THE EVALUATION OF FILTERING FACE PIECES IN MALAYSIA WORKPLACE ACCORDING TO MALAYSIAN STANDARD OF MS2323:2010

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DEDICATION

This thesis work is dedicated to my dearest wife Siti Azuana Mad Alli, who leads me through the valley of darkness with light of hope and support. This thesis is also dedicated to my beloved kids Muhammad Muhaimin Rizqi and Muhammad Muqaffi Rifqi whom I can't force myself to stop loving. Special thanks to my parents Osman Ahmad and Asbah Md Lajim who have always loved me unconditionally and whose good examples have taught me to work hard for the things that I aspire to achieve.

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ABSTRACT

Personal Protective Equipment (PPE) is meant to protect the safety and health of workers. PPE, including Filtering Face Piece 2 (FFP2), is subject to assessment against the legal requirements related to occupational safety and health under Malaysian law. The Occupational Safety and Health (Use and Standards of Exposure of Chemicals Hazardous to Health) Regulations 2000 (USECHH 2000), a piece of legislation under the Occupational Safety and Health Act (OSHA 1994) stipulates that all PPE must be assessed and approved prior to use. The objective of this study is to identify the factors influencing the purchase of FFP2 among Safety and Health Officers (SHO) through qualitative analysis, followed by an evaluation of the FFP2's quality, and make recommendations for selected FFP2 based on MS2323:2010 quality criteria. Thirty FFP2 designs are selected and divided into three groups, namely cup and valveless, cup and valve, and folding without valve with an unique ID were assigned to each FFP2. The survey was conducted through a questionnaire form distributed to the SHO. Based on the findings, 390 respondents agreed that product quality and price were the two most important considerations when making a FFP2 purchase. FFP2 efficiency varies by brand and has been identified and investigated through laboratory testing according to Malaysian standard MS2323:2010. The majority of FFP2 did not meet the standard for qualitative testing, except for the brands ID 5, ID 6, ID 8, ID 14, ID 26, ID 29, and ID 30. All FFP2 brands met the requirements for quantitative testing, with the exception of penetration testing, where 10 brands with IDs 7, 9, 11, 13, 17, 19, 22, 23, 24, and 28 failed to do so. Based on the performance test, each FFP2 has been analysed and ranked according to a Likert scale. The selected FFP2 was recommended based on the highest points for each group were obtained by IDs 5, 28, 6, and 8. The results of this study will assist Malaysian employers and workers in determining the proper selection or choice of the FFP2 .

ABSTRAK

Peralatan perlindungan diri (PPD) adalah untuk melindungi keselamatan dan kesihatan pekerja. PPD termasuk *Filtering Face Piece 2* (FFP2) tertakluk kepada penilaian terhadap keperluan undang-undang yang berkaitan dengan keselamatan dan kesihatan pekerjaan. Peruntukan di bawah undang-undang Malaysia menggariskan Peraturan Penggunaan dan Piawaian Pendedahan Bahan Kimia Berbahaya kepada Kesihatan (USECHH 2000) di bawah Akta Keselamatan dan Kesihatan Pekerjaan (AKKP 1994) yang menyatakan bahawa semua PPD mesti dinilai dan diluluskan sebelum digunakan. Objektif kajian ini adalah untuk mengenal pasti faktor-faktor yang mempengaruhi pembelian FFP2 dalam kalangan Pegawai Keselamatan dan Kesihatan (SHO) melalui analisis kualitatif. Seterusnya menilai kualiti FFP2 dan membuat pemilihan cadangan FFP2 berdasarkan kriteria kualiti mengikut MS2323:2010. Tiga puluh reka bentuk FFP2 dipilih dan dibahagikan kepada tiga kumpulan iaitu *cup and valveless, cup and valve* dan *fold without valve* dengan setiap FFP2 tersebut diberikan satu unik ID. Kaedah yang digunakan untuk tinjauan adalah melalui borang soal selidik di kalangan SHO. Berdasarkan penemuan yang diperolehi, 390 responden bersetuju bahawa kualiti dan harga produk adalah dua pertimbangan paling penting semasa membuat pembelian FFP2. Kecekapan FFP2 berbeza mengikut jenama telah dikenal pasti dan disiasat melalui ujian makmal mengikut piawaian Malaysia MS2323:2010. Majoriti FFP2 tidak memenuhi standard untuk ujian kualitatif, kecuali untuk jenama ID 5, ID 6, ID 8, ID 14, ID 26, ID 29 dan ID 30. Semua jenama FFP2 memenuhi keperluan untuk ujian kuantitatif, kecuali ujian penembusan, di mana sepuluh jenama dengan ID 7, 9, 11, 13, 17, 19, 22, 23, 24 dan 28 gagal dalam ujian tersebut. Berdasarkan ujian kecekepan yang dijalankan, setiap FFP2 telah dianalisis dan ditarafkan mengikut skala Likert. ID 5, 28, 6, dan 8 adalah cadangan yang dipilih bagi pemilihan FFP2 berdasarkan mata tertinggi bagi setiap kumpulan. Hasil kajian ini akan membantu majikan dan pekerja dalam menentukan pemilihan atau pilihan FFP2 yang betul.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

API	Air Pollution Index
BR	Breathing Resistance
CDC	Center for Disease Control
CO_2	Carbon Dioxide
COPD	Chronic Obstructive Pulmonary Disease
CPC	Condensation Particle Counter
DIY	Do It Yourself
DOE	Department of Environment
DOS	Department of Statistic Malaysia
DOSH	Department of Occupational Safety and Health
DOSM	Department of Standard Malaysia
FFR	Filtering Face-Piece Respirators
FIRS	Forum of International Respiratory Society
FMA	Factory and Machinery Act
HEPA	High Efficiency Particle Arrestanse
ID	Identification
IDLH	Immediately Dangerous to Life and Health
MOHR	Ministry of Human Resource
IL	Inward Leakage
ILO	International Labour Organization
MPPS	Maximum Penetration Reported Sizer
MS	Malaysian Standard
NIH	National Institute of Health
NIOSH	National Institute of Occupational Safety and Health
NPPTL	National Personal Protective Technology Laboratory
OSH	Occupational Safety and Health

OSHA	Occupational Safety and Health Act
USECHH	Use of Standard Exposure Chemical Hazardous to Health
PPE	Personal Protective Equipment
RPE	Respiratory Protective Equipment
SCBA	Self-Contained Breathing Apparatus
SEM	Scanning Electron Microscopy
SMPS	Scanning Mobility Particle Sizer
SOSCO	Social Security Organization
TB	Tuberculosis
TIL	Total Inward Leakage
US NIOSH	United States National Institute of Occupational Safety and Health
UTHM	Universiti Tun Hussein Onn Malaysia
WHO	World Health Organization

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

In this chapter, the background of the study is outlined, the problem statement it seeks to address is identified, and the objectives and scope of the study it aims to achieve are described. The significance of the study is highlighted, and the thesis arrangement concludes this chapter.

1.2 Background of the study

In Malaysia, all employees are covered under the Occupational Safety and Health Act 1994 (Act 514) (OSHA 1994) and the Factories and Machinery Act 1967 (Act 139) (FMA 1967) (Baderin *et al*., 2021). The Department of Occupational Safety and Health (DOSH) in the Ministry of Human Resources (MOHR) implement these Acts to ensure safety and health of workers. The Occupational Safety and Health Act 1994 is a legislative framework enacted to secure the safety, health, and welfare of persons at the workplace, to protect others from safety and health risks in activities pertaining to their workplace, and to promote occupational safety and health culture in workplace. Section 15 in Part IV of OSHA 1994 states the responsibility of every employer to ensure the safety, health, and welfare of the employees at work, which includes the provisions of information, instruction, training, and supervision. The Occupational Safety and Health Act 1994 is not only a piece of legislation; it also acts as a reference for employers to be aware of and promote their company's safety and health culture.

"The 11th Malaysian Plan was framed by giving priority to the people in all development efforts. This approach reinforces the government's commitment to improve people's living standards, dignity and potential to take advantage of economic development and progress". The Ministry of Human Resources (MOHR) has declared that the Occupational Safety and Health Master Plan 2016-2020 (OSHMP 2016-2020) was intended to increase awareness, knowledge, and commitment to occupational safety and health in all undertakings to reduce the number of injuries, diseases, and fatalities. Furthermore, the Master Plan provided the action framework to back up and complement legislative framework from the Occupational Safety and Health Act (OSHA) 1994. "The OSHMP 2020 is a strategy and programme formulated to further boost national occupational safety and health (OSH) to a greater level to protect the nation's human resources which are an important asset to the success of national development programs in realizing the goals of vision 2020". The main strategy of OSHMP 2020 is the inculcation of a preventive culture at the workplace. This approach will follow through with the implementation and inculcation of the principle of responsibility and self-regulation carried out in the previous two plans in order to bolster the nurturing of a safe and healthy work culture among employers and workers. Basically, a safe and healthy work environment will benefit employers and workers, as tabulated in Table 1.1.

Table 1.1: Benefits of safe and healthy work environment (OSHMP, 2016-2020)

No	Employer	Workers
1	Increased company productivity	Increased confidence to carry out work productively.
2	Increase in organisational competitiveness	The capability to work as a consequence of the prevention of occupational accidents and diseases, which can jeopardise health and cause injury or death.
3	Reduced business costs	Not being a burden to family, society, and the nation following occupational accidents and diseases.
4	Increase productivity and quality	Positive effect on the quality of working life and the quality of life of workers.
5	Less workplace injury and workers compensation claims.	Improved morale.

Protection of workers' safety and health should be the most vital consideration for employers, as workers are at risk of exposure to various types of hazards that exist due to the nature of the work involved. A safe and healthy work environment can be

achieved when hazards at the workplace can be controlled at their source (where the problem occured). The closer control is to the source of the hazard, the better. This method is often referred to as "applying engineering controls". If this does not work, hazards can often be controlled along the path to the worker, between the source and the worker. Selecting a suitable control is important to improve the safety and health of the work environment. Essentially, the hierarchy of controls have five (5) types of controls for the hazards that have been tabulated in Table 1.2.

Table 1.2: Five (5) Types of control measures (HSE, 2013)

Control measure		**Technique**
1.	**Elimination**	Eliminating a hazardous job, tool, process, machine, or substance is perhaps the best way of protecting workers. For example, a salvage firm might decide to stop buying and cutting up scrapped bulk fuel tanks due to explosion hazards.
2.	**Substitution**	Sometimes doing the same work in a less hazardous way is possible. For example, a hazardous chemical can be replaced with a less hazardous one. Controls must protect workers from any new hazards that are created.
3.	**Engineering controls**	Methods that are built into the design of a plant, equipment, or process to s the hazard. Engineering controls are a very reliable way to control worker exposures as long as the controls are designed, used, and maintained properly.
4.	**Administrative controls**	Training, procedure, policy, or shift designs that lessen the threat of a hazard to an individual. Some common examples of administrative controls include work practice controls such as prohibiting mouth pipetting and rotating worker shifts in coal mines to prevent hearing loss.
5.	**Personal protective equipment (PPE)**	Personal protective equipment means any equipment that is intended to be worn or held by a person at work and that protects him against one or more risks to his health or safety, and any additional accessories designed to meet that objective; PPE is usually chosen to provide protection appropriate to each of type of hazard present. There are specifications for the types of PPE used for protecting an individual's head, eyes, footwear, limbs, and body, as well as for fire retardant clothing, respiratory, hearing, and personal flotation devices. It may also include required apparel, for example, when traffic hazards are present and highly visible and distinguishable: "vests must be worn"

The history of personal protective equipment (PPE) dates as far back as ancient times, when soldiers wore protective headgear, face gear, and body armor in order to fight their enemies without being killed themselves. Much of the gear used by these soldiers was very heavy, so if a soldier fell off his horse, for example, he couldn't have the strength to get back on without help. Nevertheless, such ironclad personal protective gear helped many an army get a stronghold over their enemies (Levi Anatolia *et al*., 2022).

Despite their drawbacks and limitations, the use of PPE may, in certain circumstances, be the only practicable protection. When this is the case, theseequipment must be properly selected, used, and maintained so that adequate protection will be provided. PPE is any equipment that is intended to be worn or held by a person at work and that protects him or her against one or more risks to health or safety, as well as any additional accessories designed to meet that objective.

Preference should always be given to safe-place rather than safe-person policies. ′Safe-place′ means that the working environment is ensured to be free from contaminants or hazardous conditions or factors that pose a risk to workers or any other person who may be present at the place of work. It refers to the control of risk at the source, which can be achieved through the application of engineering principles and the adoption of a safe system of work. Risks are eliminated, isolated, or minimised. The use of PPE, which represents the safe–person approach, offers protection only to the wearer. However, measures controlling the risk at the source can protect everyone at the workplace (OSHA, 1994). The theoretical maximum levels of protection are seldom achieved with PPE in practice, and the actual level of protection is difficult to assess. The use of PPE may give a false sense of security to the wearer as the risk is not eliminated but merely prevented the hazards from coming into contact with the worker. Effective protection is only achieved through suitable, correctly fitted, properly used, and properly maintained PPE (DOSH, 2005). Another problem with PPE is that it may restrict the wearer to some extent by limiting mobility, or visibility, or by requiring additional weight to be carried. Due to these reasons, the wearing of PPE to control risk is to be used as a last resort or as the ′last line of defence′. Engineering controls and safe systems of work should be considered first. However, in some circumstances, PPE will still be needed to adequately control the risk of being exposed to hazards.

i) One of the actions to control exposure under Regulation 15(1) of the Occupational Safety and Health (Use and Standards of Exposure of Chemicals Hazardous to Health) Regulations 2000 (USECHH), is the provision of approved PPE. Under the USECHH Regulations 'approved' means approved in writing by the Director General of Occupational Safety and Health. For PPE, the criteria for approval should be based on these underlying principles stated by (DOSH, 2000):be suitable for the type of work in which they are employed;

ii) fit the employees;

iii) not adversely affect the health or medical condition of the employees; and

iv) sufficient supply and is readily available to employees who require it.

DOSH had decided to formalise the enforcement of the requirements to use approved types of PPE stipulated under various occupational safety and health regulations. All PPE for use in all places of work shall be approved by DOSH (OSHA, 1994). For PPE, the criteria for approval is as follows (DOSH, 2005):

i) Designed to recognised standards;

ii) Tested according to recognised standards;

iii) Passed the test conducted by an accredited testing laboratory; or

iv) A developed country approves the use of the equipment

The requirement for supplier's manufacturers of PPE to comply with testing and certification requirements by SIRIM was first introduced by DOSH in 2019. DOSH had appointed SIRIM QAS International Sdn Bhd as the inspection and testing body (DOSH, 2019). The scope of DOSH approval is applicable to all PPE used in the workplaces, including both imported and locally made PPE products. Approved PPE will have SIRIM DOSH Certification Marks affixed to the product (e.g., head protection and respiratory protection devices) or on the individual packaging and have a unique serial number. Employers must ensure all PPE is used in workplace in order to comply with OSHA 1994 and its regulations. There are seven types of PPE that require the approval of theDirector General of DOSH, which includes respiratory, hearing, eyes, hands, feet, body, and head protection.

In order to understand how chemical hazards can affect humans, it is important to first understand how chemicals can get into the body and do damage. The four main routes of entry are inhalation (the most common route), ingestion, injection, and absorption through the skin and eyes (DOSH, 2018). Since inhalation is the main route of entry into the body for chemical substances, respiratory protection is of great importance when handling these substances. Protection of the respiratory system against the entry of harmful dust, fumes, mists, vapours, and gases is crucial, as respiration is a vital process of the body (DOSH, 2005). Figure 1.1 depicts an example of respiratory protection available in the market.

Figure 1.1: Example of respiratory protection available in the market

Respiratory protection can be categorised in terms of the pressure created in the respirator or the oxygen content in the environment where work is carried out. Air-purifying and air-supplying respirators can be either positive pressure or negative pressure devices. A positive pressure respirator maintains a positive pressure with respect to ambient pressure inside the facepiece during both inhalation and exhalation. The positive pressure is maintained by forcing air into the facepiece from a hose connected to a pressurised tank, compressor, or blower motor. Regulator valves are also used when the air supply comes from a high-pressure source. A positive pressure respirator is safer because the slightly over-pressured facepiece will prevent hazardousor toxic materials from entering the facepiece should there be minor leakages. A negative pressure respirator has a negative pressure inside the facepiece relative to the ambient pressure during inhalation and positive pressure during exhalation. Air for breathing is drawn into the facepiece by the inhalation pressure. The air may be ambient air drawn through filters, or it may come from an external

source (a tank or nearby clean air) through hoses. Air-purifying respirators can be generally be classified as:

i) Filtering Facepiece (FFP) , which protects the wearer from airborne particulates such as dust, fumes, aerosols;
ii) Gas and vapour or chemical-cartridge respirators, which remove gaseous contaminants by passing the contaminated air through material that traps the harmful gases or vapours;
iii) Powered air-purifying respirators which utilise a blower to draw in contaminated air through a filter element that removes the contaminants and supplies purified air to the wearer.

FFP are disposable respiratory protection against dusts, also known as often referred to as disposable dust masks. They are generally require no cleaning or maintenance. They are available in three classes: FFP1, FFP2, and FFP3, with the higher numbers corresponding to better filtering efficiency and Total Inward Leakage (TIL) performance (DOSM, 2010). A wide variety of models are available from many different manufacturers.

Basically, to understand the real performance of respirator filter media in the field, it is required to investigate the penetration of particles through respirator filters under cyclic flow conditions representing breathing flow patterns of human beings (Qiang, 2016). Hence, it is important for Malaysia to focus on safety and health-based standardisation and certification of products, as practiced in some developed countries such as Japan and Korea. Respirators, like other products in the market, are varied according to quality, price, and design. According to Viegas (2015), identifying all the tasks developed in each workplace and conducting a task-based exposure assessment help refine the exposure characterisation and reduce assessment errors. A task-based assessment could also provide a better evaluation of exposure variability than assessing personal exposures using continuous 8-hour time-weighted average measurements. In a study by Anas (2012), it was found that respirator selection and the design of tasks that require respirators are critical issues. The choice of suitable respirator type to be employed was based on the exposure level and severity of the exposure to hazardous substances (DOSH, 2005).

Different designs may provide a similar level of protection but are sold at different prices. Most employers choose to buy respirators based on price but not the

quality due to cost savings (Asyraf *et al*., 2017). Employers have borne a financial burden as a result of the widespreasd use and frequency of respirators. With all kinds of FFP now available on the market, the challenge is to ensure that consumers have access to quality products that offer the protection they need. Wearing a low quality or ill-fitting FFP does not provide adequate protection and puts the user at risk. Worse, it gives a false sense of security.

National Institute of Occupational Safety and Health (NIOSH) Malaysia through its Respiratory Protective Equipment (RPE) testing centre can lead the nation in issues related to FFP available on the market by testing the quality. The results will be shared with interested parties to help choose the best FFP used by employees.

1.3 Problem Statement

Workers commonly use FFP as PPE. As employers, it is their responsibility to provide employees with the PPE they need to do their job safely. This includes ensuring that the PPE is adequate for the task at hand and that employees are properly trained on how to use it. Employers should also regularly inspect all PPE and ensure that it is in good condition.

Respiratory disease, which is classified as penumonia, was one of the causes of death in Malaysia. The sources of the disease are multiple, including air pollution, smoking habits, and working enviroment (DOSM, 2018). As reported by (DOSH, 2019), Occupational Lung Disorders is one of the highest Occupational Poisoning and Disease reported. A research carried out by Ahmed (2019) shows that failure to purchase a good quality of FFP for workers was one of the causes of poor safety performance in the workplace. One of the functions of Safety and Health Officer (SHO) is to advise the employer or any person in charge of a place of work on the measures to be taken in the interests of the safety and health of the persons employed in the place of work. Therefore, SHO is responsible for purchasing PPE at the workplace. The first objective of this study is to provide a response to validate that one of the factors of SHO purchasing lowquality of FFP is contributing to the highest rates of disease at the workplace.

Various FFP2 products are offered in Malaysia's market today (Ng Yee Enn, 2020). This has led to various perceptions among the users, particularly regarding the

safety and health features, as well as the quality of the products offered by various companies. According to Baderin (2022), all of the FFP2 discovered on the DOSH list were only evaluated using the testing report given by the manufacturers prior to the introduction of the DOSH-SIRIM approval series, which was before 2019. At the time, DOSH had not established any requirements for manufacturing using the Malaysian standard for FFP2 testing. This prevents the majority of FFP2 from using the Malaysian standard as a testing reference, which increases the likelihood that the testing results are inaccurate. This occurred because Malaysia's FFP2 testing facility, which permits testing to be done using the Malaysian standard, was not completed until approximately 2019. As a result, all quality controls and testing for FFP2 were carried out abroad and in accordance with the conditions, environment, and standards of that particular country, which are vastly different from Malaysian standard. Therefore, it is possible that the FFP2 on the DOSH list do not meet Malaysian requirements. This situation makes it difficult for users to decide on an appropriate FFP2 based on quality and standard compliance.

In order to know the quality of the FFP2 discovered on the DOSH list in the Malaysian market, this study was carried out with full testing using Malaysian standards to approve the quality and reduce various perceptions among users with the recommendation of selected FFP2 based on quality criteria.

1.4 Research Objectives

The objectives of this study are as follows:

i. To identify the factors influencing the purchase of Filtering Facepiece 2 (FFP2) among Safety and Health Officer (SHO) through qualitative analysis;
ii. To evaluate the quality of selected FFP2 according to MS2323:2010 testing; and
iii. To make recommendations for selected FFP2 based on quality criteria established by MS2323:2010.

1.5 Research Scope

The scope of this study is as follows:

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