San Pedro S.A. -
Taking the First Step to a Safer Work Environment
Santa Cruz, Bolivia

Fredrik Ölund

The Department of Mechanical Engineering
Mentors at LiU: Stig Algstrand, Matz Lenner
Mentor at CADEFOR: Per Thomsgård
San Pedro S.A. – Taking the first step to a safer work environment

Författare
Fredrik Ölund

Abstract
As a part of improving the production, the Bolivian door manufacturer San Pedro S.A. needs to develop their level of industrial safety. Today their safety level is considered to be almost non-existing. Together with CADEFOR, San Pedro wishes for a handbook that show them how to work with industrial safety, how to implement it and were to begin.

Much needs to be done at San Pedro and the task has been to show both them and CADEFOR which parts San Pedro need to focus on to increase the overall safety.

It is considered important that they chose to start with the most crucial areas but the aim is that they will, during a period of time, attend to all problem areas mentioned.

The first thing San Pedro needs to do is to form an aim for the safety work. This means setting up a policy and routines for the ongoing work. Secondly they should start working with improving the fire security, informing the personal about the risks they are exposed to. Further they should educate attendants in first aid, use the protection on the machines available and create a better luminosity environment.

Keywords
Industrial safety, Bolivia, MFS, Ergonomics, Noise, Luminosity Environment, Personal Protection, First Aid
Preface

When I first found out that I had the opportunity to go to Santa Cruz, Bolivia, I was thrilled. Not only was I to go to South America, I was also going to spend eight wonderful weeks in one of the poorest but also most beautiful countries in the world. The people I have been working together with and the new friends I have met in Santa Cruz have been warm and helpful and for that I am very grateful.

This thesis is the result of an eight week field study at Tecnocarpinteria San Pedro S.A. in Santa Cruz, Bolivia. It is a so-called Minor Field Study (MFS) and the purpose is for students from Sweden to increase their knowledge about a developing country.

The purpose of the MFS scholarship, distributed by SIDA (Swedish International Development Authority), is to give the student financial support for eight to ten weeks while making the MFS.

I would like to thank the people at CADEFOR (Sp. Centro Amazónico de Desarrollo Forestal, Eng. Amazonian Centre for Sustainable Forest Enterprise) for helping and supporting me. I would also like to thank Lennart Hågeryd, Matz Lenner, Per Larsson and Claes Moberg at the University of Linköping (LiU) for making this study possible.

I would also like to give a special thanks to my mentors Stig Algstrand (LiU) and Per Thomsgård (CADEFOR) for great support and also to the Navarra family for letting me be a part of their life for two months.

This report has been written in a very simple language since the purpose is to help a company in a country where English is not broadly accepted and spoken. Since the level of safety is very low at the company it is important to note that this thesis deals with the basics and fundamentals on how to prevent accidents and how to implement a better personal safety.

This thesis shall also work as a reference for CADEFOR when dealing with similar problems at other industries in the future.

Linköping, 2006-06-09

____________________________________
Fredrik Ölund
Abstract

As a part of improving the production, the Bolivian door manufacturer San Pedro S.A. needs to develop their level of industrial safety. Today their safety level is considered to be almost non-existing. Together with CADEFOR, San Pedro wishes for a handbook that show them how to work with industrial safety, how to implement it and were to begin.

Much needs to be done at San Pedro and the task has been to show both them and CADEFOR which parts San Pedro need to focus on to increase the overall safety.

It is considered important that they chose to start with the most crucial areas but the aim is that they will, during a period of time, attend to all problem areas mentioned.

The first thing San Pedro needs to do is to form an aim for the safety work. This means setting up a policy and routines for the ongoing work. Secondly they should start working with improving the fire security, informing the personal about the risks they are exposed to. Further they should educate attendants in first aid, use the protection on the machines available and create a better luminosity environment.
Sammanfattning

Som en del i att utveckla sin produktionskapacitet måste den Bolivianska dörrtillverkaren San Pedro höja nivån på sin arbetssäkerhet. Dagens säkerhetsnivå kan ses som nästan obefintlig. Tillsammans med CADEFOR, har San Pedro lagt en förfrågan på en säkerhetsmanual som ska visa hur företaget ska jobba mot att utveckla den interna arbetssäkerheten, hur de ska implementera den och vart de ska börja.

Mycket behöver göras för att höja säkerhetsnivån och fokus har varit att visa både CADEFOR och San Pedro vilka delar som de ska rikta in sig på för att lyckas höja upp säkerhetsnivån.

För att i möjligaste mån förenkla arbetet är det viktigt att de börjar med att ta hand om de områden som anses farligast. Målet är dock att de i slutändan att skapa, under uppsatt tidsperiod, ta hand om alla delar som nämns i rapporten.

Det första steget mot förändring är att formulera ett mål för säkerhetsarbetet. Detta innebär att upprätta en säkerhetspolicy och ta fram rutiner för hur det fortgående arbetet ska genomföras.

San Pedro bör börja med att förbättra sin brandsäkerhet och informera sin personal om samtliga risker de utsätts för av att jobba i den miljö som är på företaget. Vidare bör de så snart som möjligt utbilda några i personalen i första hjälpen-åtgärder. Viktigt är också att de verkligen använder de skydd de har tillgång till idag och att ljusmiljön i byggnaden förbättras.
## Table of Contents

1 Introduction ........................................................................................................ 1  
1.1 Background ..................................................................................................... 1  
1.2 Objective ....................................................................................................... 1  
1.3 Aim ............................................................................................................... 1  
1.4 Method .......................................................................................................... 1  
1.5 Outline ......................................................................................................... 1  

2 Frame of Reference .......................................................................................... 3  
   2.1 Fire Security ............................................................................................... 3  
      2.1.1 Documentation of the Fire Security ....................................................... 3  
      2.1.2 Seven Important Parts of the Fire Prevention Work ....................... 5  
      2.1.3 Evacuation Planning ........................................................................... 6  
   2.2 First Aid ................................................................................................... 7  
      2.2.1 Risk Assessment ............................................................................... 7  
      2.2.2 Routines and to Give Information ..................................................... 8  
      2.2.3 The Need of First Aid Attendants and Education ......................... 8  
      2.2.4 Preparing for Crisis Support ............................................................ 9  
      2.2.5 First Aid Boxes ............................................................................... 11  
      2.2.6 Eye Flushing ................................................................................... 11  
   2.3 Basic Ergonomics ...................................................................................... 12  
      2.3.1 What is Ergonomics? ...................................................................... 12  
      2.3.2 An Introduction to Anthropometry ................................................. 13  
      2.3.3 Working in the Correct Area .......................................................... 15  
      2.3.4 Lifting Heavy Objects ..................................................................... 17  
      2.3.5 Lifting Correctly ............................................................................. 18  
      2.3.6 Head and Neck Positioning ............................................................. 19  
      2.3.7 What to Consider when Improving the Workstations ................... 20  
      2.3.8 Working in Warm Environments .................................................... 21  
      2.3.9 Propositions for Improvements ...................................................... 22  
   2.4 The Importance of Light ............................................................................ 26  
      2.4.1 How to Measure Light .................................................................... 26  
      2.4.2 Light Sources .................................................................................. 28  
      2.4.3 The Daylight Factor ....................................................................... 29  
      2.4.4 General Guidelines ......................................................................... 29  
   2.5 Noise .......................................................................................................... 31  
      2.5.1 What is Decibel and How Does it Work? ....................................... 31  
      2.5.2 How Noise Affects the Human .......................................................... 32  
      2.5.3 How to Measure Noise .................................................................. 33  
      2.5.4 Maximum Exposure of Noise .......................................................... 34  
      2.5.5 Reducing the Noise ...................................................................... 34  
   2.6 Personal Protection and Health ................................................................. 36  
      2.6.1 Hearing Protection ........................................................................... 36  
      2.6.2 Safety Glasses .................................................................................. 37
6.2.3  Ergonomics ................................................................. 66
6.2.4  Light ................................................................. 67
6.2.5  Noise ................................................................. 67
6.2.6  Personal protection ................................................. 68
6.2.7  Machine protection ............................................. 68
6.2.8  What Should Be Done? ........................................ 68
7   Conclusion ............................................................... 69
8   References .............................................................. 71
  8.1  Sources ............................................................. 71
  8.2  Elecronical sources ............................................... 71
  8.3  Verbal sources ..................................................... 72
9   Appendix ............................................................... 73
Table of figures

Figure 2-A Example of an easy-to-understand sign............................................. 6
Figure 2-B shows the differences between needed heights ......................... 15
Figure 2-C shows the difference between the normal area and maximum area 16
Figure 2-D the preferred and critical areas when lifting ............................... 17
Figure 2-E shows the correct and wrong way of lifting heavy objects......... 18
Figure 2-F recommended vision area............................................................. 19
Figure 2-G shows examples on when to avoid manual transport ................. 22
Figure 2-H when to use automatic lifters or rollers ..................................... 22
Figure 2-I splitting up contents into smaller boxes ..................................... 23
Figure 2-J avoid lifts from low or high levels .............................................. 23
Figure 2-K easy ways of adjusting the height of the workstations ............. 24
Figure 2-L installing hydraulic lifters .......................................................... 24
Figure 2-M how to avoid a bad working posture ........................................ 25
Figure 2-N illustrative picture for calculating the illuminance .................... 27
Figure 2-O shows easy solutions to avoid glaring ..................................... 30
Figure 3-A inside the door manufacturing area at San Pedro S.A.............. 45
Figure 4-A shows possible evacuation doors that are nailed to the wall ..... 49
Figure 4-B a pool of water outside the building ....................................... 49
Figure 4-C shows lifting from a high level ............................................... 50
Figure 4-D shows incorrect lifting ............................................................. 50
Figure 4-E polishing the doors ............................................................... 51
Figure 4-F switching sides ....................................................................... 51
Figure 4-G a big hole in the path .............................................................. 51
Figure 4-H shows how the electric fittings at San Pedro looks ................... 52
Figure 4-I incorrect use of protection ....................................................... 53
Figure 4-J shows a machine that is not prepared for adding protection ...... 54
Figure 4-K an operator that uses a template ............................................. 54
Table of tables

Table 6-1 recommended illuminance values when performing light measurements ................................................................. 67
Chapter 1

1 Introduction
This thesis is the result of a two-month field study in Santa Cruz, Bolivia. It deals with basic industrial safety planning and its purpose is to give the reader understanding and instructions on how to develop the level of safety at companies with almost non-existing safety. This is a case study at a chosen company and therefore custom made in some areas.

1.1 Background
Tecnocarpinteria San Pedro S.A. is a woodworking company in Santa Cruz, Bolivia. The company consists of 250 employees and they are specialists in making solid wooden doors. They have recently begun working together with CADEFOR, which is a USAID consultant firm in Bolivia specialized in wood manufacturing. They consider industrial safety to be a matter of course for San Pedro to develop, as a part of increased productivity. Therefore CADEFOR wishes for a safety handbook that will help them develop the level of industrial safety at San Pedro and also at other companies in the future.

1.2 Objective
The purpose of this thesis is to give instructions on how to increase the level of industrial safety on both the facilities and for the personal at Tecnocarpinteria San Pedro S.A. The report will also work as a reference for CADEFOR when dealing with basic safety work at other woodworking industries in Bolivia in the future.

1.3 Aim
The aim of this thesis is to create a guideline on how to act when increasing the level of industrial safety at San Pedro S.A. The propositions should be realistic and economically viable.

1.4 Method
The report is mainly based on observations and measurements made in the factory. Light and noise measurements have also been done to identify hazardous areas. The Analysis will, based on literature studies, give instructions on what needs to be done and in some cases propositions on how to do it. An interview with the general manager has also been done and will give an introduction to how the company works with industrial safety.

1.5 Outline
The report will begin with the Frame of Reference in which the reader will get all necessary information concerning the conclusions made in the end. The chapter will also work as a reference when analyzing problems at other industries. The next chapter contains short information about the company San Pedro and is based on the interview made with the general manager. In chapter 4
the observations and measurements made will be presented and the chapter that follows will give the analysis based on the frame of reference. In the next chapter a discussion, mainly as a complement, of the analysis is presented. In chapter 7 the conclusions made will be presented.
2 Frame of Reference

This chapter will give the reader a better understanding of the conclusions made in the end of the report. It can also be used as a reference when dealing with and implementing safety routines.

2.1 Fire Security

One cannot evaluate the fire security just by looking at a specific object but must consider all factors concerning fire prevention. It calls for knowledge about how to work with fire security and how the company is applying it, how the fire prevention co-operate and how it acts to reduce the risks of fire. Fire prevention work needs to be continuous and done on a regular basis. Always assume that the risk of fire occurs.

Working with fire prevention this way ensures that the knowledge of how the plan works is maintained and developed within the company. The extent of the prevention plan is depending on the activities being performed in the facilities. It is also important to note that if the activities are changed one must also revise the fire prevention plans (Statens räddningsverk, 2004).

Systematic fire security work shall not only be preventive, it also needs to give instructions on how to act if a fire occurs. Note that it is still important to do everything possible to reduce or eliminate the risks of a fire occurring in the facility (Ibid).

2.1.1 Documentation of the Fire Security

Always keep records of the fire prevention work and ensure that the documentation is to the extent needed for the plans and systems to function properly. Also it is considered important that the documentation is made available for the people it may concern such as workers, production managers etc. It shall include a description of the building and the solutions concerning the fire security work. It should also include information about the activities in the facilities, how the fire prevention plan is organized and the changes made (Ibid.).

The documentation is often stored separately but can also be part of other documentation or separated if it does not reduce the understanding of its purpose.

It should be stored, if possible, close to the area it involves and should be easy to find when needed to use or revise. Be sure to work continuously with the fire prevention and upgrade the plans when needed or if changes that affect the plans are made.
In cases where different activities are being performed within the same area (e.g. Refinement, milling and drying) separate documentation should be set up at each activity area. Note that overall prevention plans is still important.

Employees that are well intimate with the activities in the organization should set up the plans and documentation. If needed, the company should hire a consultant. The Company will also need a responsible person in charge of the fire prevention work (Ibid).

The contents of the documentation are decided by the specific situation but to simplify the work some guidelines are given below:

- An overall description of the building that shows the design, position and in some cases the building materials.
- An overall description of the activities and the risks that may occur. A lay out could be needed to show where the different activities are being performed and how the risks changes.
- How the organization works. Instructions concerning responsibility, inspections and maintenance.
- Descriptions of the technical aspects of the fire preventions. The functions, installations and how it is expected to work if a fire occur.
- The possibilities of saving the facility if a fire occur together with the own personal and/or the fire department.
- Education plan and how the exercises are to be made and its content.
- When and how inspections and exercises are to be performed. Also records of the inspections and exercises made earlier.
- How to handle inflammable equipment.
- How to revise the documentation.

It is not enough to just make the documentation. The decisive work is to maintain and improve the fire security. The records are only means to give information and guidelines (Ibid).
2.1.2 Seven Important Parts of the Fire Prevention Work
When implementing and working with fire security it is, as mentioned previously, important to work systematic. The following seven steps are guidelines that deal with different parts in the implementing process and it also shows how the lay out of the documentation and organization can be done. The level of security needed and the extent of the documentation is depending on the activities. (Eskilstuna kommun, 08-03-2006)

1. Policy
Form an overall aim for the fire prevention work (Ibid). Decide how the company is going to work with it (Staffan Malmberg, 07-05-2006).

2. Responsibility and the Organization
Be sure to clear out the responsibility. Decide who is in charge of the fire prevention work and the crew members that is a part of it. Make clear the tasks and authorities. (Eskilstuna kommun, 08-03-2006).

3. Education
The employees within the organization need education to secure that everything runs as planed. Decide what kind of competence that is needed. Plan the educations and exercises (Ibid).

4. Instructions and Routines
Create routines for the different types of activities being performed (Ibid).

5. Technical Aspects on Fire Prevention Work
The fire security work should be documented. This can be made in an easy way but sometimes, depending on the activities, it has to be detailed (Ibid).

6. Controlling the Equipment and Maintenance
To ensure that the fire prevention work functions properly, it demands maintenance. This means testing the equipment (fire alarm, fire extinguishers etc) on a regular basis and also upgrade and maintain it (Ibid).

7. Follow-Up
To maintain the level of security, both the security equipment and the documentation must be followed-up and verified continuously (Ibid).
2.1.3 Evacuation Planning
The employees need to know how to act if a fire occurs. This knowledge is brought about through regular evacuation exercises. (Arbetsmiljöoverket, 2002). How often these exercises are to be performed should be decided by the company management and the employees together. The exercises can, in some cases, be replaced with equal information, e.g. information boards.

Important groups to focus on when planning an exercise is:
- New employees.
- Workers from foreign countries.
- People with handicaps.

Not only is the fire dangerous. Some materials can create a thick and poisonous smoke when burning. Therefore it is important to have good plans on how to evacuate. This means planning what kind of signs, evacuation alarm, fire doors etc. that needs to be installed.

If the company is prepared when a fire occur the risks of accidents and injuries can be reduced (Ibid).

Important parts to take in consideration when planning evacuation routes is:
- Lay out and size of the evacuation routes.
- Keeping the evacuation routes clean at every time.
- Discover the danger at an early stage (evacuation alarm).
- Giving people the knowledge about how to act and what is dangerous.
- Easy-to-understand signs that show the way to the closest evacuation door (Figure 2-A).
- Information board that shows a lay out of the factory with signs that shows the way of evacuation.
- First aid, if people are in chock or injured.
- Emergency lights (>1 lux).

(Ibid)

Figure 2-A Example of an easy-to-understand sign
2.2 First Aid

The fundamentals of improving the work environment are to prevent that a worker is exposed to accidents and injuries and also reducing the consequences of an injury, illness or equal when it occurs. The employer needs to identify the risks and make the assessments as well as taking necessary precautions. Note that even if precautions are made, it is impossible to avoid that human beings are exposed to dangers in different ways. Therefore it is important to have the necessary equipment in possession so that an injured person can be taken into immediate care and as soon as possible get the correct medical treatment (Arbetarskyddsstyrelsen, 1999).

It is also important that the persons involved in first aid attendance have the right knowledge. This calls for adequate education, e.g. stop bleedings, CPR (Cardiopulmonary Resuscitation), clearing the airways of an unconscious person etc. These exercises are an important part to consider when planning first aid equipment and attendance. This knowledge need to stay fresh which means that exercises needs to be performed on a regular basis (Ibid). Once every year at least. (Eva Ölund, 15-04-2006)

Some accidents may lead to social and psychological problems. Because of this the company has to be prepared for crises as well. This can minimize the risks of personal suffering and prevent further illness which otherwise can lead to reduced production (Arbetarskyddsstyrelsen, 1999).

2.2.1 Risk Assessment

When planning first aid equipment and attendance, one has to analyze the risks that come with working in the environment concerned. This means understanding what kinds of damages that may occur. The easiest way is to look at statistical data from both the own company and from other equal industries.

Making a risk assessment also includes knowing about the diseases that the employees suffer from such as diabetes, asthma, allergies and epilepsy. This does not mean having medication available but it may be a way to avoid further damages if knowing how to act if a worker has an attack.

The geographic location of the facility has to be taken in consideration as well (Ibid).
2.2.2 Routines and to Give Information

To be prepared for taking care of injured people includes having routines. The management or some kind of internal working improvement group needs to decide which persons that should be first aid attendants. It is important that the company organization guaranties a continuous quality and that the company adapts easily to changes because with new machines, new risks will be discovered.

Giving information to the employees is also a crucial part of the work. The workers need information on how the organization surrounding the first aid precautions works, who is in charge and who the first aid attendants are. One way is to make information boards that show easy-to-understand pictures of the first aid procedures and also photos of the attendants. These have to be understood even by a temporary visitor. The information board should have green background color and be marked with the first aid sign. It may also include a map that shows the location of the first aid boxes.

Be sure to have emergency telephone numbers written on the information board. It should include instructions on how to act when calling.

These instructions should always be mentioned when calling:

1. Your name
2. The place you are calling from
3. Kind of accident
4. Number of injured persons
5. Kind of injury or problem

Also have a routine on how to get in contact with the families of the injured person/persons, e.g. make a telephone list (*Ibid*).

2.2.3 The Need of First Aid Attendants and Education

When deciding how many first aid attendants that are needed, one needs to analyze several factors (e.g. Risks, size of the factory, temporary workstations, the spreading of workers and the distance to a hospital). The further the distance to a hospital, the greater is the need for first aid attendants, especially when it comes to bleedings, cardiac arrest and clearing the airways of an unconscious person. In matter of minutes the conditions may be worse for the worker concerned and it may lead to greater damages. Therefore it is important to have competent persons within the facility when accidents occur.
The education should be well suited for the company and its activities. Note that the need for education and first aid materials differs depending on the activities and risks. It is also important to consider the staff turnover when planning both the education and which persons that are going to be attendants (Ibid).

The first aid attendants need education and knowledge in several areas. One part is to know how to act when a highly dangerous situation occurs. Always move the injured person/persons to a safer location before performing first aid attendance. Always inform the attendants, especially in environments where highly dangerous situations may occur, of the importance of moving away from the danger before starting the first aid attendance (Ibid).

Basic knowledge in first aid attendance is also crucial. The following parts are of great importance for a first aid attendant to master:

- Securing that the injured person/persons has cleared airways.
- Knowing how to stop large bleedings.
- Cancel circulatory failure.
- Alleviate the anxiety of a chocked person.
- CPR.

Further it is an advantage if the attendants are trained in how to act when the following problems occur:

- Acute diseases.
- Head injuries.
- Neck-, back- and other skeleton injuries.
- Burns, chemical incidents and eye injuries.

This knowledge needs, as mentioned previously, to be maintained continuously. Exercises and refresher courses are needed on a yearly basis. As a complement to the courses, the company should have information boards that can work as a reference and to refresh the memory (Ibid).

2.2.4 Preparing for Crisis Support

Serious incidents may cause personal suffering and psychological problems. If these injured people get help in an early stage, they may be able to get back to work quicker.

Crisis support is about showing the persons concerned that the company cares about them. It is also about protecting the person from future illness. This calls for human compassion and letting the worker talk about what happened and share it with other people.
Information is another crucial part when dealing with a crisis. If the information is clear and easy to understand it reduces the risks of rumors and incorrect information spreading within the company. The human being has a way of adding new information and using his/her imagination when something is difficult to understand. This is why it is important to give information continuously even when the value of it may seem low (Ibid).

For people that have been exposed to a trying situation, a temporary change in tasks may be one way of dealing with a crisis. Sometimes it may be a good idea to reduce the working hours as well. Always talk to the affected person about the changes and never give him/her a task he/she can not handle (Ibid).

When a crisis may appear:

- **Working Accidents.** When a working accident occurs it is not only the person exposed that needs support. Even colleagues and people close to the injured person may need help.
- **Violence or Threat.** To be exposed for violence or threatened can be traumatic, especially when weapons are used.
- **Death of a Colleague.** To lose a colleague as a result of an accident or illness can trigger psychological problems and cause a crisis.
- **Accidents or Catastrophes Outside of Work.** Not only accidents at work may cause a crisis but also problems in the workers personal life.
- **Other Work Related Burdens.** Insults or sudden unwanted changes in work can, for some people, lead to a crisis.

To be able to give the best help needed when a crisis occurs, it is important to have routines. These routines should include information on how to act and the distributions of tasks.

Examples on how to act and things to do when a crisis appears:

- Attend to the persons concerned.
- If needed, call an ambulance and the police.
- Give first aid.
- Follow the persons to the hospital or home.
- Take care of witnesses and people that were close to the accident.
- Get in touch with the relatives.
- Inform the rest of the workers.
- Attend to the media if needed.

(Ibid)
2.2.5 First Aid Boxes
An extensive range of first aid items are available on the market but very often the first aid box can be custom made concerning the risks and conditions within the company.
As mentioned previously, the risks have to be identified before taking necessary precautions.
It is very important that the equipment is easily accessible but secure. The first aid attendants should be responsible for its content and make sure that it is changed when needed (*Ibid*).
Equipment for smaller injuries, such as plasters which the workers themselves know how to use, may be stored separately and easily accessible but separated from other items such as bandages and larger blood stoppers.

The boxes must be easy to find and therefore it is considered important to have signs or other equal equipment to make them noticeable (*Ibid*).

2.2.6 Eye Flushing
When getting foreign particles in the eyes, such as sawdust it is important to flush the eye.
When doing this, one should use a soft water flow from a flushing device. If using water be sure that it is clean. Flush the eye until the particle is gone. If it cannot be flushed away be sure to see a medical doctor.
If using contact lenses, take these away otherwise it might aggravate the damage (*Ibid*).

Three mayor conditions needs to be concerned to obtain the best result when flushing the eyes:

- Begin the flushing immediately; it may be the only way of preventing an injury. It can be a matter of seconds.
- Flush for a long time.
- Keep the eyelids wide apart.

When choosing eye flusher device it should fulfill some functions such as:

- Easy to trigger.
- Enable the possibility of not using the hands (the hands should be used to keep the eyelids apart).
- Effective flushing during an adequate period of time.
- Enable temperate water.

Also decide if the device should be attached to the water distribution system or if it is better to use separate sodium chloride solutions (*Ibid*).
2.3 Basic Ergonomics
According to IEA (International Ergonomics Association, 28-04-2006) the definition of ergonomics is:

“The scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance”.

“Ergonomists contribute to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities and limitations of people”.

2.3.1 What is Ergonomics?
Ergonomics is about focusing at the human capability and needs when designing a technological system or product. The objective is to create an environment where man and machine are working in harmony (The Ergonomics Society, 28-04-2006).

Ergonomics can be used in many ways but especially for increasing the efficiency, safety, health and productivity. For example:

- Designing systems and equipment (including computers) so that the risks of errors are reduced and the equipment is easier to use.
- Make jobs and tasks more efficient when designing them by focusing on the human needs. For example lunch breaks, sensitive shift pattern and also other factors like intrinsic rewards of the work itself.
- Designing gear and work arrangement so that it improves the posture, reduces the load on the body and lessen repetitive work and incorrect postural.
- Designing the information so that it is easier to read and understand signs, displays and handbooks. From this follows a reduced risk of errors occurring.
- Creating and designing work environments to go well with the worker. It includes an analysis of the light and heat as well.
- If necessary, creating and using personal protections in a hostile environment.

(Ibid)
Human beings can get used to unsuitable conditions but it often leads to errors, stress, inefficiency, physical or mental problems (*Ibid*). Always remember that a badly developed working place increases the risk of bad health for the employees. This may lead to reduced production and lesser qualities on the products (*Träbranchernas ergonomigrupp, 1977*).

To reduce the risk of muscle injuries, broken backs, knee problems etc. it is important to look at ergonomically principles when designing a workstation. A lot of literature is available within this area.

### 2.3.2 An Introduction to Anthropometry

Every day people use things that are specially developed for the characteristics and dimensions of the human being, such as tools, furniture etc. It is important that the working environment is designed for the capabilities of humans. A bad design may lead to bad health, safety and wellbeing. Even, as mentioned previously, it may lead to reduced production and poor quality. Always have the worker in mind when designing a work station (*Ericson, Odenrick, 1997*).

*Anthropometry* is a science in which people are focusing on the measures of the human body, especially its size, shape and parts. *Applied Anthropometry* (Sometimes *Engineering Anthropometry*) is about using data from the anthropometry science to design a product or working environment.

Fundamental questions within Applied Anthropometry are:

- What is the best design, concerning products and environments, when designing for different users?
- When is it necessary to use adjustable dimensions?

To be able to answer these questions, one needs the following information:

- The anthropometrical properties of the users.
- The restrictions that comes with these data concerning the design.
- Which criteria that applies on making an effective adaptation between the human being and the system.

(*Ibid*)

The dimensions of the human body are Normally Distributed in a population. This means that it can be described by using only two measures; the *Mean Value* and the *Standard Deviation*. Body weight and muscular strength are two examples of dimensions that differ more and are difficult to take in consideration.
When a population is normally distributed it is symmetric around its mean value, which means that 50% of the population is under the mean value and 50% over. An individual in the population that corresponds to the mean value is said to be the 50th percentile. As well as a person that corresponds to the lower 5% of the population is said to be within the 5th percentile. The 5th percentile is the individuals in a population which is considered “small” in different ways (Ibid).

In applied anthropometry there are some things that are considered fundamental, these are:

- **Enough Space for Moving**, it is necessary to take the amount of space needed in concern when designing a workstation. Here it may be appropriate to design for the 95th percentile, which is the taller people (or as well the limit which covers 95%) of a population.
- **Reach**, the distances that persons need to reach within and still maintain a correct posture. Here it is appropriate to design for the 5th percentile, which are the small individuals in the population.
- **Posture**, It is necessary to use two limits when designing for posture, e.g. between the 5th and 95th percentile. This is very important to consider when the workers are standing.
- **Muscle Strength**, This may demand two limits and needed when designing workstations that includes heavy lifts etc.

(Ibid)

Anthropometric data is also divided into *Static* and *Dynamic* data, where static data is body length, length of a limb etc. and the dynamic data is reach, enough space for moving etc. For anthropometric data of the U.S. population, see appendix A (Ibid). Note that when using anthropometric data in the design process it must be representative for the population concerned (Sanders and McCormick, 1993).

The relationship between the design of the workstation and the dimensions of the body is what decides the posture. To avoid loads it is important to take these recommendations in consideration:

- Change the posture on a regular basis.
- Avoid a bent body or head position.
- Avoid keeping the arms above the head.
- Avoid twisted and asymmetrical postures.
- Avoid letting the joints stay in an inappropriate position for a longer period of time.
- Always have a back support when sitting down.
- When using a high amount of strength, make sure the part of the body that works is in the position that provides the best strength.
- Avoid high pressures on sensitive tissue when support is used (Ibid.).
- Rotate between the workstations (Träbranchernas ergonomigrupp, 1977).
If the workers follow these guidelines it will keep them stronger and more alert during the spell of duty since the supply of blood to the muscles is more constant (Ibid). Note that no posture that can not be adapted naturally is dangerous. The risks appear when a worker regularly or within a longer period of time adapts an unnatural posture (Arbetarskyddsstyrelsen, 1998).

The possible muscle strength applied when performing for example a heavy lift or pushing is not always depending on the pure strength of the muscles but is also on the working posture. This means that even though it may be difficult one needs to consider and plan the workers posture when designing a workstation (Ibid).

2.3.3 Working in the Correct Area

When working in a standing position the posture is very often decided by how high or low the workstation is. If the station is high the arms must be held in a high position and thereby create load on the shoulders. It also complicates the use of high force in a downward direction. If the workstation is too low the worker will have a bent back or/head which will lead to other damages on the body (Ericson, Odenrick, 1997).

It is important to distinguish between what height is needed when performing different kinds of jobs. The following directions can be used as a reference:

- **Precision Work**, 50-100 mm over the height of the elbow.
- **Light Manual Work**, 50-100 mm under the height of the elbow.
- **Heavy Work**, (especially if it demands a use of high force in a downward direction) 150-400 mm under the height of the elbow.

Figure 2-B shows the differences between needed heights

Always have in mind that the workstation may be used by people in different sizes. In these cases an adjustable station may be proper (Ibid).
Always consider the horizontal work surface area if a worker is seated or "half-seated" (Ibid). Sanders and McCormick (1993) says that when analyzing the horizontal surface it is regarded to focus on the width of the arms. They propose that the reach of the arms has two limits; the Normal Area and the Maximum Area (see Figure 2-C).

- **Normal Area**, this area is reached with a sweep of the forearm with the upper arm in a natural hanging position.
- **Maximum Area**, this area is reached when the arm is extended from the shoulder.

Figure 2-C shows the difference between the normal area and maximum area

Further they say that if the bench is slightly tilted when working the effect is that the worker keeps a straighter neck which reduces the risks of injuries (Ibid).
2.3.4 Lifting Heavy Objects

Manual lifting may lead to back and knee injuries. When performing a lift, the load on the body is highly dependent on the weight of the item being lifted and the distance between the body and the item. The risks can be divided into three categories:

- *Damages by Accidents*, such as dropping the item or slipping.
- *Overloads*, is the result of lifting materials that are heavy.
- *Cumulative Damages*, comes from repeated lifting.

Heavy lifting related body damages are serious problems both for the employee and the employer since the worker has to be away from work for a long period of time (*Ericson, Odenrick, 1997*).

The National Institute of Occupational Safety and Health (2006-08-03) say that it is best to handle heavy materials between the knees and shoulders. The worst scenario is below the knees, above the shoulders and distances more than a forearm from the body. The workers should not bend down low or lifting high. Figure 2-D shows the preferred and critical areas when lifting.

Also consider the weight of the object being lifted. According to the Swedish Work Environment Authority (1998) it is unsuitable to handle objects heavier than 25 kg manually regardless the strength of a person.

![Figure 2-D](image)

Figure 2-D the preferred and critical areas when lifting
2.3.5 Lifting Correctly

It is important that the workers lift objects correctly to avoid damages. The Oklahoma State University (2006-04-28) mean that when lifting heavy materials in an awkward posture added with other factors such as uneven footing and poor balance is an invitation to eventual injuries. This is because of the unnecessary strain that is applied on the back and abdominal muscles. Further they say that the following guidelines are to be observed when lifting:

- Consider the distance to carry and the weight of the object, decide if help is needed.
- Analyze the area before lifting, look for:
  - Risks of tripping,
  - Risks of slipping,
  - Small doors,
  - Sharp edges,
  - Blind spots etc.
- Be sure to place the feet correctly, both stability and strength must be considered.
- Keep the object close to the body.
- Be sure to get a good grip, avoid using only the fingers.
- Be sure to tuck in your chin so that it creates an alignment from head to pelvis.
- Use the legs when lifting not the back.
- Act the same way when lowering the object.
- Never twist the body when it is under stress, always turn the whole body when changing position.
- Use a coordinator when lifting heavy objects as a team.

(Ibid)

Figure 2-E shows the correct and wrong way of lifting heavy objects

Correct

Wrong
2.3.6 Head and Neck Positioning
The head and neck positioning is determined by the degree of vision needed for the work concerned. Different studies show that the most restful angle is 15° below the horizontal eye vision. The angle that supplies most advantages is 30° below. The area may increase if the neck is slightly tilted. (Ericson, Odenrick, 1997).

Figure 2-F recommended vision area.
A: Minimum comfortable viewing distance: 500 mm
B: Resting line of sight
C: Horizontal line of sight
D: Preferred display zone
E: Acceptable display zone
2.3.7 What to Consider when Improving the Workstations

There are a lot of ways to increase the level of ergonomics and avoiding different kinds of work related injuries. For example when working in a standing position:

- Make sure that the workstation has the appropriate height
- If heavy material needs to be lifted, design the station so that the workers always work with straight a back.
- Make the station adjustable if needed.
- Be sure that the ground, on which the workers stand, is stable, easy-to-clean and non-slippery. Use a rubber carpet or similar.
- Build or use standard platforms (e.g. pallets) for individual fitting of the employees. Be sure to paint the edges on the platforms to avoid accidents such as tripping.
- Arrange enough space for the legs and feet.
- Be sure to rest seated during the breaks.

*(Träbranchernas ergonomigrupp,1977)*

The purpose is to create a safer environment that improves the working posture and movement to avoid:

- Work related injuries.
- Uncomfortable working conditions.
- Physical inactivity.

A correctly designed working area should provide a good moving pattern for the worker. A good moving pattern is distinguished by:

- An easy and natural rhythm.
- Soft moving curves.
- Using the “living force” within the work piece.
- Simultaneous and symmetric movement of the arms.
- The reach is within the correct area (see chapter 2.3.3).

Having breaks is an important part of the work. During the breaks the employees are given an opportunity to rest strain muscles if they have been standing or activate the body if they have been seated. This way the workers will stay more alert during the working hours (*Ibid*).
Chapter 2

Sometimes it is not possible to change a certain working area because of technical issues or equal so that the related injuries disappears. The best way to avoid damages in these situations is to let the operators rotate between the workstations. The time between the rotations should be, from a physiological point of view, 30 minutes to two hours. When introducing rotation the employer should:

- Inform about why the company introduces rotation.
- Enable education and practice.
- Consider the risks of accidents during the introduction period of the new machines.
- Take one step at the time. Start gentle by having two workstations for the employee and then expand.

2.3.8 Working in Warm Environments

The human being is sensitive of heat variations when it differs from the ideal temperature. Even small changes may lead to discomfort. Since the body reacts to heat this way, hard work combined with heat and a high degree of humidity is harmful in several ways. Heat can also lead to headache, feeling of sickness and irritableness etc.

Different persons react different to heat. Persons with heart problems, kidney problems or overweight are extra sensitive.

When sweating, the body loses a lot of water and some salt. This is easily compensated by drinking water. Extra salt is not normally needed since it is added when eating (Arbetsmilvöverket, 2006-03-13) but just drinking water and never add salt can be lethal (Eva Ölund, 15-04-2006). To prevent the loss of water one should drink much water even if not thirsty. Thirst is not an indicator of how much water that needs to be added. A rule of thumb is to drink until the feeling of thirst disappears and then add just as much.

Since heat affects both body and mind the work tempo decreases to lower the body temperature. Both attention and judgment gets worse which increases the risks of injuries and misjudgments.

This leads to the conclusion that by creating a good indoor climate, the company makes sure that the productivity and quality stays on top (Arbetsmilvöverket, 2006-03-13).

To reduce the warmth in the facility, one could make several measures to obtain a better working environment. For example reduce the income of sunlight, shelter heat gaining machines or if possible move them to another location. Also consider to shut off machines that are not used for that day. The change of air can be temporarily obtained by open windows. Always air on the side of the building that has a shadow, otherwise the temperature inside may increase instead of decrease. Sometimes it can also be wise to let the ventilation run during the night since the temperature is lower during these hours. This enables the cooler night air to cool down the facility frame and hopefully it stays colder for a longer period of time (Ibid).
2.3.9 Propositions for Improvements

This chapter will give some propositions on measures that may work as guidelines when improving the workstations.

Transports

Always avoid manual transport of materials if:

- Great force is needed.
- The object is difficult to grab (e.g. too big).
- The objects are heavy.

Figure 2-G shows examples on when to avoid manual transport

(Träbranchernas ergonomigrupp, 1977)

In these cases try to use technical tools when moving the material such as:

- Trucks.
- Fork lifters.
- Roller conveyers.
- Winches.
- Carts.

Figure 2-H when to use automatic lifters or rollers
It is possible to make the items easier to handle by:

- Adding handles.
- Splitting its contents into smaller boxes (*Ibid*).

![Figure 2-I splitting up contents into smaller boxes](image)

*Packaging, Polishing and Processing*

Avoid lifts from high or low levels by:

- Having limit restrictions when piling material.
- Using technical equipment such as lifters.
- Use adjustable carts or similar to simplify transference of objects.
- Install automatic pilers.

![Figure 2-J avoid lifts from low or high levels](image)
Adjust the height of the workstation for the workers by:

- Making the workbenches adjustable.
- Using pallets as platforms for smaller people to stand on.
- Building and using custom made platforms in modules for individual fitting (*Ibid*).

![Figure 2-K easy ways of adjusting the height of the workstations](image)

Create a flexible, non-slippery and firm surface to avoid damages by:

- Using wooden pallets to stand on.
- Rubber carpets.
- Good working shoes.

Avoid manual turning of heavy or hard-to-grip material by installing hydraulic lifters in the benches (*Ibid*).

![Figure 2-L installing hydraulic lifters](image)
Avoid bad postures when working because of:

- Difficulties of reaching within the working area.
- High stations.
- Lifting heavy manual tools.
- Keeping tools in a hard-to-reach place.

Instead try to:

- Build flexible fixtures for the work piece. Create flexibility by making it adjustable in height and easy to tilt.
- Hang the tools in spring balancers (Ibid).

![Figure 2-M how to avoid a bad working posture](image)

If possible, organize the work so that it can be made both seated and standing and implement rotation in work.

(Ibid).
2.4 The Importance of Light

The human being mainly gets its information about the environment through the eyes. With the sight one can decide the size, shape, color and movement of an object and also the distance to it.

It is important that the workers are given a good luminosity environment so that tiredness, headache etc is prevented. The need for light is different depending on the task being performed but it is essential when preventing accident and increase achievements (Akselsson. R, Bohgard. M, Johansson. G, Swensson. L, 1997).

It has been proven that better light increases the production (Sanders and McCormick, 1993).

The eye is complex and the most advanced instrument when it comes to analyzing the environment and its light. Young people often have better vision than old people but the vision also differs much between persons in the same age. This is why it is important to take different people in consideration when planning the light (Ibid).

Creating a good luminosity environment is complex because of its many parameters such as individual planning, task and environment. To simplify the work, general guidelines have been made which are to be presented later in this chapter (Ibid.).

2.4.1 How to Measure Light

Light is a kind electromagnetically radiation where the wavelengths between 400-700 nanometers is visible for the human eyes. When the light reflects on an object and then bounces to the human eye the colors of the item becomes visible (Wikipedia, 2006-04-15; Akselsson. R, Bohgard. M, Johansson. G, Swensson. L, 1997).

When measuring light (scientific word: Photometry) a lot of terms and units are used but one of the most fundamental quantity is Illuminance (has the unit Lux) which is the energy of the light per square meter (Sanders and McCormick, 1993).

When measuring lux a special measuring instrument, a Lux Meter, is used. The Lux Meter contains of a photo detector which is to be put on the surface being measured. The instrument returns values of the illumination perpendicular to the surface. If measured on a horizontal surface it is called the horizontal illumination (note that it is a vertical component since it is perpendicular) and when it is measured on a vertical surface (the horizontal component) is called the vertical illuminance (Akselsson. R, Bohgard. M, Johansson. G, Swensson. L, 1997).
Theoretically it is possible to calculate the flow of light from its sources due to requirements considering the illuminance. This is on the other hand difficult since a lot of parameters have to be included. It can be made with a simple method called the *Point Method*. The illuminance on a horizontal surface is given by:

\[
E_h = \frac{I_\alpha \cos^3 \alpha}{h^2}
\]  

(1)

\[ L = \frac{h}{\cos \alpha} \]  

(2)

Where:

- \( I_\alpha \) is the luminous flux (the energy of the light) [lm]
- \( E_h \) is the illuminance measured in lux [lm/m²].
- \( h \) is the vertical height between the source of light and the station concerned.
- \( \alpha \) is the angle between the perpendicular line from the surface and the vector of \( I_\alpha \) or as well the angle between the vectors \( E_h \) and \( I_\alpha \).

\[ A \] is the source of light.

\[ B \] is the workstation.
The method has some restrictions since the source of light is a point and does not consider reflections from walls, roofs etc. Using specially designed software simplifies the calculating and makes it more accurate (Ibid).

2.4.2 Light Sources

The design and indoor color of the facility, the choice of electric fittings and its placing is of great significance for the luminosity environment. This is an important part for the illuminance, origin of shadows and reproduction of colors. The energy consumption and the economy are also factors that are important to consider.

The two types of artificial light (light that is not naturally distributed) sources often discussed are the **Incandescent Filament Lamp** (the most common type is the **Fluorescent Lamp**) and the **Light Bulb**. The Fluorescent Lamp lasts ten times longer than the Light Bulb and has ten times the exchange of light [lm/W]. (Ibid).

One problem that may occur with fluorescent lamps is the flickering. This may cause irritation and annoyance. Be sure to shield the edges which often flicker and change the lamp immediately when flickering in an unnatural way.

The electric fittings are important to consider when designing the luminosity environment. The fittings are to direct and divide the light and be designed so that glaring is avoided.

The expressions **Light on Spot** and **Overall Light** are important to consider when planning luminosity environment (Ibid).

Light on Spot is the light that supports the individual worker at his/her workstation. It should be directed individually and give enough light needed but not glare the employee. It should be considered as a complement to the overall light.

Overall Light is often the light coming from the electric fittings in the ceiling. They should have reflectors to optimize the exchange of light and also be equipped with shields to avoid glaring.

In facilities with a high amount of air pollution the light may decrease and the fittings will be dirty (Ibid).

The placing of the electric fittings should be well suited for the activities in the facility. When installing the fittings the easiest way is trying and measuring until the proper and wanted values are achieved (the “trial and error”-method). Always consider objects such as overhead cranes etc. when installing the fittings. Place them so that they are reached easily when needed to be cleaned or the lamps have to be changed (Ibid).
2.4.3 The Daylight Factor

The human need for daylight is depending on a lot of factors like for example a lot of the biological functions of the body is run by sun light. The outdoor contact also gives a lot of practical information such as the weather and time of the day that the humans are depending on even if being unaware of it (Ibid). The *Daylight Factor* is the relationship between the indoor light on a chosen spot created by the sun and the outdoor light. The relationship is described in percentage.

This is mathematically illustrated as:

\[ \Delta = \frac{E_{h,\text{indoor}}}{E_{h,\text{outdoor}}} \cdot 100, \text{ } \Delta \text{ is the Daylight Factor } [\%] \]  

(3)

The daylight factor should be at least 1% (\( \Delta \geq 1 \)) and measured halfway into the room and one meter from the side wall (*Ejhed, 1996*).

2.4.4 General Guidelines

Avoid glaring is important since it may be disturbing for the worker. Glaring is defined in four ways:

- *Direct Glaring*, from light source.
- *Indirect Glaring*, reflection from shiny materials.
- *Contrast Glaring*, glaring because of luminous flux differences in the field of vision.
- *Adaptation Glaring*, glaring because of fast changes between light and dark.

The overall light should be spread in a diffuse way and not be directed. Shiny objects should not be placed so that they reflect the light in an unnatural way. Note that machine tables often are shiny. Place the source of light so that it does not reflect or paint the tables in non reflecting colors.

Try to install the electric fittings in a way that ensures the same level of illuminance throughout the whole facility. Changes in light may be irritating for the eyes (*Akselsson, R, Bohgard, M, Johansson, G, Swensson, L, 1997*). Try to use colors on walls and ceilings that improve the overall luminous flux. If they are painted with bright colors, less power from the light sources is needed (*Ibid*).

When planning and installing the electric fittings it is important to consider the maintenance of them. The company should have routines for how to change lamps and when to clean the fittings. If it is too hard to perform these operations it is possible that it is done less often which will decrease the level of light (*Ibid*).
Frame of Reference

Daylight is needed for a number of reasons but can also be a major problem. Badly designed windows may cause the sun to glare the workers and also create annoying shadows. This is important to consider when planning the luminosity environment (Ibid).
Try to avoid these risks by using technical solutions. See Figure 2-O for propositions (Ejhed, 1996).

The amount of illuminance needed is different depending on the activities. Here are some rules of thumb for the lowest level of light:

- Corridors: 100-200 lux
- Halls: 300 lux
- Workstations: >300 lux

(Fagerhult, 2006-04-13)

When considering the workstations a rule of thumb is that the smaller the details are that needs to be focused on, the better the light have to be (Akselsson. R, Bohgard. M, Johansson. G, Swensson. L, 1997).
2.5 Noise

Humans are exposed to sound everyday but it is important to know the differences between wanted and unwanted sound. Unwanted sound, or noise, is often depending on time of exposure, if the sound is meaningless or if it is too loud. The level of sound is measured in decibel [dB] (Akselsson. R, Bohgard. M, Johansson. G, Swensson. L, 1997).

2.5.1 What is Decibel and How Does it Work?

Decibel is a logarithmic unit and used to describe a ratio between to objects, for example two speakers with different power but the same sound. The ratio can be power, sound pressure, voltage or several other things. When using pressure, $p$, as a reference, which is very common, decibel is defined as:

$$20 \log \left( \frac{p_2}{p_1} \right) dB,$$  \hspace{1cm} (4)

(University of New South Wales, 2006-03-20)

Where $p_1$ is the reference and $p_2$ is the measured value. As seen in the definition, decibel is a quotient and works the same way as percentage.

When concerning power, $P$, it is important to note that the power in a sound wave goes to the square of the pressure which can be shown as:

$$\frac{P_2^2}{P_1^2} = \frac{P_2}{P_1} \rightarrow 20 \log \left( \frac{P_2}{P_1} \right) dB = 10 \log \left( \frac{P_2}{P_1} \right)^2 dB = 10 \log \left( \frac{P_2}{P_1} \right) dB$$  \hspace{1cm} (5)

(Ibid)

Since decibel is a logarithmic scale it is important to note that when measuring the noise, small differences on a meter can mean huge differences in sound. If the sound level is doubled it is only a step three on the decibel scale.

(Sagitta, 2006-02-20)

This can easily be described mathematically as:

$$P_1 = 10, P_2 = 20$$  \hspace{1cm} (6)

$$10 \log \left( \frac{P_2}{P_1} \right) = 10 \log(2) = 3 dB$$  \hspace{1cm} (7)

(University of New South Wales, 2006-03-20)
2.5.2 How Noise Affects the Human

The worst effect that comes with noise exposure is temporary or, the worst scenario, permanent hearing impairment. The damages often develop during a longer period of time and are not noticed until years of exposure to normal noise levels. A typical hearing impairment begins with a reduction of the frequencies between 4000-6000 Hz and later on in the lower frequencies.

The loss of hearing in this interval will cause difficulties to understand toneless consonants when listening to speech.

When exposed to substantial noise the first step is a temporary hearing impairment which may cause a low murmur and reduced hearing. This could be a way for the ears to protect themselves but can also be the beginning of a permanent hearing reduction. Very substantial noise, especially loud impulses, often leads to a quick and permanent hearing impairment.

Damages that comes from a long exposure of normal noise levels often destroys the hair cells in the ear while substantial noise will cause mechanical damages of the inner ear (Akselsson. R, Bohgard. M, Johansson. G, Swensson. L, 1997).

When people get exposed to noise a lot of physiological reactions occur. The reactions are depending on the sound level, the changes in the sound levels, if the sound brings some kind of information or if the sound is expected or not. When a sudden change in the sound level occurs, especially if it is unpredicted, the brain reacts quickly. The pulse and blood pressure decreases, the pupil expands, the flow of blood to the fingers becomes lower and the glands that produces sweat is activated. The brain gets used to these sudden changes after a while and the reactions described will decrease.

If exposed for substantial noise the reactions are stronger, the pulse increases and the brain does not accustom to the changes.

The only way for the body to adapt to such an environment is to produce stress hormones (Ibid).

Other symptoms that occur when exposed to noise are:

- Headaches.
- Sleeping Disorders.
- Permanent high Blood Pressure.
- Psychosomatic Deceases.
- Tinnitus.

Another problem that takes place in noisy environments is when wanted sound, e.g. alarm signals or speech, disappears. Especially the risk of not hearing an alarm signal can be very dangerous (Ibid).
2.5.3 How to Measure Noise

The most common way of measuring noise is by using a Sound Level Meter. When using a Sound Level Meter to measure the level of noise, of which the workers are exposed to, always use a meter with a dB(A) filter. The dB(A) filter corresponds well to the same frequencies as the human ear (WorksafeBC, 2006-03-18). Sometimes a dB(C) filter may be used which is specially attended to high levels of sound (Wikipedia, 2006-04-15). Note that a sound level meter hardly ever contains a frequency meter and different frequencies may affect humans.

When measuring noise one must consider two things: The Level of Sound and the Time of Exposure, even if it may be difficult. To estimate the time of exposure correctly it is necessary to use a specially designed Sound Level Meter (a Dosimeter) which is attached to the worker during the day (WorksafeBC, 2006-03-18).

The measurements are used to determine:

- The sources of dangerous noise.
- Which workers that need hearing protection.
- Dangerous workplaces to be considered risk areas.

The first step when analyzing hazardous noise areas is making Area Noise Measurement and Spot Measurements. Area noise measurements are when measuring the general noise level in a work area and spot measurements are when measuring close to a running machine. Note that these methods are not providing data on the length of exposure (Ibid).

Before making the measurements the meter should be checked or field calibrated. Calibrating the equipment before making a survey ensures that the data delivered is more accurate. A complete calibration of the meter is needed every two years and should be done in a certified laboratory.

When performing the measurements, made with a sound level meter, it is important to ensure that it provides the correct level of sound of which the worker is exposed to. To guarantee this one should measure close to the ear of the worker concerned (Ibid)

Always redo the measurements when:

- New machines are installed or remaking the internal flow.
- The conditions are changed and cause changes in sound level.
- Changes are made in the building structure (e.g. removing a wall).
- The time of exposure changes (e.g. longer working days). (Ibid)
2.5.4 Maximum Exposure of Noise

According to the Swedish Work Environment Authority (Arbetsmiljöverket, 2005) the maximum exposure of noise is 85 dB(A) over an eight hour working day. If the level of noise is 85 dB(A) or higher during these hours, hearing protection must be used (WorksafeBC, 2006-03-18). If peaks or impulse sounds (measured with dB(C) and time < 50 µs) is below 135 dB it is still considered to be acceptable.

If the sound level is 80 dB(A) or higher (<85 dB(A)) the employees should be given the opportunity to use ear protection even though it is not considered to be dangerous (Arbetsmiljöverket, 2005).

As mentioned previously the decibel scale is logarithmic and a doubling of the sound level is only a step three on the decibel scale. This is also known as the “3 dB doubling”. Appendix B shows the relationship between maximum time of exposure and the chosen level of sound (WorksafeBC, 2006-03-18).

2.5.5 Reducing the Noise

Reducing the noise is important in several aspects and should be done systematically. When dealing with noise reduction one should consider:

- To reduce or eliminate the noise by the source.
- Preventing the noise from spreading.
- The use of ear protection.


Reduce the Noise by the Source

The most important noise reduction method is reducing the noise by the source. Making this possible ensures that noise problems do not occur. This is often made through new mechanical designs, new materials and/or combinations of materials, redesigning shields, cups and protection etc.

Unwanted sound is usually created through transference of energy. A rule of thumb is that the faster the transference of energy, the higher the pitch and the higher the level sound.

Reducing the noise can be achieved through reducing vibrations or making the process slower (Ibid).

Prevent Spreading of Noise

To prevent the noise from spreading it is necessary to look at the design and technical aspects of the facility concerned. Ways of doing this could be installing vibration dampers on the machines or shielding them, using sound absorbing shields or by redesigning the facility with other materials. A rule of thumb is that the harder the walls and ceiling, the more the sound bounces (Ibid).
Using Ear Protection

Ear protection should never be seen as a permanent solution. The primary objective is to reduce the noise by the source but in some cases it may not be possible to perform this. In such cases ear protection should be used but long-term use should be avoided.

Letting the workers rotate between the stations can solve this.

If the use of ear protection is permanent, hearing test should be done once in a while to see if damages are occurring (Ibid).
2.6 Personal Protection and Health

Sometimes it may be impossible to create a working environment that is perfectly safe for the workers. In these cases the use of personal protection should be better in order to prevent injuries and other work related problems in the future.

2.6.1 Hearing Protection

Sometimes reduction of noise is difficult and the use of ear protection may be the only way to protect the ears. Hearing protection must be used if the level of sound exceeds 85 dB during an eight-hour working day.

The main types of hearing protection are Earplugs and Earmuffs. These reduce the noise but that also mean reduction of all sounds. Even sound that is wanted or needed such as speech and warning signals (WorksafeBC, 2006-03-18).

Earplugs are inserted in the ear canal and works buy blocking it. Canal Caps are also available and are a type of earplug that seals only the opening of the ear canals. If the earplugs are properly inserted no irritation or problem should occur but if done poorly the proper reduction of noise will not be obtained and discomfort may arise.

Always inform the workers individually about how to insert the plugs so that they dampen properly. Earplugs are available in several models and sizes (Ibid).

Earmuffs cover the entire ear (if not, the wrong size is used). The domes must cover the entire ear for proper seal. Never modify the domes such as making holes or equal. Note that the use of safety glasses or having facial hair may cause difficulties to achieve proper seal. Be sure to obtain enough pressure from the headband so that the muffs work properly.

Selecting proper hearing protection is not complicated but some factors need to be concerned:

- Ensure that the protection reduces the noise below 85 dB(A) but not below 70 dB(A). Below 70 dB(A) may give the worker a feeling of being isolated.
- Use protection that render possible communication where needed.
- When combined with other protective equipment it must be comfortable to use.
- Earmuffs are often used in cold environments and earplugs in warmer.
- Earplugs do not suite everybody since the size of the ear canals may be different. People with large ears or head may have difficulties when using earmuffs.
• People with ear problems such as chronically ear infections should use muffs and people with external ear problems such as eczema should use plugs. 

(Ibid)

The employer should provide different types of ear protection since there is no model that suits everybody. Doing this ensures that the protection is worn correctly and not likely removed because of an uncomfortable model.

Note that hearing protection is not to be repaired if damaged but should be replaced immediately.

Be sure to clean the ear protection for longer lifetime and also for better hygiene. Clean the plugs with soap and water and never use alcohol or other solvents.

Never leave earmuffs outside since insects may nest in them (Ibid).

2.6.2 Safety Glasses
Eye damages are often caused by flying particles, dirt or dust. These accidents can easily be avoided by using safety glasses. Even small accidents are important to take seriously since it may lead to greater damage. Many models are available and some are very close to ordinary glasses. When choosing models it is important to look at models equipped with side shields and reinforced glass. Safety glasses that cover all the edges are also available. When choosing safety glasses always remember to ensure that they fit correctly and provide the correct protection (Konsumentverket, 2006-03-01).

2.6.3 Respiratory Protection
Many employees are daily exposed to airborne dangers. Dust, fibers and mists may cause irritations in the nose, the upper airways and in the throat. Small particles may enter the lungs and cause damages on the tissue and complicate breathing. Being exposed to fine particles may also provide asthma, silicosis, asbestosis and nasal cancer (from hard wood).

When exposed to gases and vapors, the substance inhaled may cause irreparable damage to the brain, liver and kidneys (3M, 2006-04-03).

Respiratory protection equipment is available in many models depending on the process it is needed for. Sometimes its applications overlap but no model is universal. Therefore it is important to know about the limitations of the masks.
First a risk assessment should be made to see what kind of hazards the workers are exposed to. Then it is necessary to analyze what kind of protection that is needed for the environment concerned. When choosing equipment one should always be aware of that every employee looks different concerning the shape of the head, facial hair etc. Always have these guidelines in mind when choosing respiratory protection equipment:

- Size and shape of the head.
- Facial hair.
- Work rate and environment.
- Time it should be worn.
- Physical shape of the workers.
- Visibility when worn.
- If compatible together with other protection equipment.
- Contamination.
- Mobility.
- Heat exhaustion and sweating.
- Possibility to communicate.

(Ibid)

When the correct equipment has been chosen it is necessary to educate and inform the employees in the proper use, maintenance and care of the mask. The workers should be aware of the risks they are exposed to if they do not use the protection. Always give instructions on how the mask is to be attached correctly to the face to obtain maximum safety. The masks always have limitations of which the employees must be aware.

Always chose a mask that supplies the proper protection and is comfortable for the user (Ibid).

### 2.6.4 Working Shoes

No working area necessarily looks like the other. Even if two persons are working in the same facility, the conditions may be different. Small details like the hardness of the floor, the postures and the shape of the foot are important to have in mind.

When walking, the foot is applied with a load of 100-150 % of the body weight. With the correct shoes the load will be reduced not only on the feet but also on the knees and back.

A lot of people buy cheep sandals because they are easy to put on and gives the feet the opportunity to “breathe”. This may cause serious body damage (Jobi, 2006-05-16).
Working shoes are used because of:

- They reduce the load on the body.
- The workers stay more alert.
- Maintains a better health.

When choosing working shoes it is necessary to ensure that:

- The load is applied correctly on the foot and that it does not slide.
- The sole is stable, feathering and bowl shaped.
- The shoes have stable heels.

(Ibid)

2.6.5 Working Gloves

The hands are often the primary tools of the workers. They are irreplaceable and need good protection. Working gloves provide good protection when exposed to the hazards that arise when working manually.

When choosing gloves one should consider:

- The material and the performance.
- Size and fitting.
- Reliable standards.

The choice is always a compromise between the desirable qualities such as safety, price and durability. Furthermore it should not cause other problems like allergic reactions or similar.

One way is to make a checklist of the needs to make the purchase easier.

Every company should have different models and sizes available so that the employees may chose and find a model that suits them well.

Working gloves comes in different materials and has different qualities. Try to find gloves that:

- Does not cause new problems.
- Does not irritate the skin or cause allergic reactions.
- Have a variety of sizes for maximum fit.
- Provide good finger movement.
- Render possible the appropriate protection.

(Byggindustrins Centrala Arbetsmiljöråd, 200605-15)
2.6.6 Working Clothes
Working clothes is significant for the effectiveness and safety within a company. It also gives a worker the feeling of belonging. The clothes should be comfortable, good-looking and be well suited for a tough environment. The material must be strong but should not itch or be difficult to maintain (PDWorld, 2006-05-16).
2.7 Machine Safety

When dealing with safety procedures one can not only attend to the operators but must also consider the equipment used by them. Necessary precautions must be taken where hazards can not be eliminated through the use personal protection.

2.7.1 Information

The tools that are used when working or the products being made at the machines must not place the worker in unnecessary danger. It should not be possible to work incorrectly by the machines but sometimes that is hard to counteract. When such occasions occur it is important to inform about how to act (Arbetarskyddsstyrelsen, 1993).

All working equipment must have all the warning- and information signs needed to inform the operator about the safety risks (Arbetarskyddsstyrelsen, 1998). It is important that all information available and needed on the machines is easily understood and can only mean one thing. On the other hand it shall not be extensive so that it affects the operator in a negative way (Arbetarskyddsstyrelsen, 1993).

2.7.2 Starting and Stopping the Equipment

Machines shall only be started if activated intentional. For this a particular device tools should be used. If several device tools are used to start a machine it should not be possible for the operators to expose each other of danger.

The machines also need to have a device for stopping the machines completely. The device for stopping the machine must be superior to the start mechanism and the machine must never start if the stop mechanism is activated (Ibid).

Emergency Stop

All machines must be equipped with one or several emergency stop buttons except for automatic hand tools. The emergency stop button must:

- Be easily identified.
- Be easy to reach.
- Be easy to find.
- Stop the dangerous course of events quickly.
- Not create new hazards.
- Stay in pushed-in position until released.

If the machines have a computer based operating system the emergency button must be superior as well (Ibid).
Note that the emergency stop button shall not disconnect the power to other needed equipment during the emergency situation (Arbetarskyddsstyrelsen, 1998).

2.7.3 Stability
The machines must be stable so that they do not tip over, fall or get into sudden movement. If the shape or installation of the machine does not ensure stability it needs to be attached to the floor or a wall (Arbetarskyddsstyrelsen, 1993).

2.7.4 Protection
When the risk of flying or falling objects is imminent, precautions needs to be taken. Moving parts on the machines must be supplied with protection so that accidents are easily avoided. Protective devices that are used to ward off possible accidents are to be chosen after making a risk assessment. The characteristics of the hazards must be analyzed to ensure that the correct protection is used (Ibid).

When choosing protective devices one should follow these guidelines. The design must:

- Be sturdy and stable.
- Not cause new risks.
- Be hard to evade or be put out of function.
- Not limit the general view of the process.
- Render possible maintenance, new installations and the shifting of tools to be made easy.

One must also consider what type of hazards that the protection is to prevent.

Moving Transmission Parts
Protection that is used to protect the operators from risks that arise from moving transmission parts (gear wheels, straps etc) must:

- Be fixed and only to be opened with a tool or
- If absolutely necessary, be detachable but supplied with a stopping mechanism to prevent the machine from running without protection.

(Ibid)
Detachable protections shall only be used if considered important to often enter these parts. Detachable protection has some restrictions, they should:

- Still be attached to machine when opened.
- Be supplied with a mechanism that stops the machine if opened.
- Be adjusted only if affected by human force.
- Protect against flying objects.

Moving Parts Used in Production
Protection devices that are meant to protect exposed operators against the risks of moving parts within the production process are:

- If possible, to be fixed.
- To be detachable if needed and meet the requirements mentioned above.
- To render possible manual adjusting when working.
- To be adjusted easily without tools.

(Ibid)
3 San Pedro S.A.

This chapter will give the reader some information about the company on which the study has been made. It is mainly based on an interview with the general manager. The questions asked are presented in Appendix C.

Tecnocarpinteria San Pedro is a joinery shop in Santa Cruz specialized in making solid wooden doors. The company has existed for 32 years and during this period they have had the same owner, Mr. Jorge Paz, but are managed by his son, Mr. José Eduárdо Paz.

San Pedro consists of 250 employees of which 130 are working in the door production area. They are producing 35-40 different door models in different woods and sizes.

Their aim is to increase the production and hope to move to a better location to improve the conditions.
3.1 Problems
Mr. José Paz agrees that a higher level of industrial safety is a part of better production but he sees several difficulties based on his experience. He finds it hard to accept that the employees are exposed to injuries but on the same time he finds it difficult to persuade them to use protection. He says that the workers do not like to use protection whether it is personal protection or on the machines. The employees say that it is a waste of time and since the company struggles to sell their products they choose to accept it. Further Mr. Paz says that it is difficult to be strict towards poor people. Their social situation is tough and he wants them to enjoy their work and to feel that they are a part of the company.
Other problems are that the workers often lie and that their advanced planning often is on short period of time. Sometimes the workers arrive drunk at work and that is hard to discover. Mr. José Paz claims that he has told them not to arrive drunk but since the workers need their money they do it anyway.

3.2 Education and Introduction of Workers
60-70 % of the employees have compulsory school education and the rest are self-instructed or have been working at other industries.
When new workers are introduced, San Pedro hires experts in wood manufacturing to train them. Sometimes other workers in the factory teach the new employees.

If a person claims to have previous experience from similar machines a certificate is needed and a test of the skills has to be performed.

The machines are equipped with information stickers that show how to act by the machines but they are all written in English. Mr. Paz agrees that it would be better if they were written in Spanish since none of the workers speak English.

3.3 Injuries
Most of the injuries that occurs can be related to the older and more experienced workers. This is probably because of increased nonchalance and carelessness that comes with the working routines. Mr. José Paz says that he do not want the injured workers to be put at the same machine that exposed them for the accident and tries to put him/her in a less dangerous position when returning to work.

All accidents that occurred in 2005 were hand or finger injuries. 15 of 16 injuries were related to machines and one was caused by a chisel. See appendix D for injury statistics.
3.4 The Use of Protection
The company management makes sure that some personal protection is available but since the workers are not aware of the risks they are exposed to they do not use it.
Other aspects are that the protection sometimes is used incorrectly, for example if the workers gets new working shoes they might use them when playing soccer which leads to quicker worn and ultimately it becomes a question of money for the company.

When the workers have irritated airways caused by sawdust they are given milk to “clean” the body. The workers claim that it is the best way. Each worker is given half a liter of milk everyday.

3.5 Breaks
The employees working in the day shift have a 48-hour working week and are given a half hour lunch break.

The night shift workers have a 42-hour working week and are given a 15 minutes break with a sandwich and coffee.

The workers have bathrooms to their disposal but according to Mr. José Paz they need more.
Further he says that the workers take every chance they got to have an earlier break by going to the bathroom or sometimes just sneak away and play cards.

The workers however have the chance to drink water and refilling water bottles during the day which is important when working in tropical heat.

3.6 Ergonomics
The management of San Pedro does not concern ergonomically aspects when designing the workstations but do not actually know why.

The workers however do get the possibility to sit during the day but only during lunch.

When it comes to rotating between the workstations, Mr. Paz says that the workers do that a lot but that he does not like it since he wants to have experts at every machine.

He claims that the workers have been instructed on how to lift correctly which is a fundamental and important part when dealing with heavy doors that weigh between 35-48 kg.
3.7 Fire Security
San Pedro does not have an evacuation alarm or evacuation routes. The only fire security tools they have are fire extinguishers. According to Mr. José Paz the building has a lot of large doors and is easy to leave if needed. Fires have occurred but only on the outside of the factory.

3.8 First Aid
The facility has one first aid kit in one end of the hall which has, according to Mr. Paz, everything that is needed and that the material is regularly changed and refilled. He also says that the company lies within a close range to a hospital and that it is fast and easy to take an injured person there.
4 Measurements and Observations

This chapter will describe and show the problems discovered when studying the factory. Pictures will be shown to simplify the understanding of the problems. The headings will follow the frame of reference.

4.1 Fire Security

The air in the production area is filled with sawdust. Sawdust, if put on fire, may create a dust explosion. A dust explosion comes in several steps; the first explosion will release new dust and create a second explosion and so on (Staffan Malmberg). The facility is also filled with wood materials which can easily be put on fire if it occurs. The spreading of fire will be fast and the people need to evacuate quickly.

The fire security at San Pedro S.A. is based on a couple of fire extinguishers and the facility is not equipped with an evacuation alarm. There is no evacuation routes except for the ones naturally created through the sporadic placing of materials.

No documentation that deals with fire security and no evacuation plan are available.

The facility has doors that could be used for evacuation but these have been nailed to the walls (Figure 4-A) which make them impossible to use.

The building however has three larger openings which are used for entering the facility, loading materials and used for incoming materials. These are the only ways to use when needed to leave the building fast.

No fire doors are available but even if they were, they would not stop the fire since all the windows are broken and the walls consist of air holes.

If the fire department has to turn out they will have to cross a pool (Figure 4-B) of water and mud before entering a good extinction position.

Another thing is that the cleaning after manufacturing is done very badly.
4.2 First Aid
One first aid box is available at company but it is placed far from were the accidents may occur. It contains most of the materials needed except for a stretcher. Smaller first aid boxes containing plasters etc. is not closely available for the workers and they are not equipped with eye flushing solutions.

The employees do not have any education in first aid attendance.

In one way they do have a way of handling crisis since they let the injured workers change their work position to a less dangerous area. That does not necessarily mean that the worker feel better.

4.3 Ergonomics
The management at San Pedro S.A. does not consider ergonomics when designing workstations. They claim that the workers are informed about how to lift correctly but a quick look around the workstations shows something different. Figure 4-C and Figure 4-D shows the lifting and also the fact that the piles of material are to high.

![Figure 4-C shows lifting from a high level](image1)

![Figure 4-D shows incorrect lifting](image2)
The workstations used in the polishing area are fixed in the same height which means that small or tall workers has bad postures when working. As shown in Figure 4-E the worker has a stretched arm and a bent back.

![Figure 4-E polishing the doors](image1)
![Figure 4-F switching sides](image2)

When the sides need to be switched it is done manually (Figure 4-F) instead of automatic. This is often done by two workers.

Since Santa Cruz has a tropical climate the temperature is very high during the summer. The facility is not equipped with an air conditioner and only relies on the air blowing naturally through the building. This means that the temperature is very high. The only way for the workers to cool down is by drinking water.

![Figure 4-G a big hole in the path](image3)

There are no chairs in the production area to relieve the pressure on the body. The workers are only allowed to sit during the lunch.

The floor is uneven in many places and the risk of tripping is high. At one place a hole, a half-meter deep, was located in one of the paths (Figure 4-G).
4.4 Light
The light in the building is, during daytime, totally depending on sunlight. The light comes through windows in the ceiling. In some places these windows were painted in green which provide a very bad light in the area concerned. Since the indoor light is sunlight it is depending on the weather outside.

The light was measured with a Lux Meter inside the building. The meter showed very different values throughout the facility. Measures between 60-700 lux were obtained. For values obtained at every machine see appendix E. The lowest value were obtained in the polishing area were good light is needed the most. This area has windows painted in green in the ceiling.

![Image of electric fittings at San Pedro](image.jpg)

Figure 4-H shows how the electric fittings at San Pedro looks

The electric fittings, used only on the night shift, are very dirty and do not have reflectors (Figure 4-H).

The walls in the building are made of bricks with a dark red color which does not give any reflection of light.

The daylight factor was not concerned in these measurements.

4.5 Noise
The noise was measured with a Sound Level Meter equipped with a dB(A) filter. The measurements were made close to the ears of the operators and the level of sound was measured both when the machine worked up a material and when it was only running. These values became the maximum and minimum sound level. After the measurements were done, it showed that nowhere, close to the machines, was the maximum sound level below 85 dB.
Note that these measurements were **not** done over an eight hour working shift. In this case the important part was to find out if a risk of noise related damages could occur.

For sound level values at every machine see appendix E.

### 4.6 The Use of Personal Protection

The use of personal protection among the workers was miscellaneous. For statistic see appendix F.

The most common protection is hearing protection which is used by approximately 50 % of the operators. Very often the use of protection is done incorrectly, especially the use of respiratory protection.

Only one worker was considered to have good working shoes. The rest of them were working in flip flop sandals.

65 workers out of 130 were observed.

### 4.7 Machine Protection

Some of the machines has instructions on how to act and what protection that should be used when working by them. The problem is that they are all written in English.

Some machines, especially the newer machines, are equipped with emergency stop buttons but in some cases benches have been put close to them which make them difficult to use if needed.

On some machines the start/stop button is located below the machine table which makes them difficult to reach.
According to the measurements made, eleven out of 48 machines has some kind of protection. This is not entirely true. Actually only four machines has a complete protection. On one of these machines the protection is used incorrectly (Figure 4-I).

The reason why eleven machines were chosen is because they are considered to have more protection than some of the other machines even if they are not properly shielded.

Many machines however do not have any kind of protection and the risks of injuries are considered high amongst these machines. The machines can cause all kinds of injuries. In some cases dangerous parts such as gears is visible, which can cause serious damages. Some of the machines are not even prepared for extra protection such as cups or shields. Figure 4-J shows one of the machines that are not prepared for protection.
In some cases templates is used by the operators which makes it possible for them to get the hands away from the cutters (Figure 4-K). The problem is that they often consider them as a waste of time.
Measurements and Observations
5 Analysis

This chapter will present an analysis of the problems discovered based upon the frame of reference. For more detailed information see each chapter in the frame of reference.

Industrial safety is not only about wearing personal protection but also to consider fire preventions, accident prevention, how to act if an accident occur, applying ergonomically design methods etc. This work does not necessarily have to be difficult or complicated. It can be done using simple means. What the literature described in the Frame of Reference focus on the most and can be considered the basics when implementing industrial safety is the need and importance of creating routines for the different parts of the safety work.

5.1 Fire Security

As mentioned previously, the fire security at San Pedro is based upon a couple of fire extinguishers. They do not have any official evacuation routes or any documentation concerning the fire prevention work. To increase the level of fire security they need to concern several aspects such as how to act to prevent fires from occurring, the importance of educating the staff, how to implement fire security in the organization, how to document it etc.

5.1.1 Organization

First of all the company needs to decide how they are going to work with fire prevention and create a policy for the work. The management should decide this. The management should then appoint a responsible person in charge of the work and also if this person should work alone or be the leader of a team. If a team is put to together it is important to clear out the responsibility and the tasks to be performed by every member of the group.

When this has been decided the members will need education. The best way of doing this, is probably to contact the fire department and let them decide what competence that is needed. Important parts of the education should be:

- What does the company need in order to increase the level of fire security?
- Analyze hazards.
- How should the company warn or be warned if a fire occurs?
- Knowledge of how to maintain the equipment.
- How the equipment works.
- How the fire should be extinguished, what system should the company use?
- How evacuation routes should be planned and to inform about the routes.
• What internal rules does the company need?
• How to perform exercises and its contents.
• How to document the work.
• What kind of signs should be used?
• How inspections are to be performed.

5.1.2 Documentation
To maintain this knowledge given, it is absolutely necessary to keep records of the work being done. If things are changed within the facility, new risks will occur and the documentation needs to be revised. The documentation should include:

• A description of the building that should include at least:
  o Where the fire department can enter the area.
  o How the building looks.
  o Where explosive materials, such as gas tanks, are stored.
  o How the evacuation routes are planned.
  o Where fire extinguishers are available.
  o Flammable materials in the building structure.
• A description of the activities being performed in the different areas. This could also be a part of the building description.
• How the organization is organized.
  o Who is in charge?
  o Who are his coworkers?
  o How are the inspections performed and how often are they made. Records from previous inspections and exercises.
  o How the fire prevention equipment is maintained.
• Technical aspects.
  o How the equipment is expected to work if a fire occur.
  o How the installations of the equipment is made.
  o How the equipment functions.
• The possibilities of saving the facility.
  o How to act when a fire occurs
  o How to contact the fire department
• Education.
  o How to educate the workers.
  o How exercises are performed.
  o The contents of the education.
  o How often exercises are performed.
• How to handle inflammable equipment
• How to revise the documentation.

Always be sure to maintain and upgrade the fire security equipment when needed. The documentation is only means to give guidelines and information.
5.1.3 Evacuation Routes
Since the air in the production area is filled with sawdust and wood material is placed everywhere, evacuating may be difficult if a fire occurs. The fire will spread fast and if routes are blocked the situation can be very dangerous.

First of all the evacuation routes must be planned. It is necessary to decide which ways that is best suited for this purpose. It is also necessary to decide which doorways that should be used when evacuating. Try to use as many doorways as possible for this purpose. It is also important to decide what kind of signs to be used. The sign shown in chapter 2.1.3 is very educational and easy to understand. Finally an information board that shows a layout of the building with the evacuation routes and evacuation doorways marked should be set up on a spot that is easy to find. This information board should also contain the number to the fire department and where the fire extinguishers are placed. If much smoke develops during a fire it is important to stay low to avoid inhalation.

Always be sure to keep away material from blocking the evacuation routes. Consider marking the routes by painting them or equal.

5.2 First Aid
Only one first aid box available at the company and it is placed in one end of the hall. It contains, according to the general manager, all the things needed for first aid attendance but just having a first aid box is not enough. It calls for knowledge on how to act if attendance needs to be performed, what equipment to use and to judge if the person is in shock etc.

5.2.1 Identifying the Hazards
The first thing that San Pedro needs to do is to analyze what kinds of damages that may occur and to be prepared for them. This analysis can be based on the 2005 accident statistics available within the company. Note that even if all the damages that took place during 2005 were hand or finger related, other kinds of accidents may occur. Everything from getting caught on fire to falling of a ladder needs to be concerned.

5.2.2 Education, Routines and Information
When the analysis has been performed San Pedro need to educate chosen personal in first aid attendance. First of all a responsible person in charge of buying materials for the first aid boxes and maintaining it should be chosen. Then chosen personal among the workers should, together with the person in charge, be educated by medical personal in first aid attendance. One way of solving this is by contacting a nearby hospital.

When the workers have the necessary education it is time to create routines.
These routines should include:

- Who will act if an accident occurs?
- How often should the education be refreshed?
- What should the first aid boxes contain of?
- How often do we need to refill or change the contents of the first aid boxes?
- How do we handle crisis.
- How do we act if a worker gets a sickness related attack (e.g. epilepsy, asthma etc.)?
- Who makes sure that the injured person gets medical treatment?
- How do we act if a first aid attendant leaves the work or is fired?

Further it is of great importance that the other workers at the company are aware of which persons that are first aid attendants and also that the attendants are spread throughout the building and present during all shifts.

5.2.3 First Aid Boxes

When the risks have been analyzed and the routines have been set it is time to consider necessary first aid equipment. The contents of the first aid boxes should be based upon the risk assessment.

Equipment for smaller injuries, such as plasters, eye-flushing solutions etc. should be stored close to the workstations so that they can easily be used if needed. A stretcher is good to have as well.

5.3 Ergonomics

Not only the machines cause injuries but also how people act when they are working. Incorrect postures, heavy lifting and heat exhaustion can lead to great damage.

Many workers at San Pedro work in incorrect postures. They are constantly exposed to high body loads since either the floor or their shoes have any feathering capacity. These situations may lead to work related injuries in the future.

Obviously the workers do not know how bad they treat their own body. This calls for information and training and also a policy on how to act when designing workstations. Always consider:

- Do the stations have the correct height?
- Is the workstation flexible?
- Do they have a correct posture?
  - Are they standing straight?
  - Is the neck tilted?
  - Are twisted postures needed to perform the work?
  - Can they change their posture while performing the task?
  - Are the motions symmetric and simultaneous?
• Do the workers have a good working rhythm?
• Are all employees working in the correct area?
• Do they have good vision?
• Is high force needed to perform the work?
• Do they reach everything needed to perform their task?
• Do they have enough space for moving?
• Are they lifting correctly?
• Are they lifting from a high or low level?
• Is the object to be carried difficult to grab?
• Do the workers have to lift more than 25 kg per person?
• Do they need to walk far while lifting?
• Are there any risks of tripping or slipping?
• Is it possible to install automatic lifters?
• Is it possible to rest after performing heavy work?
• Are the workers given an opportunity to change task?

If these questions, according to chapter 2.3, are given a wrong answer, measures should be performed.

Since the temperature is high in the working area it is necessary to inform the workers about the importance of drinking water. Later on in the implementing process, measures should be taken to reduce the temperature to a more comfortable level.

5.4 Light

The light varies very much within the building because of the cloudiness outside. In some places the windows in the ceiling are painted in green which reduces the income of sunlight, which the indoor light is depending on.

The need for light is different in the building. The polishing area, which has the lowest level of light, needs the highest level.

The workers need to have a constant level of light when working. Changes in light may lead to discomfort and tiredness.

It would be better to use the electric fittings during the dayshift since they deliver a constant light flow but they should be equipped with reflectors.

Panting the walls in brighter colors would also increase the level of illuminance.

If reinstalling the electric fittings, which are necessary, it is probably best to do it using the “trial and error”-method which is hanging the fittings, measure, decide and redo if necessary.

The level of light at the machines must be more than 300 lux. At the polishing area it should be at least 500 lux.

For instructions on how to measure the light see appendix G and chapter 2.4.
5.5 Noise
Noise causes stress, headaches and may lead to serious hearing damages. The primary focus should concern reduction of noise by its source. If the level of noise is more than 85 dB during an eight-hour working day measures must be taken.

The level of noise in the production area at San Pedro is very high. In some cases the level of noise was below 85 dB when the machine was only running but during manufacturing the level was always above the allowed value.

The first thing that should be done is to get the workers to use hearing protection. Later it is necessary to reduce the noise created by the machines. Start by finding ways of reducing it through working correctly (correct cutting speed and feeding). Then look at the possibilities of redesigning parts on the machines that may cause noise and also if the cutters, saws etc are sharp enough.

5.6 Personal protection
When hazards cannot be avoided, protection must be used. At San Pedro the use of accurate protection is not broadly accepted. According to the general manager, the workers claim that the personal protections are uncomfortable and unnecessary. This is probably because of the heat, the chewing of coca leafs and ignorance.

It is of great importance that the workers are informed about the reasons why they should use protection and how to use it correctly.

The present environment put the workers not only in the risk of getting physically injured but also the risk of getting chronically diseases such as cancer, permanent hearing impairment, muscle damages, asthma etc.

It is also significant that the protection is used correctly. For example, respiratory protection must seal properly around the edges and earplugs must be correctly inserted in the ear canals.

5.7 Machine Safety
To reduce the risks of injuries even more it is necessary to focus on the machines as well. First of all the necessary information on the machines (information stickers) must be understood by the workers. Since nobody speaks English these stickers needs to be translated into Spanish.

The emergency buttons may never, under any circumstances, be covered or blocked. Try to rearrange the working benches needed by the machines so that they do not cover the emergency buttons.
It is necessary to analyze what kind of protections that are needed at the machines. Consider if it is possible to make them at the factory. Follow the guidelines given in chapter 2.7.4.

Use protection if it exists on the machines, they are there to reduce the hazards.

The use of templates is good since they render possible to get the hands away from the cutters. Consider using them more often.
6 Discussion

In this chapter the author will present his own thoughts and ideas for the company. The discussion is to be seen as a complement to previous chapters.

6.1 Comments on the References

The references used when writing this report are considered reliable. In some cases, concerning the commercial Internet sources, it might be necessary to read them more carefully since their aim is to market a product.

At some places the author has used Swedish laws as references. These laws are probably not applicable in Bolivia but are to be seen as advices given from professionals.

6.2 Overall Protection at San Pedro S.A.

A lot of things can and needs to be done to improve the industrial safety at San Pedro. The advices given in this report is to be seen as the first step to improve the working conditions for the workers. The most important thing is that San Pedro starts with creating routines for their safety improvement work. It will probably be tough in the beginning of the process but when the basic work is done everything is probably going to be faster and smoother.

Another important part is that the company decides a safety policy. According to the general manager he has some difficulties in pursuing the workers to use protection. If the company has a safety policy it will probably be easier to do this.

The workers should not be working without personal protection since the environment is harmful in many ways. The management must inform them about why they should use protection and about the consequences if they do not use it.

6.2.1 Fire security

Another important part in the present situation is to focus on what is considered to be the most dangerous parts in the production. The risk of a fire occurring is high and a better and more effective fire prevention work is necessary. Perhaps it would be better to install a sprinkler system instead of having fire extinguishers. An Evacuation Alarm and Evacuation Routes are absolutely necessary to have so that people may be warned before it is too late and has a chance of leaving the building safely.

On the other hand it is expensive to maintain a sprinkler system. It might be best to just focus on getting the people out of the building as quick as possible.

What really needs to be done is to improve the cleaning after manufacturing. Especially the insides if machines close to heat gaining parts such as the motor.
6.2.2 First Aid
It is absolutely necessary to focus on how to act if a serious accident occurs and this call for basic knowledge on how to perform first aid attendance. It would be wise to educate chosen personal in these procedures to increase the chances of surviving a serious accident.

Another part is having more first aid equipment. If a small accidents takes place like small wounds, particles in the eyes etc. The worker should be able to manage this himself. A good way of solving this would be to place smaller, less equipped first aid boxes on chosen locations in the production hall. These boxes should be under the supervision of the first aid attendance so that stealing etc. is avoided. These boxes could contain:

- Blood stoppers.
- Plasters in different sizes.
- Some kind of eye-flushing solution.
- Disinfection pads for cleaning the wounds.

If considered necessary it could also include:

- A mouth-to-mouth mask.
- Rubber gloves.
- Elastic bandage.
- Scissors.
- A triangular bandage.

It is considered very important that a responsible person is constantly checking the first aid boxes so that everything is in place if an accident occurs.

The production area should be divided into smaller areas which should be supplied with a small first aid box and a first aid attendance in charge.

6.2.3 Ergonomics
Working with ergonomics is a good way to reduce the risks of work related injuries such as broken backs, knee problems etc. It might be hard to realize all aspects of ergonomics but knowing about how small changes may increase the production and the health of the workers is important. Often small changes may provide a much better environment for the workers.
Almost every workstation at the company needs improvement concerning the ergonomics. The first step would be analyzing the ergonomics in the flow, like for example:

- Having limits for the height of the door piles.
- Render possible correct lifting all the time.
- Render possible to work in the correct area.
- Use tools (e.g. spring balancers) to reduce body loads.

6.2.4 Light
The light is very bad in the production area. Mainly since it is depending on the outdoor light and also because of the painted windows. The factory should not only be depending on sunlight because of the variation of light. New electric fittings with reflectors should be installed and it would also be a good idea to consider painting the walls and ceilings in brighter colors.

The author’s advice is to follow these guidelines:

<table>
<thead>
<tr>
<th>Lux</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>Machine</td>
</tr>
<tr>
<td>300</td>
<td>Hall</td>
</tr>
<tr>
<td>150</td>
<td>Corridors</td>
</tr>
</tbody>
</table>

Table 6-1 recommended illuminance values when performing light measurements

6.2.5 Noise
As mentioned previously, the level of noise is very high at San Pedro. Because of this it is considered important that the workers use protection. In 2.5.5 and 2.6.8 ear protection are discussed. These must be used as a first step to reduce the noise. Since ear protection may cause discomfort and a feeling of being isolated it is important to start looking at how to reduce the noise in other ways.

When using ear plugs it is also important to consider hygiene. Be sure to clean the plugs or change them once in a while.

Be sure to redo noise measurements at least on a yearly basis and when rearranging the flow or adding a machine.
6.2.6 Personal protection
Some of the workers do use protection but concerning the hazards they are exposed to, everyone should use protection. The management must inform the workers of the risks they are exposed to and have a policy that force the workers to use protection. Follow the advices given in chapter 2.6.

Sometimes it might be a good idea to have double hearing protection since some machines are very noisy. Ear plugs dampens $25 \pm 5 \text{ dB} \rightarrow 25 \text{ dB}$ dampening: $120 \text{ dB} (< 15 \text{ sec})$ gives $95 \text{ dB} (< 1 \text{ h})$. This shows that using ear plugs may cause a false security.

Be sure to mark dangerous noise areas with signs that says “Ear Protection must be used”.

6.2.7 Machine protection
It is difficult to give advices on which protection to use on the machines. This calls for both a risk assessment and to study the Bolivian market of protection. A part of the safety policy should be to buy machines that are already equipped with protection and an emergency button or at least prepared for attaching protection.

6.2.8 What Should Be Done?
The company must decide where to begin. According to the author the best way is to look at the most dangerous scenarios first. The fire security must definitely be improved. Evacuation routes should be the number one priority and later on evacuation alarm and extinguishing method. Also start working with the organization surrounding the fire prevention.

Another important part is first aid attendance. Informing and educating chosen personal should be done quickly and also adding smaller first aid boxes. Much has to be done to improve the working environment but until then, personal protection should be used by all employees when working. Set up a safety policy that ensures the use of personal protection.

Another part is to use equipment that is already available. Be sure to use the protection available on the machines and buy protection to the machines prepared for it.

Be sure to inform the workers of the hazards they are exposed to. The reason why they do not use the protection is probably because they are not aware of the risks they are exposed to.

Note that it is difficult to consider the economically aspects for the propositions made in this thesis. San Pedro and CADEFOR know more about the possibilities and the market in Bolivia and surrounding countries than the author.
7 Conclusion

A lot is to be done at San Pedro to increase the level of industrial safety. The company must set up a safety policy and routines on how to work with industrial safety.

Many areas within the facility are considered to be hazardous and over a period of time these risk areas needs to be attended to and has to be improved.

The best way to begin this work is by looking at the areas that are considered most dangerous to the workers. All of the problems discussed in this report should be taken care of but concerning how much work that needs to be done, it is important to work systematically. To render this possible the advice is to start looking at the five propositions given below. These advices are considered to be the most crucial and important parts to improve right away:

- Inform and educate the employees in why they should use personal protection, how to use and maintain it and also what may happen if they do not use it. They should not be allowed to work without it until the environment is improved.
- Arrange evacuation routes and information boards.
- Educate first aid attendants and improve the first aid supplies.
- Use the protection available on the machines and be sure not to cover emergency stop buttons.
- Improve the luminosity environment by installing new electric fittings with reflectors.

It is important that the safety work is continuous and done systematically. Be sure to keep records of the work and revise the documentation when needed. To ensure this the company should set up an improvement group as a part of the organization. This group should have members from both the management and among the workers.
Chapter 8

8 References

8.1 Sources


- Arbetsmiljöverket, 2005, Buller, Stockholm, Elanders Gotab.

- Ejhed. J, 1996, Att se, höra och andas i skolan, Falköping, Gummesons tryckeri AB.


- Statens räddningsverk, 2004, Statens räddningsverks allmänna råd och kommentarer om systematiskt brandskyddsarbete, Stockholm, Norstedts juridik AB.

- Träbranschernas ergonomigrupp, 1977, Bättre arbetsplatser i träindustrin.

8.2 Elecronical sources


- Arbetsmiljöverket, http://www.av.se/, 16/3-2006

References

- Eskilstuna kommun, http://eskilstuna.se, 8/3-2006
- Jobi, http://www.jobi.se/, 16/5-2006
- Sagitta, http://www.sagitta.se, 18/3-2006
- The University of New South Wales, http://www.phys.unsw.edu.au, 20/3-2006
- 3M, http://solutions.3m.com, 3/4-2006

8.3 Verbal sources

- Eva Ölund, Victoria Medical Group, Stockholm 15/4-2006
- Staffan Malmberg, Räddningsverket, Karlstad 7/5-2006
9 Appendix

Appendix A - Anthropometrical Data ................................................................. 1
Appendix B - Decibel and Time Table ............................................................... 3
Appendix C - Questions for San Pedro ............................................................. 5
Appendix D - Injuries at the Machines .............................................................. 7
Appendix E - Measurements ............................................................................. 9
Appendix F - Amount of Workers Using Protection ....................................... 19
Appendix G - Measuring light, Noise and Doing a Mini Risk Assessment ...... 21
Appendix A - Anthropometrical Data

The pictures below shows the different measures considered in anthropometrical science. Source: Sanders and McCormick, 1993
The table below shows the different measures of the 5th, 50th and 95th percentile of U.S. civilians. The dimensions showed are both in inches and centimeters.

Source: Sanders and McCormick, 1993

<table>
<thead>
<tr>
<th>Body dimension</th>
<th>Dimension, in</th>
<th>Dimension, cm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sex</td>
<td>5th</td>
</tr>
<tr>
<td>1. Stature (height)</td>
<td>Male</td>
<td>63.7</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>58.9</td>
</tr>
<tr>
<td>2. Eye height</td>
<td>Male</td>
<td>59.5</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>54.4</td>
</tr>
<tr>
<td>3. Shoulder height</td>
<td>Male</td>
<td>52.1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>47.7</td>
</tr>
<tr>
<td>4. Elbow height</td>
<td>Male</td>
<td>39.4</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>38.9</td>
</tr>
<tr>
<td>5. Knuckle height</td>
<td>Male</td>
<td>27.5</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>25.3</td>
</tr>
<tr>
<td>6. Height, sitting</td>
<td>Male</td>
<td>33.1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>30.9</td>
</tr>
<tr>
<td>7. Eye height, sitting</td>
<td>Male</td>
<td>23.6</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>26.6</td>
</tr>
<tr>
<td>8. Elbow rest height,</td>
<td>Male</td>
<td>7.5</td>
</tr>
<tr>
<td>sitting</td>
<td>Female</td>
<td>7.1</td>
</tr>
<tr>
<td>9. Thigh clearance</td>
<td>Male</td>
<td>4.5</td>
</tr>
<tr>
<td>height</td>
<td>Female</td>
<td>4.2</td>
</tr>
<tr>
<td>10. Knee height, sitting</td>
<td>Male</td>
<td>19.4</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>17.8</td>
</tr>
<tr>
<td>11. Buttock-knee distance, sitting</td>
<td>Male</td>
<td>21.3</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>20.4</td>
</tr>
<tr>
<td>12. Popliteal height, sitting</td>
<td>Male</td>
<td>15.4</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>14.0</td>
</tr>
<tr>
<td>13. Chest depth</td>
<td>Male</td>
<td>8.4</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>8.4</td>
</tr>
<tr>
<td>14. Elbow-elbow breadth</td>
<td>Male</td>
<td>13.8</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>12.4</td>
</tr>
<tr>
<td>15. Hip breadth, sitting</td>
<td>Male</td>
<td>12.1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>12.3</td>
</tr>
<tr>
<td>X. Weight (lbs and kg)</td>
<td>Male</td>
<td>123.6</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>101.6</td>
</tr>
</tbody>
</table>
Appendix B - Decibel and Time Table

The table shows for how long a person should be exposed to a certain level of noise.

<table>
<thead>
<tr>
<th>dB(A)</th>
<th>Max. time</th>
</tr>
</thead>
<tbody>
<tr>
<td>85</td>
<td>8 h</td>
</tr>
<tr>
<td>88</td>
<td>4 h</td>
</tr>
<tr>
<td>91</td>
<td>2 h</td>
</tr>
<tr>
<td>94</td>
<td>1 h</td>
</tr>
<tr>
<td>97</td>
<td>30 min</td>
</tr>
<tr>
<td>100</td>
<td>15 min</td>
</tr>
<tr>
<td>103</td>
<td>8 min</td>
</tr>
<tr>
<td>106</td>
<td>4 min</td>
</tr>
<tr>
<td>109</td>
<td>2 min</td>
</tr>
<tr>
<td>112</td>
<td>1 min</td>
</tr>
<tr>
<td>115</td>
<td>30 sek</td>
</tr>
<tr>
<td>118</td>
<td>15 sek</td>
</tr>
<tr>
<td>121</td>
<td>8 sek</td>
</tr>
<tr>
<td>124</td>
<td>4 sek</td>
</tr>
<tr>
<td>127</td>
<td>2 sek</td>
</tr>
<tr>
<td>130</td>
<td>1 sek</td>
</tr>
</tbody>
</table>
Appendix C - Questions for San Pedro

Background
1. For how long has the company existed?
2. Who is the owner?
3. Who is the general manager?
4. How many employees does the company have today?
5. How many different door models are you producing?
6. What are your strategies for the future?

Overall industrial safety questions
7. How does the company look at the changes that are going on right now?
8. What is your opinion on creating a safer work environment?
9. What do you think it will give the company?
10. What are your strategies for creating a good work environment?
11. Which are the most common accidents?
12. What kind of education do the workers have?
13. Are the employees having breaks? (Lunch break, coffee break etc)
14. Is the company aware of the risks that come with working in saw dust filled environment?
15. Are there any possibilities for the workers to drink water and/or add water while working?
16. How do you introduce new workers in the company?

Personal protection
17. Are the employees informed about the reasons why they are using protection?
18. Why aren’t protections being used more today?
19. Are the employees aware of the risk that comes by working with these machines?
20. What kind of protection is available for the workers?
21. Do they have to buy these themselves?
22. Is it the workers own responsibility to use protection?
23. Why are all signs on the machines in English when nobody speaks it?

Ergonomics
24. When designing a work station, do you consider ergonomically principles?
25. Are there any possibilities for the employees to sit during the day?
26. Do you let the workers rotate between the stations?
27. Are the workers informed about how to lift correctly?
28. Toilets, showers and wash-basins, how many are available?
Appendix C

**Fire safety**
29. Do you have a fire alarm?
30. How do you work with fire security?
31. Do you have evacuation plans?
32. Do you have fire extinguishers?

**First aid boxes**
33. Do you have a first aid kit?
34. How often do you change what’s in it?
Appendix D - Injuries at the Machines

The histogram below shows the number of injured workers at a chosen machine during the year 2005 at San Pedro.
Appendix E - Measurements

The histograms and pictures showed in this appendix will give the reader an understanding of the level of noise and illuminance at San Pedro. The histograms that show the noise levels will provide both the minimum and maximum decibel level. After each histogram a lay out is available to illustrate where the measurements in the facility were made.
Light by the machines
Layout of spot measurements
Appendix E

**Noise**

<table>
<thead>
<tr>
<th>Spot</th>
<th>Max dB</th>
<th>Min dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>90</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>95</td>
<td>65</td>
</tr>
<tr>
<td>3</td>
<td>90</td>
<td>70</td>
</tr>
<tr>
<td>4</td>
<td>85</td>
<td>75</td>
</tr>
<tr>
<td>5</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>6</td>
<td>75</td>
<td>85</td>
</tr>
<tr>
<td>7</td>
<td>70</td>
<td>90</td>
</tr>
<tr>
<td>8</td>
<td>65</td>
<td>95</td>
</tr>
<tr>
<td>9</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Lux**

<table>
<thead>
<tr>
<th>Spot</th>
<th>Lux</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>700</td>
</tr>
<tr>
<td>2</td>
<td>650</td>
</tr>
<tr>
<td>3</td>
<td>600</td>
</tr>
<tr>
<td>4</td>
<td>550</td>
</tr>
<tr>
<td>5</td>
<td>500</td>
</tr>
<tr>
<td>6</td>
<td>450</td>
</tr>
<tr>
<td>7</td>
<td>400</td>
</tr>
<tr>
<td>8</td>
<td>350</td>
</tr>
<tr>
<td>9</td>
<td>300</td>
</tr>
<tr>
<td>10</td>
<td>250</td>
</tr>
<tr>
<td>11</td>
<td>200</td>
</tr>
<tr>
<td>12</td>
<td>150</td>
</tr>
<tr>
<td>13</td>
<td>100</td>
</tr>
<tr>
<td>14</td>
<td>50</td>
</tr>
<tr>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
</tr>
</tbody>
</table>
Lay out of area measurements
Appendix E

Noise in the polishing area

Light in the polishing area
Lay out of measurements made at the polishing area

$L = \text{Light}$

$S = \text{Sound}$
Appendix F - Amount of Workers Using Protection

This appendix provides information about the amount of workers using protection.
### Number of workers using:

<table>
<thead>
<tr>
<th>Protection</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ear protection</td>
<td>35</td>
<td>53.8%</td>
</tr>
<tr>
<td>Eye protection</td>
<td>10</td>
<td>15.4%</td>
</tr>
<tr>
<td>Working clothes</td>
<td>6</td>
<td>9.2%</td>
</tr>
<tr>
<td>Mouth protection</td>
<td>18</td>
<td>27.7%</td>
</tr>
<tr>
<td>Working shoes</td>
<td>1</td>
<td>1.5%</td>
</tr>
<tr>
<td>Working gloves</td>
<td>16</td>
<td>24.6%</td>
</tr>
</tbody>
</table>

**Number of workers**  
65 100.0%

**Number of machines measured**  
48

**Number of machines with protection**  
11
Appendix G - Measuring light, Noise and Doing a Mini Risk Assessment

To simplify the measurements, two custom made sheets has been prepared. The first is for making overall measures and the other for making measures at every machine. Note that the measurements are not for making noise analyzes over a period of time but only to see if the company is considered to be in the danger zone.
The sheets are available on the pages to come.

**Overall Measurements**
Overall measurements demand a systematic dividing of the factory. The factory should be divided into several sectors in which the measurements will be performed. The measurements made are:

- Maximum noise level [dB].
- Minimum noise level [dB].
- Illuminance [Lux].

From the given noise level values the measurer should decide if the operators in this are in the danger zone of getting hearing impairments and should use protection.

**Spot Measurements**
The spot measurements are a little more advanced. Not only are the measurer to perform the same task mentioned above but also do a risk assessment, measure the daylight factor, consider what wood is being manufactured and analyzing the use of protection and if protection is needed.

The noise measurement should be done close the ear of the operator to obtain good and reliable values. The light measurements should be done with the lux meter close to the machine and towards the operator.

Analyze the electric fittings, extra light and sunlight falling into the building and answer the questions given on the sheet. Decide if measurements must be taken according to the instructions given in the frame of reference. The same is when analyzing the daylight factor.

Study the operator and see if he/she has the appropriate personal protection. Be sure to study the assistant taking part of the work too. Answer the questions given in the sheet and decide if measurements need to be taken.
Appendix G

The reason why the type of wood that is manufactured should be mentioned is because all wood has different hardness and the values may differ depending on the wood.

In the risk assessment the measurer is suppose to analyze risks that may occur at the machine and what precautions that needs to be taken and what kind of protection that may need to be added on the machines.
### Noise, light and protection

**Information:** The purpose of this sheet is for the user to make notes from the measures made. Make sure that the machines has some kind of identification number or similar. Prot. Needed concerns hearing protection.

<table>
<thead>
<tr>
<th>Sector</th>
<th>Lux</th>
<th>Min dB</th>
<th>Max dB</th>
<th>Prot. Needed</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td>Y ☐ N ☐</td>
<td></td>
</tr>
</tbody>
</table>
# Noise, light and risk assessment

<table>
<thead>
<tr>
<th>dB(A)</th>
<th>Max. time</th>
<th>Lux</th>
<th>Place</th>
<th>Type of wood</th>
</tr>
</thead>
<tbody>
<tr>
<td>85</td>
<td>8 h</td>
<td>500</td>
<td>Machine</td>
<td></td>
</tr>
<tr>
<td>88</td>
<td>4 h</td>
<td>300</td>
<td>Hall</td>
<td></td>
</tr>
<tr>
<td>91</td>
<td>2 h</td>
<td>150</td>
<td>Corridors</td>
<td></td>
</tr>
<tr>
<td>94</td>
<td>1 h</td>
<td></td>
<td></td>
<td>Daylight factor</td>
</tr>
<tr>
<td>97</td>
<td>30 min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>15 min</td>
<td></td>
<td></td>
<td>( \frac{E_{h,\text{indoor}}}{E_{h,\text{outdoor}}} \cdot 100 = \Delta )</td>
</tr>
<tr>
<td>103</td>
<td>8 min</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Min dB**
- The machines has extra light? Y N

**Max dB**
- The electric fittings has reflectors? Y N
- The electric fittings glares? Y N
- \( \Delta > 1 \) Y N

**Lux**
- The sun glares? Y N

**Add light?** Y N

<table>
<thead>
<tr>
<th>Protection</th>
<th>Uses?</th>
<th>Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ear</td>
<td>Y N</td>
<td>Y N</td>
</tr>
<tr>
<td>Eye</td>
<td>Y N</td>
<td>Y N</td>
</tr>
<tr>
<td>Clothes</td>
<td>Y N</td>
<td>Y N</td>
</tr>
<tr>
<td>Mouth</td>
<td>Y N</td>
<td>Y N</td>
</tr>
<tr>
<td>Shoes</td>
<td>Y N</td>
<td>Y N</td>
</tr>
<tr>
<td>Gloves</td>
<td>Y N</td>
<td>Y N</td>
</tr>
</tbody>
</table>

**Operator**

**Assistant**

<table>
<thead>
<tr>
<th>Protection</th>
<th>Uses?</th>
<th>Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ear</td>
<td>Y N</td>
<td>Y N</td>
</tr>
<tr>
<td>Eye</td>
<td>Y N</td>
<td>Y N</td>
</tr>
<tr>
<td>Clothes</td>
<td>Y N</td>
<td>Y N</td>
</tr>
<tr>
<td>Mouth</td>
<td>Y N</td>
<td>Y N</td>
</tr>
<tr>
<td>Shoes</td>
<td>Y N</td>
<td>Y N</td>
</tr>
<tr>
<td>Gloves</td>
<td>Y N</td>
<td>Y N</td>
</tr>
</tbody>
</table>

**Machine has protection** Y N

**Kind of protection needed**

---

**Risks than can occur at this machine**

---

**Name:**