REDUCING THE RISK OF CUMULATIVE TRAUMA DISORDERS – LOW BACK PAIN AND TINEA PEDIS DISEASE AT LEAK TESTING AREA OF PT. FRS BY DESIGNING TOOLS USING QUALITY FUNCTION DEPLOYMENT AND ERGONOMIC APPROACH

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THESIS ADVISOR

RECOMMENDATION LETTER

This thesis entitled "**Reducing The Cumulative Trauma Disorders – Low Back Pain and Tinea Pedis Disease at Leak Testing Area of PT. FRS by Designing Tools Using Quality Function Deployment and Ergonomic Approach"** prepared and submitted by **Faris Ali Jaidi** in partial fulfillment of the requirements for the degree of Bachelor Degree in the Faculty of Engineering has been reviewed and found to have satisfied the requirements for a thesis fit to be examined. I therefore recommend this thesis for Oral Defense.

Cikarang, Indonesia, April 18, 2018

Ir. Andira, M.T.

DECLARATION OF ORIGINALITY

I declare that this thesis, entitled "**Reducing The Cumulative Trauma Disorders – Low Back Pain and Tinea Pedis Disease at Leak Testing Area of PT. FRS by Designing Tools Using Quality Function Deployment and Ergonomic Approach"** is, to the best of my knowledge and belief, an original piece of work that has not been submitted, either in whole or in part, to another university to obtain a degree.

Cikarang, Indonesia, April 18, 2017

Faris Ali Jaidi

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ABSTRACT

The problem related to Cumulative Trauma Disorders – Low Back pain and Tinea Pedis Disease appears in leak testing area while doing leak testing of AHZ tank. The manual material handling which leak is testing the AHZ tank should be done manually with bending body by the operator. Moreover, the operators have complaint about Low Back pain and Tinea Pedis Disease during the interview session. After analysis by using Anthropometry shows that the body dimension while doing the activity is non-ergonomic posture and Rapid Entire Body Assessment (REBA) analysis results 8 REBA scores which means high risk and need to improve because it's dangerous. An improvement is conducted related to the material handling equipment by using quality function deployment method and product selection. The product is Future leak tester. Future Leak Tester can reduce REBA result become 2 and it became low risk.

Keywords: *Cumulative Trauma Disorders (CTDs), Low Back Pain, Tinea Pedis Disease, Leak Testing, Manual Material Handling, Anthropometry, Rapid Entire Body Assessment (REBA), Quality Function Deployment, Product Selection.*

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TABLE OF CONTENTS

THESIS ADVISOR RECOMMENDATION LETTER i
DECLARATION OF ORIGINALITY ii
ABSTRACT iv
ACKNOWLEDGMENT v
TABLE OF CONTENTS vii
LIST OF TABLE ix
LIST OF FIGURES x
LIST OF TERMINOLOGIES xii
CHAPTER I INTRODUCTION 1
1.1 Problem Background 1
1.2 Problem Statement 3
1.3 Objective 3
1.4 Scope 3
1.5 Assumptions 3
1.6 Research Outline 4
CHAPTER II STUDY LITERATURE 6
2.1 Ergonomics 6
2.2 Manual Material Handling 6
2.2.1 Manual Material Handling Assessment 7
2.3 Anthropometry 9
2.3.1 Anthropometry Data 9
2.4 Cumulative Trauma Disorders 10
2.4.1 Cumulative Trauma Disorders: Lower Back Pain 11
2.5 Tinea Pedis disease 11
2.6 Rapid Entire Body Assessment (REBA) Analysis 12
2.6.1 REBA Analysis Process 12
2.7 Differences between REBA Other Methods 20
2.8 Quality Function Deployment Method 21
2.8.1 House of Quality 22

CHAPTER III RESEARCH METHODOLOGY 25
3.1 Initial Observation 27
3.2 Problem Identification 27
3.3 Literature Study 27
3.4 Data Collection & Analysis 28
3.5 Conclusion & Recommendation 29
3.6 Detailed Framework 29
CHAPTER IV DATA COLLECTION & ANALYSIS 33
4.1 Initial Observation 33
4.1.1 Workplace Overview 33
4.1.2 Non-ergonomic Activity 33
4.2 Data Collection 34
4.2.1 Specification of Tools and Personnel 35
4.2.2 Specification of AHZ tank 36
4.3 Data Analysis 38
4.3.1 Rapid Entire Body Assessment Analysis (REBA) 38
4.3.2 Anthropometry Data 48
4.4 Proposed Improvement 49
4.4.1 Product Selection 50
4.4.1.1 Product Selected Specification 54
4.4.2 Quality Function Deployment 55
4.5 Product Specification 65
4.6 Future Leak Testing Cost 71
4.7 Before-After Analysis 72
CHAPTER V CONCLUSION AND RECOMMENDATION 79
5.1 Conclusion 79
5.2 Recommendation 79
REFERENCES 80
APPENDICES 82

LIST OF TABLE

Table 2.1 Indonesian Body Dimension Standard Anthropometry Data 10
Table 2.2 Body Parts A Matrix 15
Table 2.3 Body Parts B Matrix 17
Table 2.4 REBA Score C Matrix 19
Table 2.5 Risk Level 20
Table 2.6 Main Features and Function of Some Ergonomic Methods 20
Table 2.6 Main Features and Function of Some Ergonomic Methods (Cont'd)......... 21
Table 2.7 Exposure Factors Assessed by Some Ergonomic Methods 21
Table 2.8 Advantage and Disadvantage of QFD 24
Table 4.1 Complaint Data from Operator 34
Table 4.2 Operator Data... 36
Table 4.3 AHZ calculation.. 37
Table 4.4 Table A of REBA... 41
Table 4.5 Table B of REBA... 44
Table 4.6 Table C of REBA... 45
Table 4.7 Level of Risk... 48
Table 4.8 Product Selection Process 53
Table 4.9 Operator Needs 55
Table 4.10 List of Technical Specifications.. 56
Table 4.11 Relationship between Operators' Needs and Technical Specifications.... 57
Table 4.12 Degree of Importance of Operator's Need.. 60
Table 4.13 Future Leak Testing Cost... 71
Table 4.13 Future Leak Testing Cost (Cont'd) 72
Table 4.14 Table A of REBA... 74
Table 4.15 Table B of REBA... 76
Table 4.16 Table C of REBA... 77

LIST OF FIGURES

Figure 2.1 Bad Practice of Hand Lifting 8
Figure 2.2 Good Practice of Hand Lifting 9
Figure 2.3 Tinea Pedis Disease 12
Figure 2.4 REBA Flow Diagram 13
Figure 2.5 REBA Assessment Worksheet 14
Figure 2.6 Example of REBA Scoring: Body Parts A 16
Figure 2.7 Example of REBA Scoring: Body Parts B 18
Figure 2.8 Example of REBA Score C and Final Score 19
Figure 2.9 Example of House of Quality 22
Figure 3.1 Research Framework of The Research 25
Figure 3.1 Research Framework of The Research (Cont'd) 26
Figure 3.2 Detailed Framework 31
Figure 3.2 Detailed Framework (Cont'd) 32
Figure 4.1 Container Box 35
Figure 4.2 Leak Tester 36
Figure 4.3 AHZ Tank 37
Figure 4.4 REBA of Trunk 39
Figure 4.5 REBA of Neck 40
Figure 4.6 REBA of Legs 40
Figure 4.7 REBA of Force/Load 42
Figure 4.8 REBA of Upper Arm 43
Figure 4.9 REBA of Lower Arm 43
Figure 4.10 REBA of Wrist 44
Figure 4.11 REBA Assessment Worksheet 47
Figure 4.12 Container Box Dimension 49
Figure 4.13 Adjustment Table 50
Figure 4.14 Hydraulic Table 51

Figure 4.15 Stainless Table 52
Figure 4.16 Adjustment Table Specifications 54
Figure 4.17 Matrix of Relationship between Operator's Needs and Technical 58
Figure 4.18 Matrix of Interrelationship in Technical Specification 59
Figure 4.19 Competitive Assessment Related to Operator's Needs 61
Figure 4.20 Product Specification Priority 63
Figure 4.21 House of Quality for the Material Handling Equipment 64
Figure 4.22 Future Leak Testing Tools Design 65
Figure 4.23 Transparent Acrylic box and Rubber Gloves 66
Figure 4.24 Adjustment Table 67
Figure 4.25 Sliding Metal 68
Figure 4.26 Raw AHZ Tank Container Box 69
Figure 4.27 Finish Good AHZ Tank Container Box 70
Figure 4.28 Design of the Proposed Improvement of Future Leak Testing Tools 71
Figure 4.29 Body Parts A with Future Leak Tester 73
Figure 4.30 Body Parts B 75
Figure 4.31 REBA with Future Leak Testing Worksheet 78

LIST OF TERMINOLOGIES

Anthropometry	:	A measurement of human body that is various in term of weight, height and size with considering also the thicknesses of skinfold, circumferences, lengths and breadths.
Quality Function Deployment (QFD)	:	Is to match the needs of operator with engineering characteristics. Constructing voice of operator is the starting point of quality function deployment. In addition, it also brings together multifunctional teams to work together in satisfying operators.
Rapid Entire Body Assessment (REBA)	:	Is defined as the process to analyse conditions and features of a human body, to provide an evaluation of any existing disorder on the musculoskeletal (MSD), and the potential risks.
Ergonomic	:	As a process to create the best possible environment for humans to work in.
Leak Testing	:	Process to test the reject product of leak.
AHZ tank	:	Is a tank for motorcycles air radiator, the AHZ tank is requested by number one motorcycles industries in the world.

CHAPTER I

INTRODUCTION

1.1 Problem Background.

Manual material handling is quite common and widely known among the manufacturing companies in the industry. Up to this date, many manufacturing companies still employ human labor instead of implementing automations, in this case is the manual material handling activity. Therefore, with the extent of human labor in this industry, we need to make sure that these human workers will work thoroughly, carefully, and sustainably.

Poor ergonomics in the environment and activities in the workplace can cause these human workers terrible pain and endanger them permanently. The activity affects the workers over the long run, so the risks are often overlooked. In order to prevent these risks, it is imperative to implement the essentials of ergonomics to design a workplace for the human workers involved in the within. Freivalds (2009) defined ergonomics as a process of thoroughly designing a workplace – the tools and equipment used as well as the work environment, all the while considering the human factors – the employees' conditions and capabilities, in order to enhance and optimize the work system. According to Fernandez & Goodman (2010), a good practice of ergonomics within a work system will yield a safe and healthy environment for the wellbeing of the human workers. Thus, it is clear that ergonomics are crucial to be implemented in the work system of companies to prevent and overcome the safety and health issues that affect the workers.

PT. FRS is a manufacturing company that works in the plastic industry, focusing on plastics packaging. Well known for its good safety standard, PT FRS takes priority in the safety of their activities, especially in their core production activities. Manual handling in their core production activities has become the main concern of the company. Despite the implementation many automations in the production line, the company still utilize manual material handling in many activities.

The focus of this study where the research has been done, PT. FRS, can be taken as an example of poor ergonomics implementation. As the core business of the company is dealing with plastics and machineries, there are many human-operators based activities in the production line. These activities could increase the chance for non-ergonomics activities to occur to these workers.

A non-ergonomics activity is found the company's leak testing area, specifically in their manual handling activity process. This particular process requires the operators to perform a leak testing activity by constantly submerging their hands in the water. In other words, the operators responsible for this activity are required to perform a non-ergonomic activity for few continuous hours in a day.

The operators in charge of the activity have complained regarding the work that they are doing. The operators have reported discomforts during the activity, as they have to do it in bent-spine sitting. During the activity, the operators must sit while bowing their back in order to test and check the leaks using their hand, which must constantly be in the water. This working condition may cause Cumulative Trauma Disorders – Low Back Pain and Tinea pedis disease to the workers. Preventive actions must be taken immediately to resolve the issue, since the non-ergonomic activity will cause harm to the operators be it in the short run or the long run.

Regarding the situation and problem presented, a research approach needs to be done. This study aims to find a way to improve non-ergonomic elements in the leak testing activity of PT. FRS by providing a tool to support the workers during the activity. Therefore, the leak testing activity can be done in a safer and healthier condition.
This research is done to observe and analyze the assumption in the beginning. Then, as the assumption is proven as correct – that the leak testing activity in the production

area of PT. FRS is determined as a non-ergonomic activity, the research continues with plans of improvements. The whole process of observation, analysis, and improvement planning will be explained in this research, as well as the evaluation of the improvement to assess the research's significance.

1.2 Problem Statement

The problem background that has been stated leads to the statement below:

1. How to identify the Cumulative Trauma Disorders – Low Back Pain and tinea pedis disease in leak testing area?
2. How to reduce the potential Cumulative Trauma Disorders – Low Back Pain and tinea pedis disease in leak testing area?

1.3 Objective

The problem statement above leads to the objectives below:

1. To identify the Cumulative Trauma Disorders – Low Back Pain and tinea pedis disease in leak testing area.
2. To reduce the potential Cumulative Trauma Disorders – Low Back Pain and tinea pedis disease in leak testing area.

1.4 Scope

The scope of doing this research is as follows:

1. The observation was conducted from February 2018 to May 2018.
2. The activity observed is the activity of leak testing on AHZ tank.
3. Temperature of workstation is not included in data calculation and analysis.

1.5 Assumptions

The assumptions defined to help this research are:

1. The body posture of operators in leak testing activity is assumed the same.
2. All the AHZ tank has same size.
3. The flow activities of all operator are the same.

1.6 Research Outline

Chapter I Introduction

This chapter identifies the background of the problem, problem statements, research objectives, scope, assumptions and the description of research outline.

Chapter II Literature Study

This chapter provides the knowledge about manual material handling, ergonomics, and the explanation where the non-ergonomics occurred, the poor ergonomics implied in a work system that can be dangerous, Rapid Entire Body Assessment analysis (REBA), anthropometry data, product design and the development method as these literatures are used in supporting the analysis of the research.

Chapter III Research Methodology

This chapter describes the steps taken in the whole process of the research. First thing to do is the initial observation, where the initial observation is done and how the activity is assumed as a non-ergonomics activity is explained, why it may cause the danger of Cumulative Trauma Disorders – Low Back Pain and tinea pedis disease.

Chapter IV Data Collection & Analysis

This chapter delivers the data of the research, which consists of the documentation and the description of the activity of leak testing of AHZ tank in PT. FRS. The information is also gained from documenting the operators during the leak testing activity with photographs and direct interview to the operators. Then it proceeds to the analysis of how the non-ergonomics activity is occurred, how it leads to Cumulative Trauma Disorders – Low Back Pain and *Tinea pedis* disease, and how to improve this non-ergonomics activity into an ergonomics one by providing a support tool. Then finally, the proposed improvement is tested and evaluated to know the effectiveness of the improvement.

Chapter V **Conclusion & Recommendation**

This chapter provides the conclusion of the whole process of the research and improvement as the result. This chapter also provides recommendations for the further research with related topic.

CHAPTER II

STUDY LITERATURE

2.1 Ergonomics

It is concisely define Ergonomics as a process to create the best possible environment for humans to work in (Freivalds, 2009). This includes the machinery, tools, and everything that is involved in the process. Alternatively, this is can describe the process as the designing of an optimal working environment that takes into consideration several factors: psychology, physical and biomechanics that exists within the current workspace. With those factors in mind, the working environment can be prepared in the most effective working conditions for the workers and the betterment of the production (Fernandez & Goodman, 2010). Ergonomics is meant to better adapt the working conditions to the workers, instead of the other way around.

When applied properly, good ergonomics enable the workers to provide better overall results for the company. Workers' performance can influence other work-related fields, such as better management of insurance and health benefits for the workers and government policies that protect them (Fernandez & Goodman, 2010). Ergonomics also matter in ensuring the safety and security of activities conducted by the workers as well as to better cater other human factors in the working space. Better ergonomics also affects workers' satisfaction, morale and participation in the work place.

2.2 Manual Material Handling

Manual material handling is defined as the actions made by men that inflict movement towards a load in the workspace as the part of the process in the system (Mohammadi & Motamedzade, 2013). Any kinds of activity done by the worker by hands can be classified into this category of action in the workspace. Workspaces that provide a better guidance for this type of handling can significantly improve the performance of the workers, especially in reducing workplace related accident and other kinds of costs.

This manual handling may cause physical afflictions to the workers that can eventually lead to injuries, wasted time, and energy. To avoid or to minimize the chances of these physical afflictions, improving the balance between the demands of work tasks and the capabilities of the workers is absolutely needed. In order to improve the workplace, the variances of workers abilities to perform work tasks must be considered. The variances can be in age, physical condition, strength, gender, stature and other factors.

2.2.1 Manual Material Handling Assessment

Based on the Industrial Accident Prevention Association (2008), there are standards that should be followed during the assessment process to identify hazards.

1. Load

   During the manual handling, the workers need to consider the kind of load that is being handled. Many factors that need to be considered include the mass, volume, dimensions, type of surface, and other features.

2. Method

   Manual handling requires identifying the method used by the worker during this process. Workers should consider factors such as the distance of movement, body posture, and tasking during one time.

3. Environment

   Workplace conditions cannot be separated from the conditions surrounding the environment of the workplace itself. Many factors contribute to the assessment, such as temperature, humidity, light, and others.

4. Human

   The assessment needs to consider the human factor working for the handling process. Basic assessment would include the factors such as health, physiology, and mental factors.

The Figure 2.1 below describes an incorrect posture for manual handling process during work. The spine bends too low, which would be a burden that would cause aching to the worker.

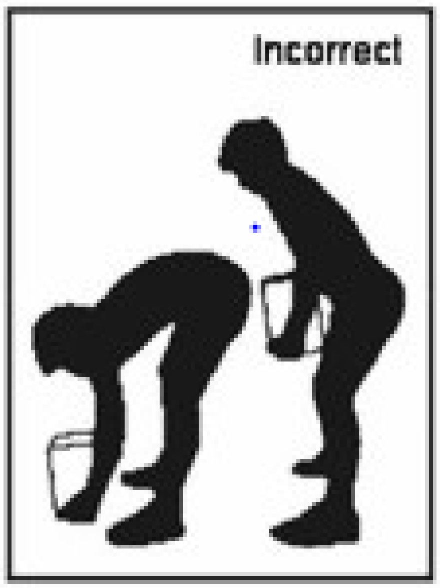


Figure 2.1 Bad Practice of Hand Lifting

Then below Figure 2.2 is the example of correct practice of hand lifting that should be done instead of the previous one. The correct practice of hand lifting that is much safer to human spine is when the spine is not bowing too low and it is kept straight. The figure below describes the better method of hand lifting.

Figure 2.2 Good Practice of Hand Lifting

2.3 Anthropometry

We define Anthropometry as the measure for the many variables of assessments in humans. The measure calculates different features such as mass, tallness, and thickness. (Fryar CD, 2012). The process of Anthropometry can provide data to support calculation in taking account of the human body during the working process. The data allows for better explanations on the status of the workers, based on their health and physiology, and analyse the probable risk and hazards caused by the human condition. Anthropometry can be used as a guide to designate work that can be suitably conducted by workers based on their data. The suitability of the worker to their tasks can reduce the risk of hazard.

2.3.1 Anthropometry Data

Anthropometry takes into consideration the human body, and its physiological features. Commonly, there are differences when considering the anthropometry of a person from different origins. Below Table 2.1 is the Indonesian Body Dimension Standard Data (Nurmianto, 1998).

Table 2.1 Indonesian Body Dimension Standard Anthropometry Data

No.	Body Dimension	Dimension (cm)		
		5%	**50%**	**95%**
1	Stature (Height)	146.4	159.7	173.2
2	Eye Height	135	148.3	161.5
3	Shoulder Height	118.4	130.5	142.9
4	Elbow Height	88.6	98.0	107.4
5	Knuckle Height	64.6	71.3	78.2
6	Height, Sitting	77.5	84.9	91.9
7	Eye Height, Sitting	66.6	73.5	80.4
8	Shoulder Height, Sitting	50.1	56.1	62.1
9	Elbow Rest Height, Sitting	17.5	23	28.3
10	Thigh Clearance Height	11.5	14	16.5
11	Knee Height, Sitting	33.7	39.25	44.5
12	Buttock-Knee Distance, Sitting	48.8	54.1	59
13	Poplitical Height, Sitting	40.5	49.35	58.6
14	Bideltoid Width	34.2	40.45	46.6
15	Hip-Breadth, Sitting	29.1	33.8	39.2
16	Chest Depth	17.4	22.95	27.8
17	Abdominal Depth	17.4	22.95	28.7
18	Elbow-Fingertip Length	37.4	42.4	47.3
19	Head Width	13.5	14.8	16
20	Handpalm Length	15.3	17.2	19.1
21	Handpalm Width	6.4	7.5	8.7
22	Left-Right Fingertip Length	140	159.3	180.6
23	Hand Grip Height in Vertical Arm Position, Standing	171.3	188.2	205.1
24	Hand Grip Height in Vertical Arm Position, Sitting	94.5	109.95	127.3
25	Hand Grip-Shoulder Length in Horizontal Arm Position	61	68.4	76.7

2.4 Cumulative Trauma Disorders

Cumulative Trauma Disorder (CTD) is a condition where an injury occurs due to trauma to the human body on the muscular or skeletal level, from the accumulation of heavy burdens on the body during its excessive use owing to wrongly assigned tasks. (Freivalds, 2009). The traumas might include the use of excessive burden, unease of joints, duration of work, and repeated tasks. Based on this, there are several conditions that can identify as Cumulative Trauma Disorders, which are:

2.4.1 Cumulative Trauma Disorders: Lower Back Pain

This type of Cumulative Trauma Disorders is a type of injury to the area related to the spine, due to excessive burdens on the back caused by bad conditions of the workplace. (Arya, 2014). If ignored, the pain on the lower back can lead to major injuries, and can lead to permanent disability. This type of Cumulative Trauma Disorders is a common problem that has contributed in the rise of medical treatments of such injury. Factors that can contribute to lower back pain includes heavy burdens to the human body, and also lifestyle.

2.5 Tinea Pedis disease

Tinea pedis is a dermatophyte infection of the hands, especially between fingers and palms. Among many fungal infection on the skin, *Tinea pedis* is the most common to occur. (A.Price & M. Wilson, 1995). The most frequent cause is *Trichophyton rubrum*, giving chronic aberration on the skin. (Hafeez, ZH, 2002). It is commonly found in its initial stage between the fourth and fifth finger, and then spread to the nether fingers and between the other fingers. Because the area is moist, the infected skin appears white, macerated, and brittle. If the dead skin is cleansed, it will look new skin, but still likely to be infected by the fungus.

In general, moisture factor of the skin causes the fungus to grow on the hands. Hands and fingers that frequently sweat, and/or have frequent interaction with water or moist areas in their daily lives are more vulnerable and likely to acquire the fungus (Soekandar, TM, 2004).

Therefore, it can be concluded here that *Tinea* relates to cleanliness, and perspiration of the skin. The infection may develop over the years, without significant complaints. Even some of the infected are totally symptom-free. Some new sufferers of the infection feel disturbed when there was an unpleasant smell from the skin of their hands. The symptoms may worsen, as the possibility to contract bacterial infection (secondary infection) with mild (red stinging nodules) to severe (pain and fever) certainly exists (Hainer, BL, 2013). Figure 2.3 above shown *Tinea Pedis* Disease.

Figure 2.3 Tinea Pedis Disease

2.6 Rapid Entire Body Assessment (REBA) Analysis

In this study, we define Rapid Entire Body Assessment Analysis as the process of analysis of conditions and features of a human body, to provide an evaluation of any existing disorder on the musculoskeletal (MSD), and the potential health risks (Middlesworth, 2014).

MSD is identified as the accumulation of muscle disorders, also involving nerves and joints problems. The disorders are commonly found during manual handling process in the workplace.

2.6.1 REBA Analysis Process

REBA Worksheet is required for the assessment process, in order to analyse it properly. It begins with grading the human body parts when a person conducts manual handling. The assessment flow is shown in the Figure 2.4 below.

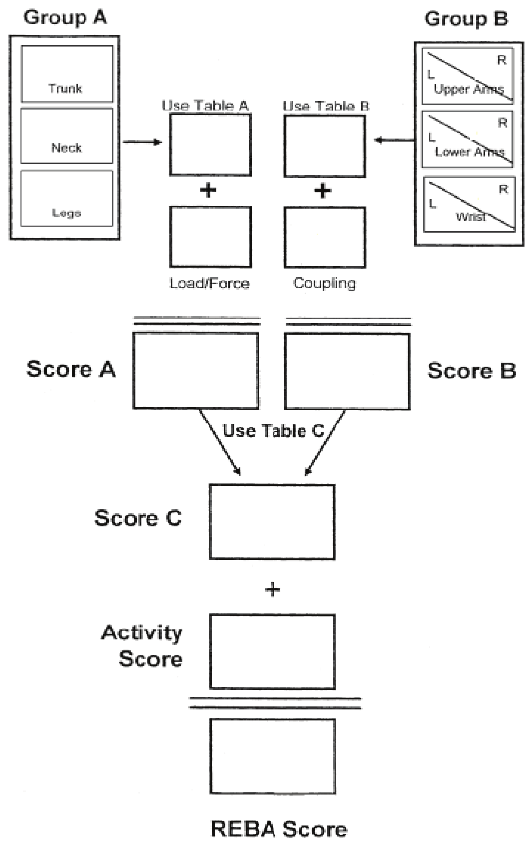


Figure 2.4 REBA Flow Diagram

In the REBA assessment, we focus on two groups of body: body parts A and body parts B. The flow of the assessment is to measure the score of group A and group B, and then the score is used for the next measurement until it comes to the final score of REBA. The REBA assessment worksheet is shown in the Figure 2.5 below.

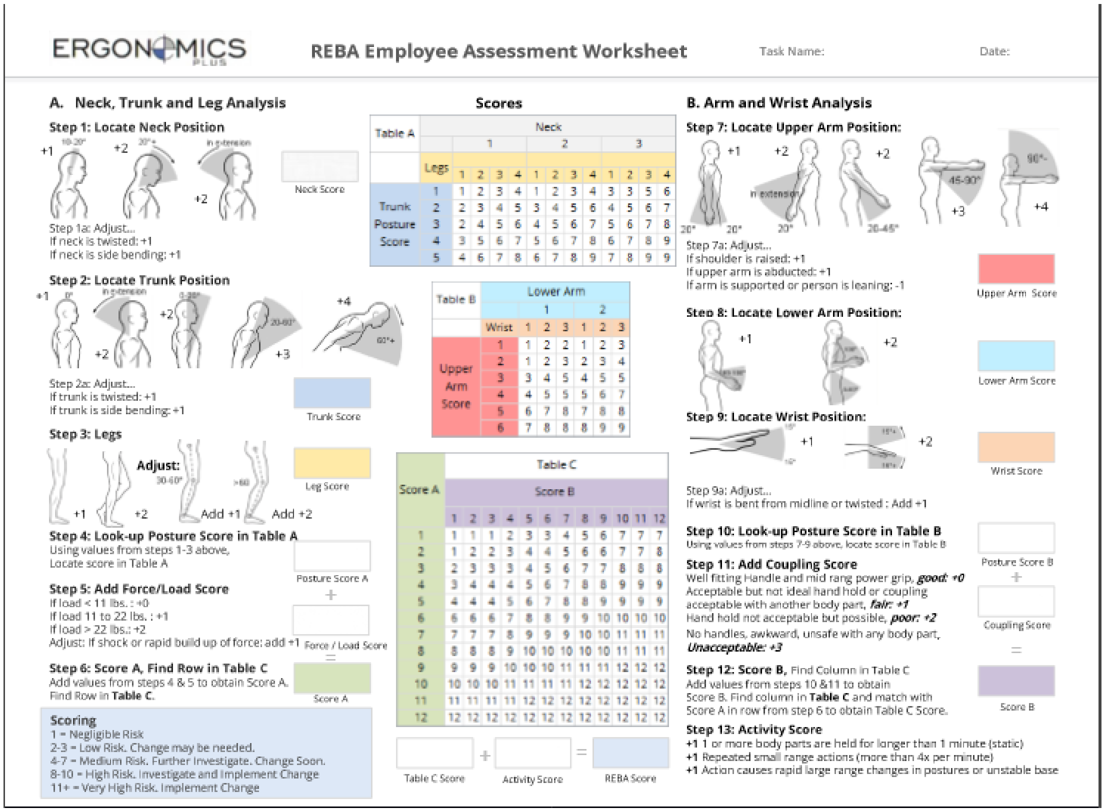


Figure 2.5 REBA Assessment Worksheet

Group A comprises of the axis of the body: the neck, trunk, legs, and force/weight. For the measurement, there are criteria that need to be followed to provide the proper scoring of each part.

- Neck

  The factor that needs to be measured is how much the neck can bend. For the bending around 10 to 20° downwards input scoring as +1. If the bending can go for more than 20° downwards and upwards, score as +2. For neck twisting, score as +1, for bending to the side, add by +1.

- Trunk

  Measure the bending of the trunk, be it downwards or sideways. If the body is standing straight up, or measured as 0°, input score as +1. If the trunk bends upwards, score is +2, and the same score if the trunk bends downwards for less than 20°. If it bends around 20° to 60°, the score is +3. If it goes further than 60°, then the score is +4. If it's twisted or bending sideways, add a score of +1.

- Leg

  Measure the bend of the knee. If the person stands straight with steadily, give a score of +1. If only one leg that is steady, the score is +2. If the bent of the knees are between from 30 to 60°, add score +1, and if it is more than 60°, add score +2.

  Then the assessment continues by referring the scores to the matrix of body parts A.

Table 2.2 Body Parts A Matrix

Table A	Neck												
		1				2				3			
	Legs	1	2	3	4	1	2	3	4	1	2	3	4
Trunk	1	1	2	3	4	1	2	3	5	3	3	5	6
	2	2	3	4	5	3	4	5	6	4	5	6	7
	3	2	4	5	6	4	5	6	7	5	6	7	8
	4	3	5	6	7	5	6	7	8	6	7	8	9
	5	4	6	7	8	6	7	8	9	7	8	9	9

- We measure using the scores matrix above, and then adding the score of the load that the body parts can bear. For the score of the load, we measure it by its mass. If it is less than 11 lbs., score is 0. If it is from 11-22 lbs., the score is +1. If it is more than 22 lbs., then add +2. Should there be a sudden force built up, add the score by +1.

The Figure 2.6 below explains the REBA assessment for Group A. The example shows as the following: neck +1; trunk +3; legs +1. And based on the scoring sheet for Group A, the result is +2.

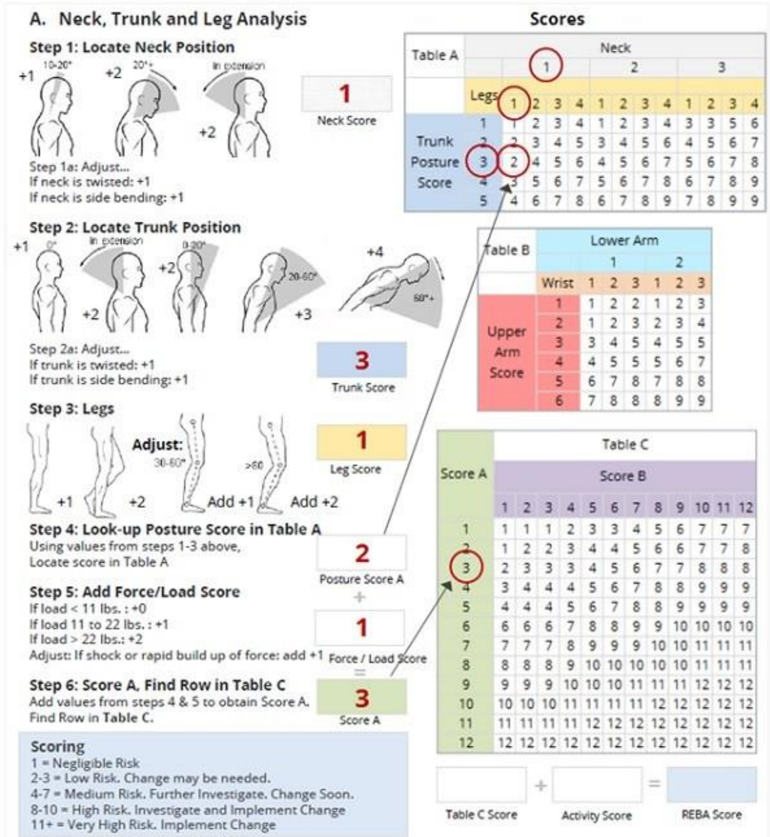


Figure 2.6 Example of REBA Scoring: Body Parts A

The next step of the assessment is the measurement of Group B. This group includes body parts mostly in the upper auxiliary of the body: the arms. We measure from the upper and lower arm, wrists, and coupling. The following are the criteria to be followed for the scoring process:

- Upper arm.

  The baseline of the measuring process is the degree of bending of the upper arms. If the upper arms bend 20° either frontwards or backwards, the score is +1. If the upper arm bends backwards for more than 20°, the score is +2. If it bends from 20 to 45° frontwards, score is +2. If it bends around 45 to 90° frontwards, score is +3, and if it is above 90° score is +4. For conditions of abduction or the shoulder is raised, add score by +1. If a support is needed for the arm, then reduce the score by -1.

- Lower arm

  We measure the bending degree of the lower arms. If the degree is between 0 to 60°, score is +1. If it is between 60 to 100° or more, score is +2.

- Wrist

  We measure the bending of the wrist. If the wrist bend at around 15° either upwards or downwards, score is +1. If it could bend above 15° either upwards or downwards, score is +1. If the wrist could be twisted, then add the score by +1.

- Continue the assessment process and refer the score result to the matrix for group B.

Table 2.3 Body Parts B Matrix

Table B	Lower Arm						
		1			2		
	Wrist	1	2	3	1	2	3
Upper Arm	1	1	2	2	1	2	3
	2	1	2	3	2	3	4
	3	3	4	5	4	5	5
	4	4	5	5	5	6	7
	5	6	7	8	7	8	8
	6	7	8	8	8	9	9

- We combine the results of the matrix for Group B with the coupling score. If the coupling fits well to the handle and have power range for mid power level, then score it as 0. If the coupling is passable, but no ideal handhold, then score it as +1. If the handle is not acceptable but still possible to be handheld, then score as +2. If there are not any handles, and it is awkward for coupling, or unsafe for any parts of the body, then score it as +3. The figure below elaborates the example for the REBA assessment of Group B.

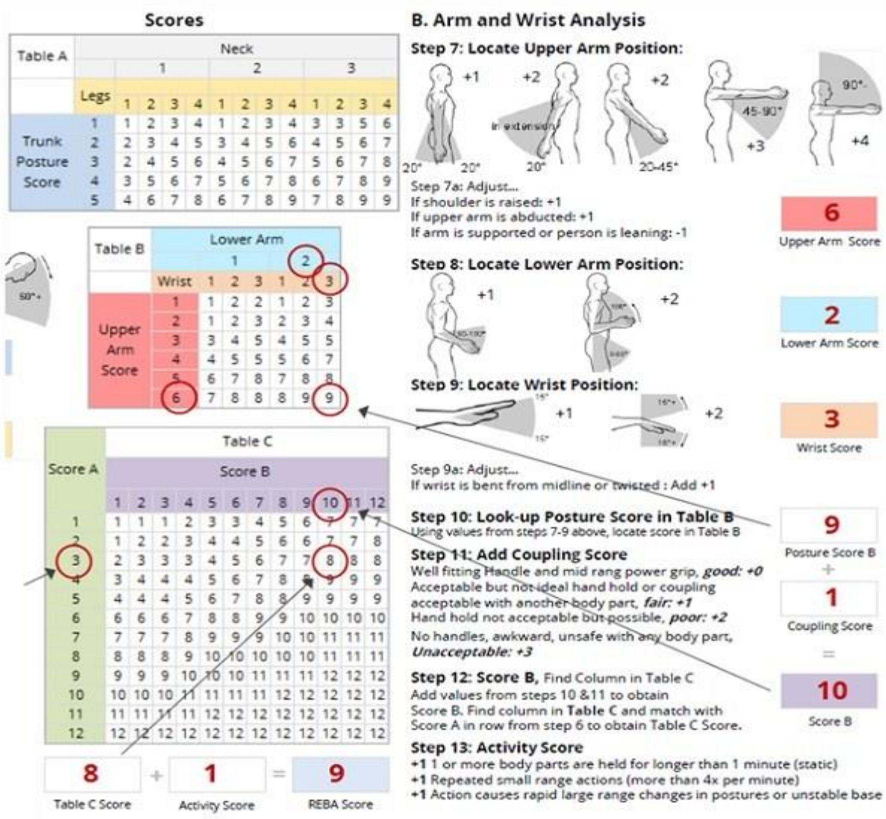


Figure 2.7 Example of REBA Scoring: Body Parts B

The Figure 2.7 shows that the scores for the group B used as the example are the upper arm (+6), lower arm (+2), wrist (+3), and coupling (+1). Based on the matrix, the REBA score for the Group B body part is 10.

After the Group A and Group B is calculated, we continue to the REBA score C, as shown in the table 2.4 below. If the score C is calculated, continue the assessment process to the addition of score C with the activity score. We base the activity score's criteria on the duration and repetition. If one or more body parts is hold for more than a minute, the score is +1. If the activity requires repetition in small actions as much as 4 times a minute, then score is +1. If the consequence of the action would cause a large scale of change in posture or base, score is +1.

Table 2.4 REBA Score C Matrix

Score A	Table C											
	Score B											
	1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	11	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

Take a look at the Figure 2.8 below showing the final score of the example for score C. previous scores of group A (3) and score B (10), and score C (8), added with the activity score that is +1, then it can be concluded that the REBA score finally is 9.

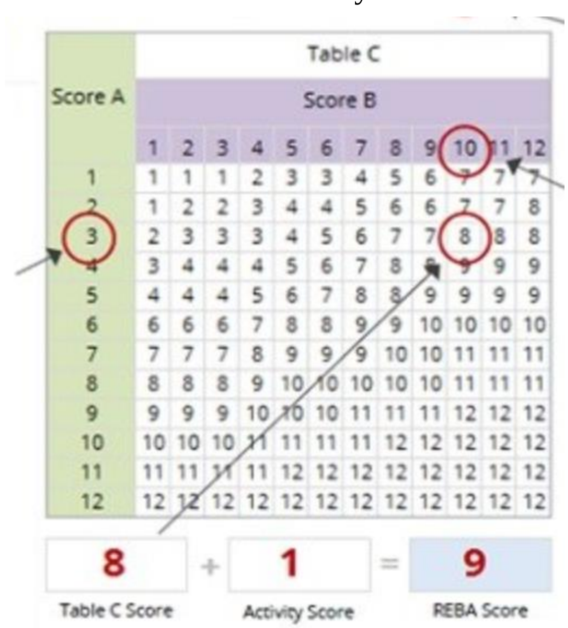


Figure 2.8 Example of REBA Score C and Final Score

When the final REBA score is resulted through the assessment process, the next step would be to determine the risk of manual handling. The table 2.5 shows a range from 1 to 15 based on the REBA score and the risk level that can be shown and the action plan required for the appropriate risk level.

Table 2.5 Risk Level

REBA Score	Risk Level	Action Plan
1	Negligible	None necessary
2-3	Low	Change may be needed
4-7	Medium	Further investigate, change soon
8-10	High	Investigate and implement change
11-15	Very High	Implement change

2.7 Differences between REBA Other Methods

Besides REBA, Biomechanics, and RWL, there are other methods in assessing posture, such as Ovako Working Posture Analysis System (OWAS), PLIBEL, Rapid Upper Limb Assessment (RULA), Strain Index, Quick Exposure Checklist (QEC), NIOSH Lifting Equation, and Occupational Repetitive Action (OCRA). Table 2.7 and Table 2.6 provide differences between REBA, Biomechanics, RWL, and the other said methods.

Table 2.6 Main Features and Function of Some Ergonomic Methods

Methods	Main Features	Function
OWAS	Time sampling for body postures and force	Whole body posture recording and analysis
PLIBEL	Checklist with questions for different body regions	Identification of risk factor
RULA	Categorization of body posture and force, with action levels for assessment	Upper body and limb assessment for dynamic task
REBA	Categorization of body posture and force, with action levels for assessment	Entire body assessment for dynamic task
Strain Index	Combined index of six exposure factors for work task	Assessment of risk for distal upper extremity disorders

Table 2.6 Main Features and Function of Some Ergonomic Methods (Cont'd)

QEC	Exposure levels for main body regions with worker responses and scores to guide intervention	Assessment of exposure of upper body and limb for static and dynamic tasks
Niosh Lifting Equation	Measurement of posture related to biomechanical load for manual handling	Identification of risk factors and assessment
OCRA	Measures for body posture and force for repetitive tasks	Integrated assessment scores for various types of jobs

(Source: David, 2005, P.3 and P.4)

Table 2.7 Exposure Factors Assessed by Some Ergonomic Methods

Methods	Posture	Load/Force	Movement frequency	Duration	Recovery	Vibration	Others
OWAS	✓	✓					
PLIBEL	✓	✓					✓
RULA	✓	✓	✓				
REBA	✓	✓	✓				✓
Strain Index	✓	✓	✓	✓			✓
QEC	✓	✓	✓	✓		✓	✓
Niosh Lifting Equation	✓	✓	✓	✓	✓		✓
OCRA	✓	✓	✓	✓	✓	✓	✓

(Source: David, 2005, P.3 and P.4)

2.8 Quality Function Deployment Method

In 1996, the QFD was developed by Professor Yoji Akao in Japan (Akao, 1972). The purpose of QFD is to match the needs of customer with engineering characteristics. Conveying and realizing the voice of the customer is the starting point of quality function deployment. In addition, it also brings together multifunctional teams to work together in order to satisfy the customers.

QFD assists the team to focus on customer needs through total development cycle in the form of visual linking process. For each stage of the deployment of quality functions process, appropriate technical requirements are being translated from customer needs (Clausing and Pugh, 1991).

2.8.1 House of Quality

House of quality is a matrix that captures important points within the planning process in the dissemination of quality functions. For example, Figure 2.8 shows quality homes for chocolate chip cookies. In order to set problem targets, the team is assisted by house of quality to find out what matters most to customers and the technically plausible method of the mechanisms that can be done (Clausing and Pugh, 1991). House of quality contains of six components; customer requirements, technical specifications, planning matrix, an interrelationship matrix, technical correlation matrix, and technical priorities/benchmarks of target sections.

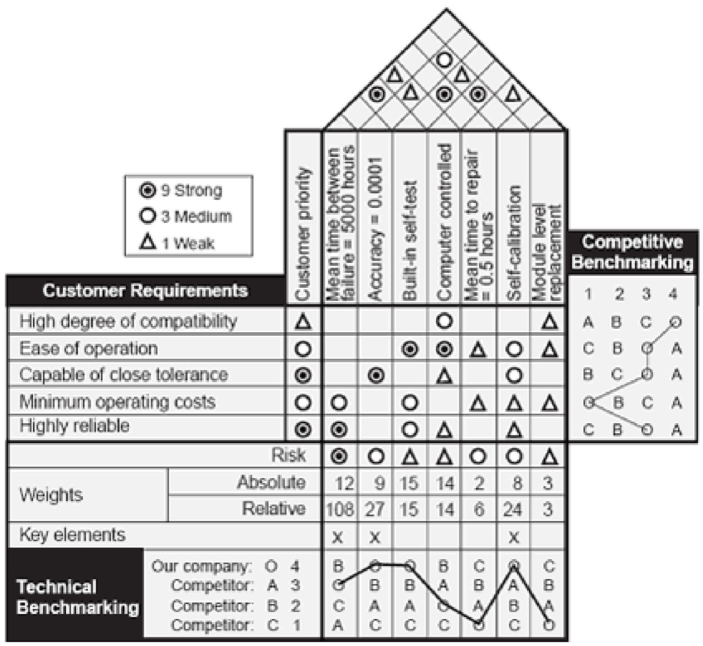


Figure 2.9 Example of House of Quality

According to Charantimath (2003), there are six steps in constructing a House of Quality:

1. **Listing customer needs**

   into account, companies are more likely to design products that customers value. To accomplish this, everyone involved in product development must work together throughout the development process to focus their best efforts on what matters most to customers. The result is a product or service superior to the competition, and which satisfies customers by providing value. This can only be achieved when product developers accurately understand the true needs of the company's customers

2. **Listing technical specification**

   The goal of the house of quality is to design or change the design of a product in a way that meets or exceeds the customer expectations. Now that the customer needs and expectations have been expressed in terms of customer requirements, the QFD team must come up with engineering characteristics or technical descriptors that will affect one or more of the customer requirements.

3. **Constructing a relationship between customer's needs and technical specification.**

   The next step in building a house of quality is to compare the customer requirements and technical descriptors and determine their respective relationships. Tracing the relationships between the customer requirements and the technical descriptors can become very confusing, because each customer requirement may affect more than one technical descriptor, and vice versa

4. **Developing interrelationship in technical specifications**

   The roof of the house of quality, called the correlation matrix, is used to identify any interrelationships between each of the technical descriptors. The correlation matrix is a triangular table attached to the technical descriptors, Symbols are used to describe the strength of the interrelationships.

5. **Developing a competitive assessment for customer needs**

   The competitive assessments are a pair of weighted tables (or graphs) that depict item for item how competitive products compare with current organization products. The competitive assessment tables are separated into two categories, customer assessment and technical assessment.

6. **Developing prioritized technical specification**

   The prioritized customer requirements make up a block of columns corresponding to each customer requirement in the house of quality on the right side of the customer competitive assessment. These prioritized customer requirements contain columns for importance to customer, target value, scale-up factor, sales point, and an absolute weight.

Advantage and disadvantage of QFD method can be seen in table 2.8

Table 2.8 Advantage and Disadvantage of QFD

Advantage	Disadvantage
Focus on customer	The voice of customer has many meaning
Consist of large amounts of verbal data	Large amounts of subjective data should be inputted and analyzed deeply
Development time and engineering cost can be reduced become 50 percent and 30 percent respectively	The development records of QFD are rarely kept
At the design stage the product can be evaluated to improve design quality	The input of customer survey for house of quality (HOQ) is done manually and time-consuming and difficult
The data is organized in a logical way	The house of quality can become very complex and large

CHAPTER III

RESEARCH METHODOLOGY

In this chapter, the flow of the whole process of this research is explained. The steps were planned before the research is done so that they can become a guide for the researcher to start and do the research effectively until the objectives of the research are reached. Here is the flow chart and the description of the research methodology made by the researcher.

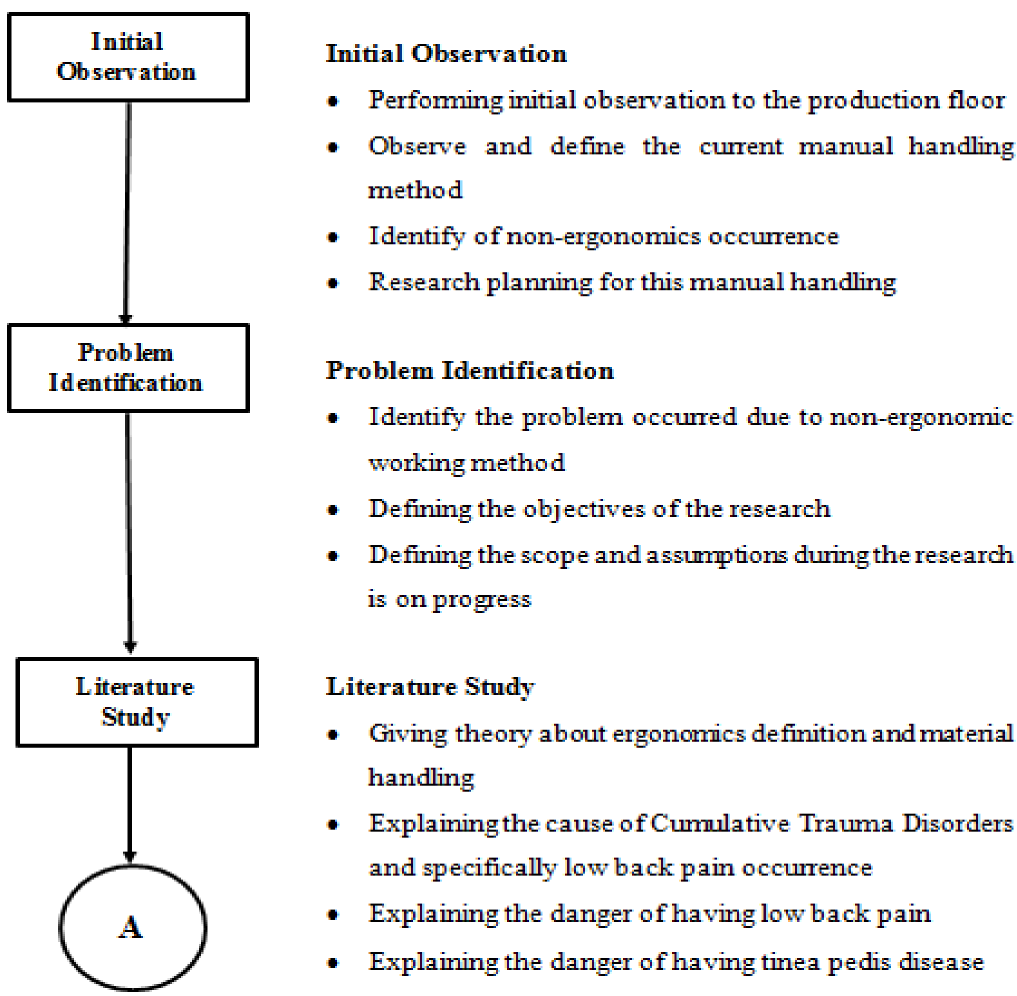
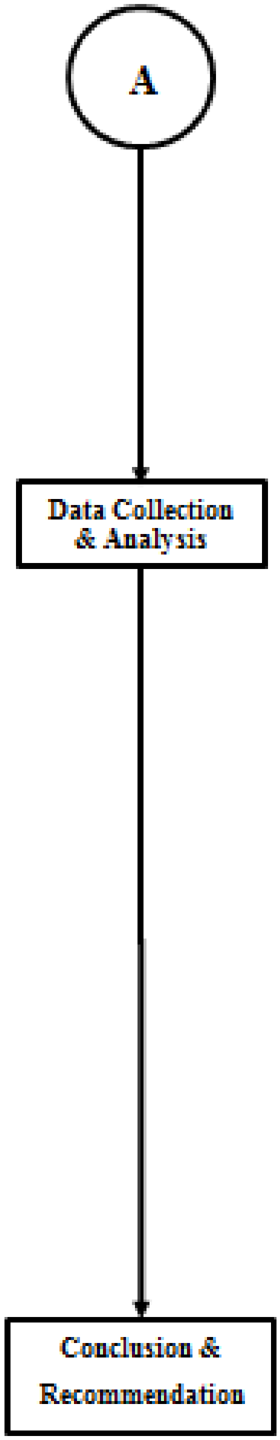


Figure 3.1 Research Framework of The Research



- To describe the utilization of REBA analysis for a non-ergonomics working situation
- Describing anthropometry theory as it is used for measurement to find the improvement for the working method
- Describing Quality Function Deployment (QFD) method as it is use measurement to find the improving tools.

Data Collection & Analysis

- Overview of the current working condition in leak testing area
- Collect the raw data for the research in the form of documentation and non-ergonomics activity being analyzed
- To collect the Indonesian Human Body Standard Anthropometry data
- To analyze the non-ergonomics activity with utilizing REBA analysis
- To analyze the workplace condition utilizing anthropometry data
- Using QFD method to make improving tools and provide product selection
- Conducting before-after analysis

Conclusion & Recommendation

- Answering the problem statement
- Giving recommendations for the reader or the future researcher who will deal with an observation in the similar field of study

Figure 3.1 Research Framework of The Research (Cont'd)

3.1 Initial Observation

Initial observation is the first step in the research where the researcher found that the operator in charge of leak testing activity on AHZ tank in PT. FRS was doing the activity in an awkward position. Since the activity is routinely done with an awkward posture to the operator, it may cause the operator to have Cumulative Trauma Disorders – lower back pain and *Tinea pedis*. Assuming that the problem was about non-ergonomics, then the planning for observation can be constructed.

3.2 Problem Identification

This step is conducted to understand the problems selected on the initial observation. In this step, problem statements should be defined as the base of this research, which will lead to the objective in doing this research. The main problem for this research is the lower back pain issue and *Tinea pedis* disease that is contracted by the leak testing operators on AHZ tank of PT. FRS. This condition will put the operators in a risk of permanent handicap as the worst-case scenario of this ergonomic problem. In addition to that, the current work place and tools of the leak testing activity do not support for proper ergonomics when working and direly need to be-redesigned, which would be done after the researcher defines the research objective, then the scope, limitations, and assumptions required for the research have to be defined in order to run this research.

3.3 Literature Study

This part is where the literature references are required in order to support the theories that used for this research. Moreover, the literature references help the main theories to achieve the main goal of this research itself, which is to make improvements on the method of manual handling. The theory used in this research would be the main parameter for the assessment of the result obtained in the end.

Therefore, in this particular research, the researcher will use several supporting theories to expedite the research processes. Firstly, the theory of manual material handling and the basics of ergonomics. Secondly, the theory about Cumulative Trauma Disorders and *Tinea pedis* disease. This trauma occurs due to lower back pain that is subsequently caused by non-ergonomics manual handling. Therefore, the explanation of the risk and danger of having lower back pain is also required as the supporting theory. Lastly, the researcher also considers the theory of anthropometry and the principles of working design. Moreover, for the non-ergonomics condition, the supporting theory used would be REBA and the likes. In addition to that, to help make the design for the tools, the theory used the house of quality and product selection.

3.4 Data Collection & Analysis

In this step, the whole data related to the leak testing activity is gathered and collected. During the process of data collection, the researcher did the observation of the leak testing area of PT. FRS. The data taken were in photos from the area. The information regarding the details of the tools used for the manual handling, such as the dimension of container box, is also documented. In order to know the feedback and the opinion of the operator in charge of the activity, interviews to several operators were also conducted. This is an additional approach to come up with better recommendations and solutions to improve the current condition of the activity.

After all of the prior steps were through and all of the data required to conduct a research are collected, the analysis of these relevant information will be conducted. The analysis will start from assessing the current condition by using several ergonomic tools and methods. After obtaining the assessment result of the current condition, the analysis will be continued to the presentation of solutions and improvements for the manual handling activity. The very last step is to observe and analyze the result of the improvements by means of assuming the result of the performance after using the improved solution. The assessment is supposed to see whether there is the occurrence of Cumulative Trauma Disorders – Lower back Pain and *Tinea pedis* disease or not on the workers following the improvements.

3.5 Conclusion & Recommendation

As the last step of the research, the conclusion summarizes the whole process of the research up to the accomplishment of the research objectives. The statement of problems will be answered and the improvement for the manual handling will be presented. Furthermore, the conclusion part will be completed with the recommendations intended to the future studies in the related fields. The recommendations will be consisted of advices and suggestions for future research in order to fill the gap between the existing and future studies.

3.6 Detailed Framework

Figure 3.2 below shows the detailed research framework for this research. In the figure below, the breakdowns of every step in completing the research were explained. The steps conducted during data calculation and analyses are also mentioned. Firstly, the research is done by observing directly the activity of leak testing of AHZ tank in PT. FRS. This activity still uses manual material handling in leak testing area of the company that forces the operators to perform the task in an awkward body posture and position. The duration and repetition of the activity may cause the operator to have Cumulative Trauma Disorders – Lower Back Pain and *Tinea pedis* disease. Therefore, this activity is categorized as a non-ergonomics activity.

All the data related to the activity of leak testing on AHZ tank by manual handling is gathered. The data gathering and observation process were done directly in the production floor of PT. FRS. The data and information taken in the production floor were documented clearly in the format of photographs. The other information gathered is about tools used for the manual handling, such as dimension of container box. Interviews were also done with the operators of the leak-testing activity to know what the operators feel while doing the activity and what should be recommended to improve this current condition of the activity.

After collecting all the data, the activities of leak testing will be analyzed using the REBA method. REBA is an ergonomic approach used to analyze posture by considering the physical condition of body parts, such as neck, shoulders, legs, arm, coupling, and material weight. Then the workstation of leak testing is analyzed by using anthropometric data. Anthropometry is used as data for equipment design to ensure the usability of the workstation and comfort of the operator who uses it. Finally yet importantly, is analyzing the activity of leak testing of AHZ tank and leak testing area by using the said anthropometric data. After that, the researchers will design the improvements using quality function deployment (QFD) to get the operators tools needed to support them. QFD assists the team to focus on operator needs through total development cycle in the form of visual linking process. For each stage of the deployment of quality functions process, appropriate technical requirements are being translated from the operators' needs (Clausing and Pugh, 1991). After that, the researchers will select and choose the product that the operators will use to assist the leak testing activity of AHZ tank. At the end of this study, there will be a comparison relating to the final REBA score to determine the impact of the improvement. After that, a tool will be selected and provided to reduce the potential risks for operators in leak testing activity of the company.

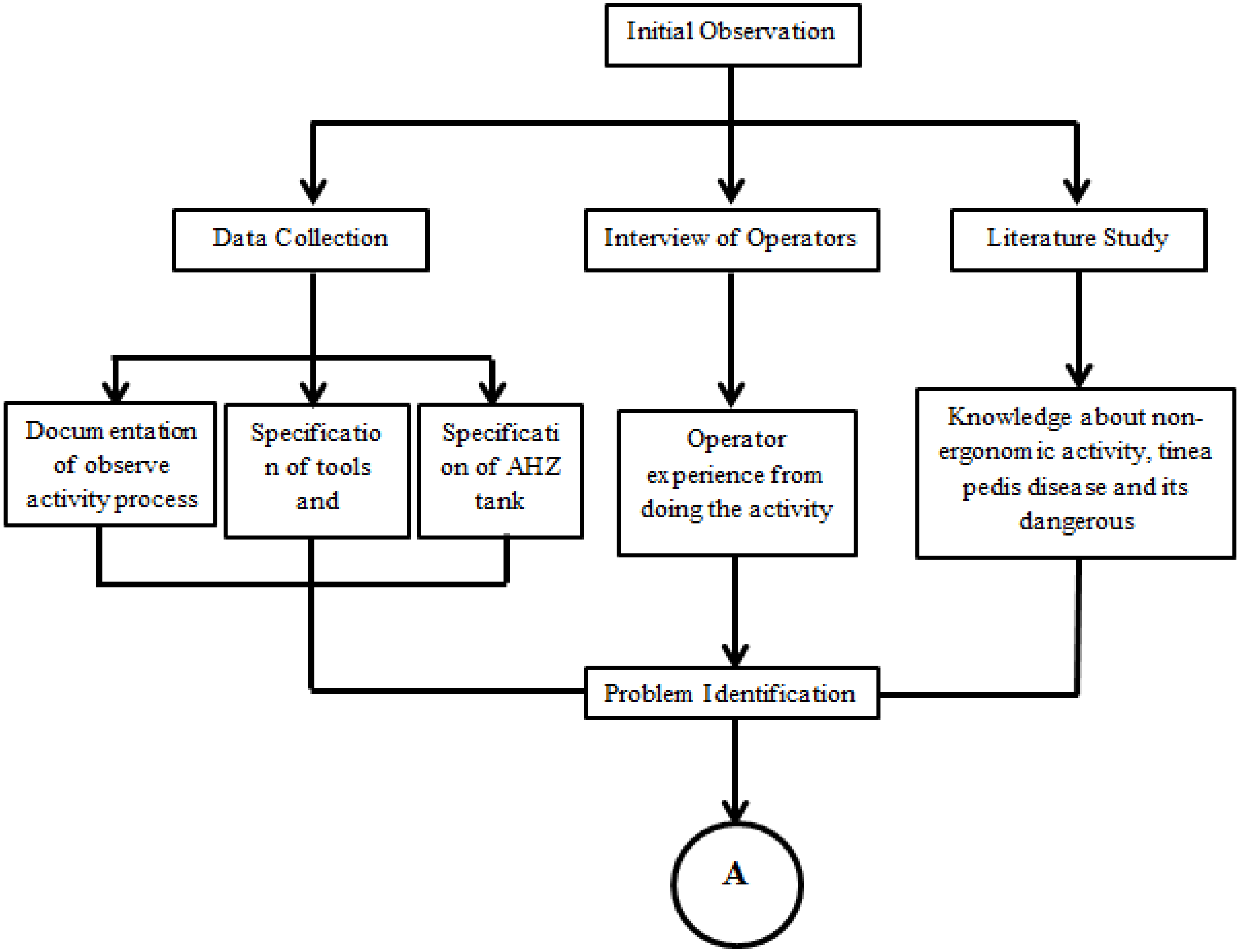


Figure 3.2 Detailed Framework

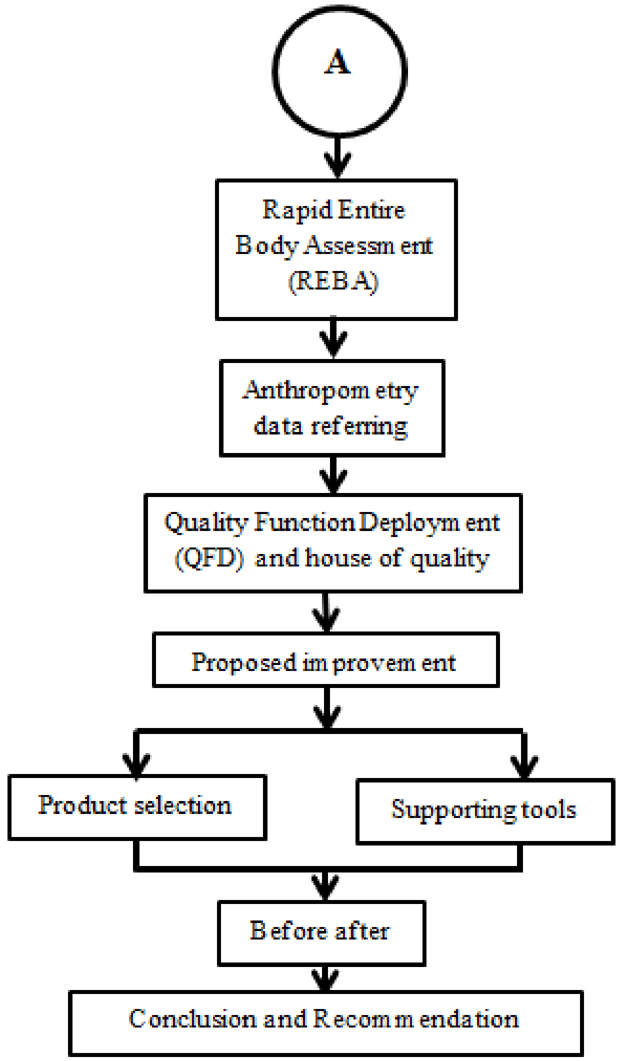


Figure 3.2 Detailed Framework (Cont'd)

CHAPTER IV

DATA COLLECTION & ANALYSIS

4.1 Initial Observation

4.1.1 Workplace Overview

In PT.FRS there is a large machine that produces plastic packaging, such as oil bottle, bottle drink, tank for motor cycle radiator etc., in workstation in leak tester of AHZ tank is located beside AHZ tank making machine itself. The temperature of the work places is according to standards and does not require improvement. The operator performs leak testing activities beside the machine from the AHZ tank itself.

The problem appears when the operator doing the activity of leak testing, in this workstation of leak tester, the material handling is still done manually. It require the operator to leak tester the AHZ tank repetitively with hand in the box of water, and within 4 hours of working, the frequency of the operator to leak testing the AHZ tank can reach 4 bag of AHZ tank, in which one bag contains 400 piece of AHZ tank, the operator need 1 hour to done the leak testing of 1 bag of AHZ tank, This will eventually causes to a Cumulative Trauma Disorders - Low Back Pain and tinea pedis disease.

4.1.2 Non-ergonomic Activity

The leak testing activity is routine activity conducted at PT.FRS. This activity is done every day until the AHZ tank still produce in PT.FRS. After observation the leak testing on AHZ tank, it has found the activity risk in leak testing process. The activity of leak testing is highly risky and non-ergonomics, since operators force himself to bend his body when he sit and doing leak testing. Table 4.1 will show the complaint data from operator.

Table 4.1 Complaint Data from Operator

	At the time of leak testing activities the operator is uncomfortable because the position is bent and often feel pain at the waist (low back pain), and the work is done 4 hours per day, and his sitting position almost like squatting and often feel pain in the leg after doing leak testing activities, so also in the neck, operators often feel the pain because they have to follow the shape of the back less good.
	At the time of leak testing activities the operators often complain to feel itchy in hands (tinea pedis disease) caused by the hands that are too long in the water.

4.2 Data Collection

To analyze such problems that occur in the leak testing area, it is necessary to observe using the ergonomic tool, the results will be analyzed and provisioned using 2 methods in the ergonomic which are; Rapid Entire Body Assessment (REBA) and Anthropometry to reduce the occurrence of Cumulative Trauma Disorders - Low Back Pain and tinea pedis disease. The data needed to perform this observation are data operators, AHZ tank, anthropometry data and so on.

4.2.1 Specification of Tools and Personnel

The following are the detail for tools requires for the activity when the operator doing the leak testing in PT. FRS and also the data operators that consists of the information about gender, body weight and body height.

a. Container Box

Figure 4.1 below shows the container box using by the operator for chair and to hold water and doing leak testing activities. The length of container box 54cm, the width 30cm the height 41cm and the weight is 1,5kg

Figure 4.1 Container Box

b. Leak Tester

Figure 4.2 below shows the leak tester use to leak testing the AHZ tank, leak tester need 7 second to doing the leak testing of 1 AHZ tank , the length of a handle of a leak tester is 11cm , the width is 1cm and the diameter of leak tester is Ø 3cm.

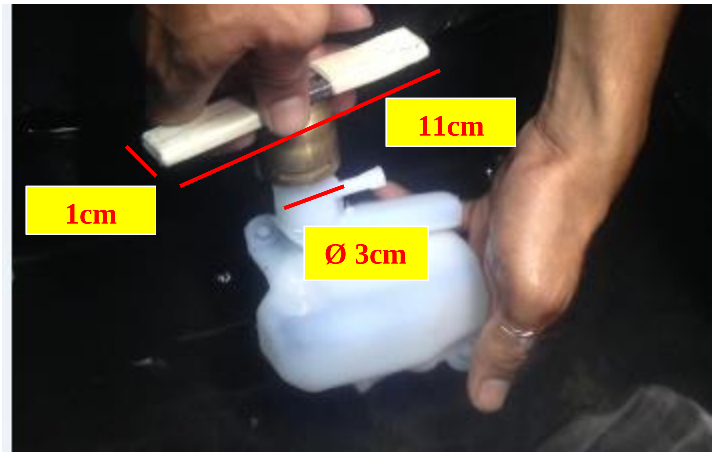


Figure 4.2 Leak Tester

c. **Operator**

PT. FRS has 2 operators for leak tester activity. Every operator will work in 2 different shift, per shift the company have 8 hours working time first shift will work from 08:00 AM – 05:00 PM, second shift will work from 05:00 PM – 01:00 AM, the operator just have 4 hours working time to finish 4 bag of AHZ tank, and after the operator finish leak testing activity they have a different job. It means if operator A works for shift 1, operator B for shift 2. The information of operators is shown in Table 4.2 Operator Data

Table 4.2 Operator Data

Operator	**Gender**	**Height**	**Body Mass**
Operator A	Male	173 cm	58 kg
Operator B	Male	169 cm	55 kg

4.2.2 Specification of AHZ tank

AHZ tank is a tank for motorcycles air radiator, the AHZ tank is requested by number one motorcycles industries in the world, and the AHZ tank must be finish in perfect condition without reject in every aspect such as in leak, and this is the last activity in AHZ tank it is leak testing of AHZ tank, this activity is done manually and repeatedly. Figure 4.3 shows the condition of AHZ tank and Table 4.3 shows the calculation of AHZ tank for one shift.

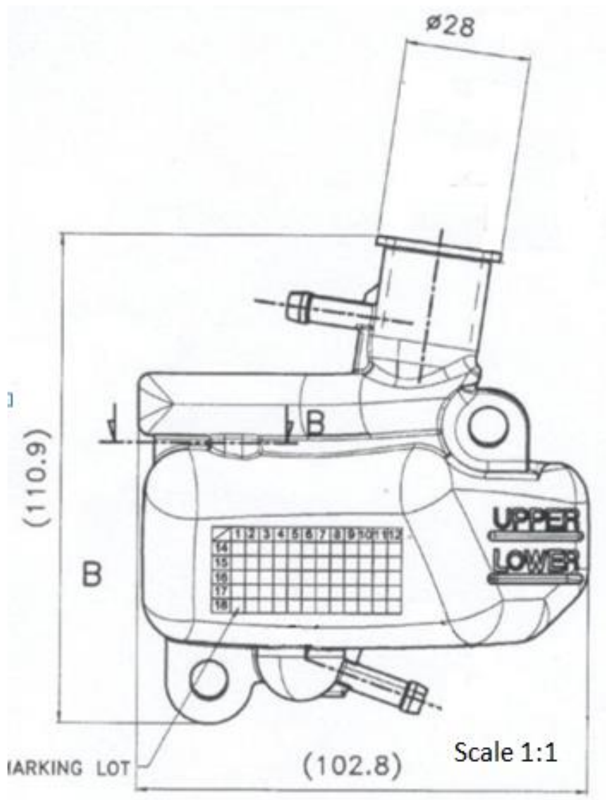


Figure 4.3 AHZ Tank

Table 4.3 shows that operator can finish 1600 AHM tank in four hours working in one shift, in one bag PT.FRS have 400 of AHZ tank and the operator can finish leak tester of one AHZ tank with eight second, it mean the cycle time to doing leak testing for one AHZ tank is eight second.

Table 4.3 AHZ calculation

Item	storage	Cycle time
AHZ tank	400pcs/ bag	8 second
Total	1600pcs (4bag)	14400 second

4.3 Data Analysis

The further step after calculating all required data is data analysis which will discuss in this part. The result of data analysis is the improvement process on leak testing on AHZ tank which expected to reduce the non-ergonomic activity in leak testing area the potential of tinea pedis disease and Cumulative Trauma Disorders – Low Back Pain.

4.3.1 Rapid Entire Body Assessment Analysis (REBA)

This activity is categorized as non-ergonomics activity because it consists the manual handling with risk of having Cumulative Trauma Disorders – Low Back Pain because the activity is done in awkward postures. According to Corporate Work Health Australia on 2013, bending spine in doing leak testing of AHZ tank and the bending position of the legs that make the body posture is not ideal, the position of the body of the operator is sitting almost squatting when doing leak testing activity. It increases stress on the vertebral joints and intervertebral discs-can lead to Slip Disc.

In this activity, it is always difficult for the operator to doing the leak testing of AHZ tank because the operator get awkward posture when do leak testing activity that the worker must bending his back to do leak testing and the hand of the operator is always in the water.

To evaluate the current body posture condition while doing leak testing of AHZ tank, Rapid Entire Body Assessment or REBA analysis is done. This assessment is used to evaluate the whole crucial body parts of the human worker which consists of the angle of bending, the body parts condition. In this current activity, neck, truck, upper arm, lower arm, wrist and leg of the operator are assessed. Then, the total score of REBA at the end will determine if the current condition of the activity needs to be improved.

1. REBA Body Parts A: Trunk

Figure 4.4 REBA of Trunk

REBA analysis starts with the assessment of body parts group A. Group A consists of trunk, neck and legs. The first body part is trunk. In the current condition of the activity, it is obviously seen that the operator has to bend his trunk while leak testing of AHZ tank are not ergonomics. It is risky as the operator must bend in 4 hours every day, in this condition, trunk of operator is bended to approximately 70^o. It is categorized as more than 60^o downward bending trunk which the REBA score resulted is +4.

2. REBA Body Parts A: Neck

The next body part to assess is neck. The operator looks quite forced to tilt up his neck due to leak testing on AHZ tank. The upward bending of operator’s neck is 22^o degrees. Since the neck position is categorized as in extension, so the REBA score of neck resulted is +2.

Figure 4.5 REBA of Neck

3. REBA Body Parts A: Legs

The third body part assessed in group A is legs. In the current condition legs of the operator bending leg while doing leak testing of AHZ tank. The knees of the operator are bended to 34°. The both bending legs result the REBA score of legs +1. Meanwhile, the degree of knees bending does not result more REBA score of legs.

Figure 4.6 REBA of Legs

After all group A body parts are assessed, the score of group A is determined using REBA Table A matrix as shown in table 4.4 below.

Table 4.4 Table A of REBA

Table A		Neck											
		1				2				3			
	Legs	1	2	3	4	1	2	3	4	1	2	3	4
Trunk	1	1	2	3	4	1	2	3	5	3	3	5	6
	2	2	3	4	5	3	4	5	6	4	5	6	7
	3	2	4	5	6	4	5	6	7	5	6	7	8
	4	3	5	6	7	5	6	7	8	6	7	8	9
	5	4	6	7	8	6	7	8	9	7	8	9	9

From table A of REBA, it is determined that the score for group A body parts of REBA is equal to 5. Then, this score is added with the REBA score of the Force/Load in the activity. In this case, the force/load score comes from the mass of AHZ tank.

4. REBA Body Parts A: Force/Load

As shown in the figure 4.7 below, in the current condition of the activity, it shows that the operator doing leak testing activity using both hands. The load resulted from the AHZ tank is 0,045 kg or it is equal to 0,099208018 lbs. This load results +0 REBA score as it is categorized as less than 11 lbs. The load REBA score is then added to the REBA score of group A body parts. Therefore, the score is:

Score A = Group A Body Parts Score + Load Score

Score A = 5 + 0

Score A = 5

Figure 4.7 REBA of Force/Load

After the score of REBA group A is determined, the next step of assessment is for those body parts of group B. Group B of REBA body parts consist of upper arm, lower arm and wrist.

5. REBA Body Parts B: Upper Arm

The first body part to be assessed in group B is upper arm as it is seen in the figure 4.8 below shows that in leak testing activity, operator has to bend forward his upper arm to 73^{o}. This degree gives +3 REBA score. Then the REBA score of upper arm resulted is +3.

Figure 4.8 REBA of Upper Arm

6. REBA Body Parts B: Lower Arm

The second body part to be assessed in group B is lower arm. The assessment of the lower arm is determined from the degree resulted between the extended direction of the upper arm and the direction of the lower arm when bended. It shows that the degree resulted from bended lower arm is 45^o. The degree resulted gives +2 REBA score as it is categorized as 0^o – 60^o bended lower arm. The REBA of lower arm is shown in figure 4.9 below

Figure 4.9 REBA of Lower Arm

7. REBA Body Parts B: Wrist

The wrist of the operator doing leak testing activity made 64°. The degree resulted gives +2 REBA score as it is categorized as more than 15°. The final REBA score of wrist is +2. The REBA of wrist is shown in figure 4.10 below.

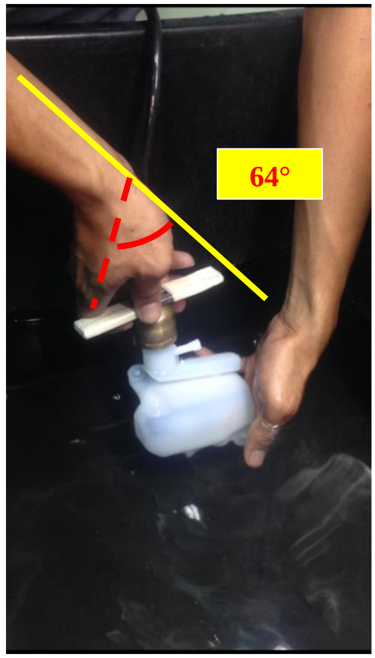


Figure 4.10 REBA of Wrist

After all group B body parts are assessed, the score of group B is determined using REBA Table B matrix.

Table 4.5 Table B of REBA

Table B	Lower Arm						
		1			2		
	Wrist	1	2	3	1	2	3
Upper Arm	1	1	2	2	1	2	3
	2	1	2	3	2	3	4
	3	3	4	5	4	5	5
	4	4	5	5	5	6	7
	5	6	7	8	7	8	8
	6	7	8	8	8	9	9

From table B of REBA, it is determined that the score for group B body parts of REBA is equal to 5. Then, this score is added with the REBA score of the coupling in the activity. In this case, when doing leak testing activity the AHZ tank is coupling acceptable but not ideal hand hold.

From the observation, the current condition of the operator's hands while leak testing AHZ tank is categorized as fair coupling. Therefore, the hand hold is acceptable but hand hold is no ideal. Fair coupling results +1 REBA score.

The coupling REBA score is then added to the REBA score of group B body parts. Therefore, the score is:

Score B = Group B Body Parts Score + Coupling Score

Score B = 5 + 1

Score B = 6

The score A and score B resulted are used to determine the score C. Score C is determined by referring to the matrix table of REBA score C.

Table 4.6 Table C of REBA

Score A	Table C											
	Score B											
	1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	11	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

Using table above, the REBA score C is determined as 7. This score C is then added with activity score to determine the final REBA Score. The final REBA score is then used to define the risk level and the action needed for the assessed activity.

From the direct observation to this activity, the activity score is determined equal to +1. This score comes because the action causes repeated small range action (more than 4x per minutes). This score is then added to score C to determine the REBA final score. Therefore, the score is

Final REBA Score = Score C + Activity Score

Final REBA Score = 7 + 1

Final REBA Score = 8

To gain more accurate REBA score, the excel function worksheet is used also to assess the body posture of the worker. The figure 4.11 below gives the result of REBA analysis through excel function worksheet.

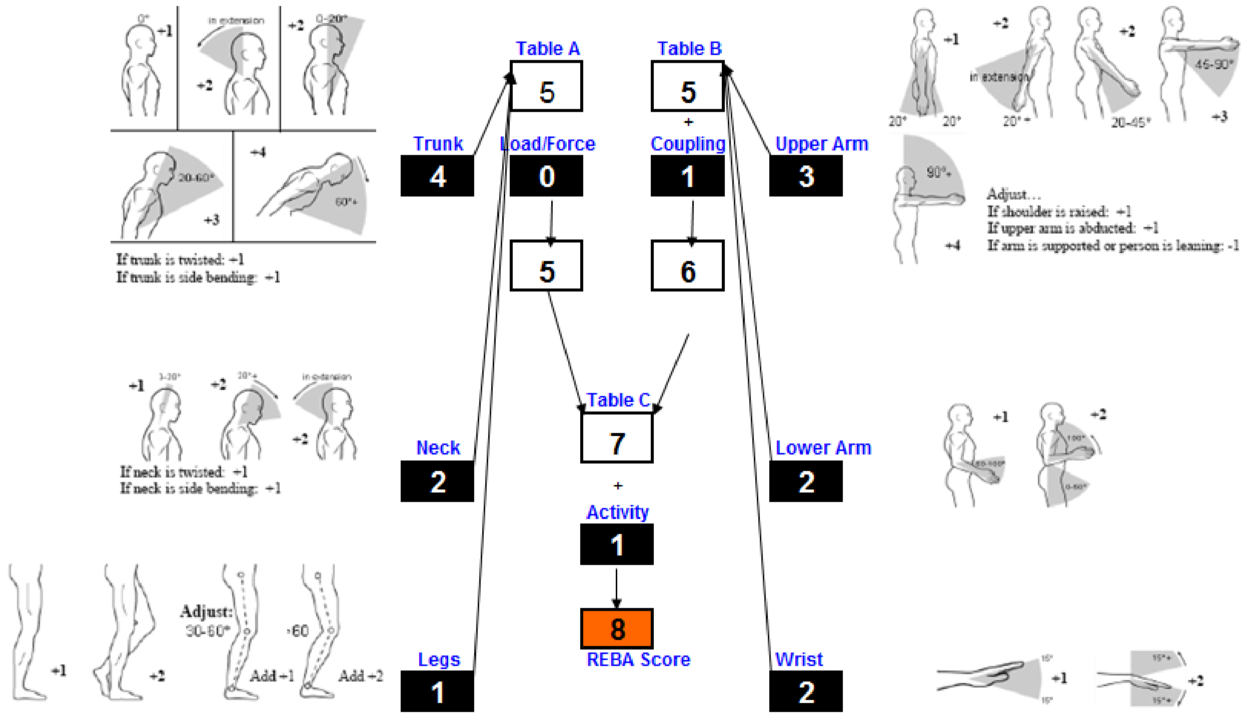


Figure 4.11 REBA Assessment Worksheet

From the REBA assessment table in excel, the REBA score for the activity of leak testing of AHZ tank (current condition) shows result 8 for final REBA score. This score is then used to see the reference of risk level to determine also the action plan needed for this activity.

Referring to risk level table that shown in Table 4.7, REBA final score of 8 is categorized as High Risk Level activity and action plan is to investigate and implement the change soon. The action plan objective is to make the activity of leak testing of AHZ tank remains running yet in safe condition. In this research, to accomplish this objective, it is planned to design supporting tools to help the operator to do leak testing of AHZ tank activity in safe condition.

Table 4.7 Level of Risk

REBA Score	Risk Level	Action Plan
1	Negligible	None necessary
2-3	Low	Change may be needed
4-7	Medium	Further investigate, change soon
8-10	High	Investigate and implement change
11-15	Very High	Implement change

4.3.2 Anthropometry Data

The activity of leak testing of AHZ tank requires the operator to interact with a containers box as a tool for sit and tools for doing leak testing of AHZ tank. Due to the height of the container box for doing leak testing of AHZ tank, the operator need to bow his body to perform the activity. While the lower arms of the operator will have to adjust with the height of the container box. The condition is still considered far from ergonomics. The evaluation of the condition of the activity using Indonesian Standard Body Dimension will define the non-ergonomics activities. The anthropometry data of Indonesian Standard Body Dimension measurement is presented in the Table 2.1.

From the table 2.1, the dimension of Elbow height is the one that has a correlation with the activity of leak testing of AHM tank. It is, of course, because the activity requires the operator to do a hand. The researcher decided to refer the standard to the 50th percentile value since the activity using elbow, in this case, are done by common people. If the standard is 5^{th} percentile, only those who are small-sized can fit with the standard comfortably. While, if the 95^{th} percentile is taken, only large-sized people can perform the activity with a comfortable position. The average value from an object measurement will equivalent with 50^{th} percentile (Soebroto, 2000).

Based on the explanation above, the Indonesian Standard Dimension of Elbow height is 98 cm (50^{th} percentile). The current height of the container box in the leak testing area of PT.FRS is 41 cm but the operator doing leak testing in the middle of the container box height in 20 cm, which is clearly below the standard of the height to get an ergonomically dimension in anthropometry data is in 98 cm.

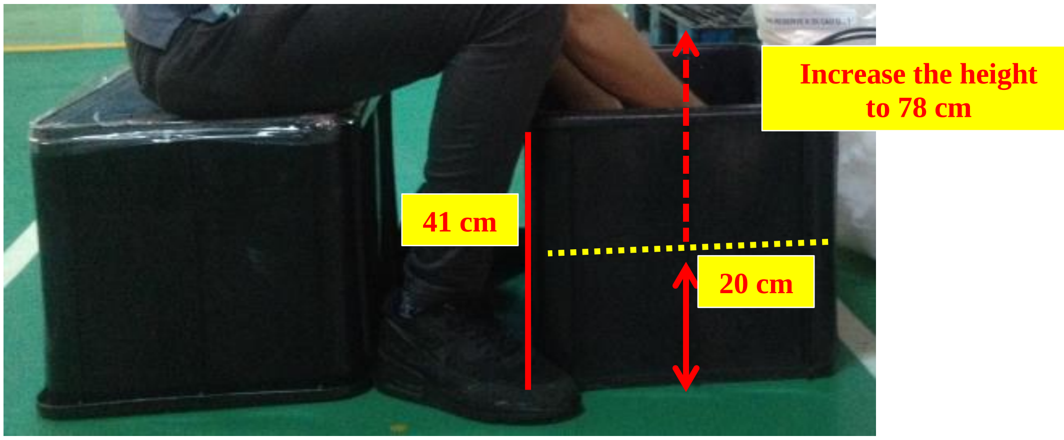


Figure 4.12 Container Box Dimension

The figure above can help to show the gap between the standard and the actual condition in the field, where the current height of the container box is 41cm but the operator doing leak testing in the middle of the container box height in 20 cm. Hence, the current condition is still non-ergonomics. The ergonomics activity in terms of hand related motion is preferred when the working area is accessible by the hands of the operator. It is to make sure that the operators do not have to force their body, or any part of their body, to perform the activity.

4.4 Proposed Improvement

The result indicated that bent trunk and tinea pedis disease was the most critical disease and posture that should be eliminated or reduces for leak testing of AHZ tank operator. Field observation showed that some poor working postures can be substantially reduce with the help of material handling equipment. To design a material handling equipment, the first step to do is product selection, after doing product selection the next step is, quality function deployment, is used to fulfill needs of operator with the material handling equipment's specification.

4.4.1 Product Selection

The result from the calculation shown that leak testing of AHZ tank was the most critical activity that should consider. The observation in the factory showed the operator doing leak testing of AHZ tank is in awkward position. In the future this activity will contribute to Cumulative Trauma Disorders – Low Back Pain and tinea pedis disease for the operator when the operator still completes the task in the awkward position. The awkward working posture can be reduced by provided tools as the material handling equipment. With providing tools in this activity may help the operators do the process easier. However, the effectiveness of the product must be considered. There are several considerations before choosing the product, such as the price of the product to be purchased, safety aspect in using the product and the maintenance of the product in the long period. In this product selection process, there are 3 products which each product has a function to assist the activity of leak testing on AHZ tank. The 3 product are adjustable table, hydraulic table and iron table.

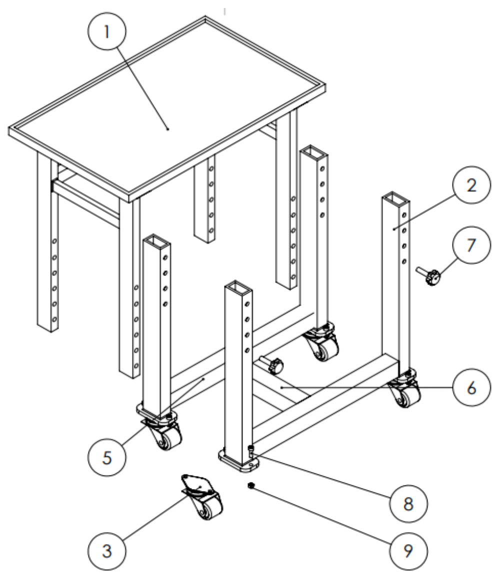


Figure 4.13 Adjustment Table

First product is an adjustment table, can help the operator doing leak testing with easier, comfortable and ergonomic posture. This tools is designed to make the operator can set the table size down and up easily with adjustments. This tool is one of the Personal Equipment that should be used by someone who works. Instead of making part of the worker's body standing with good position, when using adjustment table workers will be more flexible to be moved the table. Figure 4.14 show adjustment table.

Figure 4.14 Hydraulic Table

The second product is hydraulic table, a device that employs a scissors mechanism to raise or lower goods and/or persons is known as hydraulic table. This equipment helps raise heavy loads, for relatively small distances. Lift tables are used mostly to handle pallets, load vehicles and position workers for particular, specialized jobs. One of their advantages is that lift tables can be relatively easily adapted to perform a variety of different tasks. Figure 4.14 show hydraulic table.

Figure 4.15 Stainless Table

The last product is a stainless table, this chair is designed to be used in an industries. This table made from stainless steel, this table get category as a strong material table. Figure 4.15 show stainless table.

With 3 choices of products the selection must be done thoroughly. All products may have the purpose to help the activity of leak testing of AHZ tank, but there should be other considerations which make not all products are good choices for the current condition in the leak testing area of PT. FRS. The things to be considered may come from several perspectives such as operators which define the operator needs, the management of PT. FRS. That considers the possibility to afford the products, and the observation from the comfort by using the product that may define the safety risk of using the product.

Therefore, there are some selection criteria to products variants. The selection criteria consist of simplicity, comfort, manufacturing ease, cost, maintenance and safety. These criteria are then used as the parameter to assess the product in the selection proses. The product score is to score each product based on each criteria by giving plus, minus or zero which the explanation of the score as follow:

+ = product has strength in this criteria

0 = product has neutral value in this criteria

- = product has weakness in this criteria

The product selection process is shown in the table 4.8 below.

Table 4.8 Product Selection Process

Selection Criteria	**Products Variants**		
	Adjustment table	Hydraulic table	Stainless table
Simplicity	+	+	+
Comfort	+	+	-
Cost	0	-	+
Maintenance	+	0	0
Safety	+	+	+
PLUSES	4	3	3
SAMES	1	1	1
MINUSES	0	1	1
NET	4	2	2
RANK	1	2	3
CONTINUE?	YES	NO	NO

It shows that each product has its own plus and minus characteristics based on the selection criteria. For the 3 products get the score plus in the aspect of ease of standing, comfy and safety. In the simplicity aspect the first product got a plus score, the second product got a plus score and the third product got the plus score. Furthermore, in the comfort aspect first and second product got plus score the last product got minus score, in the cost aspect, the first product got the neutral score, second product got the minus score and third products got plus score. After that for the maintenance aspect, the first product got a plus score, the second product got the neutral and third products got the neutral score too. And the last aspect is safety all the product got the plus score, For the total score of each product has a different score, the total score of the first product is 4, followed by the second product got the total score 2 and the third product got score that is 2. Since the first product has the highest total score, the adjustment table product will be choose as tools in the activity of leak testing of AHZ tank.

4.4.1.1 Product Selected Specification

Figure 4.16 shows the product specification of adjustment table, is one of the Personal Protective Equipment that should be used by someone who works to avoid accident risk. Instead of making part of the worker's body at the time of the accident, but by wearing adjustment table workers will be more flexible to be used and can be improved.

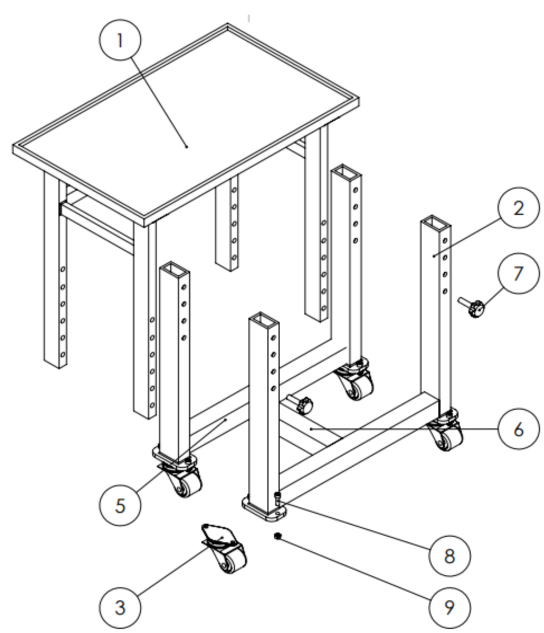


Figure 4.16 Adjustment Table Specifications

This Adjustment table can help the operator doing leak testing with easier, comfortable and ergonomic posture. Therefore, the bad position of the body is decreasing, because this tool are made, this tools is designed to make the operator can set the table size down and up easily with adjustment , the specification of this tools are make 9 part , number 1 is top table 750mm x 500mm x 20mm with metal and hollow steel , number 2 is table foot 50mm x 645mm for the inner table foot is 25mm hollow steel, number 3 and 4 is wheels it have standard dimension for wheels ,number 5 and 6 it use hollow steel , number 7 it a thumbscrew for adjust the table with a 20mm dimension , the last but not least is stainless steel for lock the part.

4.4.2 Quality Function Deployment

Quality function deployment is used to fulfill needs of operator with the material handling equipment's specification. The house of quality in the quality function deployment to design the material handling equipment. There are several steps to construct the house of quality.

1. Listing Customer Needs

In order to create the list of operator's needs for the new supporting tools to reduce or eliminate the occurrence of Cumulative Trauma Disorders - low back pain and tinea pedis disease, the operators in the leak testing area who in charge to complete the task are interviewed. The table 4.9 shows the list of operator needs for the supporting tools as leak testing activity equipment.

Table 4.9 Operator Needs

No	Operator Needs
1	Easy to use
2	Easy to move
3	Easy to look
4	Safe from tinea pedis disease
5	Strong and durable

Table 4.8 above shows the list of operator's needs. From the Table 4.8, the operators want the supporting tools can easy to use and easy to move. Furthermore, the operators also want tools who safe from tinea pedis disease since the hand of operator always in the water when doing leak testing activity. Last but not least, the operators want the product strong and durable.

2. Listing Technical Specifications

The second step is listing the technical specifications for the supporting tools to fulfill the needs of operator in the casting area.

Table 4.10 List of Technical Specifications

No	Technical specification for the product
1	The product has adjustment table
2	The product has rubber gloves
3	The product has acrylics transparent box
4	The product has a storage box
5	The product has a conveyer
6	The product has a wheels and break
7	The product has sliding metal
8	The product is constructed from strong material

In the Table 4.10 above, the technical specifications that will be proposed adjustment table because some day the operator will be change to other operator and the operator have different height body posture, the product has a rubber gloves because the operator is doing leak testing with material manual handling who always in the water, the product purposed acrylics transparent box to facilitate the operator to see the process of leak testing easier, purposed storage box to storage AHZ tank in raw and finish good ,purposed the conveyer to facilitate the operator doing leak testing in easier way and the operator no need to back and forth, the product has a wheels and break if at any time the table needs to be moved, purposed sliding metal to make the AHZ tank transfer to finish good storage easier, the last but not least purposed product constructed with strong material.

3. Constructing a Relationship between Operators' Needs and Technical Specifications

Table 4.11 below shows the relationship between operators' needs and technical specifications. The relationship is obtained from the discussion with the person in charge in leak testing area. In order to ease analyzing the relationship in Table 4.11, the relationship is converted to the matrix in Figure 4.17.

Table 4.11 Relationship between Operators' Needs and Technical Specifications

No	Operator Needs	Technical Specification for the Product
1	Easy to use	The product has adjustment table
		The product has a conveyer
		The product has sliding metal
2	Easy to move	The product has a wheels and break
3	Easy to look	The product has acrylics transparent box
4	Safe from tinea pedis disease	The product has rubber gloves
5	Strong and durable	The product is constructed from strong material
		The product has a storage box

Figure 4.17 below shows the matrix of relationship between operator needs and technical specifications. Each relationship is represented by the number that shows. The power of the relationship between operator's needs and technical specifications.

If the operator's needs have strong relationship with the technical specification, then the number that written in the matrix is 3. The example of strong relationship is the operator want the tools who easy to use because the leak testing process activity the operator need to bend his body and it's not comfortable position. Operator's needs can have many relationships even it is moderate or weak relationship. The product has steer with bearing and the product has hand break are related to each other due to ease in using the supporting tools. The tools can be adjusting up to one meter has strong relationship with the operator's needs which is easy to adjust that represented by number 3.

Strong relationship	3
Moderate relationship	2
Weak relationship	1
No relationship	0

	The product has adjustment table	The product has rubber gloves	The product has acrylics transparent box	The product has a storage box	The product has a conveyer	The product has a wheels and break	The product has sliding metal	The product is constructed from strong material
Easy to use	3		1		3		2	
Easy to move	2					3		
Easy to look			3					
Safe from tinea pedis disease		3						
Strong and durable				3				3

Figure 4.17 Matrix of Relationship between Operator's Needs and Technical

4. Developing interrelationship in technical specifications

The forth step in order to complete quality function deployment is designing the relationship among the technical specifications. This activity aims to know whether a technical specification have positive or negative relationship with other technical specifications. Figure 4.18 below shows the matrix of relationship among technical specification. The product can be adjusting up to one meter as technical specification in supporting tools has a strong relationship with the other technical specification which is the product has a wheels and break. While the product has a conveyer has positive relationship with the product has strong box.

	The product has adjustment table	The product has rubber gloves	The product has acrylics transparent box	The product has a storage box	the product has a conveyer	The product has a wheels and break	The product has sliding metal
The product has adjustment table							
The product has rubber gloves							
The product has acrylics transparent box	+	++					
The product has a storage box							
The product has a conveyer				+			
The product has a wheels and break	++						
The product has sliding metal			++	+			
The product is constructed from strong material				++	+		

Strong positive relationship	++
Positive relationship	+
Negative relationship	-
Strong negative relationship	--

Figure 4.18 Matrix of Interrelationship in Technical Specification

5. Developing a Competitive Assessment for Customer Needs

After designing the relationship among the technical specifications, the next step is developing the assessment for operator needs. The first step to create the matrix is determining the degree of importance for each operator's needs with the ordinal scale from 1 to 10 which represent the priority of the custom needs based on the operators.

Table 4.12 Degree of Importance of Operator's Need

No	Operator Needs	Degree of Importance
1	Easy to use	9
2	Easy to move	5
3	Easy to look	8
4	Safe from tinea pedis disease	9
5	Strong and durable	7

Table 4.12 above shows the degree of importance of operator's needs. The operator's need which is easy to use has the highest degree of importance. The score that obtained in operator's needs easy to use is 9. Operator's needs easy to move obtained score 5 as degree of no importance, besides that, this matrix also consists of current condition and proposed product rating. The score comes from the operator related to the customer needs. The highest score which is 5 is obtained if the current condition and proposed improvement can fulfill the operator's needs. In the other hands, the lowest score which is 1 is obtained if the current condition and proposed improvement cannot fulfill the operator's need

	The product has adjustment table	The product has rubber gloves	the product has acrylics transparent box	The product has a storage box	The product has a conveyer	The product has a wheels and break	The product has sliding metal	The product is constructed from strong material	Degree of importance	Current material handling	Proposed material handling	Improvement level	Raw weight	Relative raw weight (%)
Easy to use	3		1		3		2		9	1	5	5	45	24.32
Easy to move	2					3			5	1	4	4	20	10.81
Easy to look			3						8	1	5	5	40	21.62
Safe from tinea pedis disease		3							9	1	5	5	45	24.32
Strong and durable				3				3	7	1	5	5	35	18.92
													185	100

Figure 4.19 Competitive Assessment Related to Operator's Needs

Figure 4.19 above shows the competitive assessment related to operator's needs. It shows the score of current condition for the need of easy to use is 1 and the proposed improvements get scored 5. It means the proposed improvement is better in completing the operator's needs rather than the current condition. The score of current condition is 1 occur due to there is no supporting tools as material handling equipment so the operator gives that rating. The score of improvement level depends on the proposed improvement score towards the current condition score. Below is the example in calculating the improvement level.

$$\text{Easy to use} = \frac{\textit{Proposed improvement rating}}{\textit{Current condition rating}}$$

$$= 5/1$$

$$= 5$$

6. Developing Prioritized Technical Specifications

This matrix as the base of the house of quality, the importance weight is determined by considering the technical specifications. This importance weight depends on how strong the relation between technical specifications and operator's needs and also how high the priority from related needs' is. The matrix is used to know which technical specifications should be prioritized.

Figure 4.18 below shows the product specifications priority. The product has adjustment table of the technical specifications has the highest importance weight score, which is 94.59. This score is coming from the relationship score multiplies by the relative raw weight. The product has adjustment fulfills both needs of easy to use and easy to move, then it will multiply by these two relationship score. So, the importance weight for specification "the product has adjustment table" is:

$$\text{Importance weight} = (24.32 \text{ x } 3) + (10.81 \text{ x } 2) = 94.54$$

Raw weight score is obtained from degree of importance multiply by importance level. Then, the percentage of relative raw weight is calculated from raw weight score divided by total raw weight and the result. Moreover, all calculation for the technical specifications is done to know importance weight. The result will be used to determine which technical specification should be developed.

	The product has adjustment table	The product has rubber gloves	the product has acrylics transparent box	The product has a storage box	The product has a conveyer	The product has a wheels and break	The product has sliding metal	The product is constructed from strong material	Degree of importance	Current material handling	Proposed material handling	Improvement level	Raw weight	Relative raw weight (%)
Easy to use	3		1		3		2		9	1	5	5	45	24.32
Easy to move	2					3			5	1	4	4	20	10.81
Easy to look			3						8	1	5	5	40	21.62
Safe from tinea pedis disease		3							9	1	5	5	45	24.32
Strong and durable				3				3	7	1	5	5	35	18.92
													185	100
Important Weight	94.59	72.97	89.19	56.76	72.97	32.43	48.65	56.76	524.32					
relative weight (%)	18.04	13.92	17.01	10.82	13.92	6.19	9.28	10.82	100					

Figure 4.20 Product Specification Priority

The product has adjustment table							
The product has rubber gloves							
The product has acrylics transparent box	+	++					
The product has a storage box							
The product has a conveyer				+			
The product has a wheels and break	++						
The product has sliding metal			++	+			
The product is constructed from strong material				++	+		

	The product has adjustment table	The product has rubber gloves	the product has acrylics transparent box	The product has a storage box	The product has a conveyer	The product has a wheels and break	The product has sliding metal	The product is constructed from strong material	Degree of importance	Current material handling	Proposed material handling	Improvement level	Raw weight	Relative raw weight (%)
Easy to use	3		1		3		2		9	1	5	5	45	24.32
Easy to move	2					3			5	1	4	4	20	10.81
Easy to look			3						8	1	5	5	40	21.62
Safe from tinea pedis disease		3							9	1	5	5	45	24.32
Strong and durable				3				3	7	1	5	5	35	18.92
													185	100
Important Weight	94.59	72.97	89.19	56.76	72.97	32.43	48.65	56.76	524.32					
Relative weight (%)	18.04	13.92	17.01	10.82	13.92	6.19	9.28	10.82	100					

Figure 4.21 House of Quality for the Material Handling Equipment

Figure 4.21 above shows the house of quality for the material handling equipment. Based on the result that stated on the figure above, the proposed improvement should create tools with adjustment table because this specification represents 18.04% of operator needs based on the importance weight. Since there is no negative correlation among the product specifications, then the rest of specifications can follow without any consideration.

4.5 Product Specification

The proposed improvement from quality function deployment is created in Figure 4.20 below. The tool is future leak testing tools. This tool can help the operator doing leak testing with easier, comfortable and ergonomic posture. Therefore, the bad position of the body is decreasing, because this tool is made.

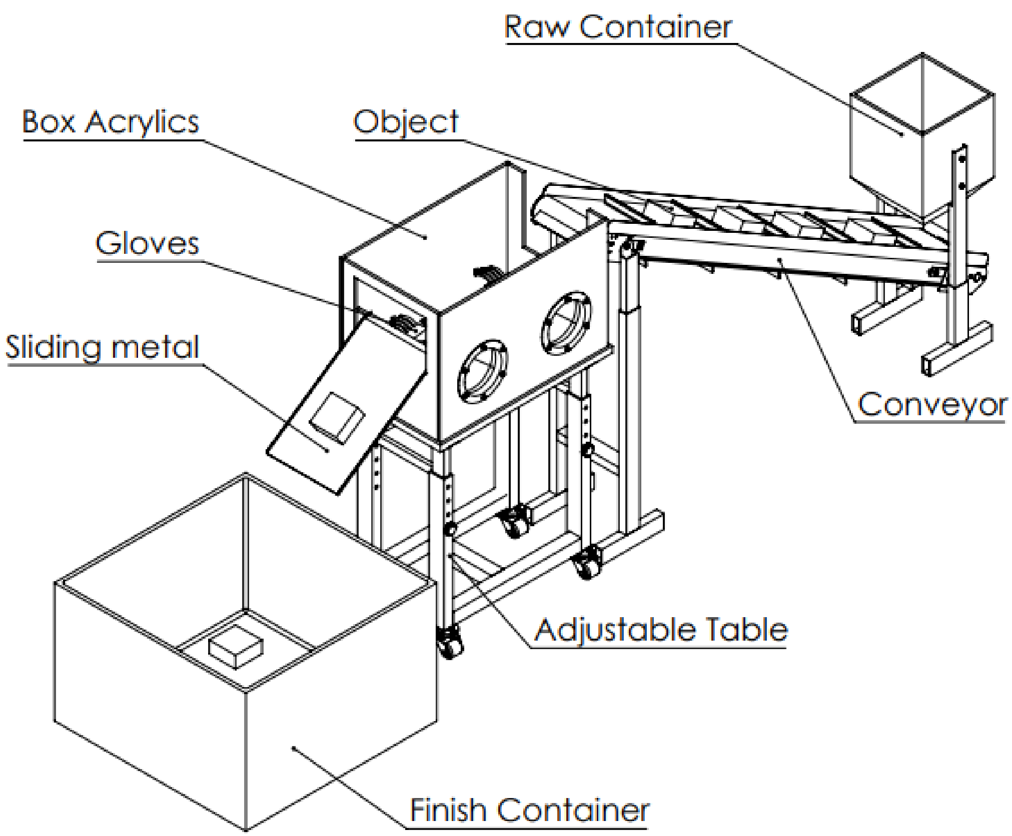


Figure 4.22 Future Leak Testing Tools Design

The first is a table adjustment table designed so that the operator can set the table size down and up easily, as desired and the posture of the operator, the second is a transparent colored acrylic box to make it easy for the operator to see the AHZ tank in performing a leak testing activity. The third is a rubber glove that can keep the operator's hand from the water in the acrylic box used for doing activity of leak testing of AHZ tank. the fourth is a sliding metal made of iron, sliding metal incorporated in acrylic box, which serves to facilitate the operator move the AHZ tank that have passed the leak testing into the finish container. The fifth is a conveyer, which has been provided from PT.FRS, whose function as a tool AHZ tank transferred who want to get leak testing process, does not make the operator to do the manual material handling to transfer the AHZ tank. and the last but not least is, finish container of AHZ tank and raw container of AHZ tank, which is made of strong material that is iron plate that serves to accommodate the AHZ tank before and after the leak testing process.

A. Acrylic Box and Rubber Gloves

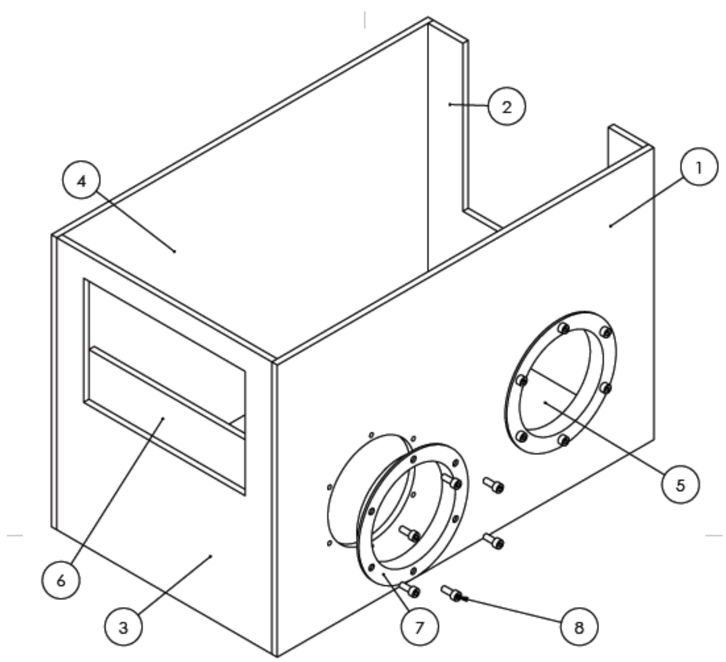


Figure 4.23 Transparent Acrylic box and Rubber Gloves

In Figure 4.23 that shown a transparent colored acrylic box, this tools made to make the operator easier to see the AHZ tank in performing a leak testing activity. In transparent acrylic box that we can see this tool has a circle to put the gloves rubber in ,and has a square to transfer a AHZ tank to the finish good container with supporting from sliding metal, the specification dimension of a transparent colored acrylic box number 1 is front acrylic 750mm x 500mm x 15mm with acrylic material, number 2 right side acrylic 450mm x 500mm x 15mm with acrylic material, number 3 is left side acrylic 450mm x 500 mm x 15mm with acrylic material, number 4 is back acrylic 750mm x 500mm x 15mm with acrylic material, number 5 is bottom acrylic 750mm x 450mm x 15mm with acrylic material, number 6 is bulk 450mm x 300mm x 15mm with acrylic material, number 7 is flange with diameter 203 mm, (r) 3.18mm, the last but not least is screw with 8mm dimension, and for the rubber gloves that can keep the operator's hand safe from the water in the acrylic box used for doing activity of leak testing of AHZ tank its use a general market of dimension of rubber gloves.

B. Adjustment Table

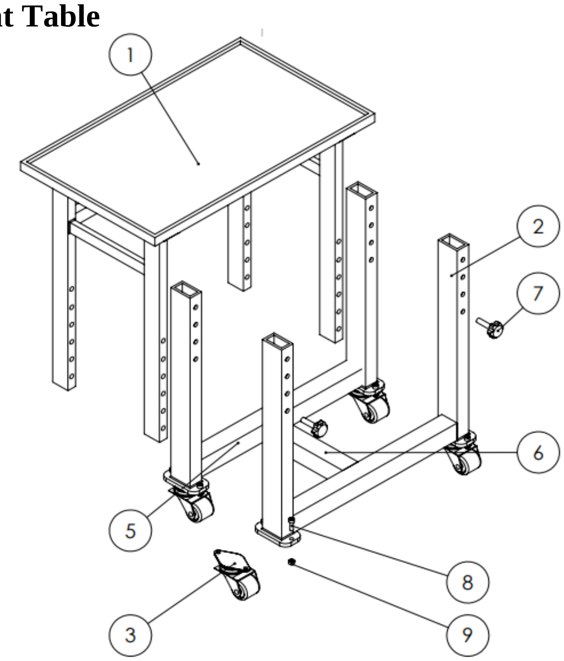


Figure 4.24 Adjustment Table

In Figure 4.24 shown Adjustment table, can help the operator doing leak testing with easier, comfortable and ergonomic posture. Therefore, the bad position of the body is decreasing, because this tool are made, this tools is designed to make the operator can set the table size down and up easily with adjustment , the specification of this tools are make 9 part , number 1 is top table 750mm x 500mm x 20mm with metal and hollow steel , number 2 is table foot 50mm x 645mm for the inner table foot is 25mm hollow steel, number 3 and 4 is wheels it have standard dimension for wheels ,number 5 and 6 it use hollow steel , number 7 it a thumbscrew for adjust the table with a 20mm dimension , the last but not least is stainless steel for lock the part.

C. Sliding Metal

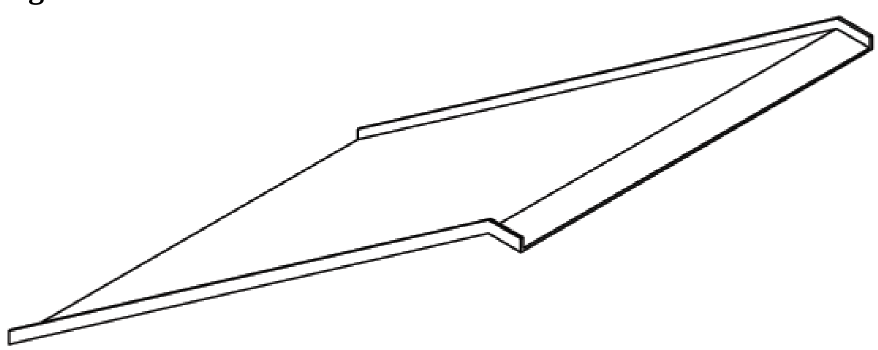


Figure 4.25 Sliding Metal

In figure 4.25 shown sliding metal, sliding metal made of iron, sliding metal incorporated in acrylic box, which serves to facilitate the operator move the AHZ tank that have passed the leak testing into the finish container the specification of sliding metal is 500mm x 300mm x 10mm.

D. Raw AHZ Tank Container Box

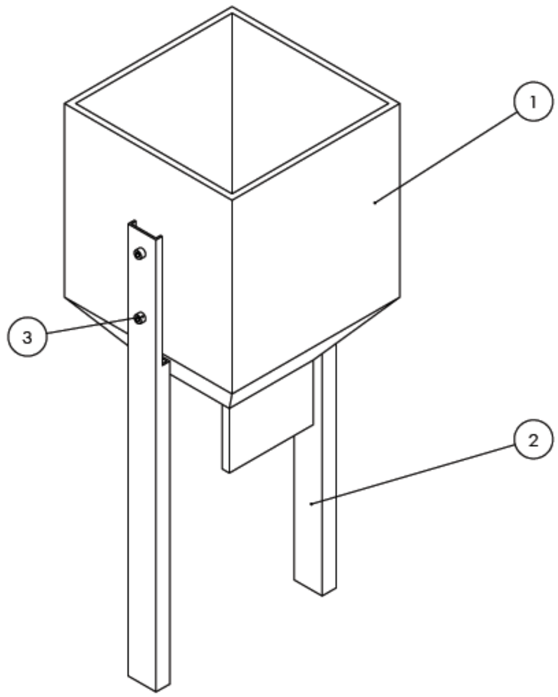


Figure 4.26 Raw AHZ Tank Container Box

In figure 4.26 shown Raw AHZ tank container box, which is made of acrylics that serves to accommodate the AHZ tank before leak testing process, the specification dimension of raw AHZ tank container box is, number 1 is 350mm x 350mm x 15mm for the bottom is 350mm x 100mm x 15mm, number 2 is 700mm x 50mm x 25mm made of hollow steel, and number 3 is screw with 15mm made from steel. the upper hole of AHZ tank container box is have hole extensive with 12.550 mm and for the bottom hole is have hole extensive with 10.000 mm to make the AHZ tank come out one by one.

E. Finish Good AHZ Tank Container Box

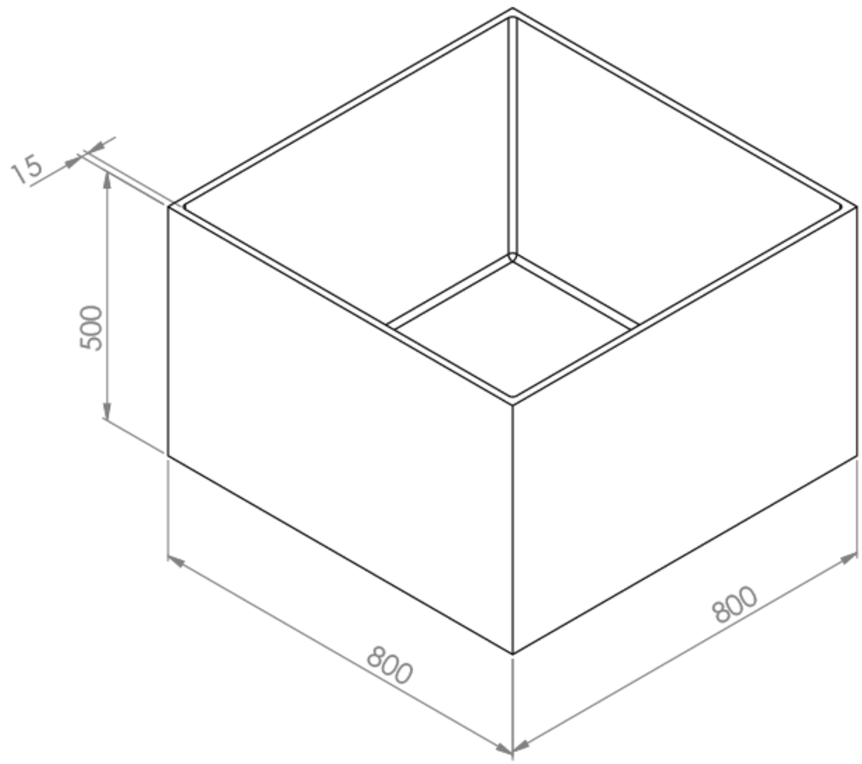


Figure 4.27 Finish Good AHZ Tank Container Box

In figure 4.27 shown finish good AHZ tank container box, which is made of strong material that is iron plate that serves to accommodate the AHZ tank after the leak testing process the finish good AHZ tank container box specification 800mm x 500mm x 15 mm. this finish good AHZ tank container box is the tools to keep the AHZ tank in a good condition before packaging.

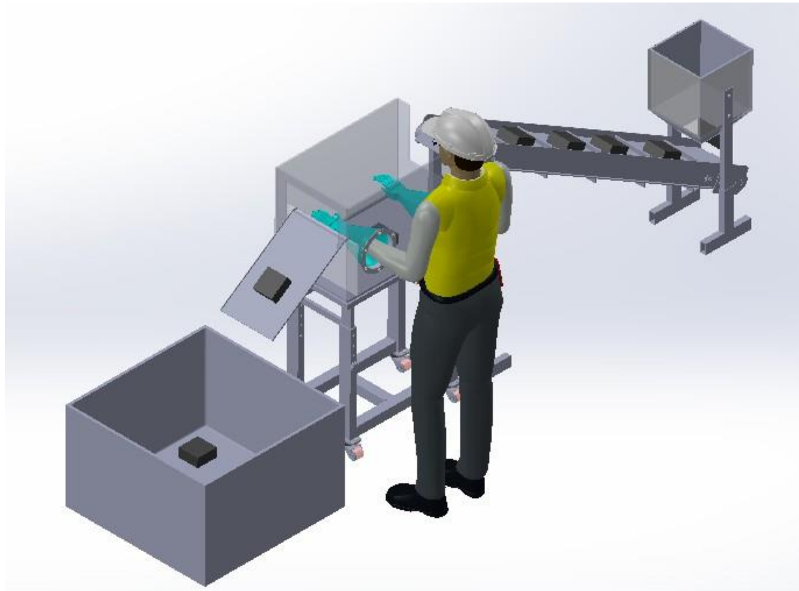


Figure 4.28 Design of the Proposed Improvement of Future Leak Testing Tools

Figure 4.28 above shows the proposed improvement in leak testing area. In the simulation, There are the operator doing the leak testing activity with the future leak testing tools by using adjustment table, acrylics transparent box, rubber gloves, sliding metal, conveyer, containers box and using safety shoes in leak testing area, the operator will not doing leak testing of AHZ tank in the awkward position, this tools will reduce and eliminate the non-ergonomic activity.

4.6 Future Leak Testing Cost

In table 4.13 shown the total material handling cost for the future leak testing is Rp.9, 960,000.00. Since some tools do not count as the cost because it already provided in production floor equipment such as conveyer.

Table 4.13 Future Leak Testing Cost

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.	PRICE PER PIECE
1	Front acrylics	Toko Trus jaya	1	800000
2	Right Side Acrylics	Toko Trus jaya	1	500000
3	Left Side Acrylics	Toko Trus jaya	1	500000
4	Back Acrylics	Toko Trus jaya	1	800000

Table 4.13 Future Leak Testing Cost (Cont'd)

5	Bottom Acrylics	Toko Trus jaya	1	800000
6	Bulk	Toko Trus jaya	1	40000
7	Flange	mc master	2	150000
8	ISO 4762 M8 x 20 - 20N	Toko Trus jaya	12	36000
9	CONTAINER	toko agen cikarang	1	200000
11	Table Foot	TB. BJM	4	200000
12	WHEEL__1_	mc mater	4	600000
13	Hollow Steel	Toko Trus jaya	2	400000
14	Hollow Steel 2	Toko Trus jaya	1	200000
15	tumb screw	mc master	2	100000
16	ISO 4762 M8 x 25 - 25N	TB. BJM	12	36000
17	ISO - 4032 - M8 - D - N	TB.BJM	8	16000
18	Raw AHZ Container box	Toko Trus jaya	1	2500000
19	Raw Container Foot	Toko Trus jaya	2	200000
20	sliding metal	toko agen cikarang	1	300000
23	Gloves	Toko Trus jaya	2	50000
24	Safety shoes	Safety shoes online	2	1232000
				Rp. 9,960,000.00

4.7 Before-After Analysis

After conducting the improvement in the way of operator doing leak testing of AHZ tank, then the position of the operator also completely changed. This improvement is expected to reduce tinea pedis disease and the probability of operator get Cumulative Trauma Disorder – Low back pain. Below is the comparison between before conducting improvement and after improvement.

A. REBA

REBA analysis is used as the first comparison to see the effect of using the supporting tools and changing the way of leak testing of AHZ tank. The Figure 4.29 below shows the position of operator when doing leak testing activity of AHZ tank by using supporting tools. The REBA score for each body part is as follows;

Figure 4.29 Body Parts A with Future Leak Tester

Group A body parts:

- Trunk is in the straight position, which the degree is equal to 0. The REBA score of trunk is +1.
- Neck is in in the straight position, which the degree is equal to 0. The REBA score of neck is +1.
- Legs are in the straight standing position. This condition make the operator stand steady on two legs. The REBA score of legs is +1.

Table 4.14 Table A of REBA

Table A	Neck												
		1				2				3			
	Legs	1	2	3	4	1	2	3	4	1	2	3	4
Trunk	1	1	2	3	4	1	2	3	5	3	3	5	6
	2	2	3	4	5	3	4	5	6	4	5	6	7
	3	2	4	5	6	4	5	6	7	5	6	7	8
	4	3	5	6	7	5	6	7	8	6	7	8	9
	5	4	6	7	8	6	7	8	9	7	8	9	9

The load REBA score is +0. The load resulted from the AHZ tank is 0,045 kg or it is equal to 0,099208018 lbs. This load results +0 REBA score as it is categorized as less than 11 lbs. The load REBA score is then added to the REBA score of group A body parts. Therefore, the score is:

Score A = Group A Body Parts Score + Load Score

Score A = 1 + 0

Score A = 1

After Score Group A is calculated, the next assessment is for body parts B. Since the condition of leak testing of AHZ tank is already adjusted to anthropometry elbow height standard. It is assumed that the operator when leak testing AHZ tank is in the standing position as shown in the Figure 4.30.

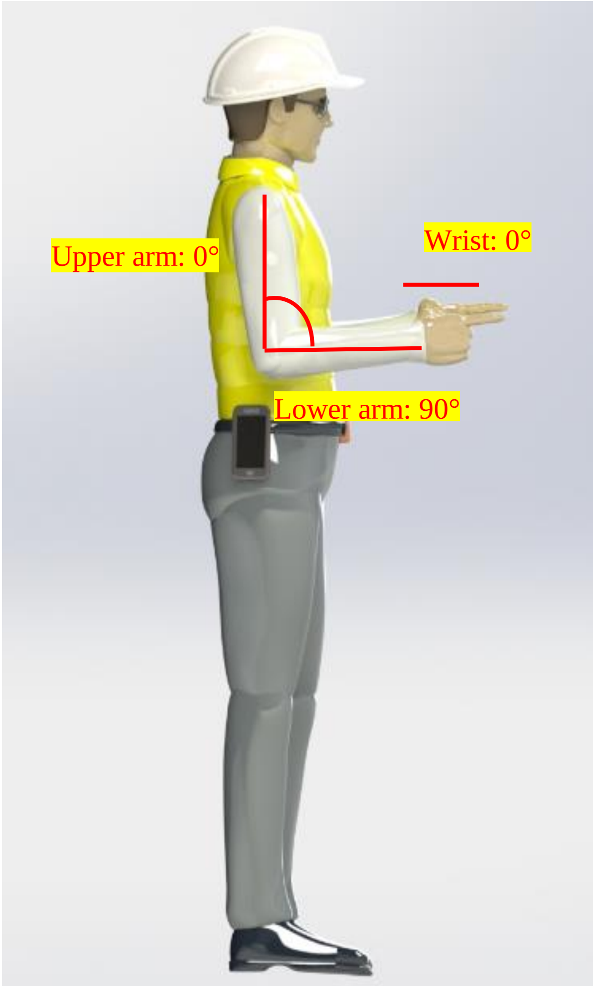


Figure 4.30 Body Parts B

Group B body parts:

- Upper arm is in straight position, which the degree is equal 0°. The REBA score of upper arm is +1.
- The proposed method is already adjusted to the anthropometry of elbow height, then the lower arm will be straight forward 90° to the upper arm. The REBA score of lower arm is +1.
- Wrist is expected as in the straight position in leak testing AHZ tank. REBA score for wrist is +1.

- The operator's hands while leak testing the AHZ tank is categorized as fair coupling. Therefore, the hand hold is acceptable but hand hold is not ideal. The REBA score for coupling is +1.

After all group B body parts are assessed, the score of group A is determined using REBA Table B matrix.

Table 4.15 Table B of REBA

Table B		Lower Arm					
		1			2		
	Wrist	1	2	3	1	2	3
Upper Arm	1	1	2	2	1	2	3
	2	1	2	3	2	3	4
	3	3	4	5	4	5	5
	4	4	5	5	5	6	7
	5	6	7	8	7	8	8
	6	7	8	8	8	9	9

From table B of REBA, it is determined that the score for group B body parts of REBA is equal to 1. Then, this score is added with the REBA score of the coupling in the activity. In this case, when doing leak testing activity the AHZ tank is coupling acceptable but not ideal hand hold.

From the observation, the current condition of the operator's hands while leak testing AHZ tank is categorized as fair coupling. Therefore, the hand hold is acceptable but hand hold is no ideal. Fair coupling results +1 REBA score.

The coupling REBA score is then added to the REBA score of group B body parts. Therefore, the score is:

Score B = Group B Body Parts Score + Coupling Score

Score B = 1 + 1

Score B = 2

The score A and score B resulted are used to determine the score C. Score C is determined by referring to the matrix table of REBA score C.

Table 4.16 Table C of REBA

Score A	Table C											
	Score B											
	1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	11	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

Using table above, the REBA score C is determined as 1. This score C is then added with activity score to determine the final REBA Score. The final REBA score is then used to define the risk level and the action needed for the assessed activity.

From the direct observation to this activity, the activity score is determined equal to +1. This score comes because the action causes repeated small range action (more than 4x per minutes). This score is then added to score C to determine the REBA final score. Therefore, the score is

Final REBA Score = Score C + Activity Score

Final REBA Score = 1 + 1

Final REBA Score = 2

To gain more accurate REBA score, the excel function worksheet is used also to assess the body posture of the worker. The figure 4.31 below gives the result of REBA analysis through excel function worksheet.

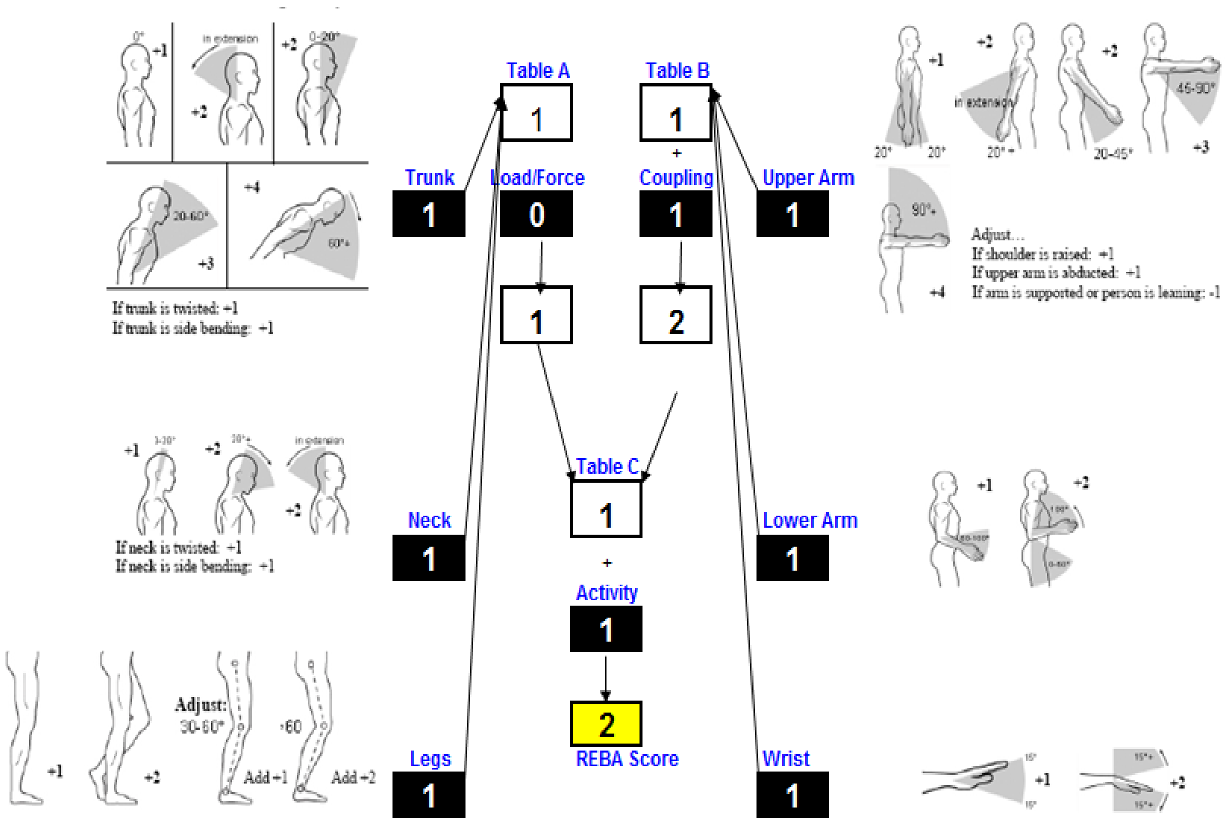


Figure 4.31 REBA with Future Leak Testing Worksheet

Final REBA score for leak testing of AHZ tank activity after the operator use supporting tools in PT. FRS is 2. The new activity conducted by the operator is categorized as low risk activity that change or other improvements may be needed. This proposed improvement gives a substantial to the safety risk of leak testing of AHZ tank activity. This proposed improvement is suggested to be implemented.

CHAPTER V

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In conclusion after collecting and processing data obtained from PT.FRS can be concluded that:

1. To identify Cumulative Trauma Disorders - Low Back Pain using REBA, The result of the total REBA score is 8, the score is categorized as high risk level activity. From the results of REBA calculations, activities of leak testing of AHZ tank are categorized as non-ergonomic activity that can cause operators to be affected by Cumulative Trauma Disorders - Low Back Pain in the future.
2. By using a future leak testing tools, the operator will not doing leak testing of AHZ tank in the awkward position, this tools will reduce and eliminate the non-ergonomic activity, can reduce the potential for Cumulative Trauma Disorders - Low Back Pain and tinea pedis in the future.

5.2 Recommendation

From the conclusion about the Cumulative Trauma Disorders – low back pain and tinea pedis disease at leak testing area of PT.FRS, it needs further research to develop the material handling equipment that can eliminate the non-ergonomic activity

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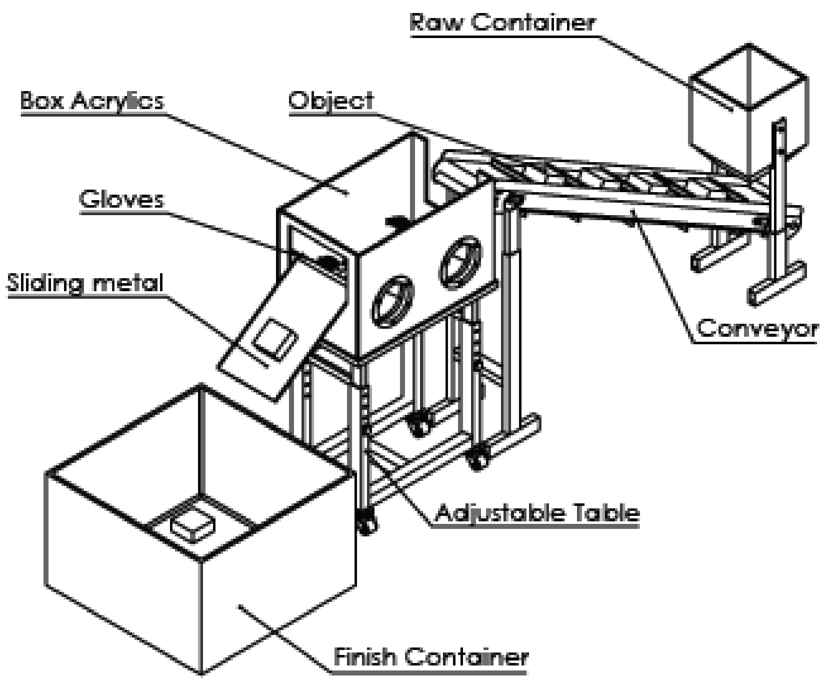
APPENDICES

APPENDIX – Engineering drawing



No.	Qty.	Part Name	Description
1	1	Acrilics Box - Sub Assy	Sub Assembly
2	1	sliding metal	part
3	1	Gloves	part
4	1	Object	part
5	1	Adjustable Table - Sub Assy	Sub Assembly
6	1	Finish Container	part
7	1	Conveyor	part
8	1	Raw Container - Sub Assy	Sub Assembly

Surf Rough 1000 mircomm	Dim Tolerance 1000 micromm	Revision			
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Date	4/8/2018	Checked by			
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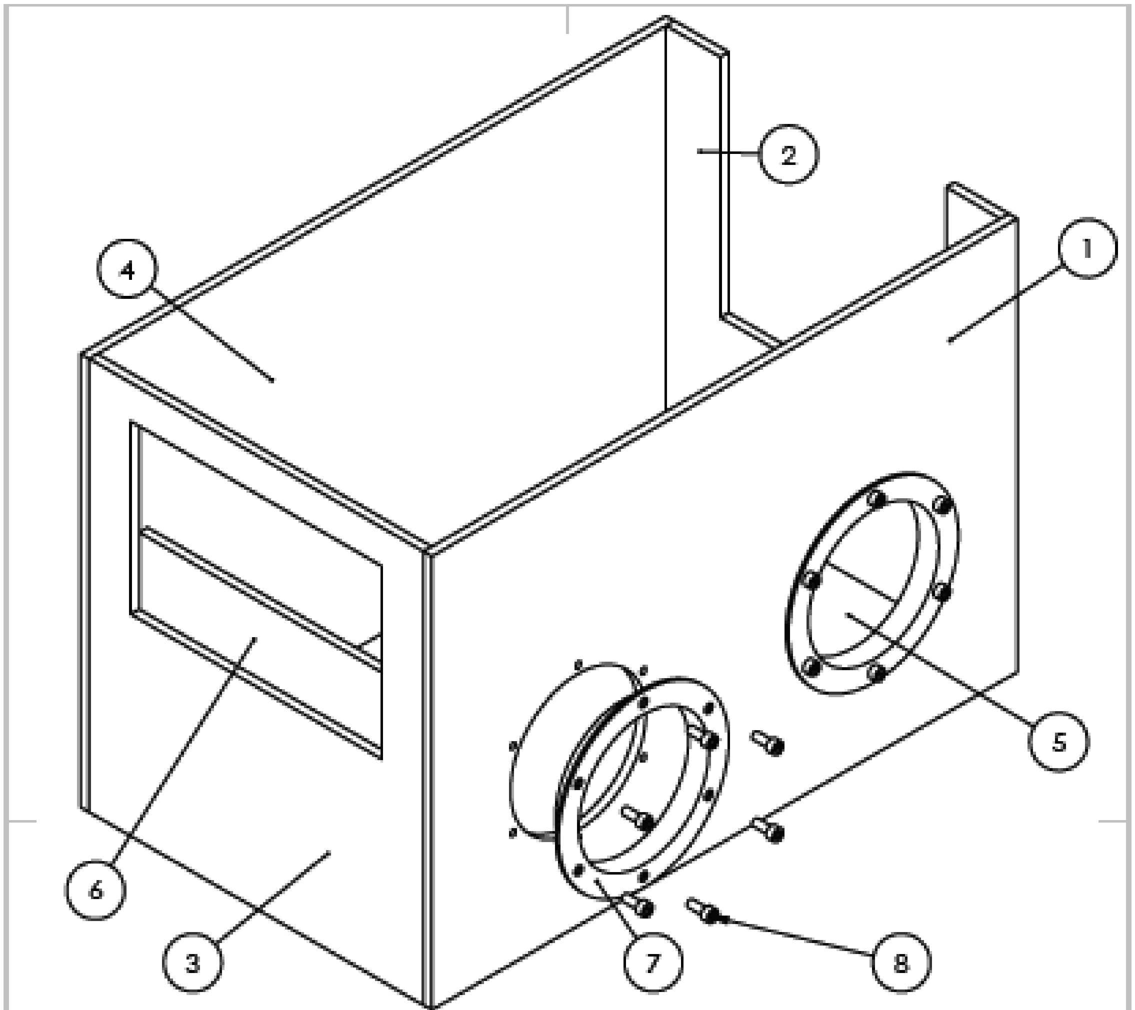

No.	QTY.	Part Name	Dimensions	Materials
1	1	Front acrylics	750 x 500 x 15	Acrilics
2	1	Right Side Acrilics	450 x 500 x 15	Acrilics
3	1	Left Side Acrilics	450 x 500 x 15	Acrilics
4	1	Back Acrilics	750 x 500 x 15	Acrilics
5	1	Bottom Acrilics	700 x 450 x 15	Acrilics
6	1	Bulk	450 x 300 x 15	Acrilics
7	2	Flange	-	Aluminum Alloy
8	12	ISO 4762 M8 x 20 - 20N	-	Stainless Steel

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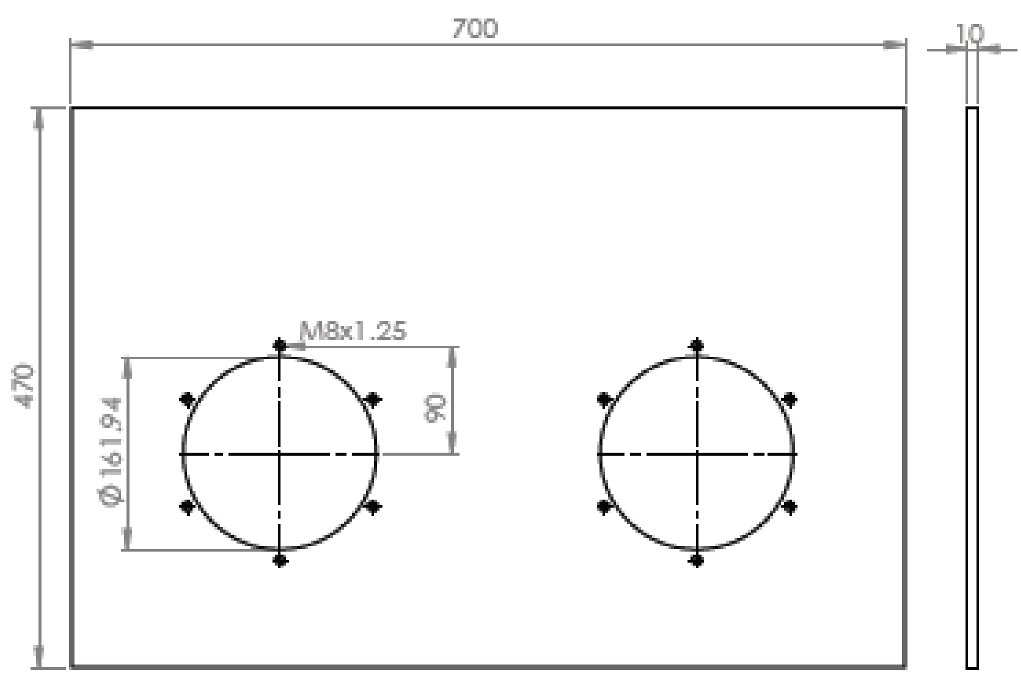

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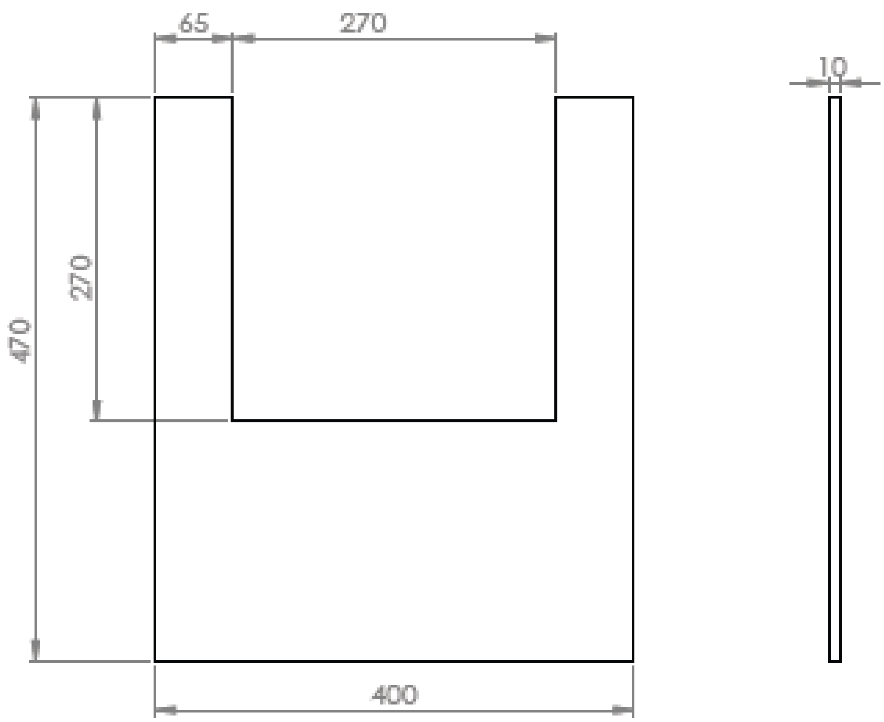

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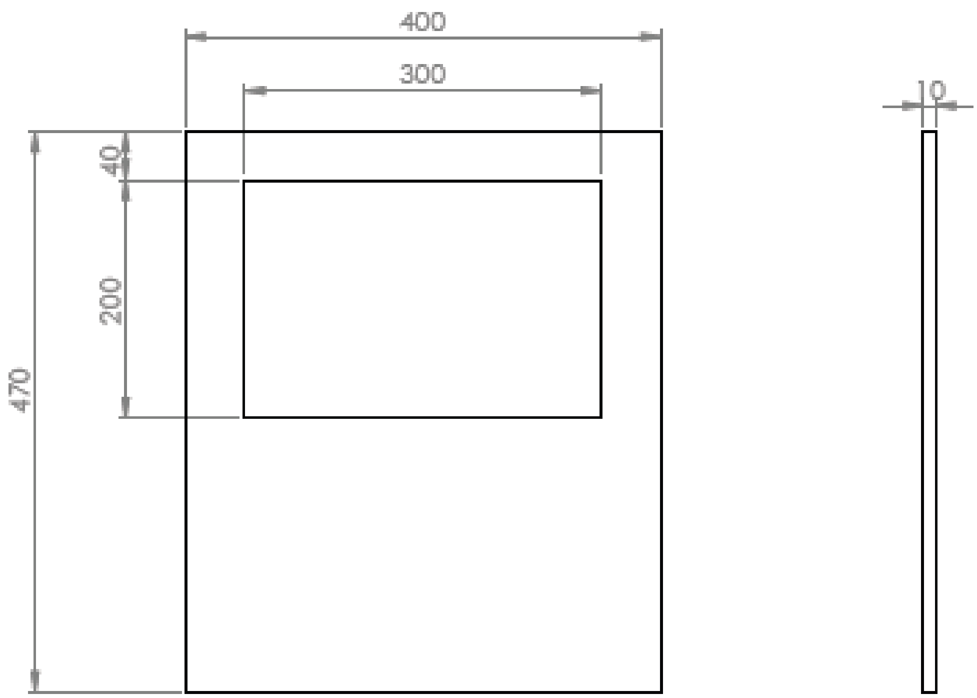

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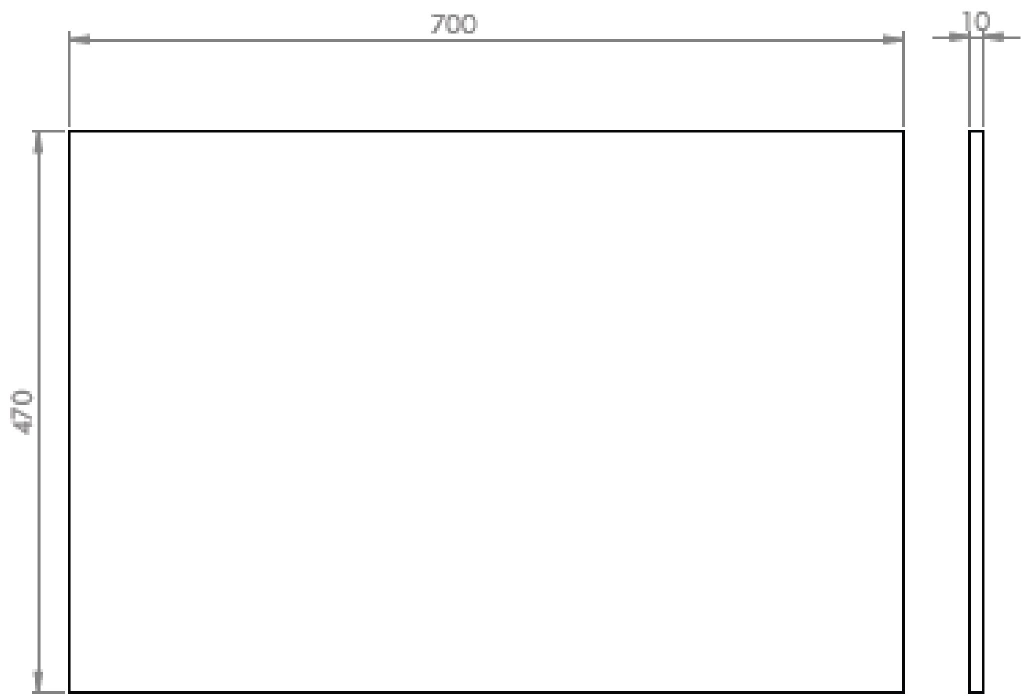

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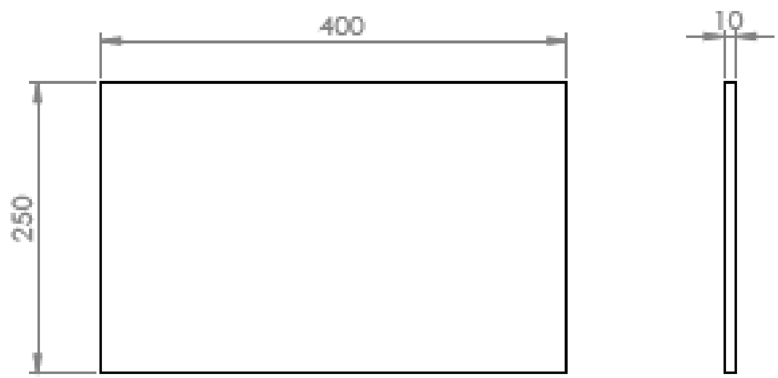

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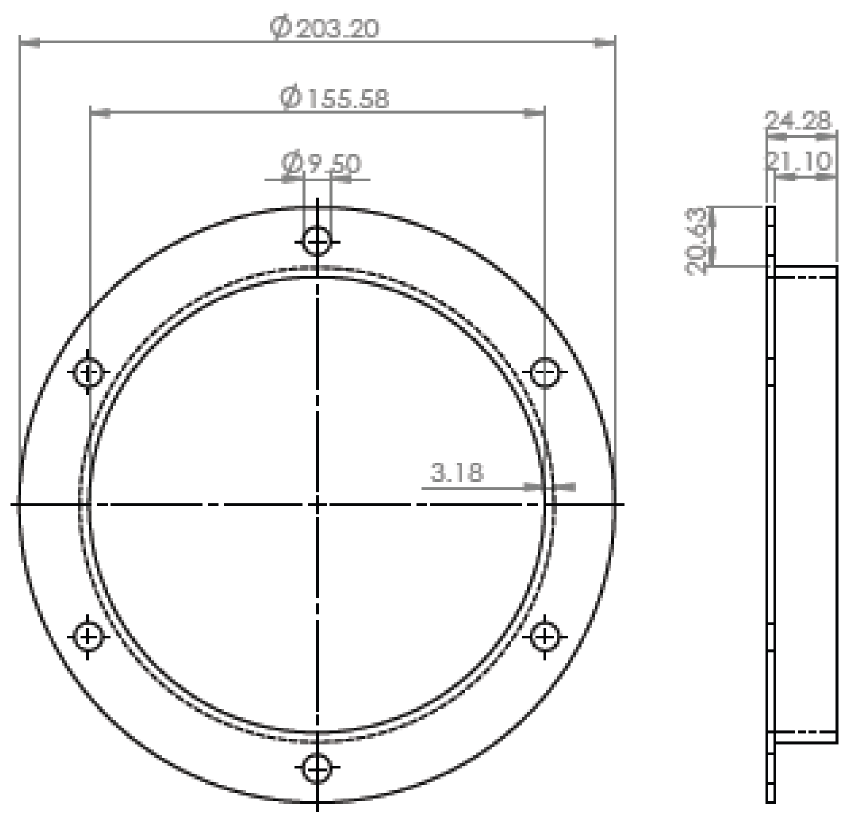

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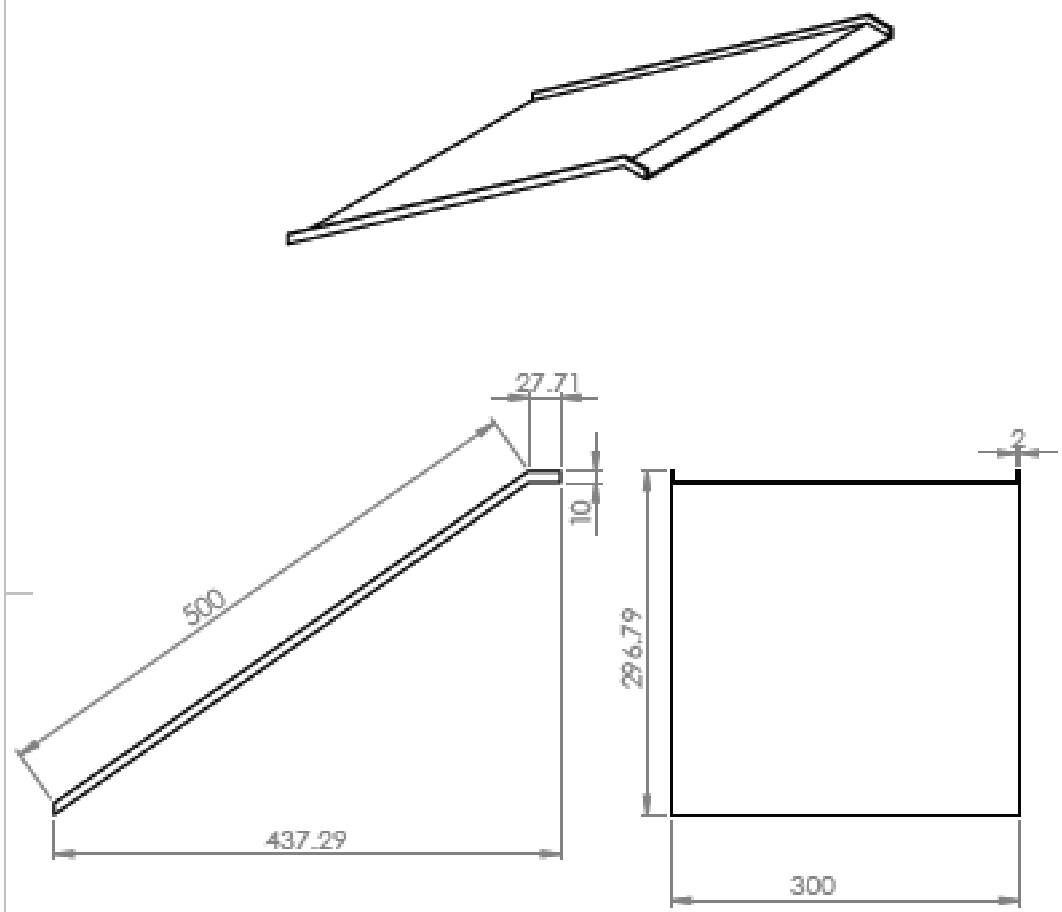

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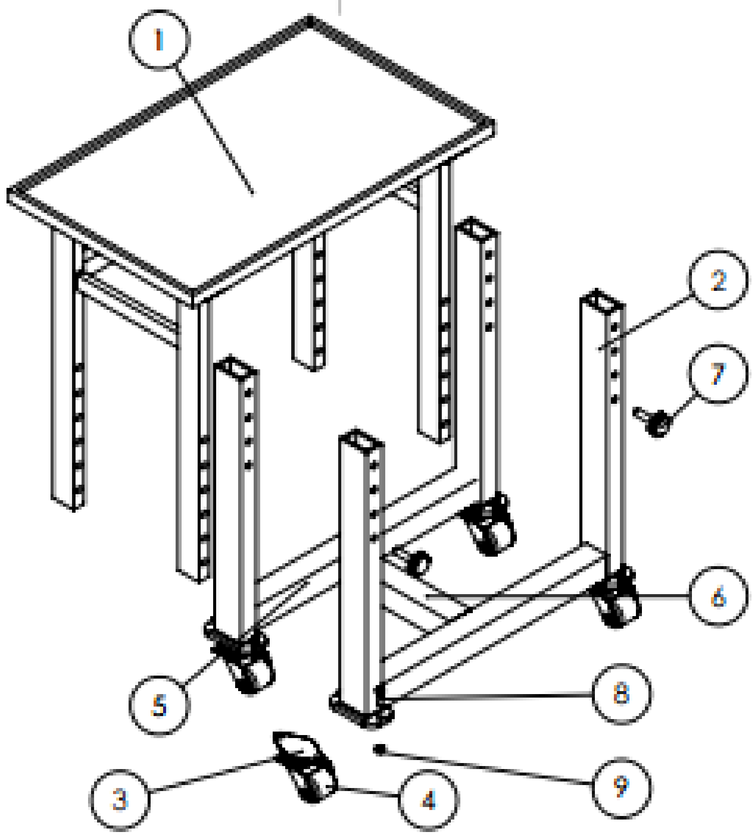

No.	QTY.	Part Name	Dimensions	Materials
1	1	Top Table	(740x460x25)sheet metal 1pc (620x50x25)4pc (570x50x25)1pc (270x50x25)2pc	Sheet metal, Hollow Steel
2	4	Table Foot	570x50x25	Hollow Steel
3	4	Wheel	-	-
4	4	Roller	-	-
5	2	Hollow Steel	550x50x50	Hollow Steel
6	1	Hollow Steel 2	270x50x50	Hollow Steel
7	2	tumb screw	-	-
8	8	ISO 4762 M8 x 25 - 25N	-	Stainless steel
9	8	ISO - 4032 - M8 - D - N	-	Stainless steel

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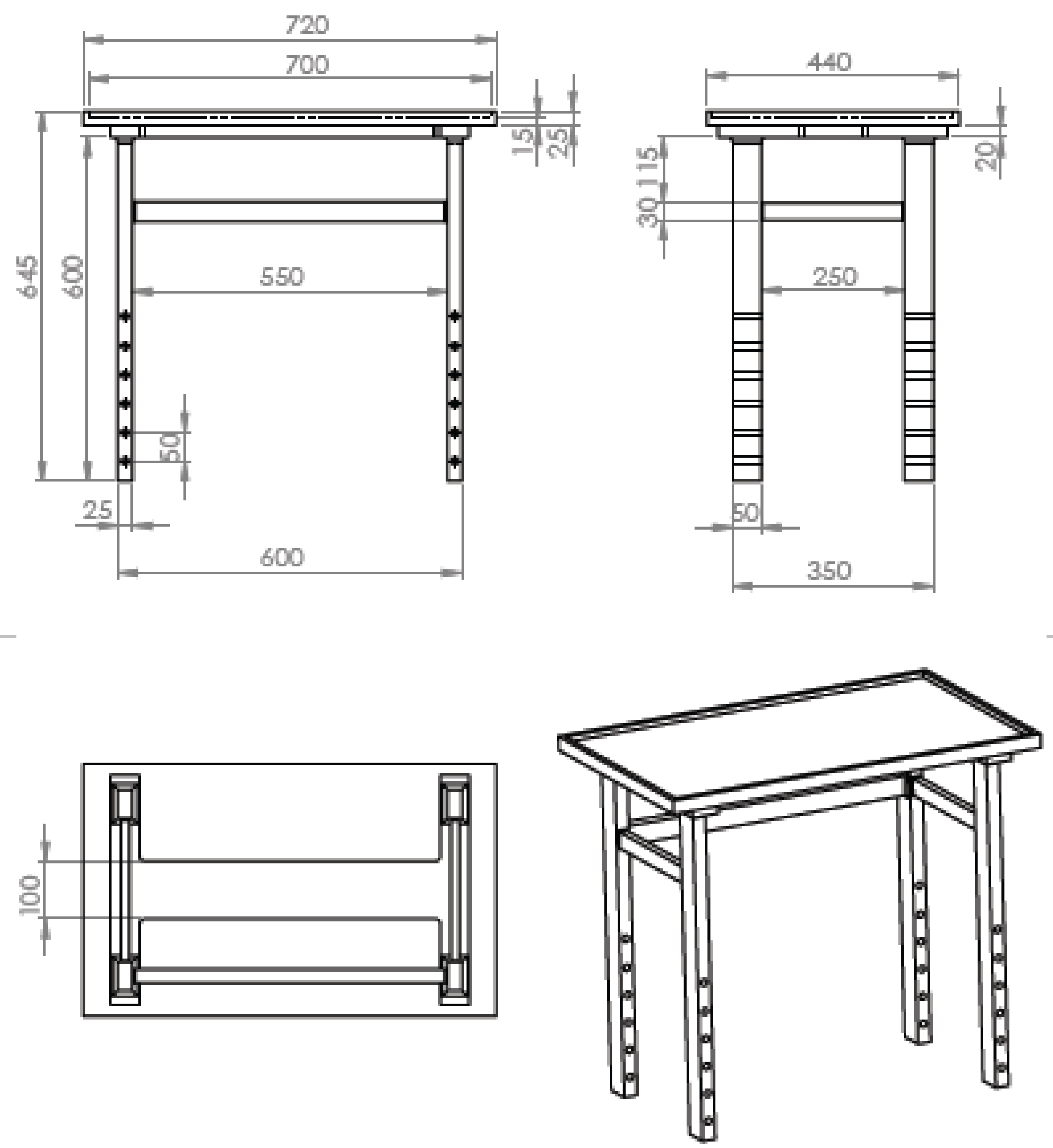

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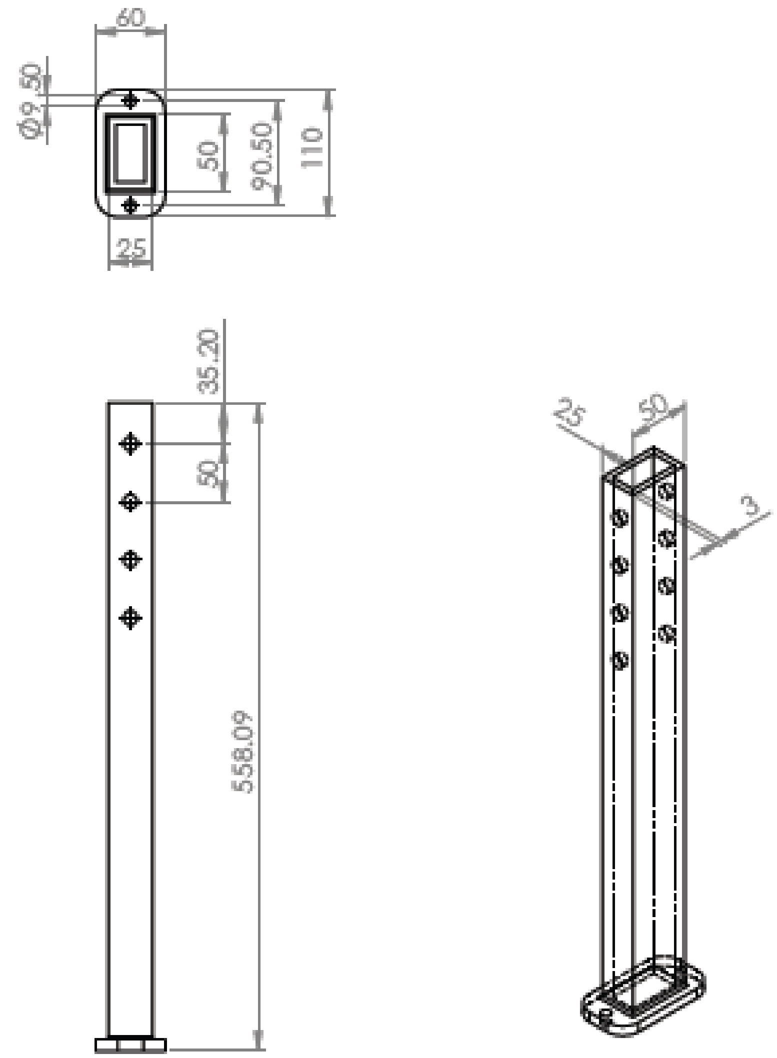

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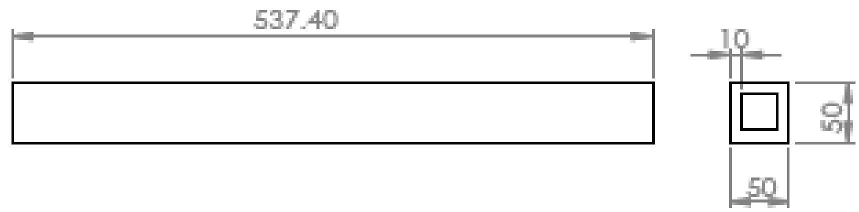
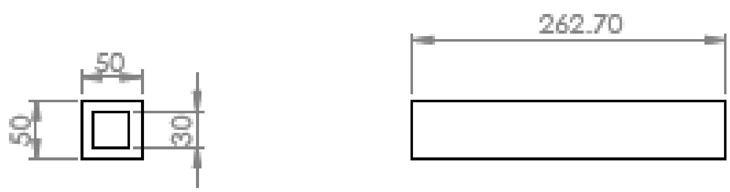
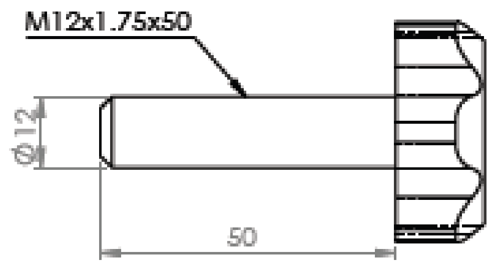
Date	4/12/2018	Checked by		
President University	Table Foot - Adjustable Table Sub Part		Drawing No. 13	Size A4



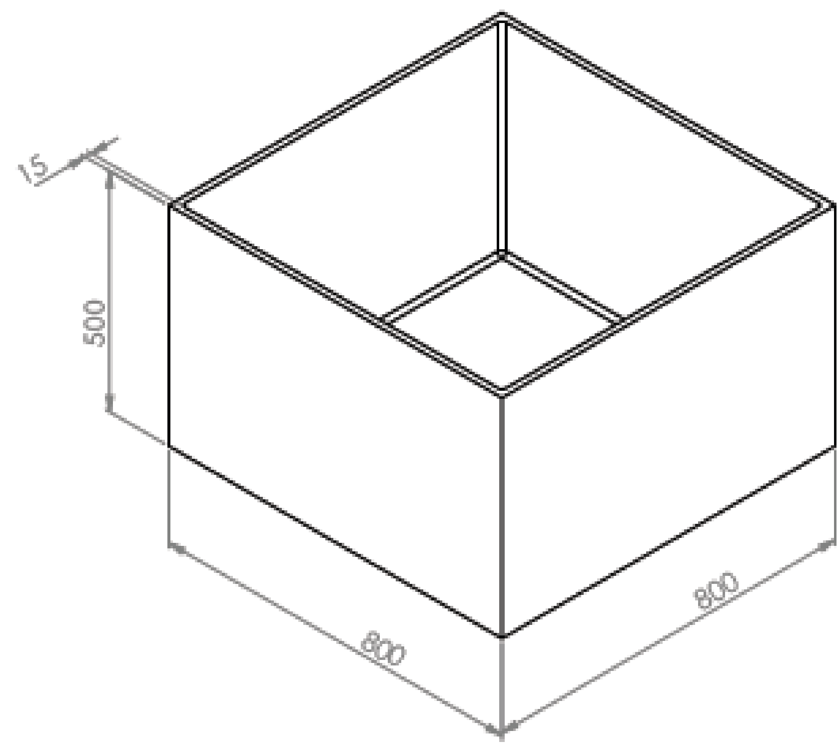
Surf Rough 1000 mircomm		Dim Tolerance 1000 micromm	Revision		
	Scale	1:5	Drawn by	Faris Ali Jaidi	Remarks
	Unit	mm	Dept./ ID No.	IEN / 004201300016	
	Date	4/12/2018	Checked by		
President University		Hollow Steel - Adjustable Table Sub Part		Drawing No. 14	Size A4



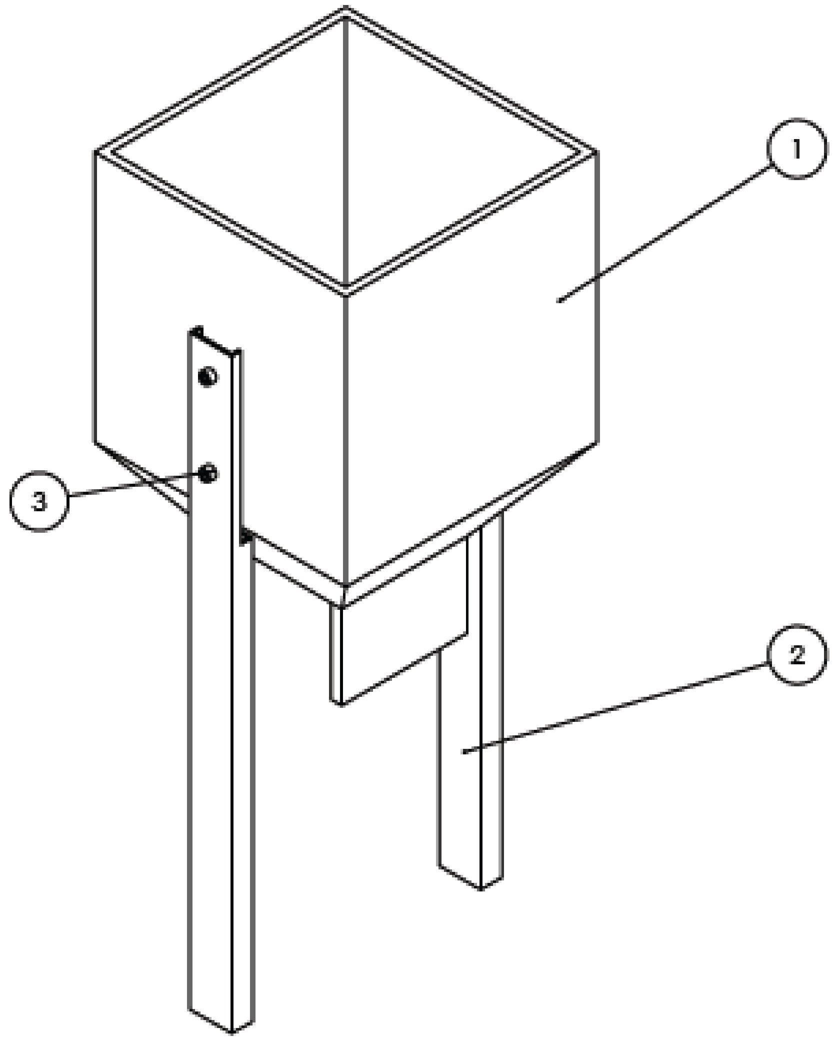
Surf Rough 1000 mircomm	Dim Tolerance 1000 micromm		Revision		
	Scale	1:5	Drawn by	Faris Ali Jaidi	Remarks
	Unit	mm	Dept./ ID No.	IEN / 004201300016	
	Date	4/12/2018	Checked by		
President University	Hollow Steel 2 - Adjustable Table Sub Part			Drawing No. 15	Size A4



Surf Rough 10 micromm	Dim Tolerance 10 micromm	Revision			
	Scale	1:1	Drawn by	Faris Ali Jaidi	Remarks
	Unit	mm	Dept./ ID No.	IEN / 004201300016	
	Date	4/9/2018	Checked by		
President University	TumbScrew - Adjustable Table Sub Part			Drawing No. 16	Size A4



Surf Rough 1000 mircomm	Dim Tolerance 1000 micromm		Revision			
	Scale	1:10	Drawn by	Faris Ali Jaidi	Remarks	
	Unit	mm	Dept./ ID No.	IEN / 004201300016		
	Date	4/9/2018	Checked by			
President University		Finish Container - Part			Drawing No. 17	Size A4



No.	Qty.	Part Name	Dimensions	Materials
1	1	Raw AHZ Container box	(350x350x15)4pc (300x100x15)4pc	Acrilics
2	2	Raw Container Foot	700x50x25	Hollow Steel
3	4	ISO 4762 M8 x 25 - 25N	-	Stainless Steel

Surf Rough	Dim Tolerance	Revision		
1000 mircomm	1000 micromm			

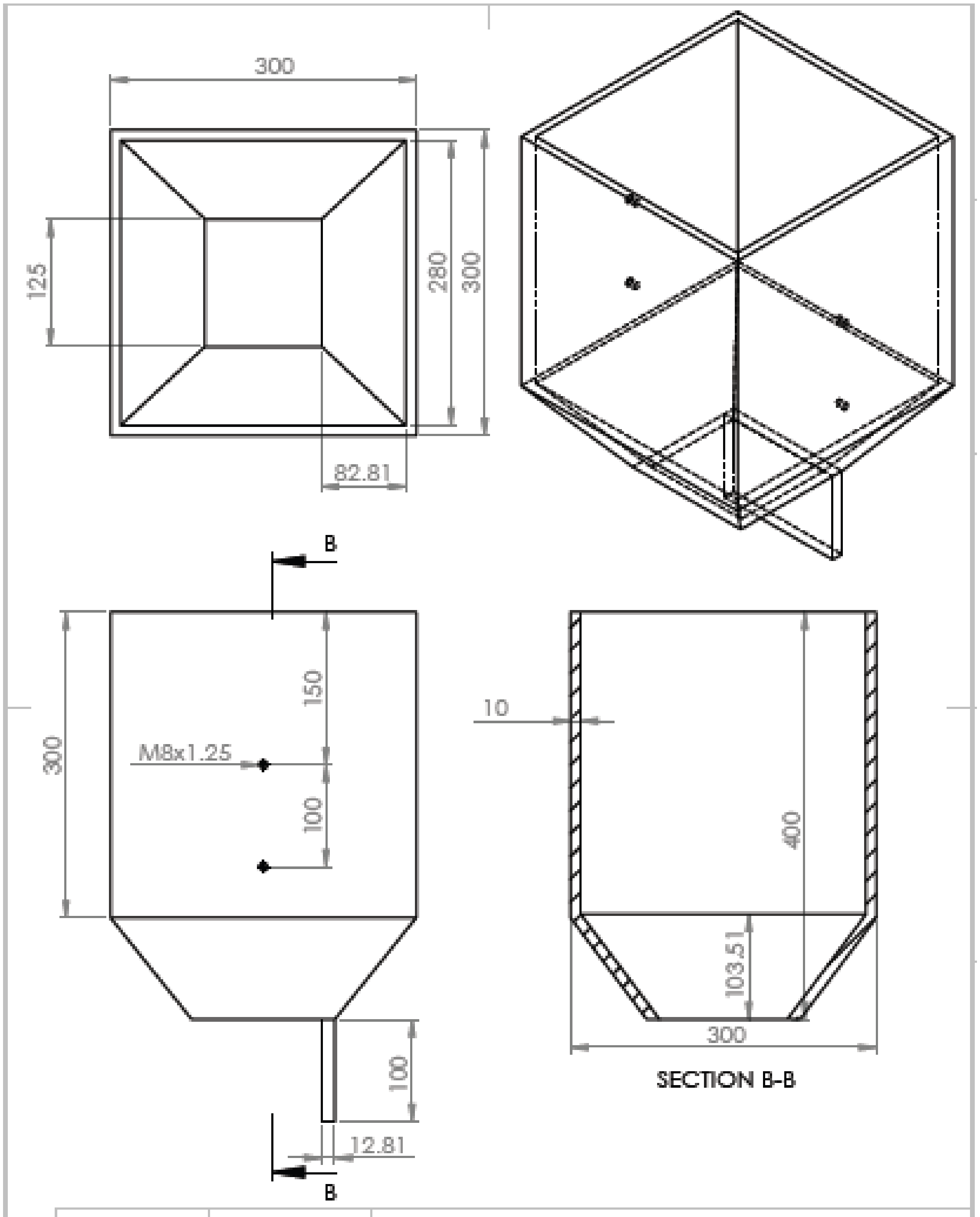
Scale	1:5	Drawn by	Faris Ali Jaidi	Remarks
Unit	mm	Dept./ ID No.	IEN / 004201300016	
Date	4/12/2018	Checked by		

President University

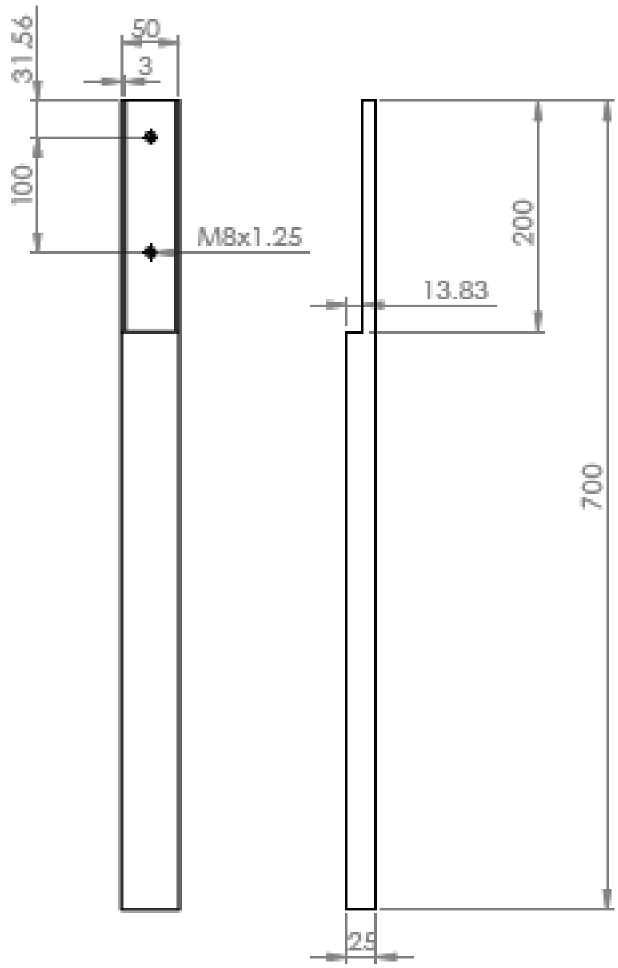
Raw Container - Sub Assembly

Drawing No. 19

Size A4



Surf Rough 1000 mircomm	Dim Tolerance 1000 micromm	Revision		
	Scale 1:5	Drawn by	Faris Ali Jaidi	Remarks
	Unit mm	Dept./ ID No.	IEN / 004201300016	
	Date 4/12/2018	Checked by		
President University	Raw AHZ Container - Raw Container Sub Part		Drawing No. 20	Size A4



Surf Rough 1000 mircomm		Dim Tolerance 1000 micromm	Revision		
	Scale	1:5	Drawn by	Faris Ali Jaidi	Remarks
	Unit	mm	Dept./ ID No.	IEN / 004201300016	
	Date	4/12/2018	Checked by		
President University		Raw Container Foot - Raw Container Sub Part		Drawing No. 21	Size A4