INHERENT SAFETY IMPLEMENTATION IN OFFICE BUILDING

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KUALA LUMPUR

2021

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DISSERTATION SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SAFETY, HEALTH AND ENVIRONMENT ENGINEERING

FACULTY OF ENGINEERING
UNIVERSITY MALAYA
KUALA LUMPUR

2021

UNIVERSITY OF MALAYA

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ABSTRACT

This study is conducted based on the inherent safety design practiced in oil and gas, and chemical industries. The inherently safer design is introduced in these industries to eliminate or minimize the chances of an accident can occur by considering every small amount of action that can take place in the plant. As such, today, most people are working in office buildings and the percentage of office employees involved in accidents at workplace and having health issues are considerably high. These happens due to the lack importance given when it comes to office setups. Mostly priority is given to the interior looks and space saving instead of functionality and employee health benefits. Even if these are considered, only the minimum is fulfilled. In this work, the common safety issues in office buildings are identified and the possible ways or methods to implement inherent safety design are proposed through inherent safety principles. Some of the identified hazards in office buildings are poor air quality sick building syndrome, electrostatic charges, danger of electromagnetic radiation, work stress etc. A guideline in developing safer offices by integrating the inherent safety measures are also discussed in this work. The advantages of using inherently safer design assessment tools such individual safety attributes test methodology is explained and the techniques are discussed on how it can improve office safety in overall. Proper office setup and configuration are introduced and justified on how it will help productivity of the employees. In addition the importance of natural elements in office environment and its benefits in terms of the employees' health and how it is related to productivity is explained. Lastly, the benefits of short break and its relationship with office employees are discussed.

Keywords: office buildings, employee health, productivity, inherent safety design.

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ABSTRAK

Kajian ini dilakukan berdasarkan reka bentuk keselamatan yang wujud dalam industri minyak dan gas, dan kimia. Reka bentuk yang semestinya lebih selamat diperkenalkan di industri ini untuk menghilangkan atau meminimumkan kemungkinan berlakunya kemalangan dengan mempertimbangkan setiap tindakan kecil yang dapat terjadi di kilang. Oleh yang demikian, hari ini, kebanyakan orang bekerja di bangunan pejabat dan peratusan pekerja pejabat yang terlibat dalam kemalangan di tempat kerja dan mempunyai masalah kesihatan sangat tinggi. Ini berlaku kerana kurangnya kepentingan yang diberikan ketika menyiapkan pejabat. Sebahagian besar keutamaan diberikan kepada penampilan dalaman dan penjimatan ruang dan bukannya fungsi dan faedah kesihatan pekerja. Walaupun ini dipertimbangkan, hanya minimum yang dipenuhi. Dalam kajian ini, masalah keselamatan umum di bangunan pejabat dikenal pasti dan kemungkinan cara atau kaedah untuk melaksanakan reka bentuk keselamatan dicadangkan melalui prinsip keselamatan yang wujud. Sebilangan bahaya yang dikenal pasti di bangunan pejabat adalah sindrom bangunan sakit berkualiti udara yang buruk, cas elektrostatik, bahaya radiasi elektromagnetik, tekanan kerja dll. Garis panduan dalam membangun pejabat yang lebih selamat dengan mengintegrasikan langkah-langkah keselamatan yang ada juga dibincangkan dalam kajian ini. Kelebihan menggunakan alat penilaian reka bentuk yang lebih selamat seperti metodologi ujian atribut keselamatan individu dijelaskan dan teknik dibincangkan mengenai bagaimana ia dapat meningkatkan keselamatan pejabat secara keseluruhan. Penyediaan dan konfigurasi pejabat yang betul diperkenalkan dan dibenarkan mengenai bagaimana ia akan membantu produktiviti pekerja. Di samping itu, pentingnya elemen semula jadi dalam persekitaran pejabat dan faedahnya dari segi kesihatan pekerja dan bagaimana ia

berkaitan dengan produktiviti dijelaskan. Terakhir, faedah rehat pendek dan hubungannya dengan pekerja pejabat dibincangkan.

Kata kunci: bangunan pejabat, kesihatan pekerja, produktiviti, reka bentuk keselamatan yang wujud.

ACKNOWLEDGEMENTS

First and foremost, I am extremely grateful to my mother for her love and care, my dad for his sacrifices and providing me with the strength to endure this journey and their combined prayers and blessings in preparing me with the courage for this journey.

I would like to express my deep and sincere gratitude to Professor Ir. Dr. Abdul Aziz bin Abdul Raman, the Deputy Vice Chancellor (Development), University of Malaya, Dr. Mohd Izzudin Izzat Bin Zainal Abidin, and Dr Archina Buthiyappan, Department of Chemical Engineering, Faculty of Engineering, University of Malaya, for providing invaluable guidance throughout the research period. Their vision and motivation have inspired me deeply and their guidance has helped me to understand the subject matter deeply. Making it possible for me to present the work as clearly as possible. It has been a great privilege and honor to study and work on this paper under such a dynamic team.

I would like to extend my praises and thanks to the God for His showers of blessings with good health, good strength and being able to complete the research successfully.

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LIST OF SYMBOLS AND ABBREVIATIONS

ISD	:	inherently safer design
ICI	:	Imperial Chemical Industries
SAWS	:	State Administration of Work Safety
EISI	:	Extended Inherent Safety Index
OFISI	:	Optimizable Fuzzy Inherent Safety Index
ISAPE	:	Inherently Safety Assessment for Process Equipment
GISAT	:	Graphical Inherent Safety Assessment Technique
i-SDT	:	Inherently Safer Design Tool
SBS	:	Sick Building Syndrome
ECA	:	European Concerted Action
WHO	:	World Health Organization
NIOSH	:	National Institute for Occupational Safety and Health
VOC	:	Volatile organic compound
IAQ	:	Indoor air quality
LOB	:	Large office building
BTEX	:	Benzene, Toluene, Ethylbenzene and Xylene
ESD	:	Electrostatic Discharge
OSHA	:	Occupational Safety and Health Administration
HVAC	:	Heating, ventilation, and air conditioning
CPI	:	Chemical process industries
DNA	:	Deoxyribonucleic acid
RF	:	Radiofrequency
EMF	:	Electromagnetic field
ISAT	:	Individual Safety Attributes Tests

cm	:	Centimeter
LED	:	Light-emitting diode
PPE	:	Personal protective equipment
%	:	percent sign

CHAPTER 1: INTRODUCTION

1.1 Background

Office buildings are places where most businesses are conducted. All the finances and documentations are completed under time pressure and efficiency is the key for a complete work. The workload can at times make the workers to not be aware of the surroundings and accidents can occur. As an example, a person using a conventional paper-cutter can be distracted by another coworker, causing this person to lose concentration for second on the job at hand. That second of distraction can cause serious injuries to the person. Next example is overloading the power outlet due to limited availability of power outlet at workstation. Ideally, three outlets need to be provided to accommodate a desktop unit, a monitor and a spare unit. But sometimes only two is provided, hence one of the power outlets might be overloaded. This can cause power surge and increase the risk of electrocution to the worker or be a reason for a fire to break out. These dangerous situations can be avoided by simply identifying the hazards and eliminating it.

This can be accomplished by applying inherent safety design (ISD), a concept for focusing safety concerns on facility operation and design (Andy et al., 2021). The term "inherent" refers to something that exists as an essential element or quality. As a result, something is said to be inherent if it occurs "as an essential element or trait." Whenever something is naturally not dangerous, it is incorporated into the procedure or product rather than being applied to it as a safety measure (Andy et al., 2021). Hazards are removed rather than managed, and the methods for eliminating hazards are so essential to the design process that they cannot be altered or eliminated without altering the process.

ISD deals with the immediate consequences of singular occurrences on people, the environment, property, and business (Gao et al., 2020). Risks to the environment, chronic health, or consumers or product users can all be addressed with an ISD. This will also lead to simpler and less pricey plants. When comprehensive safety methods are necessary to handle severe risks, as they bring complexity as well as expenses, both in terms of the original financing for the protective apparatus and the continuous running costs for operation and maintenance (Gao et al., 2020).

The term "inherently safer design" first appeared in the manufacturing industry in the 1970s. After a 1974 eruption of hydrocarbon vapor cloud at Flixborough, England, Trevor Kletz, an ICI senior safety adviser, challenged the need for such huge volumes of combustible or hazardous ingredients in a manufacturing facility, as well as the requirement for processing at increased temperature and pressure. It was advised that industries redirect its risk analysis efforts toward hazard elimination whenever possible. Instead of spending significant resources on safety systems and processes to handle the associated risks, business may strive to discover process changes that minimize or eliminate vulnerabilities. This might be achieved, for instance, by lowering the amount of dangerous material used, utilizing less harmful material, or inventing equipment that functions in less harsh settings.

For academics, regulators, and industrialists specializing in process safety, the scientific concept of inherent safety has evolved from common sense to common knowledge (Hara et al., 2020). To date, after almost forty years since the principle of inherently safer design was articulated, inherently safer strategy for risk management and loss prevention has been recognized globally. Various government has corroborated inherent safety design rules and regulations in their countries (Hara et al., 2020).

The European Council Directive has stipulated that "Hazard should be possibly avoided or reduced at source through the application of inherently safe practices." After the eruption at West Fertilizer Company on April 17, 2013, incident the president of the United States promulgated Executive Order 13,650, it was proposed that chemical plants should use technology that are intrinsically safer. This is one example of the many rules and regulations to implement inherent safety formulated by the United States government. Besides that, in China, the State Administration of Work Safety (SAWS) has issued the Executive Order 103, seeking to enhance plant architecture, planning, monitoring and production management by utilizing intrinsic security principles (Hara et al., 2020).

Several inherent safety evaluation systems, which are used to rank and pick the intrinsically safer choices, have been presented and refined (Syaza et al., 2020). These tools are classified into two types: overall approaches and particular approaches, and they are further classified into six types: indexing techniques, graphical methods, consequence and risk-based methods, numerical methods, optimization methods, computer-aided methods, and experimental methods (Syaza et al., 2020). It is important to highlight that intrinsic safety metrics are continually being developed, and several new evaluation techniques have just been published. Examples include Extended Inherent Safety Index (EISI), Optimizable Fuzzy Inherent Safety Index (OFISI), and Inherently Safety Assessment for Process Equipment (ISAPE), Graphical Inherent Safety Assessment Technique (GISAT), and Inherently Safer Design Tool (i-SDT).

Noteworthy is the fact that intrinsic safety has been broadened and expanded to include a broader range of sectors. Examples may include green/sustainable chemistry, occupational health, inherent environmental hazard reduction, human error reduction, mechanical material selection, dust explosion prevention and mitigation, and chemical process approaches are inherently benign. It should be emphasized that intrinsic safety

is not a stand-alone strategy and should always be used in conjunction with other available add-on safeguards for loss prevention and risk management (e.g., spatial, passive, active, and procedural safety). Furthermore, an inherent safety measure capable of systematically integrating inherent safety with a variety of hazardous variables has yet to be established (Syaza et al., 2020).

1.2 Problem Statement

When it comes to the workplace environment there are several variables to consider. Healthy and comfortable working conditions should be provided at the office, and to achieve that, the correct combination of these element must be maintained. Safety hazards commonly faced in office buildings are slipping and falling, collisions and obstacles, poor lighting, noise pollution, fire hazards, and so on. Inherent safety design can be overlooked most of the times in office buildings as people tend to believe that the office environment does not pose any threat or have any hazard causing tendencies. But contrary to popular believe, office injuries are more common to happen due to reasons that can be prevented by implementing inherently safer design. The recommended technique in the hierarchy of controls is to design the danger out of the process. Although this technique makes logical, designers do not always use it to its full potential. The only way to avoid accidents is to apply the principles of inherent safety across the process's entire life cycle. To make a facility fundamentally safe, risks must be removed so that accidents do not occur.

Office buildings are still having many accidents happening therefore inherent safety design should be implemented to reduce the accidents.

1.3 Research Questions

To be able to implement the right and proper techniques of inherent safety design in office buildings, certain common issues and possibilities should be investigated. Hence such as:

i. What are the common safety issues in office buildings?
ii. What are the possible ways to implement inherent safety design to a selected office building?

1.4 Aim of the Study

Developing safer offices through inherent safety principles.

1.5 Objectives of the Study

The objective of this research is:

i. To determine common safety issues in office buildings.
ii. To determine methods to implement inherent safety design in a selected office building.
iii. To propose a guideline in developing safer offices by integrating inherent safety measures.

1.6 Scope of Study

The scope of this study is on office buildings and on how inherent safety design can improve the safety features of the building and environment. For example, the office floor needs to have carpet to prevent slip and fall incidents. Next, every cubicle should have three three-pin power outlets to prevent electric shock. The chairs used should be based on general height of employees with height adjustability. Through this study it is expected to find a suitable office setup that will benefit the employer, employees, and the environment. This study will be discussing on the general hazard found in office buildings and be limited to the interior safety of the office buildings.

1.7 Significant of Study

The primary theoretical underpinning of this research is that inherent safety design is important, and it should be encouraged to be implement regardless of the industry. Different industry has different ways to implement inherent safety design and most of the times, the chemical industry tends to give more importance to inherent safety design, followed by aviation industry and semiconductor industry. The existing work to date on office buildings inherent safety are very limited. More detailed research work will help build a better and inherently safer office place.

1.8 Dissertation Outline

This study consist of five (5) chapters as follows:

i. Chapter 1 – Introduction

This chapter provides background information on inherent safety design and the inherent safety concept. Also discussed in this chapter are the issue statement, the study's purpose and objectives, and the study's scope and limitations.

ii. Chapter 2 – Literature Review

This chapter discusses about the findings and implementations of inherent safety design in different industries. Besides that, this chapter also explains about how inherent safety design helps the said industry. Discussions on detailed improvements and methods have also been highlighted here.

iii. Chapter 3 – Research Methodology

This chapter explains the various methods and techniques used in data collection and information gathering, relevant to this study. Among such methods used includes questionnaires, interviews, and site visits. All the gathered information is analyzed for possible inherent safety design implementation.

iv. Chapter 4 – Results and Discussion

This chapter discussed the outcome from the data collected and information gathered. All the findings are analyzed and discussed in this chapter to find barriers and challenges on the implementation of inherent safety design.

v. Chapter 5 – Conclusion and Recommendation

This chapter summarizes the overall results and findings for the implementation of inherent safety design while assessing if the objective of the study was met. Suggestions and recommendation for future studies being highlighted in another segment of this chapter.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter analyses previous work and study on inherent safety design and the implementations in various industries. There are potential risks which can be or might be overlooked as “not dangerous” or “not important”, and these causes’ unexpected incidents later on. A summary on the types of hazards and ways inherent safety design were implemented are discussed here. Inherent safety design differs according to the industry it is implemented, but the general methods and process to identify and implement can be used across the industries. Therefore, previous studies on inherent safety design and implementation of inherently safer design could provide with important references. Nowadays, industries consider implementing inherent safety design as a priority as it helps to make the workplace safer and it also safe cost. The implementation of inherent safety design to office buildings will provide a more comfortable and safe work environment. Besides that, by implementing inherently safer design, it is believed that it can also help to sustain the environment while providing and worry-free workplace.

2.2 Case Study on Office accidents

Multiple cases are reported around the world regarding accidents in office buildings. The most reported cases are related to slip and fall, and trip and fall. A case in California was reported when an office employee accidentally tripped on the torn carpet floor in her office, causing her to suffer fractured shoulder (Sarkhosh et al., 2021).

This example shows that small defect in the office environment caused a severe injury to the occupant. This mishap could have been avoided if:

1. The person responsible for the carpet to be damaged put a caution sign on the floor.
2. The maintenance department were to fix the damaged part sooner.
3. The person was to move around the office more carefully.

But this incident could have been totally avoided if inherently safer design was implemented. In implementing ISD, the type of material the carpet is made of will be considered and the position of carpet on work floor would have been predetermined to avoid danger.

There are many similar minute hazards in an office that can cause danger to the occupants. Therefore, every aspect in an office should be considered as hazardous to make sure the whole environment is danger free.

2.3 Safety issues in office buildings

For the most part, people think of industrial safety in terms of massive machinery in factories or the inherent hazards of construction sites or the destructive potential of power tools.

However, office environments do not provide the same level of protection. Many office workers are injured or have health problems connected to their jobs, causing them to miss work. While the risk of harm is not as obvious as on a factory floor or a big construction site, it may be just as costly to employers. And the safety-related techniques that have shown to be effective in industrial settings are also applicable when it comes to reducing lost-time concerns in the office.

Employees are twice as likely to experience a devastating fall in the workplace as they are in any other situation. Most office injuries are caused by slips and trips, and

they are nearly all preventable. Wiring that runs in or near traffic areas is another important cause of trips and falls. Any non-permanent wire should be covered so that employees' feet do not become entangled.

Workers utilizing inappropriate methods to access items in high areas is one of the leading causes of this sort of harm. They frequently climb on workplace chairs that have rolled out from under them. Stepladders should be used by employees who need to reach goods on high shelves or in tall cabinets. Ladders are not safe alternatives for desks, tables, or other forms of furniture.

Slips and falls are exacerbated by flooring choices. Tripping hazards are created by carpet or mat edges that are turned up. When damp or dirty, surfaces like tile and terrazzo may become slippery. Mats at external doors, in addition to regular cleaning, will protect employees and visitors from tracking in rain and snow, which can contribute to slippery situations.

Hence, the following subtopics has more details on each of the hazard found in office buildings. By identifying the hazards, a safer alternative can be implemented to reduce the risk of accidents and provide a risk-free working environment for the office occupants.

2.3.1 Poor Air Quality and its effect

Apparent air quality, Sick Building Syndrome (SBS) symptoms, and productivity were investigated in an existing workplace where the degree of air pollution could be altered by adding or removing a source of pollution. As stipulated in the new European design requirements for the indoor environment, this reversible intervention permitted the space to be categorized as either non-low-polluting or low-polluting. Pollutants produced by building materials and furnishings can lead to complaints of poor indoor

air quality (Sarkhosh et al., 2021). It can have a detrimental impact on building inhabitants' health by raising the occurrence of mucous membrane, cutaneous, or general symptoms.

Some researchers have already shown that reducing the pollution load on ambient air can reduce the number of people who are dissatisfied with the perceived air quality and the pervasiveness of SBS symptoms: for example, the pollutant load on the air was decreased in a naturally ventilated office building in Denmark by installing a polyamide boucle floor carpet. From the studies done previously, it has been observed that air quality plays a role in causing sick building syndrome among office workers, and volatile organic compounds contributes to unhealthy air quality at workplace.

The air pollution generated indoors is caused by the building's buildup of pollutants, while some come from the outside. These contaminants may be created across a broad region by a restricted source or several sources and may be regularly or constantly produced. Tobacco smoke, organic creatures, construction materials and decorations, cleaning chemicals, copying machinery and pesticides are the common contributors of indoor air pollution (Sarkhosh et al., 2021).

Dangerous contaminants from several sources can lead to building-related diseases which have obvious causes, such as Legionnaire's. Sick building syndrome (SBS) can help HVAC systems which are not properly run or kept; SBS has physical symptoms, with no obvious reasons. Some of these are severe mucous membranes and irritation of the eye, nose and throat. These diseases result in more sick days and lower productivity in the workplace.

The most successful method for the maintenance of clean indoor air is the control of pollutants at the source. However, it is not always practicable or practical to monitor or

mitigate all sources. The second most successful method for supplying appropriate interior air is ventilation, whether natural or mechanical.

In general, an increase in the pace at which the building receives external air lowers indoor air issues. But other ventilation mechanisms are just as vital. Indoor air issues might arise because of unequal air distribution and/or inadequate exhaust ventilation in buildings which have high ventilation rates. Indoor air quality can be adversely affected even in well-ventilated buildings. However, the closer a source to an exhaust, the more efficient the ventilation will be; the more effective is local exhaust ventilation, in example, a chemical fume hood. In locations where copying machinery or solvents are utilized, it is excellent practice to establish separate exhaust systems. Localized exhaust for these sources can lead to a decrease in the overall exhaust ventilation required by the building.

2.3.2 Sick Building Syndrome

If persons in a building experience acute health and comfort issues that appear to be connected to their time spent there, but no specific illness or cause can be determined, they are said to have Sick Building Syndrome (SBS). Sick Building Syndrome (SBS) is a term used in European Concerted Action (ECA) to describe a collection of symptoms most experienced by people who work in air-conditioned buildings.

Some of the symptoms of Sick Building Syndrome (SBS) include general symptoms (headache and tiredness), mucosal symptoms (coughing and eye irritation), and skin manifestations such as rashes on the face, hands, or scalp. WHO and NIOSH say these symptoms are linked to indoor environmental problems such as unfavorable room temperature, air humidity, dampness in the building, ventilation flow, building materials, noise, and lighting (VOCs).

According to a study done, it is understood that majority of the workers, did not have the symptoms at the end of working hours or after leaving their work place (Sarkhosh et al., 2021). Though other symptoms in humans can be observed immediately and are not dependent on time, the diagnosing and variability key to Sick Building Syndrome (SBS) is the exacerbation of symptoms in different people over a relatively short period of time, which is relieved by leaving the room or workplace. (Sarkhosh et al., 2021).

Psychological variables have been one of the other major elements in raising the incidence of Sick Building Syndrome (SBS); other research have indicated that this parameter has a substantial influence on the prevalence of SBS. The significance of this component stems from the fact that chronic and sustained unhappiness with working circumstances and surroundings can aggravate symptoms even when other aggravating variables such as inadequate ventilation are addressed. As a result, if it is feasible to alleviate discontent due to unsuitable environmental circumstances, improving workplace conditions might be a beneficial approach to lower the prevalence of Sick Building Syndrome (SBS) (Sarkhosh et al., 2021).

Furthermore, building materials, office equipment, and most of the office equipment may release Volatile Organic Compounds (VOCs). These pollutants can linger for a long period, emphasizing the significance of this potentially hazardous situation. As a result, there was a significant connection between the concentration of these chemicals and an increased occurrence of Sick Building Syndrome in other investigations (SBS) (Sarkhosh et al., 2021).

Although the quantities of Volatile Organic Compounds (VOCs) are not over the exposure limit standards, they are substantial in terms of continuous exposure time. One cause of this incident might be when the windows are closed, and the cooling systems are turned on. It has been shown that while the air conditioner is on and the windows are

closed, there is an increase in Volatile Organic Compound (VOC) concentration in the interior air, but that concentration rapidly decreases when the windows are open. Hence the probability of the employees to have SBS will be reduce tremendously.

2.3.3 Volatile Organic Compounds (VOC) in Office

Air that is clean and free of pollutants is essential for human health and well-being. However, as human and industrial activity expand, air pollution continues to rise, posing a danger to global health. Volatile organic compounds (VOCs) are the most common type of air pollution in both the outdoor and interior environments. VOCs play an important role in atmospheric chemistry, contributing significantly to the formation of hazardous oxidants that affect ecosystems, human health, and the environment.

Indoor air quality (IAQ) in large office buildings (LOBs) is an essential element that has a significant influence on employees' health, comfort, and productivity. LOBs often house a wide range of operations that emit a variety of air pollutants, such as hazardous gases, VOCs, airborne dust, and fungal spores. Exposure to such pollutant combinations may have significant health consequences depending on the exposure dosage and human sensitivity. Low-level and/or short-term exposures, on the other hand, may produce a general sense of unhealthiness and ill-ness, giving rise to the phrase "sick-building syndrome" (SBS).

Some of the commonly found VOCs in office environment were identified and measured. As shown in Table 2.1, it was found that, of the 28 VOCs measured, 10 types of the compounds were found in the samples. The highest concentrations were Benzene, Toluene, Ethylbenzene and Xylene (BTEX), including toluene, m,p-xylene, ethylbenzene, and o-xylene. Toluene exposure was associated with feeling exhausted, head feeling heavy, weakness, and blurred vision; ethyl benzene exposure was

associated with sore throat, chest pressure or pain, head feeling heavy, weakness, and feeling exhausted; m,p-xylene exposure was associated with periodic headaches, feeling exhausted, and eye irritation; and m,pxylene exposure was associated with periodic headache, feeling exhausted, and eye irritation.

Table 2.1: VOC's concentration in office building (Sarkhosh et al., 2021)

Name*	B 2	B 1	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19
Benzene	11.39	N.d	N.d	N.d	N.d	N.d	N.d	N.d	N.d	N.d	13.89	N.d	N.d	N.d	16.67	N.d	N.d	N.d	10.83	36.11	16.67
Toluene	121.94	50.83	100.28	N.d	207.50	233.06	181.94	27.78	93.33	63.05	172.78	31.94	121.38	264.17	251.39	103.33	283.89	211.11	72.50	207.78	376.39
Ethylbenzene	51.94	37.78	29.17	N.d	61.94	60.83	53.89	5.83	55.00	11.94	65.28	7.22	28.06	69.17	74.29	N.d	49.44	55.56	71.39	69.17	87.78
m,p-Xylene	77.78	50.56	36.94	N.d	85.28	76.67	66.39	8.33	71.11	18.05	83.89	17.50	33.89	88.61	92.78	N.d	75.56	70.83	87.78	74.72	127.50
o-Xylene	23.33	12.22	11.11	N.d	23.89	21.11	20.28	3.89	18.61	7.22	20.28	5.28	8.89	22.22	26.94	N.d	50.83	17.78	24.72	22.78	39.72
Propyl Benzene	11.94	4.44	3.33	N.d	2.78	9.72	2.22	5.00	1.94	6.94	3.33	9.17	2.50	10.83	9.17	N.d	10.56	6.11	12.22	6.39	21.11
1-ethyl-4-methyl-benzene	10.00	5.00	5.00	N.d	14.17	3.33	9.72	4.72	7.78	7.22	10.00	8.33	3.61	10.83	14.44	N.d	11.11	10.28	11.94	9.17	21.39
1-ethyl-3-methyl-benzene	6.39	5.28	3.33	N.d	11.94	12.50	4.17	N.d	7.78	N.d	8.06	N.d	N.d	8.89	15.28	N.d	5.28	9.72	4.44	5.83	5.83
1,2,3-tri methylbenzene	5.00	4.72	3.33	N.d	7.50	9.44	10.00	N.d	6.11	N.d	8.61	N.d	N.d	9.72	8.61	N.d	6.68	7.50	9.17	9.44	10.28
1-methyl-4-(1-methylethyl) benzene	6.39	3.61	3.05	N.d	7.22	7.78	2.50	N.d	5.28	N.d	7.50	N.d	N.d	21.39	6.67	N.d	7.50	6.39	7.78	7.50	8.33

= unit ($\mu g/m^3$) B1= Out of building No. 1 B2= Out of building No. 2 S1-19 = Sampling stations N.D = Not Detected.

The materials used in office buildings; therefore, need be checked and if the materials are made or contains of VOCs, proper steps should be taken to make sure it does not spread through the office. Employee's health should be monitored and if any illness if observed, safety measures should be taken.

2.3.4 Improper use of office equipments

Wheeled chairs are often intended for modest movements in confined spaces. Racing over large spaces increases the likelihood of accidents or stumbling over barriers. Also when someone lean back in a wheeled chair, it may tip over.

Chairs and desks, like any other piece of equipment, wear out, but employers are typically hesitant to replace them when they do. Broken or missing casters and other pieces, on the other hand, can make a chair or desk dangerously unstable. To avoid accidents caused by defective equipment, it should be inspected on a regular basis, and any flaws should be rectified or replaced as soon as possible.

When used improperly or incorrectly, time-saving office gadgets can cause injury. Paper cutter blades are very sharp and can inflict catastrophic damage on an unwary user. Unthoughtfully placed scissors or sharpened pencils might pierce a worker who reaches inside a drawer. To decrease the risk of infection, cuts and punctures must be treated correctly.

Therefore the employees should be briefed on the equipment usage and in case of any mishaps, it should be reported. The use of first aid kit should be brief to them as well and the kit should be checked from time to time. The office equipment should undergo maintenance also to avoid any injuries from them.

2.3.5 Electrostatic Risk

The human body could retain substantial positive charges, whereas synthetic materials, such as plastics, prefer to accumulate negative charges. ESD, which may be thought of as a miniature type of lightning, is a major cause of damage to electronic devices.

Static charges can be generated by friction between two objects of different charges or by the induction charge of an ungrounded metal present in an electric field. The ESD produced by these charges can be innocuous, irritating, or deadly, depending on the intensity of the charge and the environment in which it resides.

Electrostatic discharge relates to several dangers. If it happens in a workplace with flammable gases, the ensuing spark might cause the gas to ignite, resulting in a fire or explosion. Hazard prevention measures that rely on electronic equipment may also be susceptible to ESD damage, thereby increasing the likelihood of a safety incident.

Finally, ungrounded metal in an electrical field can accumulate a considerable static charge. If an unprotected worker encounters this metal, he or she might receive a possibly deadly shock. The use of high-resistance safety mats, also known as non-conductive, switchboard, or dielectric matting, can help to mitigate the danger of this latter hazard. Safety mats are constructed of material that prevents charged items from discharging by blocking the flow of ESD over their surface.

Static electricity, which is both invisible and discreet, frequently emerges in a soothing but always pernicious manner. It can create mishaps such as fires and explosions, which can have devastating effects like as fatalities, major injuries and burns, and significant property loss.

Hence non-static appliances should be used. The available electrical appliances should be well grounded, and the danger of static electricity should be explained to the employees. The danger of static electricity can also be felt through metal doorknobs. This type of awareness should be there in the office buildings.

2.3.6 Noise pollution

Surprisingly, offices may be loud places. Although the noise levels are generally not severe enough for people to lose their hearing, they can be a major factor to stress and morality. Offices for the separation of employees from loud appliances such as printers and ventilation might be helpful. In addition, the volume can decrease by increasing the distance between workstations or utilizing noise-absorbing materials such as cubicle walls, tapestries and acoustic tiling (Amaliyasari & Periostiawati, 2021).

The use of printers and photocopy machines also contributes to noise. The constant noise from printing and photocopy machines can cause disturbance to employees in the office. Placing these machines should be away from the working area. Instead of giving priority to convenience, it should be accessible to the employees but away from the common workspace (Amaliyasari & Periostiawati, 2021). Continuous noise from activities from these machines can cause stress and discomfort in long term .

2.3.7 Poor lighting

Office illumination may not appear a threat, but it may contribute significantly to a range of dangers and diseases. One apparent problem is insufficient illumination to hide dangers. Poor illumination is an example in corridors and storage rooms (Gaston et al., 2014).

But one of the less well-known difficulties in workplace lighting is the regions in which duties are carried out. Poor illumination in offices may short-term lead to issues

of vision, such as eyesight and associated headaches, and visual impairment if the condition is untreated (Gaston et al., 2014). It can also contribute to increased stress on workers, lowering productivity and enhancing disease vulnerability. Poorly planned workplace lighting generates shadows and brightness too. Some vision specialists propose that the light overhead lights and task lighting at each workstation be less dependent.

A major cause of vision-related issues is computer displays. Slightly under the level of the eye and approximately two meters from the faces of employees, monitoring can decrease eye strength as well as eliminate sources of glare and use larger fonts on the screen (Amaliyasari & Periostiawati, 2021). Many optometrists now advise special lenses for regular usage of computers. But one of the most basic weapons is also one: to take 10 minutes away from the screen for each hour you spend on it, according to OSHA guidelines.

Therefore the lighting should be adequate in the office area. The working space should be fixed with suitable lighting to not hurt the eyes of the employees. Eyesight damage can sometimes be incurable.

2.3.8 Radiation: Electromagnetic fields

Differences in voltage generate electrical fields: the greater the voltage, the stronger it will be. When electric current flows, magnetic fields are created: the more the current flows, the higher the magnetic field (Ozdemir & Kargi, 2011). Even if there is no current flow, there will be an electric field. If current flows, the intensity of the magnet field varies with electricity consumption, while the strength of the electric field is constant.

There are no new phenomena of exposure to electromagnet fields. However, ambient exposure to electromagnetic fields generated by humans gradually increased in the 20th century, with expanding power requirements, constantly evolving technology and changes in social behavior. Everyone is exposed to a complicated combination of weak electrical and magnetic fields, from power generation and transmission to home and work to telecommunications, residential appliances and industrial equipment (Ozdemir & Kargi, 2011).

The major biological impact of radiofrequency field electromagnetic fields is heating. This fact is used to warm up food in microwave ovens. The radiofrequency field levels to which humans are usually exposed are far lower than those required for substantial heating. For current recommendations the heating impact of radios provides the basis. Researchers also explore the possibility of consequences of long-term exposure under the threshold for body heating.

A wide range of symptoms has been ascribed to modest levels of electromagnetic field exposure at home by certain members of the public (Ozdemir & Kargi, 2011). Symptoms reported include headaches, anxiety, suicide, sadness, nausea, tiredness and libido loss.

Some people claim "hypersensitivity" to magnet or electric fields. They question if the association of epileptic exposed fields might include anchored pains, headaches, depression, lethargy, sleeping problems and even convulsions and epileptic seizures.

The notion of electromagnetic hypersensitivity is supported by scant scientific data. Recent investigations in Scandinavia have shown that persons do not have consistent responses to electromagnetic field exposure under controlled settings. There is no biological explanation acknowledged to justify hypersensitivity. This research is

complex because, apart from the direct impacts of the fields themselves, numerous additional subjective responses might be involved. There is further research on this topic.

Despite several research, there is extremely disputed evidence of any impact. It is obvious, however, that if the electromagnetic fields have a cancer effect, there will be a very tiny increase in risk. There are several discrepancies in the data to yet, but no major increases in risk of cancer in children or adults were identified. Hence this opens to a whole new, more advanced safety concerns at office buildings.

2.4 Inherent Safety Design and Its Concept

Where possible, the safety strategy is inherent in removing or substantially reducing the risk by converting the process into non-hazardous or far less dangerous materials and circumstances. The modifications must not be readily rejected or modified but must be intrinsic to the process or product without affecting the design or plant fundamentally. One example is the replacement of water as a carrier for a color or coating with a flammable or perhaps hazardous solvent (e.g., using water-based latex paints instead of oil-based paints). The removal of the flammable or poisonous solvent is an intrinsic feature of the product and the process of its production. During the manufacturing process and throughout the production supply chain, the risk of fire or exposure to hazardous solvent vapors is removed for the product consumer.

Safer plants inherently employ fundamental design measures to remove, prevent and reduce hazards. The basic definition of a safe plant or activity is one that does not harm people or the environment under any circumstances. This may be because:

a. It utilizes solely inoffensive content.

b. There are such tiny hazardous material stocks that they are not adequate to cause substantial damage even when discharged.
c. Dangerous materials are maintained in or under conditions that effectively render them harmless.

This same principle is applied to hazardous equipment to make it more inherently safer. But, in practice it is almost impossible build a plant that is entirely risk-free, as in most cases the very reactive nature of materials makes them useful in energy and manufacturing industries. Hence, it is better to think in terms of inherently safer processes which is by comparison involve less inherent hazard. It is significant since it helps to reduce the complicated design and operation of the entire plant. This results in a friendlier plant with less equipment that can go wrong and less chances for human error. Sometimes this is also regarded as part and parcel of a broader notion of safer design.

To create an essentially safer design, designers must balance risk prevention, control and mitigation and make use of the core design characteristics instead of relying on active and passive add-on systems. This connection may be given as a framework for the entire management of hazards in design.

Table 2.2: A Framework for Hazard Management in Design

Principle	Mitigation	Control	Prevention	Avoidance
Inherent Design Measures	Design to limit or decrease the scale of the danger if it occurs and design to limit or lessen the consequences of the hazard if it occurs.	Containment of hazards within the design envelope. Limit heat transfer capability or temperature of heating media to slow down thermal runaway.	Design characteristics that make it less probable for a danger to develop or to become a problem.	Avoid using hazardous materials, conditions, equipment or activities and design the fundamental process such that hazards do not occur as part of the design process.
Add-on Passive Measures	Non-initiated measures to minimize the scale or consequences of a danger once it has been identified.	Without the need for initiating, preventative measures are those that reduce or eliminate the risk of an accident before it occurs.	Measures that avoid or minimize the chance of a danger occurring, but do not involve initiating any action on your part.	Not Applicable
Add-on Active Measures	Measures that must be initiated to reduce the scale or consequences of a danger after it has been identified.	Initiation of measures to reduce the severity of a hazard or halt the chain of events before it becomes an accident	Measures that prevent or minimize the chance of a danger occurring and that must be implemented.	Not Applicable
Procedural Measures	Manual steps to minimize the scale or consequences of a danger after it is discovered.	Risk management is the process of taking steps to reduce or eliminate hazards before they cause an accident.	Measures are taken to avoid or lessen the chance of the danger occurring.	Not Applicable

As in Table 2.2, this framework shows the inherent design measures for each principle with the add-on of passive and active measures. It also shows the procedural measures accordingly. The framework is based for improving the inherent safety design in offshore technology.

Previous studies show that before the implementation of inherent safety design, the possible hazards need to be identified. From there, the possible ways to prevent the hazard to magnify is identified.

2.5 Incorporating inherent safety design

The route of sustainable production has been aimed at balancing the three pillars of environmental, social and economic sustainability. In order to incorporate safety in combination with these three pillars, a deeper knowledge of sustainability in chemical process industries (CPIs) is needed, as indicated in Figure 2.1. In particular, the CPIs address dangerous materials and processes that might greatly influence the well-being of the surrounding populations and natural resources. Inherently Safer Design (ISD) for sustainable chemical operations is one of the most efficient techniques for risk reduction. At the design stage, the goal is to identify and eliminate hazards.

Figure 2.1: Safety as a key pillar towards sustainability.

The ISD is a proactive method to reduce the possibility or the effect of accidents, and aims to create cost-optimal security solutions, rather than just adding safety equipment or gadgets. Many facilities are at higher risk of disastrous incidents without a proper ISD strategy. The lessons acquired from past disasters indicate probable consequences for our society, the environment and the economy.

2.6 Importance of Natural Light for Occupants of Office Buildings

Each form of light has a particular spectrum that affects the human mind and body. As a result, the benefits of daylighting are difficult to quantify. Improvements in mood and morale have been linked to daylighting as well as a reduction in tiredness and eyestrain. In addition to satisfying a need for interaction with the outside living environment, daylighting also has major psychological benefits, such as reducing anxiety and depression (Gaston et al., 2014).

In the same way that the body utilizes water or food as a nutrition, it uses light. Colors of natural light promote key biological activities in the brain. Lack of color perception on gloomy days or under bad lighting circumstances might impact our mood and energy level.

The general well-being of those who work in daylit, and full-spectrum office buildings has improved. Better health, reduced absenteeism, greater productivity and financial savings are just a few of the specific benefits of working in these sorts of offices. As a result, several European countries restrict office workers to be within 27 feet of a window (Gaston et al., 2014).

Using full spectrum bright lights in buildings where daylighting is not or cannot be incorporated has been demonstrated to have a good impact on workers. Day and night workers can change their internal clocks or circadian cycles to fit their work cycles

using full-spectrum bright lighting. As a result of greater illumination, night shift employees have seen an increase in morale and productivity, as well as a decrease in accidents.

A workspace's light spectrum and the eye's capacity to refocus are both factors that influence eyestrain. If daylighting in an office building is properly integrated and managed, your eyes will receive the finest spectrum of light. It's possible to develop nearsightedness or farsightedness when the eye's muscles aren't permitted to refocus to different distances over a prolonged length of time. Landscape views via windows reduce eye fatigue because the combination of short- and long-range images helps the eye to refocus and reorient itself.

The presence of natural plants in the office or through windows can help reduce stress and enhance attentional focus. Compared to a windowless room without plants, individuals in one research had lower blood pressure readings and were more attentive.

Figure 2.2: Example of Office with adequate lighting.

2.7 Electromagnetic Radiation in Office Environment

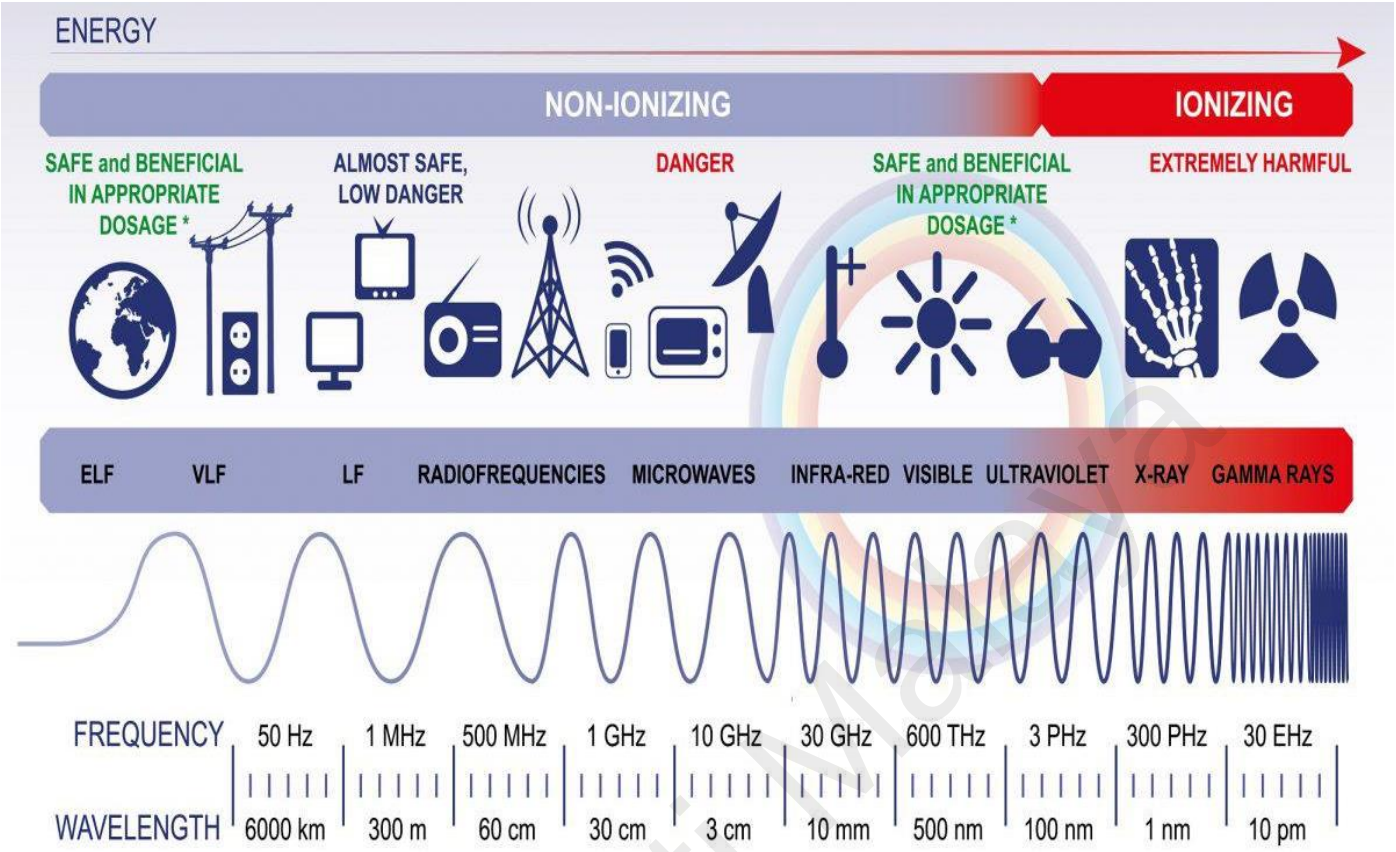


Figure 2.3: Electromagnetic spectrum around us.

Figure 2.3 shows the various types of electromagnetic radiation that humans are exposed to and the safety of each level of exposure. Even though technological advancements make living simpler, they can sometimes have detrimental impacts on the quality of life. Magnetic waves may travel vast distances and play an essential part in daily life. RF electromagnetic fields are utilized in communications, radio and television broadcasting, cellular networks and indoor wireless systems, among other applications. People are exposed to electromagnetic waves at levels far greater than those found in nature because of technology advancements.

Due of radiofrequency waves' potential to harm humans, the rapidly rising number of mobile phone users is of particular concern. There are concerns regarding the influence of mobile phone networks on health since mobile phones are used near the human body

and need a high number of base station antennas. Figure 2.4 shows the heat dissipation from office computers and laptops. This explains that radiation is still present in the form of heat at work desk. This radiation can affect the employees body temperature and cause them to fall ill.

Figure 2.4: Heat from common office devices.

Generally, there is no direct evidence that low-frequency radiofrequency radiation have harmful impacts on human health. At the cell level, which utilizes comparatively higher frequencies, studies have shown unfavorable impacts on cells (Toledano et al., 2018). Different diameters of electromagnetic waves have not caused DNA damage in different cell lines, according to some research. Radiofrequency waves, for example, have no direct mutagenesis impact on cells, according to a recent analysis (Gaston et al., 2014).

Other studies have come out in recent years that suggest the opposite. There is a growing worry among scientists that electromagnetic waves may have biochemical or cellular consequences. A study by Marino and Becker found that electromagnetic fields

that are static or extremely low frequency can cause biological effects linked with ion redistribution. In addition, numerous investigations have shown that low-frequency magnetic fields have biological effects that can permeate deeper tissues (Toledano et al., 2018).

Aside from making life more convenient, technological gadgets and advances in communications may also have negative impacts. Electromagnetic fields in the Radiofrequency (RF) zone, utilized in communications, radio and television broadcasts, cellular networks, and indoor wireless systems, are particularly susceptible to these detrimental consequences

The widespread consensus is that there is no direct proof of low-frequency radiofrequency radiation causing harm to human health. Studies at the cellular level, which employs comparatively higher frequencies, reveal unfavorable results.

The rapidly rising number of mobile phone users raises serious worries about the possible harm to those exposed to radiofrequency radiation. In the recent decade, there has been an increase in the number of in vivo, in vitro, and epidemiologic research on the impacts of mobile phones, base stations, and other EMF sources.

2.8 Summary of Literature Review

Figure 2.5: Example of common office layout.

Figure 2.5 shows the most layout of office buildings. The space is not used inherently safer as there are some parts of the office which has more space and some with very little space that may cause movement to be limited. This layout is made for maximum use of space without considering the number of occupants at a time per square feet.

Hazards in office environment causes harm to workers both physically as well as mentally. Inherently safer design must be on the overall improvement of the office environment. From slipping and falling, misusing of equipment, to feeling sick due to sick-building syndrome, noise pollution, and poor lighting, all the possible hazards need to be identified and eliminated to provide an inherently safer working environment for the workers.

Hazards such as poor ventilation is seen as one of the main causes of phycological hazard to the workers of office buildings. Also, hazards like volatile organic compound (VOC) have a negative effect on the indoor air quality, where even low-level and short-term exposure can cause general feeling of unhealthiness to the workers.

Factors such as lighting and electromagnetic radiation also need to be addressed and investigated when it comes to inherently safer design for office. Poor lighting and excessive exposure to electromagnetic radiation can cause poor health condition to the workers.

Identifying the hazards is important and can be crucial to improvise the workplace productivity. Also, inherently safer design will be able to eliminate or reduce these hazards from affecting the safety of the workers. Unsafe office environment will cost more in case of an accident and for compensation for the involved party. Besides that, the productivity of employees will be affected in a congested workplace. This will have negative impact on the business growth.

An inherently safer design office will be more cost efficient as it will help by preventing investment in accessories and equipment that are not suitable for office environment. With better understanding of the safety aspect, the office environment can be made to be safer and better in terms of employees' workspace.

It is important to make sure that all the safety guidelines are well revised, and the employees are briefed on the hazards around the office. Employers could open to suggestions for improvement in the office space as well. This will help in improving the overall safety of office buildings. Any accidents or incident should be immediately reported so that prevention methods can be implemented for the future.

By considering all the mentioned issues and putting into motion the steps following inherent safety principles, safer office environment can be developed. Therefore it is important to determine common safety issues in office buildings. by doing this, the methods to implement inherent safety design can be outlined and a proper guideline can be proposed to develop safer offices by integrating inherent safety measures.

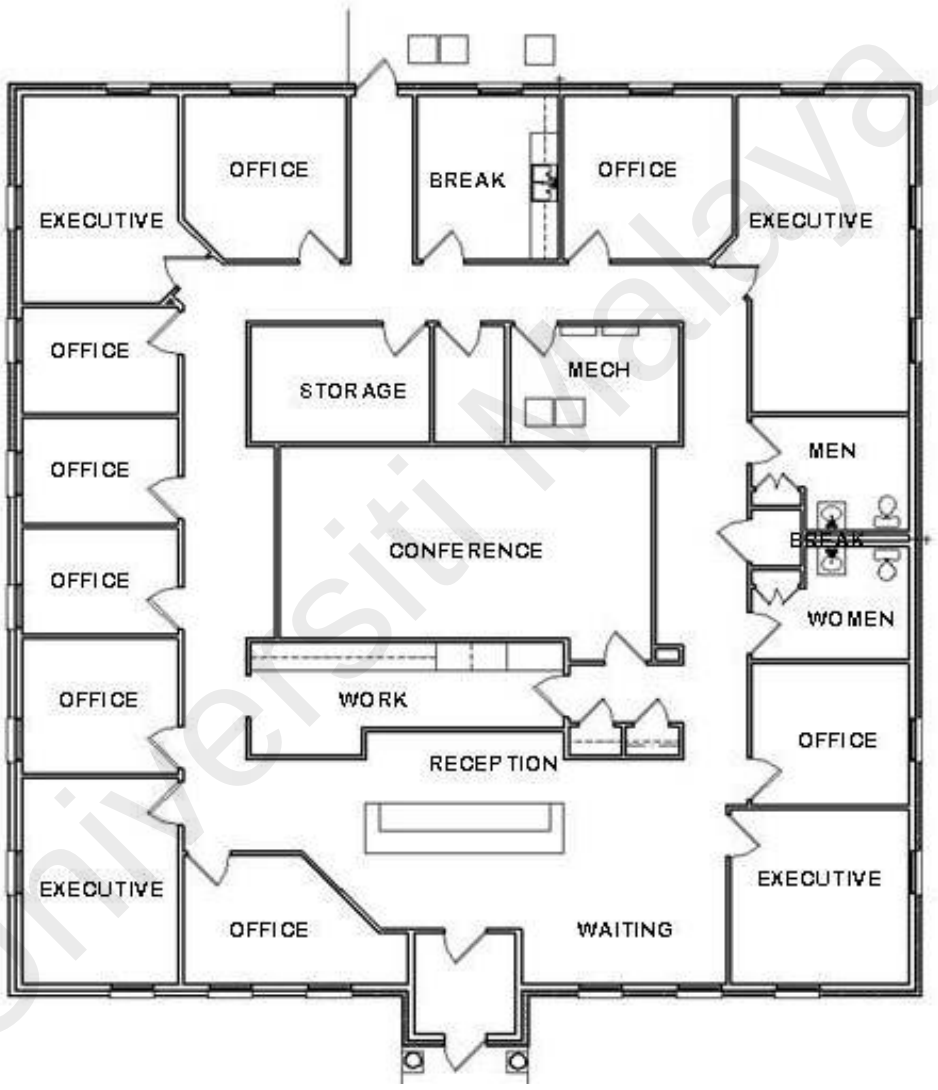


Figure 2.6: Layout example of an inherently safer design implemented office.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter recapitulates detailed processes or technique used in this study to further explain on how the necessary data was extracted and analyzed before being implemented to achieve the said objectives. The findings and possible solutions will be further discussed in Chapter 4 (Results and Discussion).

The data in this study were obtained from different types of office buildings with various size and space, and proposing the inherently safer designs that can be implemented in any types of office buildings in general. The needs and hazards were determined from previous studies conducted on the hazards in office buildings. The main methodology for this research is highlighted as per below:

i. Identify and research on safety issues in office buildings.
ii. Identify the hazards and root causes of the hazards.
iii. Understanding the nature of the hazards and its effects.
iv. Survey on office buildings and identifying the common equipment and tools used in office environment.
v. Identify ways to improve and implement inherent safety design for current and future office buildings.
vi. Suggestions to implement inherent safety design to accommodate the work from home situations.

3.2 Identifying the safety issues and hazards in office buildings

It helps to learn more when adopting inherently secure design by recognizing security problems and dangers in office buildings. When inherently safe design concepts are implemented throughout conceptual design phases, the effect of inherently safer designs is maximized. Process engineers must thus be aware of and apply the inherent safety design to effective safety assessment methods. Engineers may not find a possible danger or risk, resulting in unsafe design, without strong instruments.

Inherent design of safety should be used in combination with other safety methods to improve risk management systems since inherent design of safety is not meant to be an autonomous approach. For example, Figure 3.1 shows the process risk management system incorporating the principles of inherent safety design, domino effects, and layers of protection, based on the notions of (Park et al., 2020). Due to the greater freedom in early design phases, like as design and preliminary design, practitioners must evaluate the usage of ISD for these phases. When ISD is unworkable to minimize the risk of possible events, with the other two safety methods it may be harder to reach tolerable risk. Chemical firms must iterate this technique until tolerable ranges are established in the final stage of their risk management system.

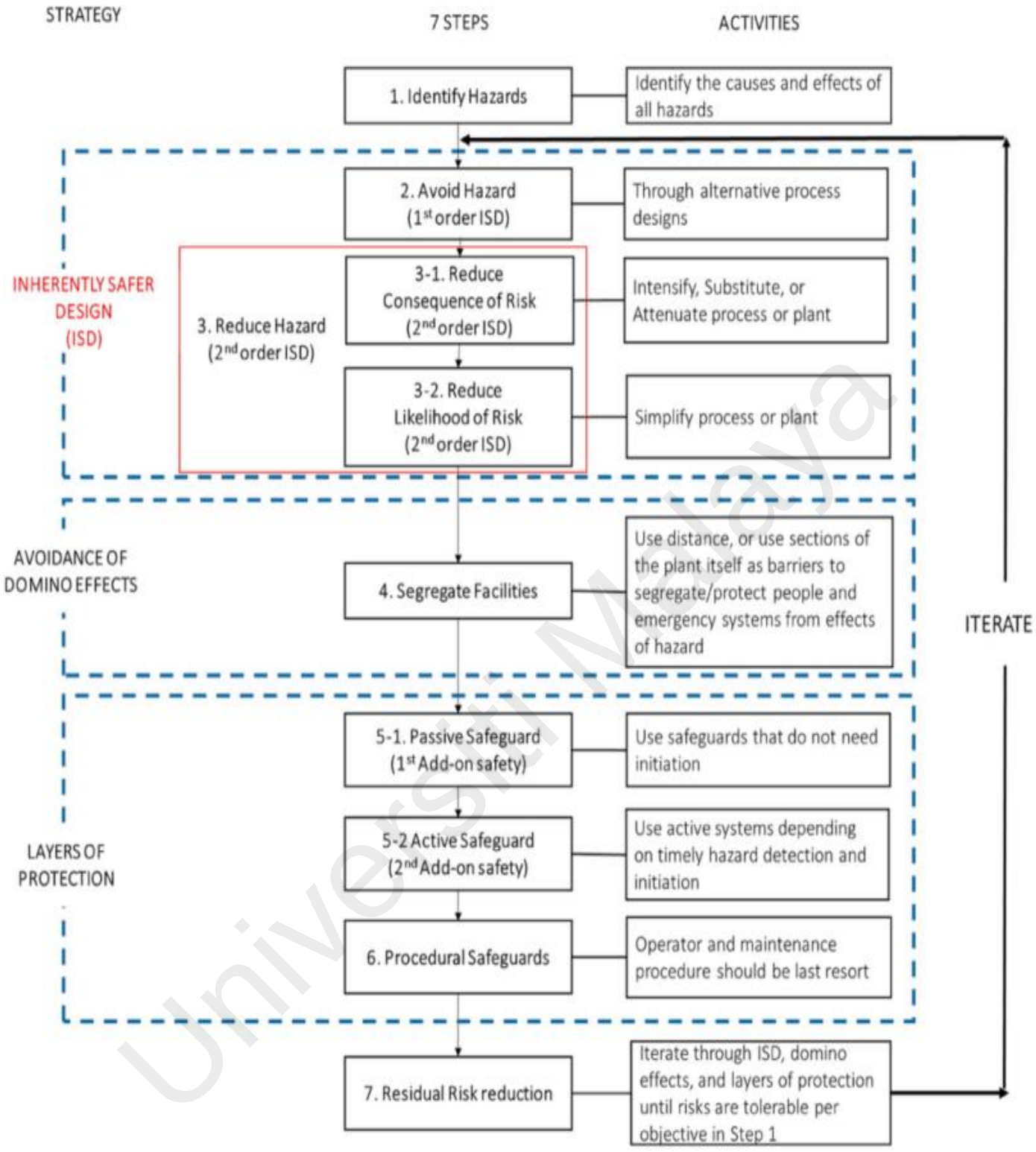


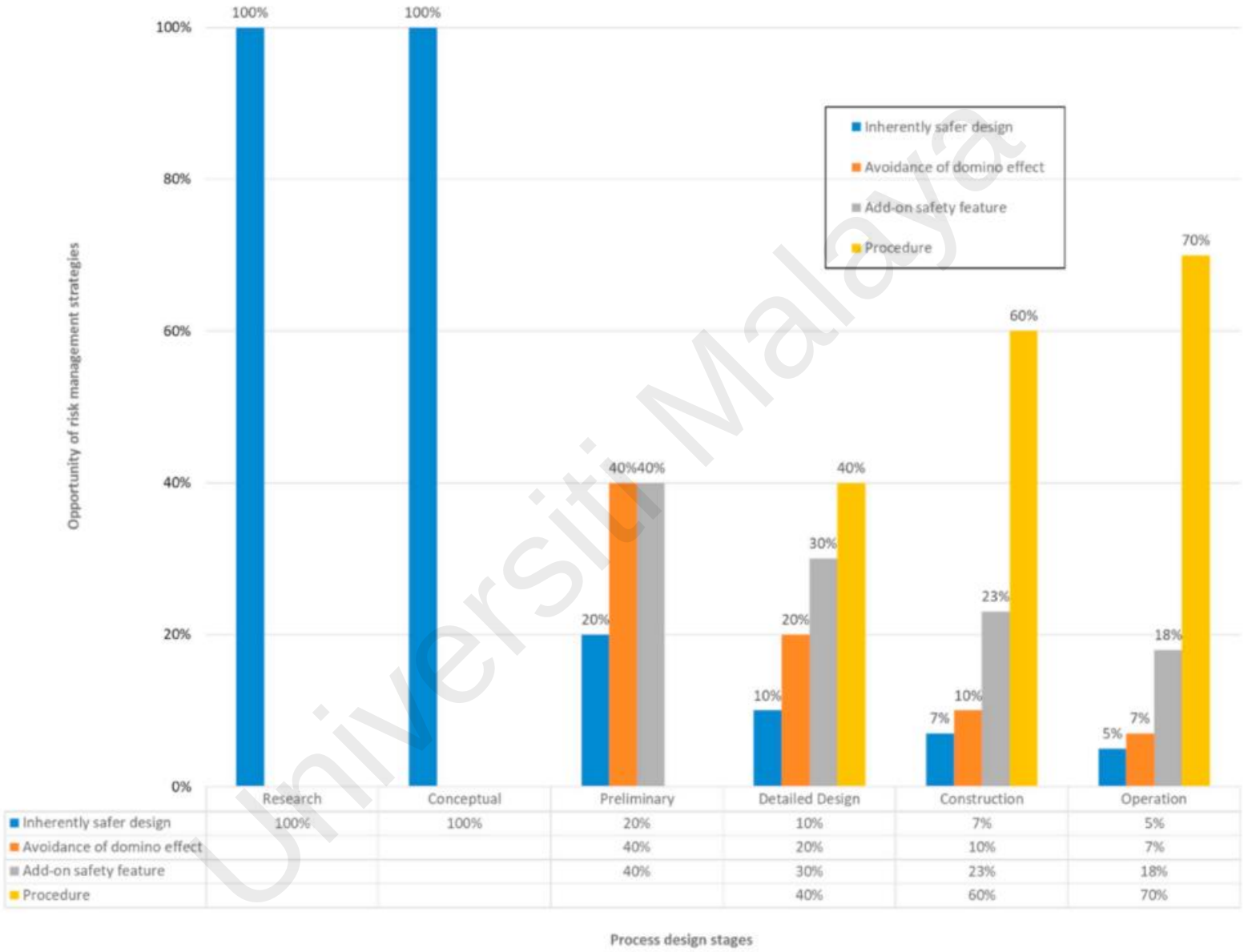
Figure 3.1: Methods to implement and practice inherent safety design. (Park et al., 2020)

3.3 Importance of inherently safer design principles

Process design takes place in various stages starting with the development and research, followed by a conceptual method synthesis and design in which the fundamental chemicals and functional processes, mass and energy balances and a high-level technoeconomic analysis are identified. Process engineers have considerable leeway to make design choices during conceptual design.

Next, detailed design requires comprehensive analysis, simulation, evaluation and optimization to establish the building and then operating requirements. In the early design phases, the main ideas of safer design are closely linked with durability. As can be seen from Figure 3.2, early design phases have significantly more freedom than future phases to integrate ISD functions.

Therefore, at research and concept design stages, the potential to adopt an intrinsically safer design is desirable; this chance is reduced, and project costs are increased if modifications are made in the next phase. The rest of the security measures should be implemented together with an intrinsically secure design after a conceptual design is finalized.



	Research	Conceptual	Preliminary	Detailed Design	Construction	Operation
Inherently safer design	100%	100%	20%	10%	7%	5%
Avoidance of domino effect			40%	20%	10%	7%
Add-on safety feature			40%	30%	23%	18%
Procedure				40%	60%	70%

Figure 3.2: Options for risk management during chemical plant construction.

3.4 Inherently safer design assessment tool

Review articles on the development of the Individual Safety Attributes Tests (ISATs) have been published in several journals. Five sample review articles focused on various ISATS were selected to give coverage of the topic. During the conceptual design stage of each article, the recommended tools were evaluated for their potential acceptance and usage.

ISD indicators and estimate techniques for ISD were examined in this study. As Figure 7 shows, the authors categorized all the indications they identified in the papers into six categories: (1) chemical and physical properties of materials, (2) process conditions, (3) reaction properties, (4) equipment, (5) types of activities/operations, and (6) consequences. Figure 3.3 presents the indicators the authors found in the 62 articles with black color lining; possible indicators proposed by the authors, but not seen in the articles, are presented with red color lining. In addition, the authors classified the estimate techniques into six groups as follows:

1. Hybrid approach

To assess the indicators, this method combines or utilizes a mix of the techniques (for example, a relative ranking and a risk-based approach). A hybrid method may produce more gratifying outcomes than an individual strategy by overlaying various processes. As a result, it serves as a testing ground for indicators.

2. Equation-based approach

A model that captures system features by identifying system variables and describing the system with sets of equations connecting these variables is known as an equation-based model. A simple closed analytical form is usually not achievable for a

complicated system. As a result, it must be represented by selecting a set of important states and converting the dynamical operations of state transitions into partial/ordinary differential equations.

3. Graphical approach

The real value of each indicator is used and shown for the various synthesis methods in this technique. The indicators are calculated utilizing variables that are represented graphically in the form of reactive layers or a simple graphical technique. This method might give a visual comparison of intrinsic safety indications or alternative process design options. Most researchers use this method in conjunction with other approaches.

4. Advanced mathematical approach

This method is founded on sophisticated mathematical approaches such as statistical, numerical, and fuzziness procedures.

i. Statistical method: A statistical technique is based on data from many databases, and it solves a suggested formula for each indication by replacing constants or relative rankings into the calculation. Each formula's output is valued from 0 to 1, with lower scores indicating intrinsically safer alternatives.

ii. Numerical descriptive method: This approach relies mostly on logistic equation, that consists of two variables, X (indicator values) and Y (score of each measure), as well as three constants: A (formula based on previous studies' data), B (same as A), and C. (maximum limit of the scores). The score of each indicator is determined by solving the suggested equation.

iii. Fuzziness method: Each indication is defined by one linguistic function, and its range is split into a fuzzy set (0 (no intrinsic risks) and 1 (severe hazards). The fuzziness approach helps compensate for the ambiguity of expert judgement. It addresses intrinsic safety issues including fire, human toxicity, and explosions.

5. Risk-based approach

A methodical, risk-based method to safe practices can assist eliminate hazards that represent unacceptable risk from the process and mitigate the possible effects of hazards.

6. Relative ranking

Based on the probable quantitative values of each indicator, a ranking system is developed. Each rank's extent is always established by expert judgement, and each rank receives a score (each score is likewise clearly defined). The indicators' values are then evaluated with this ranking method to get their score.

The authors created a table outlining how each indication was calculated based on these six criteria. By following these inherent safety design indicators as shown in Figure 3.3, the implementation can be thoroughly done, and an inherently safer working space can be achieved in wholesome.

The authors, however, did not confine the notion of ISD as it is and included numerous publications related to domino effects in their review. Furthermore, the selection of various indicators may perplex practitioners in terms of priority or usage. Process engineers, for example, may find it difficult to identify relevant indications to utilize to assess the safety status.

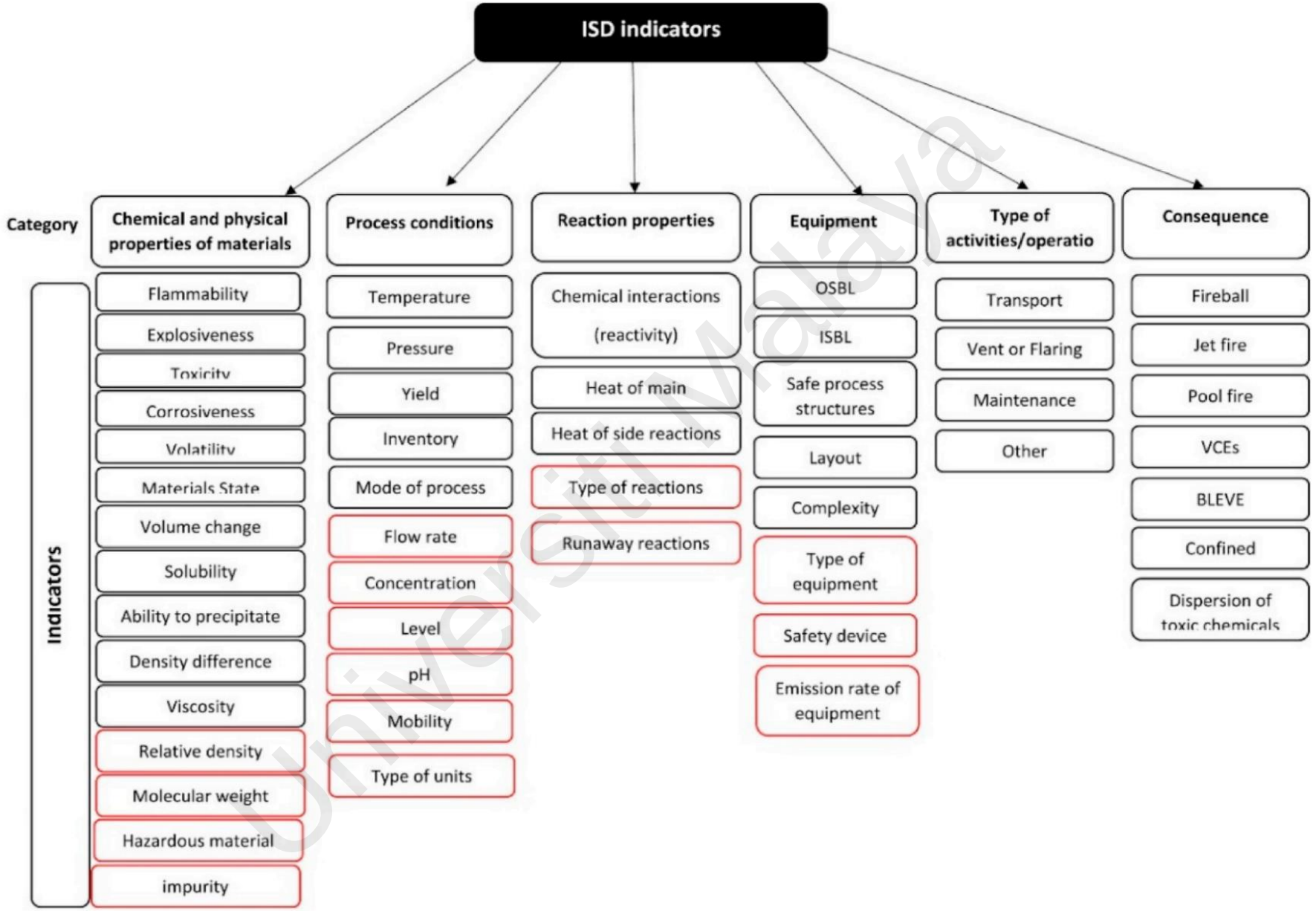


Figure 3.3: Summary of all indicators grouped into six different groups (Park et al., 2020)

3.5 Individual Safety Attributes Test Methodology

The need of ensuring a safe work environment is no longer only desirable, but rather necessary. Regulations, norms, and compliance are not enough to ensure safety. Key to success is the development of strong safety cultures, such as hiring and training personnel who will actively advocate safety.

Unlike other safety evaluation tools, this ISAT does not evaluate at whether or not a person is likely to follow the rules. In addition, the ISAT isn't just a basic poll of attitudes. Rather, the ISAT assesses whether an employee is forceful enough to enforce regulations and competent enough to guide colleagues.

Traditional safety assessment methods do not go as far as the ISAT, which assesses not just compliance with organizational standards, but also the chance that individuals would participate in learning behaviors such as asking questions and seeking feedback.

These are the things that the ISAT seeks to assess:

a. Safety Diligence and Conscientiousness

   Evaluates how well someone follows safety-related rules and procedures even when faced with expediency and group pressure.

b. Coping with Pressures

   Assesses the ability to deal with everyday events that may cause worry or tension, as well as the ability to resist expressing discontent in a public manner.

c. Confidence in Delivery

   Quality focus and self-belief in an individual's ability to provide a quality output are assessed.

d. Responsibility for Safety

Examines a candidate's propensity to take personal responsibility for preventing workplace accidents, such as how proactive he or she is in enhancing their own and others' safety.

e. Communicating Safety Information

Assess at a person's willingness to engage in open and productive safety discussion.

3.6 General Inherent Safety Awareness

Employees must be briefed on the importance of inherently safer behaviors in office environment. The set of regulations must always be obeyed to ensure the employees are safe. For example, cups should be placed in the holder far from electronics to prevent spills that may lead to equipment damage and/or electrocution hazards.

Employees should dry their hands thoroughly before leaving the washroom to prevent water droplets that may cause in slip and fall accidents in workplace. Smoking should be prohibited if possible or be done in open area to prevent the smell from sticking to the cloths and causing Sick Building Syndromes among employees.

If need to move more than 1.5kg of load, trolleys should be used to prevent muscle pain. Breaks should be taken in between long hours of screen time to prevent fatigue eyes and headache. By following regulations, accidents can be reduced and prevented. General concern about each other’s safety should be cultivated among employees.

Employees should not be allowed to bring their hot drinks to the work desk as it may spill and cause injuries. Besides that, spilled drinks may spoil the electronic gadgets on the work desk, and the user might be at electrocution risk. The desk should be clear with

only needed, important, and work-related items on it. Overcrowding the desk might cause lack of space to work.

Employees must not overload the plug points provided. They must either unplug the appliances that is not being used at the time or use the plug point provided in common area. Overloading the plug points can be dangerous as it can cause short circuits.

Next is the food items. Food should be only eaten in the pantry or cafeteria. Having food at work desk will cause the smell to linger and this will cause unpleasant smell to others. The smell will cause discomfort for the employees and lead to health issues such as headaches or dizzy feeling/ nauseous.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Introduction

In this chapter, the findings and all related details on the implementations of inherent safety is discussed. Ways for improvement and betterment of office buildings were derived from various studies conducted on the safety issues in office, as discussed in the previous chapter, literature review.

From the study conducted, it was found most accidents that happens in office buildings occurs due to preventable causes. Besides costing the employers money, these accidents also cause low productivity rate among employees.

By implementing inherent safety in office buildings, these accidents can be prevented, and an inherently safer environment can also help to increase the productivity among employees.

4.2 Safety risks in office buildings

Hazards in office buildings can cause some serious injuries and damage when overlooked. Office employees can be exposed to the risk of electrocution, and trip and fall due to poor cable management. Mismanagement of cables can cause short circuit and start fire as well.

Misplaced chairs can cause pathway obstructions and result in unexpected accidents as well. A person carrying loads can trip on the chair and hurt themselves. Besides that, carrying loads that can block a person's view also can be hazardous. The trolley should be used to move loads to the wok table. Improper sitting posture can cause damage to the spine and affect the health of employee. Chairs used should be able give provide good support to the employees.

Figure 4.2: Example of cables left out on the floor.

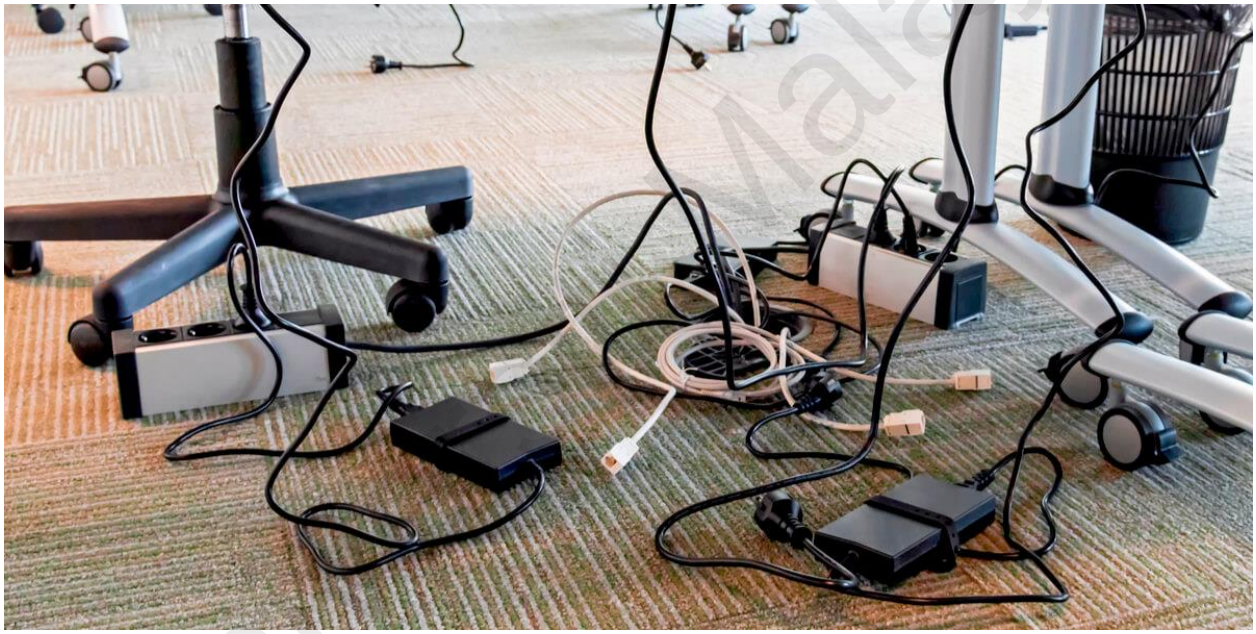


Figure 4.1: Example of overloaded extension.

4.3 Sources of accidents

One of the most accident-causing elements in office buildings is poorly managed cables. It is a common sight in offices where the cables are coming out in the middle of the office, over loaded plug points and unorganized cables at worktables.

Some of the hazards these situations can cause are trip and fall, electrocution, and even start a fire due to short circuiting. Misplacing and misusing also contributes to accidents at workplace. Lack of rest and over working can causes stress and fatigue among employees.

Work desk not aligned properly, and torn carpet can cause trip and fall incidents. Printer and photocopy machine placed too close to the working area will cause disturbance and noise, which may instigate unwanted stress and discomfort for the employees. This situation may lead to dissatisfaction among employees against those who uses the machines frequently.

Poor lighting may lead to eyesight related health concerns and migraine among the employees. The type of light used will affect the outcome of employees' health as well. Wrong color lighting also can lead to poor eye health among the occupants. The amount of natural light in the office plays a part to make sure that occupants feel healthy.

Ventilation must be well channeled and balanced to provide a healthy breathing environment for the employees. Poorly ventilated office will cause the employees to have sick building syndromes, and this may lead to poor health conditions among employees. It will increase the level of stress felt by employees.

This situation will cause the employees to be unable to focus on their actions and might overlook on the safety aspects. Breaks, screen time off and short breaks between long work hours are crucial in maintain the health and focus of an employee.

The break time must be properly utilized by the employees as lack of breaks will cause the employee to feel overloaded and stressful. Too much of this will make the employees to fall ill and affect the health. Some of the health-related issues that an employee may face due to stress are high-blood pressure and chest pain.

Cigarette smell and vaping will lead to headache, nauseousness and lack of breathing air. This activity should be avoided at all costs within the working area. The after-smoking smell of cigarette also can be a little too much for some people to bear. The smokers may be dehydrated and lose focus while working. This may lead to more accidents and injuries at workplace.

The arrangements of the work desk and chairs plays important role in making sure there is enough room for the employees to move without tripping or hitting anywhere. The Figure 4.3 shows an example of overcrowded workplace. The employees have a high chance of knocking into each other's chair while going to or leaving their station.

Figure 4.3: Example of overcrowded workplace.

4.4 Ergonomic Hazards in Office Buildings

From the literature review, it has been identified that developers and designers should be more vigilant and include inherent safety design aspects in the development of office buildings. It is suggested that the office buildings to be built by considering the elements as discussed below as to achieve an overall inherently safety working environment. Besides office buildings' structure, the equipment used in an office environment is also as important to achieve a safe working environment.

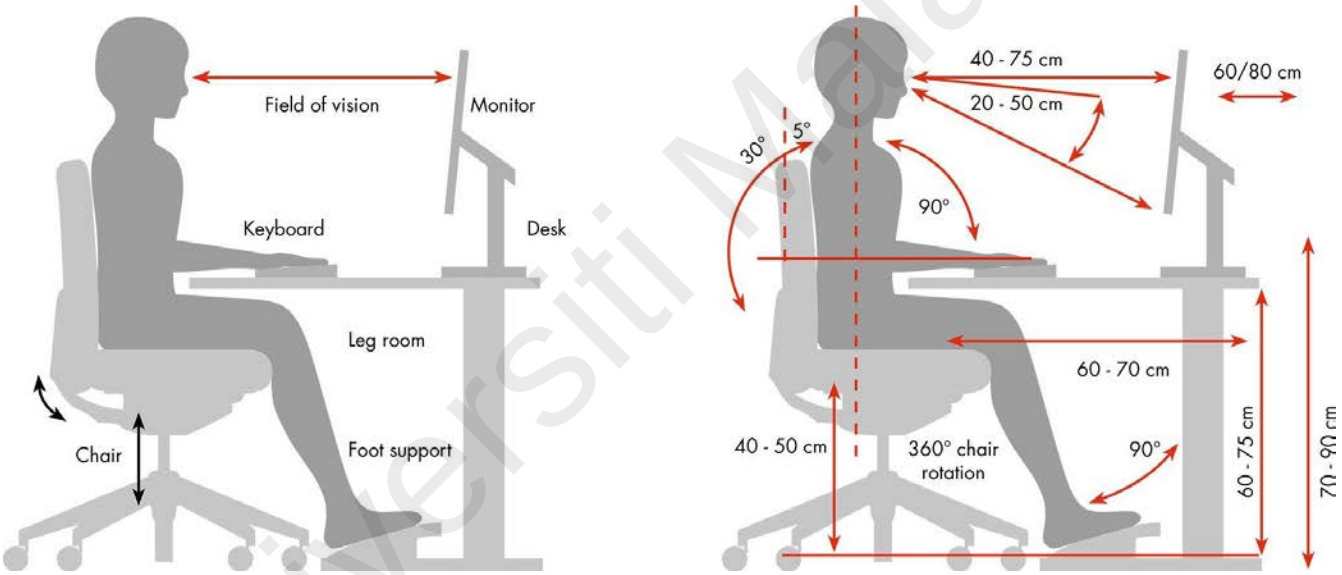


Figure 4.4: Work Desk ideal suggestion

As shown in Figure 10, the work desk has enough legroom for the employee to sit comfortably while working. The chair has the option to adjust its height to ensure proper sitting posture can be achieved. By following this guideline, backbone, wrist and various other injuries can be prevented.

There should be leg room of 60 – 70cm to allow comfortable movement. The monitor should be 40 to 75cm from the user. This to ensure the user will not suffer from fatigue eyes due to long hours of screen time.

4.5 Working space

Office buildings are normally built with idea to use the available space to maximum and this means something employees' space can have very limited space. With the common areas being victimized in the vicinity. Figure 4.5 shows an office with limited space, that is being used and at first glance, hazards can be seen. For an example, there is not enough natural light until the back of the office.

Next, the lighting provide is not suitable for long hours of working. There is not enough mobility space between the desks. The chances of the employees bumping into each other is high and this can be a dangerous hazard, as it can trigger them to fall and the close arrangements will cause injuries.

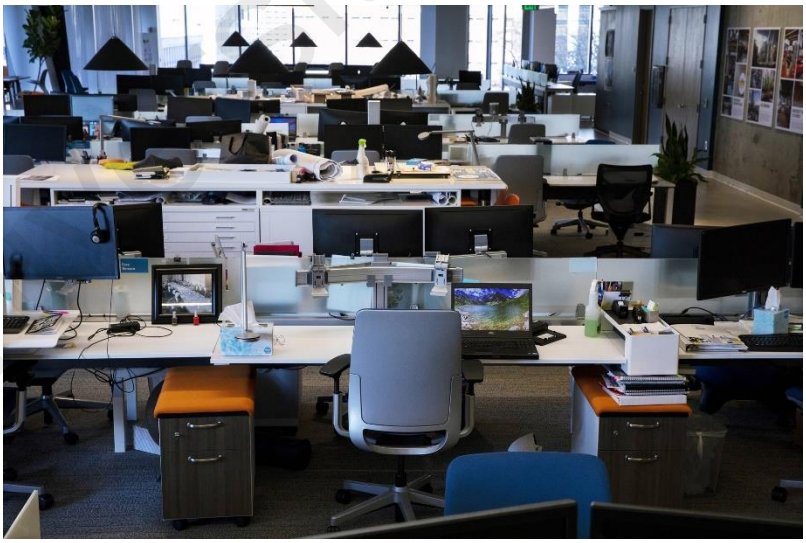


Figure 4.5: Example of a crammed office.

The most ideal amount of space for employees should be 100 square feet per person. This will allow about 50 square feet of desk space and 50 square feet to accommodate space in communal areas, such as meeting rooms, and pantry. Whilst the ideal space is

100 square feet per person, other facilities also need to be fitted in. Hence, the approximated space for some of the facilities are as follows:

1. Small meeting room to accommodate about 2 to 4 people – 100 square feet.
2. Large meeting room to accommodate about 4 to 8 people – 150 square feet.
3. Board room to accommodate about 15 to 20 people – 220 square feet.
4. Training and conference room to accommodate about 20 to 30 people – 300 square feet.
5. Pantry – 100 square feet.
6. Small server room with 1 server rack – 40 square feet.
7. Large server room with 4 server rack – 120 square feet.
8. Manager's office with two extra chairs – 100 square feet.
9. Senior manager's office with a small meeting table – 200 square feet.
10. Director's office with four-person meeting table – 250 square feet.

These are suggestions with ideal space ideas. With these the possibilities of trip and falling or lack of space issues can be overcome. Besides that, with enough space for everyone, there will not be a problem for everyone to work from office even during pandemic like Covid because the social distancing can be practiced.

There is enough room for everyone to be at a safer distance. Therefore office buildings should be built with proper workspace and the occupant limit should not be exceeded then it was intended.

4.6 Electric plug point hazards

The plug points at work desk should be with three pins. Studies have shown that three-pin sockets are safer to be used. Wires linked to the ground pin of a plug are also attached to the equipment's metal body in a 3-pin plug.

If there is any current leakage on the metal body of the device, it must be securely discharged to ground. It will protect consumers from receiving an electric shock when using the device. If there is a major malfunction with the device, the fuse will blow, safeguarding the person. To avoid electric shock, the system should be properly earthed or grounded.

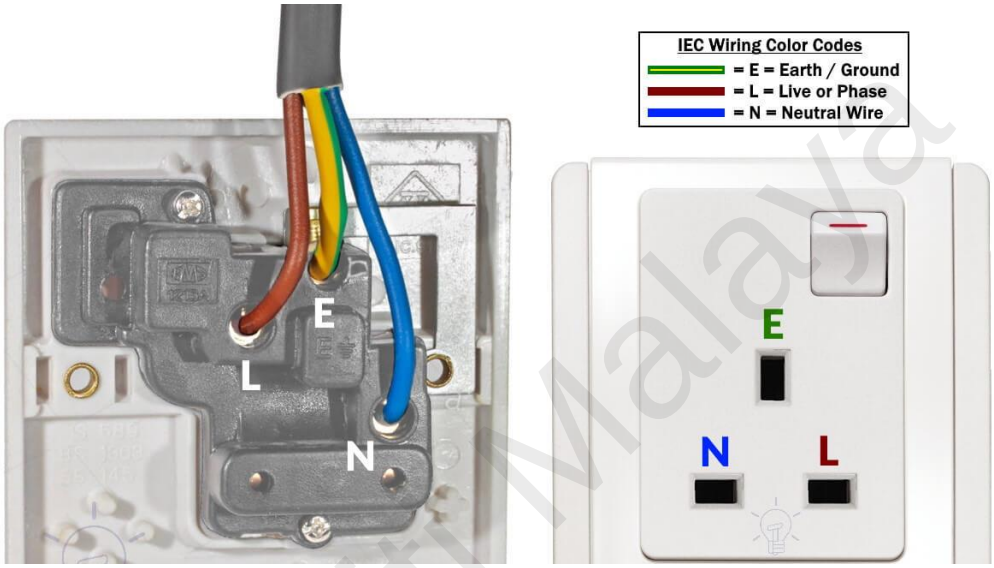


Figure 4.6: Example of Three-pin socket.

4.7 Electromagnetic Radiation free environment

Studies show the electromagnetic radiation emitted by electronic devices can cause discomfort and if exposed for long time may be harmful to the health of the user. Being around their gadgets can cause the employees to feel fatigue and tired. Hence an electronic device free zone can be introduced in the office.

The zone can be as simple as a pantry or the office balcony. The employees can take short breaks in between to unwind and this can help to increase their concentration on the work. The radiation emitted in heat form can cause discomfort to the employees and by setting up zones such as this can help promote healthy working environment for everyone.

By giving time-off from electromagnetic radiation, the employees mental health will improve and can play an important part in workplace communication among colleagues. It will prevent toxic work environment for the employees and can hinder tiredness due to bluescreen.

Productivity will have positive improvements and better workplace communication can help in understanding the company to achieve better in the field. Besides that by reducing the bluescreen time among employees, insomnia and lack of rest can be prevented.

By taking the time-outs, the employees will have less damage due to radiations. The recommended break time one should take from electronics is 5 minutes in every hour, away from the screen. During these breaks, light exercises and stretching is recommended to correct body posture and refocus the eyes.

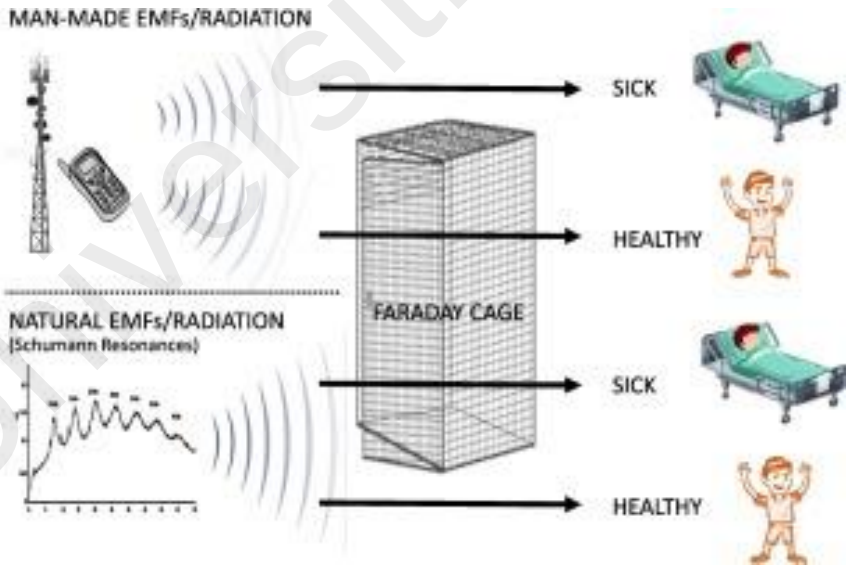


Figure 4.7: Example of shielding method from EMF

When creating an electromagnetic free space, employers can adapt the faraday's cage law to make sure that man-made radiations are blocked and have an opening to natural

radiation, such as the sun light. By having less man-made radiation exposure and more natural exposure, one can have a healthier body.

By doing this the employer creates health awareness among the employees. This indirectly promotes the company as well. To conclude, healthy employees will perform better.

4.8 Natural light and Ventilation

Office building must allow as much sunlight as possible to keep the place well lit. Also, sunlight is beneficial to humans as it can help to rejuvenate the mind and body. Besides that, an office with good natural lighting will use lesser electricity compared to an office with poor natural lighting. Good lighting will provide good line of sight at workplace, and this will ensure that employees can prevent from hitting on any objects.

Warm yellow or warm orange lights are often preferable for resting and unwinding, whereas cold blue or cool white lights are preferable for waking up, working, and focusing.

Fluorescent and LED bulbs both emit light in the blue and white spectrums, making them excellent for morning lighting. LEDs also enable to modify the color and temperature of the light they generate, allowing the users to replicate the natural light outside.

The office lighting at a workspace has a direct impact on the team's mood, energy level, and productivity. Employees will become fatigued and irritable if the lighting is too dim. Lighting that is excessively bright, on the other hand, can be difficult on their eyes, possibly producing headaches, and will disturb their body's normal circadian cycles.

The proper lighting for the area keeps employees awake, creative, enthusiastic, and in the right frame of mind to offer their all. However, striking a balance between too dark and too bright may be challenging.

500 lumens per square meter is the minimum standard office lighting for all enterprises and regular workstations. Every 6'x6' (or 36 square-foot) space should receive the equal amount of light as a 35-watt incandescent bulb.

The average desk light uses a 60-watt bulb that generates 800 lumens, so to put that in context, there are several workplace lighting standards, such as:

1. As a starting point, consider fluorescent ceiling fittings and bulbs.
2. A uniform amount of light should be provided across the whole workplace space.
3. Work lights may fill in the voids.
4. Shadows are minimized by adjusting the lighting.

Fluorescent or light-emitting diode (LED) bulbs are the ideal choice for big, open areas, such as most office situations, although halogen and incandescent lights are excellent LED bulbs have numerous benefits over fluorescent light, including.

1. LED lights are more cost-effective to run and maintain.
2. LED bulbs have a longer lifespan than incandescent bulbs.
3. LED lights do not consume excessive amounts of electricity.
4. LED lights do not produce infrared radiation.
5. LED lights do not cause migraines in migraine sufferers.
6. LED lights may be dimmed to according to the time of day and season.
7. LED lights do not interfere with sleep patterns or hinder melatonin synthesis.

As for ventilation, most office buildings currently use centralized air-conditioning. But air conditioners can cause the surrounding air to be dry and less humid. This can cause skin irritations due to the lack of humidity in the air. To prevent this, office buildings should have a space or a break room that is well ventilated with clean air. By implementing this, the employees will be able to get fresh air and shake off the work stress.

If there is smoking zone for the employees, it should be away from the common areas and office building. Secondhand smoking can cause more harm to the employees' health as well. The most effective way would be to provide air purifier and to disallow smoking during work hours. The smoke smell will stick to the cloth materials, and this will contribute sick building syndrome.

Another issue to be take note is the volatile organic compounds in office environment. Proper ventilation with constant air flow will make sure the smell does not stay in the room for long time. Instead of fixing glass panels, the windows should be able to open to provide natural air and natural lighting.

4.9 Smell and Noise in office environment

Bad smells will occasionally appear in the workplace environment. Odors are unavoidable in a closed-in room with many people, food and drink, and maybe a workstation involving chemicals. However, this does not imply that the odor must persist for an extended period and become irritating.

There are several techniques that may be utilized to spruce up the office and make the environment more attractive. A lot can be done to prevent scents from occurring in the first place, from basic ideas and products to removing odors that arise during the day to scheduling and keeping the workplace clean on a regular basis.

The preferred method for eliminating smells is to go straight to the source. Sometimes it is as easy as a garbage can with odorous items. Eliminating the garbage bag from the office and either emptying out the can or leaving it outdoors to air out can go a long way toward quickly removing smells. To keep the procedures natural and gentle, use a light cleanser in a container, such as vinegar.

If there are windows and doors in the workplace, opening them and allowing fresh air in can help to eliminate scents fast and organically. Airing out the workplace is a fantastic method to freshen the environment and eliminate any lingering odors.

Ceiling and kitchen fans can also aid increase the circulation of air in an odor-filled room, pushing it out the door. Running the air conditioning may also assist circulate stagnant air around and filter out odors, resulting in a cleaner environment around the office.

If the fridge or microwave are the causes, washing them with hot, soapy water and removing all objectionable food and throwing it out of the building will rapidly help decrease the unpleasant odors emanating from the pantry or lunchroom facilities. Keeping this area of cleanliness on a regular basis can keep it smelling fresh longer.

Noise, often known as "unwanted sounds," can have a negative influence on an employee's health. Noise-induced hearing impairment or complete/partial hearing loss is one of the most frequent workplace health problems globally. It is critical to use noise suppression techniques in open offices. Employees who are exposed to high dB levels of noise at work may have a variety of detrimental health consequences. These health consequences might occur because of a single encounter or as a result of continual exposure to increased noise levels.

The most frequent bad impact is hearing loss, although other, less prevalent, health problems might arise. Some people are more sensitive to noise than others, which means they will suffer greater harm if exposed to noise in the workplace.

Occupational stress, noise-induced hearing loss, tinnitus, and other health consequences are among the most frequent. There are other passive impacts that noise can have on employees' health, such as decreased productivity, obscuring warning signs of impending danger, and so on. All these consequences can cause problems.

Several techniques can assist in regaining concentration in a loud workplace setting. If feasible, open workplace noise control comprises reducing the noise at its source or disguising the disturbance with white noise or relaxing music. If the noise is continuous, using earplugs or other noise-cancelling PPE should suffice.

Positioning the workstations in an area of the workplace with reduced noise levels can also be extremely beneficial. Additionally, soundproofing products such as sound-reducing window drapes and soundproof wall boards can assist combat workplace noise. These devices act as sound barriers to shield workers from unwanted exposure to noise, and they are a great way to help them recover concentration.

There are several things that can be done to reduce workplace noise levels:

1. Plants are excellent for decreasing workplace noise because they absorb the undesirable sounds, preventing them from spreading.
2. Office workstation cubicles perform wonderfully for noise reduction.
3. Office dividers reduce echoing sounds, making your office a more peaceful setting.
4. Changing the workplace layout by relocating machines to one room and distributing office workstations across many rooms will decrease noise echoes.

5. Controlling ambient noise using calming sounds such as water flow, waves, natural noises, and others may be quite beneficial.
6. Carpets and vinyl floors are great sound absorbents.
7. Noise-cancelling headphones will assist to minimize unpleasant sounds to some extent, but not entirely.
8. Noise can be absorbed by furniture composed of sound-absorbing materials or cloth-like couches, sofas, and so on.

By taking these into practice, major improvement in the performance of the employees can be observed. Also the office environment will become more engaging.

4.10 Pantry and Rest area

Pantry is a common area in most offices, where the staffs will go to grab their daily coffee and grab a quick bite. Which means employees using this space will be moving quickly and might even be in a rush. This is where normally accidents that can cause serious injuries occurs. The coffee machine and hot water pot can really cause serious damage in case there's spill or misused.

A safe coffee maker should have proper cover and the hot water parts should be locked in place to avoid spilling it on the table or on the body. It should have one opening to add water and another to add the coffee. The coffee maker should be only serviced by authorized personnel to avoid getting the machine from malfunctioning at the same making it safe for others using it.

By providing an inherently safer coffee maker, the employees can be more focused on their task without need to worry about spilling hot water or the coffee while making one for themselves. Next is the table and chair provided in the pantry.

The materials used must be environment friendly and positioned in a way that it does not block any pathway or doors.

Figure 4.8: (a) Coffee spilled from the coffee maker.

Figure 4.9: (b) Example of a commonly used coffee maker.

Figure 4.10: Example of coffee maker that is inherently safer.

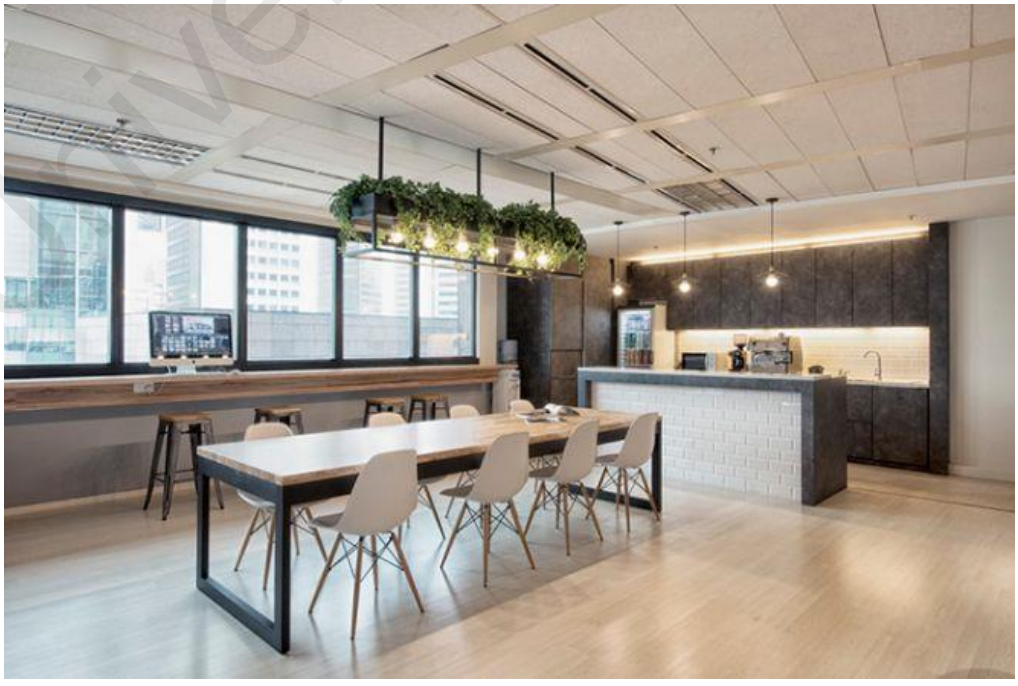


Figure 4.11: Example of office pantry.

If there is a window overlooking the street or natural scenery, will be helpful to reduce the work stress the employees might have. This also promotes healthy work practice among employees. The ample of sunlight entering the pantry also will rejuvenate the mood before employees continue with their work and tasks.

The ventilation system also must be taken into account, as the food smell might get trapped in the room causing foul smell as time goes. The pantry must be cleaned from time to time making sure it is hygienic and safe to be used.

4.11 Open Office Concept

In an open-plan workplace, employees are not confined to cubicles or offices, but rather work in a large open area that is stretched with rows of desks which has barely anything between them are common in an office with open-plan. Many open office layouts include areas where employees may gather or change their surroundings, such as open kitchen sections with plenty of seating or lounges with sofas.

Open concept offices in fashionable tech companies also feature facilities for amusement and entertainment, such as craft areas, ping-pong tables, libraries, and media rooms. These areas are intended to inspire employees to interact and be creative.

There is a reason why open workplaces have grown so popular. They offer cooperation and more close-knit teams capable of solving complicated issues, according to its proponents. Plus, the cost reductions on office supplies are a plus.

The promise of improved cooperation, creativity, and communication among employees is one of the reasons open office layouts have risen in popularity. Regrettably, that goal has not been realized. According to a recent research on open office layouts, face-to-face contacts decreased by 70% after businesses moved to open offices, but electronic connections rose.

In fact, open workplaces appear to hinder employees from participating in person due to a lack of privacy and office etiquette rules. Nobody wants to annoy 30 of their coworkers or have a private discussion in front of prying ears. As a result, it appears that open concepts might inhibit rather than encourage cooperation and communication.

There are several distractions because of the lack of privacy. According to previous study, employees in open office layouts waste an average of 86 minutes each day due to distractions. Even at a moderate volume, one chat can distract up to 20 employees. There are also visible distractions, such as employees strolling about, getting up to relax, going to heat meals, and congregating close.

Employees in open settings must go to considerable efforts to safeguard their concentration, whether that means wearing over-ear headphones, posting a "busy" sign on their workstations, or leaving their desks entirely to work in calmer areas. Employees feel hesitant of approaching their peers because of these coping mechanisms.

An unspoken disadvantage of open-plan workplaces is that employee health might suffer. Being in close sections necessitates the exchange of germs. Employees of open office environments use more sick days than their colleagues in single-person workplaces, according to a research published in Ergonomics. This sort of absenteeism has a significant impact on firms, particularly small ones. In today's world, the way we work and live is changing, more organizations will no doubt be considering how healthy it is to keep employees in close quarters, as well as how they can keep their staff safe in an open office setting.

In the corporate sector, open office concepts are becoming increasingly divisive. According to recent open-plan workplace research studies, there are substantial drawbacks to opening things up. Of course, open-plan supporters frequently object to

these findings. In fact, there is no one-size-fits-all workplace layout that works for every business. Different organizations have distinct requirements.

Besides that during the times like Covid pandemic, most open office must be closed, and the employees had to work form their homes. For most people it was a relieve as they prefer to work within their own private, comfort zone and survey shows that people chose to work from home than working from office.

This information shows that employees value their privacy and their own working space. On top of that, open offices cannot practice social distancing among employees, as most of the workspace are shared and close to each other, with space less the 6 feet apart.

Also, in open office, the operations will be hard to be controlled. For example, the disturbance will be there when someone is moving or listening to loud music. It can cause distraction and lost of focus, indirectly forcing the employee to concentrate on their work. This can lead to stressful environment for the employees.

Open office tends to have meetings in an open space, hence causing people to be distracted from the main event. With all these being said, it can be concluded that the practice of open office brings more harm as it brings stressful working conditions, which affects the employees' health directly, and this practice should not be continued.

4.12 Summary from the findings

From the study conducted about fourteen guidelines were determined as crucial and has been tabulated to ease the integrating process. These guidelines were determined by the effects of each item has on the office environment and their respective effect on the employees.

Each one of the fourteen items identified can bring tremendous differences on the productivity of the office as well as the health of the employees. These items also will help in reducing the company cost by reducing the number of accidents in office buildings.

The implementation of these items also will not be expensive, and it is mostly involving rearrangement of the office equipment. By implementing the items this guideline, the safety of the office building can be improved.

Table 4.1: Guidelines for Inherent Safety Design implementations (1)

No	Common hazard in Office Buildings	Implementation of inherent safety design
1.	Switch can have spark.	1. Spark free switches. 2. Switches with surge protection.
2.	Slippery floor surface.	1. Anti-slip mat used at points of danger. 2. Use of footwear with anti-slip soles. 3. Use of 'Caution' sign.
3.	Noise pollution.	1. Photocopy machine and printer should be kept in a different room. 2. Earphones/headphones rules should be introduced as the sound should not escape from the listener's device. 3. Ventilation system should be maintained to minimize noise. 4. Sound/noise absorbing materials should be used to minimize noise in work areas. 5. Use of mechanical items should not be near work area.
4.	Poor climate control.	1. Temperature should be maintained at a suitable level. 2. Fan type and speed should be set to allow ventilation in the office room. 3. Air conditioner's temperature should be set based on the number of occupants in the office.

Table 4.2: Guidelines for Inherent Safety Design implementations (2)

No	Common hazard in Office Buildings	Implementation of inherent safety design
5.	Poor Lighting	1. Pendaflour type and LED type lighting should be used. 2. There should be as much as natural in the office. 3. Table lamps should be of LED types.
6.	Foul Smell	1. Used of VOCs should be at the minimum. 2. Materials used in the office should be check. 3. In case there is foul smell, windows and doors should be kept open. 4. The source should be disposed immediately.
7.	Danger of hot drinks	1. Should not have hot drinks at work desk. 2. Coffee maker should be place in the pantry with 'Caution' sign.
8.	Poor Ergonomics	1. Chair should be adjustable height according to user. 2. Desk should have enough legroom and must not have any drawers that can limit space. 3. Mouse and keyboard should be at level with wrist on desk. 4. Monitor height and tilt should be adjustable according to the user height.
9.	Work stress	1. Short breaks between long working hours. 2. Common area to relax and take power nap. 3. Short breaks between long working hours. 4. Common area to relax and take power nap.

Table 4.3: Guidelines for Inherent Safety Design implementations (3)

No	Common hazard in Office Buildings	Implementation of inherent safety design
10.	Limited workspace	1. The desk and chair placement must not collide with other employees. 2. At least a minimum of 50 square feet per employee should be allocated. 3. Avoid overcrowding the place. If the team grows, adapt to hybrid working system, where employees take turn in working at office and from home.
11.	Danger of Electromagnetic Radiation	1. Be sure to provide short break between screen times, and make sure employees follow. 2. Provide Radiation Free Zone where no electronic devices are allowed. 3. Can implement Faraday's Cage principle.
12.	Eyesight damage	1. Limit screentime to one hour and take a five-minute break in between to stretch. 2. Use blue light filters to reduce damage.
13.	Trip and fall	1. Check and make sure no cables coming out of the floor. 2. The desk and chairs are arranged properly. 3. Avoid using carpets, if carpet is used schedule for inspection and maintenance every month.

Table 4.4: Guidelines for Inherent Safety Design implementations (4)

No	Common hazard in Office Buildings	Implementation of inherent safety design
14.	Electrocution	1. Make sure the plug points are not overloaded. 2. Avoid using many extensions. 3. Make sure to use three-pin plugs. 4. Make sure to provide enough plug points at the work desk. 5. To avoid employees from touching the switch with wet hands, sensors maybe used to turn the washroom lights ON and OFF. 6. Avoid have drinks at work desk or near electronic gadgets.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

Office buildings has been causing serious accidents and health issues for its occupants due to the lack of safety features. Most of the time, only the decorations are given more importance rather than the minute details of safety, that can make significant difference in the productivity of the employees.

Implementing inherently safer design in office building means it consider all the minute safety details that may otherwise be overlooked. Inherent safety design includes everything from the physical health to the mental health of the office occupants. By implementing inherent safety design, employers can ensure the employees that they are an asset to the company, and this too can improve work productivity.

Even though implementing inherent safety design in office buildings will help improve productivity and lessen the accidents, with growing the growing work from home culture, employers need to find ways to make sure that during the work hours, their employees are in safe environment. These can be ensured by making sure that the employees are in comfortable sitting positions and there is break between long working hours.

Another way to ensure that the employees is by practicing flexible working hours. Instead of continuous long hours, it can be broken to a few hours at a time until the objective is completed.

Through this study, the methods to implement inherently safety design was determined. Every aspect of an office building was identified and discussed on how inherent safety design can provide a safer working environment. Also, guidelines in developing a safer office by integrating inherent safety measures was provided.

The office surroundings and equipment can look harmless briefly but might be hiding danger in the simplest form, as an example, chair wrongly placed. A simple change in temperature, can cause employees' health to degrade. These is due to the climate change that we are having.

When from a hot environment, we move into cold environment, the body will try to adapt to a sudden change in temperature which can result with some people to fall sick. Due to this, the ventilation system in office buildings plays a very important role in maintaining the climate within the office buildings.

Further study can be done by including the effect on the health of the employees before and after the implementation of inherent safety design in office buildings, the carbon footprint produced by the office buildings before and after the implementation of inherent safety design in office buildings, and ways to improve the environment surrounding office buildings and the effect it has on the employee's productivity.

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