	°C	%RH	%RH	%RH	%RH
30.8	22.7	34	-3	N/A	2.3
49.2	23.1	53	-4	N/A	2.3
69.1	23.0	74	-5	N/A	2.3
89.2	23.0	93	-4	N/A	2.3

The uncertainty calculation is based on ISO Guide to Expression of Uncertainty in measurement.

- Note
- 1

Set Temperature at 23°C during humidity measurement
- 2

Set Humidity at 35 %RH during temperature measurement
- 3

19/7 - Unit Under Test
- 4

To derive True Value: User Instrument Reading - Correction
- 5

Interpolation: Reading between 2 sets from may be derive by interpolation and plot a straight line graph where Reference (x-axis) is Correction (y-axis)
- 6

Correction can be ignore if smaller than user specification, unless otherwise user shall apply correction to derive true value
- 7

If no adjustment done refer to "Correction Before Adjust" If adjustment was done refer to "Correction After Adjust" to derive the true value
- 8

N/A - No Adjustment done
- 9

Uncertainty - Parameter associated with the result of measurement, that characterizes the dispersion of the value that could reasonably be attributed to the measured
- 10

Calibration was perform according to international reference standard JIS B 306, JIS B 7920, JIS Z 4004, BS 1339

The expanded uncertainties are based on an estimated confidence probability of not less than 95% and have a coverage factor of k=2 unless stated otherwise

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CALIBRATION CERTIFICATE

CERTIFICATE NUMBER : VNA/A9511/16

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CALIBRATION RESULTS

Instrument Calibrated : Thermal Environment Monitor

ID. Number : V40412

Calibrated Range : (15 to 35) °C

Specification : ± 0.5 °C

Readability : 0.1 °C

WET					
REFERENCE READ	RELATIVE HUMIDITY DURING CALIBRATION	UNIT READ BEFORE ADJUST	CORRECTION		UNCERTAINTY, ±
°C	%RH	°C	BEFORE ADJUST °C	AFTER ADJUST °C	k = 2 °C
15.0	54.9	15.3	-0.3	N/A	0.3
20.0	54.7	20.3	-0.3	N/A	0.3
25.0	54.5	25.3	-0.3	N/A	0.3
30.0	54.3	30.2	-0.2	N/A	0.3
35.0	53.2	35.2	-0.2	N/A	0.3

DRY					
REFERENCE READ	RELATIVE HUMIDITY DURING CALIBRATION	UNIT READ BEFORE ADJUST	CORRECTION		UNCERTAINTY, ±
°C	%RH	°C	BEFORE ADJUST °C	AFTER ADJUST °C	k = 2 °C
15.0	54.9	15.1	-0.1	N/A	0.3
20.0	54.7	20.1	-0.1	N/A	0.3
25.0	54.5	25.0	0.0	N/A	0.3
30.0	54.3	29.9	0.1	N/A	0.3
35.0	53.2	34.9	0.1	N/A	0.3

The uncertainty calculation is based on ISO Guide to Expression of Uncertainty in measurement.

- Note
- 1

Set Temperature at 23°C during humidity measurement
- 2

Set Humidity at 55 %RH during temperature measurement
- 3

19.7 °C in Under Test
- 4

To derive True Value - User Instrument Reading - Correction
- 5

Interpolation - Reading between 2 test point may be derive by interpolation and plot a straight line graph where Reference (x-axis) Vs Correction (y-axis)
- 6

Correction can be ignore if smaller than user specification, unless otherwise user shall apply correction to derive true value
- 7

If no adjustment done refer to "Correction Before Adjust" If adjustment was done refer to "Correction After Adjust" to derive the true value.
- 8

N/A - No Adjustment done
- 9

Uncertainty - Parameter associated with the result of measurement, that characterizes the dispersion of the value that could reasonably be attributed to the measurement
- 10

Calibration was perform according to international reference standard JIS B 506, JIS B 920, JIS Z 1906, BS 1339

The expanded uncertainties are based on an estimated confidence probability of not less than 95% and have a coverage factor of k = 2 unless stated otherwise

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CALIBRATION CERTIFICATE

CERTIFICATE NUMBER : VNA/A9511/16

PAGE : 2 OF 3

CALIBRATION RESULTS

Instrument Calibrated : Thermal Environment Monitor

ID. Number : V40412

Calibrated Range : (15 to 35) °C

Specification : ± 0.5 °C

Readability : 0.1 °C

WET					
REFERENCE READ	RELATIVE HUMIDITY DURING CALIBRATION	UUT READ BEFORE ADJUST	CORRECTION		UNCERTAINTY, ± k = 2
			BEFORE ADJUST	AFTER ADJUST	
°C	%RH	°C	°C	°C	°C
15.0	54.9	15.3	-0.3	N/A	0.3
20.0	54.7	20.3	-0.3	N/A	0.3
25.0	54.5	25.3	-0.3	N/A	0.3
30.0	54.3	30.2	-0.2	N/A	0.3
35.0	53.2	35.2	-0.2	N/A	0.3

DRY					
REFERENCE READ	RELATIVE HUMIDITY DURING CALIBRATION	UUT READ BEFORE ADJUST	CORRECTION		UNCERTAINTY, ± k = 2
			BEFORE ADJUST	AFTER ADJUST	
°C	%RH	°C	°C	°C	°C
15.0	54.9	15.1	-0.1	N/A	0.3
20.0	54.7	20.1	-0.1	N/A	0.3
25.0	54.5	25.0	0.0	N/A	0.3
30.0	54.3	29.9	0.1	N/A	0.3
35.0	53.2	34.9	0.1	N/A	0.3

The uncertainty calculation is based on ISO Guide to Expression of Uncertainty in measurement.

- Note
- 1

Set Temperature at 23°C during humidity measurement
- 2

Set Humidity at 55 %RH during temperature measurement
- 3

1977 - Tins Under Test
- 4

To derive True Value: User Instrument Reading - Correction
- 5

Interpolation: Reading between 2 test point may be derive by interpolation and plot a straight line graph where Reference (x-axis) Vs. Correction (y-axis)
- 6

Correction can be ignore if smaller than user specification, unless otherwise user shall apply correction to derive true value
- 7

If no adjustment done refer to "Correction Before Adjust". If adjustment was done refer to "Correction After Adjust" to derive the true value.
- 8

N/A - No Adjustment done
- 9

Uncertainty: Parameter associated with the result of measurement, that characterizes the dispersion of the value that could reasonably be attributed to the measured
- 10

Calibration was perform according to international reference standard: JIS B 7306, JIS B 7320, JIS Z 8706, BS 1339

The expanded uncertainties are based on an estimated confidence probability of not less than 95% and have a coverage factor of k = 2 unless stated otherwise

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CALIBRATION CERTIFICATE

CERTIFICATE NUMBER : VNA/A9511/16

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CALIBRATION RESULTS

Instrument Calibrated : Thermal Environment Monitor
ID. Number : V40412

Calibrated Range : (30 to 90) %RH Specification : ± 5 %RH
(15 to 35) °C ± 0.5 °C
Readability : 1 %RH
0.1 °C

GLOBE

REFERENCE READ	RELATIVE HUMIDITY DURING CALIBRATION	UUT READ BEFORE ADJUST	CORRECTION		UNCERTAINTY, $\pm$ k = 2
			BEFORE ADJUST	AFTER ADJUST	
°C	%RH	°C	°C	°C	°C
15.0	54.9	15.4	-0.4	N/A	0.3
20.0	54.7	20.3	-0.3	N/A	0.3
25.0	54.5	25.2	-0.2	N/A	0.3
30.0	54.3	30.0	0.0	N/A	0.3
35.0	53.2	34.9	0.1	N/A	0.3

RELATIVE HUMIDITY

REFERENCE READ	TEMPERATURE DURING CALIBRATION	UUT READ BEFORE ADJUST	CORRECTION		UNCERTAINTY, $\pm$ k = 2
			BEFORE ADJUST	AFTER ADJUST	
%RH	°C	%RH	%RH	%RH	%RH
32.6	23.0	36	-3	N/A	2.3
50.1	23.3	53	-3	N/A	2.3
68.2	23.1	73	-5	N/A	2.3
89.2	23.0	94	-5	N/A	2.3

The uncertainty calculation is based on ISO Guide to Expression of Uncertainty in measurement.

Note

1. Set Temperature at 23°C during humidity measurements
2. Set Humidity at 55 %RH during temperature measurements
3. 1 °C / 1 %RH Under Test
4. To derive True Value - User Instrument Reading - Correction
5. Interpolation - Reading between 2 test points may be derive by interpolation and plot a straight line graph where Reference (x-axis) Vs. Correction (y-axis)
6. Correction can be ignore if smaller than user specification, unless otherwise user shall apply correction to derive true value
7. If no adjustment done refer to "Correction Before Adjust" If adjustment was done refer to "Correction After Adjust" to derive the true value
8. N/A - No Adjustment done
9. Uncertainty - Parameter associated with the result of measurement, that characterizes the dispersion of the value that could reasonably be attributed to the measurand
10. Calibration was perform according to international reference standard JIS B 7404, JIS B 7920, JIS Z 8406, BS 1339

The expanded uncertainties are based on an estimated confidence probability of not less than 95% and have a coverage factor of k=2 unless stated otherwise

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CALIBRATION CERTIFICATE

CERTIFICATE NUMBER : VNA/A9513/16

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CALIBRATION RESULTS

Instrument Calibrated : Thermal Environment Monitor
ID. Number : V40414

Calibrated Range : (15 to 35) °C Specification : ± 0.5 °C

Readability : 0.1 °C

WET

REFERENCE READ	RELATIVE HUMIDITY DURING CALIBRATION	UUT READ BEFORE ADJUST	CORRECTION		UNCERTAINTY, ± k=2
			BEFORE ADJUST	AFTER ADJUST	
°C	%RH	°C	°C	°C	°C
15.0	54.5	15.2	-0.2	N/A	0.3
20.0	54.3	20.1	-0.1	N/A	0.3
25.0	54.2	24.8	0.2	N/A	0.3
30.0	54.3	29.8	0.2	N/A	0.3
35.0	54.5	34.8	0.2	N/A	0.3

DRY

REFERENCE READ	RELATIVE HUMIDITY DURING CALIBRATION	UUT READ BEFORE ADJUST	CORRECTION		UNCERTAINTY, ± k=2
			BEFORE ADJUST	AFTER ADJUST	
°C	%RH	°C	°C	°C	°C
15.0	54.5	15.3	-0.3	N/A	0.3
20.0	54.3	20.1	-0.1	N/A	0.3
25.0	54.2	24.8	0.2	N/A	0.3
30.0	54.3	29.8	0.2	N/A	0.3
35.0	54.5	34.7	0.3	N/A	0.3

The uncertainty calculation is based on ISO Guide to Expression of Uncertainty in measurement.

Note

1. Set Temperature at 23 °C during humidity measurement
2. Set Humidity at 55 %RH during temperature measurement
3. UUT - Unit Under Test
4. To derive True Value: User Instrument Reading - Correction
5. Interpolation: Reading between 2 test points may be derive by interpolation and plot a straight line graph where Reference (x-axis) Vs. Correction (y-axis)
6. Correction can be ignore if smaller than user specification, unless otherwise user shall apply correction to derive true value
7. If no adjustment done refer to "Correction Before Adjust". If adjustment was done refer to "Correction After Adjust" to derive the true value
8. N/A - No Adjustment done
9. Uncertainty: Parameter associated with the result of measurement that characterizes the dispersion of the value that could reasonably be attributed to the measurand
10. Calibration was perform according to international reference standard: JIS B 7306, JIS B 7320, JIS Z 8906, BS 1339

The expanded uncertainties are based on an estimated confidence probability of not less than 95% and have a coverage factor of k=2 unless stated otherwise

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CALIBRATION CERTIFICATE

CERTIFICATE NUMBER : VNA/A9513/16

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CALIBRATION RESULTS

Instrument Calibrated : Thermal Environment Monitor
ID. Number : V40414

Calibrated Range : (30 to 90) %RH Specification : ± 5 %RH
(15 to 35) °C ± 0.5 °C
Readability : 1 %RH
0.1 °C

GLOBE

REFERENCE READ	RELATIVE HUMIDITY DURING CALIBRATION	ULT READ BEFORE ADJUST	CORRECTION		UNCERTAINTY, $\pm$ k = 2
			BEFORE ADJUST	AFTER ADJUST	
°C	%RH	°C	°C	°C	°C
15.0	54.5	15.2	-0.2	N/A	0.3
20.0	54.3	20.2	-0.2	N/A	0.3
25.0	54.2	25.1	-0.1	N/A	0.3
30.0	54.3	30.1	-0.1	N/A	0.3
35.0	54.5	35.1	-0.1	N/A	0.3

RELATIVE HUMIDITY

REFERENCE READ	TEMPERATURE DURING CALIBRATION	ULT READ BEFORE ADJUST	CORRECTION		UNCERTAINTY, $\pm$ k = 2
			BEFORE ADJUST	AFTER ADJUST	
%RH	°C	%RH	%RH	%RH	%RH
31.3	23.1	34	-3	N/A	2.3
48.7	23.1	53	-4	N/A	2.3
68.4	23.0	73	-5	N/A	2.3
89.1	23.0	93	-4	N/A	2.3

The uncertainty calculation is based on ISO Guide to Expression of Uncertainty in measurement.

Note

1. Set Temperature at 23°C during humidity measurement
2. Set Humidity at 55 %RH during temperature measurement
3. (T) T - Unit Under Test
4. To derive True Value: User Instrument Reading - Correction
5. Interpolation: Reading between 2 test point may be derive by interpolation and plot a straight line graph where Reference (x-axis) Vs. Correction (y-axis)
6. Correction can be ignore if smaller than user specification, unless otherwise user shall apply correction to derive true value
7. If no adjustment done refer to "Correction Before Adjust". If adjustment was done refer to "Correction After Adjust" to derive the true value.
8. N/A - No Adjustment done
9. Uncertainty: Parameter associated with the result of measurement, that characterizes the dispersion of the value that could reasonably be attributed to the measurand
10. Calibration was perform according to international reference standard JIS B 306, JIS B 7920, JIS Z 1906, BS 1339

The expanded uncertainties are based on an estimated confidence probability of not less than 95% and have a coverage factor of k = 2 unless stated otherwise

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