ASSESSMENT OF OCCUPATIONAL NOISE EXPOSURE OF A PLANT IN OIL INDUSTRY

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ABSTRACT

ASSESSMENT OF OCCUPATIONAL NOISE EXPOSURE OF A PLANT IN OIL INDUSTRY

Dal, Ufuk
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Noise, which is a noteworthy problem in the world of workers, influences the health, safety, productivity and efficiency of those working in heavy industries and especially those working in petroleum industry. The objective of this study is to reassess the protective measures, taken previously by the company, from the point of view of the negative effects of noise on the workers. For this purpose, two approaches are adopted. Firstly, through questionnaires (response rate: 86%) distributed to workers, their subjective rating of, the noise levels to which they are exposed, the factors affecting their working efficiency and, their working conditions are searched. Secondly, noise levels, in the buildings rated as highly and very highly noisy, are measured by sound level meter. Self-exposure of 28 workers is measured by dosimeter. The overall ambient noise level of the 11 buildings and effect of noise on the working efficiency of the workers working in these buildings were respectively found to be moderate and slightly affected. The workplace index was 3 (out of 5). The working conditions index was on the average 4 (out of 5). The L_{eq} values measured in six of the buildings were found to be in the range of 66, 8 – 100, 0 dBA. 12 out of 28 workers were observed to be exposed to noise levels greater than 80 dBA. The objective (noise

measurements) and subjective (questionnaire) results obtained at the end of the afore-mentioned approaches will be of help in the orientation of the workers while estimating their work efficiency and will also serve as a data base for the planning strategy of the interested company.

Keywords: Questionnaire, noise level measurements, dosimeter, indoor noise map

öz

PETROL ENDÜSTRİSİNDEKİ BİR TESİSTE MESLEKİ GÜRÜLTÜYE MARUZİYETİN DEĞERLENDİRİLMESİ

Dal, Ufuk
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İş dünyasında önemli bir problem olan gürültü; ağır sanayide özellikle petrol endüstrisinde çalışanların sağlığını, emniyetini, üretkenliğini ve çalışma verimini etkilemektedir. Bu çalışmanın amacı, şirketin daha önce aldığı önlemleri, gürültünün çalışanlar üzerindeki olumsuz etkileri açısından değerlendirmektir. Bu amaçla iki yaklaşım benimsendi. İlk olarak, işçilere dağıtılan anketler yoluyla (cevaplama oranı: %86) maruz kalınan gürültünün işçiler tarafından değerlendirilmesinin yanı sıra, çalışanların çalışma verimlerini etkileyen faktörler ve çalışma koşulları araştırıldı. İkinci olarak, gürültülü ve çok gürültülü olarak değerlendirilen binalarda gürültü düzey ölçer ile gürültü ölçümleri yapıldı. 28 işçinin bireysel gürültü maruziyetleri ise dozimetre ile ölçüldü. 11 binanın içortam gürültüsü ve gürültünün işçilerin çalışma verimleri üzerindeki etkisi sırasıyla orta ve az etkili olarak bulundu. İş yeri endeksi 3 (5 üzerinden) olarak belirlendi. Çalışma koşulları ile ilgili endeks ise ortalama 4 (5 üzerinden) olarak bulundu. Ölçüm yapılan altı binadaki L_{eq} değerlerinin 66,8 -100 dBA aralığında kaldığı görüldü. 28 işçiden 12'sinin 80 dBA'nin üzerinde gürültüye maruz kaldığı gözlemlendi. Yukarıda sözü edilen yaklaşımların sonucunda elde edilen öznel (anketler) ve objektif

(gürültü ölçümleri) sonuçlar, çalışanın verimliliğinin tahmininde yardımcı olacağı gibi ilgili şirketin planma stratejisine de veri tabanı oluşturacaktır.

Anahtar Kelimeler: Anket, gürültü düzeyi ölçümü, dozimetre, iç ortam gürültü haritası

To My Parents

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LIST OF ABBREVIATIONS AND SYMBOLS

A	Affected
AAOO	American Academy of Ophthalmology and Otolaryngology
AT	Administrative Team
BT	Block Valve Technician
DHP	Double Hearing Protection
DP	Diesel Fire Pump
EM	Ear Muff
EP	Ear Plug
EP	Electrical Fire Pump
ES	Electrical Supervisor
ET	Electrical Technician
HA	Highly affected
HPD	Hearing Protection Device
HPV	High Pressure Valve
HSE	Health, Safety and Environment
HSE	Health, Safety and Environmental Team
HSG	High School Graduate
JS	Job Satisfaction
$\mathbf{L_{A,eqTe}}$	A-weighted equivalent continuous noise level over a time period of T_e
$\mathbf{L_{AI}}$	A-weighed, impulse
$\mathbf{L_{Cpeak}}$	C-weighted peak noise level
$\mathbf{L_{EX,d}}$	Daily Noise Exposure Level
$\mathbf{L_{N\ (1\ to\ 99)}}$	Percentile Levels

LPV Low Pressure Valve

MA Moderately affected

MET Mechanical Technician

MS Mechanical Supervisor

MSc Master of Science Graduate

MT Maintenance Team

Mtech Metering Technician

NA Not affected

N_G Number of workers in a team

NIOSH National Institute for Occupational Safety and Health

NL Noise Level

NL-SR Noise Level-Scalar Rating

NL-VR Noise Level-Verbal Rating

OT Operation Team

PCC Pearson Correlation Coefficient

PO Panel Operator

PSG Primary School Graduate

PWC Psychosocial Working Conditions

SA Slightly affected

SE Scada Engineer

SHP Single Hearing Protection

SIL Speech Interference Level

SO Site Operator

SP Security Team

SSG Secondary School Graduate

ST Security Team

Stech	Scada Technician
TVSHEG	Technical Vocational School of Higher Education Graduate
UG	University Graduate
VHSG	Vocational High School Graduate
WE	Work Efficiency
WE-SR	Work Efficiency-Scalar Rating
WE-VR	Work Efficiency-Verbal Rating
WO	Waste Water Treatment Plant Operator
WPI	Work Place Index

CHAPTER I

INTRODUCTION

Noise is generally referred to as unwanted sound. It is one of the contributors that influences the safety and comfort of the employees in working places, which reflects this impact on the people's productivity. According to the National Institute for Occupational Safety and Health (NIOSH), noise is one of four occupational problems and is also responsible for low productivity of workers. The effect of noise is not always immediately assessable as in the case of other contaminants including leaks, oil spills, explosions and fire hazards [1].

It is anticipated that roughly 600 million workers worldwide are exposed to industrial noise [2], meaning that industrial noise is a very important problem mainly from the point of view of safety and health rather than annoyance. Continuous exposure to high noise levels may give rise to hearing damage, and the undesirable characteristics of noise may also be responsible for stress-related disorders, depression, anxiety, somatic complaints (i.e., gastrointestinal problems, constipation, heartburn, nausea, vomiting, colitis, migraines, headaches, back aches, and skin disorders), away from work, and raised accident in numbers [3-4]. It can be an important factor in work accidents, both by preventing concentration of people in workplaces and by masking hazards and warning signals.

Long term occupational noise exposure over 80 dB (A) increases the risk of perceptive hearing loss [5]. In a study, it was pointed out that hearing loss due to noise was substantially higher in employees who were exposed to noise level greater than 85 dB(A) than the ones exposed to 70-85 dB(A) and less than 70 dB(A).

Employees who had hearing handicap were affected seriously when the level of noise was increased than the ones who had no hearing handicap [6].

It is usually agreed that an 8-hours shift has to be taken into consideration while taking the noise level measurements according to American and other international regulations [7]. If someone needs to protect his or her ears from any type of noise risk, he or she must avoid the places where the noise levels are over 75 dB (A) [8].

In oil industry, people were generally exposed to 90 dB (A) or higher noise levels similar to the ones who work in other heavy industries where the level of hearing loss is high [9-10].

The effects of occupational noise exposure on work performance of employees in the working environment are dependent on a number of factors such as the characteristics of the noise and the task type [11]. Shift workers, for example, are at a greater risk of health when working in noisy occupational environments compared to relatively quiet conditions [12]. In the facility where we worked on, people work on a shift-base with 11-hours a day for 14 days and then 14 days-off. It was found in a study that people who worked as 12-hours shift (for 2 consecutive days, then 2 days off) were subjected to lower degree of hearing loss than that of ones who worked 8-hours a day (for 5 consecutive days) shift in the facility where the machines were run 24 hours a day [13]. Similarly, in the plant that is in the scope of this thesis, the whole system is operated 24-hours a day.

High noise levels may be better understood, by the individuals who need shouting to communicate with other people in the work place or, by those who feel ringing (tinnitus) in their ears following the noise exposure in the work.

Communication is very crucial in oil industry. Safe working environment has to be provided and people and equipment has to be protected from any damage. The combination of a noisy workplace and tinnitus may worsen the ability of employees to perform their work [14].

In order to assess the exposure of noise in a facility, the first thing that has to be done is to identify the main noise sources so that noise can efficiently be managed and controlled. Therefore, sound-through-assessment walk was performed to determine the noise sources in the plant. The point measurements and frequency analysis then were carried out to characterize the factors responsible for the emission and propagation of the noise.

The second issue is to determine whether or not the noise level in the workplace is complying with the standards and directives relevant with occupational health of workers. Exposure limits are typically defined by regulations as 85 and 90 dB (A).

To determine whether the daily noise exposure level [$L_{EX,\ d}$ in dB (A)] is lower than 85 dB (A), or is between 85 and 90 dB (A), or greater 90 dB (A) is the main issue [7]. For instance, it does not matter if the $L_{EX,\ d}$ is 95 or 98 dB (A), in each case, the situation is not acceptable and hearing protection measures should be applied.

If the site survey for noise indicates that the noise exceeds the threshold level stated in the previous paragraph, certain actions are required including reduction of the noise as far as is reasonably practical, marking noise hazard zones and making hearing protection available to those exposed [15].

An effective and comprehensive conservation of hearing programme is probably the only means now available whereby any industry can be certain of protecting the health of employees exposed to noise and at the same time of preventing payment of compensation for unjust claims for occupational deafness [6].

One of the control measures is audiometric test which is used to determine the noise-related occupational hearing loss of the personnel. This procedure requires the measurement of hearing ability of the people at multiple (octave band) frequencies (500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz) in each ear [9]. In this study, the frequencies, 500, 1000 and 2000 Hz were taken

into consideration while performing the audiometric tests in the plant. 10% of people who were initially of normal hearing can come across with hearing loss 20 years later [16] when exposed daily to very high noise levels.

The previous history of the personnel is also important for the evaluation of the hearing loss, including medication, family history of hearing loss, general health condition of the person; previous head injury, ear disease and exposure to occupational noise. The ears of the personnel should be checked by a medical device, otoscope, which is used to look into the ears before audiometric testing. This device looks for wax, foreign bodies that need to be removed only if the meatus is obviously fully occluded or if there is any conductive element to the hearing loss. The audiometric test should be repeated after removal of the obstruction [17].

Many affected workers actually experience losses considerably beyond 25 dB and these can have significant effects on their employment, their social interactions, and their family interactions. These workers may experience problems ranging from tinnitus to difficulty in detecting and recognizing sounds in the setting of background noise [18]. This problem may impair their ability to detect warning signals, to discriminate between different frequencies, to comprehend speech, and to localize sound sources [9].

Millions of people in the world have tinnitus which is the perception of ringing or buzzing in the ears or head. It is a common complaint that may have disabling consequences [19]. Studies showed that if the people had normal hearing, "*noise level to be exposed*" and "*duration of exposure to noise*" were not related to tinnitus. If there was hearing handicap, it was found that tinnitus risk increased with the noise exposure. However, exposure to noise level above 80 dB (A) for a long time was not the sign of tinnitus if the hearing was normal [13]. Moreover, severe tinnitus was associated with poorer hearing thresholds, and the ones with frequent or continuous tinnitus had only mild hearing losses [20]. It was also stated that

tinnitus should not be seen as prior warning of the hearing loss that may happen later [21].

The second way for control measurement is the use of hearing protectors. Providing Hearing Protector Devices, HPD, is one of the important precautions that can be taken in order to minimize the negative effects of exposure to high noise levels. For that, workers see that they must wear HPD continuously and throughout the entire exposure time. To accomplish this, comfortable devices must be provided and proper training regarding the use of HPDs should be supplied to the employees. In one study, it was found that if people worn HPDs during 90% of his 8-hours shift (meaning that HPDs not worn only 48 minutes); the attenuation value of HPD, with a nominal attenuation of 30 dB, reduces to less than 10 dB. However, a crucial difference was determined between the catalogued and effective attenuation values, such that hearing protection devices with less catalogued attenuation value but higher acceptability were much more comfortable than that of a higher catalogued value but less comfortable [22].

This protection type is directly related to risk perception of the workers. Some studies stated that there is indeed a relationship between risk perception and occupational noise exposure. Risk perception of people and subjective rating of the working places with respect to noise may affect the risk evaluation of the people where they work, consequently influence the risk and safety [23]. When people misunderstand the risks associated with their works, they tend to show inappropriate behaviours that are risky. For example, even though the noise level in a facility is too high and workers are obliged to wear ear protection before entering the area, they can assume that the noise level does not exceed the limits and cannot therefore cause any damage on their ears, as a result of which, they may ignore to use ear protection.

The type of ear protection and how they are used are also important to reduce the noise levels felt on the human ears. In our facility, there are two

types of hearing protection devices namely; disposable ear plug and hard-hat mounted ear muff. Deep-insert custom earplugs provide more reliable hearing protection performance for personnel working in extremely hazardous noise environments. Its attenuation performance was consistent in both Single Hearing Protection (SHP) and Double Hearing Protection (DHP) configurations. This performance, of course, could change depending on the experience level of user and proper insertion [24].

Pipelines pump stations, refineries and off-shore platforms in oil industry are the complex facilities in which one may find many equipments, tools and machines causing environmental noise. These facilities in general include pumps, diesel engines, exhaust pipes, back-up generators, ventilation fans and gearing mechanisms [25].

The workers employed in these facilities are exposed to high levels of noise while performing their jobs due to operations involving the above-mentioned equipments. The plant in this study was studied not only in terms of occupational noise and its effects on the employees working there but also in terms of working conditions. Relationships in between the above-mentioned issues were investigated.

The study starts with "the layout of the plant", that includes the general layout of the facility. Drawing of the site is given and general features of the buildings are introduced by adhering to the principles of company's confidentiality.

A noise-stress questionnaire consisting of 76 questions, applied to plant's personnel, is also presented. The aim of the application of this questionnaire was to obtain information about the personnel such as their work experiences, educational situations and about their noise exposure, its impact on their work productivity and efficiency. 31 questions of the questionnaire, taken from the "Health and Safety Management Analysis Tool", were reserved to the assessment of the workplace conditions of the employees working in the plant.

"Demand", "Control", "(Manager's and Peer) support", "Relationship", "Role" and "Change" are the sub-titles of the Health and Safety Management Tool questions. By these questions, it was aimed to see how people evaluate their working conditions.

The measurement protocol to be followed while performing the necessary noise measurements in the plant is presented in chapter V. The protocol consisted of ,the required permissions that has to be taken before entering the zones, the health, safety and environmental trainings that has to be given to the measurement team, sound-through assessment walk on the site in order to determine the measurement points and of performing measurements. This protocol was strictly obeyed by the measurement team while working at the site.

The data obtained as a result of measurements is given with the buildings' drawings in chapter VI. The points were marked on the layouts of the buildings together with the dimensions.

In chapter VII noise maps of the buildings prepared by using the data obtained at the end of noise measurements are given. "Noise at Work V1.30" Software Program was used to prepare these maps.

Briefly, to say, the objective of this study was to assess the precautions taken previously by the company to protect the workers from the negative effects of noise. Through questionnaires distributed to them, their subjective rating of noise levels (NL) they are exposed to, their working efficiency (WE) and their working conditions (WC) are searched.

CHAPTER II

LAYOUT OF THE PLANT

2.1. Introduction

Petrochemical plants including refineries and pipeline pump stations are industrial plants that have many facilities causing environmental noise. The noisy equipment and machineries in the facilities give rise to a noisy environment. Pump stations, performing pumping operations, have powerful pumps, small capacity pumps, and fire pumps. The presence of compressors, emergency generators and mobile ones, fans and any type of equipment being used for maintenance purposes can be regarded as causes of the noise in the plant.

92 people work and stay in the plant. Technical personnel work in 14 days "on" – 14 days "off" shift system. The plant is located at an altitude of approximately 2200 meters from the sea level. There are some utilities and buildings in it. The total area of the plant is 37800 m^2. The buildings are coded as B1 - B11 because of confidentiality policy of the company. The general layout of the buildings in the plant is shown in Fig. 2-1.

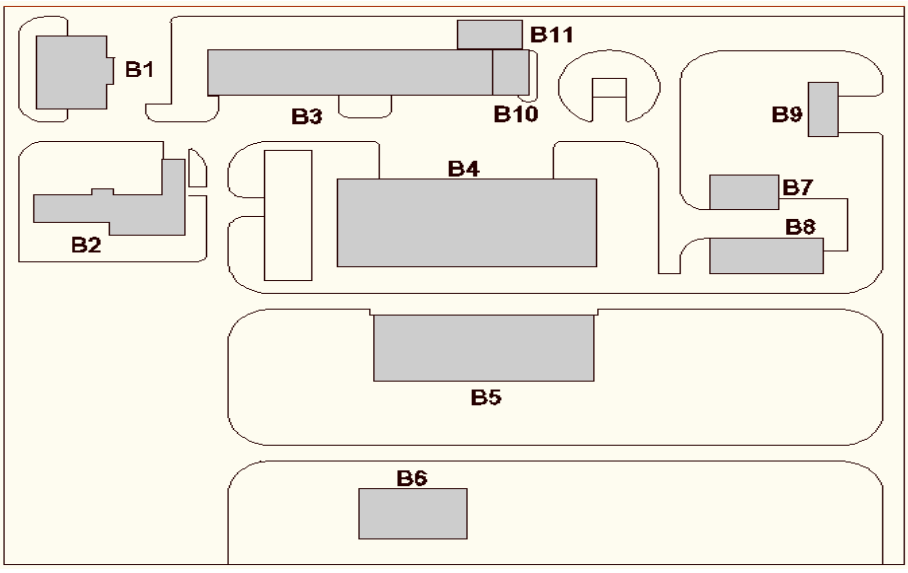

Fig. 2-1 General layout of the plant

2.2. Description of the Buildings

2.2.1. Building B1

B1 is the one-storey building that is used by the employees for recreation and resting purposes. Almost all personnel came to this building during the lunch breaks and joined to the habitual crowd of the building together with security people, who are responsible for the security of the station. Besides, it also served as a waiting place for the visitors of the plant. The layout of the B1 is demonstrated below in Fig. 2-2.

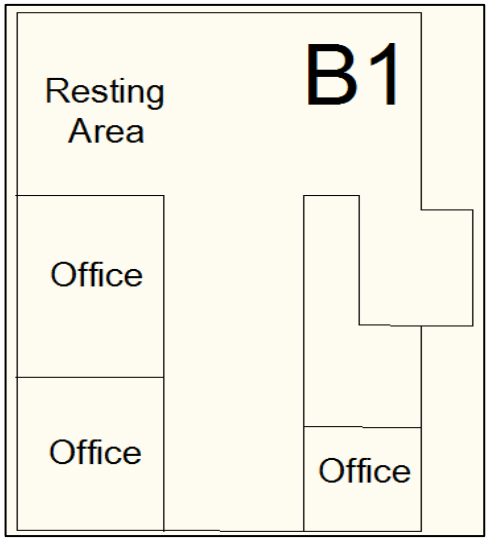

Fig. 2-2 Simple drawing of B1

Total building area is approximately 280 m^2. There are three offices in it, two of which are allocated to the administrative people and one is reserved for the security people. The safety equipments that have to be given to people who visit the site are stored in a small room for easy access. The remaining area is reserved for the employees' rest and comfort.

2.2.2. Building B2

B2 is the main management building where there are offices for management team and technical employees. The main control room is also

here. Inside the panel room, some cooling fans cause the environment to be very noisy.

The total area covered by B2 is 390 m^2, 98 m^2 of which is the area of panel room where the noise measurements were taken. Its layout is given in Fig. 2-3.

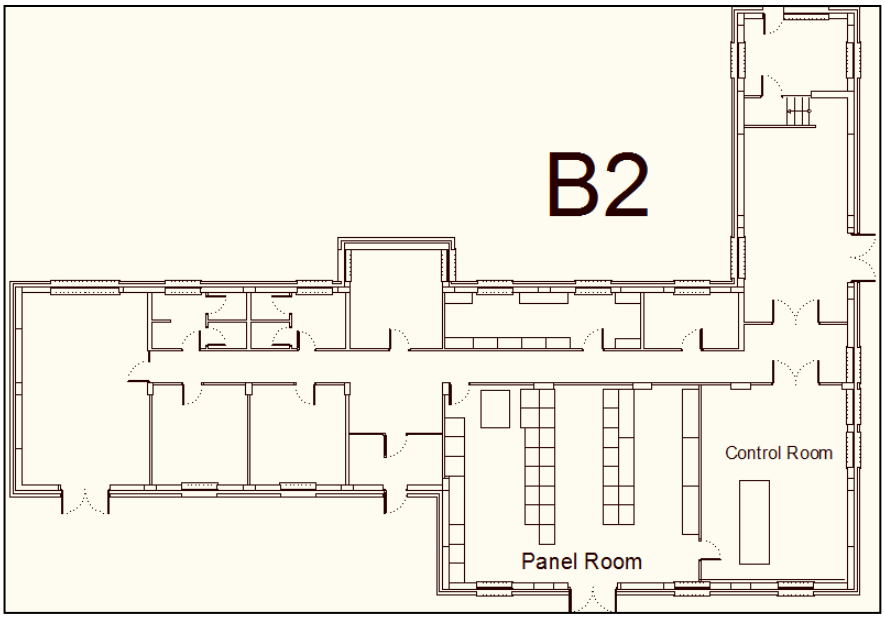

Fig. 2-3 Simple drawing of B2

2.2.3. Building B3

B3 is a two-storey building allocated to maintenance team to perform the general maintenance activities in it. There is one office for electrical team on the first floor. One another are assorted for mechanical team next to this office. On this floor, the person who is responsible for depots management also uses one separate office. A small laboratory is available in order to carry out the tests of electrical equipment by electricians on the same floor.

The chief engineer's office is located on the ground floor. On this floor, there exist also some depots and storage areas, for the equipment, tools and materials needed by the teams. Concrete walls separate the areas from each other. Some rooms are reserved to the storage of chemical materials and oil

barrels. There is also a garage on the ground floor for the foam trailers to protect the foam chemical inside the trailers from freezing in harsh weather conditions.

The top view of the B3 including ground floor and the first floor is shown in Fig. 2-4.

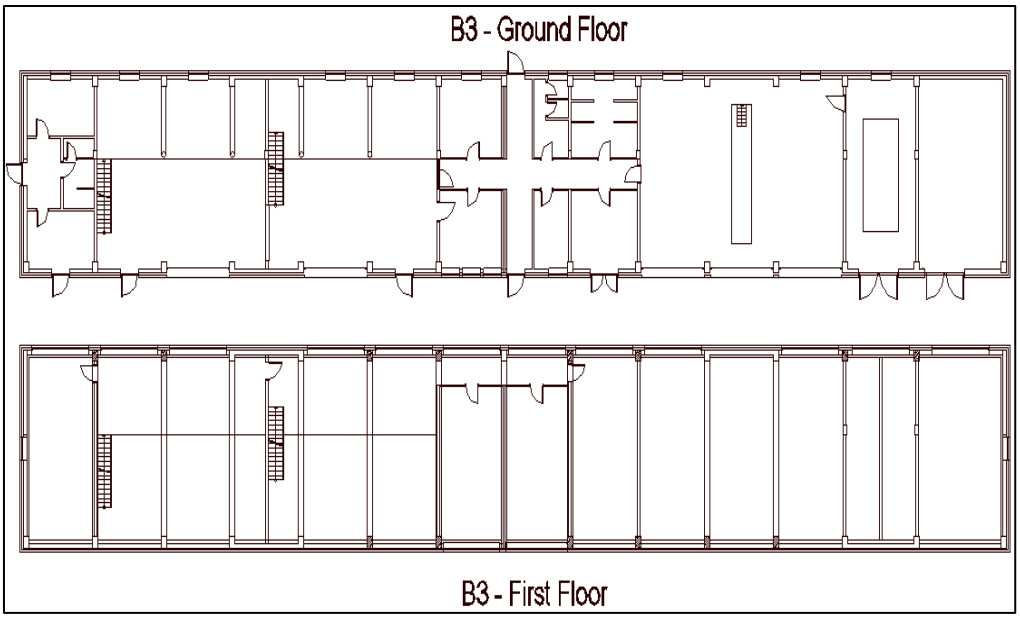

Fig. 2-4 Simple drawing of B3 (Ground floor and the first floor)

The floor area in total is 1372 m^2. People of maintenance team are generally out of office during daytime to perform the mechanical activities in the plant, and they stay in the offices mainly at early hours of the day and at early hours of the evening.

2.2.4. Building B4

B4 is the building in which the main activity of the station is performed. The main noise sources in this building are five reciprocating pumps pumping the oil. Additionally, ventilation fans belonging to each pump are installed on the walls of B4. When the pumps are on, they also contribute to already noisy environment inside B4. The whole area of this building is 1584 m^2. The simple drawing is given below in Fig. 2-5.

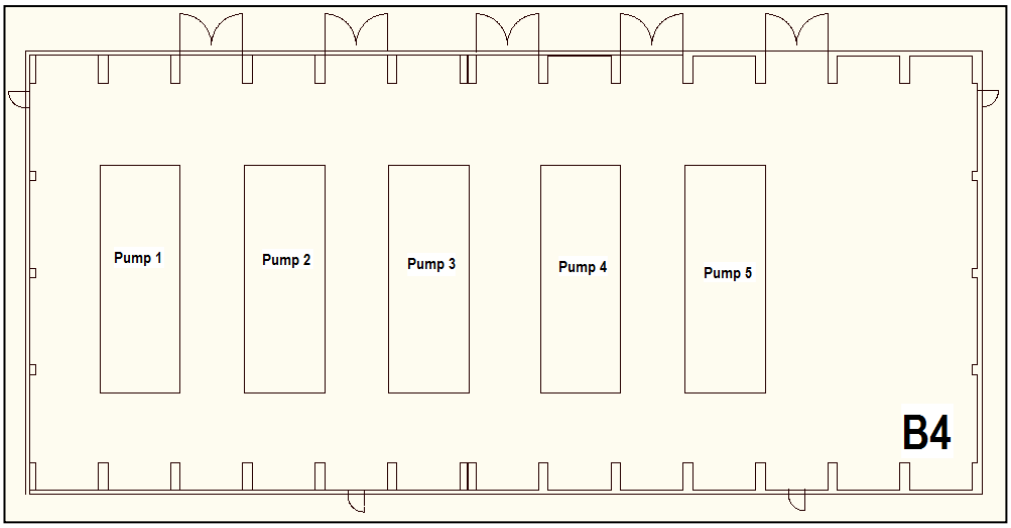

Fig. 2-5 Simple drawing of B4

The technical personnel, especially the site operators, enter periodically into this building within the daytime and during night. The periodical checks of the site are done in order to follow the changes in operational parameters so that pumping of the oil is done properly and without any breakdown.

2.2.5. Building B5

B5 is the building in which the metering unit, responsible from the measurement of the oil passage through the pipes, is established. There are many pumps and noisily operating equipment in this building.

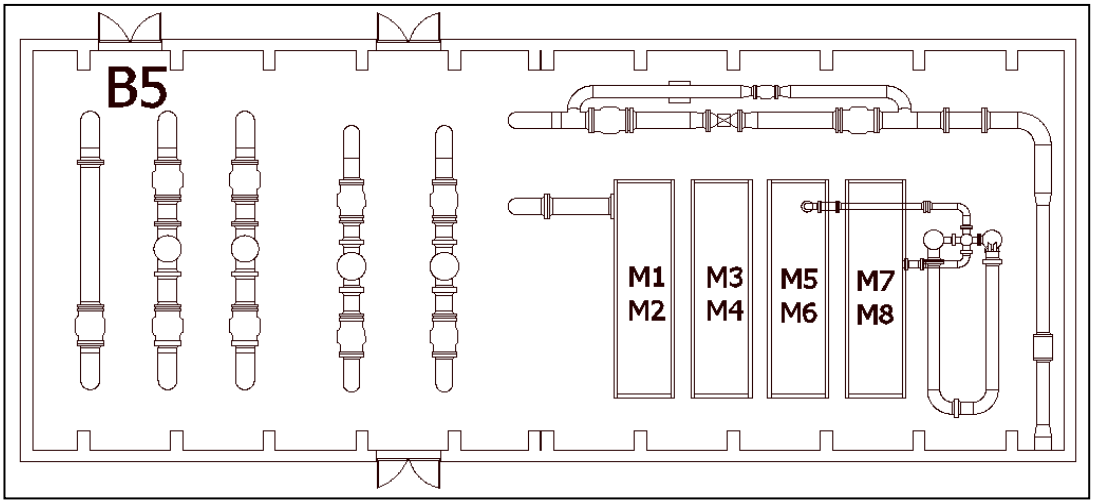

Fig. 2-6 Simple drawing of B5

The area covered by this building is 1000 m^2. In the layout of B5 (Fig. 2-6), it is seen that the metering unit consists of eight parts coded as M1 – M8. Many piping systems are also available inside of this building.

For the sake of operational integrity of the whole system, not only the site operators, metering technicians and maintenance team members but also the personnel of night shift visit the building B5 regularly.

2.2.6. Building B6

B6 is the building where pressure adjustment is fulfilled for safety purposes of the station system integrity.

The whole area of B6 is 378 m^2 and inside of which there are Low Pressure Valve (LPV) and High Pressure Valve (HPV) located side by side. They are run according to the operational requirements. The technical personnel also make routine daily checks in this building as well as in the others. The simple layout drawing is shown in Fig. 2-7.

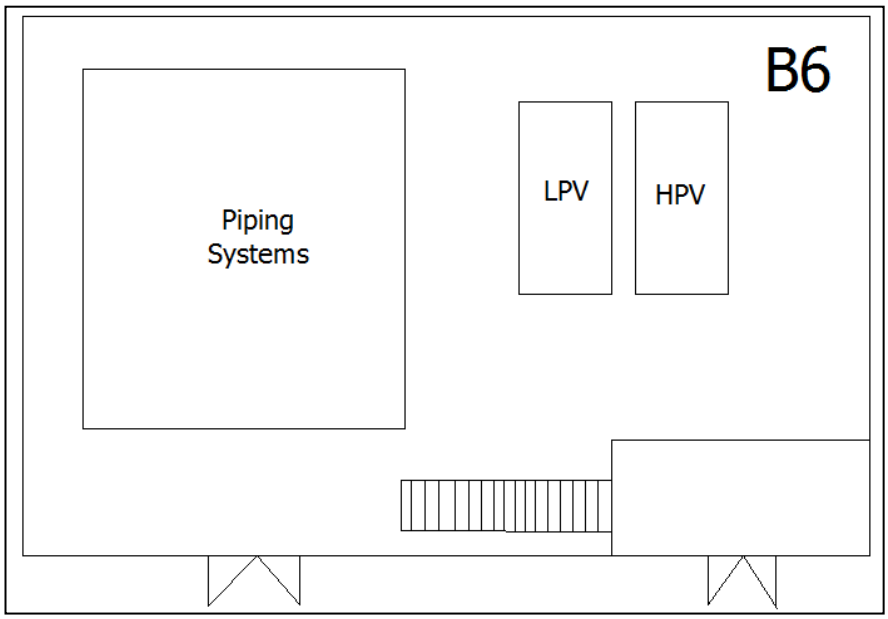

Fig. 2-7 Simple drawing of B6

2.2.7. Building B7

B7 is one of the three utility buildings .The area covered by this building is 151 m^2. In this area, three water tanks are allocated to clean and chlorinate the water coming from the wells in the camp area. Fig. 2-8 demonstrates the simple drawing of B7.

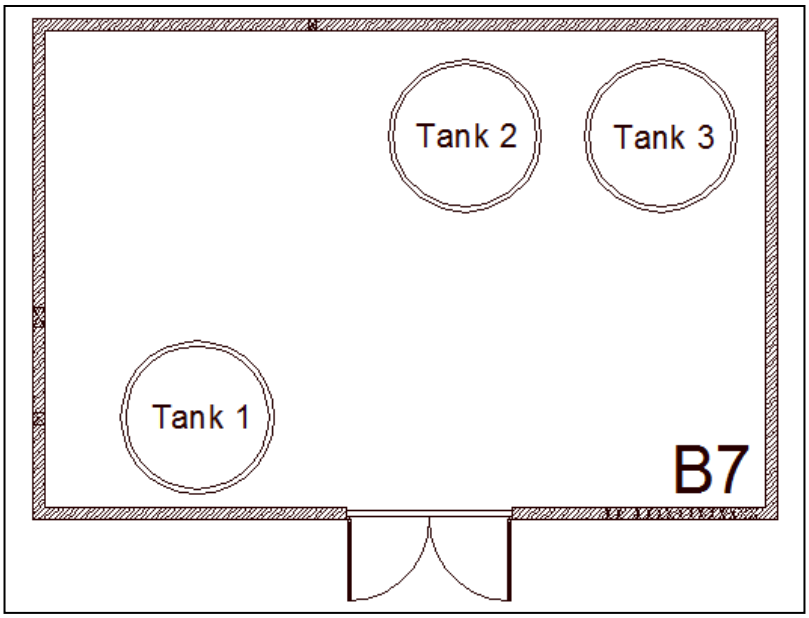

Fig. 2-8 Simple drawing of B7

2.2.8. Building B8

B8 is the second utility building that is separated into three parts. The first part is the compressor room, second one is the boiler room and the third and the last one is the electrical panel room.

The total area of B8 is 250 m^2, 150 m^2 of which belonged to boiler room where the measurements were taken.

Below, the layout of the boiler room is shown in Fig. 2-9.

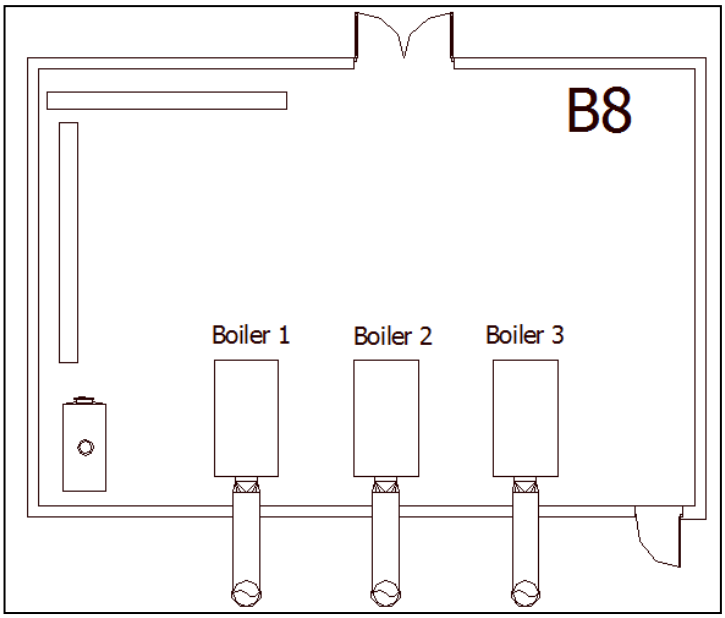

Fig. 2-9 Simple drawing of B8

2.2.9. Building B9

B9 is the last utility building, inside of which fire pumps are placed for emergency purposes. The diesel and electrical fire pumps are placed next to each other and they are run in case of an emergency situation that may happen somewhere in the station. Other than this unexpected case, they are operated once a week for the testing of the pumps.

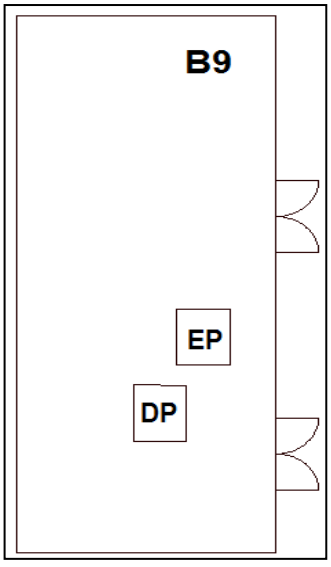

Fig. 2-10 Simple drawing of B9

The area that is covered by this building is 114 m^2. In Fig. 2-10, the locations of the pumps are indicated. EP stands for electrical fire pump and DP is the abbreviation of diesel fire pump.

2.2.10. Building B10

B10 is actually a separated part of building B3. A generator is placed there in order to protect the system integrity in case of electricity cut-offs. This generator like fire pumps is run weekly for test purposes. The total area of B10 is 62 m^2. Its layout is shown below (See Fig. 2-11).

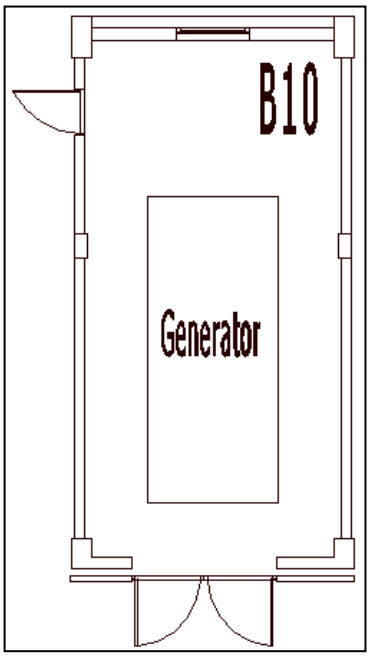

Fig. 2-11 Simple Drawing of B10

2.2.11. Building B11

B11 is the last building in the station, inside of which low-voltage electrical panels are placed. It has an area of 166 m^2. There are electrical panels mounted inside of the building. Only authorized electrical people are allowed to enter into this building. The layout drawing of B11 is given in Fig. 2-12.

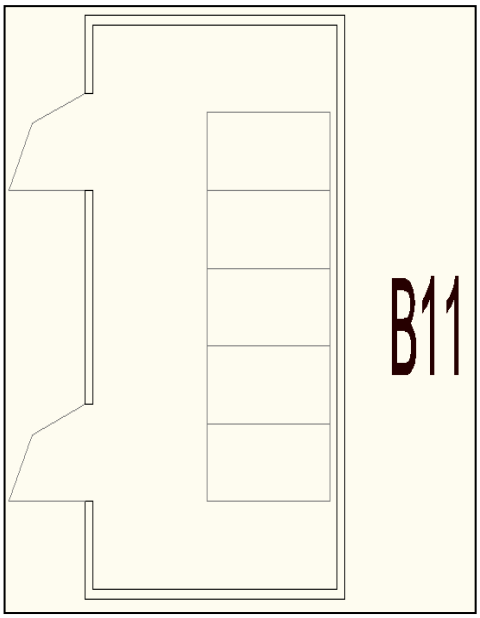

Fig. 2-12 Simple drawing of B11

It has to be noted that the accommodations of employees are not included in the above-described buildings and are considered to be outside the framework of this thesis.

CHAPTER III

QUESTIONNAIRE SURVEY ON THE EFFECT OF NOISE LEVEL

3.1. Introduction

In this chapter, the general information about the personnel will be given and the results of the questionnaire applied to the personnel who work in the station will be presented.

The questionnaire including 76 questions is applied to 79 employees actively working in the plant in order to enable them to rate their noise exposure and to assess their work stress.

Before distributing the questionnaire to the workers, a short presentation has been done, the aim and the reason of the survey are explained and the importance of their subjective description of the acoustical characteristics of the working area is emphasized.

It was also mentioned to them that, noise measurements shall be taken later in the buildings where they work in a day and actual values will be correlated with their assessments. What we refer to when we use the term "noise" was explained before the questionnaires are distributed. They also knew that the results of this questionnaire would form a database for a master thesis on "the assessment of the workplace with respect to noise". It was requested from them to answer every question in the questionnaire. "Comments" section was reserved for their comments and suggestions relevant with the questionnaire. The best feedback from the questionnaire was that all people who took the questionnaire answered all the questions willingly.

The number of people in the plant is not constant. It changes from time to time due to visitors who come to station for the purpose of auditing, technical support and so on. Sometimes, some employees who are allocated

in the other stations visit the station for operational and mechanical requirements of the plant. In such cases, the number of people in the plant increases. However, this value rarely exceeds 100.

3.2. Work Groups in the Plant

In the station, 11 people work for catering company to provide the meals, three times a day, to the employees. For emergency cases that may occur during the operation of the station, three members of the medical team are available for 24 hours. Other than these work groups, there is a subcontractor whose employees are responsible for the cleaning of the accommodation and for the laundry services.

Except general service groups described in the previous paragraph, the work teams, members of which are generally obliged to be exposed to noise in the plant, are separated into five main groups, which are in alphabetical order; *Administrative Team (AT), Health, Safety and Environmental Team (HSE), Maintenance Team (MT), Operation Team (OT)* and *Security Team (ST)*. All teams work in a shift system.

Except the security team, the shift is programmed as 14 days on – 14 days off. The work schedule of the security team however is arranged as 15 days on-15 days off. The distribution of the job groups in the station is given below in Figure 3-1.

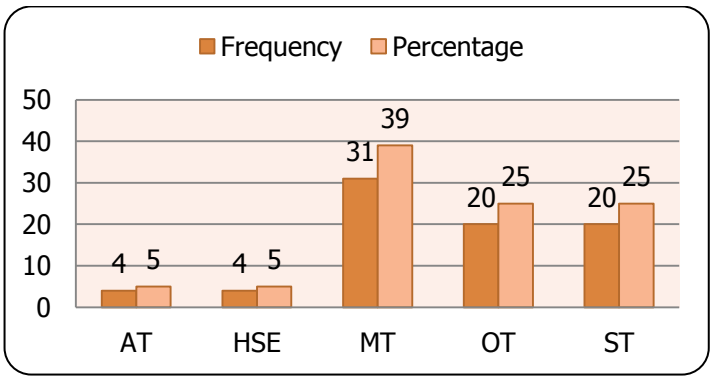

Fig. 3-1 Work Groups in the Station

3.2.1. Administrative Team

Administrative team is composed of four people working in shift system; the main task of them is to perform all administrative issues related to plant, including providing accommodation for visitors, transportation issues of people and recruitment tasks.

3.2.2. Operation Team

The operation team is responsible for all operational issues of the plant including the continuous running of the system for 24 hours a day. They are composed of 20 people including chief engineers, panel operators and site operators.

3.2.3. Maintenance Team

Maintenance Team is composed of 31 people including chief engineers and has the same responsibility like the operation team. They have to make the routine and urgent maintenance of the system and have it run for 24 hours.

3.2.4. HSE Team

The main job of the HSE Team is to support and provide assistance to the operation and maintenance teams to do their job in a safe manner and to protect the employees from accidents and incidents.

There are four people; two of them are HSE Engineers, in the HSE Team. Another responsibility of this team is to manage the environmental issues related to station and protect the environment from the harsh effects of the crude oil.

3.2.5. Security Team

Security Team is responsible for the overall security of the plant. A subcontractor undertakes the performance of this task. 21 employees work in the Security Team.

3.3. Age Profile of the Plant

Age is considered to be a very important parameter while assessing the noise effect on the employees. Age profiles of 79 people out of 92, i.e., those who are exposed to noise in one way or another while working, are given below in Figure 3-2.

The average age of the teams is **~32**, which shows that the population working in the plant can be termed as consisting of "middle-age employees".

Approximately **93%** of the employees are between 24 and 40 years old.

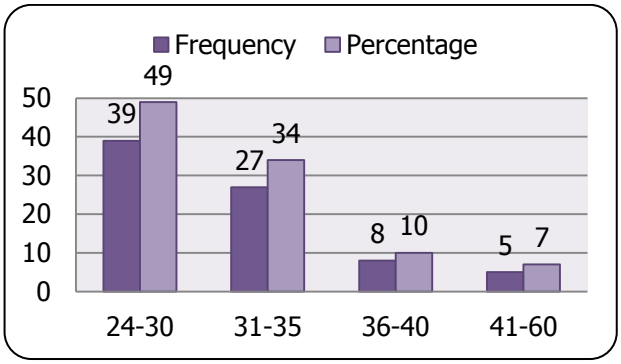

Fig. 3-2 Age Groups in the plant

3.4. Educational Background of the Employees in the Plant

Educational level of the employees changes from person to person. It ranges between graduate of the primary school and Master of Science.

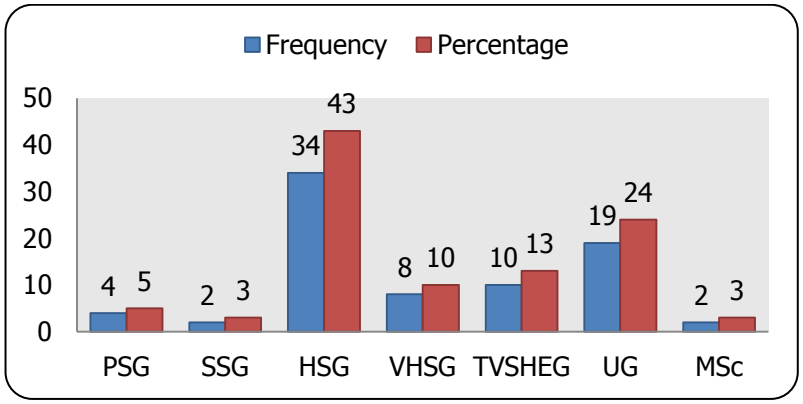

Fig. 3-3 Educational Level of the employees in the plant

As can be seen from Figure 3-3, the main portion of the personnel in the station is "High School Graduate (HSG)" with a percentage of **43%**. All of them are technicians of the operation and maintenance teams. With a total of **27%** (24% University Graduate (UG) and 3% MSc Graduate (MSc)) the engineers, chief engineers and managers are the second group following the technicians. The per cent of technical vocational school of Higher Education Graduate (TVSHEG) is **13%**. They are also the technicians working in the operation and maintenance teams. Only **7%** of the personnel are graduated from primary and secondary school, all of them are held responsible of driving the tractors in the station. **10%** of the personnel are Vocational High School Graduate (VHSG) (equivalent to high school graduates) and they are more experienced compared to High School graduates with respect to technical issues.

3.5. Working experience of the personnel in the plant

The average working year of 79 employees in this plant is approximately three years. The company has started to operate in 2006. Therefore, "operation on period" of the plant can be thought to be approximately four years. Only one person worked for six years in this station because he is the security person who worked in the firm since the construction phase of the station.

The histogram given in Figure 3-4 shows the working years of the employees in the plant.

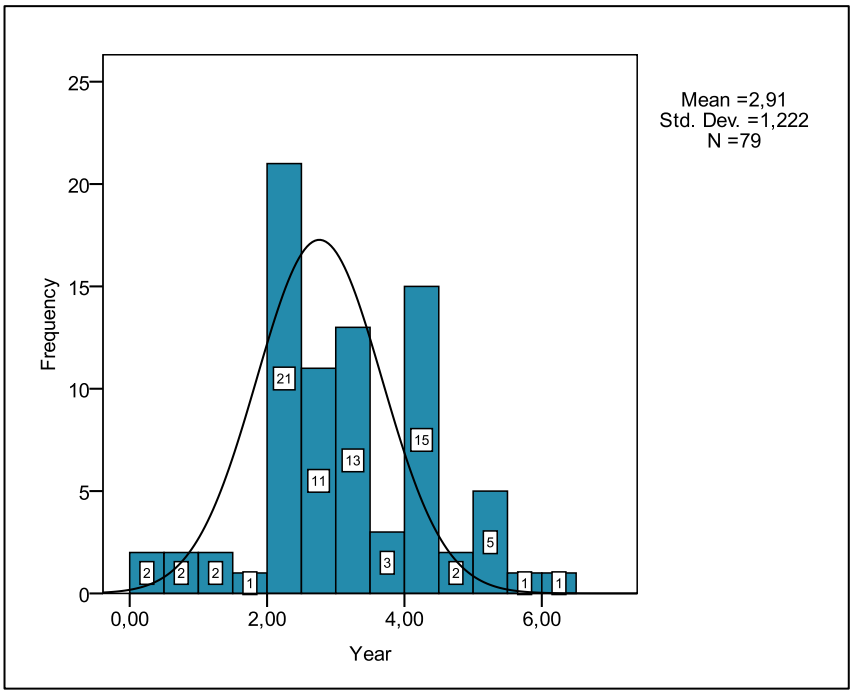

Fig. 3-4 Working experience of the employees in the plant

3.6. Working Postures in the Plant

The employees mostly do their jobs in the station by "walking around". The daily checks of the operating systems in the plant are done generally by walking around them. Stated in other words while doing their jobs, 81% of the workers walk.

Whereas the working posture of the **68%** (N=54) of the workers, i.e., managers, chief engineers, administrative team and HSE Team can be defined generally as "**seated**". It has to be noted that in addition to office work (i.e., seated posture) **22%** (N=12) of them also have to do site visits (i.e., "**walking around**"), because they have to submit a report to the management in the headquarters on "what happens in the plant".

Technicians from maintenance team (**43%**) also perform their jobs they are charged to by standing constantly on their feet. **27%** of this team stated that they work in the position of crouching or bending while doing their maintenance job. **18%** of the workers have to stand before the benches during welding operations or other mechanical activities.

Briefly, it can be said that the employees who are working in this station do their jobs generally and mainly by "*standing*" constantly on their feet, by "*walking around*" and "*staying at the office*". The above mentioned facts are summarized in graphical form in Figure 3-5. "*Office works*" in Figure 3-5 refers to "*Staying at the office*" working style.

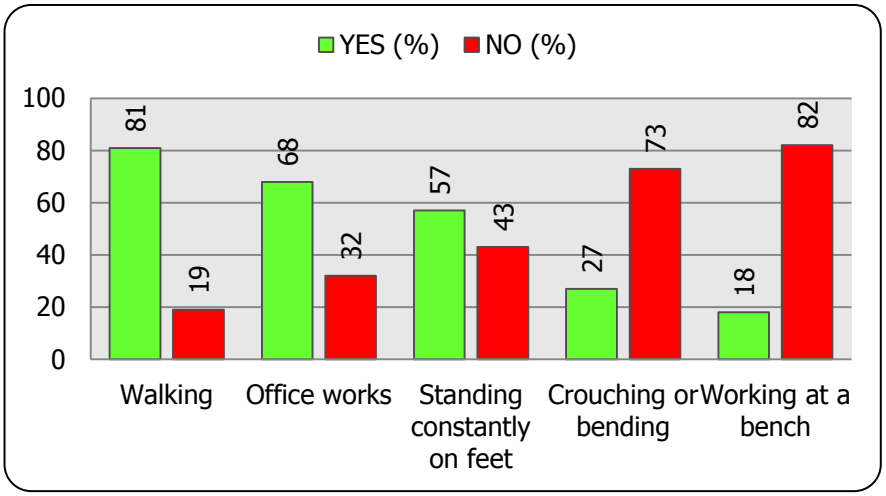

Fig. 3-5 Working postures of the employees

3.7. Working History and Noise Exposure History of the Personnel

85% of the people working in this station have worked before in another company (67 employees out of 79). They have rated their noise exposure, in their previous workplaces, to be, on the average, **2, 7** (**~3** out of 5, i.e., "Moderate level") during **6** years. (Min. =2 yrs. ≤ Experience ≤Max. =10 yrs.)

3.8. Work schedule of the employees

96% of the personnel (76 people) are working 7 days per week in the station. Only two people are working 6 days/week and one is working 5 days/week.

Approximately all (98%) of the people in the station are working 11 hours per day from Monday to Sunday. Even though 84% of the employees are not doing scheduled "overtime" at the station, depending on the operational and

maintenance requirements (including emergency cases), the possibility of overtime work is not null.

Table 3-1 Working period in the buildings

Building No	Number of people entering the building (out of 79 people)	Average time spent (in minutes)
B1	37	334
B2	46	245
B3	58	211
B4	46	167
B5	38	69
B6	29	40
B7	26	26
B8	28	34
B9	20	21
B10	25	23
B11	16	28

The average time spent by the employees in the buildings where they work is tabulated above, building by building, in Table 3-1.

3.9. Subjective rating of the noise level in the buildings and associated working efficiency

It was requested from the employees to assess their noise exposure level, NL, in the buildings they have spent time, using both verbal and numerical scales.

5-point Noise Level-Verbal Rating, NL-VR, scale was graded as "Very Low (VL)", "Low (L)", "Moderate (M)", "High (H)" and "Very High (VH)".

11-point numerical Noise Level-Scalar Rating, NL-SR, scale starts from "0 (Zero)" (indicating a very quiet workplace) and ends with "10 (Ten)" (indicating a very noisy workplace).

The effect of the ambient noise on the working efficiency of the employees are also tried to be demonstrated by their subjective ratings displayed in verbal, WE-VR, and numerical, WE-SR, scales. 5-point verbal scale was

coded as "Not Affected (NA)", "Slightly Affected (SA)", "Moderately Affected (MA)", "Affected (A)" and "Highly Affected (HA)". In addition to this scaling, they are requested to use numerical rating ranked from 0 (designating no effect of noise on WE) to 10 (meaning WE is very affected by the NL in the workplace).

The results of the NL-VR and NL-SR ratings and "WE-VR" and "WE-SR" ratings are then correlated with each other, in order to see the fitness of the answers based on different scales ,using Pearson Correlation Coefficient (PCC).

3.9.1. Building B1

As described in chapter 2, B1 is the building one part of which is used for recreational purposes. 37 people out of 79 use this building every day. The evaluation of NL-VR for B1 by the employees is given in Figure 3-6 below.

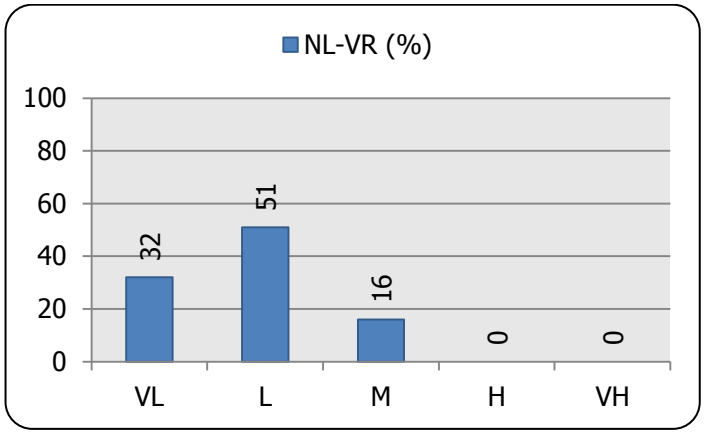

Fig. 3-6 NL-VR results (B1 building) (N=37)

As can be seen from it, noise level low, **"L"** is selected by **51%** of the people and **32%** of them assessed the NL as very low, **"VL"**. Moderate noise level, **"M"** is chosen by **16%** of them.

The mean of NL-VR is calculated as [**1,8**/5,0] for this building. The average NL-SR for B1 is also calculated as [**1,6**/10,0]. To assess the compatibility of the answers for NL-VR and NL-SR, the Pearson Correlation Coefficient (PCC)

is calculated and found to be **0,618**. In other words, the correlation between these two values is **significant** at 0.01 level (2-tailed). It is understood that people entering B1 generally evaluated the NL as low, **"L"**.

Among 37 people, nobody uses ear protection in B1 and no obligation or any sign is available to show that use of ear protection is mandatory.

3.9.2. Building B2

B2 is the most important building of the plant. It includes control room, panel room and offices for the managers and technical personals. People generally do their office works in B2. The NL-VR and WE-VR data obtained are graphed in Figure 3-7 as follows;

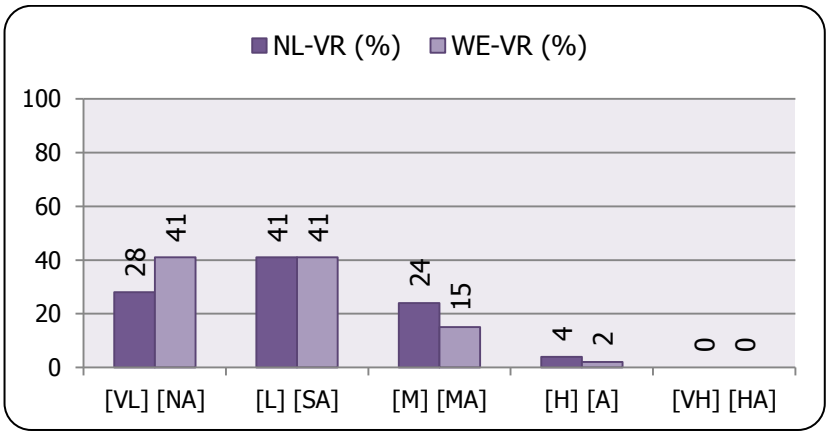

Fig. 3-7 NL-VR and WE-VR results (B2 building) (N=46)

46 personnel using this building every day evaluated the NL, in ascending order, as **"L"** (**41%**), **"VL"** (**28%**), and **"M"** (**24%**). Only **4%** assessed it as **"H"** and **2%** as **"VH"**.

The calculated average for NL-VR is [**2,1**/5,0] for B2. The mean NL-SR value is calculated as [**2,6**/10,0]. The PCC between them is **0,766** showing that the correlation is **significant** at 0.01 level (2-tailed) like B1.

From the average value of the NL-VR, it can be said that similar to B1 people feel the NL in this building as **"Low, L"**.

In case of WE-VR rating, it is seen that **41%** of the people rated their working efficiency as **"NA"** by the NL in B2. **"SA"** option was chosen by again **41%** of the employees. **15%** however evaluated the effect of NL on their Working efficiency as moderate, **"MA"**. Only **2%** selected **"A"** option in their working efficiency rating, WE-VR.

The mean WE-VR is [**1,8**/5,0] and the mean WE-SR is [**2,0**/10,0]. The PCC between two is **0,798**, which is **significant** at 0.01 levels (2-tailed), means that the evaluations, WE-VR and WE-SR are consistent with each other. Consequently, it can be said that the ambient noise in building B2 rated as **"Low"** by the employees affects slightly their working efficiency.

Two people use ear protection in B2, and the rest (which corresponds to 96% of 46 workers) do not use it. It has to be noted that use of ear protection inside the B2 building is not mandatory.

3.9.3. Building B3

50% of the employees (58 people out of 79) entering B3 assessed the noise level in this building as moderate, **"M"**. The percentage of the employees assessing the NL as high, **"H"** was **22**. Only **7%** rated the NL as very high, **"VH"**. These data are shown graphically in Fig. 3-8.

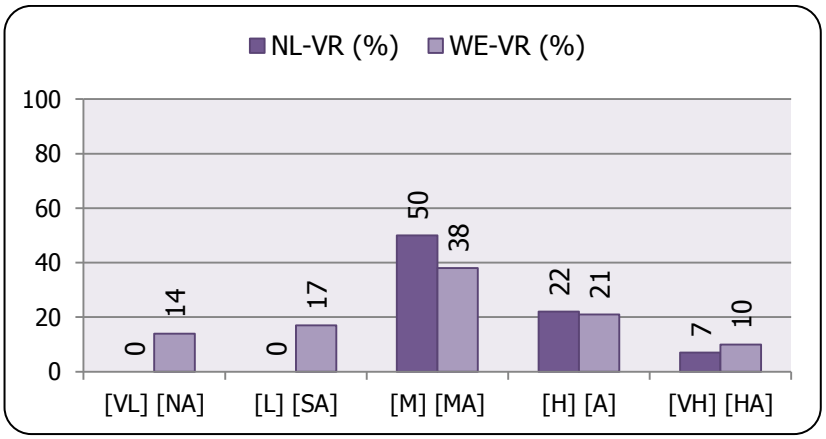

Fig. 3-8 NL-VR and WE-VR results (B3 building) (N=58)

It has however to be noted that even though **79%** of the employees entering this building rated the NL as being equal or above moderate, **M**, level; **21%** evaluated this place as not a noisy place and selected the choice low, **"L"** level for the ambient noise in this building.

The average NL-VR of [**3,2**/5,0] depicts that people entering B3 found the NL in B3 as **moderate** (i.e., M Level). The mean NL-SR rating for this workplace is found to be [**5,5**/10,0].

The correlation between the verbal and scalar rating of the noise level is **significant**. The PCC between them is **0,654** [significance level = 0.01 (2-tailed)].

14% (N = 58) of the people said that they were not affected, **"NA"**, by the NL in B3. **"SA"** option was preferred by **17%** of the employees who use this building. **38%** evaluated the effect of the NL on their work efficiency as moderate, **"MA"**. **21%** selected **"A"** option. Work efficiency of **10%** was highly affected, **"HA"**, by the NL.

The average WE-VR is [**3, 0**/5, 0] and the average WE-SR is [**4, 4**/10, 0], respectively. The PCC for these two values is **0,702** and is **significant** at 0.01 levels (2-tailed).

The above values show that the NL in B3 building that was rated by the workers as moderate affected also moderately their working efficiency. When the NL, in the environment where people are working increases, Work Efficiency decreases accordingly.

33% of the employees (19 people) use ear protection while working in B3, whereas, 67% of them (39 people) do not use any protection. However, use of ear protection is mandatory in B3.

3.9.4. Building B4

B4 is the building where the main pumping operations are being carried out by five huge reciprocating pumps. Therefore, as can be understood from Fig.

3-9, B4 is one of the noisy buildings (the measurements will be given in chapter 6) in the plant. The employees' evaluations (N = 46) for this building are as follows;

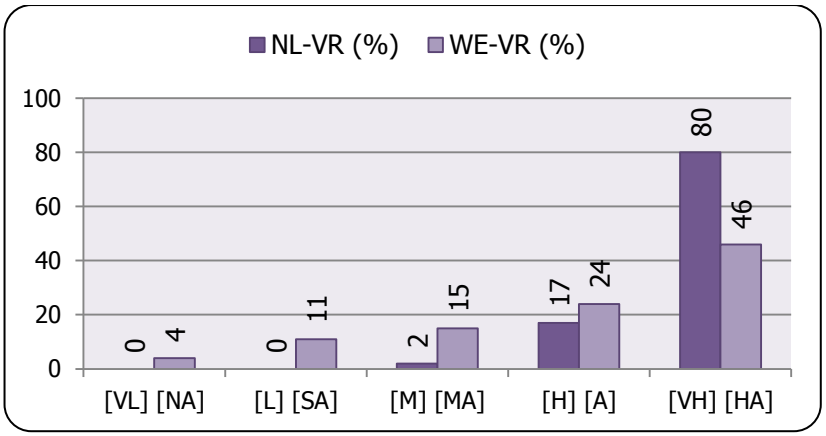

Fig. 3-9 NL-VR and WE-VR results (B4 building) (N=46)

80% of the people said that the NL is very high, **"VH",** and **18%** of them stated it as high, **"H"**. Only **2%** assessed the NL as moderate, **"M"**.

The average value of NL-VR for B4 is calculated as [**4,8**/5,0]. Similarly, the NL-SR is [**9,4**/10,0]. By looking at this value, we can say that people find this place as a very noise place.

The PCC value between NL-VR and NL-SR is **0,405**. The correlation is **significant** at 0.01 levels (2-tailed).

4% of the people said that their Working Efficiency, WE, were not affected, **"NA"**, by the NL in B4. **"SA"** option was preferred by **11%** of the employees who use this building. **15%** evaluated the effect of NL on WE as **"MA"**. **24%** selected **"A"** option for WE in B4. **46%** assessed the WE as **"HA"**.

The average WE-VR is [**4,0**/5,0] and the average WE-SR is [**6,9**/10,0]. The correlation between two is **0,784** and is significant at 0.01 levels (2-tailed).

The ear protection is also mandatory for people in B4.

3.9.5. Building B5

In B5 building, the most effective unit is the metering unit. The unit is responsible of counting how much oil is passing through the pipeline when the pipeline is online. The NL-VR rating done by the employees using B5 building as their workplace is as follows;

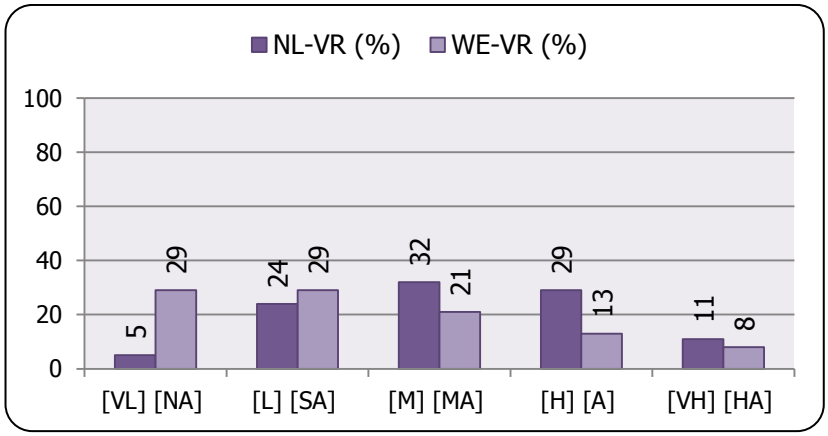

Fig. 3-10 NL-VR and WE-VR results (B5 building) (N=38)

32% of them said that the level is **"M"**, **29%** assessed the NL as **"H"** and **11%** evaluated it as **"VH"**. Only **5%** said **"VL"** and **24%** said **"L"**.

The NL-VR for B5 is [**3,2**/5,0], which means that the NL in B5 was found by employees as of Moderate Level. Whereas the average NL-SR calculated from the answers obtained from the employees was [**5,1**/10,0]. This average is in parallel with the NL-VR results. The PCC value of **0,740** between the ratings is **significant** at 0.01 levels (2-tailed).

29% of the people said that they were not affected **"NA"** by the NL in B5. **"SA"** option was preferred by **29%** of the employees who use this building in a day. The WE of **21%** were moderately affected, **"MA"**, by NL in B5. **13%** selected **"A"** option for the effect of NL on WE in B5. **8%** preferred "HA" option in WE-VR rating scale.

The Working Efficiency ratings WE-VR and WE-SR are [**2,4**/5,0] and [**3,8**/10,0], respectively. The PCC between the two ratings is **0,809** is

significant at 0.01 levels (2-tailed), showing that WE-VR and WE-SR ratings are in accordance with each other.

Although the sign "wear ear protection" is present at the entrance of B5, the employees in general neglect wearing them. Only 40% of the personnel (15 people) use Ear Protection, the remaining 60% (23 people) personnel entering this building do not use any ear protection.

3.9.6. Building B6

B6 is the building where relief valves are placed for the system's integrity and safety. The assessment of the personnel as follows;

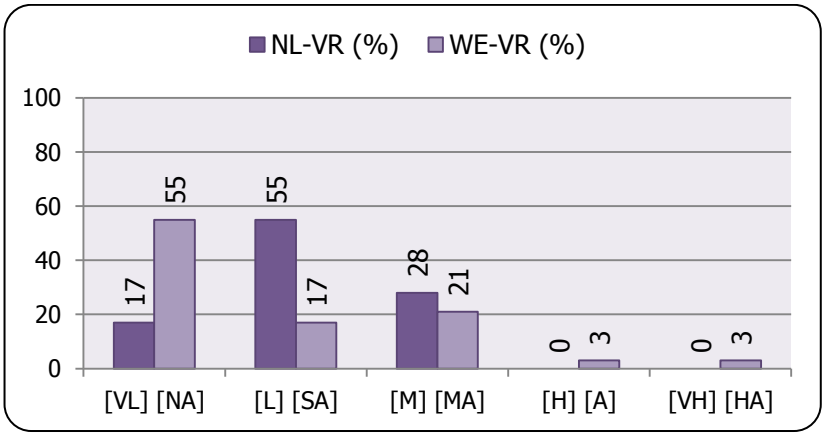

Fig. 3-11 NL-VR and WE-VR results (B6 building) (N=29)

In B6, people (N =29) generally entering into this building ranked the noise level between "VL" and "M". **55%** of them assessed the level as **"L"**. **"VL"** is marked by **17%** of employees, and **28%** said the NL to be **"M"**.

The average of NL-VR rating is [**2,1**/5,0], meaning that people think the NL in B2 as of low, L, level. The average of NL-SR rating is [**2,8**/10,0]. No difference is observed between NL-VR and NL-SR ratings.

55% of the people said that they were not affected **"NA"** by the NL in B6. **"SA"** option was preferred by **17%** of the employees who use this building daily. Working Efficiency of 21% of the employees was moderately affected

"MA", by the NL in B6. Only **3%** selected **"A"** option. Highly affected **"HA"** percentage likewise was **3%**.

The average of WE-VR and WE-SR ratings is [**1,8**/5,0] and [**1,9**/10,0], respectively. The PCC between two is **0,476** that is **significant** at 0.01 levels (2-tailed).

Ear protection wearing is not an obligation for that building.

3.9.7. Building B7

B7 is the building containing main water supply system. There are two tanks and one sanitation unit inside the building. There is not any equipment causing considerable noise. Mainly operational and maintenance team members visit this building for routine control and for maintenance purposes. The evaluation of the personnel regarding NL and effect of noise on WE is as follows;

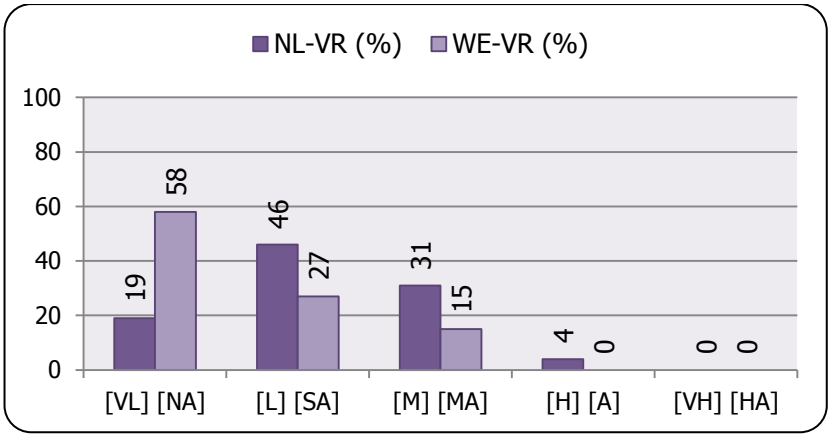

Fig. 3-12 NL-VR and WE-VR results (B7 building) (N=26)

46% of the personnel felt that the degree of NL is **"L"**. **"M"** level was selected by **31%** of the employees and **19%** described NL inside the building as **"VL"**. Only **4%** stated it to be high, **"H"**. The average NL-VR for this building is [**2,2**/5,0] and average NL-SR is [**2,3**/10,0]. This shows that people who visit B7 generally described the NL as **"L"**.

The correlation between NL-VR and NL-SR is **significant** at 0.05 levels (2-tailed) and PCC value is **0,428**.

58% of the people were not affected, **"NA",** by the NL in B7. **"SA"** option was preferred by **27%** of the employees and **15%** evaluated the effect of NL on WE as **"MA"**.

The mean WE-VR is [**1,6**/5,0] and mean WE-SR is found as [**1,7**/10,0]. The correlation between these two is **0,482** and is **significant** at 0.05 levels (2-tailed).

26 out of 79 employee visit daily the building B7. Ear protection is not mandatory for this building.

3.9.8. Building B8

B8 building is separated into three parts namely; Electrical Panel Room, Boiler Room and Compressor Room. Three boilers and one pump are the noise sources in this building. 28 people using NL-VR and NL-SR scales evaluated the noise level in B8 as follows;

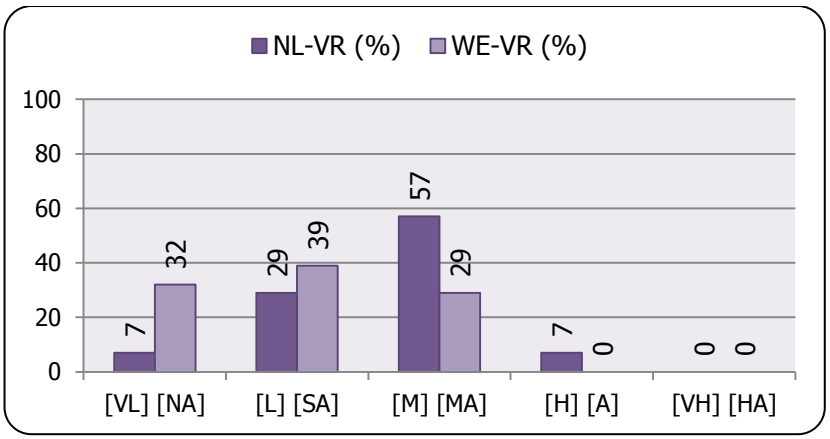

Fig. 3-13 NL-VR and WE-VR results (B8 building) (N=28)

29% of the employees ranked the NL inside the building as **"L"**, **7%** of whom selected the choice **"VL"**. **"M"** option was preferred by **57%** of the workers and only **7%** stated the NL as **"H"**.

The mean NL-VR is found as [**2,6**/5,0], meaning that B8 has low noise level. The average NL-SR for B8 is calculated as [**3,8**/10,0].

The PCC value **0,428** is not high enough, but still correlation is **significant** between NL-VR and NL-SR at 0.05 levels (2-tailed).

32% of the people said that they were not affected, **"NA",** by the NL in B8. **"SA"** option was preferred by **39%** of the employee who use this building. **29%** evaluated the effect of NL on WE as **"MA"**.

The average of WE-VR is [**2,0**/5,0] and average of WE-SR is [**2,8**/10,0]. The correlation between two is **0,703** and is **significant** at 0.01 levels (2-tailed).

Like in B4, people have to use ear protection in this building also. This protection enables people to protect themselves efficiently from the NL in B8 and decrease the effect of NL on their work efficiency. 29% of the employee uses ear protection and 71% do not.

3.9.9. Building B9

Each day 20 people visit B9 Building. The fire pumps present in this building can be considered as sources of noise when operated in case of emergency that may occur in any place of the station. The NL-VR and WE-VR data obtained are graphed in Fig. 3-14 as follows;

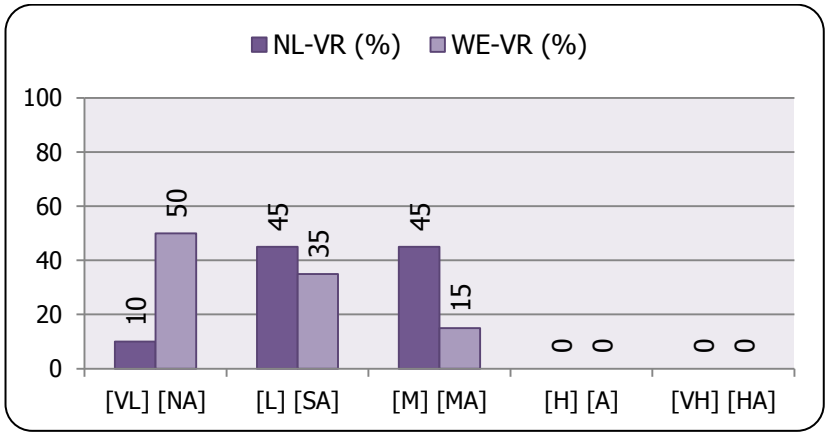

Fig. 3-14 NL-VR and WE-VR results (B9 building) (N=20)

While rating the NL in B9, the options **"M"** and **"L"** are equally selected by **45%** of the employees entering into this building. **10%** stated their opinion for the ambient NL as **"VL"**.

Overall average verbal rating of the noise level is [**2,4**/5,0]. The average scalar rating of noise level is [**3,1**/10,0]. The Pearson correlation coefficient between them is **0,692** showing a **significant** correlation at 0.01 levels (2-tailed). **32%** of the people said that they were not affected, **"A",** by the NL in B9. **"SA"** option was preferred by **35%** of the employee who use this building daily. NL at "MA" level affects WE of 15% the employees.

The average of WE-VR is [**1,7**/5,0] and average of WE-SR is [**2,4**/10,0]. The PCC between two is **0,452** and shows a **significant** correlation between two average ratings. Use of ear protection is mandatory when the fire pumps are on.

3.9.10. Building B10

The generator, of the plant that has to be available in case of power cut-offs caused by the problems on the power lines, is in B10 building. When the electricity is cut-off, the generator will be online in 10 seconds, and at that time, it will be a noise-producing machine.

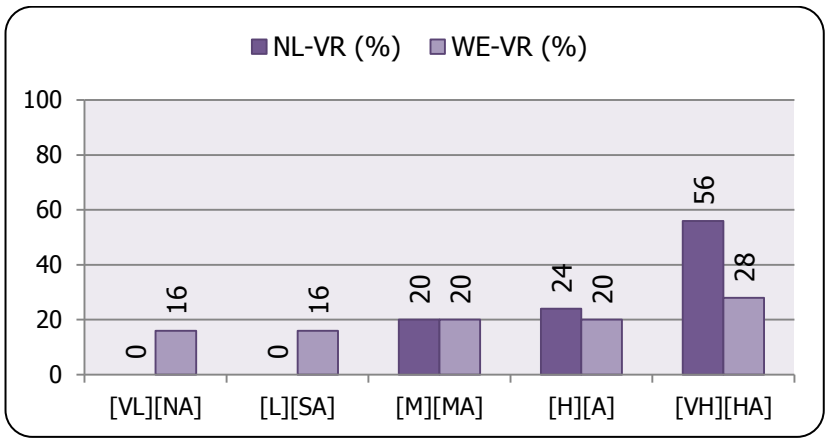

Fig. 3-15 NL-VR and WE-VR results (B10 building) (N=25)

The NL was assessed as very high, **"VH"**,by **56%** of the personnel. **24%** of the workers stated their opinion as high, **"H"** and **20%** evaluated the NL as **"M"**.

The average of NL-VR is [**4,4**/5,0] for B10, indicating the awareness of the workers about the very noisy environment when the generator is run. The NL-SR is in parallel with NL-VR with the value of [**7,7**/10,0].

The PCC between them is **0,858** meaning that correlation is **significant** at 0.01 levels (2-tailed).

16% of the people said that their WE was not affected, **"NA"**, by the NL in B10. **"SA"** option was preferred by **16%** of the employee who use this building in a day. **20%** evaluated the effect of NL on WE as **"MA"**. **20%** selected **"A"** option for the effect of NL on Working Efficiency, WE, in B10. WE of **28%** of the employees were affected highly, **"HA"**, by the ambient noise level. Ear Protection use is mandatory when the generator is online.

3.9.11. Building B11

B11 is the building named as Low Voltage Room. There are electrical panels here and only authorized electrical people are allowed to enter into this room. 16 authorized employees entering this building evaluated the noise level in B11 and its effect on their working efficiency as follows;

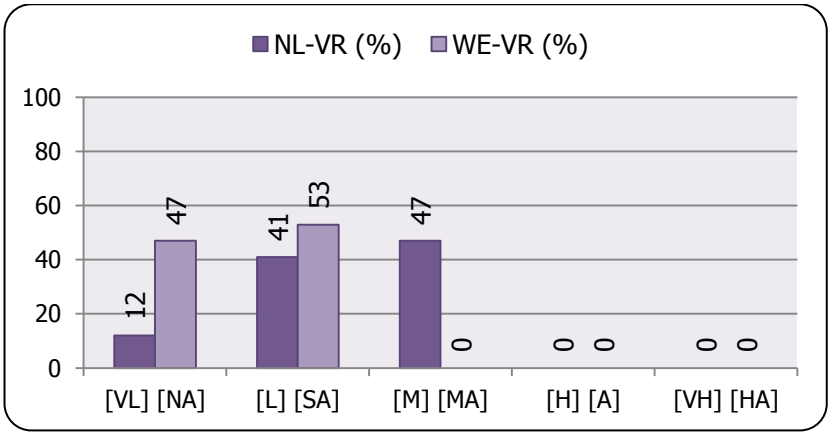

Fig. 3-16 NL-VR and WE-VR results (B11 building) (N=16)

47% of the employees rated the noise level, as moderate, **"M"**, **41%** of the workers evaluated it as **"L"** and **12%** assessed it as **"VL"**.

The average NL-VR value is [**2,4**/5,0] for B11. The average NL-SR is [**2,3**/10, 0]. The PCC between these two values is **0,516** meaning that correlation is **significant** at 0.05 levels (2-tailed).

47% of the people were not affected, **"NA",** by the NL in B11. **"SA"** option was preferred by **53%** of the employees. The mean of WE-VR and WE-SR ratings is found to be [**1,5**/5,0] and [**1,8**/10,0], respectively. The correlation between the two ratings is **0,656**, and **significance** level is 0.01 (2-tailed).

Here, ear protection is not mandatory.

3.10. Health Status of the Workers

3.10.1. Complaints of the Workers

The feedbacks obtained from the employees relevant with the situations they encounter in their work are tabulated below.

Table 3-2 Complaints of the employees relevant with their health (N = 79)

Percent	
32%	of the workers suffer from headache
28%	of the people suffer from tinnitus
28%	of the personnel has insomnia
21%	of the personnel suffer from neck pain
20%	of the personnel have recurring headaches
15%	of the personnel have cholesterol problem
14%	of the personnel suffer from back pain
8%	of the employee have some short period pains in their ear
8%	of the workers have tubal dysfunction
8%	of the personnel has chronic fatigue
5%	of the personnel frequently feel depressive, frustrated and indecisive
4%	of the personnel have a blood pressure problem
2%	of the personnel have dizziness
2%	of the personnel have shortness of breath

As seen from Table 3-2, among the first three top items, tinnitus, with **28%**, requires special attention due to its cause-effect relationship with noise. Therefore, relationship between the pairs (tinnitus and noise level in the

workplace (building by building)), (tinnitus and time spent in the buildings (i.e. noise exposure duration)), (tinnitus and age of worker), (tinnitus and working years) are analysed.

Tinnitus is found to be not significantly correlated with noise level in the workplace, with noise exposure duration, with the age of the worker and with the working years of the workers.

3.10.2. Hearing Loss of the Workers

Answers to question 26 in the questionnaire indicate that only **8%** (6 personnel) have "Hearing Loss" whereas **92%** (73 personnel) has "No" hearing loss. This is also verified in the medical tests done annually in the plant. Even though only six personnel have hearing loss, **44%** (35 personnel) has stated that there is an improvement in their hearing when they are away from the job. **40%** (32 personnel) of the personnel also mentioned their hearing is improved at nights.

44% (35 personnel) claimed that when they are on holiday, improvement on hearing is **significant**. In other words, the workers have hearing complaints but these complaints have not yet led to hearing loss in the workers.

The situations that are thought to affect the hearing ability of the people are also checked through the questionnaire survey and the results are tabulated below in Table 3-3.

Table 3-3 Situations that are thought to affect the hearing ability of the people

Percent (%)	# of person	Answers to questions
49	38	Do you swim or scuba dive ?
46	35	Do you smoke?
30	23	Have you ever been exposed to blasting or other explosive noises?
24	19	Do you use pain-killers?
22	17	Have you ever had a car or motorcycle accident before?
20	16	Do you have recurring headaches?
15	12	Do you have a cholesterol problem?
8	6	Have you had liquid from your ears?
6	5	Have you had any complaint relating to your ears?
6	5	Did you suffer any head injuries?
4	3	Do you have a blood pressure problem?
3	3	Is there anyone having hearing loss in your family (between 22-40 ages)?
1	1	Have you ever had ear surgery?
0	0	Do you have any blood circulation problem?

3.10.3. Sleeping Situation of the personnel

Sleep is an important parameter not only for working people but for every person. In industry, however people have to sleep well and enough in order to be alert and careful during the workday.

Therefore, it is requested from the personnel to state whether or not they had a trouble in sleeping at nights. The results in percentages are shown in Fig. 3-17.

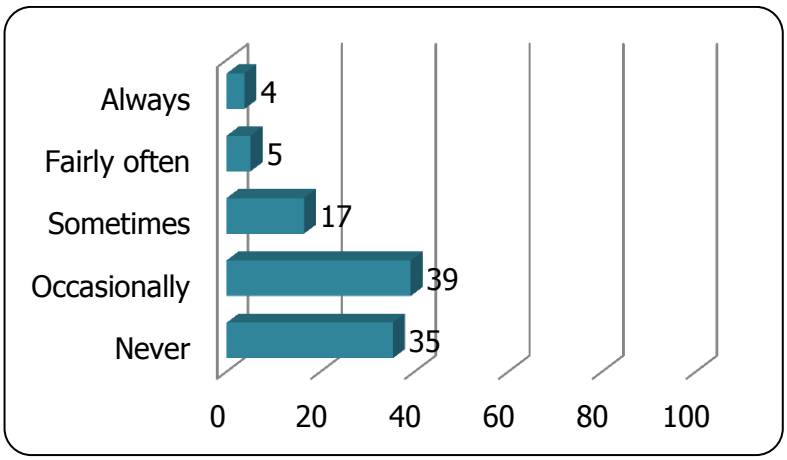

Fig. 3-17 Sleep Evaluation of the personel

35% of the personnel never had sleep trouble. **39%** stated that they occasionally had trouble in sleeping. **17%** sometimes come across with trouble while sleeping. The percentage of workers having "Fairly often" and "Always" trouble in sleeping at night was **9%**. It is worth mentioning that only **35%** of the workers **"sleep peacefully"**.

3.11. Use of Hearing Protectors in the Plant

Ear protection wearing is a very important safety tool for employees to protect themselves from the negative effects of the noisy environment in which they are working. The sign given below, "HPD use is mandatory", was placed at the entrances of the B3, B4, B5, B8 and B10 buildings.

Fig. 3-18 Hearing Protection Sign used in the plant

The two types of ear protection used in the station are displayed in Fig. 3-19;

Hard Hat Mounted Ear Muff

Disposable Ear Plug

Fig. 3-19 Hearing Protector Types

In the station, among 57 people who use ear protection, **44%** uses "Ear Muff (EM)" connected to their helmets, **14%** prefers to use "Ear Plug (EP)" type ear protection and **42%** use both of them together, while entering a building where ear protection wearing is an obligation.

44% of the employees are comfortable while using the ear protection whereas **56%** of them are uncomfortable. **79%** of the personnel is of the opinion that ear protection being used in the plant is compatible with other personnel protective equipment such as safety glasses, hardhats etc. **21%** has the opposite opinion and stated that the ear protection equipment and safety glasses are not compatible with each other. Mainly **74%** of the

personnel in the plant use ear protection ***when required*****.** No time schedule or any time limitation to use ear protectors is stated. It is expected from the people to use them wherever there is a warning stating that ear protection wearing is mandatory.

The noise reduction capability of the ear protection devices is rated by 57 personnel. Only **4%** stated, ***"Noise is prevented completely"***. According to **30%** of the employees ***"Noise is highly decreased"*** when ear protection is used. ***"Noise level is moderately decreased"*** option was selected by **56%** of the employees. The percentage of people thinking, ***"Noise is decreased slightly"*** while using ear protection in a noisy environment were **11%**.

When the question is asked to people to rate the effectiveness of the ear protectors on a numerical scale ranging from 0 (meaning "Not effective") to 10 (meaning "completely preventive"), the mean came out to be [**5, 9**/10, 0]. In other words, according to the perception of the workers, the ambient noise level was **"Moderately decreased**" by the hearing protectors.

3.12. Need of Communication within the plant

In oil industry, communication between people is very important in order to prevent the occurrence of events that may cause unwanted outputs including serious injuries, deaths, fire, and oil spill.

Radios and intrinsically safe phones afford proper communication between the personnel. However, this type of communication can be interrupted in noisy environments. **32%** of the personnel stated that they had difficulty in communicating with each other when they were in noisy environments. Therefore, some special communication ways has to be put in application such as hardhat-connected radios or visual warning systems.

According to the answers obtained from the workers (Figure 3-20), it is clearly seen that they need to communicate continuously with other people (**46%** out of 36 people). The frequency of communication choices "More

often" and "Often" are selected respectively by **14%** (11 people) and **27%** (21 people). Communication need at the level of "rarely" is stated only by **14%** (11 people) of the employees. In other words **86%** of the personnel are in need of communication.

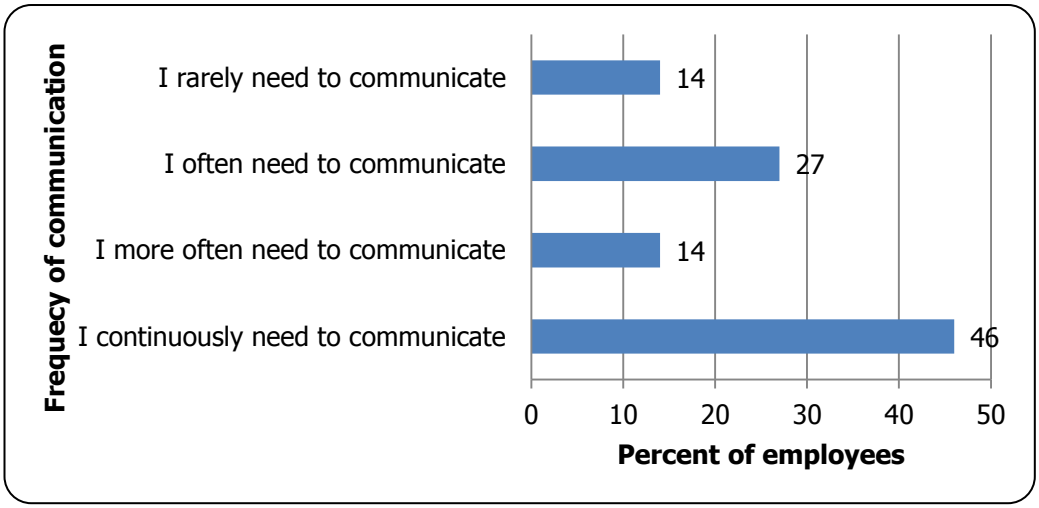

Fig. 3-20 Communication frequency of people at work

3.13. Calculation of Workplace Index

How the Work Efficiency, WE, of the employees, in general, was affected by the noise level in each building of the plant was mentioned in the previous section. In this section the effect of noise on WE will be assessed based on parameters like personnel's "*Attention*", "*Working speed*", "*Hearing and understanding of people near to him*", "*Hearing the warning signals*" and "*Speaking to people near to him*", respectively and a Workplace index, WPI will be calculated.

Each parameter was assessed, by marking the scale, in the questionnaire, graded as "Not Affected – NA", "Slightly Affected – SA", "Moderately Affected- MA", "Affected - A" and "Highly Affected- HA", by the personnel.

In order to display the relationship between the variables more explicitly factor analysis is also applied. Principal Component Analysis is used to combine the correlated variables with each other in order to decrease the number of the variables. The proportion of variance of a particular item that

is due to common factors (shared with other items) is called ***communality***. The communalities between the parameters are tabulated below.

Table 3-4 Communalities obtained from Factor Analysis

Communalities		
	Initial	**Extraction**
Attention	1,000	0,853
Working Speed	1,000	0,853
Hearing and understanding of people near to him	1,000	0,907
Hearing the warning signals	1,000	0,796
Speaking to people near to him	1,000	0,913
Extraction Method: Principal Component Analysis.		

Table 3-5 Results of Principal Component Analysis

Component	**Initial Eigen values**			**Extraction Sums of Squared Loadings**		
	Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	3,167	63,332	63,332	3,167	63,332	63,332
2	1,156	23,114	86,446	1,156	23,114	**86,446**
3	0,291	5,823	92,269			
4	0,280	5,605	97,874			
5	0,106	2,126	100			

Table 3-6 Rotated Component Matrix*

	Component	
	1	**2**
Attention	0,201	0,901
Working Speed	0,200	0,902
Hearing and understanding of people near to him	0,944	0,128
Hearing the warning signals	0,835	0,313
Speaking to people near to him	0,935	0,200
**Extraction Method: Principal Component Analysis* *Rotation Method: Varimax with Kaiser Normalization* *Rotation converged in 3 iterations*		

Table 3-7 Goodness-of-fit test

Chi-Square	**df**	**Sig**
0,084	1	0,772

Table 3-8 Reliability Statistics of "Efficiency in Work" and "Communication"

Efficiency in work			Communication		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0,830	0,830	2	0,922	0,922	3

By looking at the rotated matrix, one can see that the first component has high loadings from the items, "*Hearing and understanding of people near to him*", "*Hearing the warning signals*" and "*Speaking to people near to him*". They, therefore, has to be considered in determining the Workplace Index, WPI.

WPI is calculated as;

$$\textbf{WPI} = \frac{1}{N}\sum_{1}^{N} \left(\frac{1}{n}\sum_{i=1}^{n} v_i\right) \quad \text{..... (Equation 3-1)}$$

n = no of variables obtained at the end of factor analysis

N = no of workers

v = considered variables

i=1; workers' rating of the effect of noise on "Hearing and understanding of people near to him"

i=2; workers' rating of the effect of noise on "Hearing the warning signals"

i=3; workers' rating of the effect of noise on "Speaking to people near to him" .WPI for this plant is found to be **3, 22** out of **5, 00**. In other words, from the point of view of effect of noise on the working efficiency of employees the plant is ***moderately satisfactory***.

CHAPTER IV

PSYCHOSOCIAL WORKING CONDITIONS IN THE PLANT

4.1. Introduction

Psychosocial Working Conditions (PWC) are very crucial for employees. Workplace has to enable them to work comfortably and efficiently. The part of the questions numbered between 46 and 76 of the questionnaire were applied to the employees in order to concieve their thoughts with regard to Working Conditions in the plant.

Six key stressors, namely "Demands, Control, Managerial and Peer Support, Relationships at work, Role and Organisational Changes" are considered. Out of 35 questions of HSE Management Standards Analysis Tool, 31 questions were asked in this questionnaire. The definitions of the six key stressors are given below.

- *Demand* includes issues like workload, work patterns, and the work environment.
- *Control* indicates how much say a person has in the way they do their work.
- *Support (Manager's & Peer)* include the encouragement, sponsorship and resources provided by the organisation, line management and colleagues.
- *Relationship* includes promoting positive working to avoid conflict among workers and dealing with unacceptable behaviour.
- *Role* can be defined as whether people understand their role within the organisation and whether the organisation ensures that the person does not have conflicting roles.
- *Change* is defined as how organisational change (large or small) is managed and communicated in the organisation.

4.2. Questionnaire Survey

The questionnaire was answered by 79 personnel in the plant. The questions were answered in 5-point Likert scale format. Two types of response formats were used. They were either of frequency type (always...never) or agree type (stongly disagree....strongly agree). The ratings of the employees associated with the above-mentioned stressor groups are listed in Table 4-1. The two "Question no" columns in the table indicate respectively the number in the questionnaire given in the Appendix and the question number in [26]. The summary of the results are given in Table 4-2. The colour key scale for the evaluation of this survey is depicted next to the table. It has to be noted that suggested targets are based on a survey performed in United Kingdom in 2004 [26].

The questions marked with **X*** were not asked to the plant personnel.

Table 4-1 The average scores corresponding to stressor groups

	Q. No	[26] Q. No		Avrg.
Demands	3	-	Different groups at work demand things from me that are hard to combine	X*
	6	49	I have unachievable deadlines	3,25
	9	52	I have to work very intensively	2,45
	12	55	I have to neglect some tasks because I have too much to do	4,01
	16	59	I am unable to take sufficient breaks	3,53
	18	60	I am pressured to work long hours	4,64
	20	62	I have to work very fast	2,99
	22	64	I have unrealistic time pressures	4,38
	Overall			**3,61**

Table 4-1 (Con'd) The average scores corresponding to stressor groups

	Q. No	[26] Q. No		Avrg.
Support (Manager's)	8	51	I am given supportive feedback on the work I do	3,90
	23	65	I can rely on my line manager to help me out with a work problem	3,84
	29	71	I can talk to my line manager about something that has upset or annoyed me about work	3,73
	33	-	I am supported through emotionally demanding work	X*
	35	76	My line manager encourages me at work	3,81
	Overall			**3,82**

	Q. No	[26] Q. No		Avrg.
Support (Peer)	7	50	If work gets difficult, my colleagues will help me	4,22
	24	66	I get help and support I need from colleagues	4,35
	27	69	I receive the respect at work I deserve from my colleagues	4,10
	31	73	My colleagues are willing to listen to my work-related problems	3,86
	Overall			**4,13**

	Q. No	[26] Q. No		Avrg.
Relation	5	-	I am subject to personal harassment in the form of unkind words or behaviour	X*
	14	57	There is friction or anger between colleagues	3,99
	21	63	I am subject to bullying at work	4,21
	34	75	Relationships at work are strained	3,70
	Overall			**3,97**
	**** 20 (26%) of the staff who responded report that they are always, often or sometimes bullied.**			

Table 4-1 (Con'd) The average scores corresponding to stressor groups

	Q. No	[26] Q. No		Avrg.
Role	1	46	I am clear what is expected of me at work	4,56
	4	48	I know how to go about getting my job done	4,58
	11	54	I am clear what my duties and responsibilities are	4,42
	13	56	I am clear about the goals and objectives for my department	4,47
	17	-	I understand how my work fits into the overall aim of the organisation	X*
	Overall			**4,51**

	Q. No	[26] Q. No		Avrg.
Change	26	68	I have sufficient opportunities to question managers about change at work	3,57
	28	70	Staff are always consulted about change at work	3,38
	32	74	When changes are made at work, I am clear how they will work out in practice	4,14
	Overall			**3,70**

Table 4-2 Summary of the Results of Psychosocial Working Conditions

	Our Results	Suggested Interim Target	Suggested Longer Term Target
Demands	3,61	3,88	**4,25**
Control	3,39	3,67	**4,33**
Managers' Support	3,82	4,00	**4,60**
Peer Support	4,13	4,50	**4,75**
Relationships	3,99	4,25	**4,75**
Role	4,52	5,00	**5,00**
Change	3,70	4,00	**4,00**

Evaluation Key
Doing very well - need to maintain performance; represents those at, above or close to the 80th percentile
Good, but need for improvement; represents those better than average but not yet at, above or close to the 80th percentile
Clear need for improvement; represents those likely to be below average but not below the 20th percentile
Urgent action needed; represents those below the 20th percentile

Fig. 4-1 displays, in bar chart format, the values given in Table 4-2.

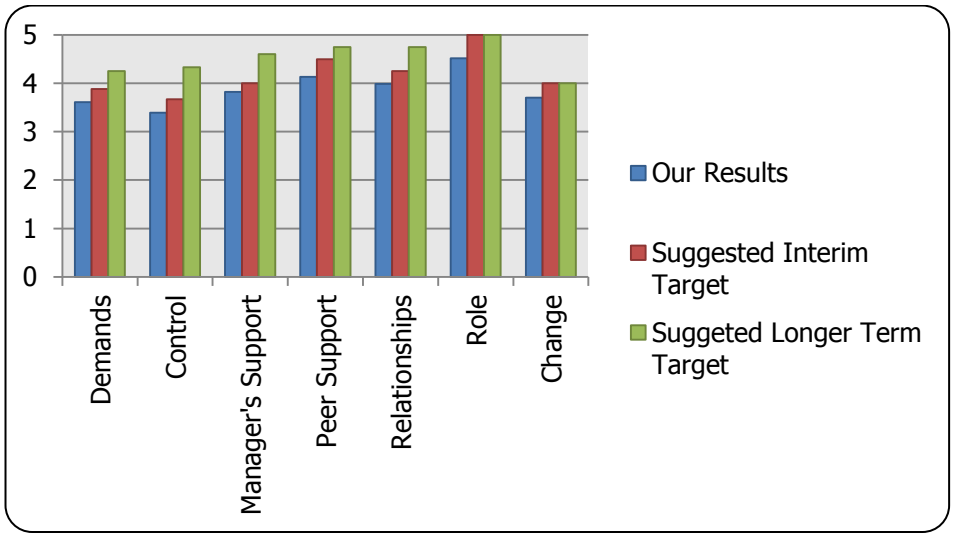

Fig. 4-1 The graphical representation of Summary of results

"Demands" has an average value **3,61** (/5,00) (4,25 is the suggested long term target value), and is very near to the "suggested interim target" value, 3,88. In other words, even though the target is nearly caught up for the employees of this plant, there is still a need for further improvement.

The value **3,39** (/5,00) obtained for **"Control"** scale indicates clearly the need for improvement in the plant. The suggested interim target is 3,67 and the suggested long term target value is 4,33.

"Manager's support" is very crucial for the workers in the plant, the higher it is, the better people work. For this plant, the value is calculated as **3,82** (/5,00), which is near to the suggested interim target value, 4,00, indicating only a need for a slight improvement in this item. Its long term suggested value is 4,60, necessitaing much more effort to reach it.

By **"Peer support"** the support of the collegues is meant i.e., people share their knowledge and experiences and they emotionally, socially or practically support each other. **4,13** (/5,00) is the value obtained from the employees working in this plant for "peer support" item. Suggested interim target is 4,50, which is very close to the found value, showing that the interim target is approximately caught up. To reach the Long term target value of 4,75, improvement is necessary.

"Relationship" between the personnel in a workplace is one of the important issues that has to be investigated. It is rated by the personnel as **3,99** (/5,00), meaning that the situation needs improvement and actions have to be taken as quickly as possible so that the relations between the people reach to a good level. The interim and long term target values are respectively 4,25 (/5,00) and 4,75 (/5,00).

"**Role"** value obtained is **4,52** (/5,00) that is far away from the suggested interim value and long term suggested target, both of which is 5,00. It means that this item should be made better by performing necessary improvements.

3,70 (/4,00) for stressor "**Change**" value, means good but still needs improvement. The suggested interim target value and long term target are both 4,00 (/4,00).

CHAPTER V

PRELIMINARY STUDIES

5.1. Introduction

In order to prepare a protocol for the noise level measurements, that has to be done in the plant, first a preliminary work has been performed.

It consists of

(i) the search of the standards that have to be followed while assessing the occupational noise exposure,

(ii) the sound walk in the plant,

(iii) the decision of the type of the measurements that have to be performed,

(iv) the description and measurement of occupational noise exposure.

5.2. Standards relevant with the assessment of occupational noise exposure

In order to assess the workplace noise, decision for "what should be measured" is important. The two main parameters that have to be measured are given in the ISO 9612 (Acoustics - Determination of occupational noise exposure -Engineering method), as $L_{A,eqT}$ and L_{Cpeak}. In the first edition of ISO 9612, unweighted L_{PEAK} was also required.

In the new edition of ISO 9612 [29], three measurement strategies are suggested. They are:

- *Task-based measurement*: a personal sampling methodology carried out by using a sound level meter to evaluate the noise levels for the specific type of work such as lifting of an equipment, welding or cutting operation [30].
- *Job-based measurement* :a group sampling methodology performed by using a sound level meter to measure the noise levels for the specific type of work to be done by work teams such as maintenance team or operation team [30].
- *Full-day measurement* : the methodology that is carried out by placing a microphone on the middle-shoulder of the most exposed ear before starting of the shift and get the data for a specified time period [30].

The height of microphone from the ground level is suggested to be adjusted to (1,55±0,075) [29-31] meters for the employee who works in standing posture. For the ones who work in crouching, bending or seated postures, the height of the microphone is suggested to be (0,91±0,05) [29-31] meters from the ground level.

In case of job based measurements, for groups of size $N_G<5$, five hours of cumulative measurement time is suggested in ISO 9612. When the group size falls in the range of $15<N_G\leq40$, cumulative measurement time has to be calculated from the equation [10h + (N_G – 15) * 0,25h].

5.3. Sound walk

Sound through assessment walk is a type of audit that is done to determine the noise sources in the facility so that precautions can be taken properly for the people working in noisy environments. The team that generally consisted of noise expert, safety person, operation supervisor, site manager, engineers and site doctor carries out this walk.

It is understood that like in questionnaire survey, permission, for noise level measurements in the buildings, was required, a priori, from the station authority. Taking photographs in the red-zone area were not allowed due to

the safety requirements and confidentiality policy. One responsible operator also accompanied us in the sound walk.

Before entering into the plant, the security personnel registered the measurement team and the badge cards were given to its members.

The measurement team members took first a site induction training in order to be acquainted with the site, and then they receive a training including the topics regarding health, safety and environment. In addition, they learn the rules that are applied on the site so that people become aware of the risks associated with the oil industry.

At the end of the sound walk, measurement points in each building are decided. Pre-measurements were carried out in all buildings by using simple noise level (NL) meter available in the safety department.

5.4. Preliminary Measurements

Several measurements were done at several time intervals (measurement time= 2, 5, 10 and 15 minutes and also half-shift) in order to track whether or not changes in the ambient noise occur with respect to time and in order to choose the period that represents best the noise climate in the buildings and remain consistent when repeated. For example, measurements were carried out in order to observe how the noise level profile in B4 changes with respect to the number of active pumps or with respect to the changes in the flow rate.

The results of these preliminary measurements are given in Table 5-1.

Table 5-1 Data obtained from the preliminary measurements

Buildings	Measurement Location	Measurement time (hours)	Noise level (dBA)	Daily noise exposure (8 hrs)
B2 (Panel Room)		0.25	66,4	51,3
B2 (Control Room)		0.25	60,6	45,5
B2 (Operator Room)		0.25	48,8	33,7
B3 (Ground Floor)		0.25	70,7	55,6
B3 (Office-Electricians)		0.25	43,1	28,0
B3 (Office-Mechanics)		0.25	43,8	28,7
B4	Wall - Pump 1	0.25	98,4	83,3
	Pump 1 – Pump 2	0.25	100,6	85,5
	Pump 2 - Pump 3	0.25	100,6	85,5
	Pump 3 - Pump 4	0.25	99,8	84,7
	Pump 4 - Pump 5	0.15	97,5	82,4
B5		0.25	69,9	55,0
B6		0.25	48,0	32,9
B7		0.25	47,1	32,0
B8 (Panel Room)		0.25	43,8	28,7
B8 (Boiler Room)		0.25	79,1	64,0
B8 (Compressor Room)		0.25	80,8	65,7
B9		0.25	43,9	28,8
B10 (Not in operation)		0.25	64,5	49,4
B10 (In operation)		0,25	107,8	92,7

Measurements were also performed outside the buildings (83,3 dB(A), measurement time=10 min.) in order to see how people, especially the security personnel, were influenced by outside noise.

Even though 15 minutes measurements are given in Table 5-1, the difference in noise levels measured for "measurement duration=2 and measurement duration=15 minutes" were less than 0, 5 dB.

5.5. Measurement Protocol

As mentioned in previous paragraph, mainly four teams work in the plant. Their activities are described in Section 3-2. For each team, each day in a

shift, except emergency and "test" days, involve more or less the same process of tasks. "Nominal day", therefore, was decided to be any day in a shift. As a measurement strategy, therefore, "job-based" and "full-day" measurements seem to be appropriate for this plant.

Even though ISO 9612 suggests 5-h, 11, 25-h and 14-h for AT, OT, ST and MT teams, respectively, the working periods indicated in Table 3-1 do not enable us to make use of this suggestion. In addition it was already known, from the preliminary measurements, that the change in noise levels was less than 3 dB in measurements having duration of 15 minutes compared to half-shift measurements. The minimum cumulative duration of measurement by sound level meter was decided to be at least 15 minutes. Further, at least 8 samples were decided to be taken at each measurement point. The duration of each measurement was decided to be 2 minutes. Full-shift measurements were decided to be appropriate for the members of HSE, MT and OT teams.

Measurement plan consists of;

(i) Noise level measurements

Type 1 Sound Level Meter was decided to be used in noise level measurements. Five buildings out of 11 were selected. The choice has been done taking into consideration the results of the NL ratings of the workers and noise levels predicted in preliminary measurements. (Table 5-1)

The noise level measurements were decided to be done, in buildings having on the average NL rating value of 2,5 (/5,0) and above ,by sound level meter.

The ratings coming from the questionnaire evaluation and preliminary noise level measurements were consistent with each other. This consistency helps us to decide easily which of the buildings are crucial for the personnel.

The selected buildings were B3, B4, B5, B8, and B10. In addition, B2 (panel room) was included in the measurements. The personnel who worked there

used ear protection and complained about the noise caused by the fans on the electrical panels.

In total, 18 measurements point are selected in order to display adequately the noise profile of the selected workplaces of the plant.

(ii) Individual noise exposure measurements

During the sound walk and work analysis, it was observed that there are differences in the noise exposures of the workers even if they belong to the same team. It was, therefore, decided to use dosimeters in order to assess the self-exposure of the workers. As mentioned previously, there were mainly four teams in the plant, namely HSE, MT, OT and ST teams. Attachment of dosimeter on the workers was decided to be done on willingness principle. Care has given to involve at least one person from each job group. Lunch period was decided to be not included in dosimeter measurements.

CHAPTER VI

NOISE & DOSE MEASUREMENTS

6.1. Introduction

In this chapter, data, obtained from the sound level measurements, carried out at the points determined during the sound walk mentioned in the previous chapter, are presented. The buildings as described in the previous chapter were chosen according to the average noise level ratings of the workers. Those rated in the questionnaires as 2,5 or above out of 5,0 (according to the results of Noise Level Verbal Ratings, NL-VR's), that is, the buildings B3, B4, B5, B8, B10, were decided to be the buildings in which the measurements have to be done.

In addition to these buildings stated in the previous paragraph, measurements were also taken inside the panel room (that is in B2 building). The personnel working there had a complaint about the continuous noise caused by the fans on the electrical panels and because of which he was forced to use ear protection while working.

Besides, dosimeter was attached to 28 personnel in order to determine their self-exposures within a day.

6.2. Noise Level Measurements

Before starting the measurements, some rules have to be followed in the plant. First, permissions were taken from the station authority.

Safety trainings were then given to the people, who will fulfil the measurements in the plant, before entering into the site so that they are aware of the risks present intrinsically in the oil industry.

After the completion of the calibration of the equipment, measurements were done in the buildings predetermined based on NL-VR's results. During the measurements a site operator (which is a rule in the plant), was always around.

The operational limitations applied in the plant were naturally respected. For example, taking photographs in the red-zone area were not allowed. Therefore, in this thesis, there are no photographs taken at the site.

The measurements were performed by (Type 1) Sound Level Meter "B & K 2260 Investigator". The measurement equipment consisted of a sound level meter and tripod. The setup was as follows:

Elapsed time	either 2 minutes or 10 minutes
Time weighting	Fast
Frequency Weighting	A or L or C
Spectrum	1/3 octave band

Measurement points are shown on the layout of the buildings. During measurements, the height of the microphone of the sound level meter (according to ISO 9612 **[29]**, which has to be the approximately at the level of the human ear from the ground) is adjusted to 1,55 meters from the ground for the employees who are standing, and to 0,91 meters for the ones who are sitting or squatting.

Totally, at 18 points noise levels were determined at the end of the measurements in six buildings. The distribution of these 18 points is as follows;

2 points in B2 panel room, 2 points in B3, 7 points in B4, 4 points in B5, 2 points in B8 and 1 point in B10, respectively.

At the above-mentioned points, totally 212 measurements were done. Due to the operational requirements, the conditions of the measurements were not always the same. Changes inevitably occur, when the set of active pumps

and flow rates of the oil change and when energy cut-offs cannot be avoided.

Noise level measurements, by sound (or noise) level meter, were done essentially to display the spectral characteristics of the ambient noise in each building.

Buildings will be presented in alphabetical order not in the order of measurements.

The circle filled with blue colour in the layouts stands for the location of noise level meter (NL Meter).

6.2.1. Building B2

The first building where measurements are done is B2 in which the panel room is especially important for us due to the existence of electrical panels (on which there are ventilation fans for cooling the heat generated by these panels). 2 points selected, in B2 panel room, for noise measurements are shown on the layout of the panel room in B2 given in Fig. 6-1.

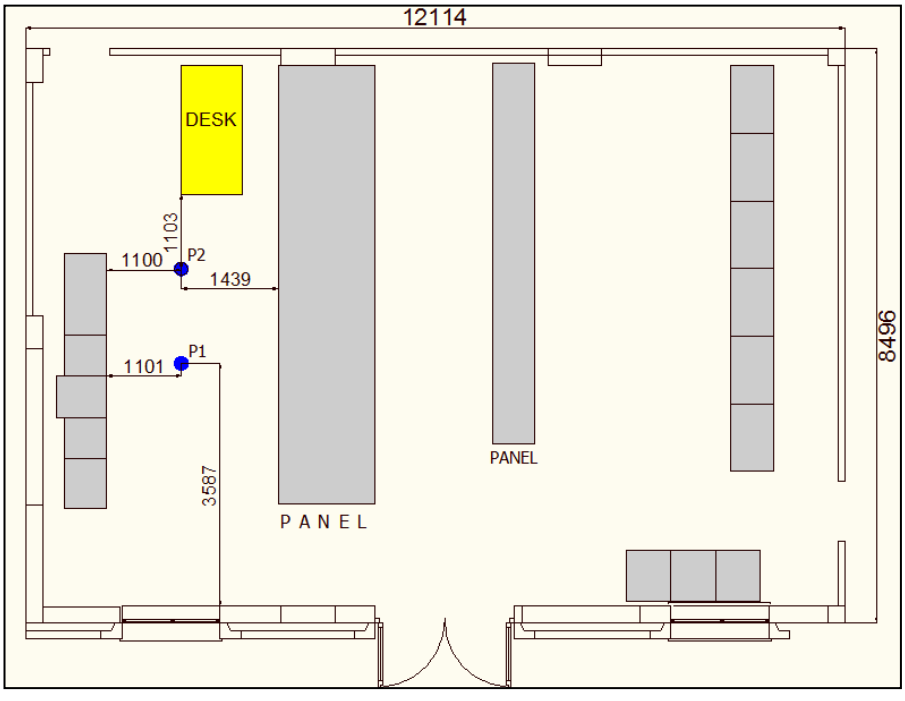

Fig. 6-1 Layout drawing of the panel room in B2 (Dimensions in mm)

The sound level meter at point 1 and at point 2 served to determine respectively the noise exposure of the person working on his feet, and seated at his desk.

(i) Point P1

The first point at which the noise measurements were done was 1, 10 meters away from the electrical panels on which there are small ventilation fans and 1, 44 meters away from the other electrical panel located on the opposite side.

In B2 panel room, the height of noise level meter was adjusted to 1,55 meters from the ground level, for the person who works by standing on his feet, at point 1, P1. 11 measurements were carried out at this point, six of which were A weighted measurements and five of which were L (un-weighted) weighted. The means and standard deviations of them were calculated for each parameter and tabulated below in Table 6-1. "N" in the table designates the number of measurements.

Table 6-1 Noise Data obtained at P1 in panel room (B2 building)
(Duration of each measurement = 2 minutes)

	L_{Aeq}	L_{Ceq}	L_{Ceq}- L_{Aeq}	L_{AF5}	L_{AF10}	L_{AF50}	L_{AF90}	L_{AF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	66,7	72,6	5,9	67,1	66,9	66,5	66,1	66,0	0,7
Std. Deviation	0,08	0,10	0,10	0,10	0,10	0,10	0,10	0,08	0,16

	L_{Aeq}	L_{Leq}	L_{Leq}- L_{Aeq}	L_{LF5}	L_{LF10}	L_{LF50}	L_{LF90}	L_{LF95}	L_{AI}-L_A
N	5	5	5	5	5	5	5	5	5
Mean	66,8	74,6	8,3	75,0	74,4	73,5	72,7	72,5	0,7
Std. Deviation	0,08	1,18	1,56	0,92	0,34	0,21	0,10	0,10	0,14

A, C and L in Table 6-1 indicates the values after A, C and L weightings are applied to the noise data. The average L_{AFmax} and L_{Cpeak} values were respectively 70,9 and 92,1 dB.

L_5, L_{10}, L_{50}, L_{90}, L_{95} are the percentile levels that are used to assess environmental noise. L_n, where n may change from 1 to 99, is that noise level exceeded for n% of the measurement time. L_{AI} is defined as A-weighed, impulse.

As can be seen in the measurement data table given above, the noise level in the room is not too high, but the personnel working in this room has a complaint relevant with the ambient noise. He wears ear protection when he is in the room in order to protect himself from the continuous noise generated by the fans. The spectrum profile corresponding to highest L_{Aeq} associated with point P1 is given below in Fig. 6-2.

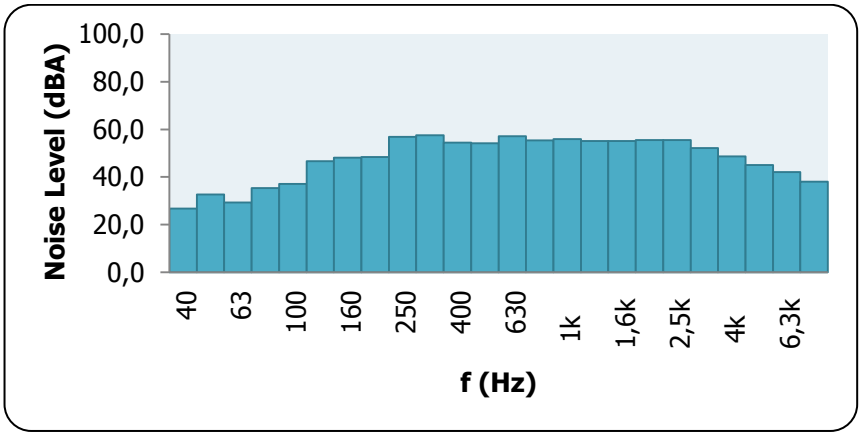

Fig. 6-2 Spectrum profile at P1 of B2 (L_{Aeq} = 66,8 dB)

(ii) Point P2

The purpose of the measurements carried out at this point was to get the noise levels corresponding to the noise exposure of a seated person.

At P2, only un-weighted noise level measurements were done.

In Table 6-2, average of the 10 measurements (duration of each measurement = 2 minutes) done at this point is shown.

Table 6-2 Data obtained at P2 in B2 panel room

	L_{Aeq}	L_{Leq}	L_{Leq}- L_{Aeq}	L_{LF5}	L_{LF10}	L_{LF50}	L_{LF90}	L_{LF95}	L_{AI}-L_A
N	10	10	10	10	10	10	10	10	10
Mean	66,3	74,7	8,4	75,1	73,5	72,6	71,9	71,7	0,7
Std. Deviation	0,28	2,14	2,13	2,30	0,45	0,16	0,10	0,13	0,33

A, L in Table 6-2 indicates the values after A and L weightings are applied to the noise data. The average L_{AFmax} and L_{Apk} values were respectively 71,3 and 85,9 dB.

The spectrum profile corresponding to highest L_{Aeq} associated with point P2 is given below in Fig. 6-3.

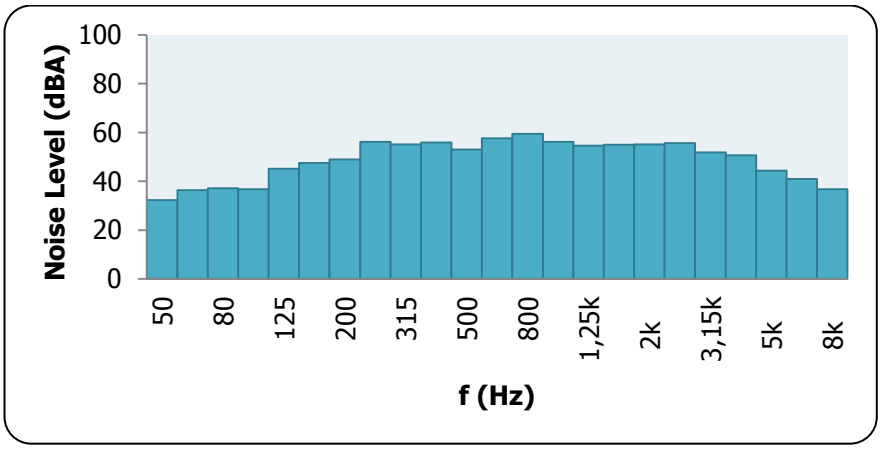

Fig. 6-3 Spectrum profile at P2 of B2 (L_{Aeq} = 67,0 dB)

6.2.2. Building B3

B3 is the building in which the routine, protective and preventive maintenance activities are carried out by the mechanical and electrical team. This building is two-storey building, on the basement of it; there is an office for chief engineers, garage for foam tractors, storage room for chemical substances that are used in the operations, toilets, heating room and depot for the storage of the equipment. Besides, there is an area for performing the maintenance activities such as welding operations, lubrication facilities and reparation of the broken parts of the machines.

The location of the points at which noise level measurements were done is shown in Fig. 6-4.

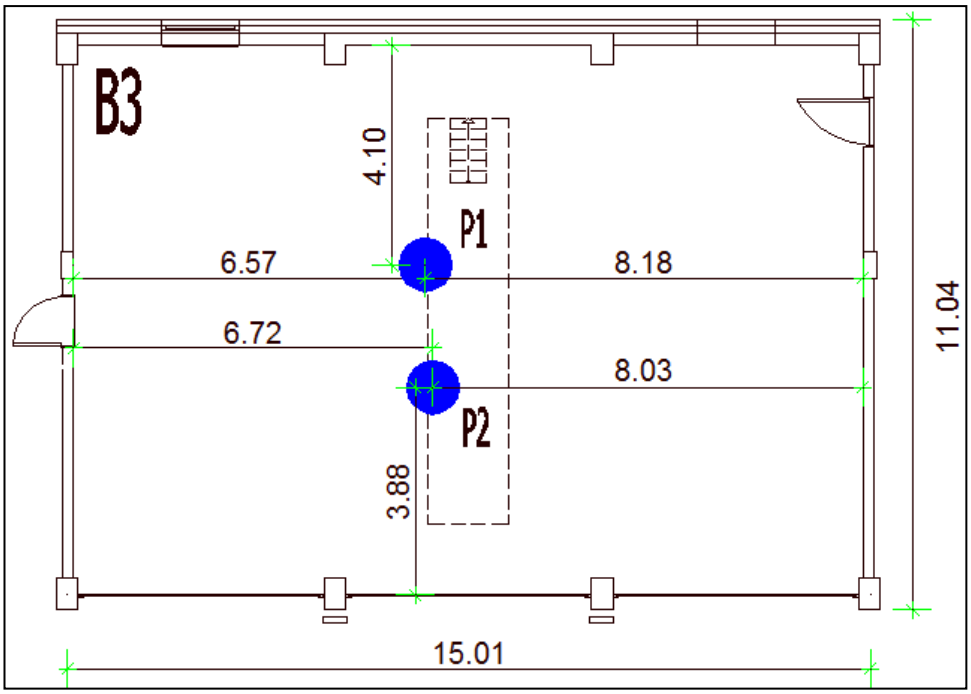

Fig. 6-4 Layout of B3 (Dimensions in meters)

The measurements were performed while seven workers were working in B3. At that time, three pumps out of five were in operation in the plant.

(i) Point 1

At the time of the measurement, the workers who were previously performing a manufacturing job were at break. Consequently, no work has been done and no workers were present in B3 at the time of measurement. In other words, there was no occupational noise in the area except the background noise coming from the pump house through the half-opened door. The data obtained for that point is tabulated below in Table 6-3.

Table 6-3 Data obtained at P1 in B3 (workers at break)

	L_{Aeq}	L_{Ceq}	L_{Ceq}- L_{Aeq}	L_{AF5}	L_{AF10}	L_{AF50}	L_{AF90}	L_{AF95}	L_{AI}-L_A
N	1	1	1	1	1	1	1	1	1
Mean	72,3	81,3	9,00	73,8	72,6	71,2	70,2	69,8	3,3
Std. Deviation	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

	L_{Aeq}	L_{Leq}	L_{Leq}- L_{Aeq}	L_{LF5}	L_{LF10}	L_{LF50}	L_{LF90}	L_{LF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	72,9	83,9	11,0	85,7	85,4	83,6	81,4	80,9	0,4
Std. Deviation	1,63	0,42	1,24	0,33	0,31	0,50	0,58	0,68	0,05

A, C and L in Table 6-3 indicates the values after A, C and L weightings are applied to the noise data. The average L_{AFmax} and L_{Cpeak} values were respectively 87,7 and 102,3 dB.

The spectrum profile corresponding to A-weighted measurements at P1 is given below in Fig. 6-5.

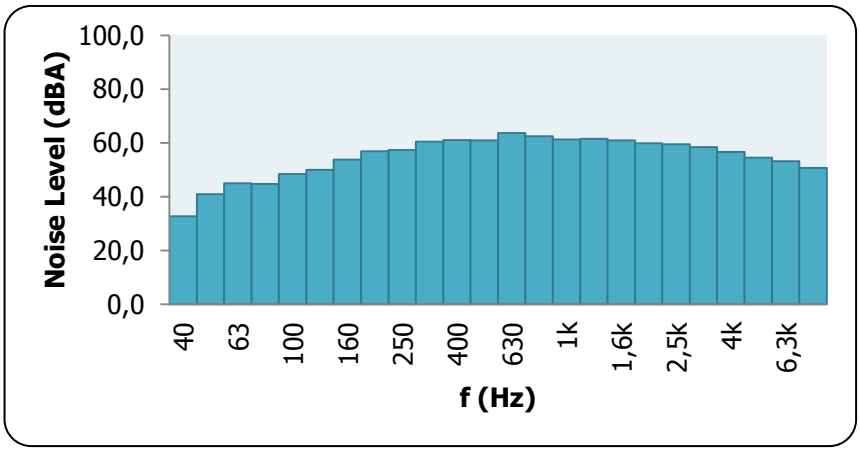

Fig. 6-5 Spectrum profile at P1 in B3 (L_{Aeq} = 72,3 dB)
(Duration of measurement = 2 minutes)

Due to the break given by the workers, it was necessary to repeat the measurements and to get new noise data associated with working conditions. Therefore, new measurements were carried out while the workers were working on their foot and working by crouching or bending separately.

The data tabulated below shows the values when the workers were working on their feet.

Table 6-4 Data obtained at P1 in B3 (workers at work)

	L_{Aeq}	L_{Ceq}	L_{Ceq}- L_{Aeq}	L_{AF5}	L_{AF10}	L_{AF50}	L_{AF90}	L_{AF95}	L_{AI}-L_A
N	3	3	3	3	3	3	3	3	3
Mean	92,8	91,9	0,9	98,9	97,6	83,5	73,5	73,0	2,3
Std. Deviation	3,23	3,34	0,13	4,24	3,11	8,21	2,48	2,37	0,85

	L_{Aeq}	L_{Leq}	L_{Leq}- L_{Aeq}	L_{LF5}	L_{LF10}	L_{LF50}	L_{LF90}	L_{LF95}	L_{AI}-L_A
N	5	5	5	5	5	5	5	5	5
Mean	78,2	84,2	6,1	86,6	85,7	81,3	80,0	79,7	2,2
Std. Deviation	9,18	5,79	3,30	8,54	7,38	0,53	0,27	0,24	1,74

A, C and L in Table 6-4 indicate the values after A, C and L weightings are applied to the noise data and measurement time for each of the measurement was 2 minutes. The average L_{AFmax} and L_{Cpeak} values were respectively 99,8 and 110,5 dB.

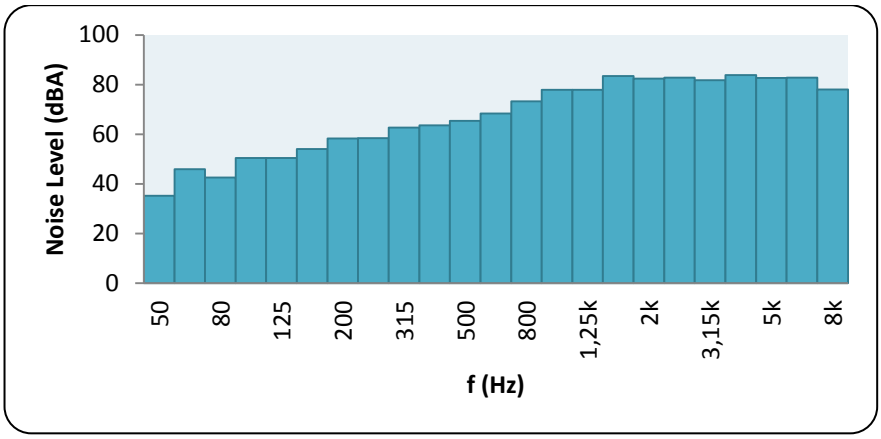

Fig. 6-6 Spectrum profile at P1 in B3 (L_{Aeq} = 92,1 dB)

(ii) Point 2

When workers were working by sitting on their feet or crouching, the height of the sound level meter was adjusted to 0,91 meters from the ground and the measurements were completed accordingly. The data obtained from these measurements are as follows;

Table 6-5 Data obtained at P2 in B3 (duration of each measurement = 2 minutes) (Workers at work)

	L_{Aeq}	L_{Ceq}	L_{Ceq}- L_{Aeq}	L_{AF5}	L_{AF10}	L_{AF50}	L_{AF90}	L_{AF95}	L_{AI}-L_A
N	4	4	4	4	4	4	4	4	4
Mean	73,7	80,4	6,8	75,0	73,6	72,0	71,1	70,9	3,9
Std. Deviation	1,47	0,46	1,06	1,18	0,34	0,00	0,10	0,12	2,70

	L_{Aeq}	L_{Leq}	L_{Leq}- L_{Aeq}	L_{LF5}	L_{LF10}	L_{LF50}	L_{LF90}	L_{LF95}	L_{AI}-L_A
N	5	5	5	5	5	5	5	5	5
Mean	74,4	82,2	7,8	83,8	83,4	81,7	80,2	79,7	3,0
Std. Deviation	1,48	0,30	1,16	0,43	0,33	0,23	0,14	0,11	1,19

A, C and L in Table 6-5 indicates the values after A, C and L weightings are applied to the noise data. The average L_{AFmax} and L_{Cpeak} values were respectively 88,5 and 105,1 dB.

The spectrum profile corresponding to the measurement having highest L_{Aeq} is shown below in Fig. 6-7.

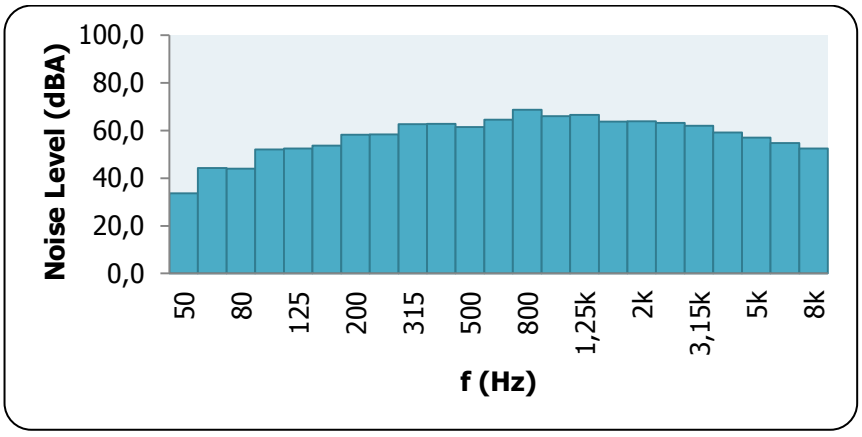

Fig. 6-7 Spectrum profile at P2 in B3 (L_{Aeq} = 75,6 dB)
(Duration of measurement = 2 minutes)

In addition to the several measurements that were performed in a period of 2 minutes, additional measurement of 10 minutes duration was also carried out at point 2. The height of the microphone of the sound level meter was this time at 1,55 meters from the ground. The data and the spectrum belonging to this measurement are as follows;

Table 6-6 Data obtained at P2 in B3 (duration of measurement = 10 minutes)

	L_{Aeq}	L_{Ceq}	L_{Ceq}- L_{Aeq}	L_{AF5}	L_{AF10}	L_{AF50}	L_{AF90}	L_{AF95}	L_{AI}-L_A
N	1	1	1	1	1	1	1	1	1
Mean	76,4	81,3	4,8	78,0	75,0	72,8	71,8	71,6	3,1
Std. Deviation	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

A, and C in Table 6-6 indicate the values after A and C weightings are applied to the noise data. The average L_{AFmax} and L_{Cpeak} values were respectively 94,2 and 107,9dB.

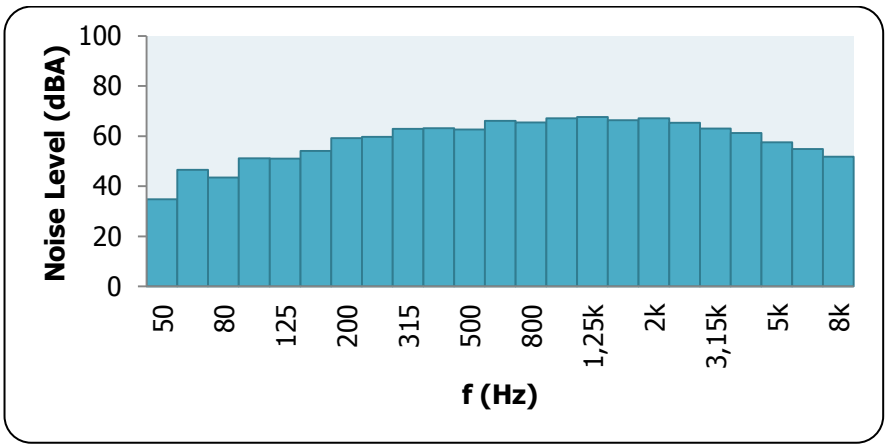

Fig. 6-8 Spectrum profile at P2 in B3 (L_{Aeq} = 76,4 dB)
(Duration of measurement =10 minutes)

6.2.3. Building B4

B4 is the main operation building in which five huge reciprocating pumps are located for pumping the crude oil through the pipeline. These pumps are the main noise sources of the station. The number of active pumps depends upon the operational requirements such as the amount of oil to be drilled at offshore platforms, loading conditions of the marine terminal, planned and unplanned shutdown of the system.

Besides these pumps, cooling fans of every pump are another noise source. They are indispensible for the ventilation of B4 building which otherwise can be very hot due to the heat generated by the pumps.

At the end of preliminary measurements, 7 points have been decided to be enough for describing the noise climate inside the B4 building.

(i) Point P1

The first point, P1, was at the middle of the staircase located on the discharge side of the pump 1 shown in Fig. 6-9.

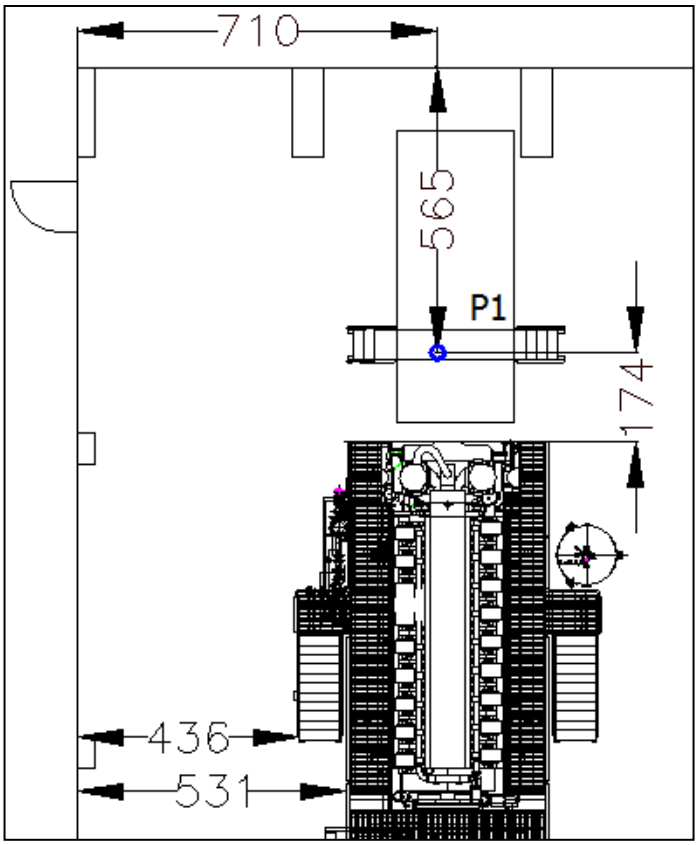

Fig. 6-9 Layout of Point 1 in B4 (dimensions in mm)

At that point, totally 12 measurements were carried out, and the results are given in Table 6-7.

Table 6-7 Data obtained at P1 in B4 (duration of each measurement = 2 minutes)

	L_{Aeq}	L_{Ceq}	L_{Ceq}- L_{Aeq}	L_{AF5}	L_{AF10}	L_{AF50}	L_{AF90}	L_{AF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	97,5	100,6	3,0	97,8	97,7	97,4	97,2	97,0	0,3
Std. Deviation	0,05	0,10	0,04	0,00	0,11	0,08	0,08	0,08	0,00

	L_{Aeq}	L_{Leq}	L_{Leq}- L_{Aeq}	L_{LF5}	L_{LF10}	L_{LF50}	L_{LF90}	L_{LF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	97,6	100,9	3,4	101,5	101,4	100,8	100,2	100,1	0,3
Std. Deviation	0,05	0,05	0,04	0,10	0,00	0,00	0,00	0,10	0,00

A, C and L in Table 6-7 indicates the values after A, C and L weightings are applied to the noise data. The average L_{AFmax} and L_{Cpeak} values were respectively 98,3 and 114,6 dB.

The spectrum profile corresponding to the measurement having the highest L_{Aeq} is shown in the below graph;

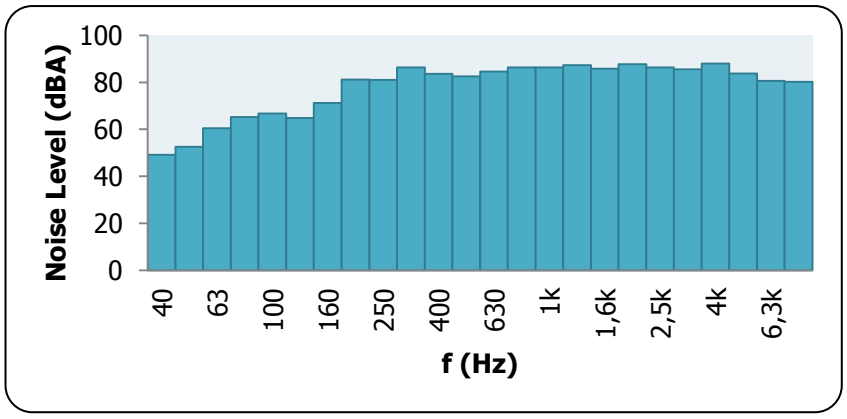

Fig. 6-10 Spectrum profile at P1 in B4 (L_{Aeq} = 97,6 dB)

(ii) Point P2

This time the sound level meter was placed on top of the ladder used to climb up the pump at the right side of pump 1.

The height of this point was approximately 2 meters from the ground level of B4. The location of P2 is shown in Fig. 6-11.

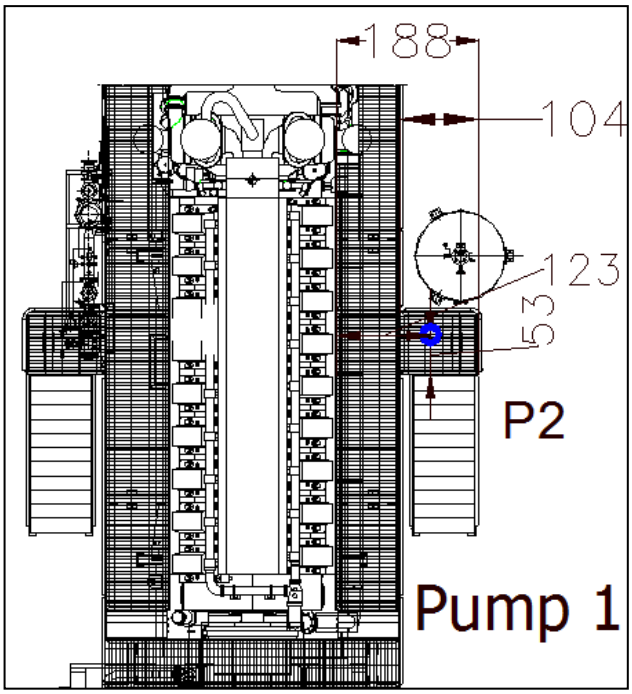

Fig. 6-11 Layout of Point 2 in B4 (dimensions in mm)

The results of 12 measurements are tabulated in Table 6-8.

Table 6-8 Data obtained at P1 in B4 (duration of each measurement = 2 minutes)

	L_{Aeq}	L_{Ceq}	L_{Ceq}- L_{Aeq}	L_{AF5}	L_{AF10}	L_{AF50}	L_{AF90}	L_{AF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	98,1	100,3	2,3	98,3	98,2	98,0	97,8	97,7	0,3
Std. Deviation	0,00	0,05	0,05	0,11	0,00	0,00	0,00	0,10	0,00

	L_{Aeq}	L_{Leq}	L_{Leq}- L_{Aeq}	L_{LF5}	L_{LF10}	L_{LF50}	L_{LF90}	L_{LF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	98,0	100,7	2,7	101,2	101,1	100,6	100,2	100,0	0,3
Std. Deviation	0,08	0,05	0,05	0,08	0,11	0,00	0,00	0,00	0,04

A, C and L in Table 6-8 indicate the values after A, C and L weightings are applied to the noise data. The average L_{AFmax} and L_{Cpeak} values were respectively 98,9 and 114,5 dB.

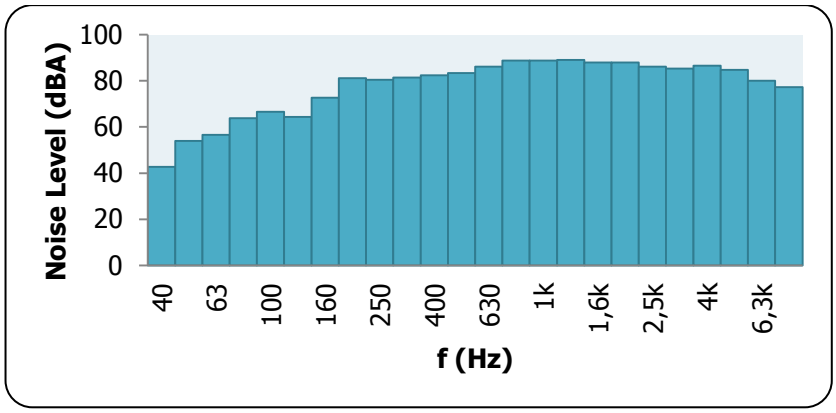

Fig. 6-12 Spectrum profile at P2 in B4 (L_{Aeq} = 98,1 dB)

As usual, the spectrum given in Figure 6-12 belongs to the measurement having the highest L_{Aeq}.

(iii) Point P3

Similar to P1, Point 3 was chosen at the discharge part of Pump 2. Figure 6-13 displays the spectrum corresponding to the measurements done at point 3.

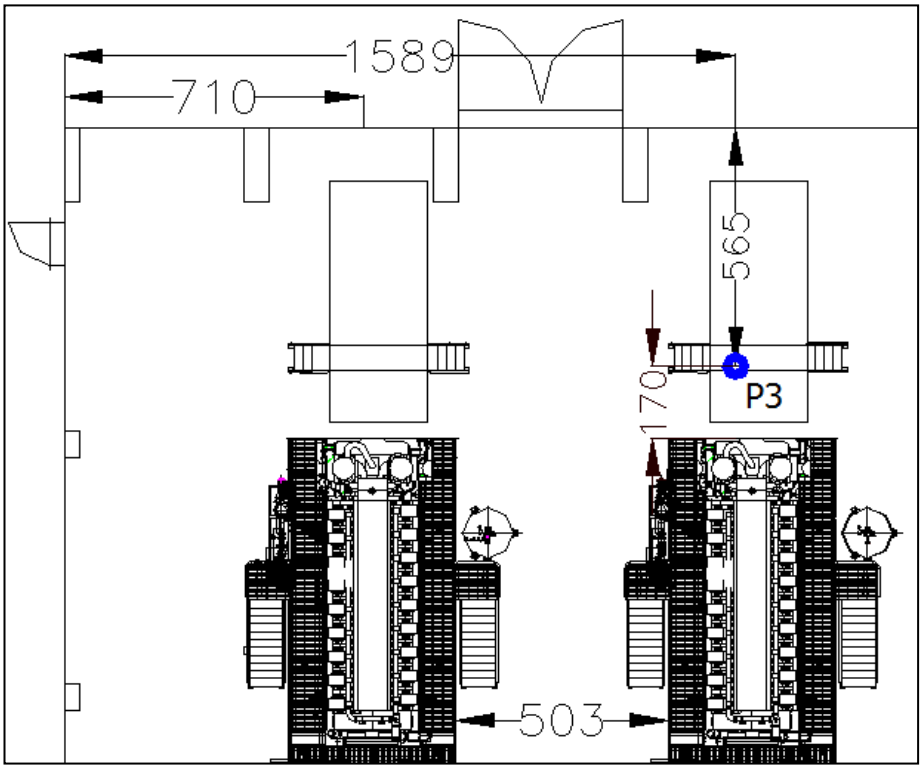

Fig. 6-13 Layout of Point 3 in B4 (dimensions in mm)

Data belonging to Point 3 is tabulated in Table 6-9.

Table 6-9 Data obtained at P3 in B4 (duration of each measurement = 2 minutes)

	L_{Aeq}	L_{Ceq}	L_{Ceq}- L_{Aeq}	L_{AF5}	L_{AF10}	L_{AF50}	L_{AF90}	L_{AF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	99,9	105,7	5,8	100,5	100,3	99,8	99,2	99,1	0,3
Std. Deviation	0,11	0,30	0,20	0,16	0,10	0,08	0,08	0,10	0,00

	L_{Aeq}	L_{Leq}	L_{Leq}- L_{Aeq}	L_{LF5}	L_{LF10}	L_{LF50}	L_{LF90}	L_{LF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	99,9	105,7	5,9	107,4	106,9	105,4	104,0	103,6	0,3
Std. Deviation	0,08	0,37	0,33	0,39	0,43	0,37	0,28	0,27	0,00

A, C and L in Table 6-9 indicate the values after A, C and L weightings are applied to the noise data. The average L_{AFmax} and L_{Cpeak} values were respectively 101,3 and 118,2 dB.

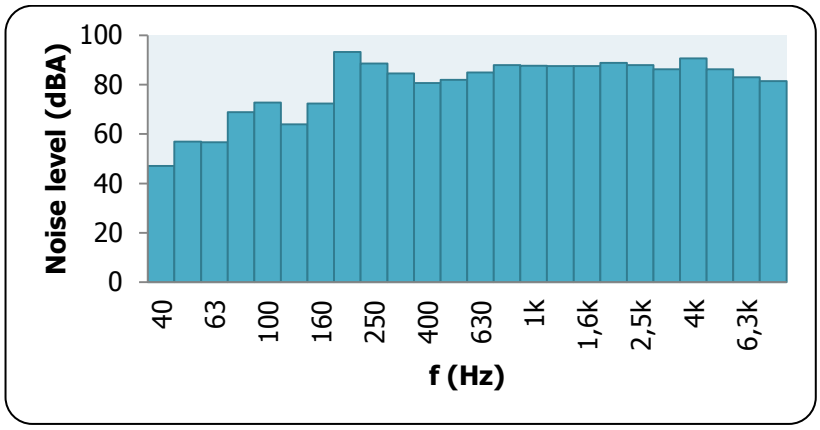

Fig. 6-14 Spectrum profile at P3 in B4 (L_{Aeq} = 100,0 dB)

In Fig. 6-14, spectrum of the measurement having the highest L_{Aeq} is displayed.

(iv) Point P4

The measurement point P4 was at the middle of the distance between pump 2 and pump 3. The layout of P4 is shown in Fig. 6-15.

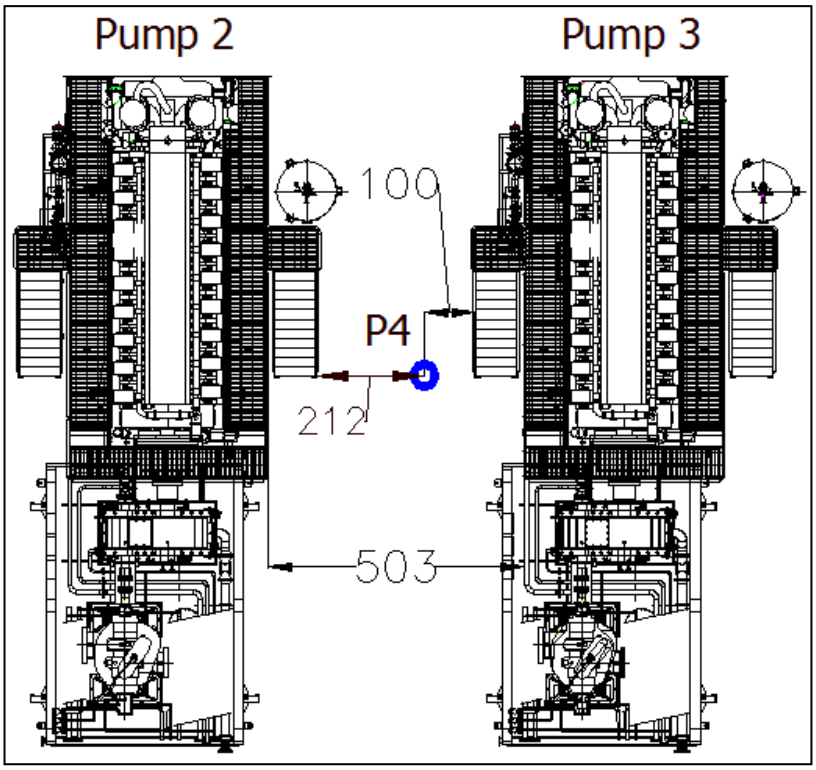

Fig. 6-15 Layout of Point 4 in B4 (dimensions in mm)

The data obtained at that point is given in Table 6-10.

Table 6-10 Data obtained at P4 in B4 (duration of each measurement = 2 minutes)

	L_{Aeq}	L_{Ceq}	L_{Ceq}- L_{Aeq}	L_{AF5}	L_{AF10}	L_{AF50}	L_{AF90}	L_{AF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	98,5	101,8	3,4	98,8	98,8	98,4	97,9	97,8	0,4
Std. Deviation	0,08	0,10	0,08	0,08	0,08	0,15	0,16	0,13	0,05

	L_{Aeq}	L_{Leq}	L_{Leq}- L_{Aeq}	L_{LF5}	L_{LF10}	L_{LF50}	L_{LF90}	L_{LF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	98,6	102,2	3,6	102,8	102,6	102,1	101,5	101,3	0,4
Std. Deviation	0,08	0,10	0,10	0,08	0,08	0,11	0,16	0,17	0,00

A, C and L in Table 6-10 indicate the values after A, C and L weightings are applied to the noise data. The average L_{AFmax} and L_{Cpeak} values were respectively 99,6 and 115,4 dB.

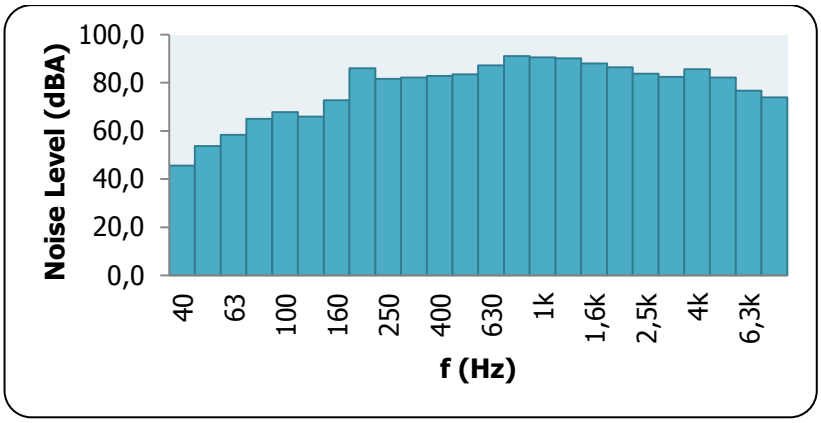

Fig. 6-16 Spectrum profile at P4 in B4 (L_{Aeq} = 98,6 dB)

(v) Point P5

Measurement point 5 was selected, like P4, between pumps 2 and 3. However, this time the sound lever meter was placed in the middle of the suction head of these pumps.

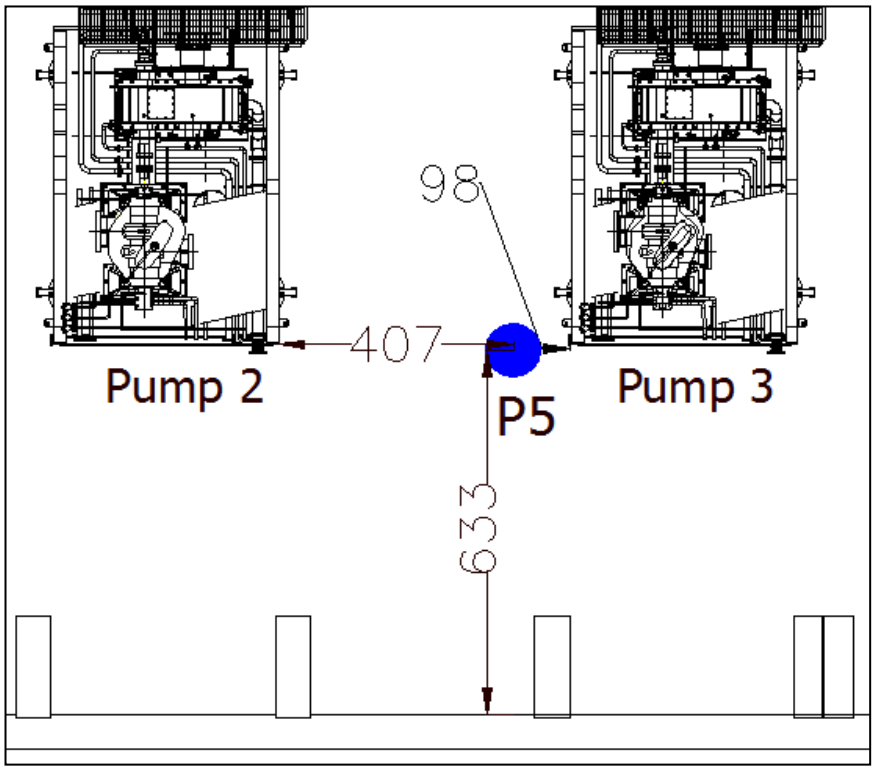

Fig. 6-17 Layout of Point 5 in B4 (dimensions in mm)

Table 6-11 shows the data obtained for point 5.

Table 6-11 Data obtained at P5 in B4 (duration of each measurement = 2 minutes)

	L_{Aeq}	L_{Ceq}	L_{Ceq}- L_{Aeq}	L_{AF5}	L_{AF10}	L_{AF50}	L_{AF90}	L_{AF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	93,0	96,7	3,7	93,6	93,4	92,9	92,4	92,2	0,4
Std. Deviation	0,08	0,10	0,08	0,08	0,08	0,11	0,18	0,18	0,00

	L_{Aeq}	L_{Leq}	L_{Leq}- L_{Aeq}	L_{LF5}	L_{LF10}	L_{LF50}	L_{LF90}	L_{LF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	92,8	96,9	4,1	97,7	97,5	96,7	95,9	95,7	0,4
Std. Deviation	0,18	0,16	0,12	0,21	0,16	0,21	0,21	0,21	0,00

A, C and L in Table 6-11 indicate the values after A, C and L weightings are applied to the noise data. The average L_{AFmax} and L_{Cpeak} values were respectively 94,3 and 110,8 dB.

The spectrum profile of the measurement having highest L_{Aeq} is given in Figure 6-18.

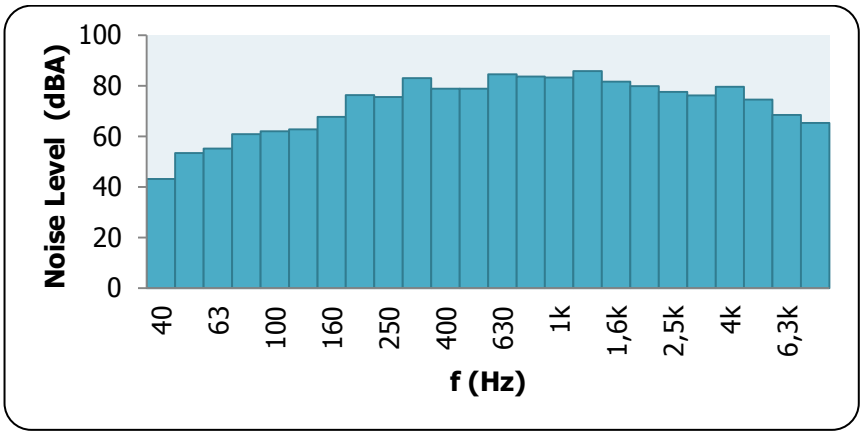

Fig. 6-18 Spectrum profile at P5 in B4 (L_{Aeq} = 93,1 dB)

(vi) Point P6

P6 was selected at the middle point of the suction heads of pumps 4 and 5. At the measurement time, Pump 4 and 5 were inactive.

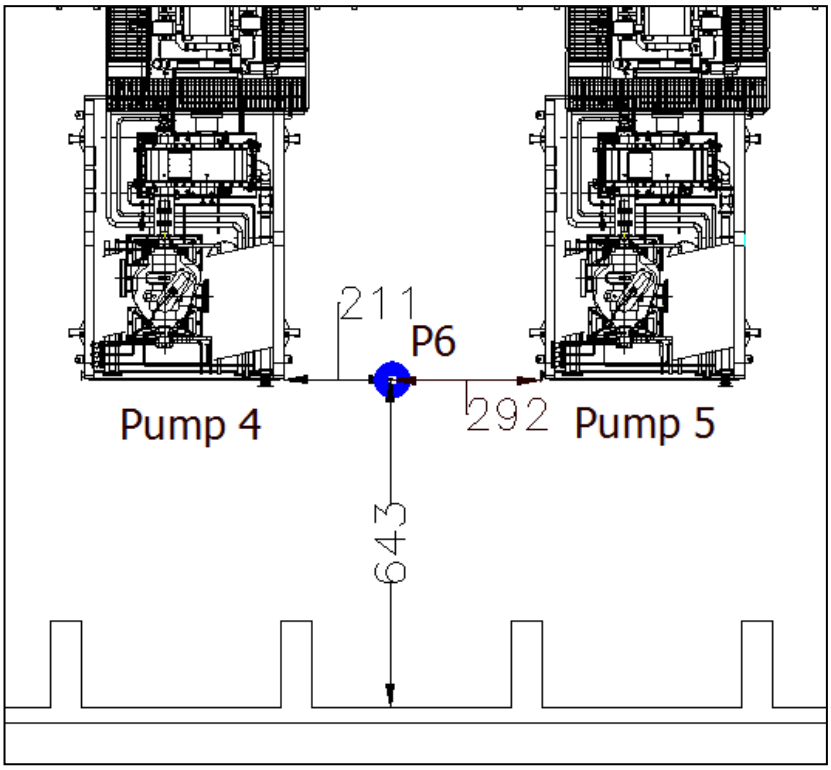

Fig. 6-19 Layout of Point 6 in B4 (dimensions in mm)

The data belonging to P6 is depicted in Table 6-12.

Table 6-12 Data obtained at P6 in B4 (duration of each measurement = 2 minutes)

	L_{Aeq}	L_{Ceq}	L_{Ceq}- L_{Aeq}	L_{AF5}	L_{AF10}	L_{AF50}	L_{AF90}	L_{AF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	87,3	93,3	6,0	88,3	88,0	87,1	86,3	86,1	0,4
Std. Deviation	0,30	0,35	0,09	0,45	0,38	0,24	0,24	0,21	0,00

	L_{Aeq}	L_{Leq}	L_{Leq}- L_{Aeq}	L_{LF5}	L_{LF10}	L_{LF50}	L_{LF90}	L_{LF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	87,7	94,3	6,6	95,6	95,4	94,2	92,6	92,2	0,4
Std. Deviation	0,08	0,11	0,05	0,27	0,23	0,08	0,32	0,31	0,00

A, C and L in Table 6-12 indicate the values after A, C and L weightings are applied to the noise data. The average L_{AFmax} and L_{Cpeak} values were respectively 89,1 and 106,9 dB.

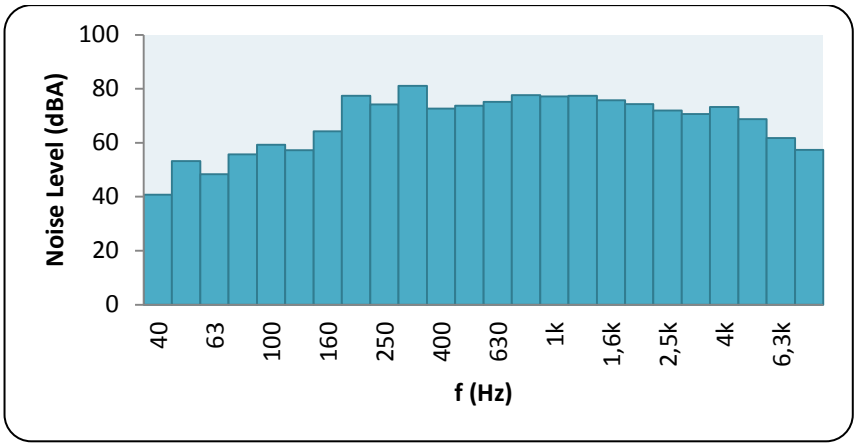

Fig. 6-20 Spectrum profile at P6 in B4 (L_{Aeq} = 87,6 dB)

Spectrum displayed in Figure 6-20 belongs to the measurement having the highest L_{Aeq} value.

(vii) Point P7

The measurement point was between pump 5 and the wall of B4. The exact coordinates of P7 can be found from Fig. 6-21.

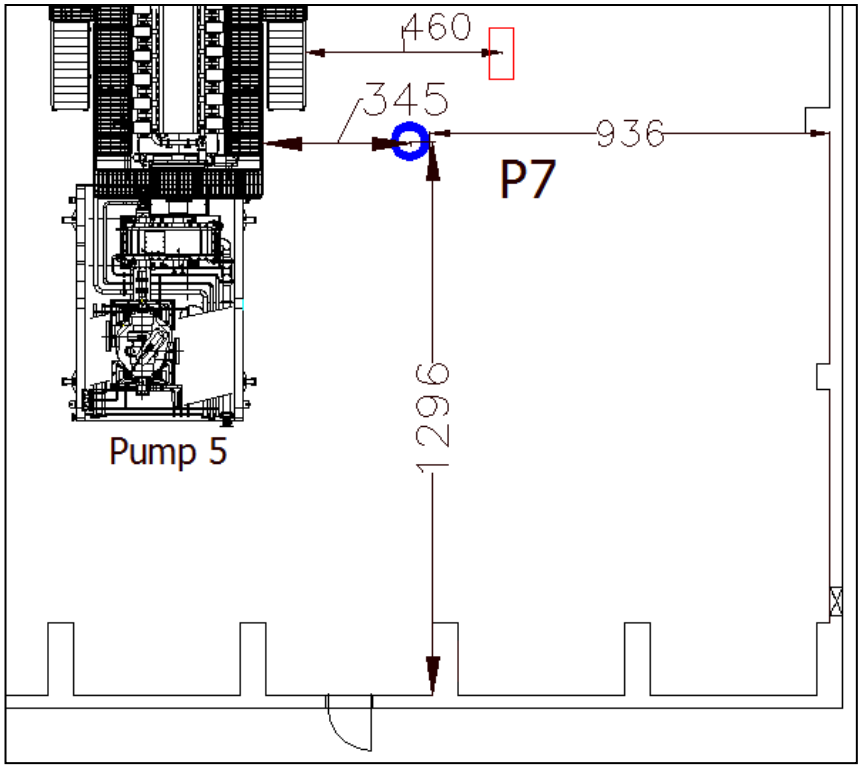

Fig. 6-21 Layout of Point 7 in B4 (dimensions in mm)

The data obtained at P7 is tabulated below in Table 6-13.

Table 6-13 Data obtained at P7 in B4 (duration of each measurement = 2 minutes)

	L_{Aeq}	L_{Ceq}	L_{Ceq}- L_{Aeq}	L_{AF5}	L_{AF10}	L_{AF50}	L_{AF90}	L_{AF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	82,5	89,3	6,8	83,5	83,2	82,3	81,5	81,3	0,4
Std. Deviation	0,08	0,14	0,14	0,16	0,08	0,10	0,10	0,10	0,04

	L_{Aeq}	L_{Leq}	L_{Leq}- L_{Aeq}	L_{LF5}	L_{LF10}	L_{LF50}	L_{LF90}	L_{LF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	82,7	91,4	8,7	93,2	92,8	91,2	89,3	89,3	0,4
Std. Deviation	0,16	0,37	0,32	0,39	0,38	0,41	0,37	0,21	0,04

A, C and L in Table 6-13 indicate the values after A, C and L weightings are applied to the noise data.

The average L_{AFmax} and L_{Cpeak} values were respectively 84,5 and 103,2 dB.

The spectrum profile of the measurement having the highest L_{Aeq} is presented in the below graph.

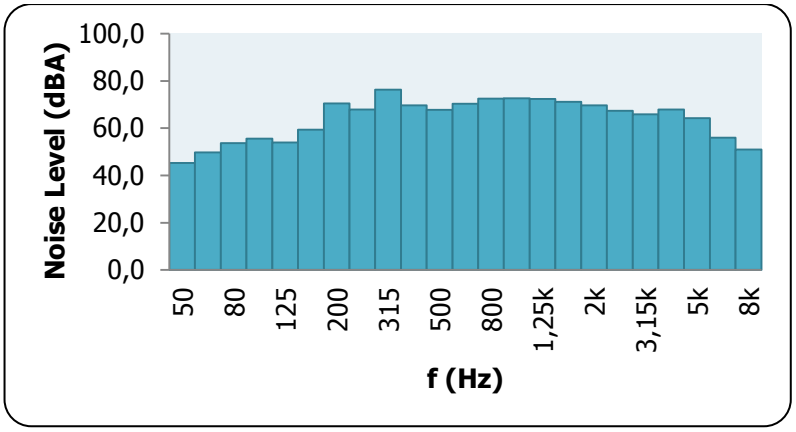

Fig. 6-22 Spectrum profile at P7 in B4 (L_{Aeq} = 82,6 dB)

6.2.4. Building B5

B5 is the building occupied by the metering unit which is responsible from the control of the amount of oil passing through the pipeline. There are also

some piping systems and valves inside the building causing considerable noise.

(i) Point P1

Point P1 in B5 was near the pressure control valve (PCV). Depending on the operational conditions this valve sometimes works, sometimes does not work. When backpressure balance is needed, this valve is run, and at that time noise occurs in the environment.

The location of P1 is depicted in Figure 6-23 given below.

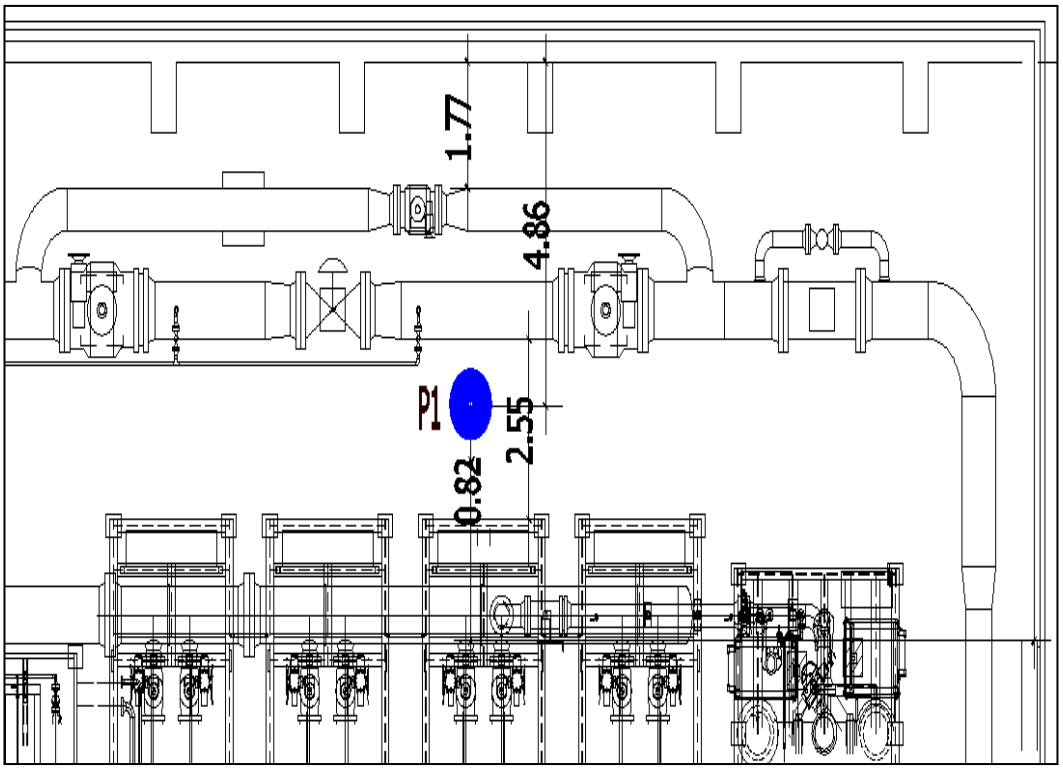

Fig. 6-23 Location of Point 1 in B5 (Dimensions in meters)

In total, 12 measurements were done at this point. The average values of the measurements performed at point 1 in B5 are given in Table 6-14.

Table 6-14 Data obtained at P1 in B5 (duration of each measurement = 2 minutes)

	L_{Aeq}	L_{Ceq}	L_{Ceq}- L_{Aeq}	L_{AF5}	L_{AF10}	L_{AF50}	L_{AF90}	L_{AF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	81,8	85,1	3,4	82,8	82,5	81,4	80,9	80,8	0,6
Std. Deviation	1,13	1,20	0,15	1,88	1,73	1,05	0,99	1,01	0,25

	L_{Aeq}	L_{Leq}	L_{Leq}- L_{Aeq}	L_{LF5}	L_{LF10}	L_{LF50}	L_{LF90}	L_{LF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	81,1	85,2	4,1	86,2	86,0	84,9	84,2	84,0	0,6
Std. Deviation	1,30	1,37	0,13	1,51	1,49	1,34	1,39	1,38	0,21

A, C and L in Table 6-14 indicate the values after A, C and L weightings are applied to the noise data.

The average L_{AFmax} and L_{Cpeak} values were respectively 84,0 and 99,4 dB.

The spectrum profile corresponding to the measurement having the highest L_{Aeq} is given below.

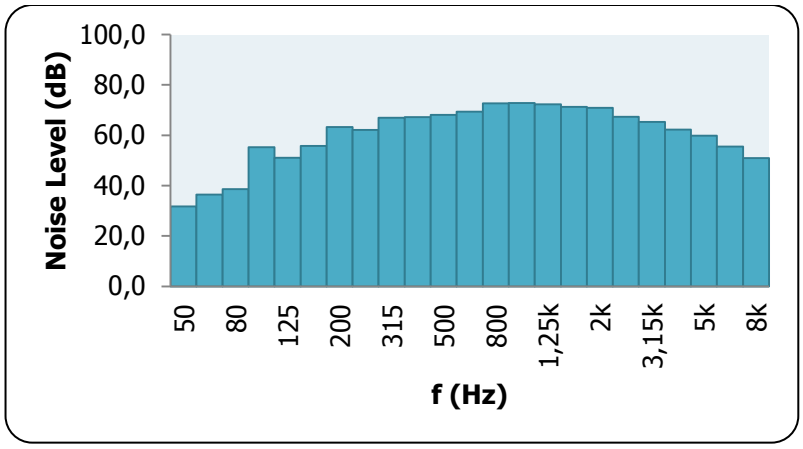

Fig. 6-24 Spectrum profile at P1 in B5 (L_{Aeq} = 83,6 dB)

In addition to 2 minutes measurements, 10 minutes measurements were also taken at point 1.

The mean of the data obtained after the measurements were calculated and are summarized as follows;

Table 6-15 Data obtained at P1 in B5 (for 10 minutes measurements)

	L_{Aeq}	L_{Ceq}	L_{Ceq}- L_{Aeq}	L_{AF5}	L_{AF10}	L_{AF50}	L_{AF90}	L_{AF95}	L_{AI}-L_A
N	1	1	1	1	1	1	1	1	1
Mean	81,2	84,0	2,8	81,6	81,4	81,0	80,6	80,6	0,4
Std. Deviation	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

	L_{Aeq}	L_{Leq}	L_{Leq}- L_{Aeq}	L_{LF5}	L_{LF10}	L_{LF50}	L_{LF90}	L_{LF95}	L_{AI}-L_A
N	1	1	1	1	1	1	1	1	1
Mean	81,1	84,6	3,4	85,4	85,2	84,4	83,8	83,6	0,4
Std. Deviation	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

A, C and L in Table 6-15 indicate the values after A, C and L weightings are applied to the noise data. The average L_{AFmax} and L_{Cpeak} values were respectively 82,5 and 98,3 dB.

(ii) Point P2

The location of point P2 was chosen near the metering unit as seen in the layout given in Figure 6-25.

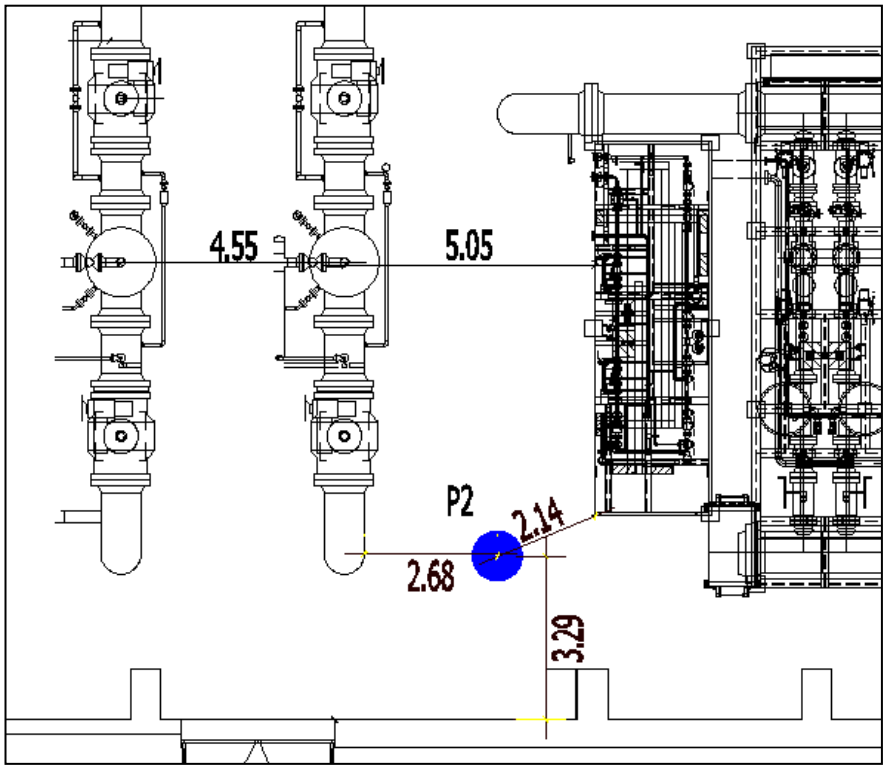

Fig. 6-25 Layout drawing of point 2 in B5 (Dimensions in meters)

The average of the data obtained from the measurements at P2 is summarized and tabulated in Table 6-16.

Table 6-16 Data obtained at P1 in B5 (duration of each measurement = 2 minutes)

	L_{Aeq}	L_{Ceq}	L_{Ceq}- L_{Aeq}	L_{AF5}	L_{AF10}	L_{AF50}	L_{AF90}	L_{AF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	76,3	81,8	5,5	76,9	76,7	76,2	75,7	75,6	0,5
Std. Deviation	0,05	0,15	0,16	0,10	0,11	0,08	0,10	0,08	0,05

	L_{Aeq}	L_{Leq}	L_{Leq}- L_{Aeq}	L_{LF5}	L_{LF10}	L_{LF50}	L_{LF90}	L_{LF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	81,9	86,8	4,9	88,9	88,2	86,2	85,1	84,1	1,2
Std. Deviation	4,27	3,33	1,09	2,93	3,48	3,74	3,80	3,42	0,45

A, C and L in Table 6-16 indicate the values after A, C and L weightings are applied to the noise data.

The average L_{AFmax} and L_{Cpeak} values were respectively 77,9 and 95,5 dB.

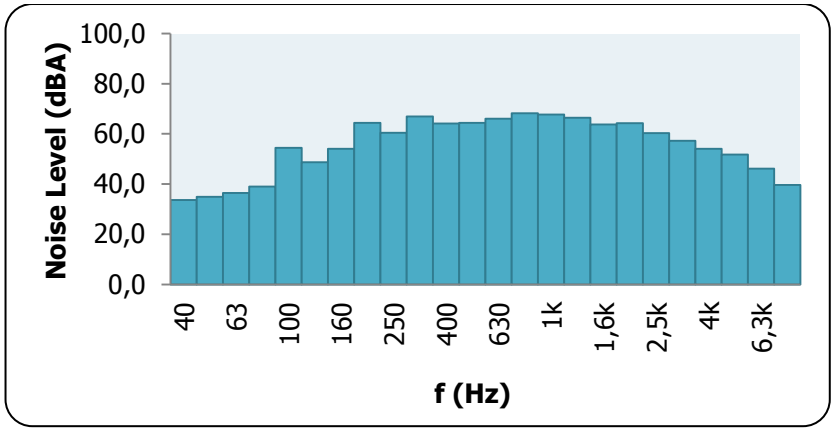

Fig. 6-26 Spectrum profile at P2 in B5 (L_{Aeq} = 76,3 dB)

(iii) Point P3

The exact location of point P3 is shown on the layout given below.

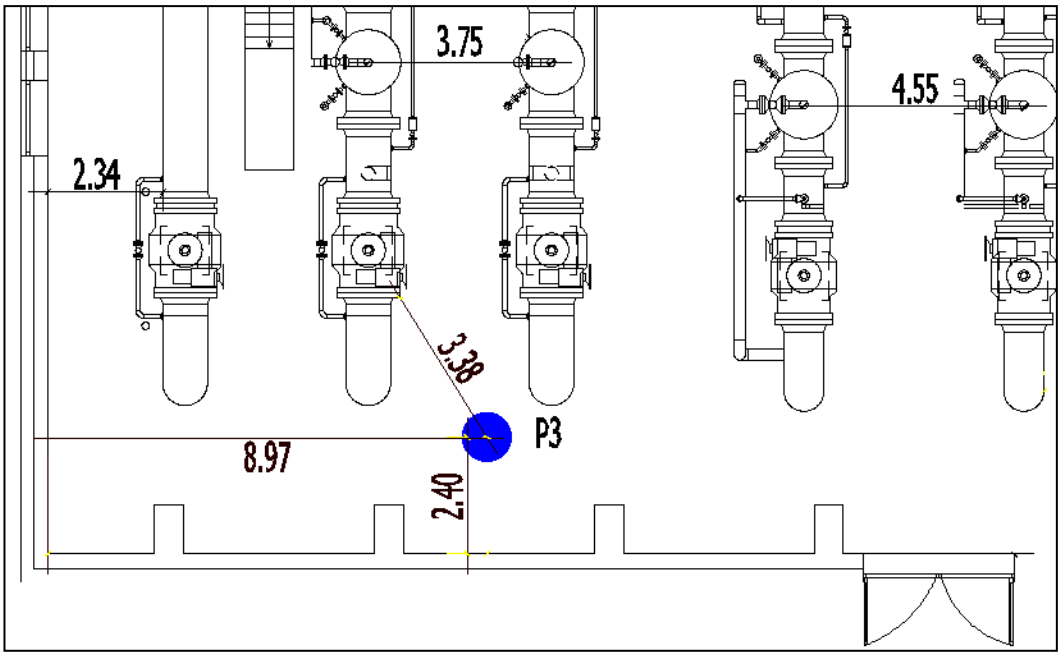

Fig. 6-27 Layout drawing of Point 3 in B5

The data of the measured noise levels are tabulated in Table 6-17.

Table 6-17 Data obtained at P3 in B5 (duration of each measurement = 2 minutes)

	L_{Aeq}	L_{Ceq}	L_{Ceq}- L_{Aeq}	L_{AF5}	L_{AF10}	L_{AF50}	L_{AF90}	L_{AF95}	L_{AI}-L_A
N	7	7	7	7	7	7	7	7	7
Mean	74,1	81,6	7,5	75,3	74,9	73,9	73,1	72,9	0,6
Std. Deviation	0,19	0,26	0,13	0,28	0,19	0,16	0,10	0,11	0,00

	L_{Aeq}	L_{Leq}	L_{Leq}- L_{Aeq}	L_{LF5}	L_{LF10}	L_{LF50}	L_{LF90}	L_{LF95}	L_{AI}-L_A
N	7	7	7	7	7	7	7	7	7
Mean	73,9	82,2	8,4	84,0	83,6	81,9	80,5	80,1	0,6
Std. Deviation	0,15	0,23	0,11	0,31	0,35	0,23	0,23	0,25	0,08

A, C and L in Table 6-17 indicate the values after A, C and L weightings are applied to the noise data.

The average L_{AFmax} and L_{Cpeak} values were respectively 76,9 and 95,5 dB.

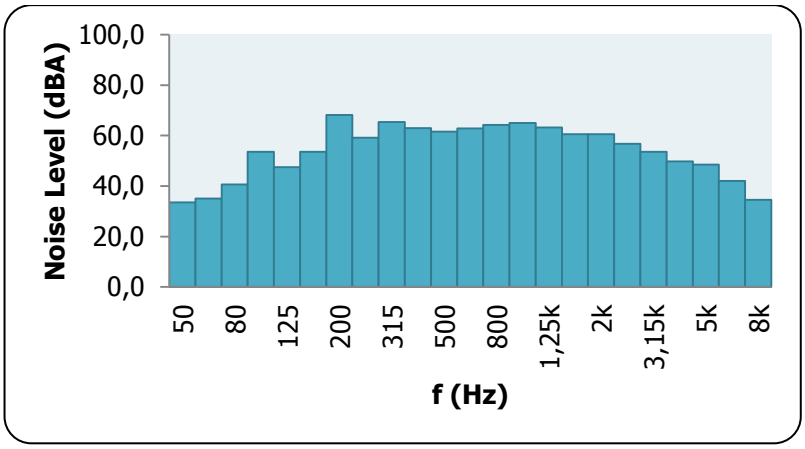

Fig. 6-28 Spectrum profile at P3 in B5 (L_{Aeq} = 74,4 dB)

Low frequency dominant spectrum associated with the measurement having the highest L_{Aeq} is given in Figure 6-28.

(iv) Point P4

The fourth point in B4 was chosen near the last metering unit (Fig. 6-29).

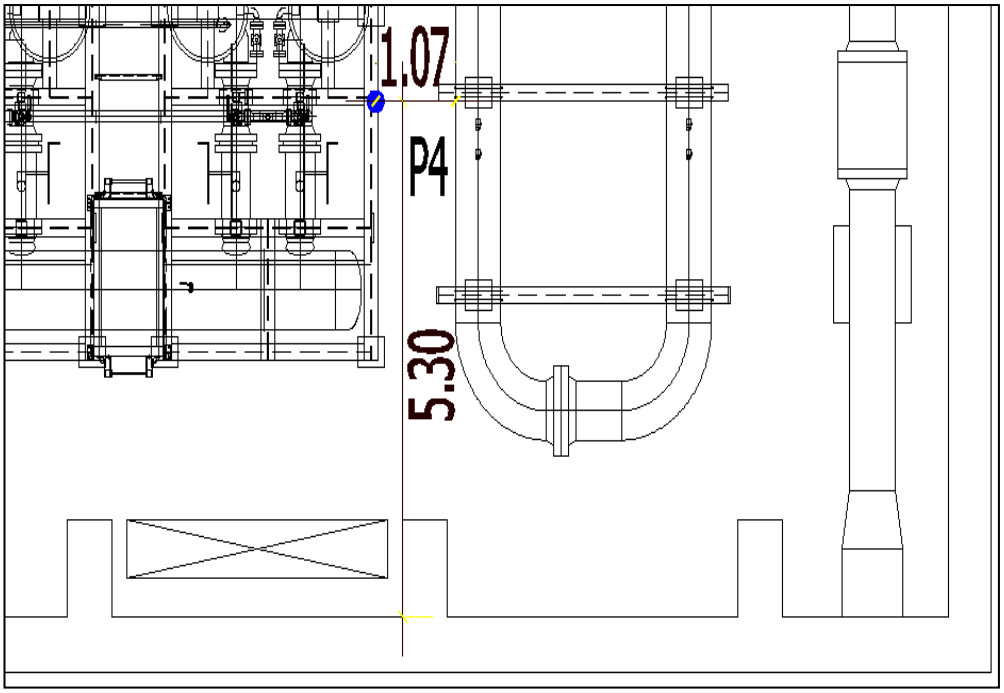

Fig. 6-29 Layout drawing of Point 4 in B5 (Dimensions in meters)

The data obtained at this point is given in Table 6-18.

Table 6-18 Data obtained at P4 in B5 (duration of each measurement = 2 minutes)

	L_{Aeq}	L_{Ceq}	L_{Ceq}- L_{Aeq}	L_{AF5}	L_{AF10}	L_{AF50}	L_{AF90}	L_{AF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	75,9	79,9	4,0	76,3	76,1	75,7	75,4	75,3	0,5
Std. Deviation	0,08	0,08	0,04	0,11	0,10	0,11	0,08	0,10	0,00

	L_{Aeq}	L_{Leq}	L_{Leq}- L_{Aeq}	L_{LF5}	L_{LF10}	L_{LF50}	L_{LF90}	L_{LF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	75,8	81,4	5,6	82,5	82,3	81,2	80,2	80,0	0,5
Std. Deviation	0,05	0,15	0,18	0,17	0,24	0,15	0,15	0,08	0,00

A, C and L in Table 6-18 indicates the values after A, C and L weightings are applied to the noise data. The average L_{AFmax} and L_{Cpeak} values were respectively 77,1 and 93,9 dB.

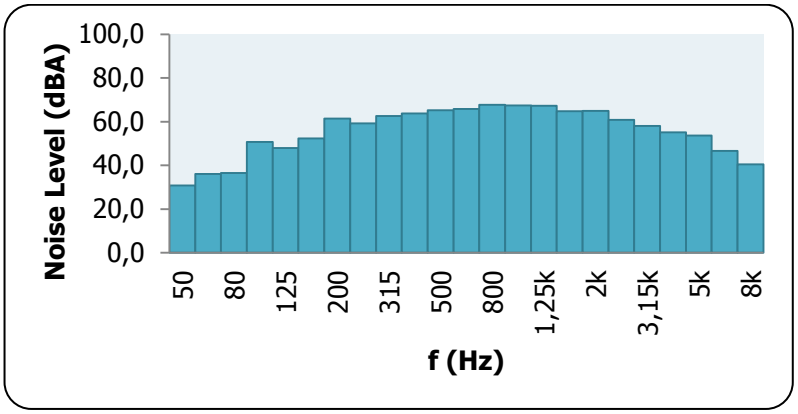

Fig. 6-30 Spectrum profile at P4 in B5 (L_{Aeq} = 76,0 dB)

The spectrum associated with the measurement having the highest L_{Aeq} is displayed in Fig. 6-30.

6.2.5. Building B8

B8 is a building consisting of three rooms separated by concrete walls. One of the rooms is an electrical panel room into which only authorized personnel are allowed to enter. The boiler room contains three boilers and the compressor room has two compressors in it. The layout drawing of the boiler room is given in Figure 6-31.

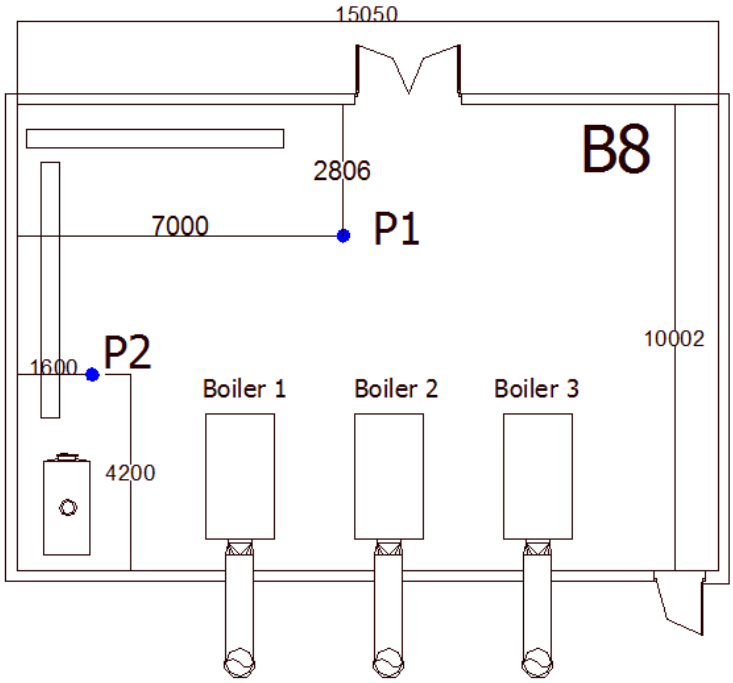

Fig. 6-31 Layout drawing of point 1 and point 2 in B8 (Dimensions in meters)

(i) Point P1

The sound level meter was placed at a point that was nearly the centre of B8. During measurements, none of the boilers was working and the door of B8 was closed. The data obtained as a result of these measurements are tabulated in Table 6-19.

Table 6-19 Data obtained at P1 in B8 (duration of each measurement = 2 minutes)

	L_{Aeq}	L_{Ceq}	L_{Ceq}- L_{Aeq}	L_{AF5}	L_{AF10}	L_{AF50}	L_{AF90}	L_{AF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	81,9	84,6	2,8	82,1	82,0	81,8	81,5	81,4	0,4
Std. Deviation	0,05	0,04	0,05	0,11	0,08	0,00	0,10	0,08	0,04

	L_{Aeq}	L_{Leq}	L_{Leq}- L_{Aeq}	L_{LF5}	L_{LF10}	L_{LF50}	L_{LF90}	L_{LF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	82,2	85,4	3,3	86,0	85,8	85,3	84,8	84,7	0,4
Std. Deviation	0,08	0,04	0,04	0,00	0,00	0,11	0,00	0,10	0,00

A, C and L in Table 6-19 indicate the values after A, C and L weightings are applied to the noise data.

The average L_{AFmax} and L_{Cpeak} values were respectively 82,7 and 98,9 dB.

The graphical representation of the spectrum profile can be found in Fig. 6-32.

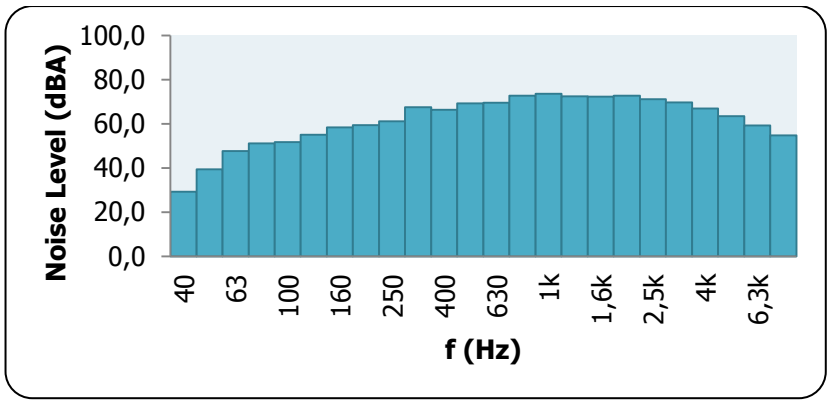

Fig. 6-32 Spectrum profile at P1 in B8 (L_{Aeq} = 81,9 dB)

(ii) Point P2

The second point selected for noise level measurements in B8 was near the oil tank. The coordinates of the point are given in Figure 6-33. The L_{Aeq} values as well as noise level percentiles are given in Table 6-20.

Table 6-20 Data obtained at P2 in B8 (duration of each measurement = 2 minutes)

	L_{Aeq}	L_{Ceq}	L_{Ceq}- L_{Aeq}	L_{AF5}	L_{AF10}	L_{AF50}	L_{AF90}	L_{AF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	82,5	85,2	2,7	82,9	82,8	82,4	82,1	82,0	0,4
Std. Deviation	0,05	0,05	0,05	0,10	0,08	0,00	0,11	0,00	0,00

	L_{Aeq}	L_{Leq}	L_{Leq}- L_{Aeq}	L_{LF5}	L_{LF10}	L_{LF50}	L_{LF90}	L_{LF95}	L_{AI}-L_A
N	6	6	6	6	6	6	6	6	6
Mean	82,6	85,9	3,2	86,4	86,3	85,7	85,2	85,0	0,4
Std. Deviation	0,10	0,05	0,08	0,08	0,10	0,10	0,08	0,00	0,00

A, C and L in Table 6-20 indicates the values after A, C and L weightings are applied to the noise data. The average L_{AFmax} and L_{Cpeak} values were respectively 83,9 and 99,5 dB.

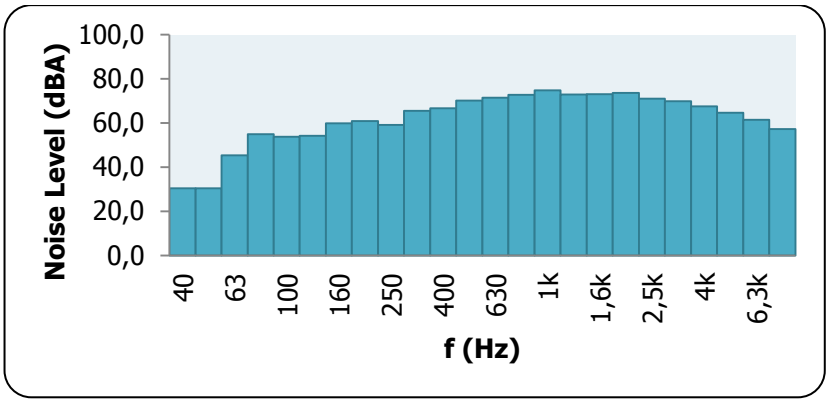

Fig. 6-33 Spectrum profile at P2 in B8 (L_{Aeq} = 82,6 dB)

To see the general atmosphere of B3, 10 minutes measurements were also done in addition to 2 minutes measurements. The data is given below.

Table 6-21 Data obtained at P1 in B8 (10 minutes)

	L_{Aeq}	L_{Ceq}	L_{Ceq}- L_{Aeq}	L_{AF5}	L_{AF10}	L_{AF50}	L_{AF90}	L_{AF95}	L_{AI}-L_A
N	1	1	1	1	1	1	1	1	1
Mean	84,2	85,8	1,6	84,6	84,4	84,2	83,6	83,6	0,4
Std. Deviation	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

	L_{Aeq}	L_{Leq}	L_{Leq}- L_{Aeq}	L_{LF5}	L_{LF10}	L_{LF50}	L_{LF90}	L_{LF95}	L_{AI}-L_A
N	1	1	1	1	1	1	1	1	1
Mean	84,2	86,1	1,9	86,6	86,4	86,0	85,6	85,4	0,4
Std. Deviation	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

A, C and L in Table 6-21 indicate the values after A, C and L weightings are applied to the noise data. The average L_{AFmax} and L_{Cpeak} values were respectively 86,2 and 100,8 dB.

6.2.6. Building B10

B10 is the room in B3 where the generator is located. As everybody can know, the generators are the noise sources, run when the power cut-offs occur and they provide the system temporary energy so that the system integrity is protected.

This generator has the same task; it provides power to the whole station so that the pumping operation continues even if the high voltage electricity power is cut-off.

Additionally, the generator is run weekly for test purposes for 5 to 10 minutes. At that time, one personnel from the operation team, and one from the maintenance team follow the test operation. Duration of which, we were unfortunately not able to take measurements corresponding to the generator "on" case. Due to operational requirements, the station authority did not allow us to get the data by running the generator again.

However, it is known that the noise level associated with "generator on" case was 107,9 dB(A).

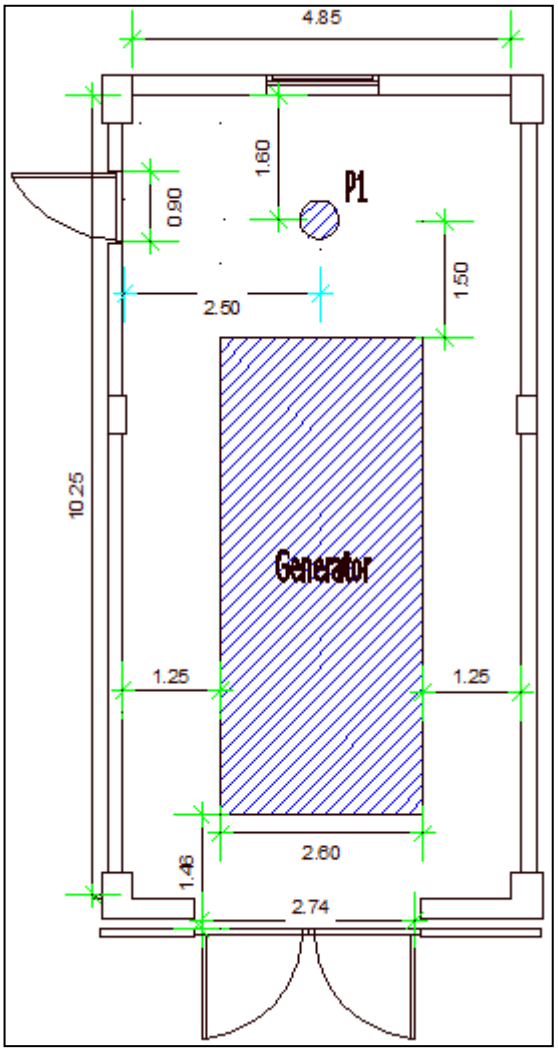

Fig. 6-34 Layout Drawing of B10

6.3. Dose Measurements

In addition to formal noise measurements performed at the specified points, dosimeter measurements were also carried out on some of the personnel.

For that purpose, a dosimeter (Model: GA 155) was used to measure the noise exposure of employees working in the plant over a period. Its microphone was mounted on the shoulders of the workers.

It was tried to select the personnel from all departments (i.e., homogenous noise exposure teams [29]), and especially from mechanical and operational team because the personnel of these departments work in nosiest places of the plant.

The results of the dosimeter measurements are given in Table 6-23. For practical reasons, it was not possible to have a full-day measurement for all workers. In order to eliminate the effect of false contributions to the self-exposure of workers, at the end of dosimeter measurements, it was required from the workers to state the time they have spent in each building. An example of the form completed by the workers is given in Table 6-22. As can be seen in the table, the quiet period was included in the measurements as suggested by ISO 9612. ISO 9612 also suggests three full-day measurements for each worker. This suggestion is ignored at the expense of involving as many volunteer workers as possible. Start and Stop time in Table 6-22 indicate the "put on" and "take off" time of the dosimeter. The period between the 12:00-13:30 indicates the paused period.

Table 6-22 Occupation Form

Title Code	Date	Start Time	Stop Time	Time Spent (Hrs)
MS-1	12.02.2009	07:30	12:00	B2 Panel Room (6,5 hrs)
		13:30	17:30	Break (2 Hrs)

Table 6-23 Dosimeter results

Working Group	Title Code	Measurement Duration (Hrs)	LEP	Pa^2h	Dose
Security Team	SP-1	02:50:00	71,7	0,032	1
	SP-2	03:36:00	55,2	0,000	0
		05:39:41	40,2	0,000	0
	SP-3	03:28:00	82,9	0,610	19
		04:18:50	65,1	0,000	0
	SP-4	02:18:00	69,0	0,000	0
	SP-5	03:54:00	83,4	0,672	21
		05:34:00	28,5	0,000	0
	SP-6	01:57:12	82,7	0,576	18
		02:44:16	90,7	3,680	115
	SP-7	04:00:00	69,1	0,000	0
		04:00:00	69,4	0,000	0
	SP-8	03:15:15	73,3	0,064	2
		01:27:30	75,2	0,096	3
Operation Team	SO-1	03:10:22	95,6	11,640	364
	SO-2	12:21:45	80,1	0,320	10
		06:16:00	84.4	0,864	27
	SO-3	02:44:32	89,0	0,253	79
	SO-4	11:30:35	69,1	0,000	0
		11:24:00	70,5	0,032	1
	SO-5	10.58:40	84,6	0,896	28
		10:20:40	71,4	0,032	1
	PO-1	06:35:00	78,8	0,224	7
		06:35:13	79,9	0,288	9
	PO-2	11:33:00	75,6	0,096	3
Maintenance Team	ET-1	07:45:00	58,4	0,000	0
	ET-2	09:30:00	83,5	0,672	21
	MTech-1	09:44:00	55,6	0,000	0
		08:00:00	75,3	0,096	3
	MTech-2	08:13:33	79,0	0,224	7
	ES-1	04:54:00	27,9	0,000	0
		08:05:00	75,3	0,096	3
	MS-1	08:27:00	84,7	0,928	29
	STech-1	10:20:00	69,9	0,000	0
	SE-1	09:30:00	86,4	1,376	43
	BT-1	08:00:00	66,5	0,000	0
	MET-1	08:14:00	83.9	0,768	24
HSE Team	HSE-1	09:00:00	77,8	0,192	6
	HSE-2	06:05:00	28,8	0,000	0
	WO-1	00:35:00	79,9	0,288	9

The abbreviations used in the title codes are explained in the below chart.

Abbreviations:

SP	Security Personnel
SO	Site Operator
PO	Panel Operator
ET	Electrical Technician
MET	Mechanical Technician
MTech	Metering Technician
ES	Electrical & Scada Supervisor
MS	Mechanic Supervisor
STech	Scada Technician
SE	Scada Engineer
BT	BVT Technician
HSE	HS Engineer
WO	WWTP Operator

LEP, Pa^2h and Dose in Table 6-23 are defined as;

LEP = Noise exposure level normalized to 8 hrs. Working day

Pa^2h = Pascal squared hours noise exposure

Dose = Noise exposure

Exchange rate and Criterion Level were respectively 3 dB and 90 dB.

It has to be noted that the workers in this plant work, in general, 11 hours. In other words, to the L_{EP} values (given in Table 6-23), 10 log (11/8) = 1,38 dB has to be added. As can be seen in Table 6-24, out of 28 personnel, 12 was exposed to noise level, NL > 80 dBA.

Table 6-24 Noise exposure of the teams

Teams / LEP values	< 70 dBA	70-74 dBA	75-79 dBA	80-85 dBA	>85 dBA
HSE (N=3)	1 worker	-	1 worker	1 worker	-
Maintenance (N=10)	3 workers	-	3 workers	3 workers	1 worker
Operation (N=7)	-	1 worker	2 workers	2 workers	2 workers
Security (N = 8)	3 workers	2 workers	-	2 workers	1 worker
Number of Workers (Total)	**7**	**3**	**6**	**8**	**4**

6.4. Speech Interference Level

Speech Interference Level of noise (L_{SIL}) is defined as (in [32]) the arithmetic mean of noise levels at four octave band frequencies, i.e. at 500, 1000, 2000 and 4000 Hz.

$L_{SIL} = 1/4\ (\sum L_{N,oct,i})$.....(i=1 to 4).....(6-1)

where $L_{N,oct,i}$ = Noise level in octave band "i" at listeners ear.

The L_{SIL} values obtained for the buildings in which noise measurements were done are tabulated below.

Table 6-25 L_{SIL} values corresponding to measured points

Building No	Point No	L_{SIL} Value
B2	P1	58,8738
	P2	58,6480
B3 (people at break)	P1	65,0100
B3 (people at work)	P1	80,9925
	P1 (10 min.)	69,4350
	P2	66,0881
B4	P1	90,5696
	P2	91,3088
	P3	91,6054
	P4	91,0608
	P5	85,6642
	P6	78,8888
	P7	74,1579
B5	P1	74,0500
	P1 (10 min.)	73,4650
	P2	67,3867
	P3	64,0929
	P4	67,8213
B8	P1	74,9971
	P1 (10 min.)	77,2575
	P2	75,6742

In Annex A of ISO 9921 [32], the local effort of a male person and corresponding speech level is given as;

Vocal Effort	**$L_{S,A,1m}$ dB**
Very Loud	78
Loud	72
Raised	66
Normal	60
Relaxed	54

$L_{S,A,1}$ = Speech level at 1 meter in front of the mouth of the speaker

Speech Interference Level, SIL, is defined in terms of $L_{S,A,L}$ and L_{SIL} as

$SIL = L_{S,A,L} - L_{SIL}$.....(6-2)

As can be seen from the values given in Table 6-25, except B2, SIL values in all other buildings (where noise level measurements were done) are <3. According to Table F.1 in ISO 9921, this intelligibility is rated as "Bad". It has to be noted that the workers in this plant "need to communicate" (See Fig. 3-20). Only 14% of the workers were in need of "rare communication". This handicap necessitates urgent mitigation.

CHAPTER VII

NOISE MAPPING OF THE BUILDINGS

7.1. Introduction

Indoor noise mapping displays graphically the distribution of the noise levels in a workplace. The area in question is coloured according to noise levels present in it. Sometimes, the noise levels may be shown by contour lines that indicate the boundaries between different noise levels in an area.

Noise maps are very crucial to see and understand the noise climate of the plant. They render it easy to, provide the necessary precautions for the well-being of the employees and consequently make it easy to eliminate the negative effects of the noise on the people.

In the plant in which we worked, the noise maps are prepared only for the buildings where the measurements were carried out. The software programme "*Noise at Work V1.30*" is used to draw the noise maps. The AutoCAD drawing of the buildings are loaded in this programme, and the below given maps are obtained. Once, the colours according to specific dB(A) intervals are specified, contour lines appeared automatically. The colour scales used for the graphics are tabulated in Table 7-1.

Table 7-1 Colour Chart for Noise Levels

From	To	Colour &
0,00	80,00	
80,00	81,00	
81,00	82,00	
82,00	83,00	
83,00	84,00	
84,00	85,00	
85,00	86,00	
86,00	87,00	
87,00	88,00	
88,00	89,00	
89,00	90,00	
90,00	100,00	
100,00	115,00	

7.2. Noise Maps of the Buildings

7.2.1. Building B2

The data obtained from the measurements carried out in B2 are given in Chapter 6. While drawing the noise map the highest L_{Aeq} value associated with the each of the measurement point is selected. They were 66,8 dB(A) for point 1 and 67,0 dB(A) for point 2.

The map is given below in Figure 7-1.

Fig. 7-1 Noise map of B2

The ambient-environmental conditions and the type of noise sources were as follows:

Outside Temperature	7 ^{o}C
Inside Temperature	44 ^{o}C
Flow Rate	4450 m^3/h
Relative Humidity	77,30%
Number of Running Pumps	3
Measurement Start Time	09:00
Noise Sources	Fans on Electronic Panels, Laptops, all 3 in one printer

7.2.2. Building B3

In B3, measurements were taken at two points. The highest L_{Aeq} value obtained for point 1 and for point 2 was respectively 92,1 dB(A) and 75,6 dB(A).

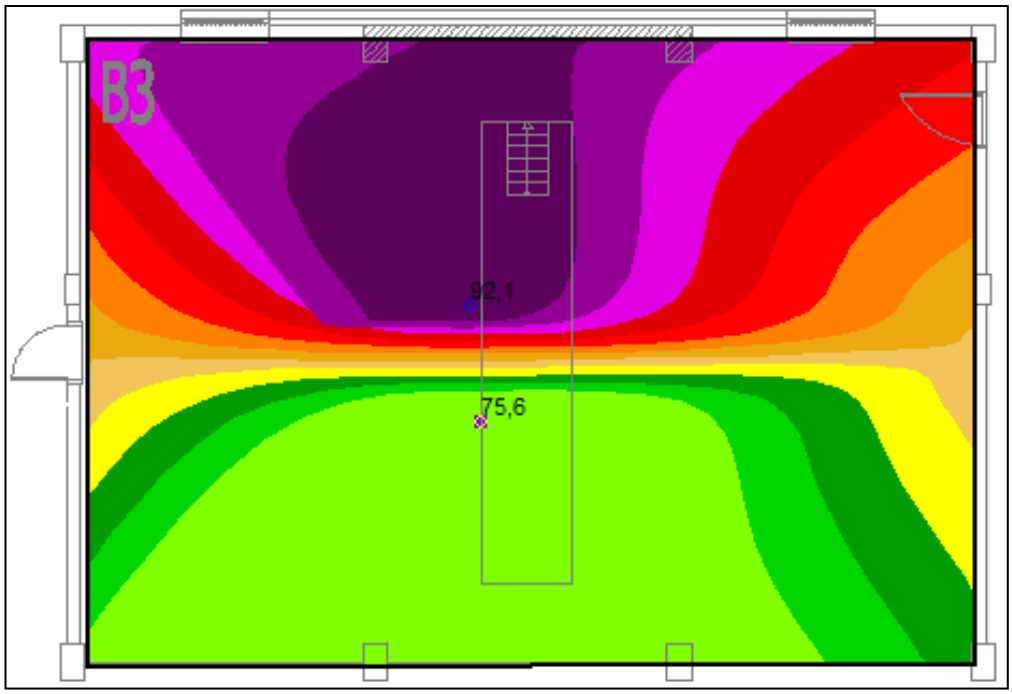

Fig. 7-2 Noise map of B3

The ambient-environmental conditions and the type of noise sources were as follows:

Outside Temperature	8 °C
Inside Temperature	10 °C
Flow Rate	4450 m^3/h
Relative Humidity	60,00%
Number Of Running Pumps	3
Measurement Start Time	10:37
Noise Sources	Welding activities, cutting equipment, forklift, foam trailer, overhead crane, mobile generator, hand tools, etc.

7.2.3. Building B4

Measurements were done at seven points in B4. During the measurements, pumps 1, 2 and 3 were pumping the oil. The pumps 4 and 5 whereas were kept at stand-by position.

The highest L_{Aeq} values for points 1 to 7 are 97,6, 98,1, 100,0, 98,6, 93,1, 87,6 and 82,6 dB(A), respectively. In the preparation of the noise map these values are used (Figure 7-3).

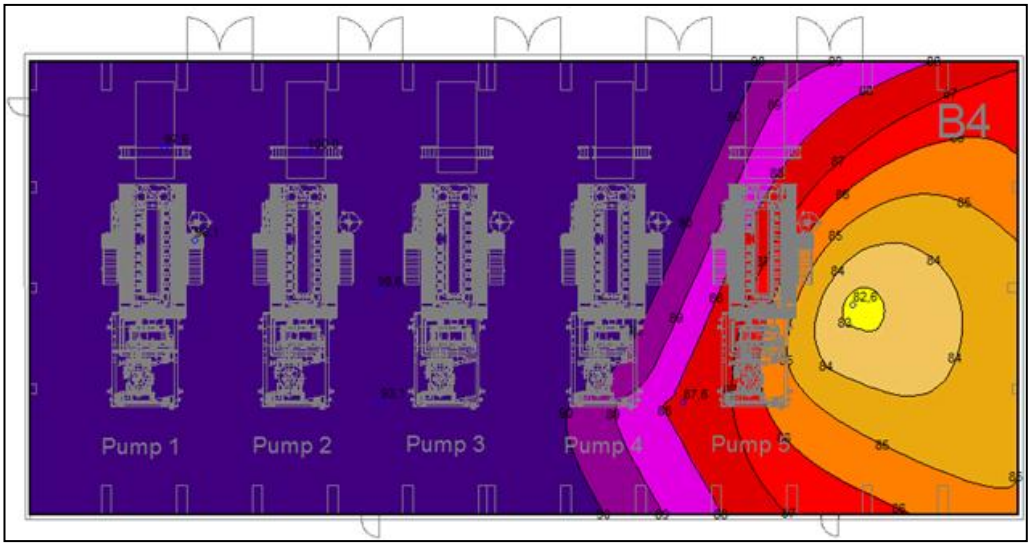

Fig. 7-3 Noise map of B4

The ambient-environmental conditions and the type of noise sources were as follows:

Outside Temperature	8 °C
Inside Temperature	31,5 °C
Flow Rate	4450 m^3/h
Relative Humidity	69,70%
Number of Running Pumps	3
Measurement Start Time	09:17
Noise Sources	Pumps, increase in flow rate, ventilation fans

7.2.4. Building B5

As mentioned in chapter 6, four points were selected in order to predict the noise climate in B5.The highest L_{Aeq} values associated with points P1 → P4 were 83,6, 76,3, 74,4 and 76,0, respectively. The noise distribution in B5 is drawn according to these values and graphed below in Fig. 7-4.

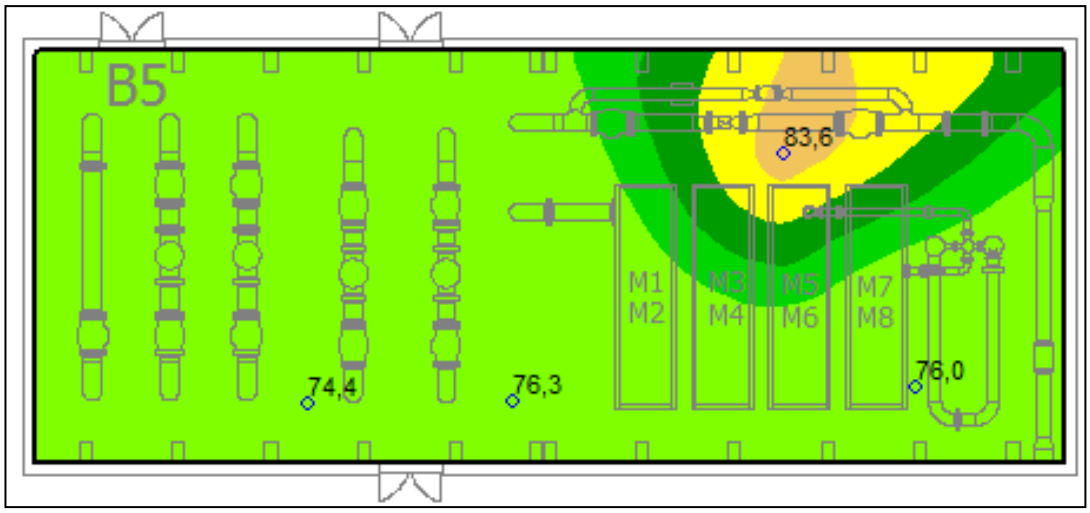

Fig. 7-4 Noise map of B5

The ambient-environmental conditions and the type of noise sources were as follows:

Outside Temperature	8 °C
Inside Temperature	15 °C
Flow Rate	4430 m^3/h
Relative Humidity	60,00%
Number of Runnıng Pumps	3
Measurement Start Time	12:41
Noise Sources	pipes,increase in flow rate, pressure control valve

7.2.5. Building B8

In the boiler room of B8 building, the measurements were taken at two points and L_{Aeq} values for point 1 and point 2 were 81,9 dB(A) and 82,6 dB(A), respectively. The map is prepared according to these values and it is given in Fig. 7-5.

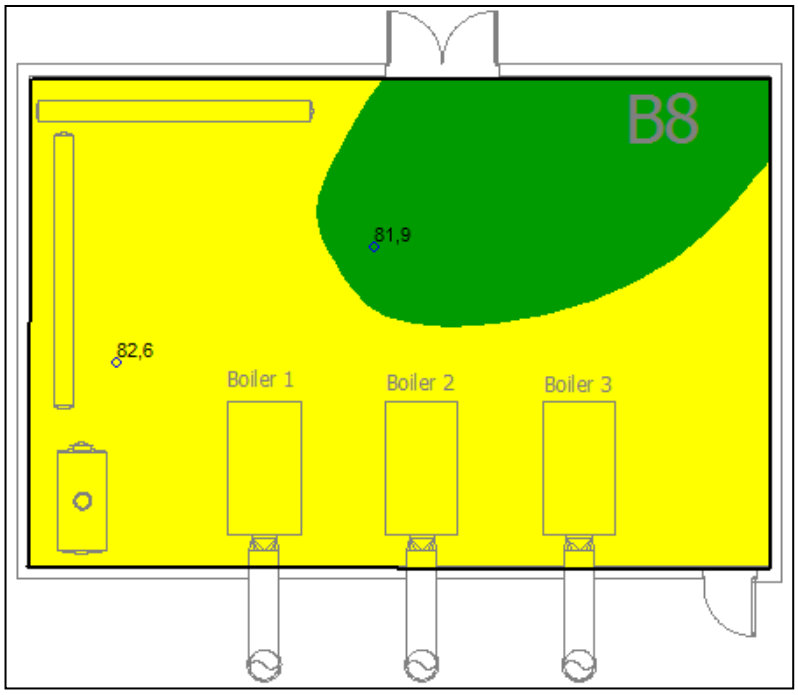

Fig. 7-5 Noise map of B8 (Boiler Room)

The ambient-environmental conditions and the type of noise sources were as follows:

Outside Temperature	7 °C
Inside Temperature	44 °C
Flow Rate	4450 m^3/h
Relative Humidity	77,30%
Number of Running Pumps	3
Measurement Start Time	09:00
Noise Sources	Boilers and pump

7.2.6. Building B10

The noise map prepared for the generator is given in Fig. 7-6 based on the previous data taken by the site safety personnel when the generator was online.

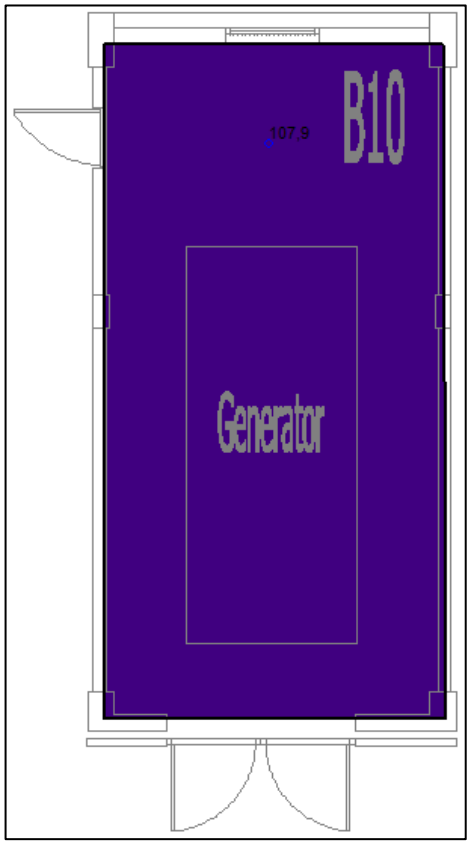

Fig. 7-6 Noise map of B10

The ambient-environmental conditions and the type of noise sources were as follows:

Outside Temperature	7 °C
Inside Temperature	24 °C
Flow Rate	3500 m^3/h
Relative Humidity	71,10%
Number of Running Pumps	3
Measurement Start Time	16:45
Noise Sources	Generator

CHAPTER VIII

DISCUSSION OF RESULTS

The reassessment of the precautions taken in the plant, up to this day, is done both subjectively (through questionnaires) and objectively (measuring the noise levels in the buildings). The summary of the results are as follows;

(i) Rating of ambient noise in the buildings

As explained in the previous chapter, two types of rating scales namely verbal rating, VR and scalar rating, SR are used in this study.

It is pointed out in [27, 28] that verbal rating has some advantages such as ease-of-explanation and familiarity compared to scalar rating. In fact, most people prefer verbal responses when performing the rating tasks. The results associated with these two scales however have been stated to have significant differences. Contrary to this popular belief, our results gave approximately similar outputs for both of the rating scales. The correlations between these two scales for each building were found significant. The overall average of the personnel's ratings showed that the buildings B1, B2, B6, B7, B8, B9 and B11 had low noise level, L (Low noise level = either NL-VR = 2 or 2 ≤ NL-SR < 4).The noise level in B3 and B5 buildings were rated as moderate M (Moderate noise Level = either NL-VR= 3 or 4 ≤ NL-SR < 6). B10's noise level was rated as high, H (High noise level = either NL-VR= 4 or 6 ≤ NL-SR < 8) and B4 building was assessed by the workers as the most noisy building and noise level was stated to be, very high, VH (Very high noise level = either NL-VR = 5 or 8≤ NL-SR < 10).

Since the ratings of the buildings were done by the employees entering into these buildings, no change is expected and observed in team ratings.

(ii) Noise Levels in the buildings

Table 8-1 Measured NL ranges and relevant NL ratings

Building No	Measured NL ranges (dBA)	NL Ratings
B2	66 - 67	L
B3	72,4 – 92,1	M
B4	82 - 101	VH
B5	73,6 – 86,5	M
B8	81,8 – 82,8	M
B10 (When generator is on)	107-112	H

Table 8-1 given above designates the noise level ranges of the buildings where the noise measurements were done and gives the NL ratings of the employees for these buildings. As can be seen in the above table, the noise levels in B2 building was rated as low, "L", by the workers. B4 and B10 buildings were rated respectively as "very highly" and "highly" noisy.

It has to be noted that people working in this plant were exposed to the noise levels indicated in table 8-1, during the last 3 years. It is also known, from their previous noise exposure history, that they were exposed to, on the average,the same level of noise since the beginning of their working days.

It is worth nothing that in none of the buildings, $L_C - L_A$ values do not exceed 15 [33-34]. Low frequency noise, LFN, effect therefore is not considered in this study.

(iii) Use of Hearing Protectors

Even though "Hearing Protection" wearing is mandatory and there are warning signs placed at the entrances of the buildings B3, B4, B5, B8, B9 and B10, people generally choose to ignore these warnings.

Table 8-2 Use of HP

Building No	Measured Average L_{Aeq} Values	% of the workers wearing HP	HP Mandatory
B2	66,5	1	No
B3	77,3	33	Yes
B4	93,5	98	Yes
B5	77,4	41	Yes
B8	82,3	30	Yes
B10	112	35	Yes

60% (N=22) of the employees entering B5 each day, for instance, do not use any hearing protection (Table 8-2).

Again, in B8, 70% do not use HPD's, though the NL inside B8 was around 82 dB (A). This can be explained by the limited time spent, by workers, in this building. In fact only six of the workers work there for 60 minutes, the rest (N=17) spent less time, so this may cause people to underestimate the significance of wearing ear protectors inside this building. This behaviour can also be attributed to the low degree of risk perception of the personnel and to the lack of training relevant with hearing protectors.

One another explanation to poor usage of HP's can be given by the efficiency rating of the HP's, done by the workers. (Fig. 8-1)

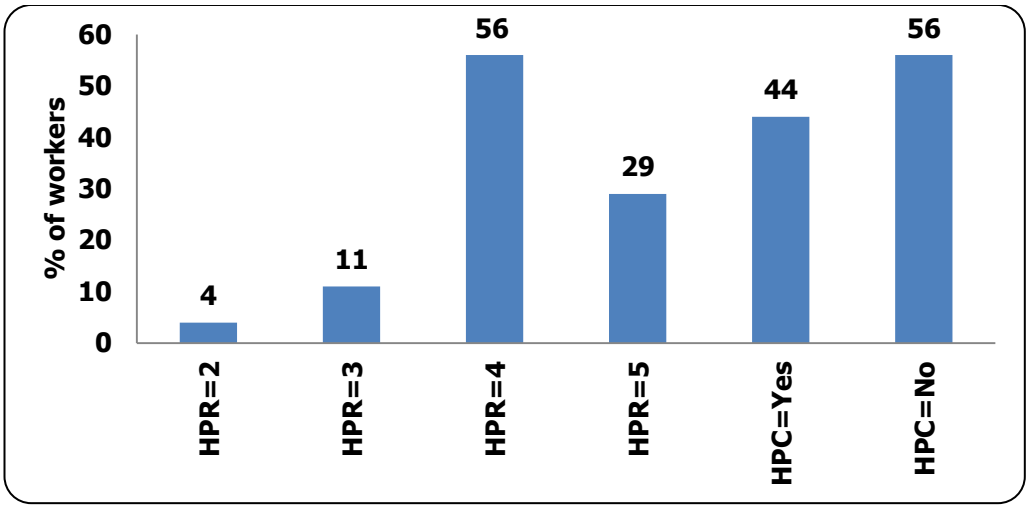

Fig. 8-1 Assessment of HP's by workers

As can be seen in the figure, majorty of the workers (56%) using HP's (N=55) assess the noise reduction efficiency, HRP, of the hearing protectors as moderate. 44% of the workers have expressed their uneasiness (Hearing Protection Complaint, HPC= Yes) while using HPs. It seems that Hearing Protective Devices do not keep people efficiently from the noise to which they are exposed and they also cause discomfort to the users. Unwillingness of the workers towards the usage of HPs accompanied by the lack of proper usage of HPs render the noise reduction capableness of this passive isolation remain at moderate level.

(iv) Auditory effects of noise

According to the questionnaire survey done on site personnel 8% (N=6) of the workers have "Hearing loss" whereas 92% (N=73) has "No" hearing loss. This situation was confirmed by the audiometric test carried out annually in the plant. However, it has to be recalled that the audiometric test period for the people who work in heavy industries including oil industry is suggested as 6 months in the Noise Control Regulations. Checking of personnel with otoscopy was also not done before the audiometric test, which could affect the results, sensibility and correctness of this test.

It is already stated in **[14]** that continuous exposure to noise level above 80 dB (A) is not a cause of tinnitus if there is no hearing handicap. However, in this study, 28% (total number of workers =79) of the personnel declared that they had tinnitus and except two workers the rest do not state any complaint with regard to hearing impairment. Actually 92% (N=73) of the workers had no "hearing loss". The people having tinnitus complaint deserve special attention and had to be followed closely. It was also found in this study that there was no relationship between tinnitus and age even though tinnitus is mostly seen in the adults who are between ages of 40-70 years. It has to be noted that, the mean age of the personnel in this plant was 32 and there was only six personnel whose age was ≥ 40 years.

Correlation between tinnitus and noise level in each building were investigated as well. Similar to tinnitus vs. age, no relationship was observed between noise level and tinnitus.

(v) Effect of noise on working efficiency and communication

The effect of noise on working efficiency is assessed both in general sense and in detail. WE-VR ratings of the buildings and associated measured NL's are given in Table 8-3.

Table 8-3 Effect of Noise on WE

Building No	Average L_{Aeq} (dB)	Average WE-VR
B2	66,5	2
B3	77,3	3
B4	93,5	4
B5	77,4	2
B8	82,3	2
B10	56,6 (Generator Off)	3
	112,0 (Generator On)	

The reason for the lesser effect of noise on WE in B5 building compared to B3 building can be explained by higher percentage of workers using HP (when they are) in B5. Very low effect of noise on WE in B8 can be due to the working time of the employees in this building. Only one worker works 140 minutes in this building. Percentage of those working between 20-60 minutes was 60.

The effect of noise on WE is further analysed in terms of the effect of noise on 5 items. Factor analysis highlighted two significant factors that have effects on the working efficiency of the personnel in the studied workplace: the first component **"communication"** consisted of *"Hearing and understanding of people near to him"*, *"Hearing the warning signals"* and *"Speaking to people near to him"*. The second factor, **"efficiency in work"**, included *"Attention"* and *"Working speed"*. By looking at the rotated matrix, the first component has high loadings from items that have to be taken into consideration in determining the Work Place Index (WPI) which is calculated

to be **3,0 (/5,0)**, indicating that the plant is moderately satisfactory with respect to effect of noise on the working of people. It has to be noted that the overall average rating of the working conditions (obtained from HSE's questionnaire) in the plant was 4(/5). The plant, therefore, needs improvement both in the working conditions of the workers and in reducing the noise to which they are exposed.

The effect of noise on communication, in general, is analysed also in terms of SIL values. Unfortunately, the communication is badly affected by the noise levels in the buildings as explained in section 6-4.

CHAPTER IX

CONCLUSIONS

Noise is the most common and is one of the most crucial problems from the point of view of environmental health and safety. Therefore, it must be managed and controlled with special attention. In the facility we have investigated, most of the noise-control measures were already taken in order to minimize the negative effects of the ambient noise caused by the noise sources present in the plant. For example, Hearing Protection Device, HPD, use by personnel is encouraged, safety signs indicating the noisy areas were placed at the entrances of the buildings, boxes containing ear plugs were also hung on the walls of the buildings so that workers can easily reach them. Sometimes noise measurements were even done in the plant by safety personnel.

However, some deficiencies still have been observed.

(i) The first item to be focused on is that the employees in the plant tend to ignore wearing HPDs. To promote HPD use, special trainings regarding noise, its effects on people, and correct HPD usage have to be given. The aim of the trainings should increase the perception level of the risk associated with the noise. People of the plant are young (average age is ~ 32) and therefore they can be unconscious of the hazards that they will come across in the future due to the noise they are now exposed. It is also recommended that people must use hearing protection continuously all through their shift so as to benefit fully from the HPDs. Research on the protection capacity of HPDs pointed out that intermittent usage of HPDs are not so effective and even decreases the work efficiency of the people. When the effectiveness of the ear protectors on the numerical scale ranging

(ii) from 0 (meaning "Not effective") to 10 (meaning "completely preventive") was assessed by the personnel, the result obtained was **5,9 (/10,0)**, meaning that the ambient noise level was "***Moderately decreased***" by the hearing protectors used in this plant.

(iii) Besides, even though 44% of the employees found HPDs comfortable, according to 56% of the workers they are uncomfortable. Therefore, the feedbacks concerning HPDs collected from the site personnel and safety department should be taken into account in the future while purchasing new HPDs. The people can be made, ergonomically more comfortable in this way. The characteristics of the workforce should be carefully considered and **"*one size fits all*"** approach should not be preferred.

(iv) In order to render the workers beware of their noise exposure and to encourage the use of HPDs the noise maps given in Chapter 7 can be hung inside the buildings.

(v) Medical checks including audiometric test for the employees in the facility were carried out annually. Nevertheless, this test is very significant in following the status of the hearing losses of the workers resulted from the noise in the plant and it should therefore be done every six months instead of performing it annually. It is actually stated as a requirement in the Noise Control Regulation for close tracking of the hearing situations of the site personnel.

(vi) Dosimeters were not used in the station. Therefore, individual data regarding to the noise exposure of the personnel was not available. Full shift noise exposure measurements using dosimeters can be more beneficial while assessing the self-exposures of the workers.

(vii) Communication between the personnel at site is vitally important in order to provide the continuity of the system integrity in a safe manner. To provide communication properly in the plant, the personnel use radios and intrinsically safe phones. However, this communication can be interrupted in noisy environments. Therefore, some special communication methods, such as hardhat-connected radios and visual warning systems that may be needed in case of emergency, have to be put in application.

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APPENDIX

THE NOISE AND STRESS SURVEY QUESTIONNAIRE

The attached questionnaire presented to your attention, aims to describe the working area in terms of its acoustic parameters.The noise measurements which shall be done later will be correlated with your assessments.

In this questionnaire, *"Unwanted and meaningless sound to the listeners"* is termed as **noise*.**

The results of this questionnaire will form a database for a master thesis on "the assessment of the noise exposure of a plant in oil industry".

You are kindly requested to answer the questions in this questionnaire.

"Comments" section is reserved for your comments and suggestions relevant with the questionnaire.

Please do not leave any questions unanswered.

Thank you in advance for your answers.

* The Republic of Turkey, Ministry of Environment & Forest XV. Noise & Vibration, p.438

Personnel ID :		Education Level	:
Your Title	:	Your Height	:
Your Age	:	Your Weight	:

1. How many years have you been working for this company?

   _____Years

2. How do you generally perform your job? (You can select more than one option)

   ☐ OfficeWorks (Computer etc.)
   ☐ Standing constantly on your feet
   ☐ By walking
   ☐ By crouching or bending
   ☐ By working at the bench
   ☐ Other (Please Explain)_____

3. Have you worked for another company before?

No	The name of the company for which you worked previously	How long you worked there	How would you rate the noise level where you have worked previously?				
			Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
1			☐	☐	☐	☐	☐
2			☐	☐	☐	☐	☐
3			☐	☐	☐	☐	☐
4			☐	☐	☐	☐	☐

4. How many days in a week are you working in your current employment?

☐ 1 day
☐ 2 days
☐ 3 days
☐ 4 days
☐ 5 days
☐ 6 days
☐ 7 days

5. What is your work schedule? Please select the appropriate one.

☐ Weekdays (From Monday to Sunday), 11 hours per day
☐ Weekdays (From Monday to Saturday) 7,5 hours per day
☐ Weekdays (6 days per week, the day off can be one of the weekdays) 7,5 hours per day
☐ Other:_____
(Please enter how many hours you work and what is your schedule)

In overtime;

☐ I am not doing overtime work
☐ I am doing _____hours overtime work after 19:00, I have totally_____hours break
☐ I am doing _____hours overtime work after 16:00, I have totally_____hours break
☐ Other (Please enter the duration of breaks and indicate its time)_____

6. Please select your working times

Normal Working Hours (From Monday to Sunday);

☐ Morning (From 07:00 to 12:00) Afternoon (from 13:00 to 19:00) by having break between 12:00-13:00
☐ Other : Morning_____/ Afternoon _____ ; having _____ hours break.

When I work overtime,

☐ I am not doing overtime work
☐ I am seldom work overtime. When I work overtime, it is generally between the hours of from_____ to _____
☐ Everyday, I am working overtime between hours from _____ to _____.
☐ I am working overtime between hours from _____ to__ _____ on _____days. (Fill out the gaps)

7. How many days holidays do you have in one year?

   _____ Days

8. How many hours in a week are you working overtime?

   ☐ I am not doing overtime work
   ☐ 1 hour
   ☐ 2 hours
   ☐ I am seldom working overtime
   ☐ In a month, _____Times_____Hours
   ☐ In a year,_____ Times_____ Hours
   ☐ Other _____
   (Please specify how many hours are you working overtime)

9. How many times are you working overtime in a week?

   ☐ Once a week
   ☐ Twice a week
   ☐ 3 Times a week
   ☐ 4 Times a week
   ☐ 5 Times a week
   ☐ 6 Times a week

10. Please specify the time periods that you spend in the following buildings within your working hours. (You can select more than one option)

B1	Working Time : _____Hours _____Minutes
B2	Working Time : _____Hours _____Minutes
B3	Working Time : _____Hours _____Minutes
B4	Working Time : _____Hours _____Minutes
B5	Working Time : _____Hours _____Minutes
B6	Working Time : _____Hours _____Minutes
B7	Working Time : _____Hours _____Minutes
B8	Working Time : _____Hours _____Minutes
B9	Working Time : _____Hours _____Minutes
B10	Working Time : _____Hours _____Minutes
B11	Working Time : _____Hours _____Minutes

11. How would you describe the "NOISE" level in your place of work?

	Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
B1	☐	☐	☐	☐	☐
B2	☐	☐	☐	☐	☐
B3	☐	☐	☐	☐	☐
B4	☐	☐	☐	☐	☐
B5	☐	☐	☐	☐	☐
B6	☐	☐	☐	☐	☐
B7	☐	☐	☐	☐	☐
B8	☐	☐	☐	☐	☐
B9	☐	☐	☐	☐	☐
B10	☐	☐	☐	☐	☐
B11	☐	☐	☐	☐	☐

12. How does "NOISE LEVEL" in your work place affect your work efficiency?

	Not affected (1)	Slightly affected (2)	Moderately affected (3)	Affected (4)	Highly affected (5)
B1	☐	☐	☐	☐	☐
B2	☐	☐	☐	☐	☐
B3	☐	☐	☐	☐	☐
B4	☐	☐	☐	☐	☐
B5	☐	☐	☐	☐	☐
B6	☐	☐	☐	☐	☐
B7	☐	☐	☐	☐	☐
B8	☐	☐	☐	☐	☐
B9	☐	☐	☐	☐	☐
B10	☐	☐	☐	☐	☐
B11	☐	☐	☐	☐	☐

13. Please indicate the "NOISE" level in your work place on the opinion scale below. If you select "too high" please mark "10", for "quiet" you can select "0". To determine other levels, please select other numbers between 0 and 10.

	Quiet										Too High
	0	1	2	3	4	5	6	7	8	9	10
B1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B2	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B3	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B4	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B5	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B6	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B7	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B8	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B9	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B10	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B11	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

14. Please indicate the effect of the "NOISE" level on your "Working Efficiency" on the opinion scale below.

	Not affecting										Highly affecting
	0	1	2	3	4	5	6	7	8	9	10
B1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B2	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B3	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B4	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B5	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B6	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B7	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B8	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B9	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B10	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B11	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

15. How does "NOISE" affect you in the work place?

	Not affected	Slightly affected	Moderately affected	Affected	Highly affected
	1	2	3	4	5
My attention	☐	☐	☐	☐	☐
My work speed	☐	☐	☐	☐	☐
Hearing and understanding people near to me	☐	☐	☐	☐	☐
Hearing warning signals	☐	☐	☐	☐	☐
Speaking to people near to me	☐	☐	☐	☐	☐

16. Do you believe in your opinion concerning your health, you will be able to perform your current job two years from now?

☐ Unlikely
☐ Not Certain
☐ Relatively Certain

17. Do you use ear protection in following buildings?

	Yes	No
B1	☐	☐
B2	☐	☐
B3	☐	☐
B4	☐	☐
B5	☐	☐
B6	☐	☐
B7	☐	☐
B8	☐	☐
B9	☐	☐
B10	☐	☐
B11	☐	☐

18. Please mark the ear protection type you use.

☐ Ear Muff
☐ Ear Plug
☐ Ear Muff & Ear Plug together

19. Are you disturbed when using hearing protection?

☐ Yes
☐ No

20. Is your ear protection equipment compatible with the other personnel protective equipment (Hard Hat, Safety Glasses, etc)?

☐ Yes
☐ No

If "No", please describe the incompatibility_____

21. How often do you use your ear protector?

☐ I do not use ear protection
☐ Continuously 1 hour
☐ Continuously 2 hours
☐ Continuously 3 hours
☐ Continuously 4 hours
☐ When required
☐ Other _____

☐ Once a day
☐ Twice a day
☐ 3 times a day
☐ 4 times a day
☐ 5 times a day
☐ Other _____

22. Up to what level does your ear protection affect the noise level?

☐ I do not use ear protection
☐ Noise is prevented completely
☐ Noise is decreased slightly
☐ Noise level is moderately decreased
☐ Noise is highly decreased
☐ Noise is not decreased

Please indicate also on the opinion scale given below.

Not effective Completely prevents

0 1 2 3 4 5 6 7 8 9 10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

23. How often do you need to communicate with your colleagues while you are at work?

☐ No need to communicate
☐ I rarely need to communicate
☐ I often need to communicate
☐ I more often need to communicate
☐ I continuously need to communicate

24. Please indicate the situations you come across while working.

☐ Some short period pains in my ear
☐ Tinnitus in my ear
☐ Tubal dysfunction in my ear
☐ Sometimes I don't understand what is said to me
☐ I have back pain
☐ I have neck pain
☐ I have headache
☐ I have dizziness
☐ I have shortness of breath
☐ I have chronic fatigue
☐ I suffer from insomnia
☐ I frequently feel depressive, frustrated and indecisive
☐ Other _____

25. Have you recently been active and alert?

☐ Always
☐ Often
☐ Sometimes
☐ Seldom
☐ Never

26. Do you have hearing loss?

☐ Yes
☐ No

If "Yes", Please write the percentage _____

27. Does your hearing improve when you are away from the job?

☐ Yes
☐ No

	Yes	No
Overnight?	☐	☐
Days off?	☐	☐

28. Do you swim or scuba dive?

☐ Yes
☐ No

29. Have you ever been exposed to blasting or other explosive noises?

☐ Yes
☐ No

If "Yes", Please describe _____

30. Have you ever had ear surgery?

☐ Yes
☐ No

If "Yes", When? _____

31. Do you have recurring headaches?

☐ Yes
☐ No

32. What were your audiogram results?

☐ Right Ear _____
☐ Left Ear _____

33. Have you had liquid from your ears?

☐ Yes
☐ No

34. Have you have any complaint relating to your ears?

☐ Yes
☐ No

If "Yes", Please describe the complaint _____

35. Do you have a cholesterol problem?

☐ Yes
☐ No

If "Yes", Write your cholesterol values below.

Total : _____
HDL : _____
LDL : _____

36. You had trouble sleeping at night in the last six months?

☐ Never
☐ Occasionally
☐ Sometimes
☐ Fairly often
☐ Always

37. Was your sleep restless?

☐ None of the time
☐ Some of the time
☐ A moderate amount of time
☐ Most of the time

38. Do you have a blood pressure problem?

☐ Yes

☐ No

If "Yes", Please write below.

Generally; Systolic Pressure _____, Diastolic Pressure _____.

39. Is there anyone having hearing loss in your family (between 22-40 ages)?

☐ Yes
☐ No

40. Do you have any blood circulation problems?

☐ Yes
☐ No

41. Do you use pain-killers?

☐ Yes
☐ No

42. Have you ever had a car or motorcycle accident before?

☐ Yes
☐ No

43. Did you suffer any head injuries?

☐ Yes
☐ No

44. Have you recently felt yourself to be full of hope for the future?

☐ Never
☐ Seldom
☐ Sometimes
☐ Often
☐ Always

45. Do you smoke?

☐ Yes
☐ No

If "Yes", since when? and how many per day?

☐ for one month
☐ for six months
☐ for one year
☐ for two years
☐ more than 2 years
☐ other ____years
____ months

☐ 1 in a day
☐ 2 in a day
☐ 1 pocket in a day
☐ 2 pockets in a day
☐ more than 2 packets
☐ other_____

It is recognized that working conditions affect workers well-being. Your responses to the questions given below will help us to determine your working conditions now,and enable us to monitor future improvements. In order for us to compare the current situation with the past or future situations, it is important that your responses reflect your work in the last six months.

[26] Q. No	Q. No	Question	Never	Seldom	Sometimes	Often
1	46	I am clear what is expected of me at work	☐1	☐2	☐3	☐4
2	47	I can decide when to take a break	☐1	☐2	☐3	☐4
3	48	I know how to go about getting my job done	☐1	☐2	☐3	☐4
4	49	I have unachievable deadlines/targets	☐1	☐2	☐3	☐4
5	50	If work becomes difficult, my colleagues help me	☐1	☐2	☐3	☐4
6	51	I am given supportive feedback on the work I do	☐1	☐2	☐3	☐4
7	52	I have to work very intensively	☐1	☐2	☐3	☐4
8	53	I have a say in my work speed	☐1	☐2	☐3	☐4
9	54	I am clear what my duties and responsibilities are	☐1	☐2	☐3	☐4
10	55	I have to neglect some tasks because I have too much to do	☐1	☐2	☐3	☐4
11	56	I am clear about the goals and objectives for my department	☐1	☐2	☐3	☐4
12	57	There is friction or anger between colleagues	☐1	☐2	☐3	☐4
13	58	I have a choice in deciding how I do my work	☐1	☐2	☐3	☐4
14	59	I am unable to take sufficient breaks	☐1	☐2	☐3	☐4
15	60	I am pressured to work long hours	☐1	☐2	☐3	☐4
16	61	I have a choice in deciding what I do at work	☐1	☐2	☐3	☐4
17	62	I have to work very fast	☐1	☐2	☐3	☐4
18	63	I am subjected to bullying at work	☐1	☐2	☐3	☐4
19	64	I have unrealistic time pressures	☐1	☐2	☐3	☐4
20	65	I can rely on my line manager to help me with a work problem	☐1	☐2	☐3	☐4

[26] Q. No	Q. No	Questions	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
21	66	I can get help and support if I need it from colleagues	☐1	☐2	☐3	☐4	☐5
22	67	I have some say over the way I work	☐1	☐2	☐3	☐4	☐5
23	68	I have sufficient opportunities to question managers about changes of work.	☐1	☐2	☐3	☐4	☐5
24	69	I receive the respect at work I deserve from my colleagues	☐1	☐2	☐3	☐4	☐5
25	70	Staff are always consulted about changes at work	☐1	☐2	☐3	☐4	☐5
26	71	I can talk to my manager about something that has upset or annoyed me about work.	☐1	☐2	☐3	☐4	☐5
27	72	My working time can be flexible	☐1	☐2	☐3	☐4	☐5
28	73	My colleagues are willing to listen my work-related problems	☐1	☐2	☐3	☐4	☐5
29	74	When changes are made at work, I am clear how they will work out in practice	☐1	☐2	☐3	☐4	☐5
30	75	Relationships at work are strained	☐1	☐2	☐3	☐4	☐5
31	76	My manager encourages me at work	☐1	☐2	☐3	☐4	☐5

YOUR COMMENTS AND OR YOUR OPINIONS

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Thank you for your efforts.