NOISE EXPOSURE MANAGEMENT SYSTEM BASED ON FACTORIES AND MACHINERY (NOISE EXPOSURE) REGULATIONS 1989

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ABSTRAK

Kehilangan pendengaran akibat bunyi (NIHL) adalah kelaziman yang tinggi di kalangan industri di Malaysia kerana NIHL adalah kes tertinggi yang menyumbang 5366 kes yang diterima pada tahun 2015 di kalangan penyakit dan keracunan pekerjaan. Pendedahan terlalu banyak bunyi mungkin menyebabkan perubahan sementara dalam pendengaran atau dering sementara di telinga pekerja yang boleh menyumbang kepada kehilangan pendengaran yang disebabkan oleh bunyi. Selain itu, bising yang berlebihan juga boleh menyebabkan komunikasi lisan yang lemah antara pekerja dan secara tidak langsung menjadi faktor risiko untuk menyebabkan kemalangan. Pada masa ini, peraturan-peraturan pelaksanaan bunyi bising diubah dari loji ke loji kerana kurang teknik sistematik bagi syarikat dan pekerja untuk mematuhi peraturan yang merupakan Factories and Machinery (Noise Exposure) Regulation 1989 dan mengekalkan program keselamatan yang berkesan. Disebabkan masalah ini, sistem pengurusan pendedahan bunyi perlu dibangunkan dalam kajian ini untuk mengatasi masalah tersebut. Objektif kajian ini adalah untuk membangunkan rangka kerja Sistem Pengurusan Pendedahan Kebisingan (NEMS), membangunkan prototaip NEMS dan mengesahkan sistem pengurusan yang dibangunkan. Kaedah yang digunakan untuk membangunkan NEMS adalah berdasarkan konsep Plan-Do-Check-Act (PDCA). "Plan" diterima pakai untuk mengkaji dan memahami unsur-unsur dan keperluan Pabrik dan Mesin (Pendedahan Kebisingan) 1989. "Do" diadopsi untuk membangunkan rangka kerja dan sistem. "Check" digunakan untuk mengesahkan sistem dengan menggunakan data tanaman proses sebenar yang dikumpulkan. "Act" digunakan untuk mengoptimumkan sistem untuk menjadikan sistem lebih cekap dan mematuhi sepenuhnya Kilang dan Jentera (Pendedahan Kebisingan) 1989. NEMS yang dibangunkan secara sistematik memberi panduan kepada pengguna akhir untuk mengenal pasti jurang dan penyelesaian yang berkaitan dengan ketidaksempurnaan pembangunan, program dan dokumentasi tumbuhan untuk mematuhi peraturan bunyi. Dengan NEMS yang dilaksanakan, syarikat dan pekerja akan dapat mematuhi peraturan secara sistematik.

ABSTRACT

Noise-induced Hearing Loss (NIHL) is high prevalence among the industries in Malaysia as NIHL is the highest case which accounted for 5366 cases received in 2015 among occupational diseases and poisoning. Too much noise exposure may cause a temporary change in hearing or a temporary ringing in workers' ears which can contribute to noise-induced hearing loss. Also, excessive noise can also lead to poor verbal communication between workers and indirectly become a risk factor to cause an accident. Currently the noise regulations implementation degrees were varied from plant to plant due to lacking of systematic technique for companies and workers to comply with noise regulation which is Factories and Machinery (Noise Exposure) Regulation 1989 and maintain the effective safety programs. Due to these problems, a noise exposure management system needs to be developed in this study to overcome the issues. The objectives of this research are to develop framework of Noise Exposure Management System (NEMS), develop prototype of NEMS and validate the developed management system. The method used to develop NEMS is based on Plan-Do-Check-Act (PDCA) concept. "Plan" is adopted to study and understand the elements and requirements of Factories and Machinery (Noise Exposure) 1989. "Do" is adopted to develop framework and system. "Check" is adopted to validate the system by using real process plant data that collected. "Act" is adopted to optimize the system to make the system more efficient and fully comply with Factories and Machinery (Noise Exposure) 1989. The developed NEMS systematically guides the end users to identify gaps and solutions related to imperfection of the development, program and documentation of plant to comply with the noise regulations. With the implemented NEMS, companies and workers will able to comply with the regulation systematically.

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LIST OF SYMBOLS

dBA	A-weighted decibels
%	Percentage

LIST OF ABBREVIATIONS

DOSH	Department of Occupational Safety and Health
HCP	Hearing conservation program
HCP	Hearing protection device
NEMS	Noise Exposure Management System
NIHL	Noise-induced Hearing Loss
OSH	Occupational Safety and Health
P&ID	Piping and Instrumentation Diagram
PPE	Personal protective equipment
PSI4MS	Process Safety Information Management System
PSI	Process Safety Information
PSM	Process safety management
SOCSO	Social Security Organization
WHO	World Health Orgazination
PDCA	Plan-Do-Check-Act
SMEs	Small and medium-sized enterprises
EnMS	Energy Management System
KPIs	Key performance indicators
OIS	Organizational Innovation System
R&D	Research & Development
OPTRAMS	Operational Training Management System
ANMS	Aviation's Airport Noise Management System
WHO	World Health Orgazination

CHAPTER 1

INTRODUCTION

1.1 Introduction

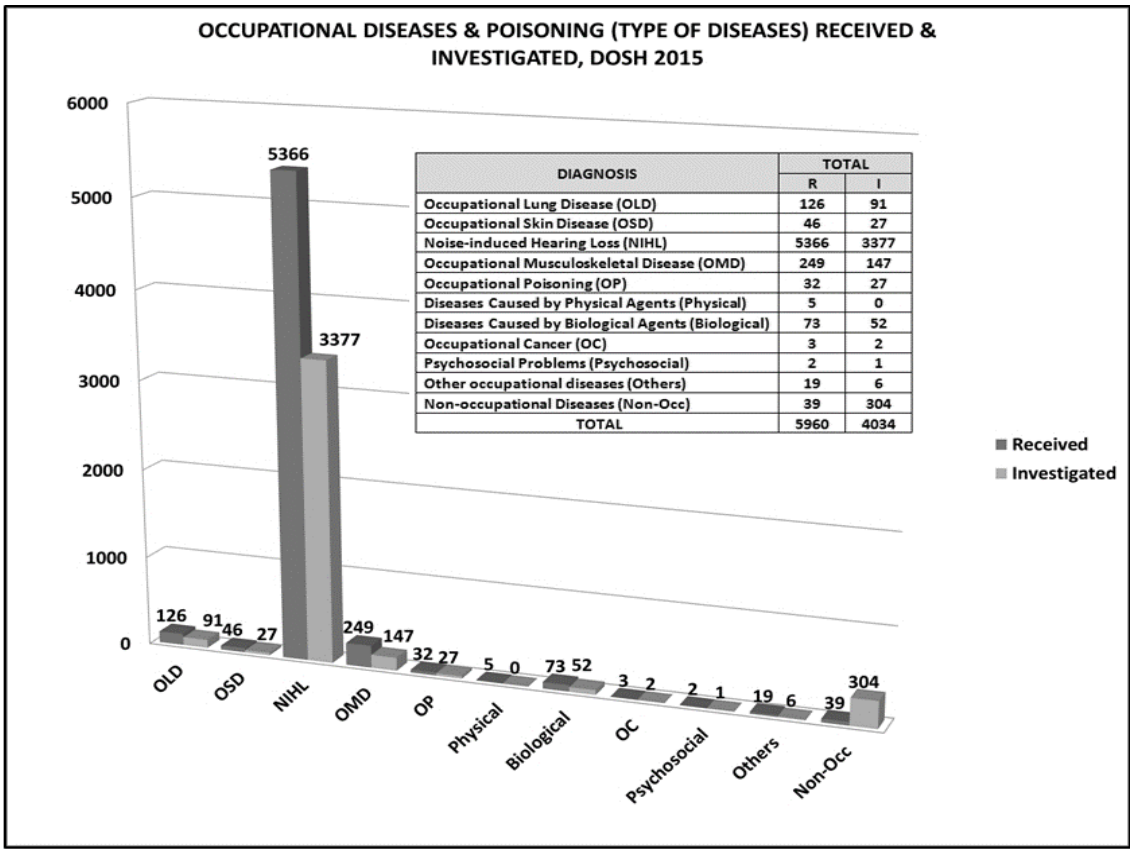
Noise is excessive or unwanted sound which potentially results in annoyance or hearing loss. Noise exposure is common in the process industry that use machine for operation. Noise can be described in terms of intensity (perceived as loudness) and frequency (perceived as pitch). Too much noise exposure may cause a temporary change in hearing or a temporary ringing in your ears. These short-term problems usually go away within a few minutes or hours after leaving the affected area of noise. However, repeated exposures to loud noise from the day to day work in an affected environment can lead to permanent, incurable hearing loss, tinnitus or other health issues. Workplace noise monitoring is required to assess the risks to its employee's health and safety created by exposure to noise in the workplace, and put the suitable control measures after the monitoring.

In addition, noise hazard is harmful which could contribute in Noise-induced Hearing Loss. Noise can cause a series of detrimental health effects on human beings, such as hearing Loss, annoyance, cardiovascular disease, sleep disturbance, immune effects, biochemical effects, reproductive effects and performance effects, among which the best studied effect produced by the overexposure to noise is loss of hearing (Li *et al*., 2016). Therefore, several kinds of measures must be implemented to take care of the safety and health of workers. For example, Guidelines for Control of Occupational Noise 2005 are intended as basic practical guidance to the employer in developing noise

control measures, thereby helping people comply with the requirements of the Factories and Machinery (Noise Exposure) Regulations 1989.

On the other hand, there are so many challenges and issues about how to cope with noise hazards. Even though some control measures are already placed by industries, there are still have many cases occurring with huge impact which harm to human hearing's ability. According to Tahir *et al.* (2014), Malaysia has become part of the world's manufacturer among Asian country. Therefore, this has put manufacturing industry as a major sector in the foreign direct investment in Malaysia. It brought a lot work opportunities to people and revenue to Malaysia, and the indirectly contributed in development of the country. However, this recognition has created occupational safety and health issues among the workers while they are at work. These arising OSH issues impacted additional noise hazards, insufficient number of OSH competent person, lacking of competent service provider and more workers were at risk in developing Noise Induced Hearing Loss (NIHL). Besides that, ineffective and unsuccessful of safety measures or programs could be leading sources to Noise Induced Hearing Loss.

Based on Figure 1.1, Noise-induced Hearing Loss (NIHL) is the highest case which accounted for 5366 cases received in 2015 among occupational diseases and poisoning (Department of Occupational Safety and Health, 2015). It due to most of the workers expose to excessive noise and the control measures might be not enough or not effective. Therefore, Figure 1.1 has shown that noise exposure is one of the main hazards in the workplace that could harm hearing's ability, and it needed to put concern on this hazard.



DIAGNOSIS	TOTAL	
	R	I
Occupational Lung Disease (OLD)	126	91
Occupational Skin Disease (OSD)	46	27
Noise-induced Hearing Loss (NIHL)	5366	3377
Occupational Musculoskeletal Disease (OMD)	249	147
Occupational Poisoning (OP)	32	27
Diseases Caused by Physical Agents (Physical)	5	0
Diseases Caused by Biological Agents (Biological)	73	52
Occupational Cancer (OC)	3	2
Psychosocial Problems (Psychosocial)	2	1
Other occupational diseases (Others)	19	6
Non-occupational Diseases (Non-Occ)	39	304
TOTAL	5960	4034

Figure 1.1. Analysis of occupational disease and poisoning by sector.

Source: Department of Occupational Safety and Health (2015)

1.2 Problem Statement

Nowadays, most of the countries are industrializing on a wide scale including Malaysia. It due to the development of industries can help a country to generate more revenue, more job opportunities and lead to the removal of poverty to a great extent. However, there are a lot of safety issues among the industries have arisen in our country. It also means that there are lot of potential hazards such as noise hazard, chemical hazard, biological hazard and other hazard in an industry which can injure workers and affect the health of workers, and then indirectly affect the work's efficiency. On the other hand, nowadays machinery is being extensively used. Most of the industries are using machineries to simplify the work process which can save time and cost. However, noise can be generated through operating machine. Too much noise exposure may cause a temporary change in hearing or a temporary ringing in workers' ears which can

contribute to noise-induced hearing loss. Also, excessive noise can also lead to poor verbal communication between workers and indirectly become a risk factor to cause an accident. Poor verbal communication will also reduce the work efficiency and cause a barrier to workers to work when they need to distribute orders verbally.

The Factory and Machinery (Noise Exposure) 1989 as specified by Department of Occupational Safety and Health Malaysia (DOSH) requires employers to meet certain documentation, implementation and training requirements. However, DOSH does not specify any methods for companies and workers to follow in order to comply with the regulations. On the other hand, even though there is some control measures taken by companies with the purpose to eliminate or reduce the risk, the accidents still happen and the noise-induced hearing loss still high prevalence among the industries. It is mainly due to low awareness among companies and workers toward noise hazard. They tend to ignore the provided Personal Protective Equipment (PPE) and did not utilize it, and this will indirectly increase the rate of accidents. It may also due to the uncomfortable wear of PPE and cause a burden to workers, thus they choose to not wearing of PPE.

Besides that, currently the noise regulations implementation degrees were varied from plant to plant due to lacking of systematic technique for industries to comply with noise regulations requirements and maintain the effective safety programs. Safety programs that implemented by industries might not be successful. Workers participation in safety program are not mandatory in some industries. This may lead to an unsuccessful and ineffective safety program. Furthermore, some of the management systems are expensive which cannot be afforded by small companies because they do not have enough of budgets. It may also due to the management systems are highly technical and the workers will face difficulties to utilize and follow it.

Moreover, companies and workers tend to not comply with the regulations. For example, they did not control the noise exposure level in the workplace within the permissible exposure limit which listed in Factory Machinery (Noise Exposure) Regulation 1989, First Schedule. Workers may not fully understand the regulation requirements and full of uncertainty that how to comply with the regulations. Also,

there is lacking of a systematic way to monitor the compliance of companies and workers. Also, there is lacking of a systematic way to guide companies and workers to comply with the regulations.

Due to these problems, a noise exposure management system needs to be developed in this study to overcome the issues. This noise exposure management system systematically guides the end users to identify gaps and solutions related to imperfection of the development, program and documentation of plant to comply with the noise regulations. With the implemented noise exposure management system, companies and workers will able to comply with the regulation systematically. Workers would carry out exposure monitoring to determine the noise exposure limit and further put suitable control measures if the exposure limit is exceeded as stated in regulation. Besides that, based on this noise exposure management system, training program will be provided to workers to ensure they utilize the hearing protection device.

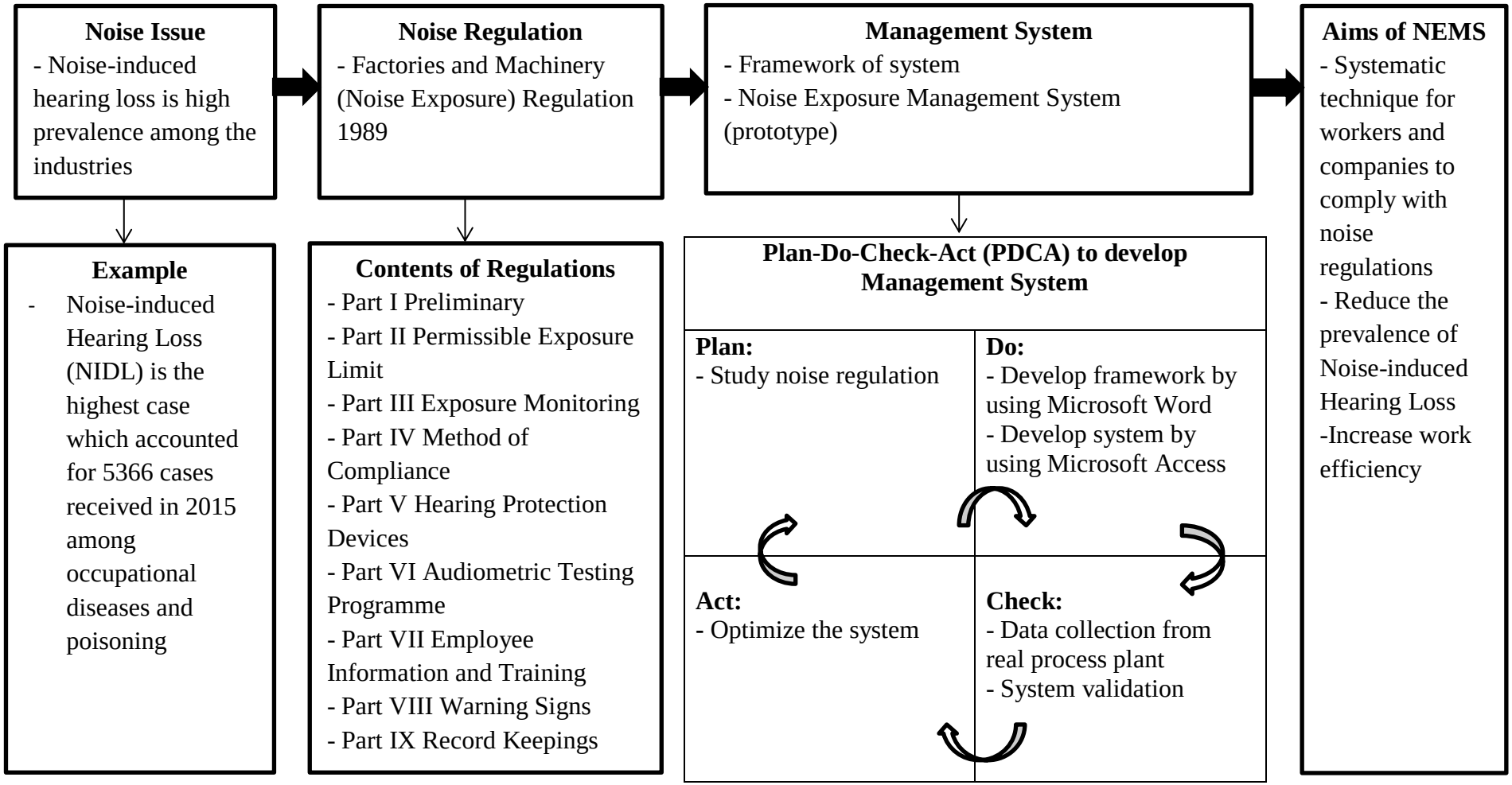
1.3 Research Questions

- What is the suitable framework for noise exposure management system that compliance with Factories Machinery (Noise Exposure) Regulation 1989?
- What is the suitable prototype for noise exposure management system that compliance with Factories Machinery (Noise Exposure) Regulation 1989?
- How the developed noise exposure management system can be validated?

1.4 Research Objectives

- To develop framework of noise exposure management system that compliance with Factories Machinery (Noise Exposure) Regulation 1989
- To develop prototype of noise exposure management system that compliance with Factories Machinery (Noise Exposure) Regulation 1989
- To validate noise exposure management system which consists of framework and prototype through case studies

1.5 Conceptual Framework



Based on the conceptual framework, it provides an outline of how the research is conducted. First of all, the noise issue is identified which will cause significant adverse effect to workers. For example, Noise-induced Hearing Loss (NIHL) is the highest case which accounted for 5366 cases received in 2015 among occupational diseases and poisoning by referring to Figure 1.1. It has shown that NIHL was high prevalence among the industries. Therefore, noise regulations such as Factories and Machinery (Noise Exposure) Regulation 1989 must be complied by all workers and companies. There are nine parts in the regulation which are:

- Part I Preliminary
- Part II Permissible Exposure Limit
- Part III Exposure Monitoring
- Part IV Method of Compliance
- Part V Hearing Protection Devices
- Part VI Audiometric Testing Programme
- Part VII Employee Information and Training
- Part VIII Warning Signs
- Part IX Record Keepings

On top of that, a management system named as Noise Exposure Management System (NEMS) which consists of framework and prototype of NEMS. Plan-Do-Check-Act (PDCA) concept was used to develop Management System. For “Plan”, study the noise regulation and identify its requirements. For “Do”, develop framework by using Microsoft Word while system was developed by using Microsoft Access. For “Check” data collection was conducted at real process plant which used to validate the developed system. For “Act”, optimize the developed system to make it more efficient and ensure it fully complied with the noise regulation. Lastly, the aim of NEMS is to provide a systematic technique for workers and companies to comply with noise regulation. Also, NEMS aims to reduce the prevalence of Noise-induced Hearing Loss and indirectly increase work efficiency.

1.6 Scope of Study

The study focuses on an element of industrial hygiene which is noise exposure. The case studies are conducted at two process plants where the employees exposed to noise hazard. These two process industries are located in Pahang. Besides that, the documents, reports or real process plant data that collected are used as document review for data validation. Interview of practitioners are also carried out to obtain the relevant information. The regulation that has referred to develop Noise Exposure Management System (NEMS) is Factories Machinery (Noise Exposure) Regulation 1989 and its requirements are revised and analysed to develop NEMS. The main purpose of this regulation is to determine the noise exposure level and put control measures to cope with the noise hazard in order to create safe work environment.

1.7 Significance of Study

By introducing the Noise Exposure Management System (NEMS), it can repair the issues and solve the problems that have arisen. The Noise Exposure Management System has shown a more systematic way to lead the companies and workers to comply with the Factories and Machinery (Noise Exposure) Regulation 1989 systematically.

Furthermore, NEMS can lead the companies and workers become more aware of their own safety and carry out works safely to minimize or prevent the accidents from happening as the developed framework shows a systematic way to comply with regulation. The NEMS can also lead the safety programs to be implemented successfully. It can make sure every worker involve in safety programs and follow the guidelines have suggested during the safety program. Besides that, health surveillance programme or audiometric test can be carried out by companies on time after workers exposed to noise hazards.

On the other hand, the Noise Exposure Management System has shown a more easy and comprehensive way to let the workers get to know about the related regulations which is Factory Machinery (Noise Exposure) Regulations 1989. Therefore,

workers can comply with the following rules in order to take care of their own safety. It can also prevent penalty such as fine for workers or companies who are not in compliance with the regulations. In addition, by introducing this noise exposure management system, it can solve the problem of companies which only have low budget. It due to the cost of this management system is low which can be afforded by them.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, there is some relevant information from journals, books and websites that related to this research. Challenges and issues of noise management also discussed in this chapter. Besides that, it focused on Hearing Conservation Program (HCP) and training program, Noise-induced Hearing Loss (NIHL), Factories and Machinery (Noise Exposure) 1989, Plan-Do-Check-Act, framework of system, noise management system and others management system.

2.2 Challenges and Issues of Noise Exposure Management

Malaysia has become part of the world's manufacturer among Asian country. This has put manufacturing industry as a major sector in the foreign direct investment in this country. However, this recognition has created occupational safety and health (OSH) issues among the workers while they are at work. These emerging OSH issues impacted additional noise sources, use of hazardous material, insufficient number of OSH competent person, lacking of competent service provider and more workers were at risk in Noise-induced Hearing Loss (NIHL). NIHL has been the most common occupational health problem in the world (Tahir *et al*., 2014).

Edward et al. (2016) has shown that nowadays occupational Noise-induced Hearing Loss (NIHL) is still prevalent in significant number. Even though noise has been shown to cause hearing loss for centuries and serious efforts were made to reduce excessive noise at work for past 40 years. Also, according to (Mihailovic *et al*., 2011), noise or undesirable sound is one of the most ubiquitous pollutants which permeate many aspects of life throughout the inhabited world. Man is exposed to unpleasant and distracting sounds at work and outside of work, which adversely affects his health and working ability. Noise pollution as a kind of physical pollution is not fatal, but it can directly influence sense organs. The impact of noise will primarily be localized on hearing damage called Noise-induced Hearing Loss (NIHL), which has profound social and occupational impact on affected individuals and substantially reduces quality of life.

Based on Figure 1.1 and Department of Occupational Safety and Health (2015), NIHL is the highest case which accounted for 5366 cases received in 2015 among occupational diseases and poisoning. This common disease has shown a raising trend in the list of occupational disease under the Department of Occupational Safety and Health (DOSH) since more than a decade ago. It has shown that noise exposure among the industries is a hot issue that should put concern on. Also, people are not really aware the severity of noise hazard because the harm are not directly hurt or harm on them. Instead, they will get temporary hearing loss or NIHL which can affect their hearing's ability and affect their work's ability. It will reduce the work rate, quality of work and lead to miscommunication among workers which can cause an accident. People tend to get NIHL due to most of the workers expose to excessive noise and the control measures are not enough.

Moreover, as NIHL was the highest reported occupational disease cases compared to other diseases such as muscular skeleton, back pain, skin and lung disease, this trend has resulted to a significant increase of eligibility for compensation from the Social Security Organization (SOCSO) from year 2003 to 2009. Therefore, Figure 2.1 has shown that noise exposure is important for people to put concern on it (Department of Occupational Safety and Health [DOSH], 2009).

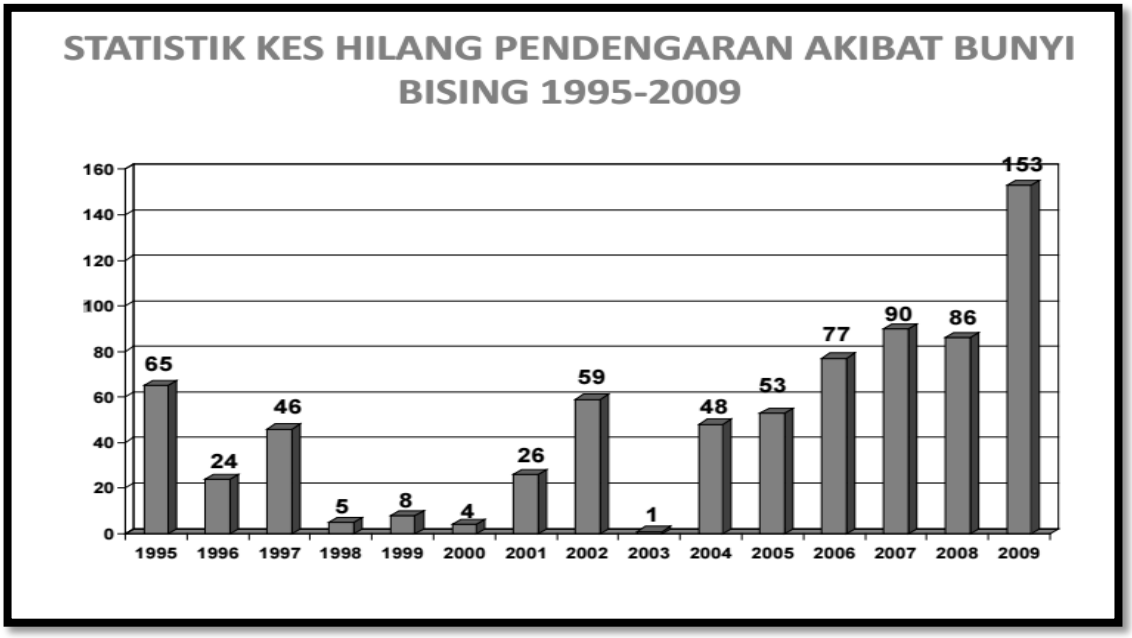


Figure 2.1. Statistic of Noise-induced Hearing Loss that are eligibility for compensation from the SOCSO from Year 1995 to 2009.

Source Department of Occupational Safety and Health 2009

On the other hand, the specific PPE used to control noise is known as Hearing Protection Device (HPD). Traditionally, there are three types of common HPD used which are the ear muff, earplugs and ear canal caps and basically, these HPD reduce noise by blocking the noise from entering the ear canal. The effectiveness of the HPD to reduce NIHL is very much depending on the regular use by the worker. Even though the advantages of the Hearing Conservation Program (HCP) and HPD have been widely exposed, there are still many of industrial workers refuse to comply with the HCP and the usage of HPD. Since this issue has become one of the major concerns among the public health expert, it is necessary to identify the reasons why the industrial workers do not want to use the HPD (Yahya *et al*., 2016).

According to Yahya *et al*. (2016), the main reasons that why workers refuse to use provided HPD: uncomfortable, barrier in communication and lack of awareness. Most of the workers from that study felt uncomfortable when they were wearing HPD. They do know the importance of HPD in reducing risk and it can prevent to get NIHL.

However, some workers are preferred to protect their ears with cotton rather than the provided HPD which cause uncomfortable. Some workers also said that HPD will cause them annoyed because HPD distracts the working activities and cause pain of ears. Besides that, one participant said that he uses his cell phone's earphone as the HPD rather than using the provided earplug because he felt more comfortable. He said that personally earphone is more comfortable for him and think that it will be slightly effective in reducing the noise that enters his ear (Yahya *et al*., 2016).

Furthermore, it will cause a barrier in communication among workers when they are wearing HPD and indirectly lead the workers not wearing the HPD in a noisy workplace. Besides that, safety issue can be raised up in some situation as putting on the HPD is a danger because they cannot hear the sound nearby. If a moving vehicle passes by, it may result in an accident. In addition, some workers still lack of awareness about the severity of noise hazard. Some of them think that they have no risk of getting NIHL and they refuse to wear HPD. Also, workers tend to influence by peer worker who did not wear HPD, and did not have any problem with his hearing since he has worked at there for many years. Therefore, the workers are not preferred to wear HPD *(Yahya et al*., 2016).

In addition, most industries failed to have an effective Hearing Conservation Programme (HCP) because they did not monitor and control the noise exposure, did not performed audiometric test to the employees exposed to noise and did not give training and education regarding noise hazard to the employees (Nor Saleha & Noor Hassim, 2006). As the HCP play an important role to improve the safety and health of workers, compliant percentage must be improved by giving more emphasis on the importance of hearing conservation programme as an effort to tackle the hearing problems among workers exposed to noise.

2.3 Noise-induced Hearing Loss (NIHL)

Noise-induced hearing loss (NIHL) is the gradual bilateral sensorineural hearing loss that occurs due to excessive noise exposure (Nor Afiah, Farhan, & Anita, 2016).

Currently, there is no cure for NIHL. Once the hair cells in the inner ear of people have been damaged by excessive noise, they cannot be restored or regrew. However, noise-induced hearing loss can be treated with the use of hearing aids. NIHL can be known as temporary or permanent sensorineural hearing loss which caused either by a single exposure to a very loud sound or by repeated exposure to louder sounds over a long period. The World Health Orgazination (1991) defines material hearing impairment as an average of the hearing threshold levels for both ears that exceed 25 dBA at 1000, 2000, 3000, and 4000 Hz.

Furthermore, Noise-induced hearing loss (NIHL) would lead to abnormal behaviour such as anxiety disorders, mood disorders, personality disorders and schizophrenia as well as communication breakdown (Filza Ismail *et al.*, 2013). These abnormal behaviours would indirectly affect the job performance of worker and sometimes it could lead to an accident. Besides that, NIHL is a worldwide problem which across many countries in the industry and it contributes to 16 percentage of hearing loss among adults globally, ranging from 7 percentages to 21 percentages in various sub-regions and higher in developing countries. Also, Razman *et al.* (2010) stated that occupational Noise-induced Hearing Loss (NIHL) is considered one of the most common occupational disorder in industrial countries nowadays. In Malaysia, cases of NIHL investigated by the Department of Occupational Safety and Health (DOSH) had increased from 120 cases in 2007 to 427 cases in 2009 (Filza Ismail et al., 2013).

In addition, noise hazard can cause different kind of health problems. Noise-induced Hearing Loss and tinnitus are among the most common and well known consequences when there is an excessive noise exposure or prolonged noise exposure. Other than these consequences, health problems such as anxiety and hypertension have also been reported to be related to noise exposure (Yongbing & Hal Martin, 2013). Also, Nair and Kashyap (2009) have stated that NIHL can cause annoyance, interference with speech and communication and psychological effect. These health problems will cause workers cannot focus on their work and further affect the work performance and efficiency.

2.4 Factories and Machinery (Noise Exposure) Regulations 1989

The Factories and Machinery (Noise Exposure) Regulations 1989 was enacted and came into force on the 1st February 1989. These regulations mainly used to sets forth maximum permissible noise limits, and provides for exposure monitoring, hearing protection devices, and audiometric testing programmes (International Law Book Services, 2014). These regulations aimed to protect workers from excessive noise while at work and to prevent workers being affected by Noise-induced Hearing Loss. Also, these regulations are applied to all factories which workers expose to excessive noise level in the workplace but cover mostly only industries involved in manufacturing, construction, mining and quarrying.

In Malaysia, exposures in the workplace are regulated under the Factories and Machinery Act 1967 and also under the more comprehensive Occupational Safety and Health Act enacted in 1994. The Factories and Machinery (Noise Regulation) 1986 is one of the regulations that under Factories and Machinery Act 1967. Factories and Machinery Act 1967 covered 23 percentage of the workforce which are manufacturing, construction, mining and quarrying work. The main purpose of this act is to prevent occurrence of occupational accidents and disease at specified workplaces. Based on the Factories and Machinery (Noise Regulation) 1989, all employers are required to have a hearing conservation programme if the noise levels is 85 dBA or higher and, to utilize noise controls, if feasible, and administrative control or both if the employee full-shift average exposures reach 90 dBA. The enforcement is under the authority of the DOSH (International Law Book Services, 2014).

Factories and Machinery (Noise Regulation) 1989 consist of 34 regulations which divided into ten parts and appended with two schedules. In general the ten parts of these regulations are as follows:

1) Part I – preliminary

2) Part II – permissible exposure limit

3) Part III – exposure monitoring

4) Part IV – methods of compliance

5) Part V – hearing protection devices

6) Part VI – audiometric testing program

7) Part VII – employee information and training

8) Part VIII – warning signs

9) Part IX – record keeping

10)Part X – miscellaneous

These regulations describe the obligations of employees to co-operate with the management by using a noise dosimeter during employee exposure monitoring, wear and make full and proper use of the hearing protection device provided for their use, attend or undergo audiometric testing or any medical examination or test arranged by the occupier and attend employee information and training programs conducted by the occupier. The permissible noise exposure level was set at 90 dBA for 8 hours and allowed to change by 5 dBA for every doubling or halving of time (please refer to the First Schedule in the FMA, 1989 in Appendix 1). The standard also set maximum exposure level for continuous noise at 115 dBA, regardless of duration, and no employee shall be exposed to impulsive noise exceeding a peak sound pressure level of 140 dB (International Law Book Services, 2014).

2.5 Hearing Conservation Program and Training Program

Safety improvement is a must to take care the safety and health of worker to prevent or minimize the occurrence of accidents and undesired health effect, as well as environment to prevent any damage to environment. To taking care the safety and health of workers in the aspect of noise by safety improvement, Hearing Conservation Program (HCP) and training program should be provided or held. In Malaysia, Hearing conservation programme (HCP) was introduced under Factory and Machinery (Noise Regulation) 1989. The main objective of hearing conservation programme is to protect

workers from noise exposure and hence preventing NIHL. According to Nor Saleha and Noor Hassim (2006), after more than 14 years of Factory and Machinery (Noise Regulation) 1989, the industries' compliance towards HCP is still unknown. There are 7 elements in HCP as follow:

1) Government policy and owner policy on the hearing conservation programme

2) Noise exposure survey and monitoring

3) Noise control

4) Hearing protection devices,

5) Audiometric evaluation and treatment

6) Training programme

7) Record keeping.

Compliance to HCP is expected to give positive effect in the reduction of noise exposure at work place. Therefore, the prevalence of NIHL among workers exposed to noise is expected to be reduced. According to Nor Saleha and Noor Hassim (2006), certain criteria of the industries i.e. status of ownership, number of employees, duration in operation and the existence of officer in charge were selected as the independent variables because it influences the compliance of the industries towards HCP. Foreign investors are mostly from developed countries where the law in their countries is more stringent and most of these investors apply their countries' related law and regulations locally.

They are also usually answerable to the parent companies in the country of origin. Number of employees was chosen as one of the factors because it reflects the size of the industries i.e. big industry or small and medium industry. Big industries basically have more capitals and are able to allocate specific budgets on safety programmes such as HCP if compared to small or medium industries. Operation years were selected because older industries are proxy to older technology where it involves a lot of hazard. Older types of machines or equipment are probably still in use at older

industries, thus the noise hazard might be more prominent at these industries compared to newer technology at newer industries.

On top of that, based on Factory and Machinery (Noise Regulation) 1989, training programme should make sure the workers are informed with the information of the effect of noise on hearing, the purpose and advantages of hearing protection devices, the provision of these regulations, and the information of purpose and procedure of audiometric test. Training programme is a must to be provided for every worker to make them familiar and adapted to their work tasks, and make them be a more competent person. Training in occupational risk prevention is an important issue, notably because it constitutes a prerequisite to improving health and safety in the workplace (Vidal-Gomel, 2017). With provided safety training, it can enhance the workers' skills in order to increase job performance. Young workers are more likely to be injured at work than older workers (Laberge, Maceachen, & Calvet, 2014), and this appears to be related to inexperience. Therefore, training should be provided to all workers regularly or follow the schedule.

2.6 Plan-Do-Check-Act (PDCA)

Plan-Do-Check-Act (PDCA) is an iterative four-step management method used in organization for the control and continual improvement of processes and products (American Society for Quality, 2017). Plan-Do-Check-Act is used as a model for continuous improvement or whenever implementing something new. According to Jovanovic *et al*. (2017), energy management system is implemented in Serbian manufacturing by using Plan-Do-Check-Act cycle approach. The study was carried out using an on-line questionnaire based on the ISO 50001 requirements to check the percentages of implementation of PDCA in Serbian manufacturing industries. Based on Figure 2.2, questions were grouped into 16 categories and presented according to the PDCA (Plan-Do-Check-Act) cycle. Based on Figure 2.3, average implementation of the PLAN phase (establishing basics for energy management) is 61.87%, implementation of the DO phase (realization of energy management processes) is 59.98%, implementation of the CHECK phase (monitoring and measurement of energy performance) is 59.61%,

and finally, implementation of the ACT phase (review and improvement of energy management) is only 35.34%. From all of these, PDCA is implemented in most of the energy management system of manufacturing industries in Serbia but also there may some requirements that those industries have not implemented.

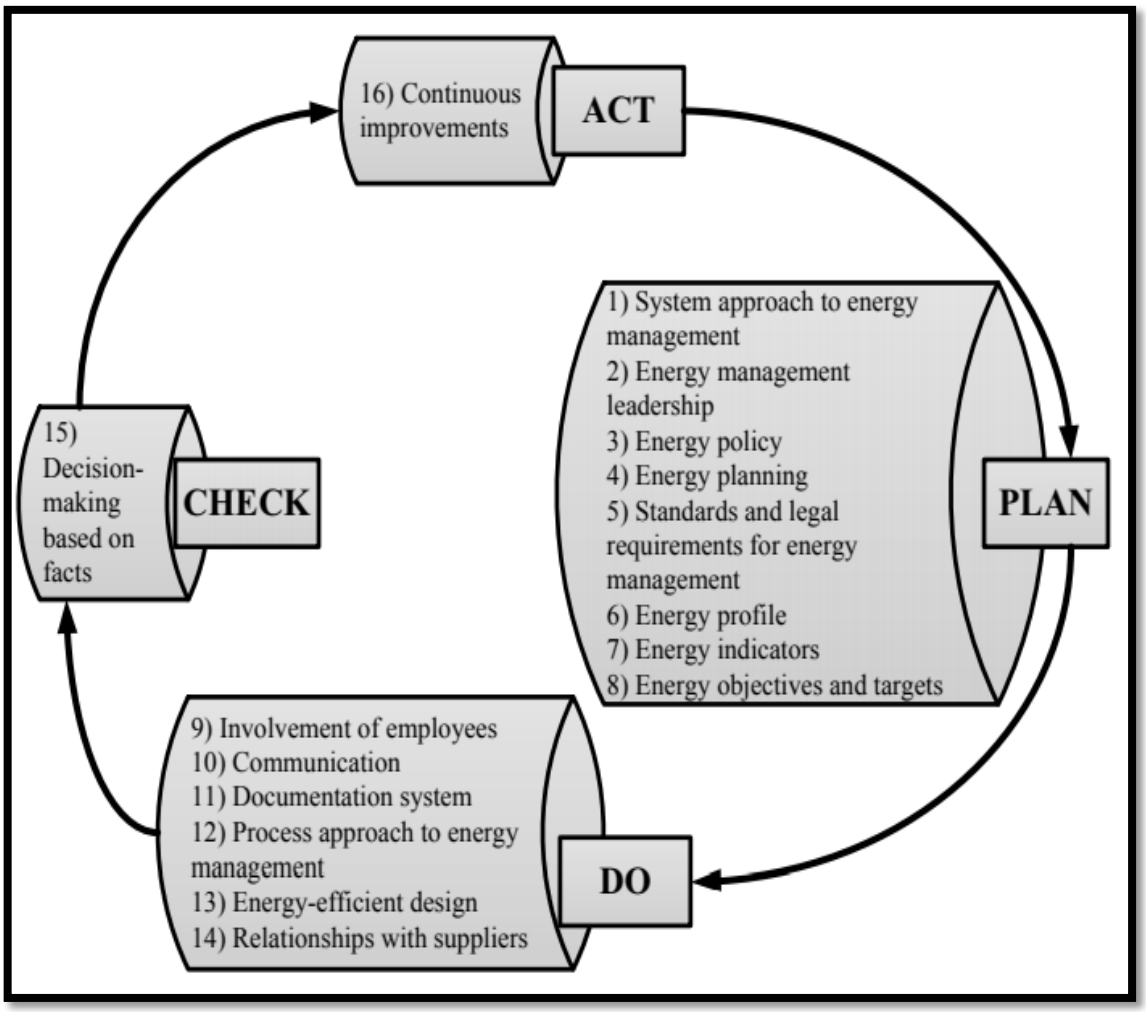


Figure 2.2. 16 categories of questions, presented according to PDCA cycle.

Source Jovanovic et al. 2017

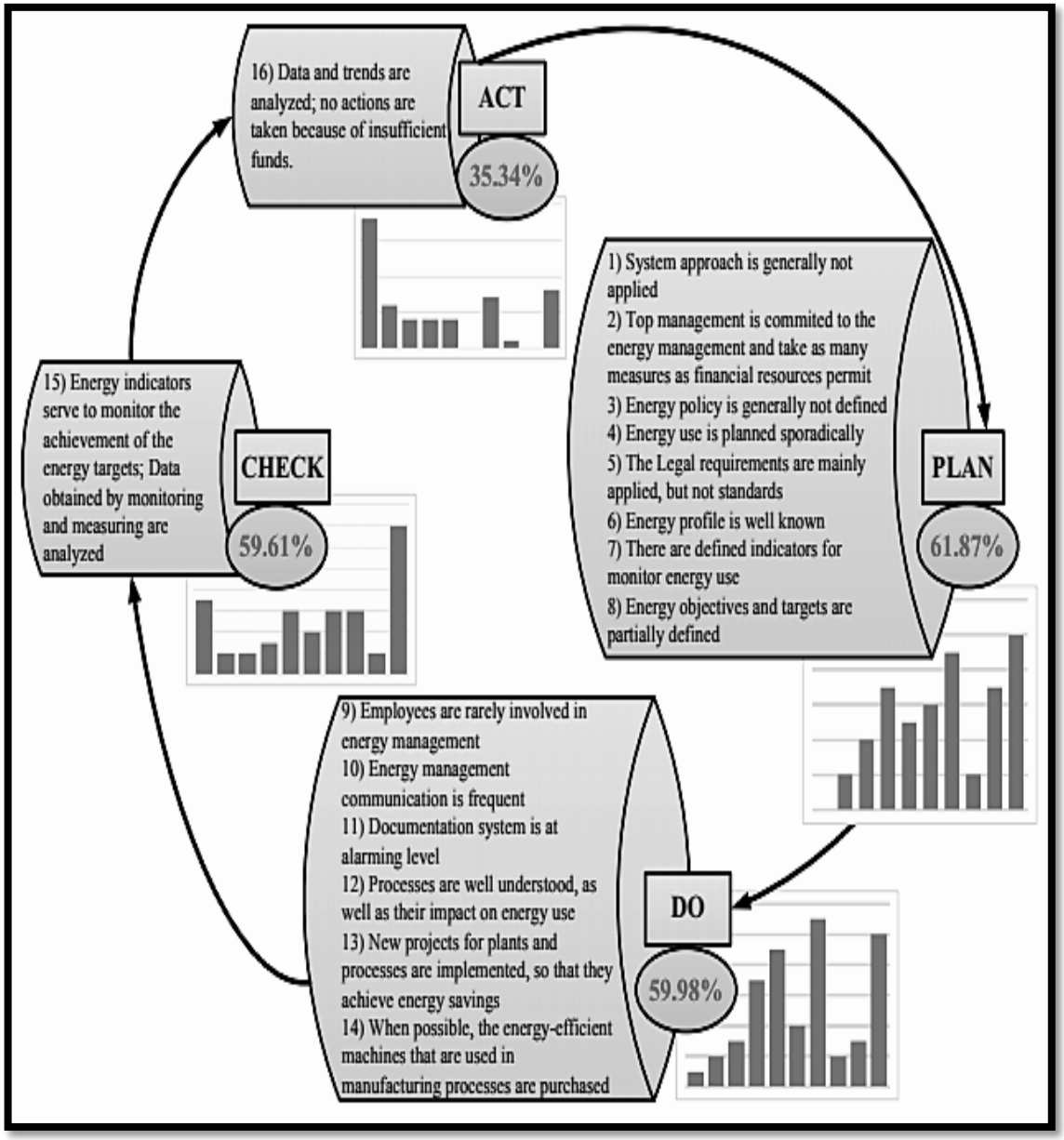


Figure 2.3. Energy management system implementation in manufacturing sectors in Serbia.

Source Jovanovic et al. 2017

Besides that, by referring to Figure 2.4, Prashar (2017) revealed that the prevailing approaches to energy optimization in the energy-intensive Small and medium-sized enterprises (SMEs) are prescriptive in nature, and lack a strategic orientation towards energy management. To fill this gap, he conceptualized a cyclic (PDCA) process based energy management system (EnMS) for the SMEs by integrating

energy saving activities to ensure continual improvement. Prashar (2017) has proposed that EnMS adopted a PDCA (Plan-Do-Check-Act) process approach for consistent energy efficiency and cleaner production.

Furthermore, for the validation of the proposed EnMS, a case of small-sized Indian paper mill was selected. The case exhibited the ramp of continuous improvement in the energy efficiency at the mill by illustrating two PDCA cycles. On top of that, there are four steps used to develop EnMS:

- Step I (Plan) involved creating energy management roles with management support, energy auditing, identifying energy-saving opportunities and developing action plan;
- Step II (Do) was about creating communication, awareness and motivation before the implementation of the action plan;
- Step III (Check) involved periodic monitoring, analysis and reporting of the energy key performance indicators (KPIs), and benchmarking enterprise energy performance.
- Step IV (Act) was about conduct periodic management review and update action plan by incorporating new ESAs. The subsequent PDCA cycle was triggered by the biannual management review for exploring the new energy saving opportunities at the enterprise.

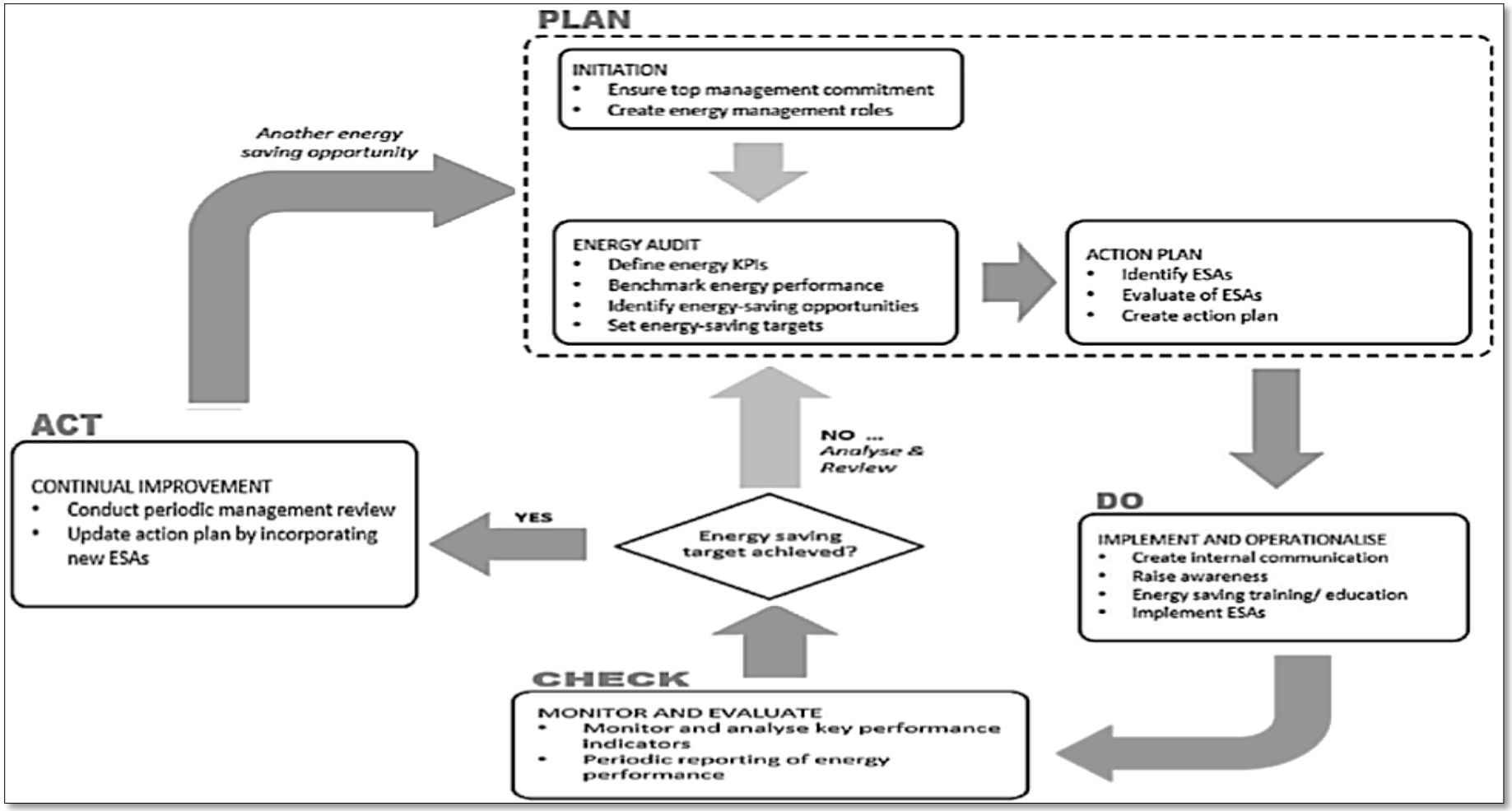


Figure 2.4. Integrated energy management system for SMEs.

Source Prashar 2017

Moreover, Ruiz (2008) has stated that Santa Clara Valley Water District adopted Plan-Do-Check-Act approach to an Environmental Management System.

“Plan” of Environmental Management System includes:

- Quality and Environmental Policy
- Strategic Planning
- Objectives and Targets
- Board Governance Policies

“Do” of Environmental Management System includes:

- Delivery of Services
- Environmental Management
- Permitting
- Targets and Objectives
- Environmental Regulatory
- Compliance

“Check” of Environmental Management System includes:

- Internal & External Audits
- Corrective and Preventive Action Request (CPAR) System
- Performance Reporting

“Act” of Environmental Management System includes:

- Reporting on status of environmental objectives and targets
- Reporting on status of compliance with environmental regulatory requirements
- Management Review

Furthermore, it stated that PDCA approach to an Environmental Management System brings a lot of benefits as it could:

- Reduction of negative impact to environment through systematic evaluation
- Increased adherence to environmental regulatory regulations

- Phased approach of implementation allows for utilization of organizational experience and knowledge
- Management review provides valuable input and promotes accountability

2.7 FRAMEWORK OF SYSTEM

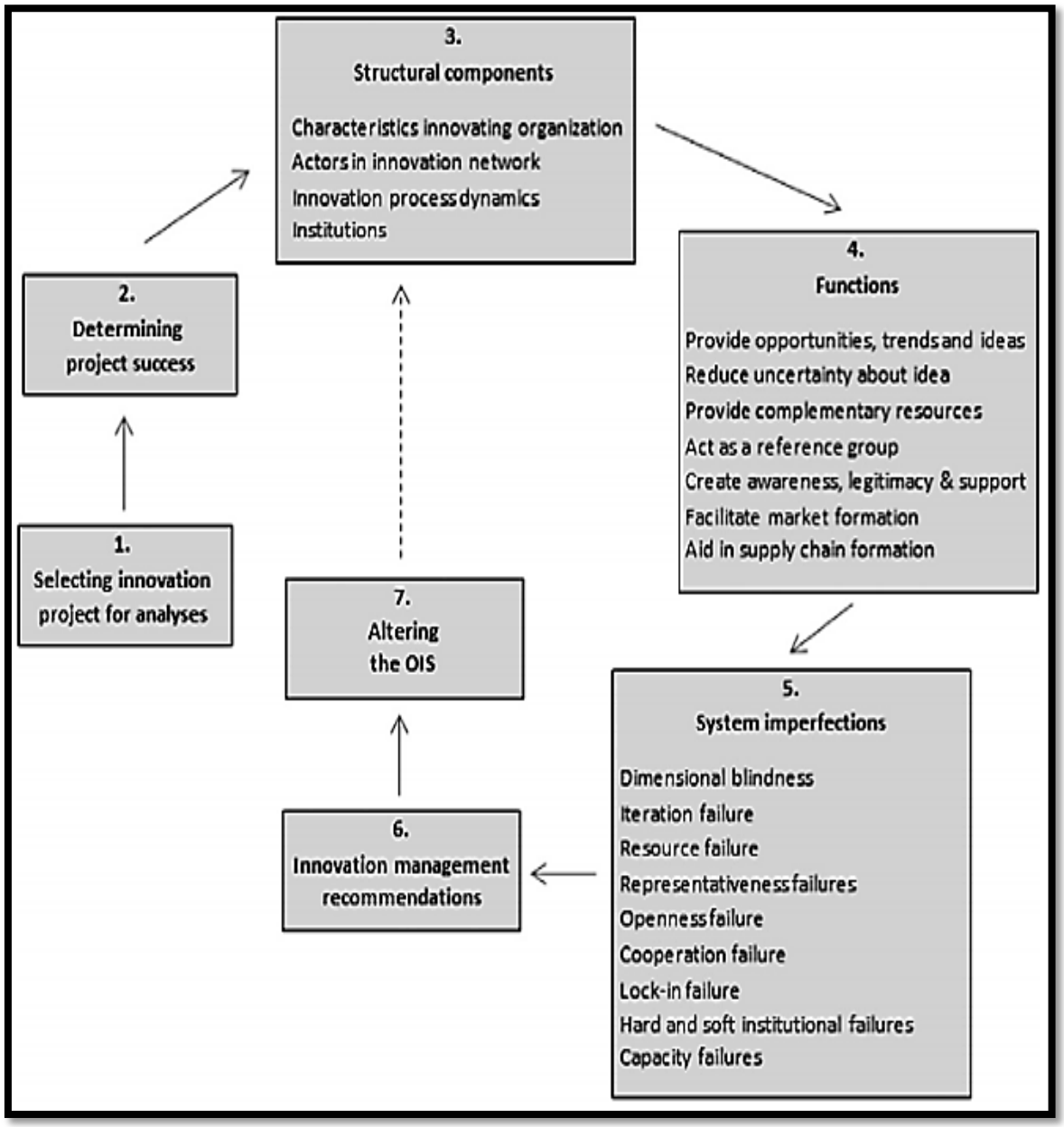


Figure 2.5. Framework for analysis of organizational innovation system.

Source Van Lancker *et al.* 2016

According to the study of Van Lancker *et al*. (2016), they define the Organizational Innovation System (OIS) and its key structural components, and discuss the identified functions and categories of potential imperfections. With the OIS, they provide a holistic, hands-on concept currently lacking in the open innovation approach. From the conceptualization, a framework for analysis as illustrated in Figure 2.5 is put forward which provides structure to the study of ongoing and finished innovation processes.

Based on the developed facilitating functions and system imperfection groups, OIS can be analysed to acquire insights on how to improve or adjust the systems under this study. According to this study, the OIS can be studied using the framework depicted in Figure 2.5. This seven step of framework for analysis can be used to study an OIS both during an ongoing innovation process to make alterations to the OIS based on the resulting insights, as well as when the innovation project is finished to analyse the reasons for failure or success. In the first step of the analysis, the innovation project to be studied is selected. In step two, the success of the project is reviewed based on the predetermined key performance indicators (KPIs) such as time to market, number of products sold in first few months after launch, Research & Development (R&D) costs and others. In step three, the structural components of the OIS are described. Then, in step 4, an analysis is made of which functions were developed, underdeveloped and undeveloped. In step five, the project is reviewed to find system imperfections. From the insights gathered in these previous steps, innovation management recommendations are formulated in step 6 and the OIS is altered accordingly should the project still be ongoing in step 7. Then, this process can be repeated starting from step 3 to further monitor the projects progress. Therefore, this framework shows the flow for analysis of OIS to improve the system.

On the other hand, a framework of Process Safety Information Management System (PSI4MS) in Figure 2.6 summarizes vital information and a strategy to manage and implement PSI as required by 29 CFR 1910.119(d). The first step in PSI implementation is by checking the availability of PSI program at the process plant. If the information is not available, the employer is required to take necessary actions for the development of the PSI program as required under 29 CFR 1910.119(d)(1) (Abdul et al., 2013).

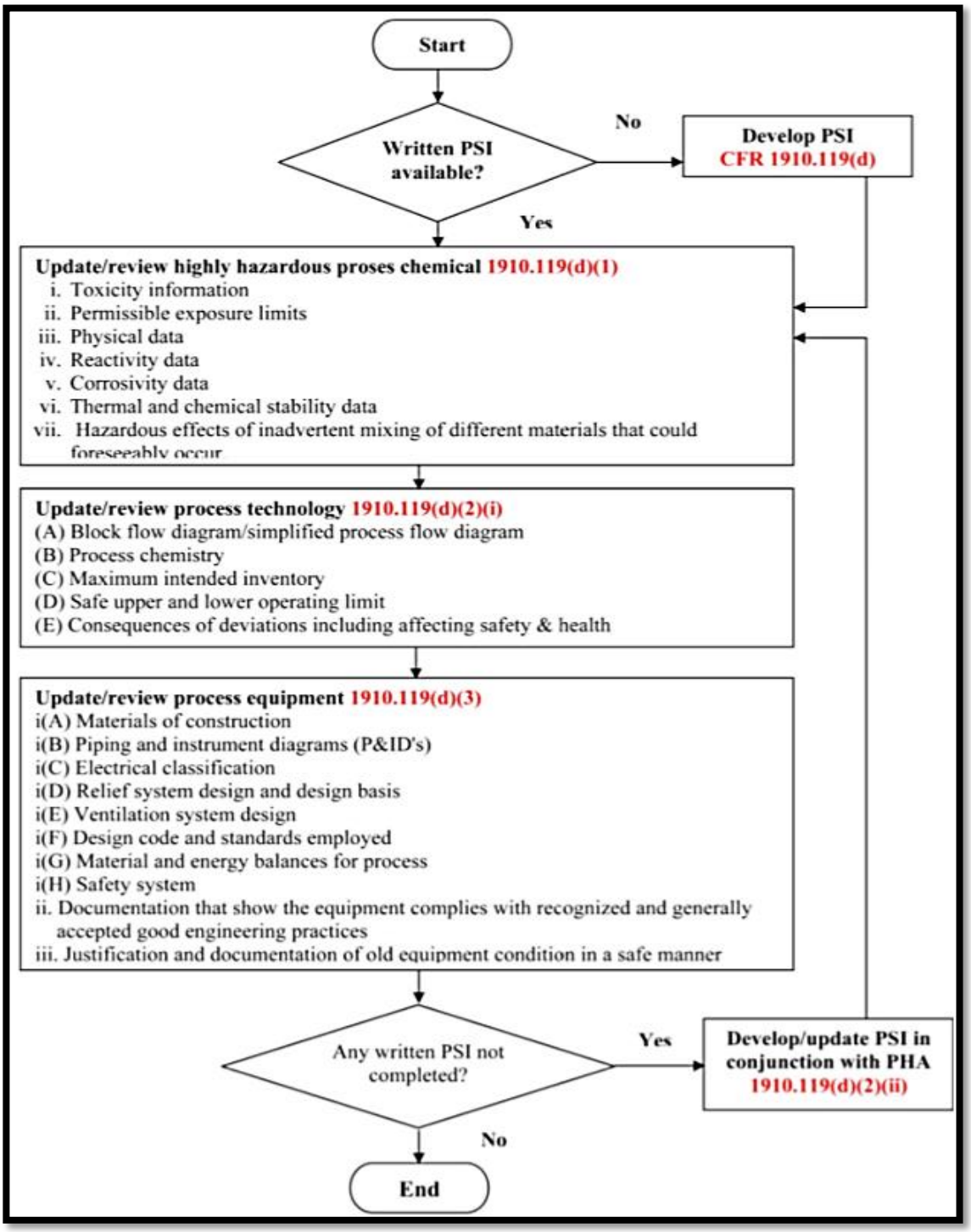


Figure 2.6. Framework of PSI management based on 29 CFR 1910.119(d).

Source Abdul Aziz *et al*. 2013

Next step, the written information of highly hazardous chemicals, the process, technology, and equipment are compiled and tracked following 29 CFR 1910.119(d)(1)(i-vii), 29 CFR 1910.119(d)(2)(i)(A)-(E), and 29 CFR

1910.119(d)(3)(iiii), respectively. The availability of the information is checked using checklist system and stored together with revision date, approval information, and evidence location. For any incomplete information, the data should be obtained in order to comply with the PSI requirements as above. However, it is crucial to have all the relevant information available prior to the development of process hazard analysis as stated in 29 CFR 1910.119(d)(2)(ii) (Abdul Aziz *et al*., 2013).

On top of that, Aziz *et al*. (2014) has proposed a system to manage training for safe operation following 29 CFR 1910.119(g) which named as Operational Training Management System (OPTRAMS). It provides strategies to manage information and documentation related to training. The study showed that all operational training can be managed efficiently with OPTRAMS and also assists end users to identify the gaps that hinder training of PSM compliance. The implementation of this technique could help end users to prevent and minimize catastrophic accidents and comply with training of PSM standard.

The framework shown in Figure 2.7 summarizes vital information and a clear strategy for Training element implementation as required by 29 CFR 1910.119(g). OPTRAMS is developed based on the framework in Figure 2.7 using Microsoft Office Access. OPTRAMS has the flexibility to allow for any changes of training information. OPTRAMS interfaces capture the mandatory requirements by Training of PSM to ensure end users provide all necessary training data for compliance. Any incomplete information can easily be identified for required actions by end users. Also The system was implemented at the Hydrocarbon Absorption System pilot plant at Universiti Teknologi Petronas as a case to validate the developed system (Abdul *et al*., 2014).

From these frameworks of system, it shown that framework can be constructed as a flowchart with feedback loop. A flowchart of framework shows a systematic way to carry an outcome, for example it can be used to help companies and workers comply with regulations systematically. Also, a feedback loop will ensure the complete compliance of regulation by checking back the requirement again.

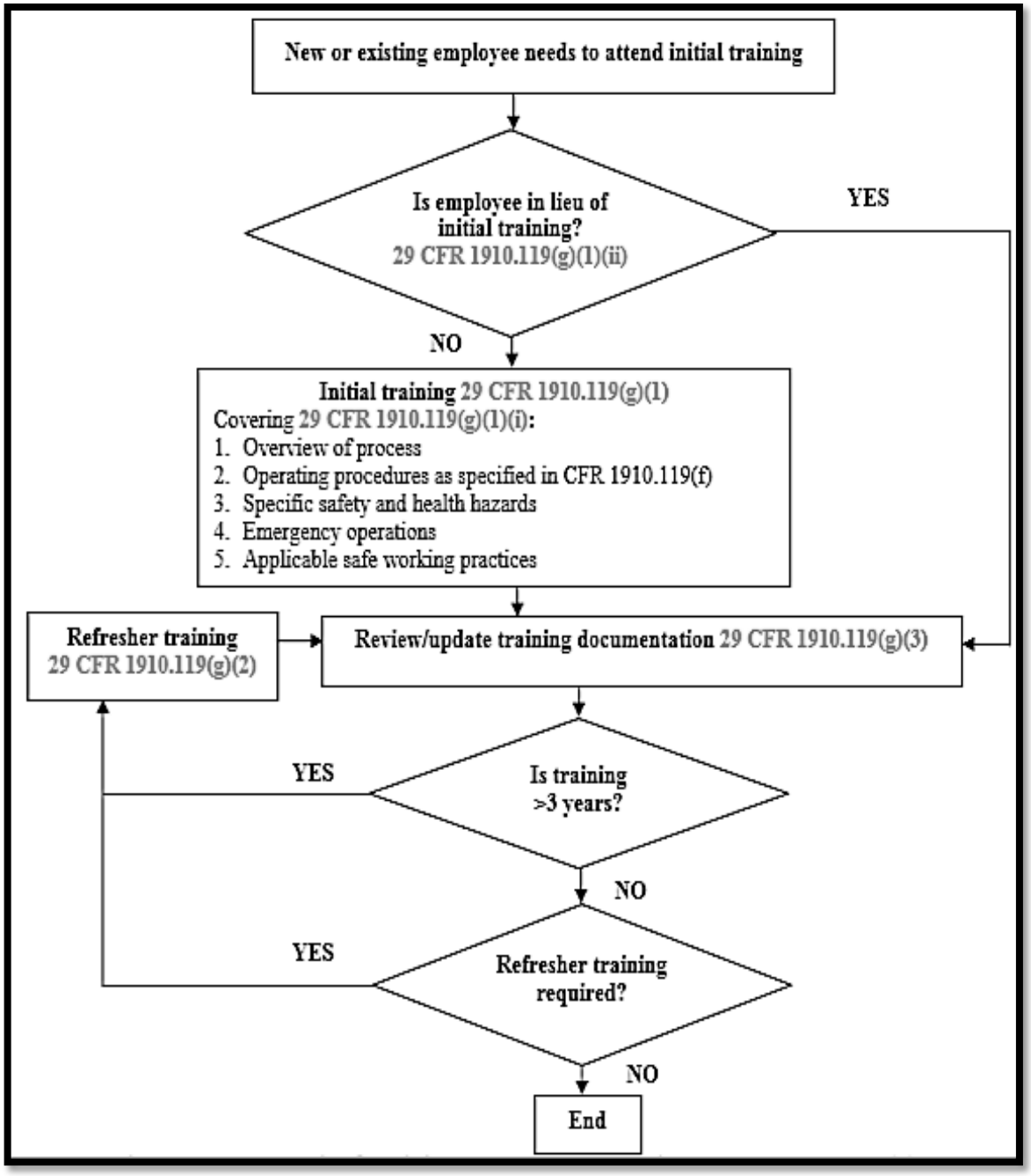


Figure 2.7. Framework of Training Management based on 29 CFR 1910.119(g).

Source Aziz *et al*. 2014

2.8 Noise Management System

According to Bureau Veritas (n.d.), an effective noise management system is critical to reducing the risks of Noise Induced Hearing Loss (NIHL) associated with long-term exposure to noise and to ensuring compliance with the Control of Noise at Work Regulations. The Control of Noise at Work Regulations 2005 place a duty on employers within Great Britain to reduce the risk to their employees' health by controlling the noise they are exposed to whilst at work. The aim of the Noise Regulations is to ensure that workers' hearing is protected from excessive noise at their place of work, which could cause them to lose their hearing ability, suffer from tinnitus (permanent ringing in the ears) or get NIHL.

Bureau Veritas' Noise Exposure Management System (NEMS) has been specifically developed to simplify the assessment process and to form the cornerstone of comprehensive noise management system. The system also provides recording facilities for the assessment of ongoing compliance and illustrates commitment to reducing noise exposure. The results of the assessment can be used to quantify Key Performance Indicators (KPIs) in relation to noise exposure risk**.** Besides that, NEMS provides a powerful tool for managing risk and enables the following:

- Calculation of personnel's noise exposure levels
- Identification of trades requiring health surveillance / noise awareness training
- Identification of areas / tasks making the greatest contribution to noise exposure
- Targeted work practice reviews to identify organisational controls to reduce personnel exposures
- Targeted noise control studies to identify technical / engineering control measures to reduce exposures As Low As Reasonably Practicable
- Determination of the effectiveness of noise control measures to ensure cost effective risk reduction
- Provision of indicators and recording facilities for assessment of ongoing compliance
- Assessment of the effectiveness of hearing protection
- Assistance in the formulation of a noise action plan

Furthermore, noise management auditing, undertaken as part of the NEMS survey, identifies the key actions required to achieve compliance with the Regulations. These actions are incorporated into noise action plan to ensure compliance and effective noise management.

On top of that, there are few noise management system can be found in other countries. Based on National Aerospace Laboratory (n.d.), as aircraft noise has become an increasing issue for airports and the surrounding communities. National Aerospace Laboratory's Noise Management System supports its users to prevent traffic noise exceeding the legal noise limits. This system has been initially developed by National Aerospace Laboratory for the Dutch Government. With the Noise Management System air traffic can be planned, monitored and re-planned continuously to avoid exceeding limits set at noise monitoring points. Besides that, the Chicago Department of Aviation's Airport Noise Management System (ANMS) is a comprehensive system to provide actual measurement of the aircraft noise levels in Chicago neighbourhoods and suburban communities around O'Hare and Midway. This integrated system includes many components, including a network of permanent noise monitors that measure the noise environment and a system directly connected to the FAA's air traffic control radar that collects aircraft flight tracks. Also, more than 5 million data points are recorded and stored by the system each day.

On the other hand, according to Mylabs (2017), there is a noise management system which is a fully automated system for motocross circuits that continuously measures the noise emission. It stores all data and makes it directly accessible. Each individual rider can be held responsible for the sound produced by their bike. The benefits of the system are:

- Identifies individual noise emission
- Measures automatically all the time
- Easy to set up and manage

With all of above noise management system, there is different kind of application of noise management system. Also, the application of noise management

system in industries is not very common yet. An effective noise management system should be implemented in more wide aspect especially in industry sector in order to lead the companies to comply with noise regulation systematically.

2.9 Other Management System

According to Abdul *et al.* (2013), a systematic technique toward Process Safety Information (PSI) element of Process Safety Management (PSM) implementation in process plant is presented in this study. A prototype database management system was developed to demonstrate the concept as illustrated in Figure 2.8 and 2.9 using Microsoft Office Access 2010.

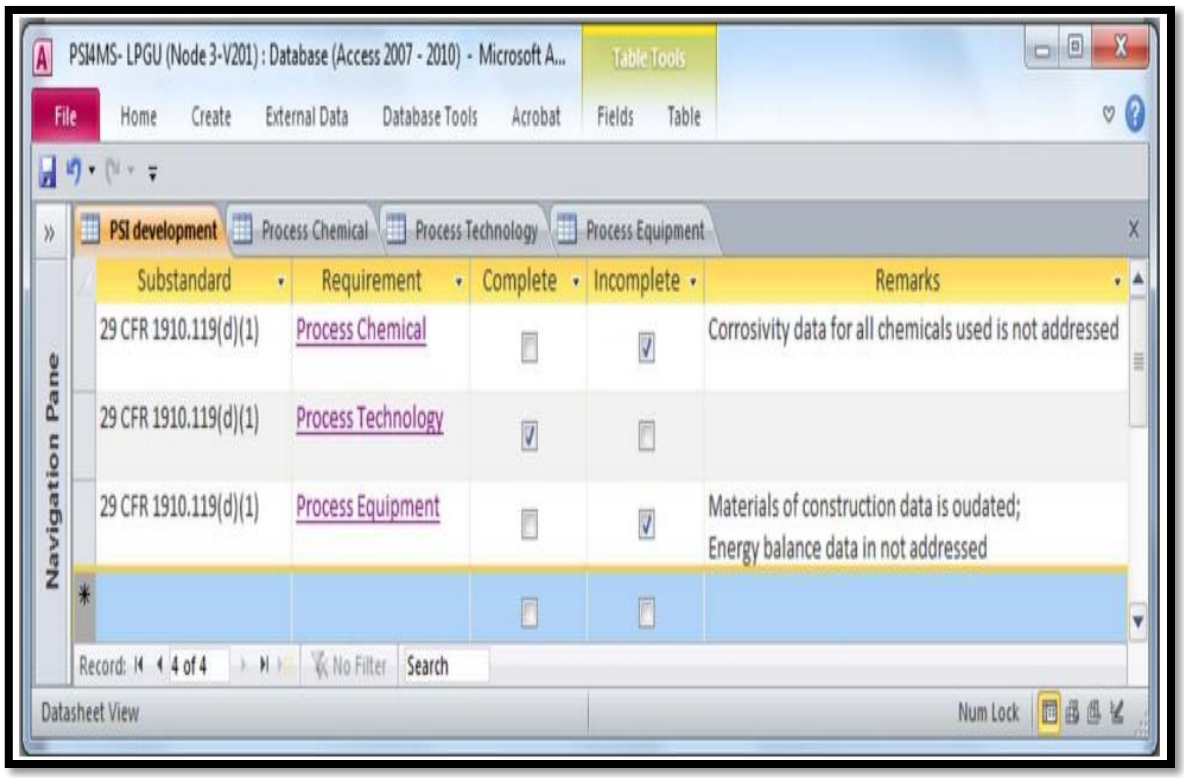


Figure 2.8. PSI development interface of management system.

Source Abdul Aziz *et al.* (2013)

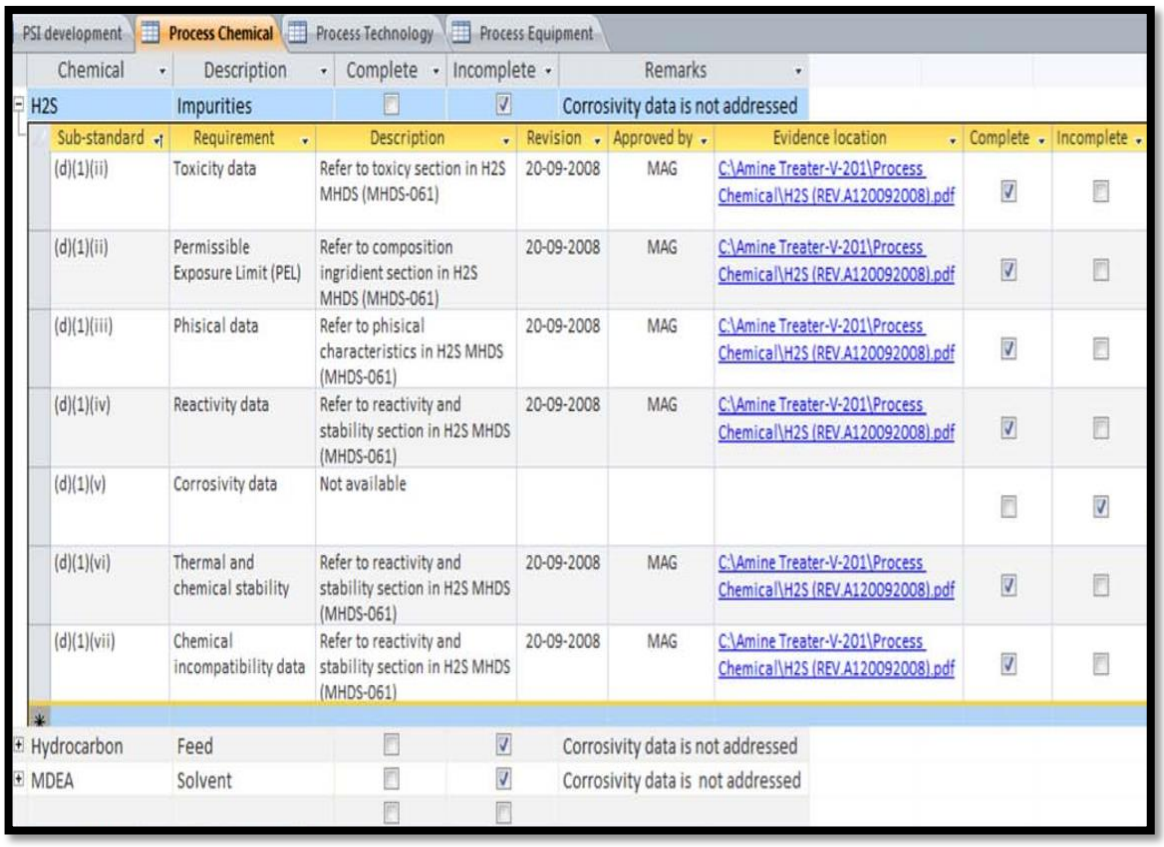


Figure 2.9. Process chemical interface of management system.

Source: Abdul Aziz et al. (2013)

Figure 2.8 shows the main interface of PSI4MS that consists of "Sub-standard", "Description", "Complete", "Incomplete", and "Remarks" columns. This interface is used to assess and monitor the compliance status of all sub-standards under 29 CFR 1910.119(d). All the requirements are managed and monitored by PSI4MS using data captured through digital forms that can be stored in a centralized database. The forms tabular required written information for process chemicals, technology, and equipment that must be compiled Process Safety Information Management System (PSI4MS) interfaces contain details of the mandatory requirements for employers to comply with PSI element of PSM. Besides that, the system provides the mechanisms for capturing information throughout the various stages of process development, design, construction, operation, maintenance, and decommissioning. Everyone involved in each stage of the process "life cycle" could also receive guidance on the types of information to be documented, where and how the information is to be retained. The information that

need to be checked may be found in many different places, such as standard operating procedures, P&ID, and original equipment manufacturer's manual. The system has been designed to allow for capturing documented data at specific evidence location either it in paper form within files, in computer data bases or on a computer aided design system.

2.10 Conclusion

This chapter provide a review of literature for the better understanding on the Noise-induced Hearing Loss, Factory and Machinery (Noise Exposure) 1989, hearing conservation program and training program and Plan-Do-Check-Act. The challenges and issues of noise exposure management indicated that the need of a management system to cope with these challenges and issues based on the regulations. In addition, there are some examples and explanations on development of framework as well as management system which can be adopted to develop framework and management system.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, the methodology parts would be discussed briefly in order to complete this research after identifying the objective and problems. It explained the method has been used in order to collect data and develop Noise Exposure Management System (NEMS). The aim of this chapter is to describe the research procedure of the study. It focused on method to develop a noise exposure management system and few case studies has been conducted at process plants to validate the developed system.

3.2 Research Design

In this research, a qualitative approach has been conducted by using literature review to understand the elements of Noise Exposure Management System (NEMS) based on Factories and Machinery (Noise Exposure) 1989. Framework and system have been developed by using Microsoft Word and Microsoft Access. Also, document review or interview as case studies have been conducted to validate the developed Noise Exposure Management System (NEMS). In addition, the concept of Plan-Do-Check-Act (PDCA) is adopted to develop Noise Exposure Management System (NEMS). “Plan” is adopted to study and understand the elements and requirements of Factories and Machinery (Noise Exposure) 1989. “Do” is adopted to develop framework and system. “Check” is adopted to validate the system by using real process plant data that collected.

Lastly, “Act” is adopted to optimize the system to make the system more efficient and fully comply with Factories and Machinery (Noise Exposure) 1989.

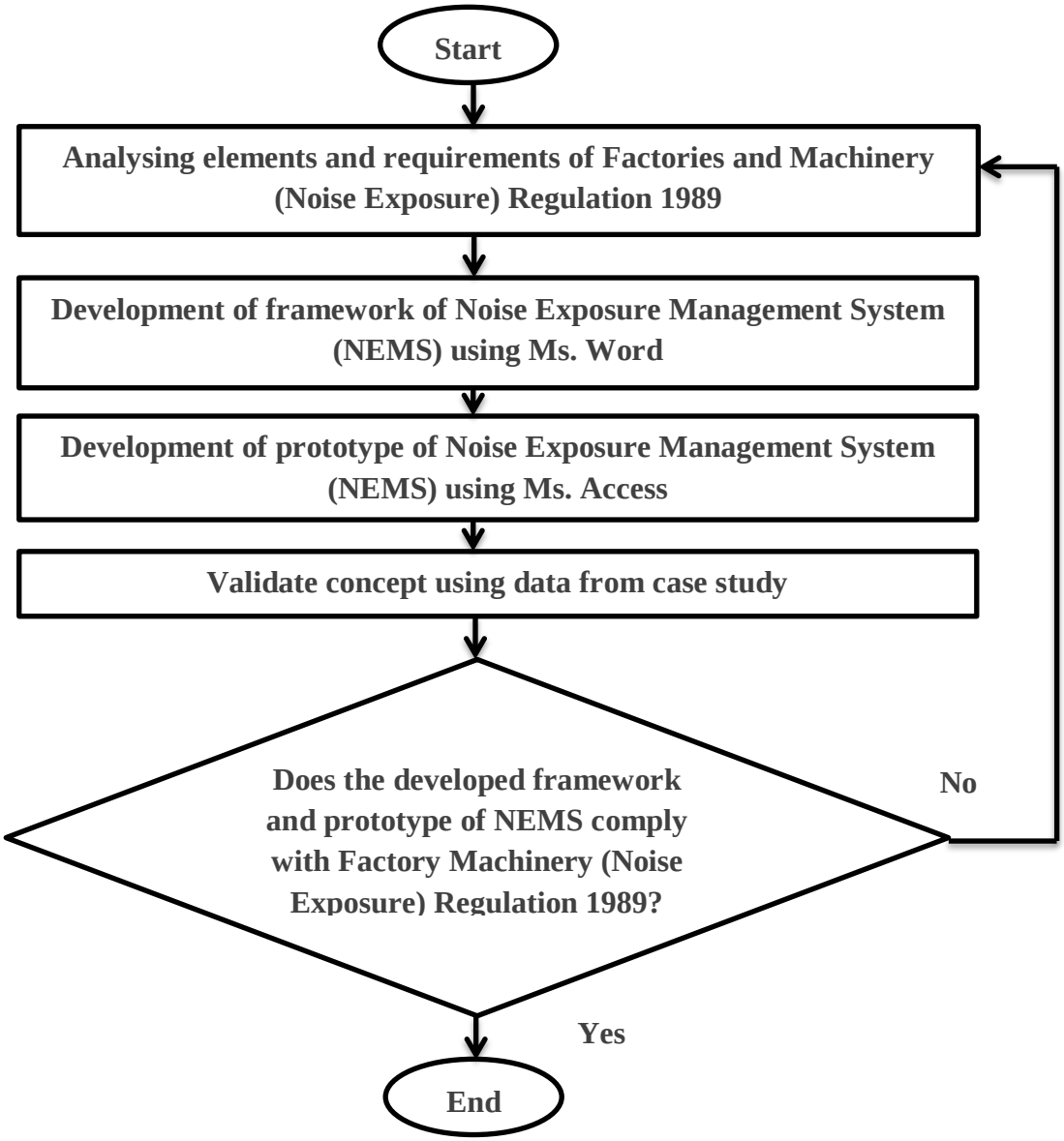


Figure 3.1. Process flow of research.

3.2.1 Analysing Elements of Factories and Machinery (Noise Exposure) Regulation 1989

The elements of Factory and Machinery (Noise Exposure) Regulations 1989 as specified by DOSH was analysed, studied and understood through literature review. Besides that, interview of practitioner has been done to obtain some professional knowledge and get to know in more comprehensive way about the elements and requirements of this regulation. Therefore, after analysing the elements and requirements of this regulation through document review and interview, vital information, elements and requirements has been used to develop framework.

3.2.2 Development of Framework of NEMS

Development of framework for Noise Exposure Management System (NEMS) was constructed by using Microsoft Word. This framework summarizes the vital information, elements, requirements or strategies to manage in NEMS as required to comply with Factories and Machinery (Noise Exposure) Regulation 1989. Framework of Noise Exposure Management System (NEMS) is a flowchart and shows a flow for companies to comply with Factories and Machinery (Noise Exposure) Regulation 1989 sequentially or in a systematic way. Besides that, feedback loop is used in developing the framework. The concept of a feedback loop is an important element of management system. Also, it is like asking a question to emphasize the certain important elements and ensure it has been carried out. A feedback loop can be positive or negative and it used to ensure the continual improvement of the management system. Besides that, feedback loop also ensure the complete compliance of regulation by checking back the requirement again.

3.2.3 Development of Prototype of NEMS

Development of prototype of Noise Exposure Management System (NEMS) was constructed by using Microsoft Access. This NEMS which based on Microsoft Access

enables the user to input data, manage and track information. There are 10 interfaces inside the NEMS which consists of a main interface and 9 sub-interface. For the main interface, it shows all the other 9 sub-interface and interlink with it. For the other 9 sub-interface, it based on Part I, Part II, Part III, Part IV, Part V, Part VI, Part VII, Part VIII and Part IX as stated in Factories and Machinery (Noise Exposure) 1989. Each of these interfaces consists of few columns which known as requirement, complete, incomplete, revision date, evidence location and others. Other than that, the evidence or documents to prove that companies have complied with a regulation can be attached into management system by inserting into columns of attachment or evidence. Also, columns of complete and incomplete indicate that the companies whether comply with such regulation or not. Therefore, the availability of the information is checked using the developed system and stored together with revision date, approval information, and evidence location. For any incomplete information, the data or information should be obtained in order to comply with the requirements of Factories and Machinery (Noise Exposure) 1989. Moreover, Microsoft Excel was used as storage of records and documents. By using Microsoft Excel, companies can track and look back the previous reports as all the reports can be listed inside Microsoft Excel and interlinked with the documents of reports.

3.2.4 System Validation

System validation was conducted by using the real process plant data which collected from process industries and interview with practitioners as case studies Therefore, the system is verified and validated based on the requirements of Factories and Machinery (Noise Exposure) 1989 through document review and interview with practitioners from industries. At this stage, the gaps of compliance which related to imperfection of the development, program and documentation of plant to comply with the noise regulations of this regulation of companies can be found. Other than that, the developed NEMS can be checked whether it is fully comply with the elements and requirements of Factories and Machinery (Noise Exposure) 1989. If lacks are found in the developed NEMS, elements and requirements of Factories and Machinery (Noise

Exposure) 1989 will be analysed and studied again to develop the optimized framework and system.

3.3 Location of Study

The case studies were conducted at two process industry where the employees exposed to noise hazard. These two process industries are located in Pahang, Malaysia. Besides that, the documents, reports or real process plant data that collected from these industries are used as document review for system validation. Also, interview of practitioners are also carried out to obtain the relevant information.

3.4 Conclusion

As conclusion, this chapter discusses the research methodology on the development of Noise Exposure Management System (NEMS). The framework summarizes the vital information, elements, requirements or strategies to manage in NEMS as required to comply with Factories and Machinery (Noise Exposure) 1989. It is a flowchart and shows a flow for companies to comply with regulation in a systematic way. The NEMS which based on Microsoft Access enables the user to input data, manage and track information. Also, the developed NEMS were validated through case studies.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

In this chapter, it shows the result and discussion in details of developing framework of Noise Exposure Management System (NEMS), developing prototype of noise exposure management system and validating the developed noise exposure management system. The developed framework and prototype of noise exposure management system are based on compliance of Factories Machinery (Noise Exposure) Regulation 1989.

4.2 Development of Framework of Noise Exposure Management System

The framework of Noise Exposure Management System (NEMS) summarizes the vital information, elements, requirements or strategies to manage in NEMS as required for complying with Factories and Machinery (Noise Exposure) 1989. As stated in chapter 3, the framework is constructed by using Microsoft Word and it is a flowchart which shows a systematic way for companies to comply with Factories and Machinery (Noise Exposure) 1989 sequentially. The overview framework for Noise Exposure Management System (NEMS) is shown in Figure 4.1 to Figure 4.3. In overall, there are included nine parts of Factories and Machinery (Noise Exposure) 1989 which are on Part I, Part II, Part III, Part IV, Part V, Part VI, Part VII, Part VIII and Part IX that need to be fulfilled by company and workers.

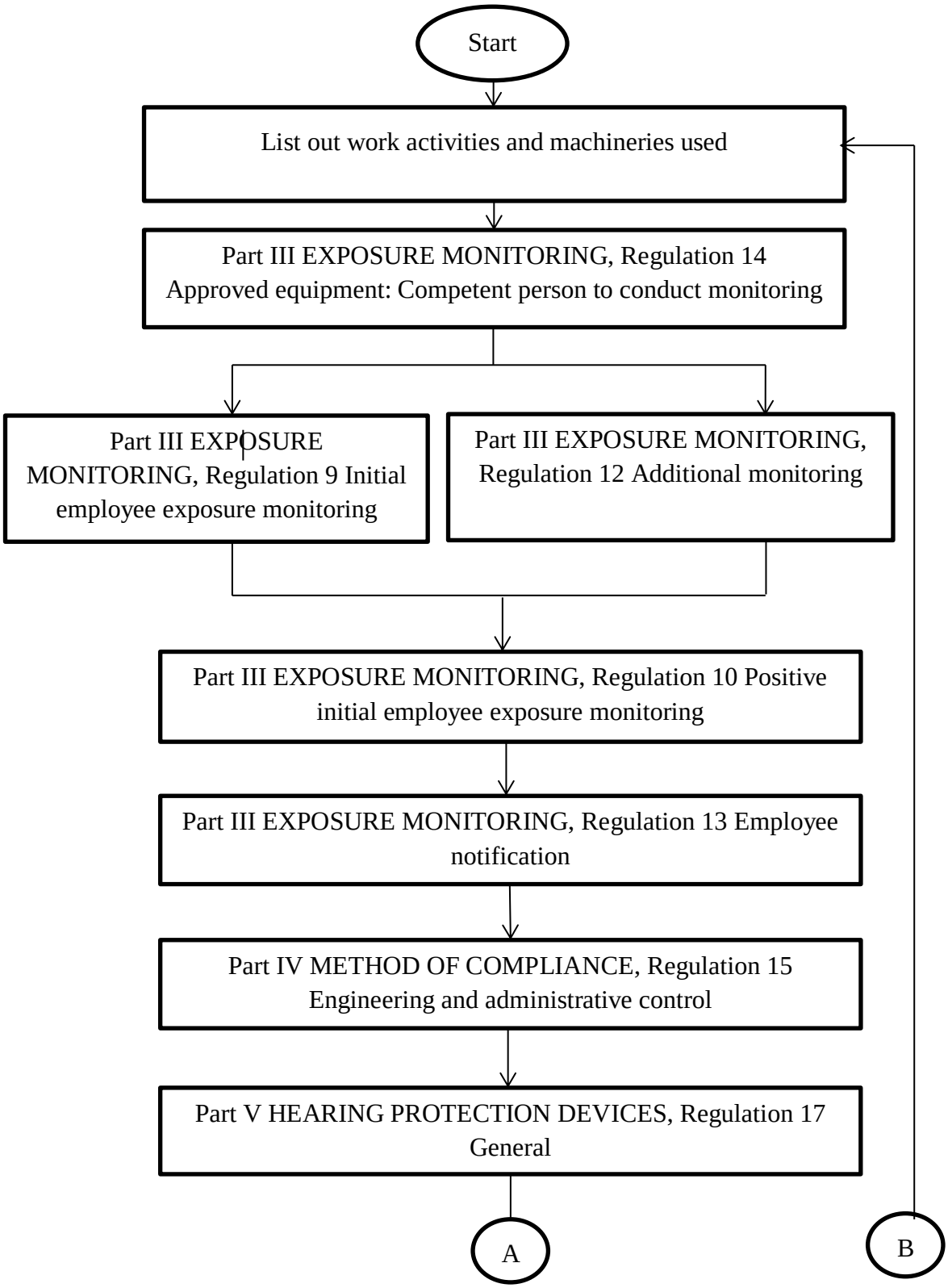


Figure 4.1. The overview framework of NEMS.

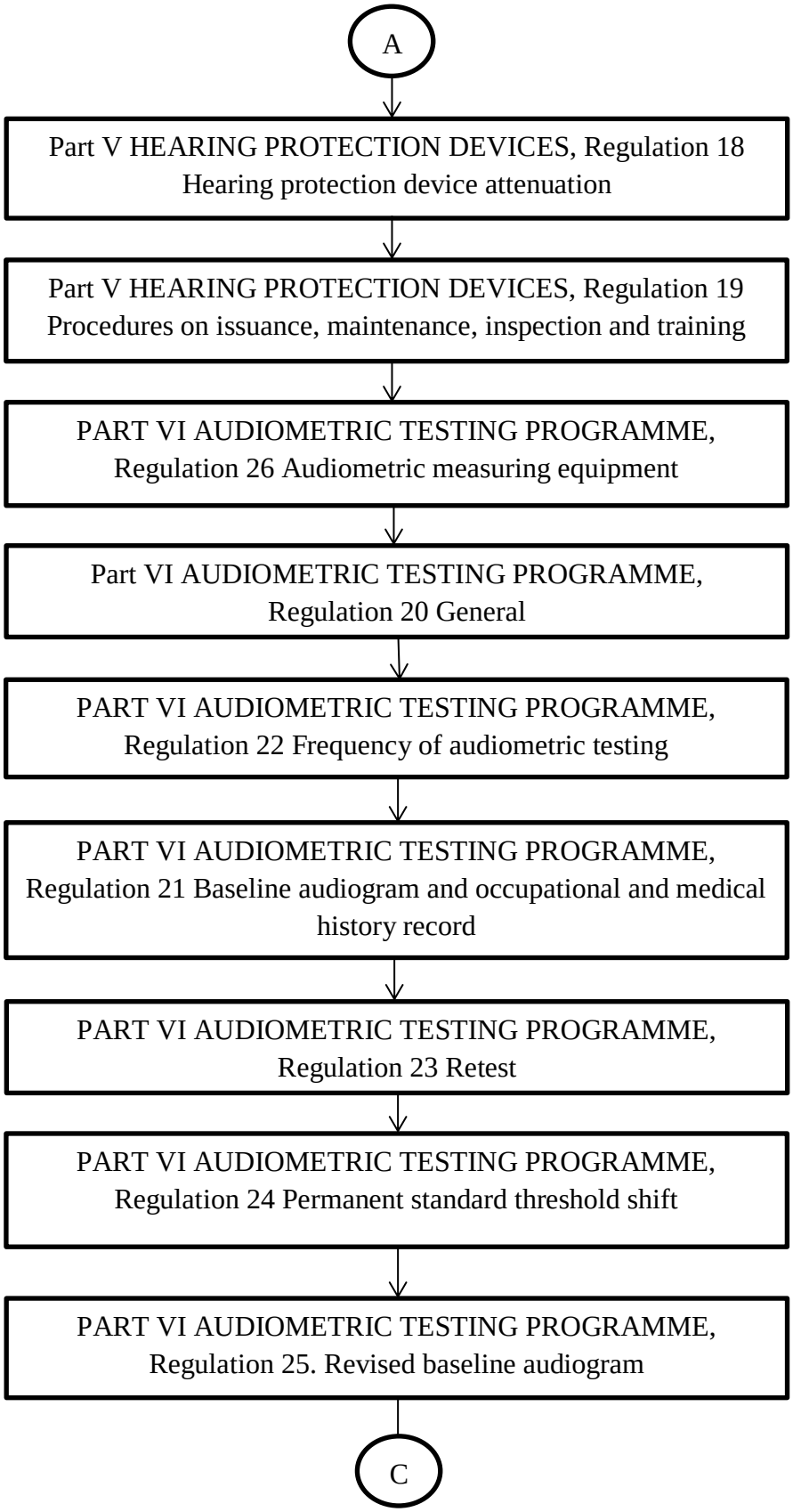


Figure 4.1. The overview framework of NEMS (continued).

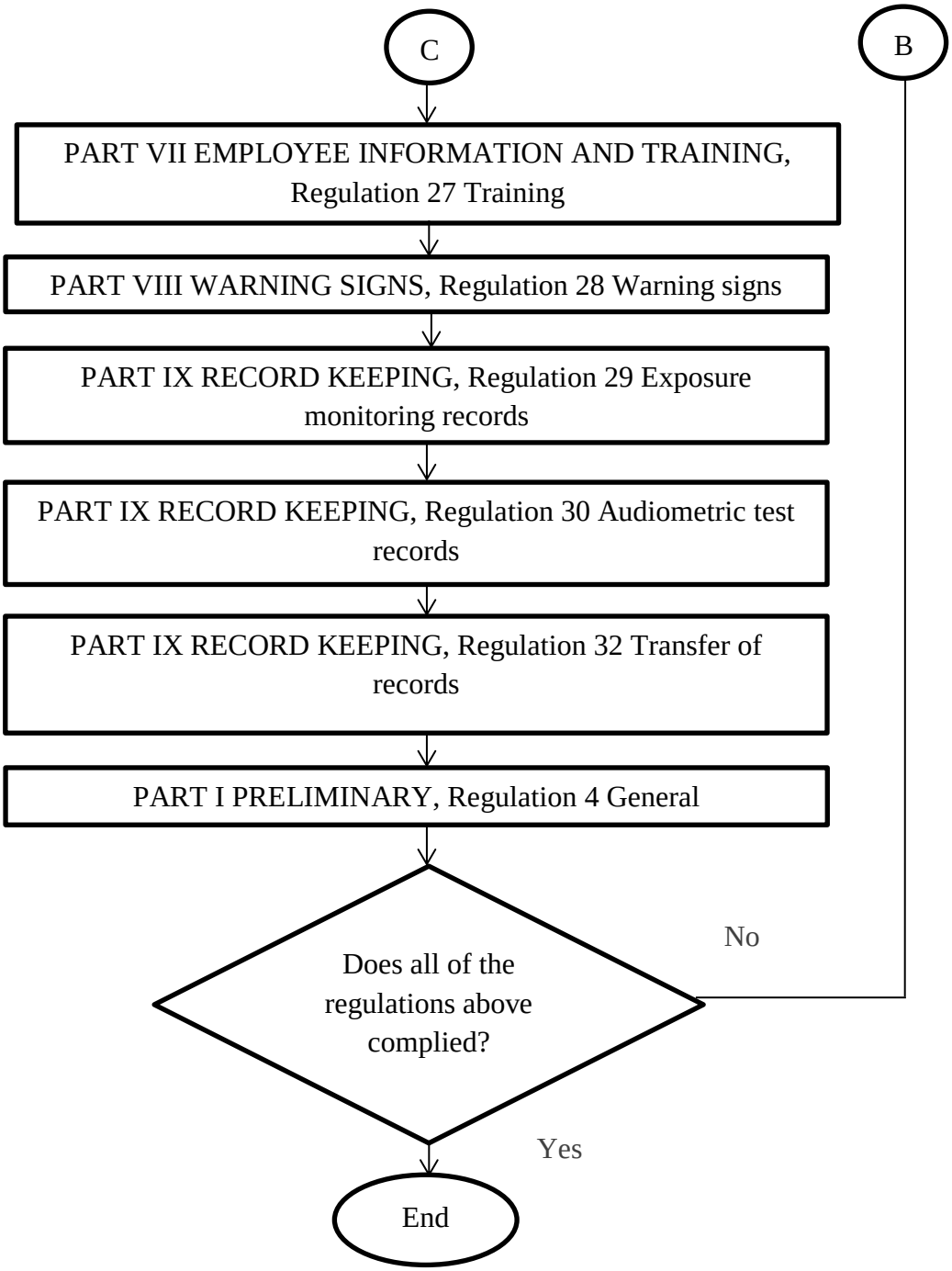


Figure 4.1. The overview framework of NEMS (continued).

Next, the complete and detailed framework of Noise Exposure Management System (NEMS) is shown in Figure 4.2 to Figure 4.12. The detailed framework consists of 14 feedback loops to ensure the compliance of regulation.

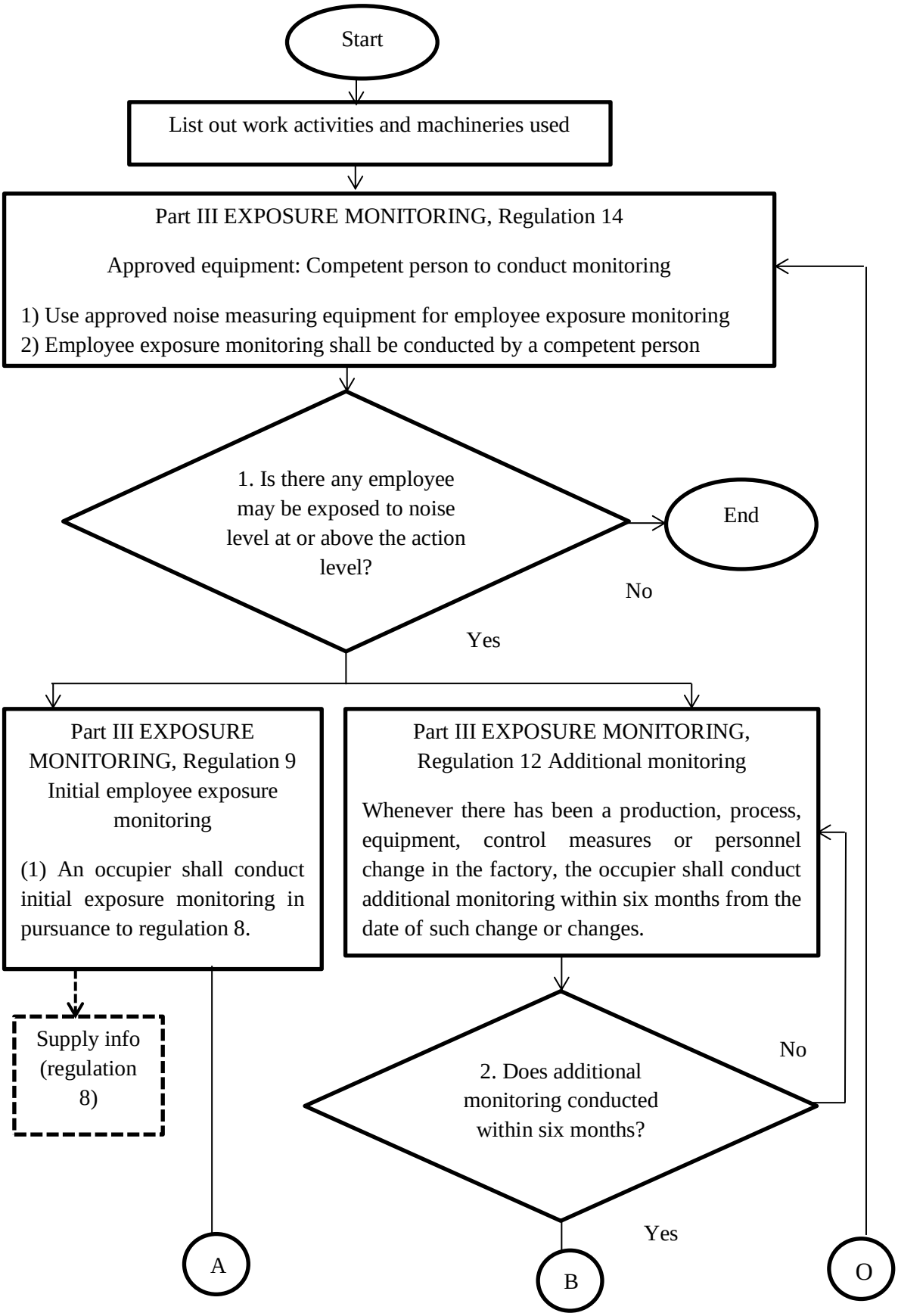


Figure 4.2. The detailed framework a of NEMS.

Based on Figure 4.2, it shows the detailed and completed framework. First of all, companies shall list out all the work activities and machineries exist in the workplace. Examples of work activities are hammering, polishing, loading & unloading by using forklift, welding, grinding and others while examples of machineries used in the workplace include sterilizer, turbine, boiler and others. The purpose of listing out all the work activities and machineries in the workplace is to identify any noise sources and determine if any employee may be exposed to noise level at or above the action level. If there is no any employee may be exposed to noise level at or above the action level, the company could end at here as noise hazard is not exist in the workplace and will not cause any harm to the hearing ability of employee's ears. Next, occupier shall use approved noise measuring equipment to conduct employee initial exposure monitoring or additional monitoring, and employee exposure monitoring shall be conducted by a competent person to ensure the validity and reliability of the results (regulation 14).

On the other hand, based on feedback loop 1 as illustrated in Figure 4.2, if yes, initial employee exposure monitoring (regulation 9) shall be conducted by occupier in pursuance to regulation 8. An initial employee exposure monitoring may be limited to one or more representative employee or employees from a particular group of employees performing the same work or from the same workplace, who the occupier reasonably believes is or are exposed to noise level representative of the group of employees. The box with dotted line is "supply info'' which shows the details of regulation 8. The detail of "supply info" is put at the end of framework. Besides that, additional monitoring (regulation 12) shall be conducted by occupier whenever there has been a production, process, equipment, control measures or personnel change in the factory within six months from the date of such change or changes. Then, a feedback loop is used at here by asking a question to ensure the additional monitoring has conducted within six months from the date of such change or changes. If occupier still has not conducted additional monitoring within six months yet when occupier need to do so, the flow will go back and remind the occupier to ensure additional monitoring has conducted within six months from the date of such change or changes.

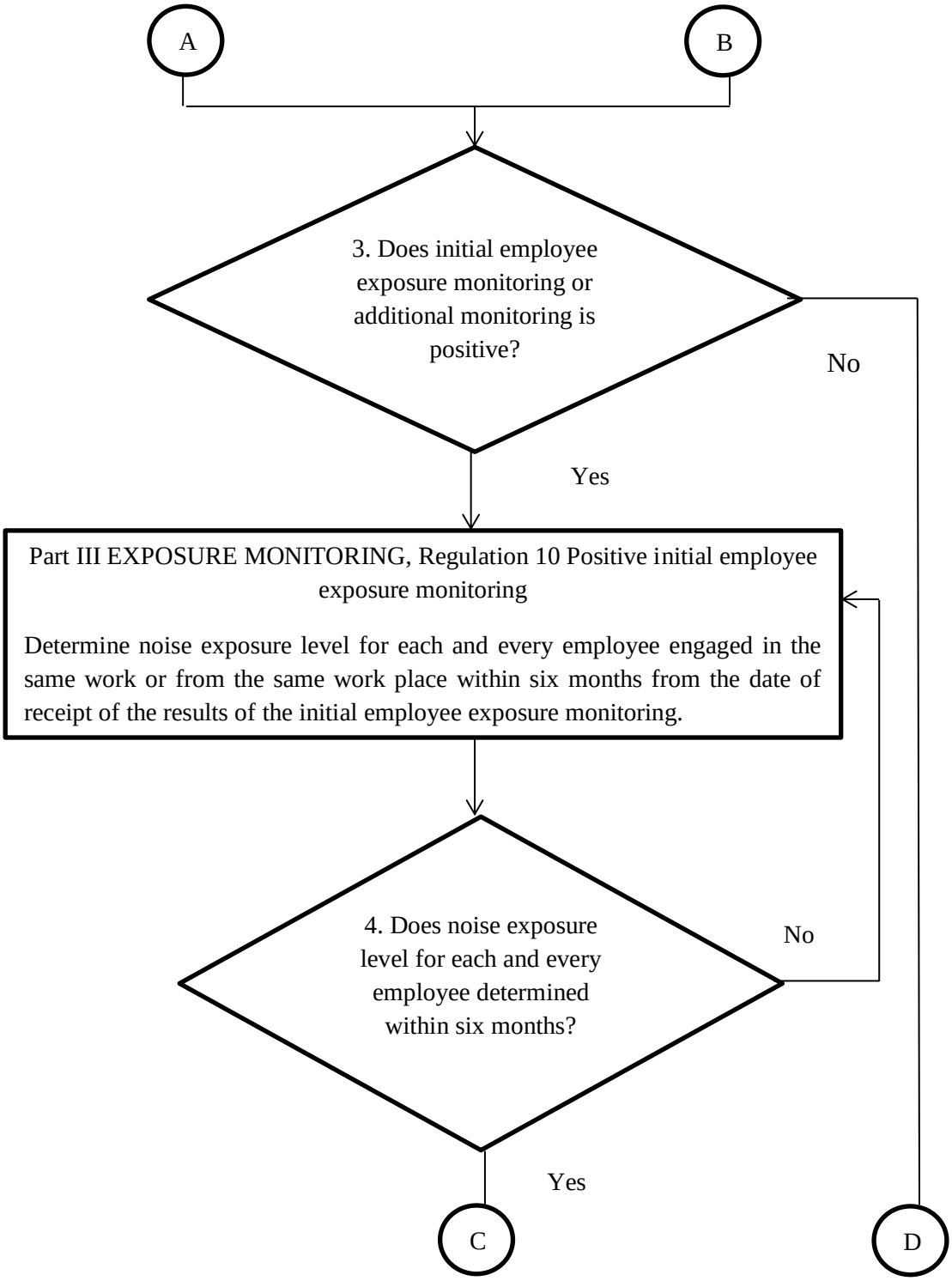


Figure 4.3. The detailed framework b of NEMS.

Next, a feedback loop is used to determine if initial employee exposure monitoring or additional monitoring is positive. An initial employee exposure monitoring may be limited to one or more representative employee or employees from a particular group of employees performing the same work or from the same workplace, who the occupier reasonably believes is or are exposed to noise level representative of the group of employees.

Based on the feedback loop 3 as illustrated in Figure 4.3, if the results is positive where an initial employee exposure monitoring shows the possibility of any employee exposure to noise level at or above the action level, the occupier shall determine noise exposure levels for employees engaged in the same work or from the same workplace within six months from the date of receipt of the results of the initial employee exposure monitoring (regulation 10). Then, a feedback loop is used at here to identify if noise exposure level for each and every employee has determined within six months.

Based on the feedback loop 4 as illustrated in Figure 4.3, if occupier still has not determined noise exposure level for each and every employee within six months yet, the flow will go back into previous one to ensure noise exposure level for each and every employee is determined within six months from the date of receipt of the results.

On the other hand, based on the feedback loop 4 as illustrated in Figure 4.3, if occupier has determined noise exposure level for each and every employee within six months, the flow will proceed to regulation 13 with the requirement to notify each employee of the results of the monitoring. Same goes to the feedback loop 3, if the answer is no, it will proceed to regulation 13.

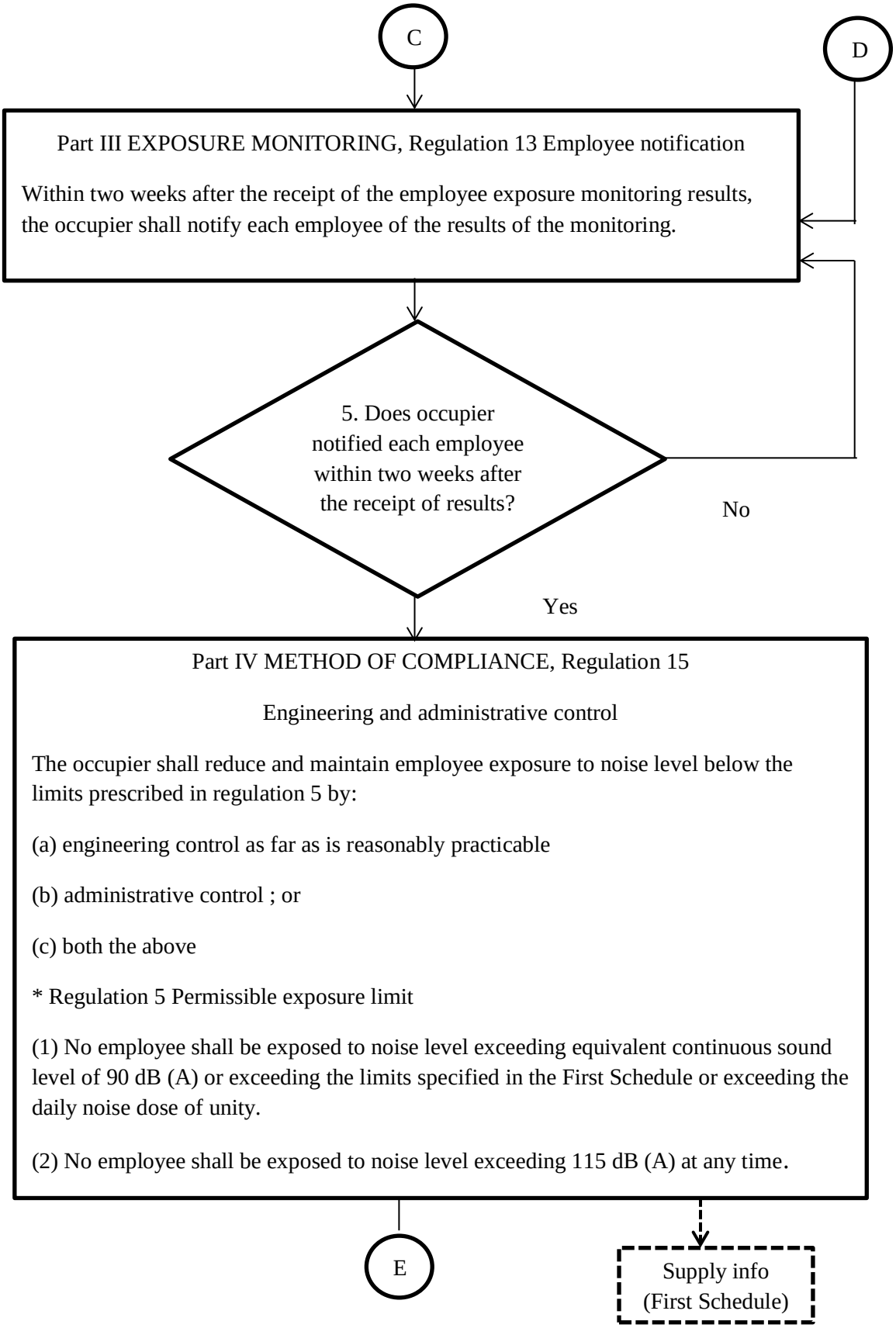


Figure 4.4. The detailed framework c of NEMS.

Based on Figure 4.4, after that, the occupier shall notify each employee of the results of the monitoring within two weeks after the receipt of the employee exposure monitoring results (regulation 13), same goes to results of negative initial employee exposure monitoring.

Then, a feedback loop is used at here. Based on feedback loop 5 as illusatrated in Figure 4.4, if occupier has not notified each employee within two weeks after the receipt of results yet, the flow will go back into previous one to ensure each employee are notified of the results of the monitoring within two weeks after the receipt of the employee exposure monitoring results. If the answer is yes at feedback loop 5, it will proceed to next regulation.

Next, based on regulation 15, the occupier shall reduce and maintain employee exposure to noise level below the limits prescribed in regulation 5 by:

- engineering control as far as is reasonably practicable,
- administrative control or
- both of these controls

As illustrated in Figure 4.4, the description of regulation 5 is stated after that which is permissible exposure limit. Under this regulation, no employee shall be exposed to noise level exceeding equivalent continuous sound level of 90 dB (A) or exceeding the limits specified in the First Schedule or exceeding the daily noise dose of unity. Also, no employee shall be exposed to noise level exceeding 115 dB (A) at any time. The “supply info” of First Schedule is attached at the end of framework.

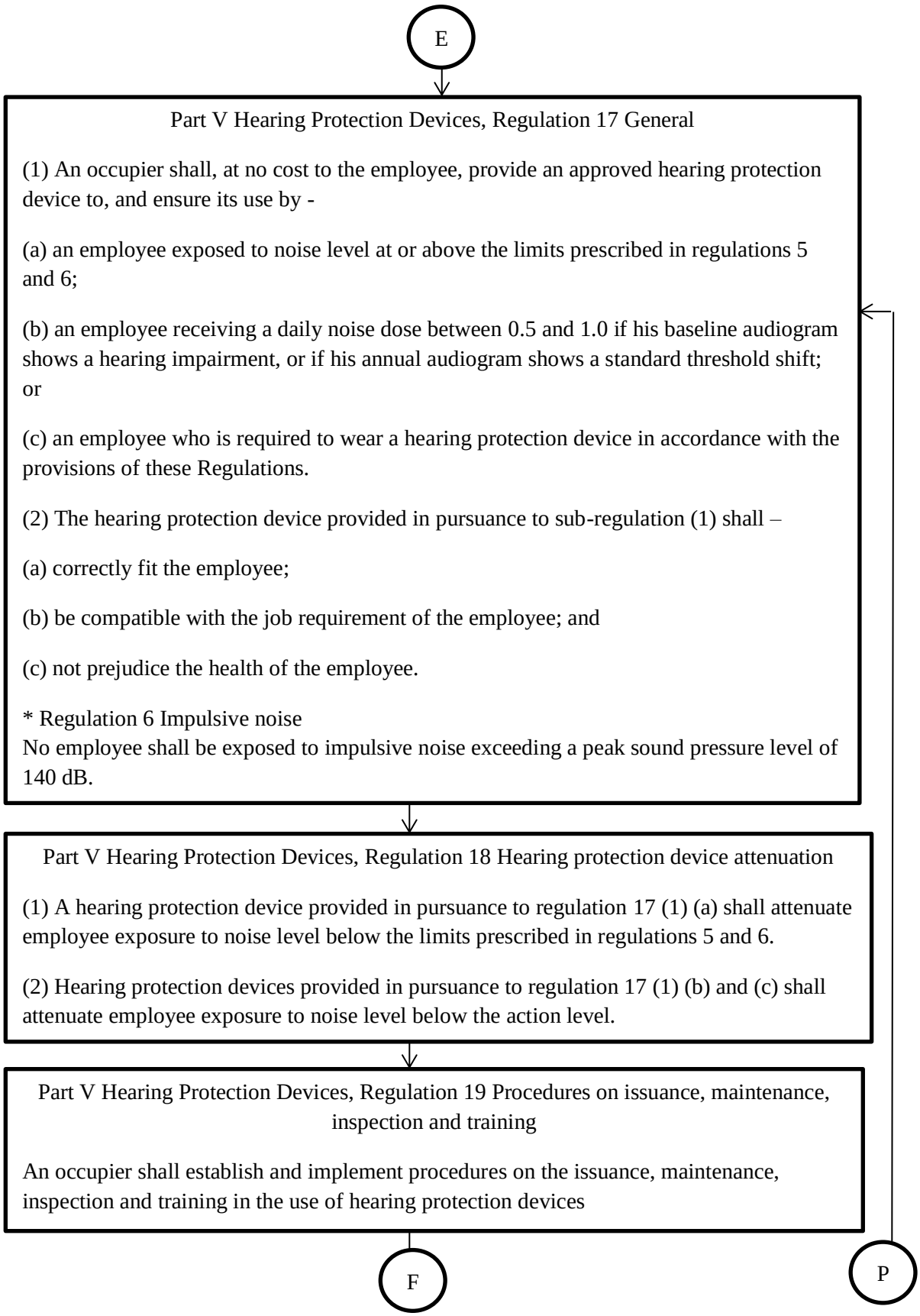


Figure 4.5. The detailed framework d of NEMS.

Based on Figure 4.5, the flow will proceed to Part V Hearing Protection Devices, regulation 17. The occupier shall, at no cost to the employee, provide an approved hearing protection device, and ensure its use by:

(a) an employee exposed to noise level at or above the limits prescribed in regulations 5 and 6;
(b) an employee receiving a daily noise dose between 0.5 and 1.0 if his baseline audiogram shows a hearing impairment, or if his annual audiogram shows a standard threshold shift; or
(c) an employee who is required to wear a hearing protection device in accordance with the provisions of these Regulations.

The description of regulation 5 is mentioned earlier and regulation 6 is stated at this stage. As illustrated in Figure 4.5, regulation 6 is impulsive noise and no employee shall be exposed to impulsive noise exceeding a peak sound pressure level of 140 dB under this regulation. Besides that, the hearing protection device provided shall:

(a) correctly fit the employee;
(b) be compatible with the job requirement of the employee; and
(c) not prejudice the health of the employee

Next, as illustrated in Figure 4.5, hearing protection device provided in pursuance to regulation 17 shall attenuate employee exposure to noise level below the limits prescribed in regulations 5 and 6. Furthermore, hearing protection devices provided in pursuance to regulation 17 shall attenuate employee exposure to noise level below the action level (regulation 18). Then, occupier shall establish and implement procedures on the issuance, maintenance, inspection and training in the use of hearing protection devices. This can make sure the hearing protection devices are in good condition and utilized by employees (regulation 19).

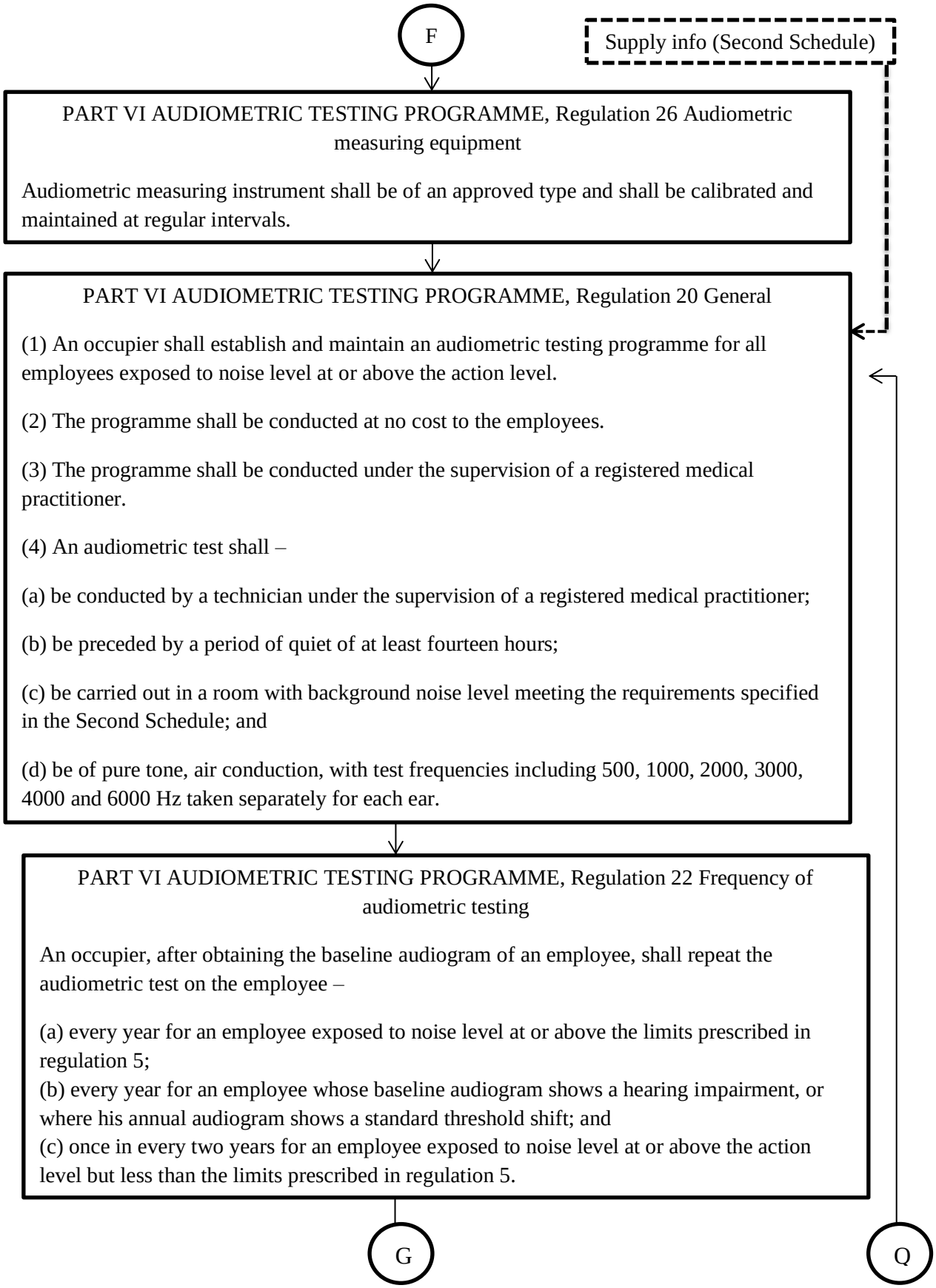


Figure 4.6. The detailed framework e of NEMS.

Next, moving to Part VI Audiometric Testing Programme regulation 20 as illustrated in Figure 4.6, occupier shall establish and maintain an audiometric testing programme for all employees exposed to noise level at or above the action level. The programme shall be conducted at no cost to the employees and under the supervision of a registered medical practitioner. The “supply info” of Second Schedule is put at the end of framework. Besides that, an audiometric test shall:

(a) be conducted by a technician under the supervision of a registered medical practitioner;
(b) be preceded by a period of quiet of at least fourteen hours;
(c) be carried out in a room with background noise level meeting the requirements specified in the Second Schedule; and
(d) be of pure tone, air conduction, with test frequencies including 500, 1000, 2000, 3000, 4000 and 6000 Hz taken separately for each ear.

Then, as illustrated in Figure 4.6, audiometric measuring instrument shall be of an approved type and shall be calibrated and maintained at regular intervals (regulation 26). This can ensure the audiometric measuring instruments are in good condition and the results of audiometric test are accurate (regulation 26). Besides that, occupier should take note and know about the frequency of audiometric testing. Under regulation 22, the occupier, after obtaining the baseline audiogram of an employee, shall repeat the audiometric test on the employee:

(a) every year for an employee exposed to noise level at or above the limits prescribed in regulation 5;
(b) every year for an employee whose baseline audiogram shows a hearing impairment, or where his annual audiogram shows a standard threshold shift; and
(c) once in every two years for an employee exposed to noise level at or above the action level but less than the limits prescribed in regulation 5.

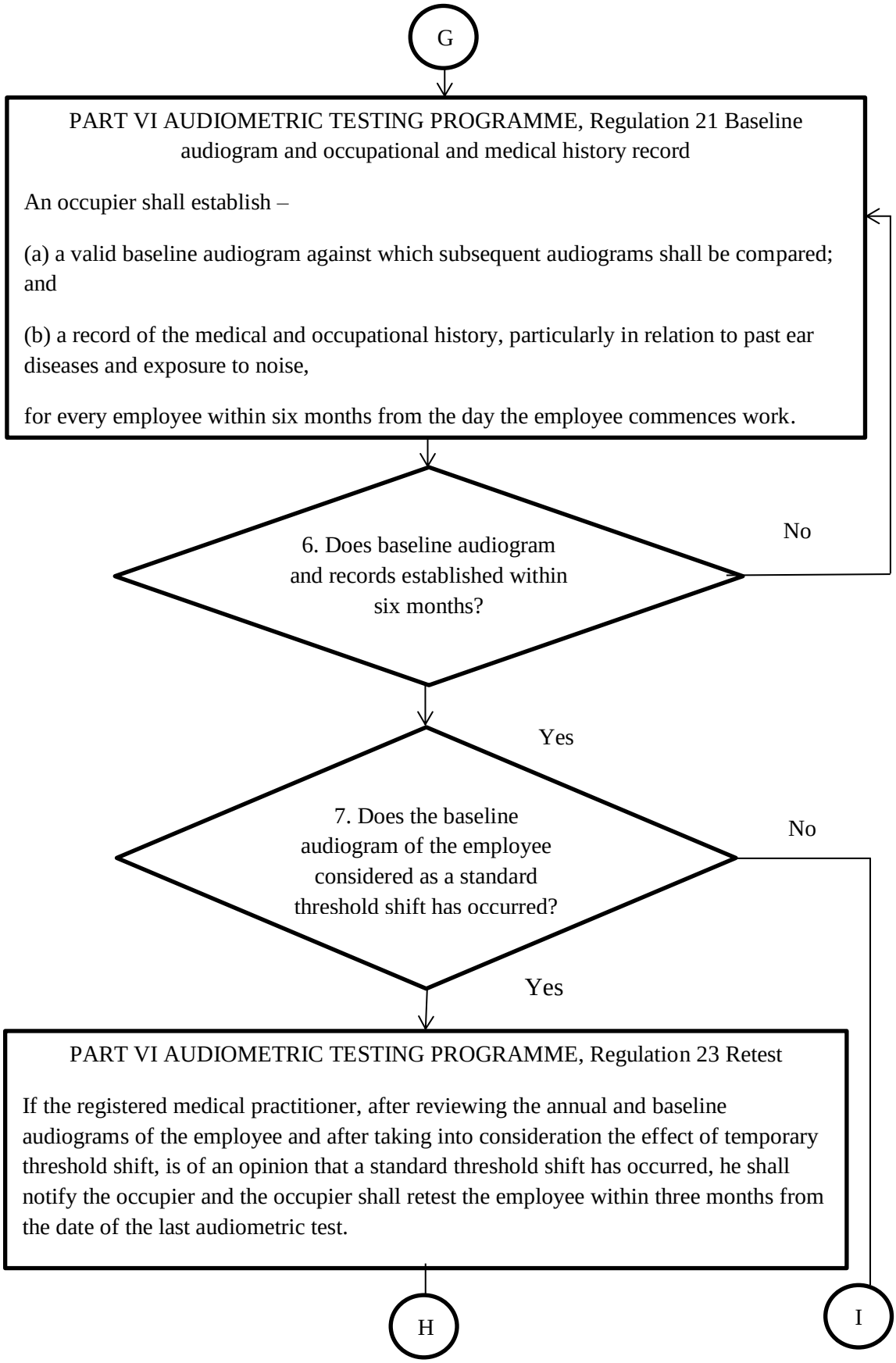


Figure 4.7. The detailed framework f of NEMS.

Based on Figure 4.7, under regulation 21, occupier shall establish below requirements for every employee within six months from the day the employee commences work:

(a) a valid baseline audiogram against which subsequent audiograms shall be compared; and
(b) a record of the medical and occupational history, particularly in relation to past ear diseases and exposure to noise.

As illustrated in Figure 4.7, a feedback loop is used after that to ensure baseline audiogram and records have established within six months from the day the employee commences work. If occupier has not established it yet, the flow will go back and recall the occupier to establish baseline audiogram and within six months from the day the employee commences work.

Then, if occupier has already established it, following will be the feedback loop again. The feedback loop at here is to determine whether baseline audiogram of the employee considered as a standard threshold shift has occurred or not.

Based on the feedback loop 7 as illustrated in Figure 4.7, if yes which baseline audiogram of the employee considered as a standard threshold shift has occurred, the registered medical practitioner shall notify the occupier and the occupier shall retest the employee within three months from the date of the last audiometric test (regulation 23). Then, the flow will go to feedback loop 8. On the other hand, if answer is no at feedback loop 7, the flow will go to feedback loop 9

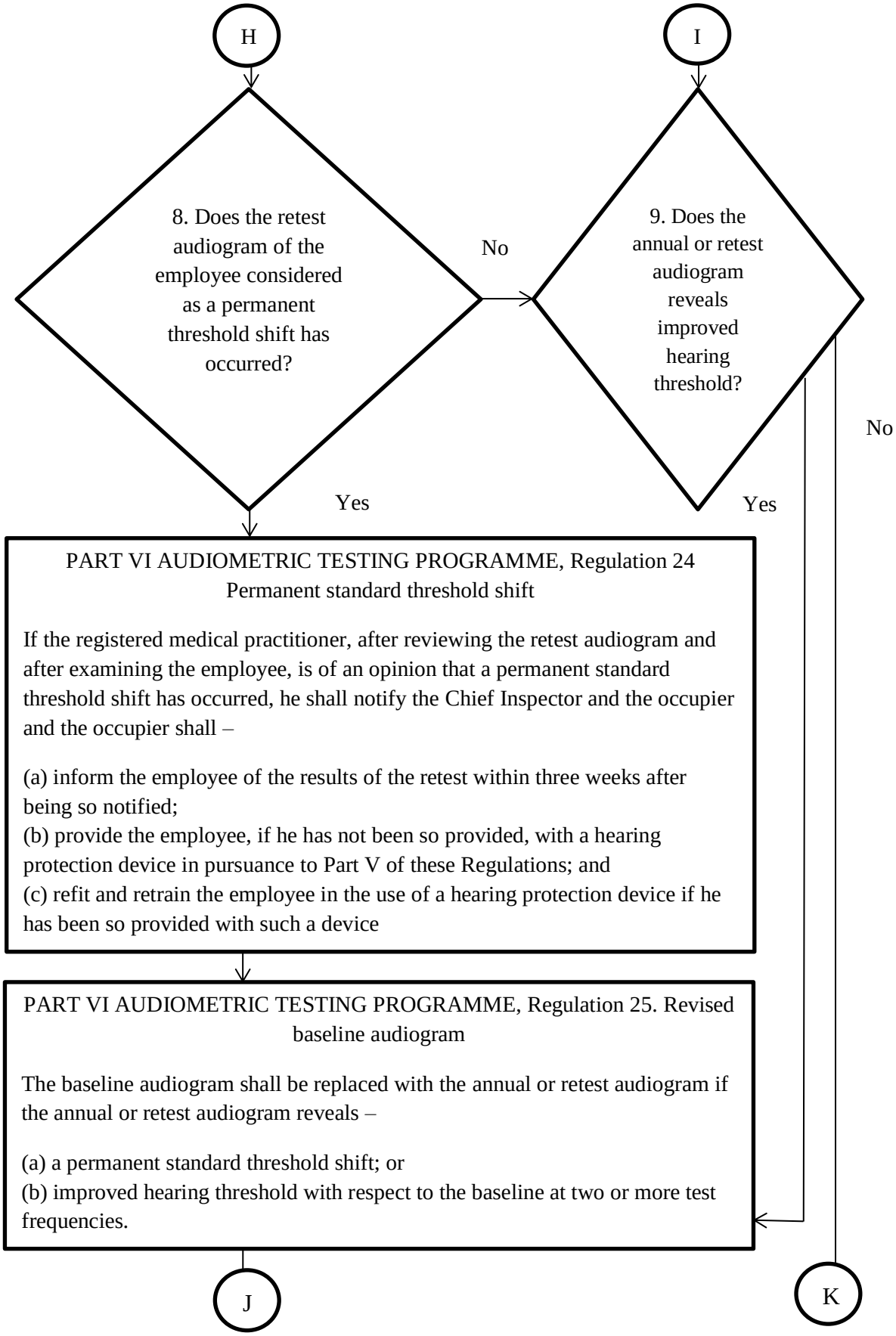


Figure 4.8. The detailed framework g of NEMS.

Based on the Figure 4.8, at the feedback loop 8, it determines whether the retest audiogram of the employee considered as a permanent threshold shift has occurred or not. If yes, under regulation 24, If the registered medical practitioner, after reviewing the retest audiogram and after examining the employee, is of an opinion that a permanent standard threshold shift has occurred, he shall notify the Chief Inspector and the occupier and the occupier shall:

(a) inform the employee of the results of the retest within three weeks after being so notified;
(b) provide the employee, if he has not been so provided, with a hearing protection device in pursuance to Part V of these Regulations; and
(c) refit and retrain the employee in the use of a hearing protection device if he has been so provided with such a device.

After that, as illustrated in Figure 4.8, under regulation 25, the baseline audiogram shall be replaced with the annual or retest audiogram as the annual or retest audiogram reveals:

(a) a permanent standard threshold shift; or
(b) improved hearing threshold with respect to the baseline at two or more test frequencies.

On top of that, as illustrated in Figure 4.8, if the answer is no for feedback loop 8, the flow will go to feedback loop 9 which is used to determine whether the annual or retest audiogram reveals improved hearing threshold or not. If the answer is yes for feedback loop 9, it will also go to regulation 25 which baseline audiogram shall be replaced with the annual or retest audiogram. If the answer is no for feedback loop 9, the flow goes to Part VII Employee Information and Training, Regulation 27 Training.

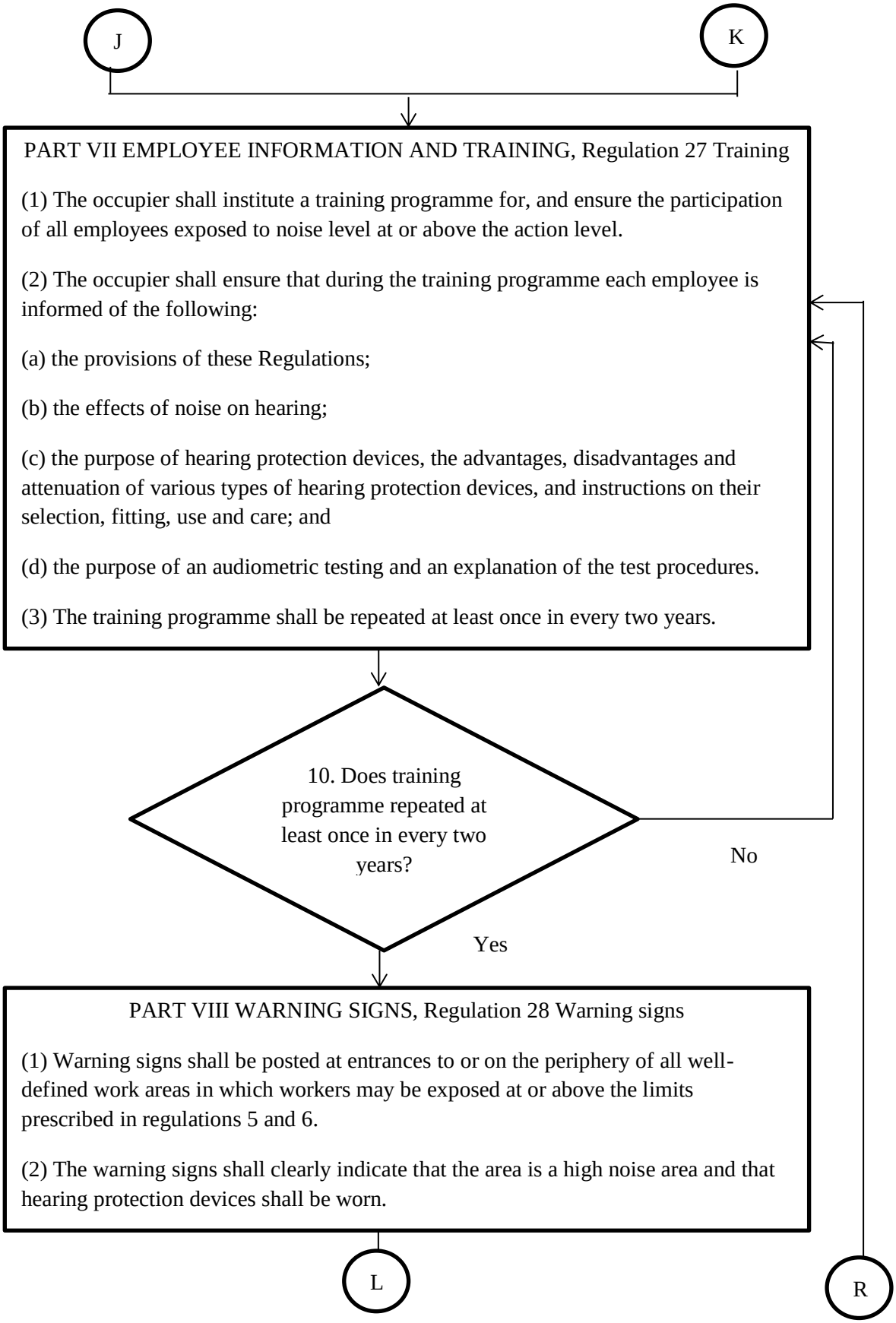


Figure 4.9. The detailed framework h of NEMS.

Based on Figure 4.9, the flow goes to Part VII Employee Information and Training, Regulation 27 Training, and same goes to the answer of no from feedback loop 9. Under regulation 27, occupier shall institute a training programme for, and ensure the participation of all employees exposed to noise level at or above the action level. Besides that, occupier shall ensure that during the training programme each employee is informed of the following:

(a) the provisions of these Regulations;
(b) the effects of noise on hearing;
(c) the purpose of hearing protection devices, the advantages, disadvantages and attenuation of various types of hearing protection devices, and instructions on their selection, fitting, use and care; and
(d) the purpose of an audiometric testing and an explanation of the test procedures.

Moreover, as illustrated in Figure 4.9, this training programme shall be repeated at least once in every two years. A feedback loop is used after that to ensure training programme is repeated at least once in every two years. If no, the flow will go back to regulation 27 to ensure training programme is repeated at least once in every two years. If yes, next will be the installation of warning signs (regulation 28).

Warning signs are used to alert employees that some kinds of hazards exist at that area. As illustrated in Figure 4.9, warning signs shall be posted at entrances to or on the periphery of all well-defined work areas in which workers may be exposed at or above the limits prescribed in regulations 5 and 6. The details of regulation 5 and 6 have been stated earlier. Also, the warning signs shall clearly indicate that the area is a high noise area and that hearing protection devices shall be worn

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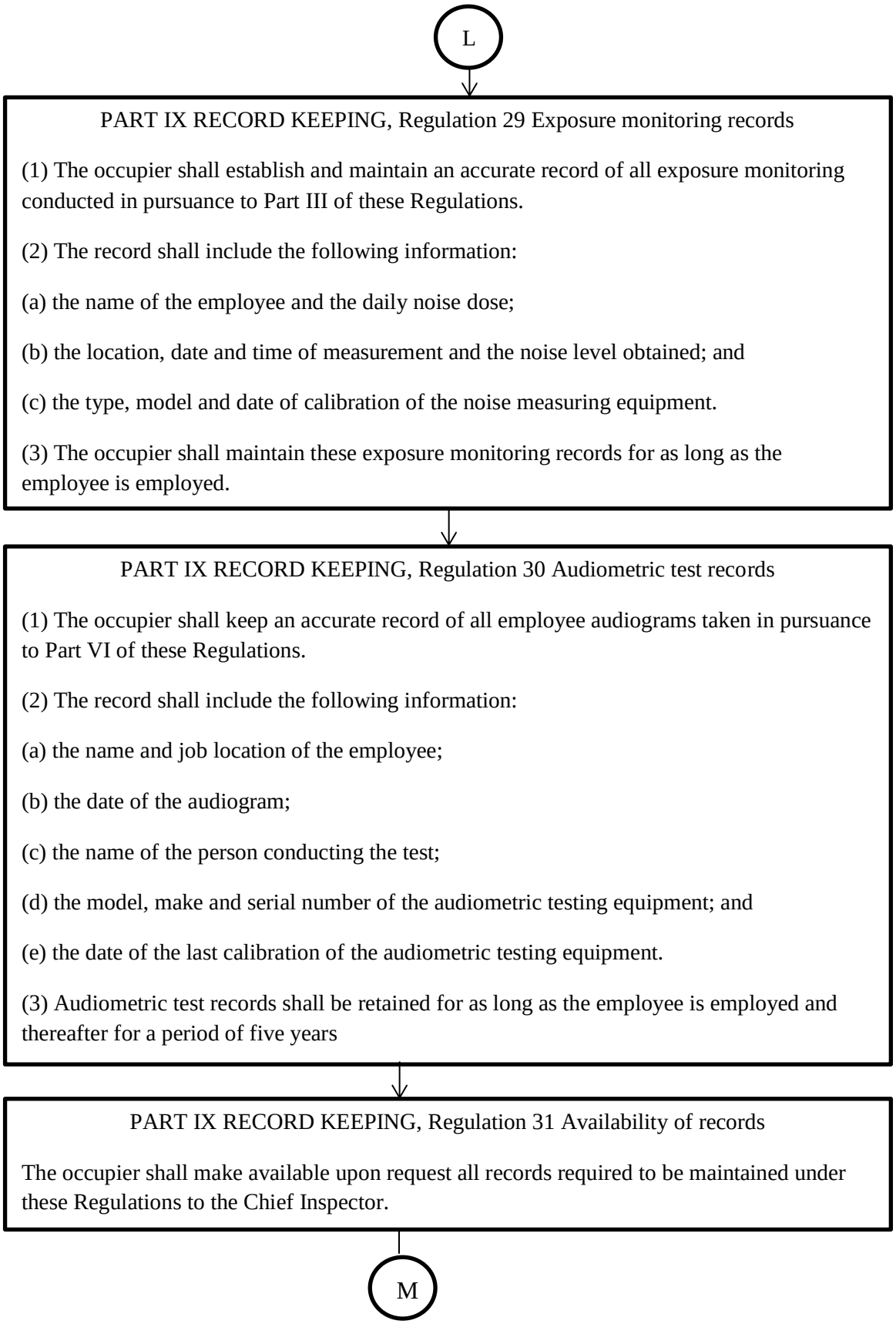


Figure 4.10. The detailed framework i of NEMS.

Based on Figure 4.10, the flow will be moving on to Part IX Record Keeping. Under regulation 29, occupier shall establish and maintain an accurate record of all exposure monitoring conducted. The record shall include the following information:

(a) the name of the employee and the daily noise dose;
(b) the location, date and time of measurement and the noise level obtained; and
(c) the type, model and date of calibration of the noise measuring equipment.

Moreover, as illustrated in Figure 4.10, occupier shall maintain these exposure monitoring records for as long as the employee is employed. Next, under regulation 31, occupier shall keep an accurate record of all employee audiograms. The record shall include the following information:

(a) the name and job location of the employee;
(b) the date of the audiogram;
(b) the name of the person conducting the test;
(c) the model, make and serial number of the audiometric testing equipment; and
(d) the date of the last calibration of the audiometric testing equipment.
(e) Audiometric test records shall be retained for as long as the employee is employed and thereafter for a period of five years

As illustrated in Figure 4.10, after keeping the records of exposure monitoring and audiometric test, occupier shall make available upon request all records required to be maintained under these Regulations to the Chief Inspector (regulation 31). This can help the companies easily track back the previous records and check the compliance.

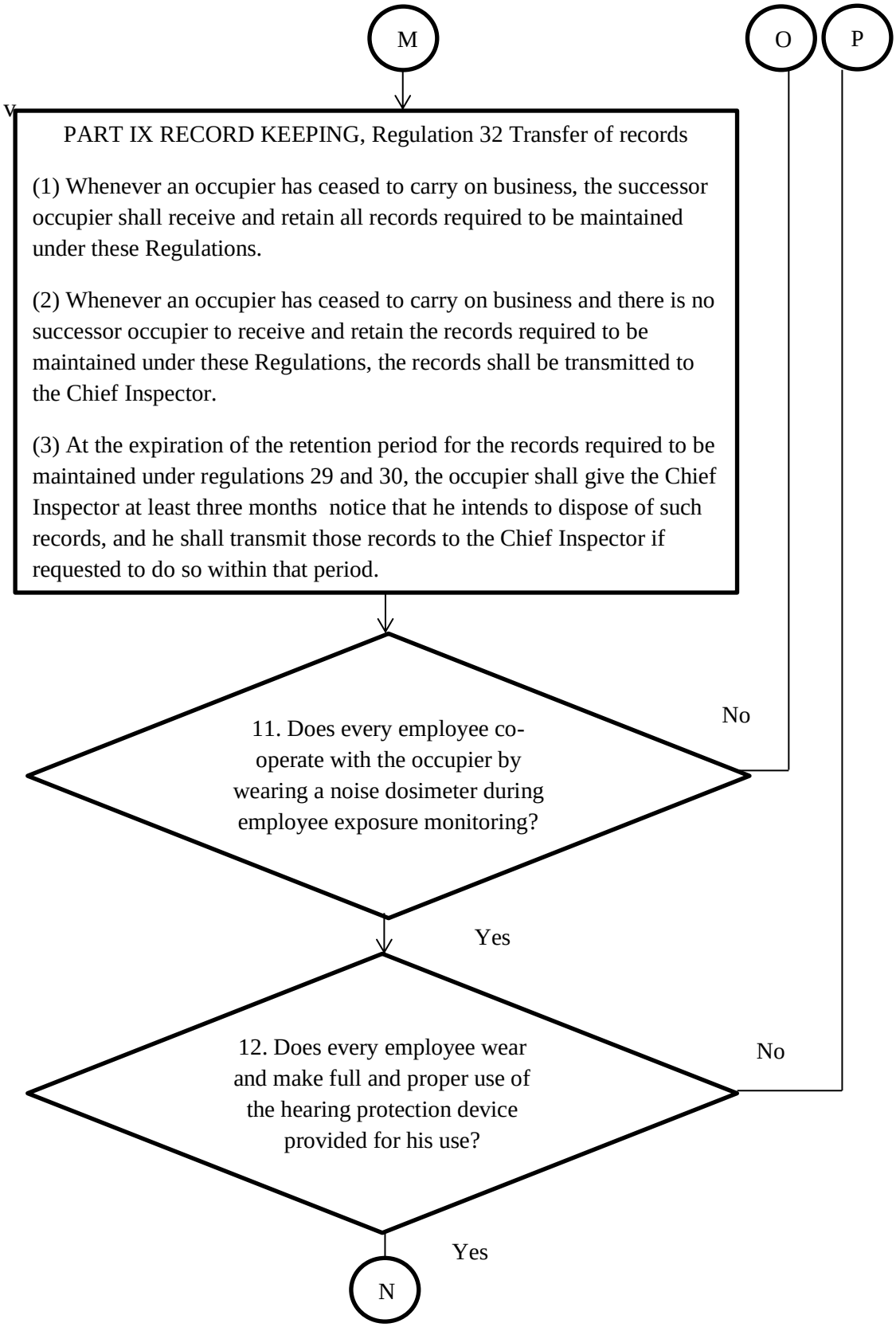


Figure 4.11. The detailed framework j of NEMS.

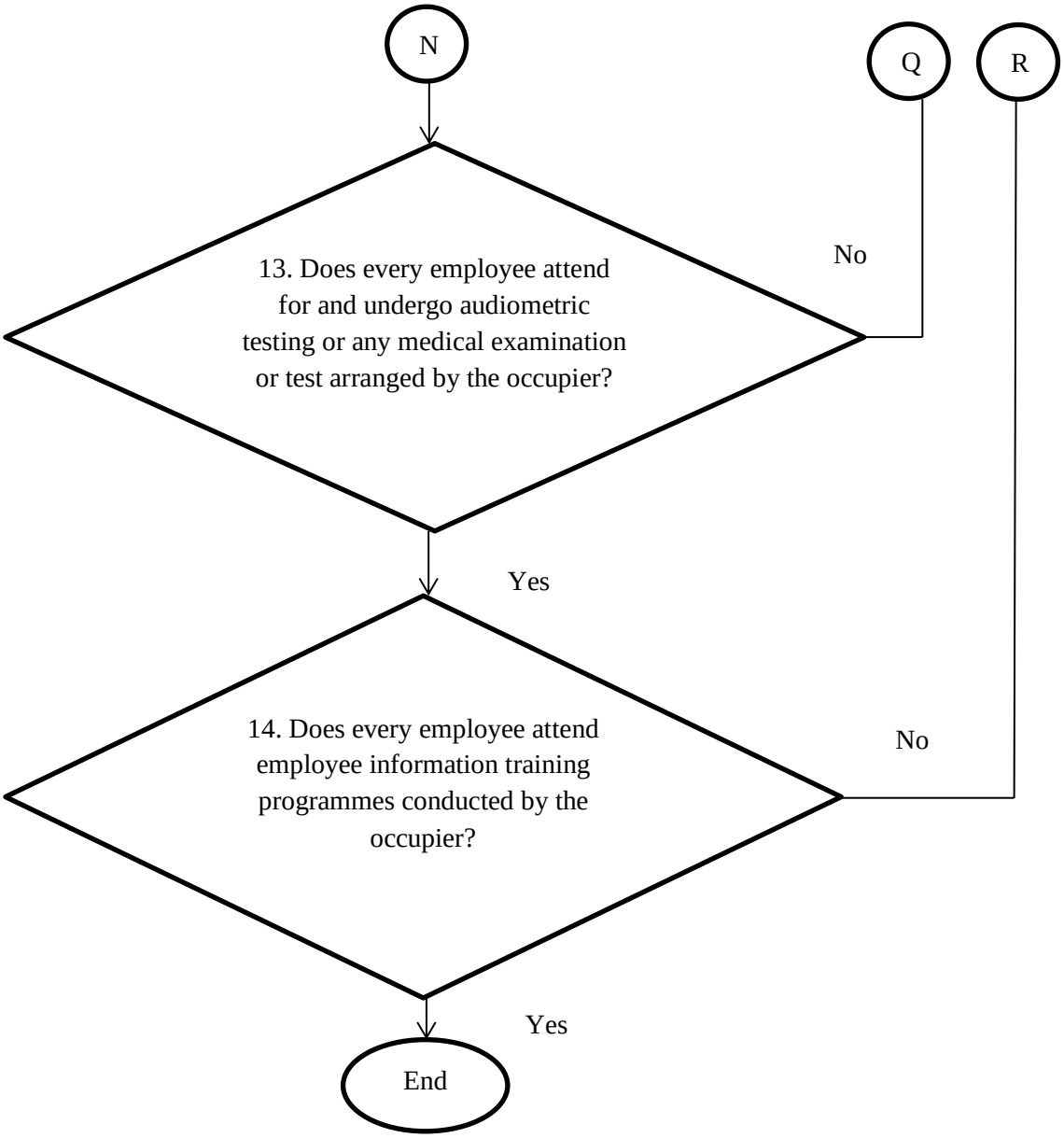


Figure 4.12. The detailed framework k of NEMS.

Based on Figure 4.11, under regulation 32 which is about transfer of records, there are three requirements:

(a) Whenever an occupier has ceased to carry on business, the successor occupier shall receive and retain all records required to be maintained under these Regulations.

(b) Whenever an occupier has ceased to carry on business and there is no successor occupier to receive and retain the records required to be maintained under these Regulations, the records shall be transmitted to the Chief Inspector.

(c) At the expiration of the retention period for the records required to be maintained under regulations 29 and 30, the occupier shall give the Chief Inspector at least three months notice that he intends to dispose of such records, and he shall transmit those records to the Chief Inspector if requested to do so within that period.

Lastly, there are 4 continuous feedback loops to ensure the obligation of employee (Part I) has been carried out. As illustrated in Figure 4.11, at the feedback loop 11, it determine if every employee co-operate with the occupier by wearing a noise dosimeter during employee exposure monitoring. If no, the flow will go back to regulation 14 as illustrated in Figure 4.3. As stated earlier, approved noise measuring equipment such as noise dosimeter for employee exposure monitoring should be worn. If yes, it will go to feedback loop 12 which determine if every employee wear and make full and proper use of the hearing protection device provided for his use. If no, the flow will go back to regulation 17 as illustrated in Figure 4.5. Under this regulation, occupier shall, at no cost to the employee, provide an approved hearing protection device to, and ensure its use by employee.

If the answer of feedback loop 12 is yes, it will go to feedback loop 13 as illustrated in Figure 4.12, which determine if every employee attend for and undergo audiometric testing or any medical examination or test arranged by the occupier. If no, the flow will go back to regulation 20 as illustrated in Figure 4.6. Under this regulation, occupier shall establish and maintain an audiometric testing programme for all employees exposed to noise level at or above the action level. Also, the programme shall be conducted at no cost to the employees. These can make sure the employee attend for and undergo audiometric testing or any medical examination or test. If yes, it will go to last feedback loop which is number 14 which determine if every employee attend employee information and training programmes conducted by the occupier. If no, the flow will go back to regulation 27 as illustrated in Figure 4.9. Under this regulation, occupier shall institute a training programme for, and ensure the participation of all employees exposed to noise level at or above the action level. Also, the training programme shall be repeated at least once in every two years. These requirements can

ensure the employee attend employee information and training programmes. If the answer of last feedback loop is yes, the flow is ended.

Regulation 8 General

(1) For the purposes of this Part, employee exposure is the exposure which would occur if the employee is not using a hearing protection device.

(2) Every occupier shall conduct employee exposure monitoring to determine if any employee may be exposed to noise level at or above the action level.

(3) All continuous, intermittent, and impulsive noise levels from 80 dB to 130 dB shall be integrated into the computation to determine employee exposure in pursuance to sub-regulation (2).

(4) Exposure monitoring conducted in pursuance to sub-regulation (2) shall be representative of the monitored employee's normal and daily exposure to noise level.

Figure 4.13. Supply info for regulation 8 in framework.

SECOND SCHEDULE

(Regulation 20 (4) (*c*))

Maximum Allowable Octave - Band Sound Pressure Levels for Audiometric Test Rooms

Octave-band centre frequency (Hz)	500	1000	2000	4000	8000
Sound Pressure Level, dB	27	30	35	42	41

Made the 10th December 1988.
[KB. (S) 32/1/2/5/1/1; PN. (PU2) 235/V.]

ENCIK LEE KIM SAI,
Minister of Labour

Figure 4.14. Supply info for Second Schedule.

FIRST SCHEDULE

(Regulation 5 (1))

Permissible Exposure Limits

Noise Level (dB (A)-slow)	Duration of Exposure Permitted per day (hours-minute)
85	16-0
86	13-56
87	12-8
88	10-34
89	9-11
90	8-0
91	6-58
92	6-4
	[Am. P.U.(A) 106/89]
93	5-17
94	4-36
95	4-0
96	3-29
97	3-2
98	2-50
99	2-15
100	2-0
101	1-44
102	1-31
103	1-19
104	1-9
105	1-0
106	0-52
107	0-46
108	0-40
109	0-34
110	0-30
111	0-26
112	0-23
113	0-20
114	0-17
115	0-15

Figure 4.15.Supply info for First Schedule.

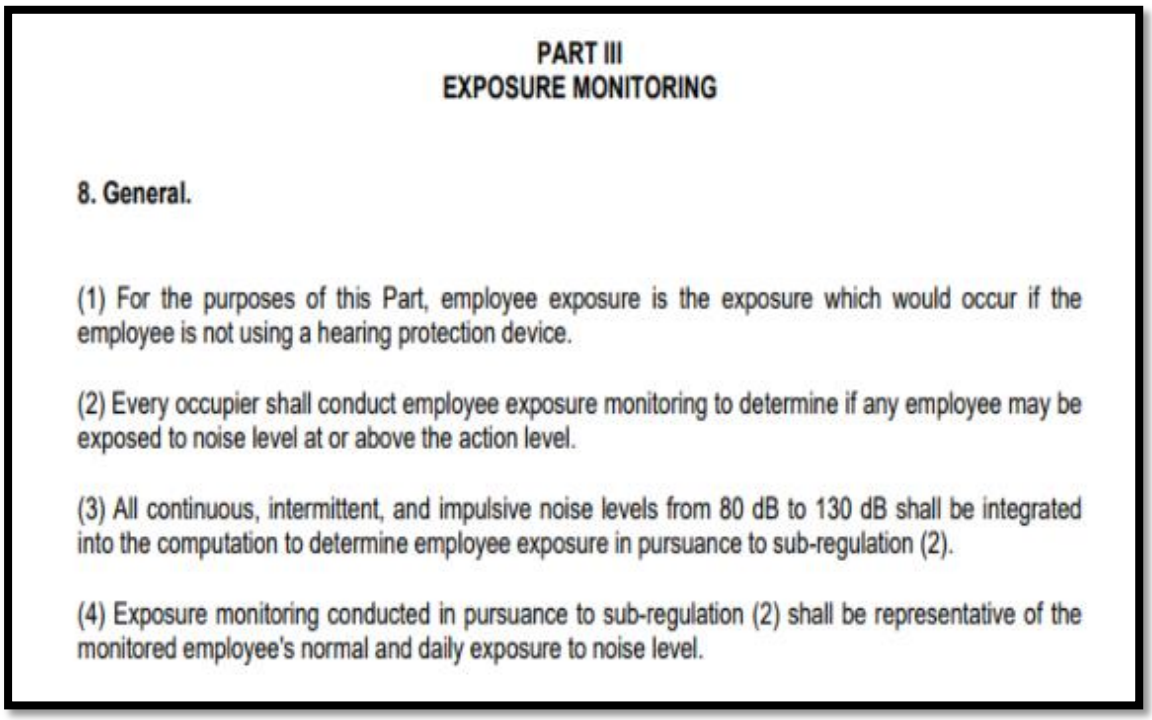
4.3 Development of Prototype of NEMS

As stated in chapter 3, a prototype database management system known as Noise Exposure Management System (NEMS) was developed as illustrated in Figure 4.17 and 4.18 by using Microsoft Office Access 2010. This NEMS which based on Microsoft Access could ensure that information, reports or documents is kept as it enables the user to input data, manage and track information.

Also, NEMS provides a systematic way in detail about how to comply with all the requirements in Factories and Machinery Act (Noise Exposure) Regulation 1989. As illustrated in Figure 4.17, there are 10 tables or interfaces inside the NEMS which consists of a main interface and 9 sub-interface. The main interface of NEMS consists of "ID", "Requirement", "Complete", "Incomplete" and "Remarks". This main interface is used to assess and monitor the compliance status of all regulations by part by part. For the other 9 sub-interface, it based on Part I, Part II, Part III, Part IV, Part V, Part VI, Part VII, Part VIII and Part IX as stated in Factories and Machinery (Noise Exposure) 1989. On the other hand, Figure 4.18 shows the sub-interface of NEMS for Part III Exposure Monitoring interface with "Regulation", "Requirement", "Supply info", "Revision date", "Approved by", "Complete", "Incomplete", "Remarks", "Evidence location" and "Due date" columns.

Besides that, as illustrated in Figure 4.18, the NEMS is operated or used based on Plan-Do-Check-Act (PDCA) concept. For "Plan" of PDCA concept, "Regulation" column has shown that what regulations are needed to comply with and included in NEMS. For "Do" of PDCA concept, it includes columns of "Requirement" and "Supply info" "Requirement" column shows the way about how to comply with the regulation. It tell companies what should they do and lead them to comply with the regulation. "Supply info" is the information to support the statement of "Requirement" and let the end user more comprehend about it. "Supply info" can also hyperlink with the documents. End user just needs to click on it and the documents will pop out after that. For example, as illustrated in Figure 4.18, at the regulation 9, initial employee exposure monitoring (1), the supply info is regulation 8. Once the column of "supply info"

clicked, the document of description for regulation 8 pop out as illustrated in Figure 4.16.



PART III
EXPOSURE MONITORING

8. General.

(1) For the purposes of this Part, employee exposure is the exposure which would occur if the employee is not using a hearing protection device.

(2) Every occupier shall conduct employee exposure monitoring to determine if any employee may be exposed to noise level at or above the action level.

(3) All continuous, intermittent, and impulsive noise levels from 80 dB to 130 dB shall be integrated into the computation to determine employee exposure in pursuance to sub-regulation (2).

(4) Exposure monitoring conducted in pursuance to sub-regulation (2) shall be representative of the monitored employee's normal and daily exposure to noise level.

Figure 4.16. Supply info for regulation 8 in NEMS.

On top of that, for "Check" of PDCA concept, it includes "Revision date", "Approved by", "Complete", "Incomplete" and "Evidence location" columns. "Revision date" is the date of the companies to conduct the checklist of NEMS for each regulation. It can also be defined as the date when a regulation was checked or determined whether comply with the regulation or not. Besides that, the completeness compliance of the regulation is tracked by a checklist in the interface. Once completed, the authorized personnel can tick the "Complete" check box. If there is a lacks, tick the "Incomplete" check box. Evidences such as reports and documents can be inserted in "Evidence location" column to prove that whether it is complete or incomplete. For "Act" of PDCA concept, it includes columns of "Remarks" and "Due date". "Remarks" is used to state out the lacks or completeness of requirements and the further action that need to be taken. Also, some actions which need to be taken to achieve the completeness of complying with regulations must not later than a date. The date will show in "Due date" column.

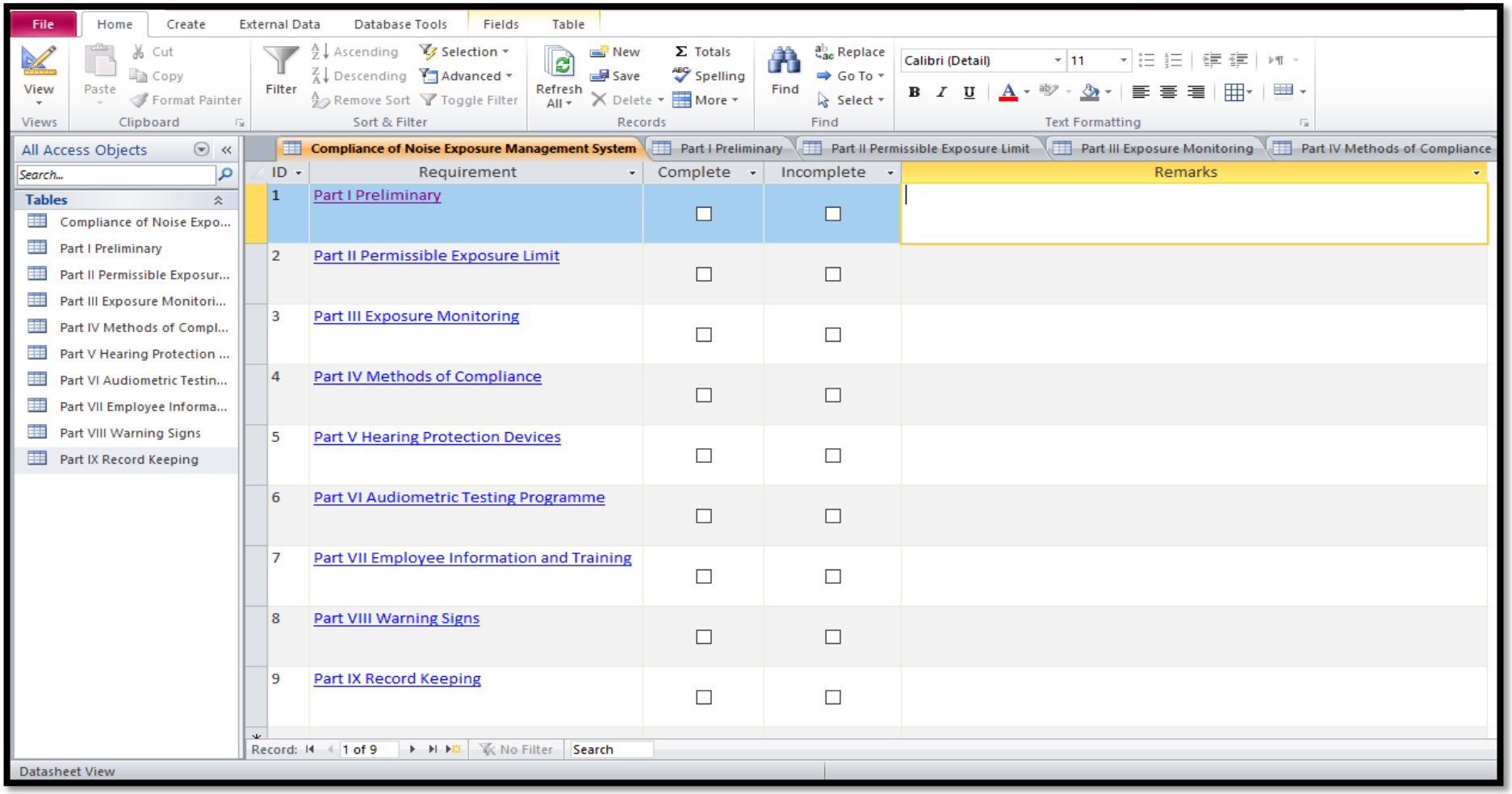


Figure 4.17. Main interface (Compliance of Noise Exposure Management System) of NEMS.

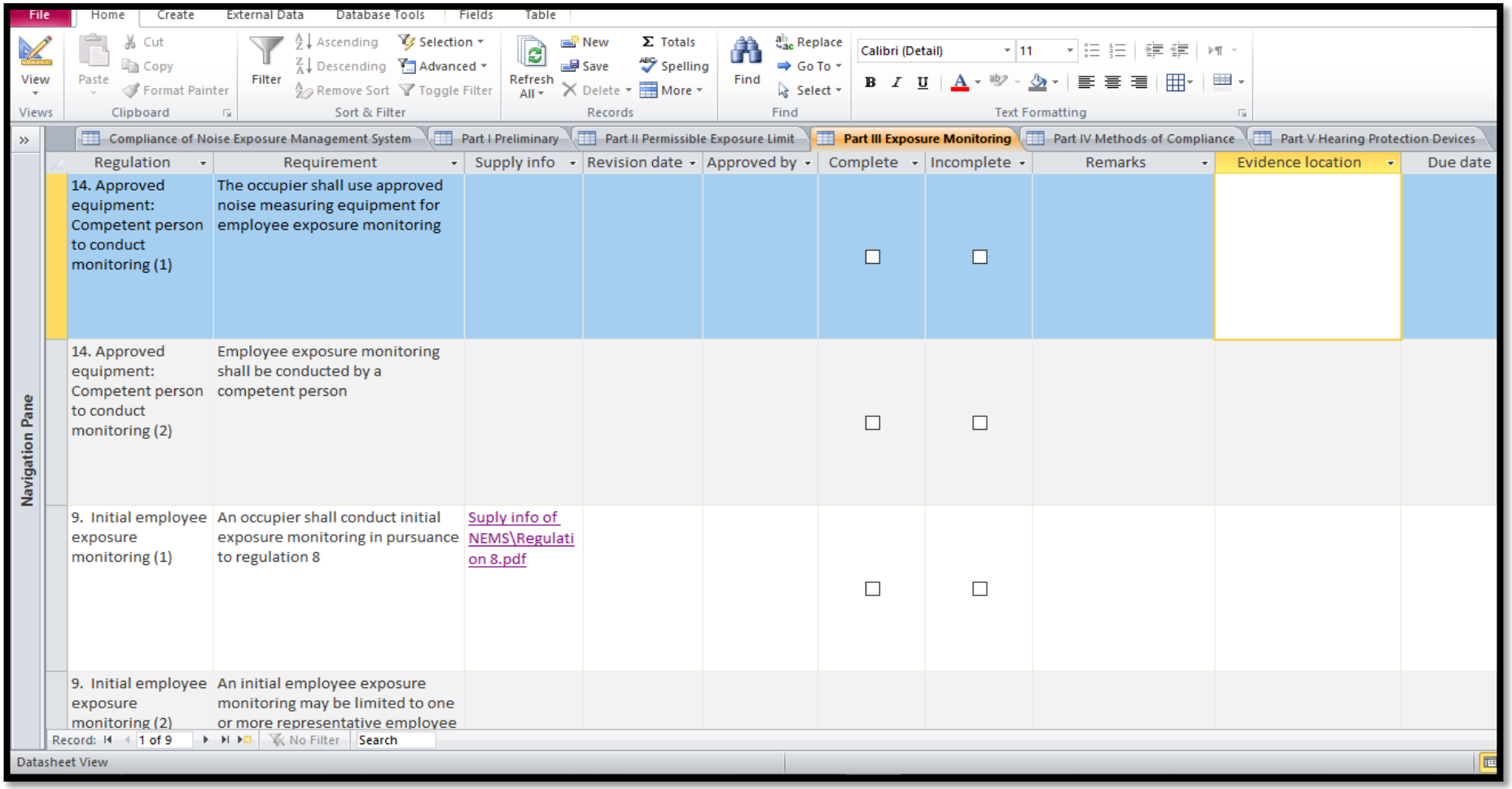


Figure 4.18. Part III Exposure Monitoring interface of NEMS.

4.4 Validation of Noise Exposure Management System

Noise Exposure Management System (NEMS) is validated by using the real process plant data which collected from process industries and interview with practitioners as case studies. There is two case studies have been conducted through document review and interview with practitioner from industries to verify and validate NEMS based on requirements of Factories and Machinery (Noise Exposure) 1989.

4.4.1 Case Study 1

For the first case study, there are two interfaces or parts as shown in the main interface have not completed yet which are Part II Permissible Exposure Limit and Part VI Audiometric Testing Programme. As illustrated in Figure 4.19, these two parts are identified gaps and ticked incomplete. At “Remarks” column for Part II, the highest equivalent continuous noise level (Leq) is 96 dBA which exceeded 90 dBA. Therefore, hearing protection devices such as earplug (NRR 33) must be provided to attenuate the employee noise exposure level. For Part VI, the “Remarks” column shows that Occupier did not repeat the audiometric test on the employee once in every two years. The last 2 audiometric tests are done on 8/10/2013 and 31/3/2015. Action need to be taken as soon as possible by conducting audiometric test. On the other hand, the other 8 sub-interfaces or parts are ticked complete.

For interface of Part I Preliminary, there have “supply info” for each regulation and they interlink with the document and other parts. The description about regulation 3 is interlinked into “Supply info” column for regulation 4 obligation of occupier and employee (1). Besides that, other regulations in interface of Part I Preliminary have interlinked with other parts at the “Supply info” column. It due to the compliance of these regulations can be checked by referring to those parts which are interlinked.

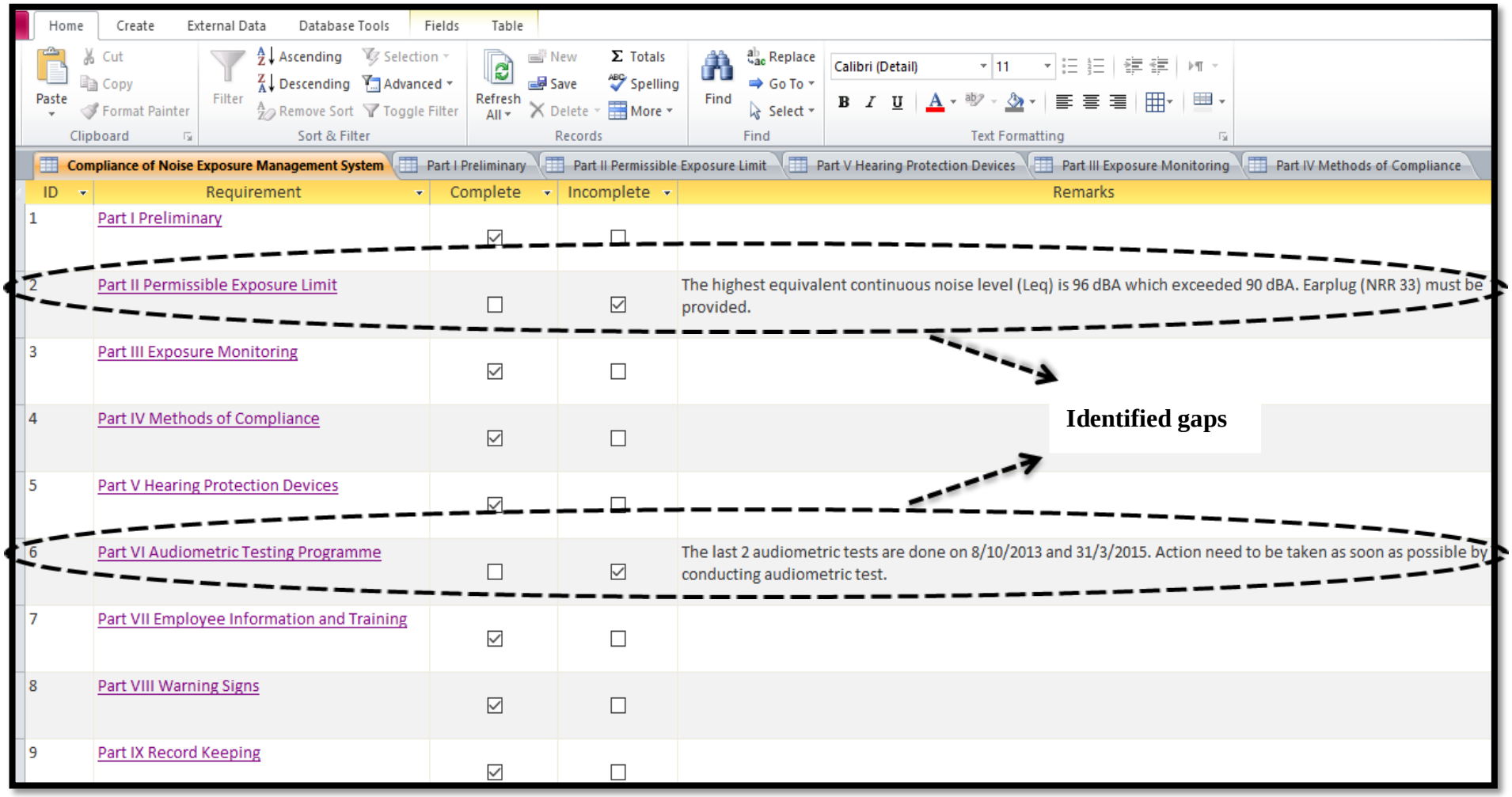
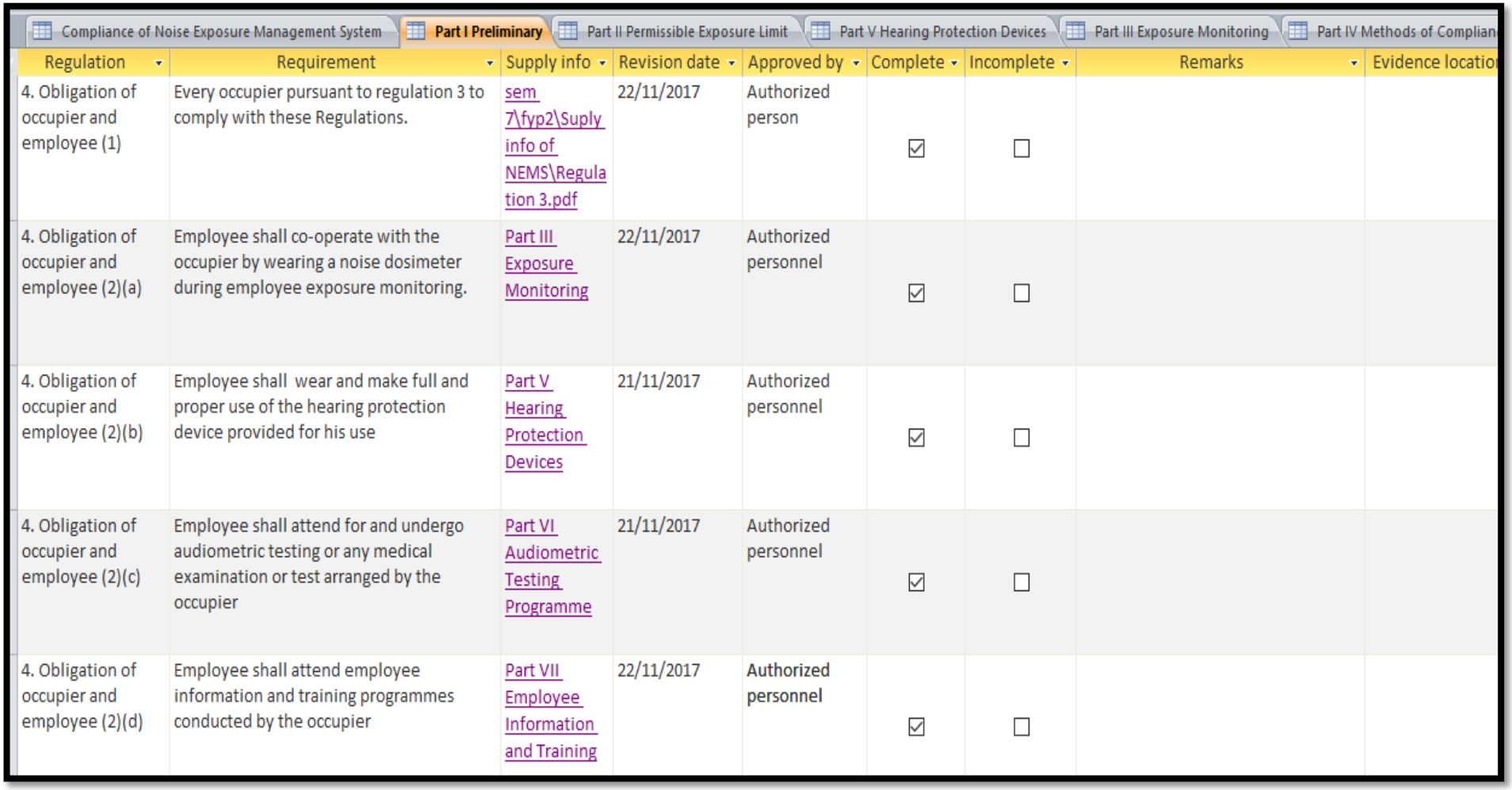


Figure 4.19. Main interface of NEMS (case study 1).



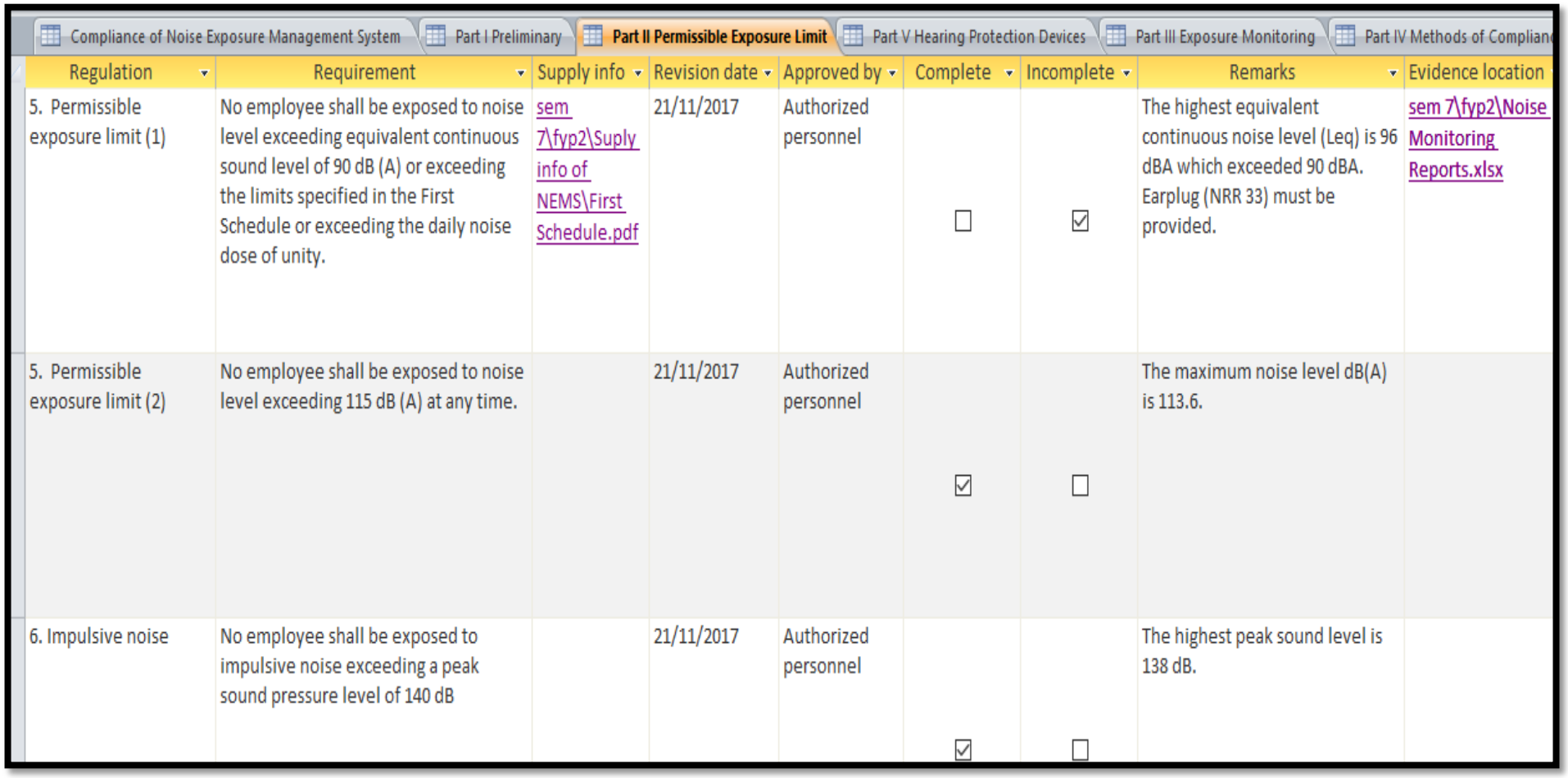
Regulation	Requirement	Supply info	Revision date	Approved by	Complete	Incomplete	Remarks	Evidence location
4. Obligation of occupier and employee (1)	Every occupier pursuant to regulation 3 to comply with these Regulations.	sem 7\fyp2\Suply info of NEMS\Regulation 3.pdf	22/11/2017	Authorized person	☑	☐		
4. Obligation of occupier and employee (2)(a)	Employee shall co-operate with the occupier by wearing a noise dosimeter during employee exposure monitoring.	Part III Exposure Monitoring	22/11/2017	Authorized personnel	☑	☐		
4. Obligation of occupier and employee (2)(b)	Employee shall wear and make full and proper use of the hearing protection device provided for his use	Part V Hearing Protection Devices	21/11/2017	Authorized personnel	☑	☐		
4. Obligation of occupier and employee (2)(c)	Employee shall attend for and undergo audiometric testing or any medical examination or test arranged by the occupier	Part VI Audiometric Testing Programme	21/11/2017	Authorized personnel	☑	☐		
4. Obligation of occupier and employee (2)(d)	Employee shall attend employee information and training programmes conducted by the occupier	Part VII Employee Information and Training	22/11/2017	Authorized personnel	☑	☐		

Figure 4.20. Part I Preliminary interface of NEMS.

For interface of Part II Permissible Exposure Limit as illustrated in Figure 4.21, regulation 5 permissible exposure limit (1) has shown incomplete. At “Remarks” column of this regulation, it stated that the highest equivalent continuous noise level (Leq) is 96 dBA which exceeded 90 dBA. Earplug (NRR 33) must be provided. At the “Evidence column”, it interlinked with Microsoft Excel file named as “Noise Monitoring Reports” which consists of previous and latest of noise monitoring reports. In the Microsoft Excel, it listed out the date of monitoring, description, approval and interlink with noise monitoring report. By using Microsoft Excel, companies can track and look back the previous reports as all the reports can be listed inside Microsoft Excel and interlinked with the documents of reports. Moreover, the other regulations are ticked complete as “Remarks” columns stated that the maximum noise level and highest peak sound are not exceeded the limits specified in these regulations.

For interface of Part III Exposure Monitoring, as illustrated in Figure 4.23, 4.24 and 4.25, all of the regulations are complied and ticked at “Complete” column. At the column of “Evidence location”, some regulations interlinked with a Microsoft Excel file named as “Noise Monitoring Reports” which consists of evidences for compliance of requirements by referring Figure 4.22. As illustrated in Figure 4.24, for regulation 9 initial exposure monitoring (1), the description about regulation 8 is interlinked at “Supply info” column. For regulation 11 as illustrated in Figure 4.25, it is ticked at “complete” column as there is no negative initial employee exposure monitoring. Same goes to regulation 12, it is ticked at “complete” column as there has not been production, process, equipment, control measures or personnel change. For regulation 13, “Remarks” column shows that the receipt of the latest employee exposure monitoring results is on 21/9/16 and employee notification has been done on the next day. The due date is on 5/10/16 as illustrated in Figure 4.23, therefore regulation 13 is completed.

For interface of Part IV Methods of Compliance as illustrated in Figure 4.26, it consists of only two regulations which are regulation 15 and 16. Both of these regulations are ticked at the “complete” columns. For regulation 15, it interlinked with Part II Permissible Exposure Limit at “Supply info” column to provide description about regulation 5. For regulation 16, it interlinked with Part V Hearing Protection devices at “Supply info” column.



Regulation	Requirement	Supply info	Revision date	Approved by	Complete	Incomplete	Remarks	Evidence location
5. Permissible exposure limit (1)	No employee shall be exposed to noise level exceeding equivalent continuous sound level of 90 dB (A) or exceeding the limits specified in the First Schedule or exceeding the daily noise dose of unity.	sem 7\fyp2\Suply info of NEMS\First Schedule.pdf	21/11/2017	Authorized personnel	☐	☑	The highest equivalent continuous noise level (Leq) is 96 dBA which exceeded 90 dBA. Earplug (NRR 33) must be provided.	sem 7\fyp2\Noise Monitoring Reports.xlsx
5. Permissible exposure limit (2)	No employee shall be exposed to noise level exceeding 115 dB (A) at any time.		21/11/2017	Authorized personnel	☑	☐	The maximum noise level dB(A) is 113.6.	
6. Impulsive noise	No employee shall be exposed to impulsive noise exceeding a peak sound pressure level of 140 dB		21/11/2017	Authorized personnel	☑	☐	The highest peak sound level is 138 dB.	

Figure 4.21. Part II Permissible Exposure Limit interface of NEMS.

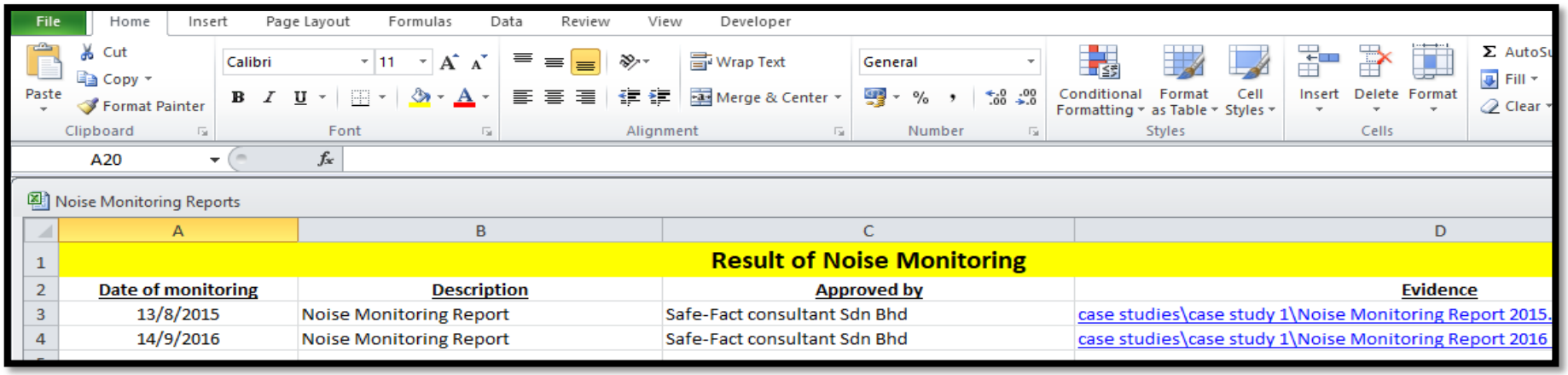
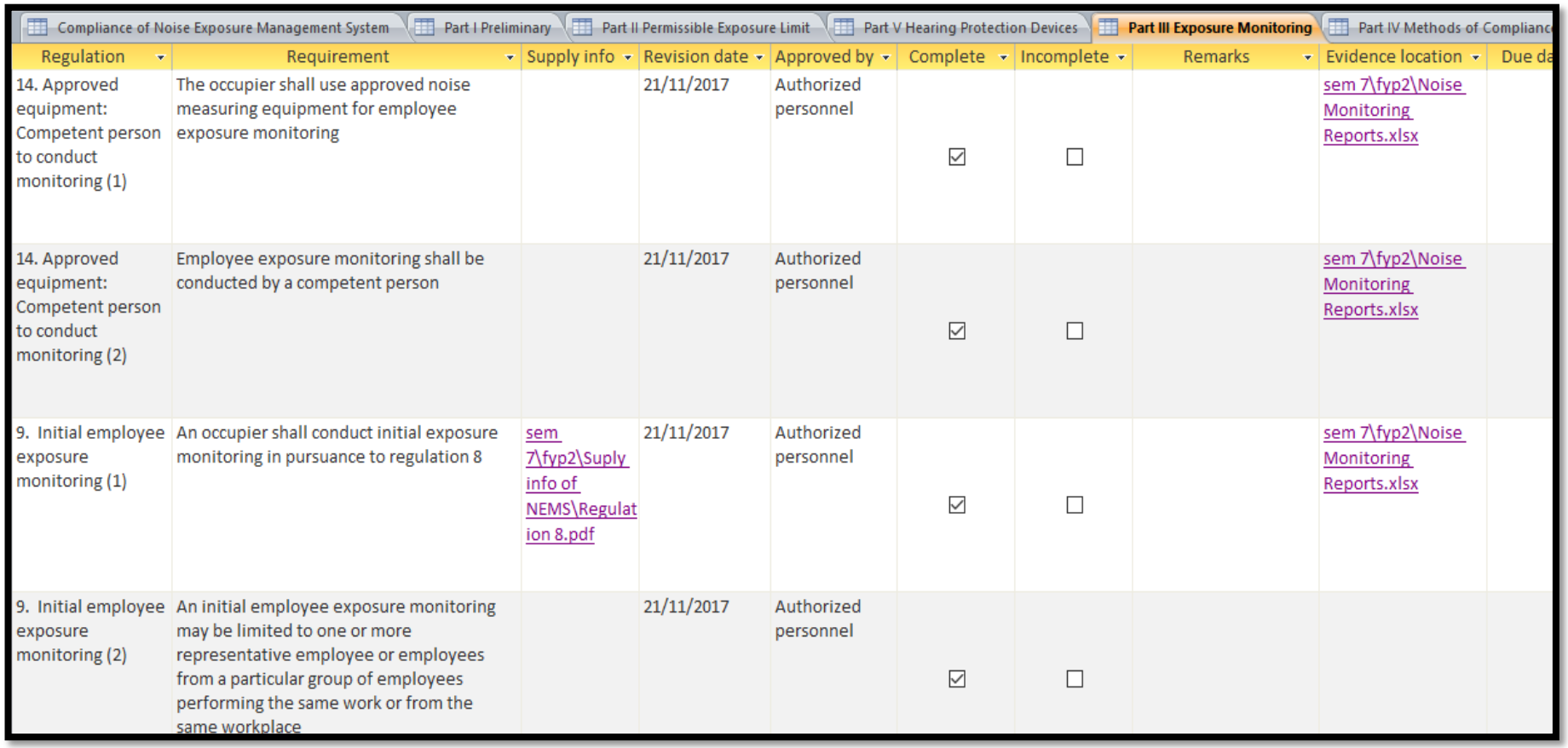


Figure 4.22. Noise Monitoring Reports (Microsoft Excel file).

Figure 4.23. Part III Exposure Monitoring interface of NEMS (Regulation 13).



Compliance of Noise Exposure Management System | Part I Preliminary | Part II Permissible Exposure Limit | Part V Hearing Protection Devices | **Part III Exposure Monitoring** | Part IV Methods of Compliance

Regulation	Requirement	Supply info	Revision date	Approved by	Complete	Incomplete	Remarks	Evidence location	Due da
14. Approved equipment: Competent person to conduct monitoring (1)	The occupier shall use approved noise measuring equipment for employee exposure monitoring		21/11/2017	Authorized personnel	☑	☐		sem 7\fyp2\Noise Monitoring Reports.xlsx	
14. Approved equipment: Competent person to conduct monitoring (2)	Employee exposure monitoring shall be conducted by a competent person		21/11/2017	Authorized personnel	☑	☐		sem 7\fyp2\Noise Monitoring Reports.xlsx	
9. Initial employee exposure monitoring (1)	An occupier shall conduct initial exposure monitoring in pursuance to regulation 8	sem 7\fyp2\Suply info of NEMS\Regulation 8.pdf	21/11/2017	Authorized personnel	☑	☐		sem 7\fyp2\Noise Monitoring Reports.xlsx	
9. Initial employee exposure monitoring (2)	An initial employee exposure monitoring may be limited to one or more representative employee or employees from a particular group of employees performing the same work or from the same workplace		21/11/2017	Authorized personnel	☑	☐			

Figure 4.24. Part III Exposure Monitoring interface of NEMS (Regulation 14 and 9).

Compliance of Noise Exposure Management System | Part I Preliminary | Part II Permissible Exposure Limit | Part V Hearing Protection Devices | **Part III Exposure Monitoring** | Part IV Methods of Compliance

Regulation	Requirement	Supply info	Revision date	Approved by	Complete	Incomplete	Remarks	Evidence location	Due date
10. Positive initial employee exposure monitoring (1)	Determine noise exposure levels for employees engaged in the same work or from the same workplace within six months from the date of receipt of the results of the initial employee exposure monitoring		21/11/2017	Authorized personnel	☑	☐		sem 7\fyp2\Noise Monitoring Reports.xlsx	
10. Positive initial employee exposure monitoring (2)	An initial employee exposure monitoring may be limited to one or more representative employee or employees from a particular group of employees performing the same work or from the same workplace		21/11/2017	Authorized personnel	☑	☐			
11. Negative initial employee exposure monitoring	The occupier need not determine noise exposure levels for each and every employee engaged in the same work or from the same workplace except as otherwise provided in regulation 12		21/11/2017	Authorized personnel	☑	☐	There is no negative initial employee exposure monitoring		
12. Additional monitoring	Whenever there has been a production, process, equipment, control measures or personnel change in the factory, the occupier shall conduct additional monitoring within six months from the date of such change or changes		21/11/2017	Authorized personnel	☑	☐	There has not been production, process, equipment, control measures or personnel change.		

Figure 4.25. Part III Exposure Monitoring interface of NEMS (Regulation 10, 11 and 12).

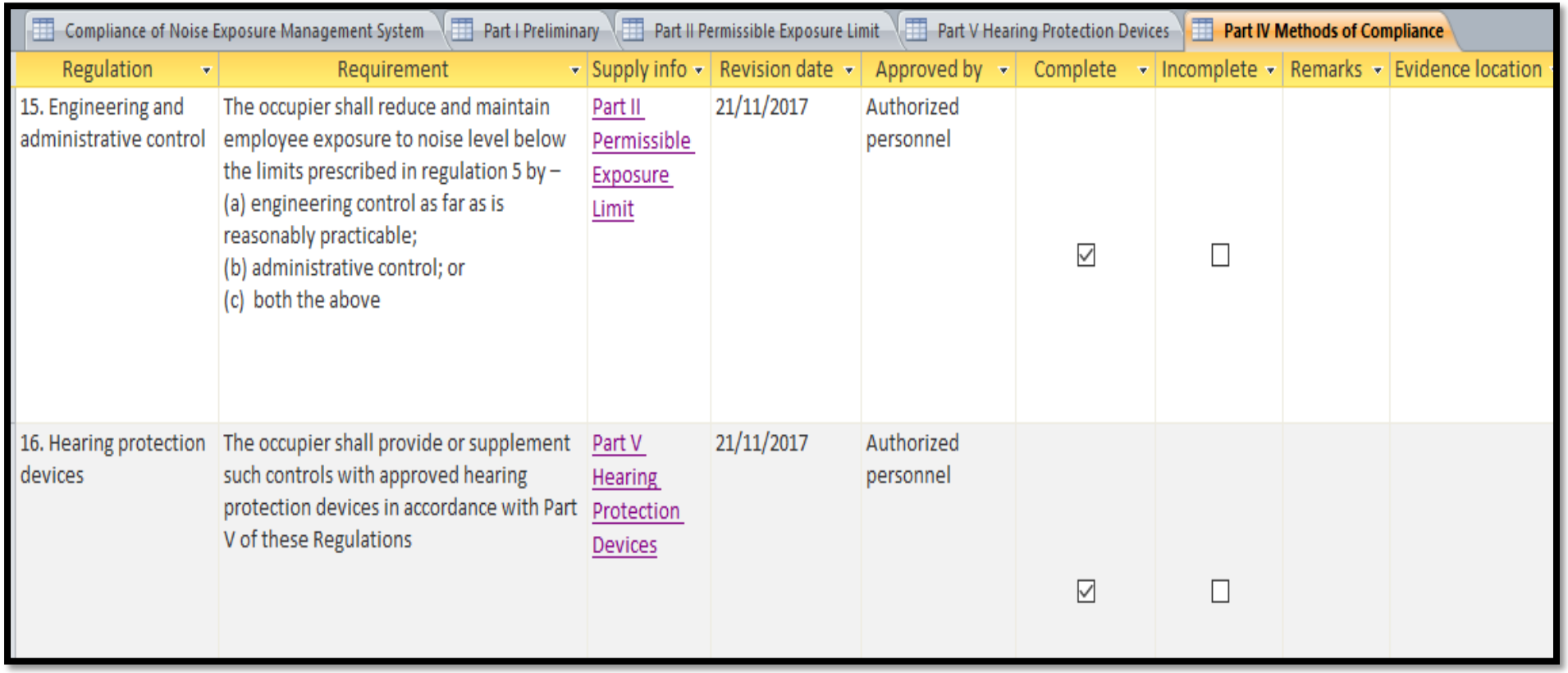
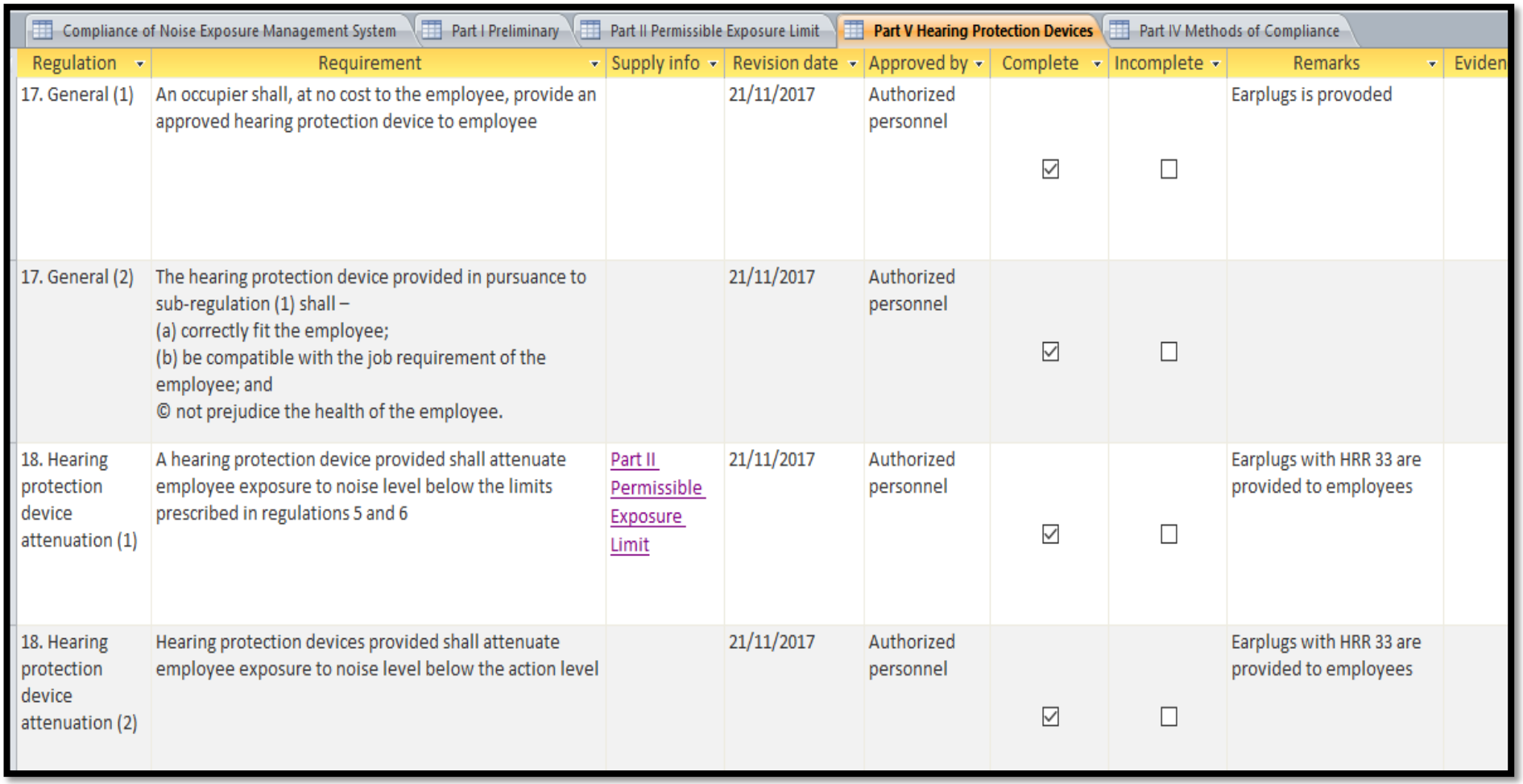


Figure 4.26. Part IV Methods of Compliance interface of NEMS.

For interface of Part V Hearing Protection Devices as illustrated in Figure 4.27, all of the regulations are complied and ticked at the “Complete” column. For regulation 18 hearing protection device attenuation (1), it is interlinked with Part II Permissible Exposure limit to provide description about regulation 5 and 6. At some of the “Remarks” columns, it stated that earplug or earplug with Noise Reduction Rating (NRR) 33 is provided to employees in order to comply these regulations.

For interface of Part VI Audiometric Testing Programme as illustrated in Figure 4.28, regulation 20 general (4) (c) is interlinked with Second Schedule at the “Supply info” column. Besides that, at the “Evidence location” column, each regulation is interlinked with a Microsoft Excel file which consists of previous and latest audiometric test reports as illustrated in Figure 4.29. Figure 4.31 shows the evidence of documents. On top of that, based on Figure 4.30, regulation 22 frequency of audiometric testing (a) has shown incomplete. It stated that the last 2 audiometric tests are done on 8/10/2013 and 31/3/2015 at the “Remarks” column. It was overdue therefore action need to be taken as soon as possible by conducting audiometric test to employees. Regulation 22 is also interlinked with Part II Permissible Exposure Limit at the “Supply info” column to provide description on regulation 5. The advantage by interlinking with Part II (refer to Figure 4.21) is the end user has a easily way to know about the further info. It is just needed to click on the “supply info” column and then directly go to source of info.

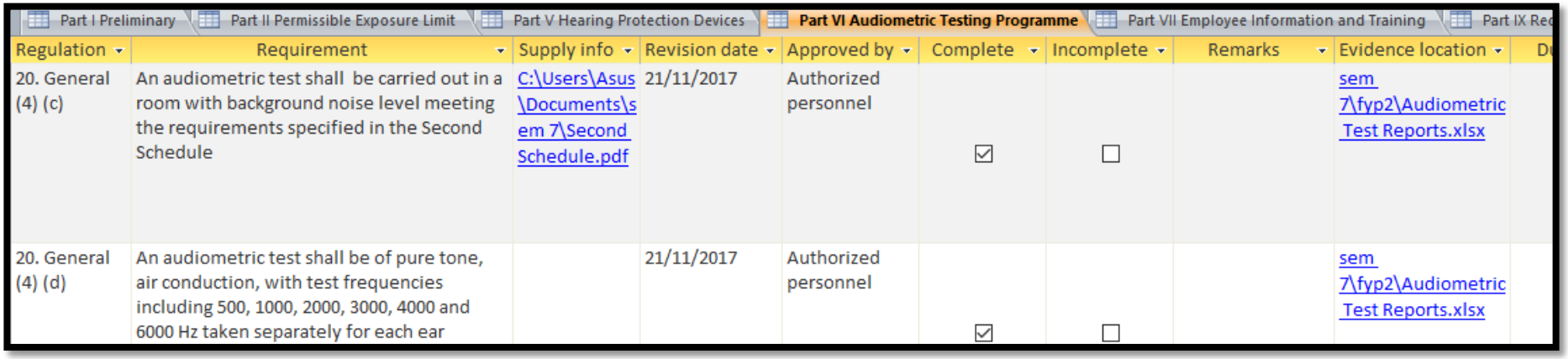
For interface of Part VII Employee Information and Training (Figure 4.32), all of the regulations are complied and ticked at the “Complete” column. At the “Evidence column”, there are interlinked with Microsoft Excel file which used to keep all of the training programme records. With this Microsoft Excel file, evidence of requirements compliance can be checked systematically at here. For regulation 27 training (3), the latest training programme has conducted on 11/5/2017. Therefore, next training programme must be conducted within 2 years and the due date is 21/11/2019 as shown at “Due date” column..



Compliance of Noise Exposure Management System | Part I Preliminary | Part II Permissible Exposure Limit | **Part V Hearing Protection Devices** | Part IV Methods of Compliance

Regulation	Requirement	Supply info	Revision date	Approved by	Complete	Incomplete	Remarks	Eviden
17. General (1)	An occupier shall, at no cost to the employee, provide an approved hearing protection device to employee		21/11/2017	Authorized personnel	☑	☐	Earplugs is provoded	
17. General (2)	The hearing protection device provided in pursuance to sub-regulation (1) shall – (a) correctly fit the employee; (b) be compatible with the job requirement of the employee; and © not prejudice the health of the employee.		21/11/2017	Authorized personnel	☑	☐		
18. Hearing protection device attenuation (1)	A hearing protection device provided shall attenuate employee exposure to noise level below the limits prescribed in regulations 5 and 6	Part II Permissible Exposure Limit	21/11/2017	Authorized personnel	☑	☐	Earplugs with HRR 33 are provided to employees	
18. Hearing protection device attenuation (2)	Hearing protection devices provided shall attenuate employee exposure to noise level below the action level		21/11/2017	Authorized personnel	☑	☐	Earplugs with HRR 33 are provided to employees	

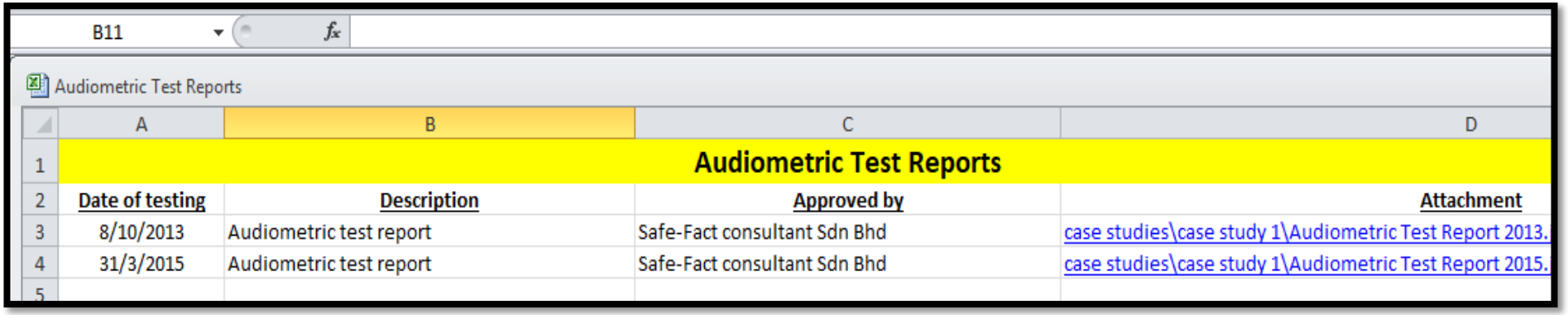
Figure 4.27. Part V Hearing Protection Devices of NEMS.



Part I Preliminary | Part II Permissible Exposure Limit | Part V Hearing Protection Devices | **Part VI Audiometric Testing Programme** | Part VII Employee Information and Training | Part IX Rec

Regulation	Requirement	Supply info	Revision date	Approved by	Complete	Incomplete	Remarks	Evidence location	D
20. General (4) (c)	An audiometric test shall be carried out in a room with background noise level meeting the requirements specified in the Second Schedule	C:\Users\Asus\Documents\sem 7\Second Schedule.pdf	21/11/2017	Authorized personnel	☑	☐		sem 7\fyp2\Audiometric Test Reports.xlsx	
20. General (4) (d)	An audiometric test shall be of pure tone, air conduction, with test frequencies including 500, 1000, 2000, 3000, 4000 and 6000 Hz taken separately for each ear		21/11/2017	Authorized personnel	☑	☐		sem 7\fyp2\Audiometric Test Reports.xlsx	

Figure 4.28. Part VI Audiometric Testing Programme interface of NEMS (Regulation 20).

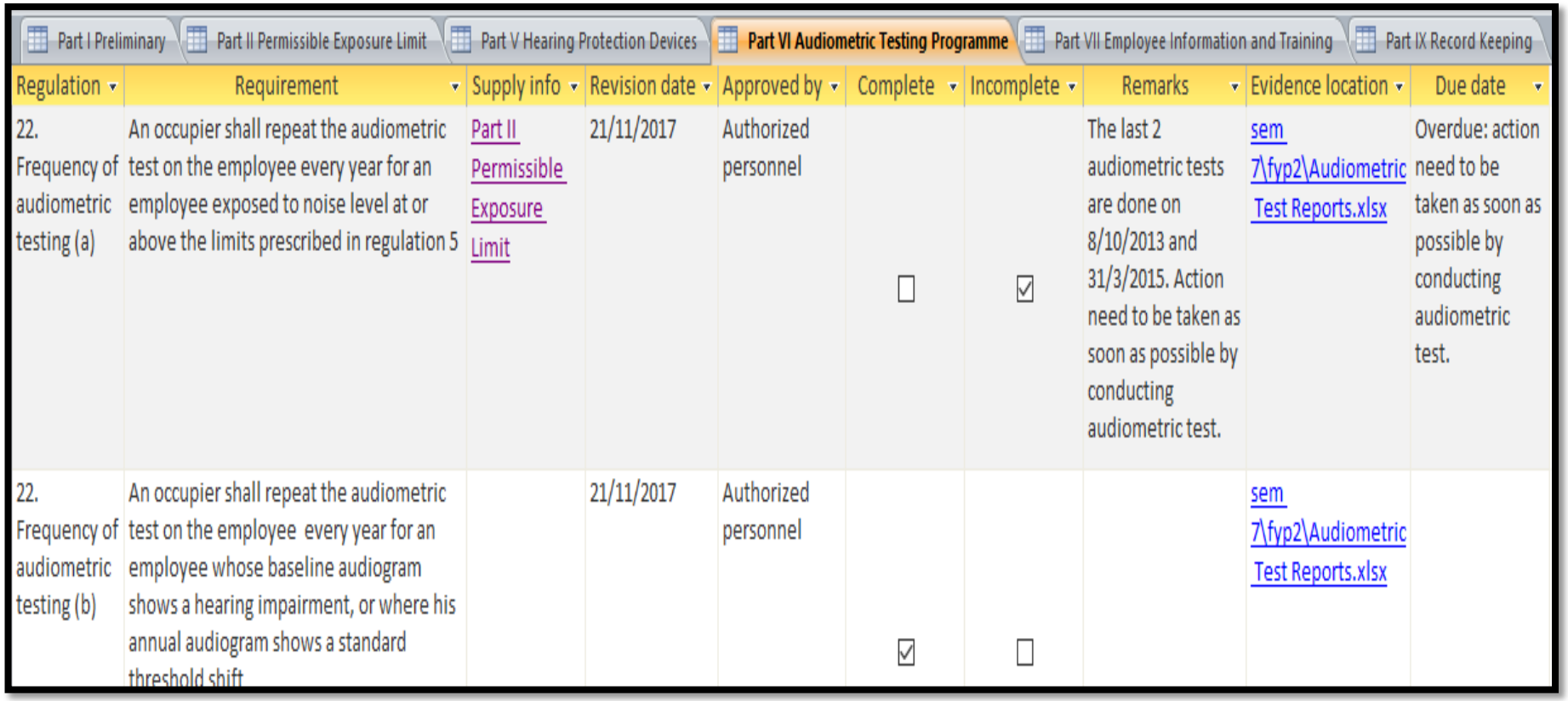


B11 f_x

Audiometric Test Reports

	A	B	C	D
1	**Audiometric Test Reports**			
2	**Date of testing**	**Description**	**Approved by**	**Attachment**
3	8/10/2013	Audiometric test report	Safe-Fact consultant Sdn Bhd	case studies\case study 1\Audiometric Test Report 2013.
4	31/3/2015	Audiometric test report	Safe-Fact consultant Sdn Bhd	case studies\case study 1\Audiometric Test Report 2015.
5				

Figure 4.29. Audiometric Test Reports (Microsoft Excel file).



Part I Preliminary | Part II Permissible Exposure Limit | Part V Hearing Protection Devices | **Part VI Audiometric Testing Programme** | Part VII Employee Information and Training | Part IX Record Keeping

Regulation	Requirement	Supply info	Revision date	Approved by	Complete	Incomplete	Remarks	Evidence location	Due date
22. Frequency of audiometric testing (a)	An occupier shall repeat the audiometric test on the employee every year for an employee exposed to noise level at or above the limits prescribed in regulation 5	Part II Permissible Exposure Limit	21/11/2017	Authorized personnel	☐	☑	The last 2 audiometric tests are done on 8/10/2013 and 31/3/2015. Action need to be taken as soon as possible by conducting audiometric test.	sem 7\fyp2\Audiometric Test Reports.xlsx	Overdue: action need to be taken as soon as possible by conducting audiometric test.
22. Frequency of audiometric testing (b)	An occupier shall repeat the audiometric test on the employee every year for an employee whose baseline audiogram shows a hearing impairment, or where his annual audiogram shows a standard threshold shift		21/11/2017	Authorized personnel	☑	☐		sem 7\fyp2\Audiometric Test Reports.xlsx	

Figure 4.30. Part VI Audiometric Testing Programme interface of NEMS (Regulation 22).

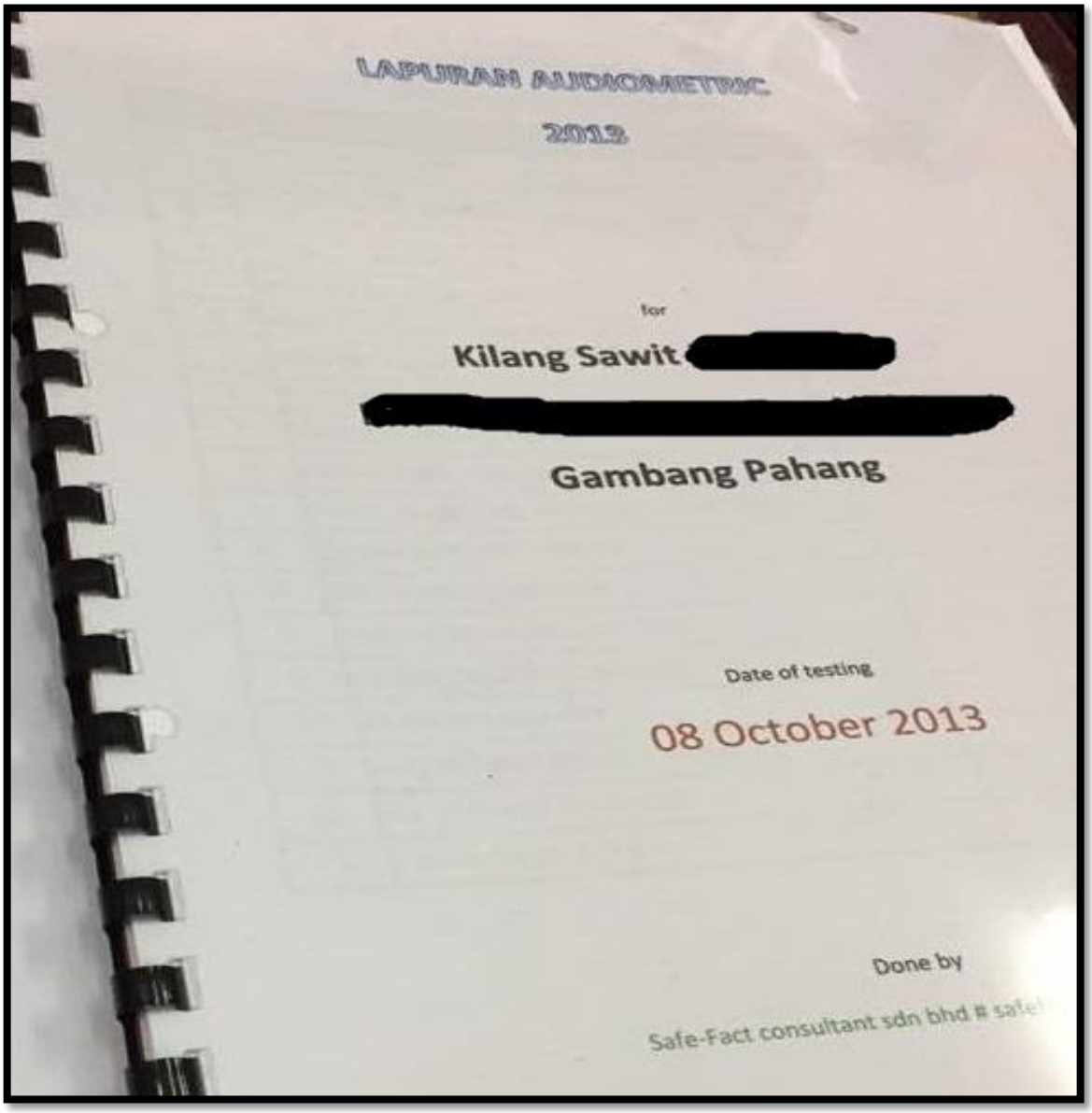
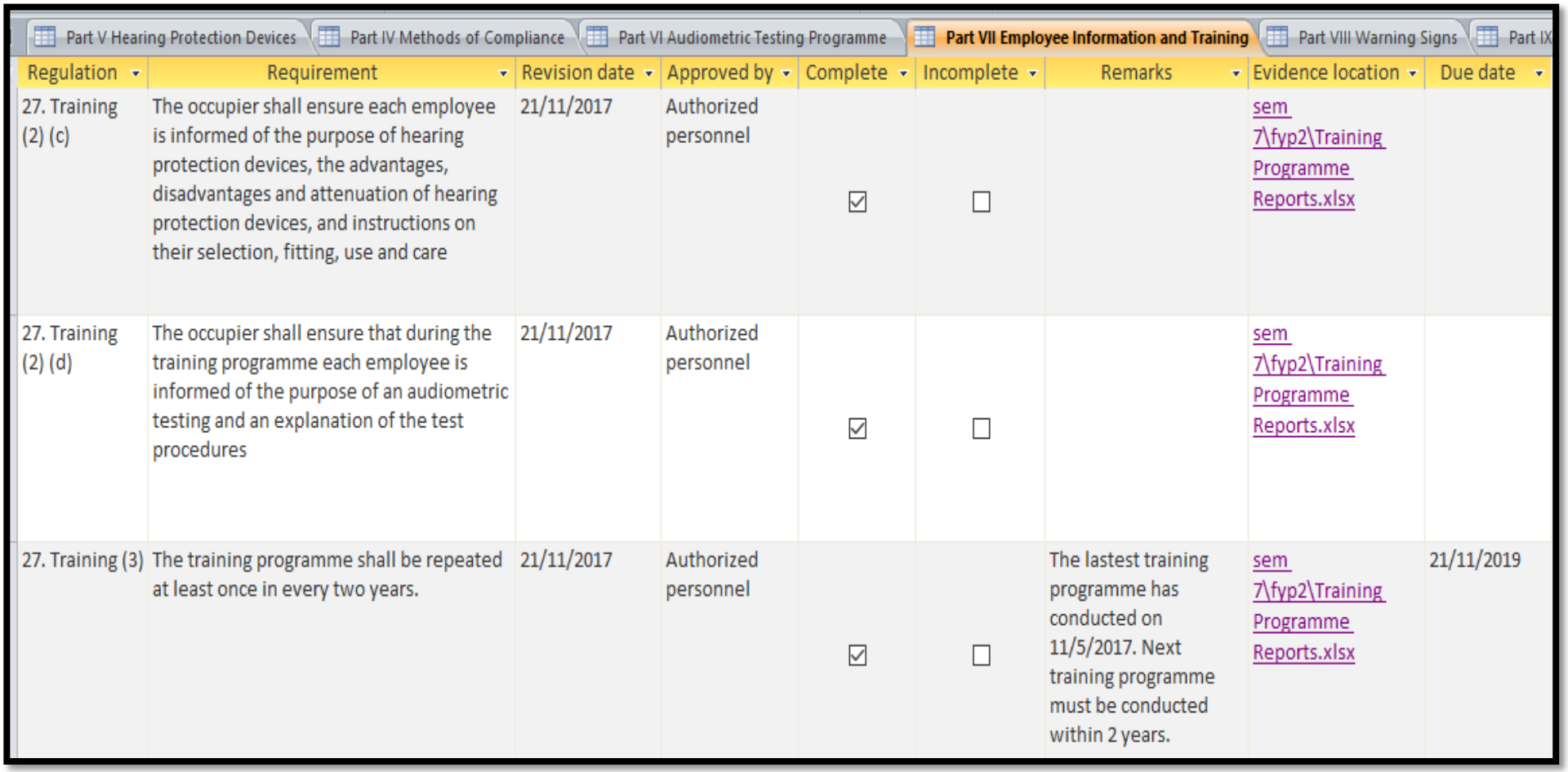


Figure 4.31. Evidence of audiometric test.



Part V Hearing Protection Devices | Part IV Methods of Compliance | Part VI Audiometric Testing Programme | **Part VII Employee Information and Training** | Part VIII Warning Signs | Part IX

Regulation	Requirement	Revision date	Approved by	Complete	Incomplete	Remarks	Evidence location	Due date
27. Training (2) (c)	The occupier shall ensure each employee is informed of the purpose of hearing protection devices, the advantages, disadvantages and attenuation of hearing protection devices, and instructions on their selection, fitting, use and care	21/11/2017	Authorized personnel	☑	☐		sem 7\fyp2\Training Programme Reports.xlsx	
27. Training (2) (d)	The occupier shall ensure that during the training programme each employee is informed of the purpose of an audiometric testing and an explanation of the test procedures	21/11/2017	Authorized personnel	☑	☐		sem 7\fyp2\Training Programme Reports.xlsx	
27. Training (3)	The training programme shall be repeated at least once in every two years.	21/11/2017	Authorized personnel	☑	☐	The lastest training programme has conducted on 11/5/2017. Next training programme must be conducted within 2 years.	sem 7\fyp2\Training Programme Reports.xlsx	21/11/2019

Figure 4.32. Part VII Employee Information and Training interface of NEMS.

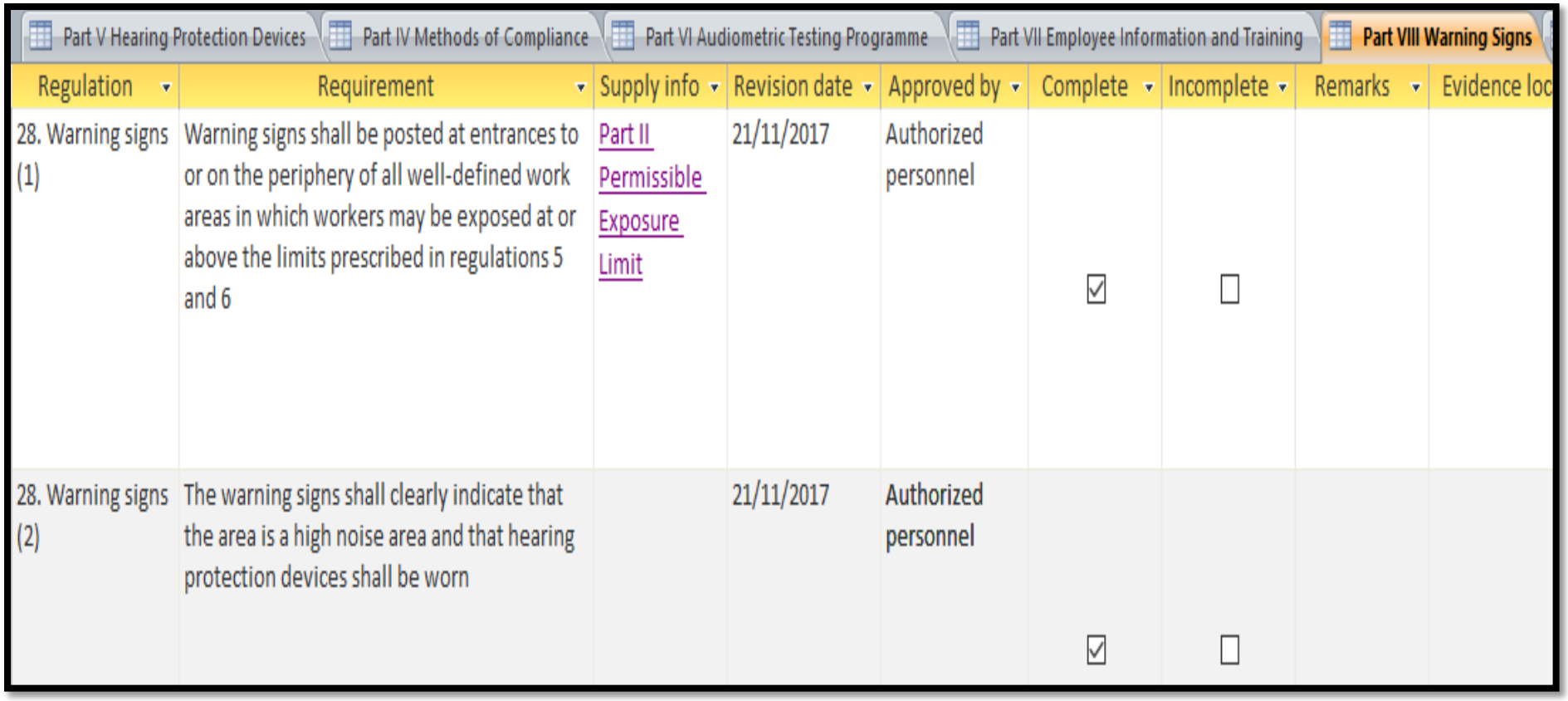


Figure 4.33. Part VIII Warning Signs interface of NEMS.

Part V Hearing Protection Devices | Part IV Methods of Compliance | Part VI Audiometric Testing Programme | Part VII Employee Information and Training | **Part IX Record Keeping**

Regulation	Requirement	Supply info	Revision date	Approved by	Complete	Incomplete	Remarks	Evidence locati
29. Exposure monitoring records (1)	The occupier shall establish and maintain an accurate record of all exposure monitoring conducted in pursuance to Part III of these Regulations	Part III Exposure Monitoring	21/11/2017		☑	☐		
29. Exposure monitoring records (2)	The record shall include: (a) the name of the employee and the daily noise dose (b) the location, date and time of measurement and the noise level obtained (c) the type, model and date of calibration of the noise measuring equipment		21/11/2017		☑	☐		
29. Exposure monitoring records (3)	The occupier shall maintain these exposure monitoring records for as long as the employee is employed		21/11/2017		☑	☐		
30. Audiometric test records (1)	The occupier shall keep an accurate record of all employee audiograms taken in pursuance to Part VI of these Regulations	Part VI Audiometric Testing Programme	21/11/2017		☑	☐		

Figure 4.34. Part IX Record Keeping interface of NEMS.

On top of that, for interface of Part VIII Warning Signs as illustrated in Figure 4.33, it has only one regulation that consists of two sub-regulations. All of these are ticked at the “Complete” columns. For regulation 28 warning signs (1), it is interlinked with Part II Permissible Exposure Limit to give description about regulation 5 and 6.

For the last interface of Part IX Record Keeping as illustrated in Figure 4.34, all of the regulations are ticked at “Complete” column. For regulation 29 exposure monitoring records (2), it interlinked with Part III Exposure Monitoring at the “Supply info” column. Besides that, for regulation 30 audiometric test records (1), it interlinked with Part VI Audiometric Test Programme at the “Supply info” column.

4.4.2 Case Study 2

For second case study, there are two interfaces or parts as shown in the main interface have not completed yet which are Part II Permissible Exposure Limit and Part VI Audiometric Testing Programme. These two parts are ticked at the “Incomplete” column as illustrated in Figure 4.11. As illustrated in Figure 4.35, there are two identified gaps which companies did not comply with the regulations.

In the interface of Part II Permissible Exposure Limit as illustrated in Figure 4.36, regulation 5 permissible exposure limit (1) is not complete. “Remarks” column stated that the highest equivalent continuous noise level (Leq) is exceeded 90 dBA. Control measures must be taken.

In the interface of Part VI Audiometric Testing Programme as illustrated in Figure 4.37, regulation 20 general (2) is ticked at the “incomplete” column. Its “Remarks” column stated that actions need to be taken to provide next audiometric testing programme at no cost to the employees.

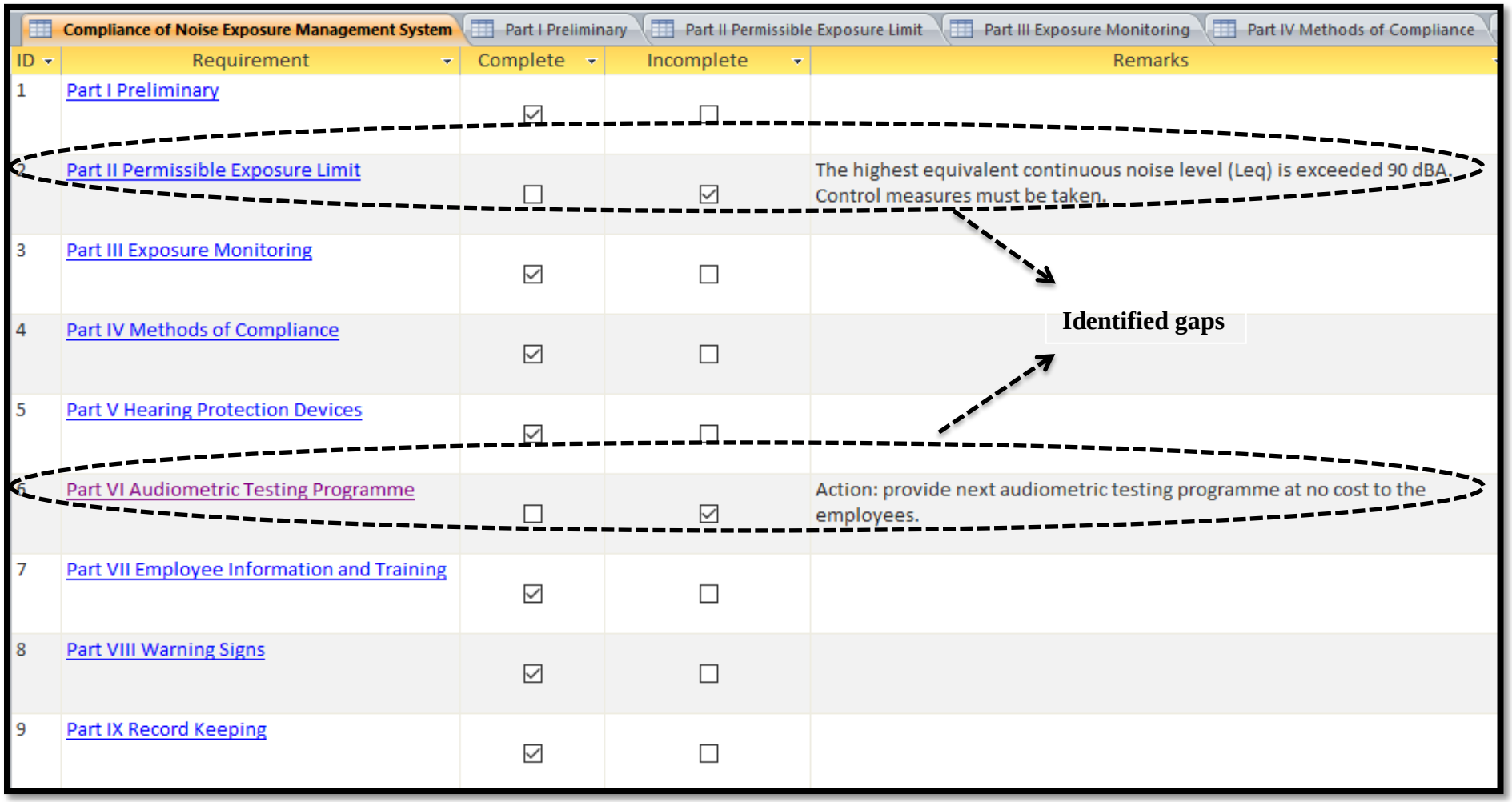
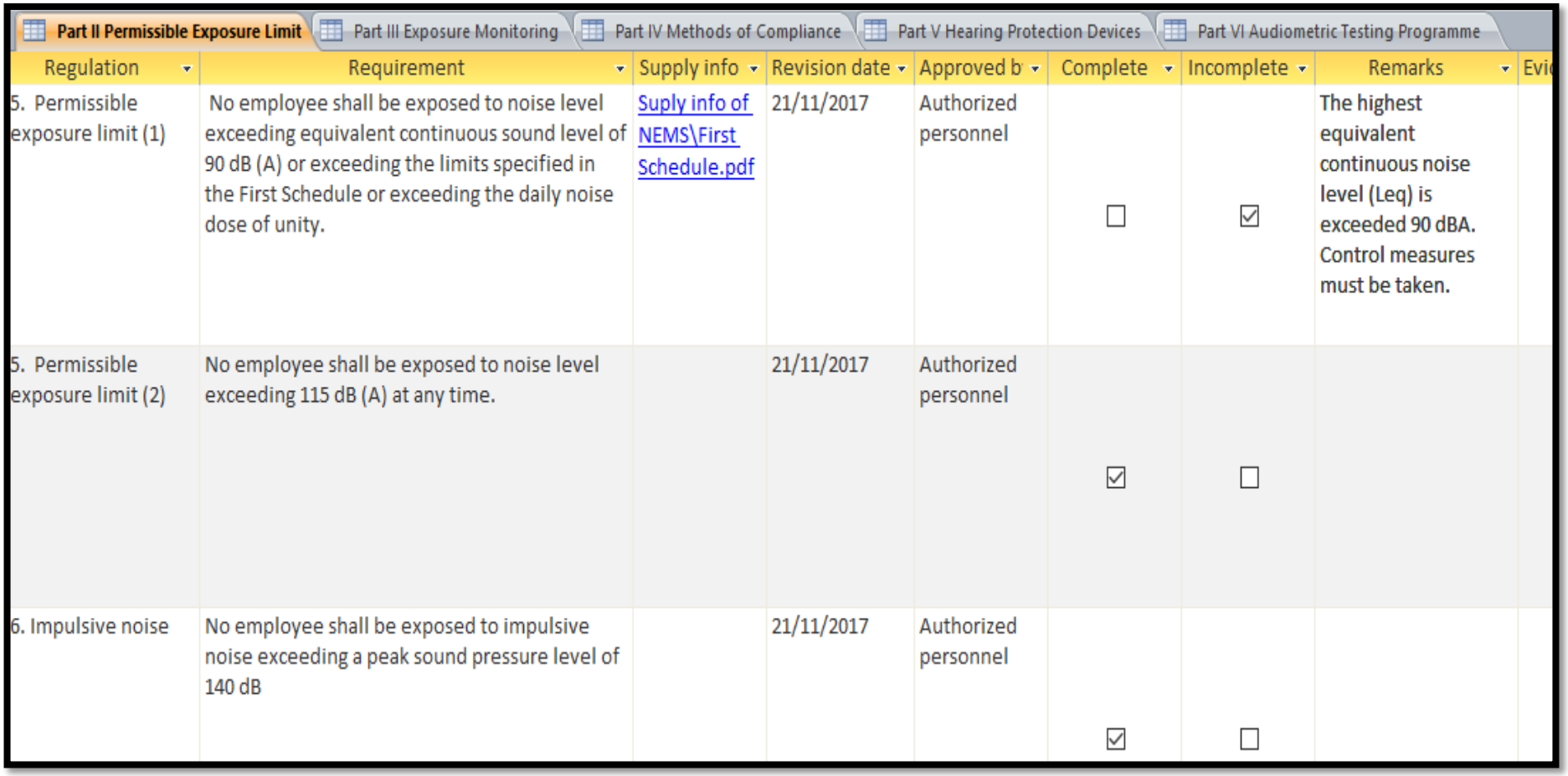


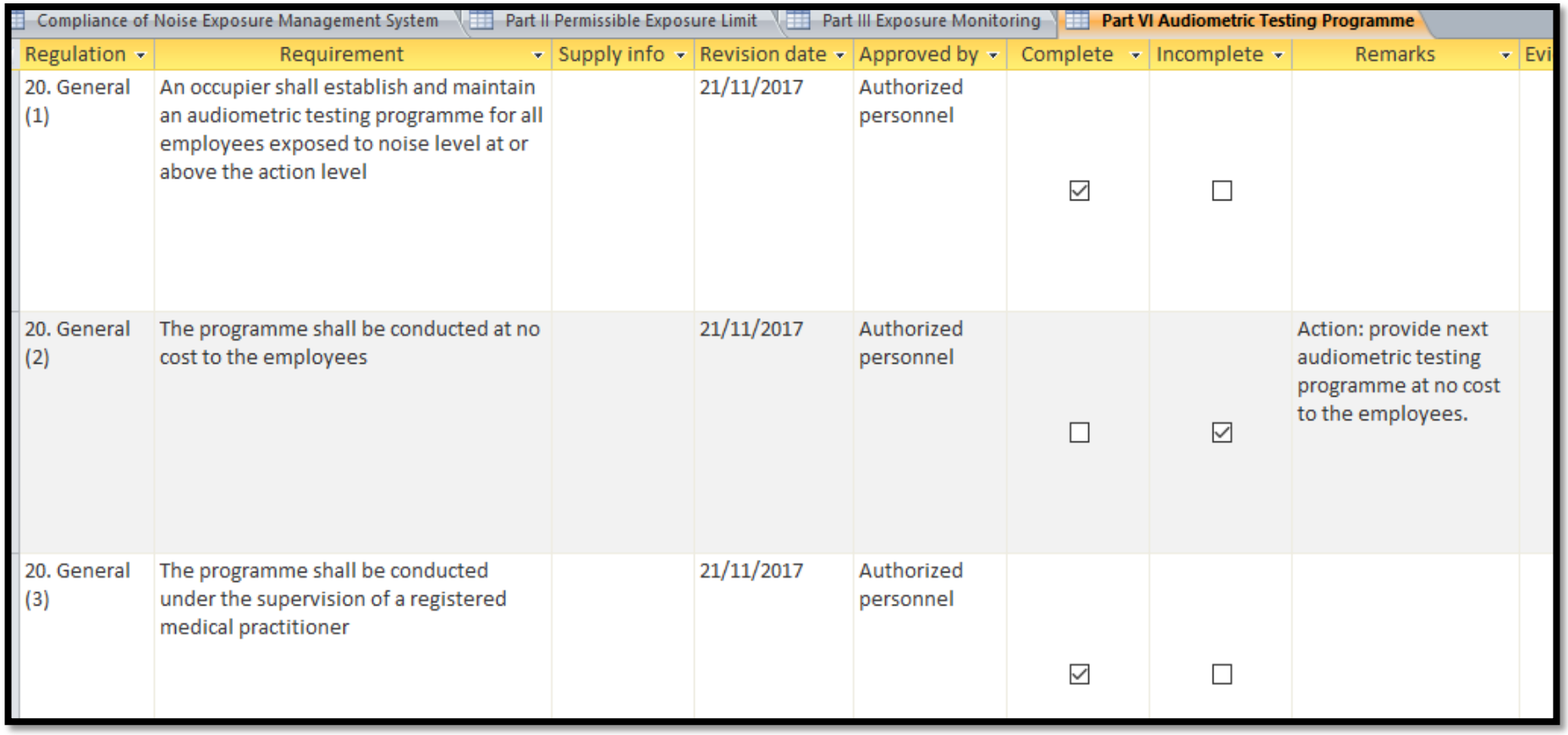
Figure 4.35. Main interface of NEMS (Case Study 2).



Part II Permissible Exposure Limit | Part III Exposure Monitoring | Part IV Methods of Compliance | Part V Hearing Protection Devices | Part VI Audiometric Testing Programme

Regulation	Requirement	Supply info	Revision date	Approved b	Complete	Incomplete	Remarks	Evi
5. Permissible exposure limit (1)	No employee shall be exposed to noise level exceeding equivalent continuous sound level of 90 dB (A) or exceeding the limits specified in the First Schedule or exceeding the daily noise dose of unity.	Suply info of NEMS\First Schedule.pdf	21/11/2017	Authorized personnel	☐	☑	The highest equivalent continuous noise level (Leq) is exceeded 90 dBA. Control measures must be taken.	
5. Permissible exposure limit (2)	No employee shall be exposed to noise level exceeding 115 dB (A) at any time.		21/11/2017	Authorized personnel	☑	☐		
6. Impulsive noise	No employee shall be exposed to impulsive noise exceeding a peak sound pressure level of 140 dB		21/11/2017	Authorized personnel	☑	☐		

Figure 4.36. Part II Permissible Exposure Limit interface of NEMS (case study 2).



Regulation	Requirement	Supply info	Revision date	Approved by	Complete	Incomplete	Remarks	Evi
20. General (1)	An occupier shall establish and maintain an audiometric testing programme for all employees exposed to noise level at or above the action level		21/11/2017	Authorized personnel	☑	☐		
20. General (2)	The programme shall be conducted at no cost to the employees		21/11/2017	Authorized personnel	☐	☑	Action: provide next audiometric testing programme at no cost to the employees.	
20. General (3)	The programme shall be conducted under the supervision of a registered medical practitioner		21/11/2017	Authorized personnel	☑	☐		

Figure 4.37. Part VI Audiometric Testing Programme interface of NEMS (case study 2).

4.5 Conclusion

As conclusion, this chapter shows results about the framework and prototype of Noise Exposure Management System (NEMS). The framework of NEMS is constructed and explained in details on each flow. Besides that, every single of column in NEMS is explained to describe the function on each of this. Two case studies are also used to validate and verify the developed NEMS. For both of these case studies, identified gaps have been shown. NEMS at here shows how to lead companies and workers to comply with Factories and Machinery (Noise Exposure) Regulation 1989. Compare with the previous Noise Management System as described in Chapter 2, the developed NEMS has shown a checklist system to lead the companies and workers to comply with Factories and Machinery (Noise Exposure) Regulation 1989. Previous Noise Management System only focused on activities that need to be carried out and did not track back the previous records and completeness of compliance.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Noise-induced Hearing Loss (NIHL) is the highest case which accounted for 5366 cases received in 2015 among occupational diseases and poisoning by referring Department of Occupational Safety and Health. It shown that how noise hazards are prevalence among the industries in Malaysia. Besides that, NIHL would lead to abnormal behaviour such as anxiety disorders, mood disorders, personality disorders and schizophrenia as well as communication breakdown These abnormal behaviours would indirectly affect the job performance of worker and sometimes it could lead to an accident.

The Factories and Machinery (Noise Exposure) Regulations 1989 with the purpose to prevent occurrence of occupational accidents and disease such as NIHL at specified workplaces must be complied by companies and workers. However, currently the noise regulations implementation degrees were varied from plant to plant due to lacking of systematic technique for companies and workers to comply with noise regulations requirements and maintain the effective safety programs. Safety programs that implemented by companies might not be successful. The involvements of workers in safety program are also not mandatory in some companies.

From this study, the Noise Exposure Management System (NEMS) which consists of requirements of Factories and Machinery (Noise Exposure) Regulation 1989 was developed to help or lead the companies and workers to comply with the regulation. The NEMS which developed by using Microsoft Access could ensure that information, reports or documents is kept as it enables the user to input data, manage and track information. Furthermore, NEMS provides a systematic way in detail about how to comply with all the requirements in Factories and Machinery Act (Noise Exposure) Regulation 1989 with the developed framework.

In conclusion, the developed Noise Exposure Management System (NEMS) could lead the companies and workers to comply with Factories and Machinery Act (Noise Exposure) Regulation 1989. With the NEMS, the prevalence of Noise-induce Hearing Loss (NIHL) can be reduced and accident rate can be indirectly reduced.

5.2 Recommendation

As the Noise Exposure Management System (NEMS) is developed based on Plan-Do-Check-Act (PDCA) concept, the contents or requirements in NEMS should always be checked to make sure they are relevant and not redundant. Also, action should be taken to make sure the contents and requirements are up to date in order to optimize its effectiveness. Furthermore, case studies can be conducted more by obtaining various real process plant data from different companies through document review and interview of practitioners to validate the developed NEMS. In addition, the developed and optimized NEMS by any chance should be implemented among industries to lead the companies and workers in order to comply with Factories and Machinery Act (Noise Exposure) Regulation 1989.

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APPENDIX A

GANTT CHART OF FINAL YEAR PROJECT 1 and 2

Items	Final Project Gantt Chart											
	2016/17 Semester 2						Semester Break		2017/18 Semester 1			
	Jan	Feb	March	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1. Decide the title												
2. Discuss with supervisor												
3. Determine problem statement and objectives, scope of study and conceptual framework												
4. Literature review												
5. Methodology												
6. Submission and presentation of FYP 1												
7. Decide the location of case study												
8. Data collection to validate system												
9. Develop framework												
10. Develop management system												
11. Conclusion and recommendation												
12. Submission of FYP 2												
13. Presentation of FYP 2												