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**ROOT CAUSE ANALYSIS OF PRODUCTION
DEFECTS IN A FOUNDRY USING LEAN TOOLS**

BY

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**A thesis submitted to the Faculty of Engineering and the
Built Environment, University of Cape Town in fulfilment of
the requirement for the degree of Master of Science in
Mechanical Engineering.**



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DECLARATION

I know the meaning of plagiarism and declare that all the work in the document, save for that which is properly acknowledged, is my own.

Justin Philip

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ABSTRACT

Lean manufacturing is one of the philosophies that many major businesses have been trying to adopt in order to remain competitive in an increasingly global market. This research project focuses on the implementation of lean principles, standardizing operations in the production line and thereby improving productivity. The study is conducted in a large scale metal casting company, Atlantis Foundries which manufactures cylinder blocks and gear box castings.

At present scrap and rework rate of heavy duty cores exceed set targets; this is a major quality concern for the company. From literature, it is known that the introduction of standardized work is one of the best practices in building the quality of products. Therefore, project focuses on introduction of standardised work at the core shop heavy duty flow line for reducing scrap rate, reducing rework rate and for increasing the production of heavy duty cores. To know how the employees accept standardised work, it is essential to diagnose the employee behaviour. The project analyses the behaviour of core shop heavy duty flow line employees towards the introduction of standardised work. Moreover, this project analyses the personal and training development of employees, whether employees structure their work environment (5S) and also existence of the seven wastes at core shop heavy duty flow line by means of a structured standardized questionnaire. At the end, this project uses A3 Practical problem solving report (PPS) for analysing the root cause of production defects for reducing the increase in rework occurred at the core shop heavy duty flow line after the introduction of standardised work.

Standardised work was introduced with the generation of standard work instruction, job element sheet, skills training matrix and layered process audit prepared in consultation with the operators. On analysis of production figures, it was known that the introduction of standardised work reduced scrap rate, reduced rework rate and increased production. Analysis of employee behaviour, personal and training development of employees, structuring of work environment (5S) and the existence of the seven wastes with questionnaire resulted in the respective conclusion that the employees are satisfied with standardised work, personal and training development of

employees increased, employees structure their work environment and lesser existence of the seven wastes at core shop heavy duty flow line. Analysis with PPS resulted that increase in rework was due to the worn bushes of Machine 150. Hence, the checks for worn bushes of Machine 150 were included in change over procedures and total productive maintenance activities.

The project suggests that lean tools like standard work instruction, job element sheet, skills training matrix and layered process audits need to be introduced at each department of the company. Standard work instructions need to be introduced for changeover as well as for total productive maintenance checks. TPM checks must be done regularly at all stations of core shop heavy duty flow line.

Keywords: Lean manufacturing, Seven wastes, Value stream mapping, Standard work instruction, Job element sheet, Skills training matrix, Layered process audit, 5S, A3 Practical problem solving, Total productive maintenance

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CHAPTER ONE

INTRODUCTION

1.1 Overview

Lean manufacturing is one of the philosophies that many major businesses have been trying to adopt in order to remain competitive in an increasingly global market. The focus of the approach is to establish flow through standardisation and eliminating non value added activities. Originating from the Toyota Production System, many of the tools and techniques of lean manufacturing have been widely used in discrete manufacturing (Liker, 1998; Womack and Jones, 1996; Rajenthirakumar and Thyla, 2011). Applications have spanned many sectors including automotive, electronics, white goods, consumer products manufacturing and services (Womack and Fitzpatrick, 1999; Rajenthirakumar and Thyla, 2011).

As the lean tools and techniques used by Toyota and other original equipment manufacturers help to improve productivity and minimize waste, other automotive component manufacturing industries necessarily need to adopt lean philosophies in order to achieve the improved market share and to compete with their global counterparts. Therefore the implementation of lean principles is highly recommended for identifying the areas generating waste, as it further facilitates the optimization of the operating conditions in a minimal investment.

The study is conducted in a large scale metal casting company, Atlantis Foundries which manufacture automotive castings. Atlantis Foundries is a Daimler company fully owned by Mercedes-Benz, South Africa. The project focuses on the implementation of lean principles in the foundry, standardizing operations in the production line and thereby improving productivity. The project analyses the response of employees towards the standardised operations. Moreover, the project also analyses the root cause of production defects, for reducing the increase in rework rate occurred at the production line by means of PPS.

1.2 Objective of the Research

Scrap and rework rate of heavy duty cores is a major quality concern for the company. On analysis it was known that, the scrap rate of heavy duty cores was

0.14% higher than the set target of 0.9% (refer Figure 1) and the rework rate was 0.22% higher than the set target of 1.85% (refer Figure 2).

The objective of research is to reduce the scrap rate and rework rate of heavy duty cores by introducing standardised work, analysing behaviour of employees to the introduction of standardised work, analysing whether employees structure their work environment (5S) and analysing the existence of seven wastes at core shop heavy duty flow line of Atlantis Foundries.

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Scrap Rate of Core Shop HD Flow Line

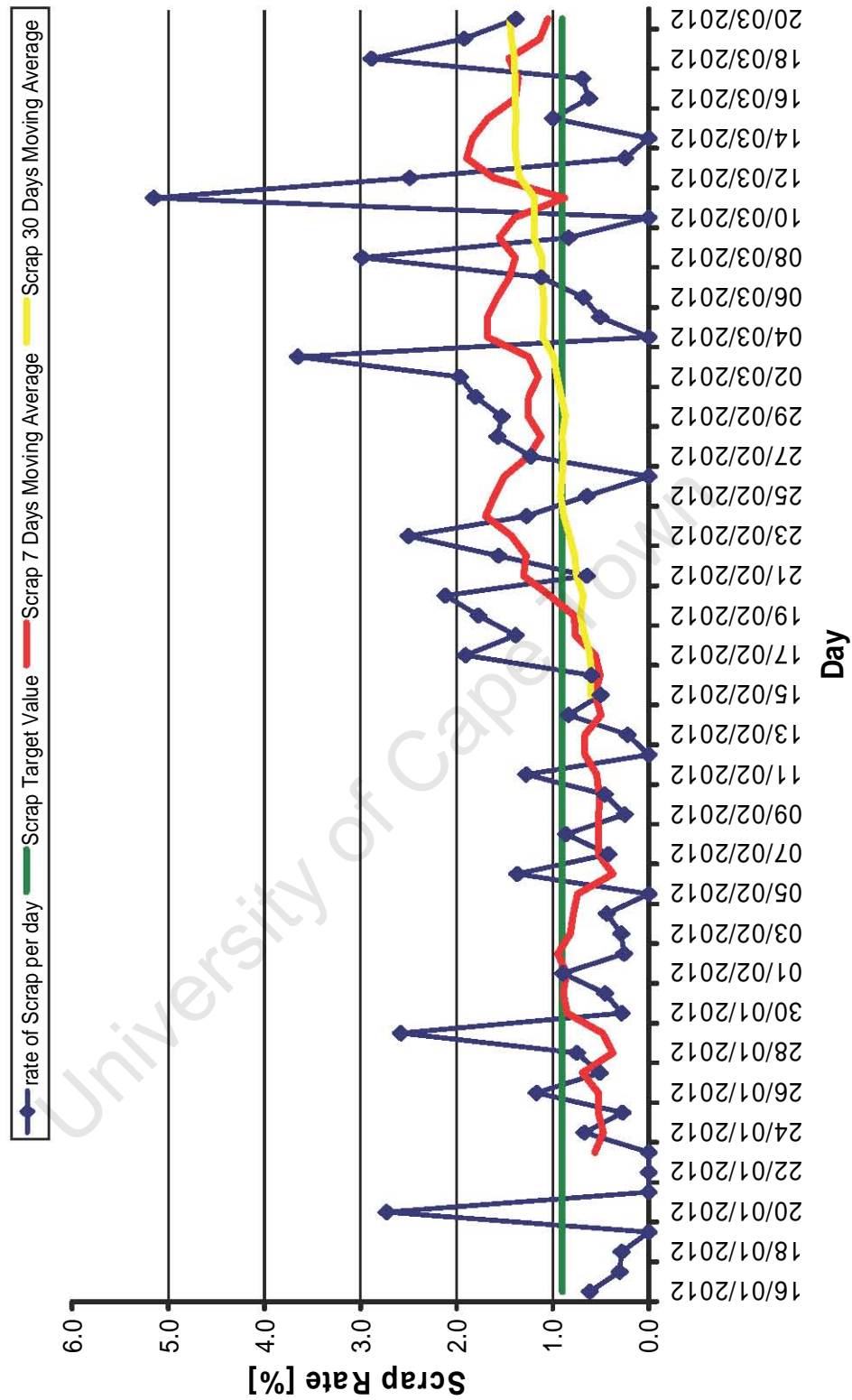


Figure 1: Chart showing the Scrap rate of core shop heavy duty cores from 16th January to 20th March 2012

Here the average rate of scrap per day is 1.04% which is 0.14% higher than the set target of 0.9%. The 7 days moving average and 30 days moving average of scrap are also plotted.

Rework Rate of Core Shop HD Flow Line

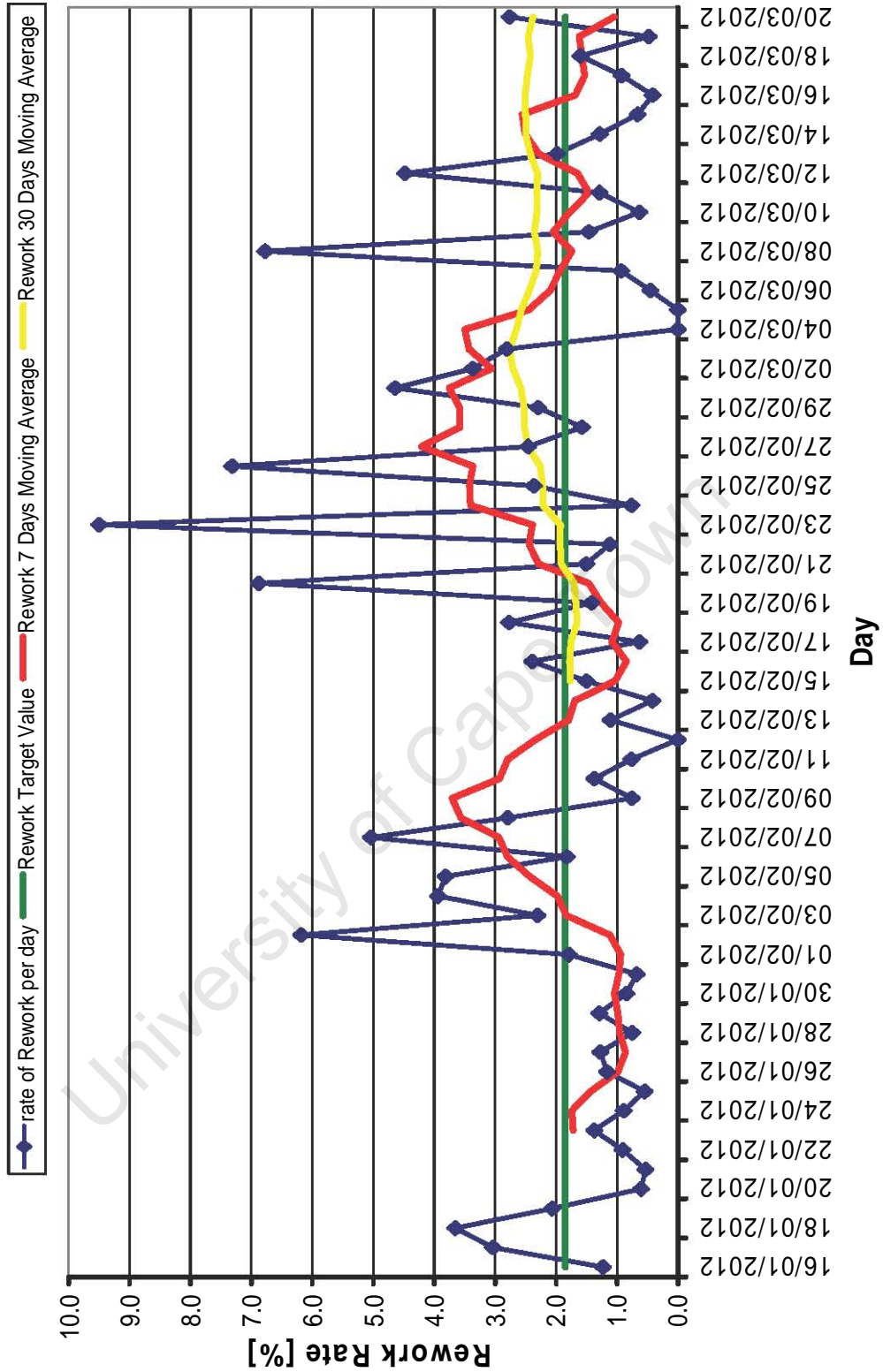


Figure 2: Chart showing the Rework rate of core shop heavy duty cores from 16th January to 20th March 2012

Here the average rate of rework per day is 2.07% which is 0.22% higher than the set target of 1.85%. The 7 days moving average and 30 days moving average of rework are also plotted.

1.3 Research Methodology

The research methodology applied in this investigation can be broken up into three stages:

- 1) Interviews and workshop for the introduction of standardised work,
- 2) Generation of questionnaire for the analysis of employee behaviour, personal and training development, 5S and the seven wastes, and
- 3) Problem solving with A3 Practical problem solving report (PPS).

At first, the actual process, actual value stream, key figures and problems of the company were analysed. On analysis, it was found that the scrap rate and rework rate of heavy duty cores was the major quality concern of the company. After a comprehensive literature review, the introduction of standardised work was considered the most appropriate method to reduce the scrap rate and rework rate of heavy duty cores as the current work procedures at the core shop heavy duty flow line was not standardized. For introducing standardised work, the actual process and actual value stream of the core shop heavy duty flow line were further analysed and the value stream map was drawn. Standardised work was introduced with the generation of standard work instructions and job element sheets prepared in consultation with employees. Skills training matrix was prepared for job rotation and for training employees on more stations. Moreover, layered process audit was prepared for validation of standardized work.

The second stage of research was to analyse the behaviour of core shop heavy duty flow line employees towards the introduction of standardised work, the personal and training development of employees, whether employees structure their work environment (5S) and the existence of seven wastes at core shop heavy duty flow line. After comprehensive literature review, a questionnaire survey combined with interviews was considered to be one of the most appropriate method for the above analysis. Therefore a questionnaire survey with direct interview was done with the employees of core shop heavy duty flow line. The questionnaire was generated on five point Likert scale (Kothari, 2003) and the questionnaire provided the employees to make decision from the five available options; strongly disagree, disagree, neutral, agree and strongly agree. The questionnaire consisted of four parts in the order; lean

tools and employee behaviour, personal and training development, methodologies for structuring work environment (5S) and existence of the seven wastes.

The target population included all employees of core shop heavy duty flow line namely the operators, senior operators, team leaders, general foreman, engineer and manager making a population size of 92. For greater reliability of results, the whole population was included as the sample size (Kothari, 2003). Before doing elaborate questionnaire survey, a pilot study was conducted for testing the questionnaire for bringing to light the weakness of the questionnaire (Kothari, 2003). For the pilot study, interviews were conducted with 3 operators of B Shift and it was found that few questions were not arranged in an orderly sequence. Based on this, questions were arranged in a sequential manner and were used for interviewing the employees of core shop heavy duty flow. Out of 92 employees interviewed, 10 employees refused to respond, therefore a total of 82 questionnaires were taken for analysis. Statistical Package for Social Sciences (SPSS) version 10 was utilized to analyze and present the data of the research (Field, 2006). Tabulation and descriptive statistics were the statistical tools used.

The third stage of the research was to reduce the increase in rework rate of the heavy duty cores occurred after the introduction of standardised work. A3 Practical problem solving report was used for reducing the increase in rework rate of heavy duty cores.

1.4 Overview of the Chapters

For getting a better understanding of the investigation of the research project and the methodology used to meet the said objectives, the document is organized into various chapters. The chapters gives an overview of the literatures used (chapter 2), functioning of the company (chapter 3), approach towards the project (chapter 4), results emerging from the project (chapter 5), conclusion (chapter 6) and further improvements (chapter 7). The summary of each chapter is as follows.

Chapter two provides an overview of the theoretical foundation that forms the premise of the study. The concepts and theories of lean manufacturing, seven wastes, value stream mapping, standard work instruction, job element sheet, skills training matrix, layered process audits, 5S, A3 practical problem solving and total productive

maintenance are introduced and discussed. Apart from this, the various literatures related to these are also reviewed.

Chapter three gives an overview of the company, its production process and quality systems. Chapter four gives insight into the approach used with specific reference to the introduction of standardised work. Moreover, chapter four discuss in detail the generation of standard work instruction, job element sheet, skills training matrix and layered process audits.

Chapter five provides an inspection of the most salient results and discussions emerged from the introduction of standardised work, analysis of employee behaviour, personal and training development, 5S and the seven wastes. The chapter gives insight into the sampling, data collection methods, inferences of pilot study and statistical tools used for data analysis and also unveil the research findings from the analysis of data collected during the study. The chapter explains how A3 practical problem solving report is used for analysing the root cause of production defects, thereby reducing the increase in rework rate occurred in the core shop HD flow line after the introduction of standardised work.

Chapter six concludes the findings of the study and the suggestions resulting from the studies. Chapter seven discuss the areas where the company needs to improve so as to tackle the expected challenges in the coming future.

CHAPTER TWO

LITERATURE REVIEW

2.1 History of Lean

After World War II Japanese manufacturers were faced with the dilemma of vast shortage of material, financial and human resources. This shortage led Japanese manufacturers difficult to adopt mass production system followed by their western counterparts. Toyota motor company led by its president Toyoda recognized that western automakers of that era were out-producing their Japanese counterparts. In order to make a move towards improvement, Toyoda Kiichiro, Shigeo Shingo and Taiichi Ohno devised a new, disciplined, process-oriented system, which is now known as “Toyota Production System” or “Lean Manufacturing” (Womack, Jones and Roos, 1990, 1994; Shingo, 1989; Nordin, Deros and Wahab, 2010). Taiichi Ohno, who was given the task of developing a system that would enhance productivity at Toyota is generally considered to be the primary force behind this system. Ohno drew up ideas from the west and particularly from Henry Ford’s book “Today and Tomorrow”. Ford’s moving assembly line of continuously flowing material formed the basis for the development of Toyota Production System between 1945 and 1970. The basic underlying idea of this system is to minimize the consumption of resources that does not add value to a product.

In order to compete in the global market, US manufactures have realized that traditional mass production concepts have to be adapted to the new ideas of lean manufacturing. A study done at Massachusetts Institute of Technology of the movement from mass production towards lean manufacturing, as explained in the book “The Machine That Changed the World” (Jim Womack, Daniel Jones, and Daniel Roos, 1990), awoke the US manufacturers from their sleep. The study underscored the great success of Toyota at New United Motor Manufacturing Inc. and brought out the huge gap that existed between the Japanese and Western automotive industry. The study made US companies to adopt lean manufacturing concept because the Japanese companies developed produced and distributed products with less human effort, capital investment, floor space, tools, materials, time and overall expense (Womack et al., 1990).

2.2 Lean Manufacturing

Lean Manufacturing is one of the philosophies that many major businesses have been trying to adopt in order to remain competitive in an increasingly global market. The focus of the approach is to establish flow through standardisation by eliminating non value added activities. The basic concepts behind lean manufacturing system are waste elimination, cost reduction and employee empowerment. The term “lean” as Jim Womack, Daniel Jones, and Daniel Roos define it, denotes a system that utilizes less, in term of all inputs, to create the same outputs as those created by a traditional mass production system, while contributing increasing varieties for the end customers (Panizzolo, 1998).

Lean focuses on abolishing or reducing wastes (or “muda”, the Japanese term for waste) and on maximizing or fully utilizing activities that add value from the customer’s perspective. From the customer’s perspective value is equivalent to anything that the customer is willing to pay for in a product or the service that follows. Therefore, the elimination of waste is the basic principle of lean manufacturing. Lean manufacturing is underpinned by five principles (i) specify what creates value from the customers perspective (ii) identify all the steps along the process chain (iii) make those processes flow (iv) make only what is pulled by the customer (v) strive for perfection by continually removing wastes.

For the elimination of waste, it is necessary to identify which steps add value and which do not. This was one of the key steps in Lean and Toyota Production System. By classifying all the process activities into value adding and non-value adding, it is then possible to start actions for improving the former and eliminating the latter. Once value-adding work has been separated from waste, then waste can be subdivided into 'needs to be done but non-value adding' waste and pure waste. The clear identification of 'non-value adding work', as distinct from waste or work, is critical in identifying the assumptions and beliefs behind the current work process. Toyota’s chief engineer Taiichi Ohno identified “Seven Wastes” as part of the Toyota Production System namely transportation, inventory, motion, waiting, over-processing, over-production and defects.

1) Transportation – Transportation was one of the seven wastes identified by Taiichi Ohno. Each time a product is moved, it stands the risk of being damaged, lost,

delayed, etc. as well as being a cost for no added value. Moreover, transportation does not make any transformation to the product that the customer is willing to pay for.

2) Inventory – Inventory in the form of raw materials, work-in-progress, or finished goods, represents a capital outlay that has not yet produced an income either by the producer or for the customer. Any of these three items not being actively processed to add value is waste.

3) Motion - Motion refers to the damage that the production process inflicts on the entity that creates the product, either over time (wear and tear for equipment and repetitive stress injuries for workers) or during discrete events (accidents that damage equipment and injure workers).

4) Waiting - Waiting was another waste identified by Taiichi Ohno. Whenever goods are not in transport or being processed, they are waiting. Waiting does not add value to what the customer is willing to pay for.

5) Over-processing - Over-processing occurs any time more work is done on a piece than what is required by the customer. This also includes using tools that are more precise, complex, or expensive than absolutely required.

6) Over-production - Overproduction occurs when more products are produced than is required at that time by customers. One common practice that leads to this muda is the production of large batches, as often customer needs change over the long times large batches require. Overproduction is considered the worst muda because it hides and/or generates all the others. Overproduction leads to excess inventory, which then requires the expenditure of resources on storage space and preservation, activities that do not benefit the customer.

7) Defects - Whenever defects occur, extra costs are incurred reworking the part, rescheduling production, etc. Defects do not add value to what the customer is willing to pay for.

2.3 Lean Manufacturing Tools and Techniques

The elimination of waste is essential in today's manufacturing world. A set of tools were developed at Toyota to eliminate or to reduce the sources of waste. A brief description of such lean manufacturing tools and techniques are discussed below.

2.3.1 Value Stream Mapping

A Value stream is a collection of all actions value added as well as non-value added that are required to bring a product or a group of products that use the same resources through the main flows, from raw materials to the arms of customers (Rother and Shook, 1999). Value stream mapping is an enterprise improvement tool to assist in visualizing the entire production process, representing both material and information flow. The goal of value stream mapping is to identify all types of waste in the value stream and to take steps to try and eliminate them (Rother and Shook, 1999). Value stream mapping was originated in Toyota. In Toyota it is known as "material and information flow mapping". It can be applied to nearly any value chain.

Although value stream mapping is often associated with manufacturing, it is also used in logistics, supply chain, service related industries, healthcare, software development, product development and administrative and office processes. Value stream mapping is a recognized method used as part of Six Sigma methodologies.

2.3.2 5S

5S is a work place organization methodology that uses five phrases namely sorting, stabilizing, sweeping/shining, standardizing and sustaining for structuring the employee work environment. The list of 5S describes how to organize a work space for efficiency and effectiveness by identifying and storing the items used, maintaining the area and sustaining the new order. The five 5S phases are described below.

1) Sorting (*Seiri*) – Sorting refers to eliminating all unnecessary tools, parts, and instructions. For this, go through all tools, materials, and so forth in the plant and work area. Keep only essential items and eliminate what is not required, prioritizing things per requirements and keeping them in easily-accessible places. Everything else is stored or discarded.

2) Stabilizing or Straightening Out (*Seiton*) - There should be a place for everything and everything should be in its place. The place for each item should be clearly labeled or demarcated. Items should be arranged in a manner that promotes efficient work flow, with equipment used most often being the most easily accessible. Workers should not have to bend repetitively to access materials.

3) Sweeping or Shining (*Seiso*) – Refers to cleaning the workspace and all equipments, and keeping it clean, tidy and organized. At the end of each shift, clean the work area and be sure everything is restored to its place. This makes it easy to know what goes where and ensures that everything is where it belongs. A key point is that maintaining cleanliness should be part of the daily work not an occasional activity initiated when things get too messy.

4) Standardizing (*Seiketsu*) - Work practices should be consistent and standardized. All work stations for a particular job should be identical. All employees doing the same job should be able to work in any station with the same tools that are in the same location in every station. Everyone should know exactly what his or her responsibilities are for adhering to the first 3 S's.

5) Sustaining the Practice (*Shitsuke*) - Refers to maintaining and reviewing standards. Once the above 4S have been established, this becomes the new way to operate. Maintain focus on this new way and do not allow a gradual decline back to the old ways. When an issue arises such as a suggested improvement, a new way of working, a new tool or a new output requirement, review the first 4 S's and make changes as appropriate. It should be made as a habit and be continually improved.

The Origins of 5S

5S was developed in Japan by Hiroyuki Hirano. Hirano provided a structure for improvement programs. He pointed out a series of identifiable steps, each building on its predecessor. He taught that any effort to consider layout and flow before the removal of unnecessary items was likely to lead to a sub-optimal solution.

The Objectives of 5S

Hirano identified a range of benefits from improved housekeeping, all of which can be regarded as falling within the lean portfolio and are all based around the elimination of waste in one form or another.

The most obvious benefit from items being organized in such a way is that of improved productivity. Production workers being diverted from production to look for tools, gauges, production paperwork, fasteners, and so on is the most frustrating form

of lost time in any plant. A key aspect of Hirano's organization approach was that the often needed items are stored in the most accessible location and correct adoption of the standardization approach means that they are returned to the correct location after use. Another element of Hirano's improved housekeeping, improved plant maintenance workers 'owning' a piece of plant, responsible for keeping it clean and tidy, can take ownership for highlighting potential problems before they have an impact on performance.

Another benefit relates to quality. The degree of impact of dirt in a manufacturing environment, obviously, varies with the nature of the product and its process. Even if it is only in the form of soiled documentation accompanying the goods to the customer, this can send a very negative message about the company and its culture. In other cases dirt can have a serious impact on product performance, either directly or indirectly, perhaps through compromising the integrity of test processes.

Another goal is improved health & safety. Clear pathways between workbenches and storage racks can minimize accidents. As with quality, a well-organized, clean and tidy facility lends itself more readily to standard practice. Hirano also described how an environment in which the workforce has pride in their workplace can contribute to a considerable extent in a number of ways including customer service. Improving the layout of the facility merges with the concept of visual management; if workers can see the status of plant and of work in the facility, thus removing the need for complex tracking and communication systems, then benefits will accrue. 5S can also be a valuable sales tool when potential customers visit; a well-organized, clean and tidy facility sends a message of a professional and well-organized supplier.

One point made by all practitioners was that the adoption of 5S must be driven by goals. An article in the journal of the UK's Institute of Operations Management written by Mark Eaton and Keith Carpenter of the engineering employers' federation noted that "the successful implementation of 5S requires that everyone understand why it is being used and what the expected results are. As with all lean techniques the aim is improvement in business performance; the adoption is not an end in itself.

2.3.3 Standardization of Work

One of the most important principles of waste elimination is the standardization of worker actions as it focuses on reducing waste within a process (Liker 1998, 2004; Liker and Hoseus, 2008). Liker (2004) identified standardisation of work as one of the basic foundations of lean manufacturing as it forms the basis for continuous improvement. Standardisation of work ensures that each job is organized and carried out in the most effective manner and the same level of quality is achieved for the job irrespective of the person doing the job. Moreover, it ensures that line balancing is achieved, unwarranted work in progress inventory is minimized and non-value added activities are reduced. Standardisation of work plays a major role in lean manufacturing as every worker follows the same processing steps. This improves productivity, reduce variation in the work performance and improve the quality of the product. The common lean tools used as part of standardisation of work are standard work instructions, job element sheets, skills training matrix and layered process audits.

1) Standard Work Instruction - Standard work instructions are specific instructions that allow processes to be completed in a consistent, timely and repeatable manner. It is a written document or instruction detailing all relevant steps and activities of a process or procedure and is usually selected as a mean to solve the deviation problem. It provides employees reference to his activities and tasks. Standard work instruction details the takt time and the order of steps to be followed while doing each job. Takt time refers to how often a part should be produced in a product family based on the actual customer demand. Takt time is calculated by dividing the available work time per day by the customer demand per day (Feld, 2000). The target is to produce product at a pace not higher than the takt time.

2) Job Element Sheet - Job element sheet defines in detail the elements of the process operations as established in standard work instruction. By means of visual aids/images, job element sheet gives a better understanding to the operator why a particular job element is performed for completing the process. Job element sheet is often referred to as visual aid sheet or process picture sheet in manufacturing industries.

3) Skills Training Matrix - Skills training matrix is a table showing the skills held by individuals in a team and the skills gap within a team. The concept is originated from Toyota production system as Taichii Ohno (1998) believed that workers need to be taught a wide variety of skills so that tasks can be rotated and workers can fill in for each other (Jim Womack, Daniel Jones, and Daniel Roos, 1990). In another perspective, training matrix helps in validation of the training procedures of the company which in turn helps to increase the skills of workers by providing them training on more machines/ stations/ processes.

4) Layered Process Audits (5 Cycle Check Observation Form) - Layered process audits is an increasingly popular quality tool developed for manufacturing management. When utilized properly, layered process audits will drive cultural change throughout an organization to improve quality, reduce scrap and rework, and reduce customer rejections. 5 Cycle check observation form is the name given to the layered process audit used at Atlantis Foundries for validation of standardized work. A layered process auditing system is comprised of three critical elements:

1) A Collection of Audits - Audits are an organized group of questions designed to examine a device or process. Audits in layered process auditing system should focus only on areas in the manufacturing process where deviation represents a high-risk for producing defective products.

2) Layers of Auditors - In layered process auditing system, the collection of audits is performed on a regular basis, at a predetermined frequency, by multiple layers of management from across the manufacturing organization.

3) Containment, Reporting & Follow-up - For a layered process audit system to be truly effective, it must integrate action, analysis and improvements. If an auditor finds a non-conformance while performing an audit, that auditor should not only record their finding, but also take immediate initial corrective actions. Information about the finding should be recorded and readily available to management for later analysis. With a good system for recording and reporting audit information, layered process auditing system provides an excellent tool for troubleshooting problem areas and identifying places which are ripe for improvement.

2.3.4 A3 Practical Problem Solving

A3 Practical problem solving is a fact-based problem solving methodology that is widely used for real time problem solving in manufacturing industries. A3 Practical problem solving is an integral part of the Toyota Production System (TPS) approach to Kaizen, or continuous improvement. This methodology grew in the factories of Japan as TPS took root under the guiding hand of Taiichi Ohno, the “father” of TPS.

The dominant concept of A3 Practical problem solving is “*Genchi Genbutsu*” or Go and See firsthand. With each step of gathering the pertinent facts the problem solver is asked to document or describe what is actually happening, based on first hand observation, versus what should be happening, or the standard. Once the real problem is identified then solutions become more apparent through a process of cause/effect analysis using actual testing for root cause and monitoring of countermeasures to assure long term effectiveness. The purpose of this method of problem solving is to identify countermeasures that will permanently resolve a problem and prevent recurrence of that problem. Once a problem has been permanently resolved, the manufacturing process can then be evaluated for possible improvement or Kaizen.

The Eight steps for successful problem solving are (refer Figure 3):

Step 1: Initial Problem Perception

Initial problem perception refers to a problem that is large, vague or unclear in nature.

Step 2: Problem Identification

Identification of the problem can be done through observing the problem by going, looking, seeing & understanding. Talking with people helps to gather information related to the problem. After the information is gathered, visualize the problem. Evaluate the problem based on seriousness, urgency, growth & priorities. Understand current results and the ideal results and analyse the performance gap. Based on facts, break down the problem into smaller groups and clarify the objectives. Decide which problems to tackle first. Select the problem based on level of importance, level of urgency, and potential to get worse.

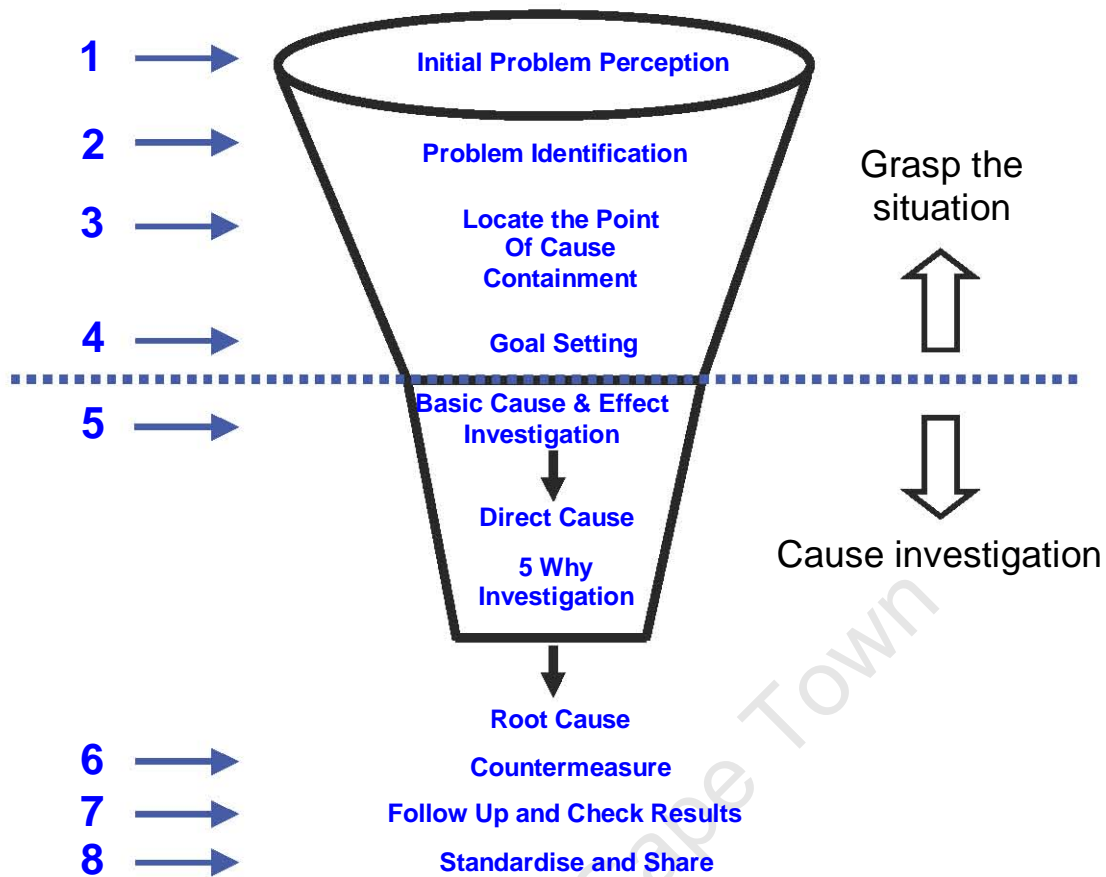


Figure 3: PPS Funnel

Step 3: Locate the Point of Cause, Generate containment action plan

When problem is solved in a large and complicated manufacturing environment sometimes, the problem found will not be the place where it is caused. In such cases solving the problem without fully understanding the point of cause leads to mistakes and the 5 Why investigation becomes unreliable. So it is necessary to visualize the flow. The flow is visualised so as to identify where the problem is first seen in the process flow. For this, the characteristics of the problem need to be clearly understood. If the characteristics of the problem are clearly understood, then by backtracking through the process the point of cause can be found. The point of cause is the place where the problem occurred.

Steps for locating the point of cause:

1. Understand the nature of the problem.

2. Break down any complicated problems, which may contain similar problems caused in different places.
3. Understand the flow of materials, parts or information leading up to where the problem was discovered.

Containment

Once the point of cause has been identified, containment can be implemented successfully. Containment consist of the activity done for temporarily stopping the problem from happening while the long term countermeasure is investigated.

Step 4: Goal Setting

Goal setting refers to setting targets to take care of the prioritized problem at the point of cause. Here a a smart goal is established which is specific, measurable, achievable, realistic, and time bound.

Step 5: Basic Cause and Effect Investigation

As point of cause of the problem is located, it is necessary to investigate facts to build up a chain of cause & effect that will lead from the direct cause to the root cause. The process is commonly known as the 5 Why investigation.

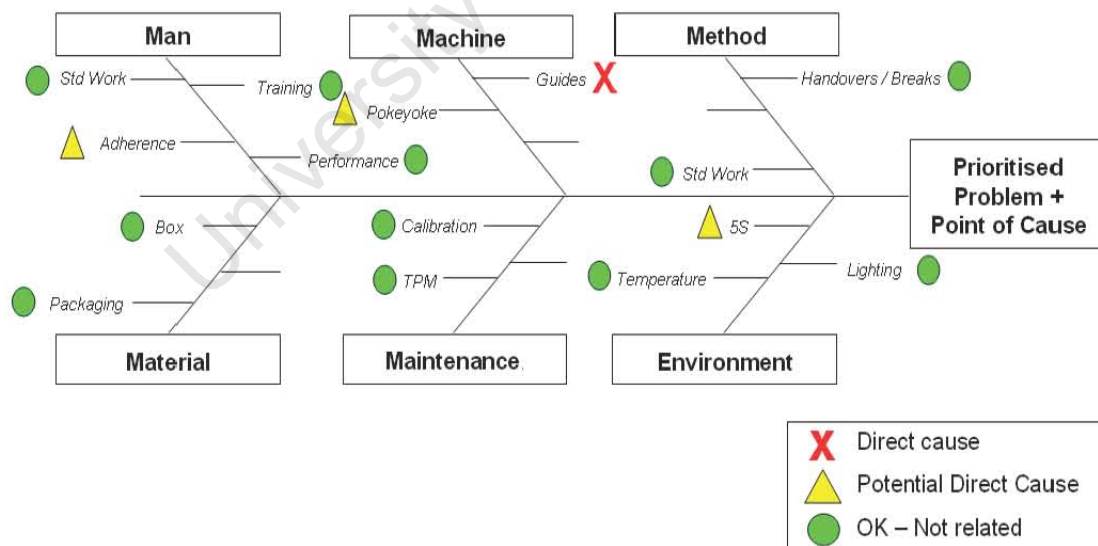


Figure 4: Fishbone diagram

For investigating the problem, Go, Look & See is the methodology used. After investigation, potential direct causes are brainstormed using a fishbone diagram (refer

Figure 4) with the team members & leaders from the problem area. For validation, each suggested cause is reviewed against a standard and the direct cause is categorically found out. After finding out the direct cause, the root cause is found by means of 5 Why investigation. 5 Why investigation is a tool used to link the cause or effect to the direct cause thereby enabling the root cause to become clear. 5 Why doesn't mean exactly 5 Why's, but it can be 5, 10 or 15 Why's. 5 Why investigation is done until no why's can be asked any more. According to *Taiichi Ohno*, "*Observe the production floor without preconceptions and with a blank mind. Repeat 'why' 5 times to every matter*". The end of 5 Why investigation leads to the root cause.

Step 6: Countermeasure

A Countermeasure addresses the root cause of the problem and prevents the reoccurrence of one or more direct causes of the problem. Countermeasure changes the current system of work.

For every root cause, there will be implementation of at least one countermeasure. This can be chosen from many countermeasures evaluated in terms of: effectiveness, cost, timing and ease of implementation.

In case of problems having many direct causes, each countermeasure can be introduced one at a time. By this the effect of each countermeasure on the overall problem can be accurately judged. Then a plan can be drawn for putting the countermeasures into effect.

Step 7: Follow Up and Check Results

For confirming the effectiveness of the countermeasures, each countermeasure must be checked in turn. The steps involved for confirming the effectiveness of the countermeasures are

1. Check for incidence of the problem. A Countermeasure is considered effective if it reduces the incidence of a problem.
2. Check whether the countermeasure is properly implemented.
3. Checks must be done close to the point of cause. This enables countermeasure to be confirmed quickly with the minimum of waste.
4. If the countermeasure is effective it must be standardised and all containments must be removed.

Step 8: Standardize and Share

As a change is made to a current process or procedure or if a new method of operating is created, it needs to be standardised. Standardisation locks the change in place and doesn't allow the process to regress back to its former state or deviate to a different state.

At Toyota Motor Corporation in Japan the phrase used for sharing is *yokoten* which means "horizontal application". Across an organisation, the levels information can be shared on specific problems are team to team, area to area, department to department, plant to plant, and country to country and so on.

2.3.5 Total Productive Maintenance

Total productive maintenance (TPM) is a maintenance process developed for improving productivity by making processes more reliable and less wasteful. The objective of total productive maintenance is to maintain the plant or equipment in good condition without interfering with the daily process. To achieve this objective, preventive and predictive maintenance are used. By following the philosophy of TPM the unexpected failure of the equipment can be minimized. TPM focuses primarily on manufacturing and is the first methodology Toyota used to improve its global position in 1950s. An accurate and practical implementation of TPM will increase productivity within the total organization. The benefits of effective TPM include (i) safer working environment (ii) improved equipment reliability – uptime (ii) increased capacity (iv) increased productivity (v) improved quality (vi) company financial performance and job security.

2.4 Contrast between the literatures and the practice followed at Atlantis Foundries

The literatures suggest that, standardisation of work is one of the most important principles of waste elimination as it focuses on reducing waste within a process. Liker (2004) identified standardisation of work as one of the basic foundations of lean manufacturing as it forms the basis for continuous improvement. The lean house set by Liker (2004) illustrated that the foundation of the house must be

stable for the pillars to stand steadily and must consist of tools like 5S, standardized work, and leveled production for reaching the lean production goals consisting of best quality, lowest costs, shortest lead time, highest safety and high morale set at the roof.

According to Liker (2004) standardized work is one of the best practices in building the quality as it reduces the process variations within a process. Standardisation of work ensures that each job is organized and carried out in the most effective manner and the same level of quality is achieved for the job irrespective of the person doing the job. The practical evidence is directed from Toyota zero defects production, done through the standardized work. In Toyota, standardized work sheets are selected as a mean to solve the quality problems and process variations. Liker (2004) claims that any good standardized task procedures need to be developed by operators and must be simple and practical enough to be used every day by the ordinary operators. Moreover, set standards connect people, equipment and material to develop the most efficient sequence, location and practice and this improve productivity, reduce variation in the work performance and improve the quality of the product (Liker 2004).

Comparison of the best practice set by Liker and the practice followed at Atlantis Foundries revealed that the work procedures at Atlantis Foundries were not standardised and were developed by engineers rather than the operators. Further analysis also revealed that the operators on different shifts are working on different work sequence and are not exactly following the work procedure developed by engineers. As scrap and rework rate of heavy duty cores is a major quality concern for Atlantis Foundries, standardisation of work can be considered as a best practice for reducing the scrap and rework rate. Therefore, the project focuses on introducing standardised work at core shop heavy duty flow line of Atlantis Foundries.

CHAPTER THREE

COMPANY PROFILE

3.1 Company Introduction

Atlantis Foundries is a South African based company manufacturing cylinder blocks and gear box castings. The company produces automotive castings for both the commercial and passenger vehicle industries. In addition, the company machines castings and forgings for automotive applications. Atlantis Foundries is situated in Atlantis approximately 50 km north of Cape Town. The company sells over 253,000 blocks per annum and has a workforce of over 1350 employees as on March 2012.

Atlantis Foundries product range comprises of

- Cast grey iron cylinder blocks ranging from 55kg to 420kg.
- Machined commercial vehicle diesel engine cylinder blocks ranging from 4 to 12 cylinder variants.
- Machined crankshafts used in commercial vehicle diesel engine applications.

The company supplies customers with a large variety of complex high quality grey iron castings, precision machined cylinder blocks and crankshafts. Major customers include Mercedes-Benz, Detroit Diesel Corporation (DDC), Cummins, Perkins, Ssangyong and MAN.

3.2 Production Process

Atlantis Foundries has a well-equipped core shop (refer Figure 5) consisting of a range of machines that produce small to large complex cores. Cores are produced using the cold box manufacturing method which consists of mixing sand with a 2 part resin compound and injecting it into a core box. Thereafter amine gas acting as a catalyst accelerates the curing of the core. The cores produced are then assembled and are coated with an exactly defined core paint wash of 0.3mm thickness. The assembly is then dried in oven before passing on to the moulding shop.

Molten metal is used for metal casting. Grey iron is produced in two 10 tonne medium frequency induction furnaces (refer Figure 5) which are backed up by smaller electrical arc and induction furnaces. The foundries melting capacity is in excess of

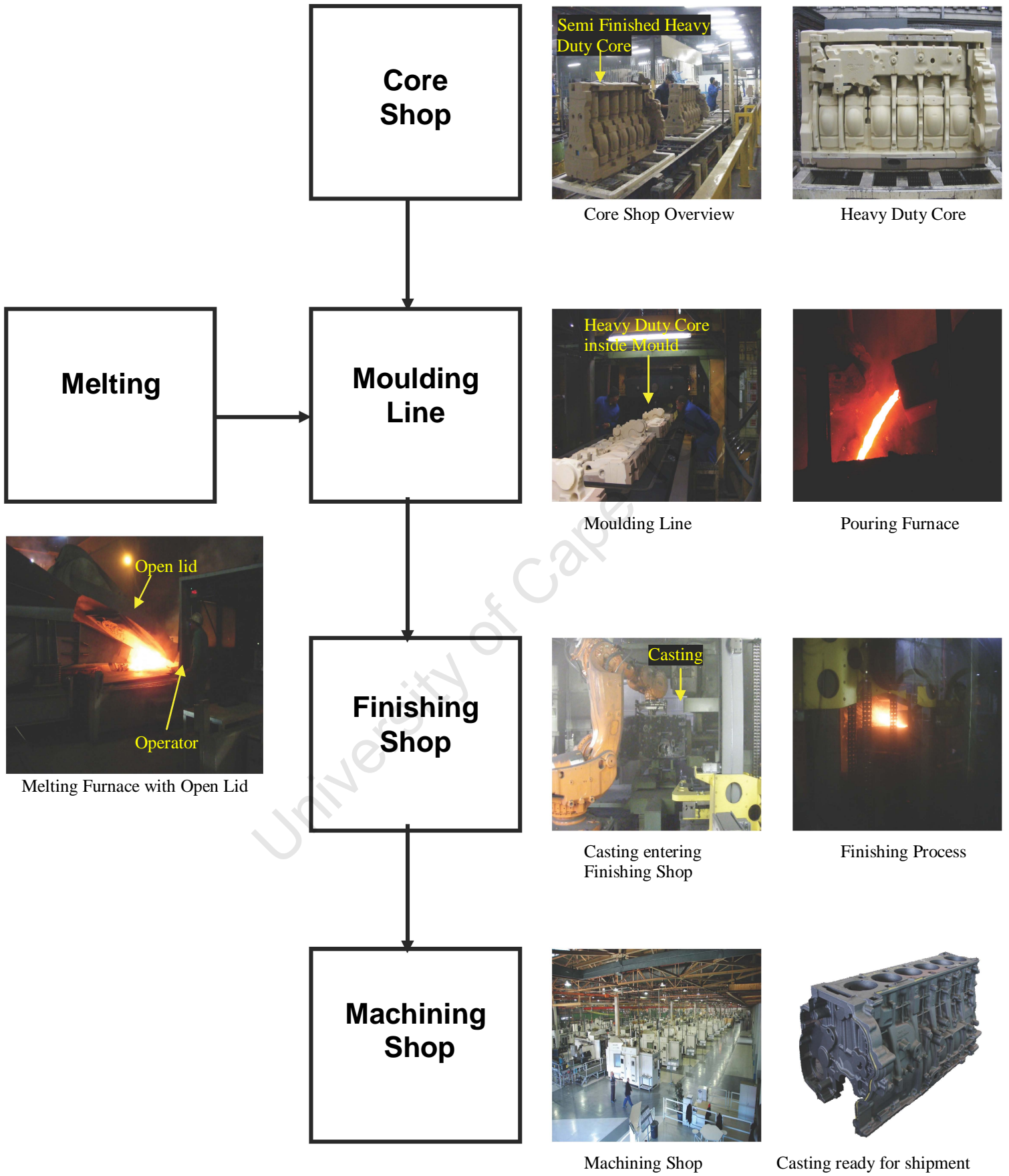


Figure 5: Sequence of production process in foundry

220 tonnes per day. After melting, the metal is transferred into two 50 tonne holding furnaces where the metal is further treated and alloyed. A fully automatic laser controlled nitrogen charged pressure pour furnace fills the mould.

The company has got a modern green sand facility where the green sand of moulding line (refer Figure 5) is produced using a modern state of the art mixer. The moulds are produced from high precision steel tools creating intricate shapes. Before pouring of molten metal takes place, the core assemblies are inserted into the moulds and then passed into the pouring furnace. A 10 tonne fully automatic pressure pour furnace is used to pour moulds of 300 to 500 kg mass at a rate of one mould per minute. Once poured, the castings remain in the moulds for three hours before being ejected out onto the shake out conveyer.

Castings from the shake out conveyer go into the finishing shop (refer Figure 5). Finishing shop prepares castings, so that they are clean, precise and ready for machining. Here, the sand covered castings are shot blasted and cleaned. Each casting is then hand fettled to customer's specifications before going to the machining shop.

In machining shop (refer Figure 5), the fettled castings are either spray painted or powder coated as well as spot faced and leak tested. Machining shop of the company has three block machining production facilities as well as a crankshaft machining line. Modern machines using the latest CNC technology are employed where the castings are reference machined on CNC machining centres. This ensures that the exacting tolerances needed to produce engines that comply with the most stringent exhaust emission standards are met. After this, castings are transferred to outbound logistics facility.

3.3 Quality System of the Company

Atlantis Foundries is accredited to all major internationally recognized automotive quality systems. Quality is the hallmark of the company. With the company's continuous improvement strategy, the company ensures that the quality is forever improving. The company's metrology, metallurgy and physical laboratories ensure that the products are controlled to the exacting requirements of the customers. Atlantis Foundries is certified to the DIN EN ISO 9001:2000, VDA 6.1, QS 9000 and ISO/ TS Quality systems (Atlantis Foundries brochure, 2011).

CHAPTER FOUR

APPROACH

Introduction of Standardised Work

Scrap and rework rate of heavy duty cores is a major quality concern for Atlantis Foundries. The literature research has shown that standardisation of work is considered to be best practice to reduce scrap and rework rate. Hence the research focuses to introduce standardised work at core shop heavy duty flow line of Atlantis Foundries.

The necessity for the introduction of standardised work at Atlantis Foundries can be analysed from the data in Table 1. The data is obtained by taking the average values of production from 16th January 2012 to 20th March 2012.

Table 1: Core shop figures

Name	Actual Value	Target Value	Difference	Inference
Scrap rate in core shop per day	1.04%	0.9%	-0.14%	Scrap rate is higher than target
Rework rate in core shop per day	2.07%	1.85%	-0.22%	Rework rate is higher than target
Cores produced in core shop per day	396	550	-154	Actual cores produced is 28% lesser than target
Shifts required per week	21	15	6	Employees are working overtime for meeting the weekly target

Standardised work can be implemented by building up an area for standardised work to generate experience to managers and operators with regards to

- 1) Standard work instruction/ Job element sheet with work steps, work sequence, durations, layout, tools, key-points and reasons.
- 2) Training of operators and developing skills matrix.
- 3) Checking standardised work through 5 cycle check - layered process audits.
- 4) Continuous improvement programme workshops.

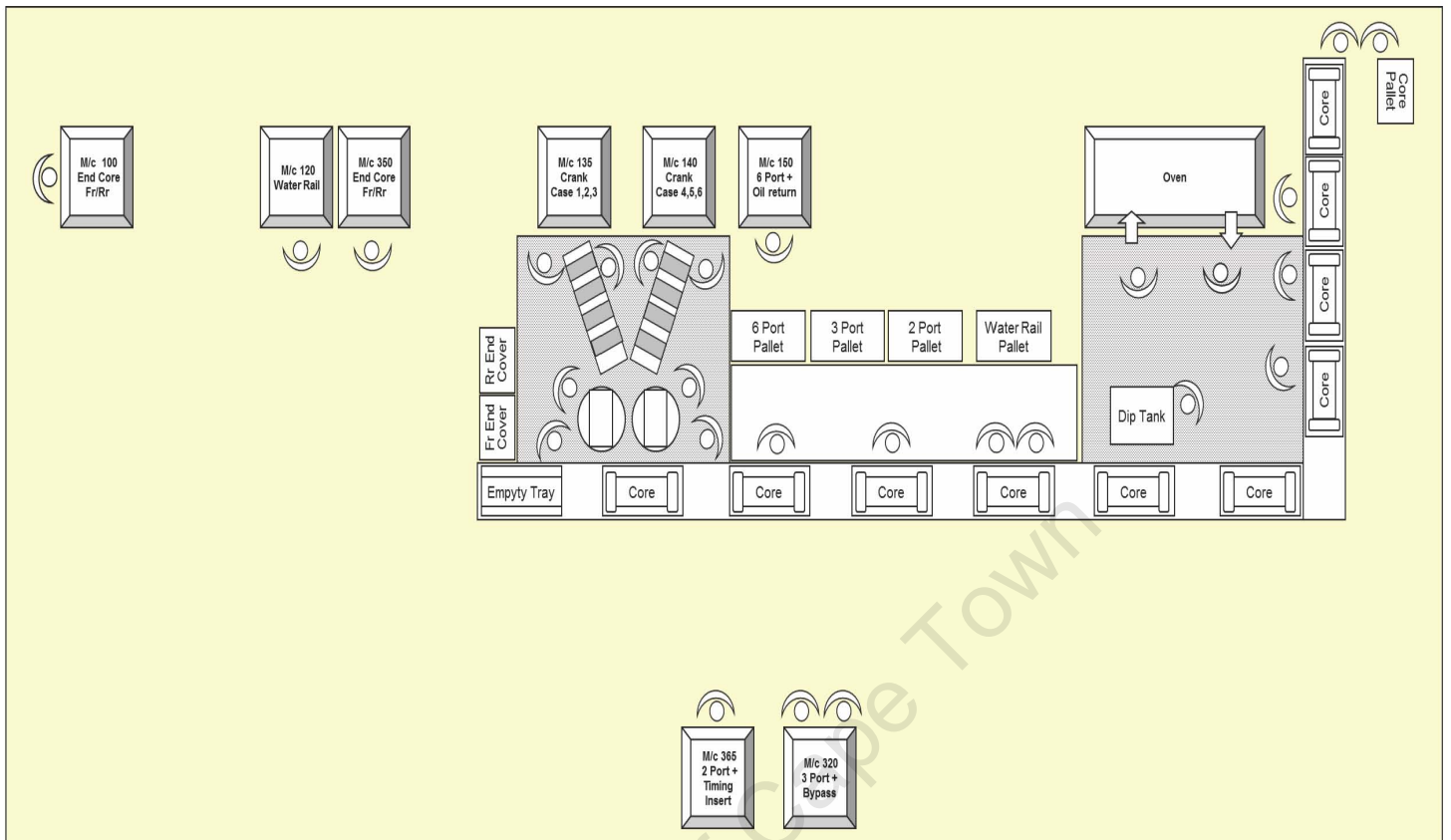
For implementation of standardised work in the foundry, the total project was divided into three phases namely planning phase, implementation phase and stabilising phase commonly known as Plan, Do, Check and Act (PDCA).

- A) Planning Phase (Plan) - In this phase, actual process, actual value stream, key figures and problems in the foundry were analysed. Moreover, standard work instruction (SWI) and job element sheet was generated along with operators.
- B) Implementation Phase (Do) - Refers to implementation of standardised work and collection of data for stabilising Phase. Workshops were conducted with managers and operators to implement standard work instruction and job element sheet.
- C) Stabilising Phase (Check and Act) - Here the data obtained in the implementation phase was checked. This data was compared with expected results and the deviation in implementation and plan was checked.

4.1 Core Shop Heavy Duty Flow Line

Core shop heavy duty (HD) flow line of Atlantis Foundries manufactures heavy duty cores. The heavy duty cores produced here are 471 EPA 10 and 472 EPA 10. In a day, HD flow line runs in 3 shifts; Morning shift (7:00 to 15:00), Afternoon shift (15:00 to 23:00) and Night shift (23:00 to 7:00). The three shifts rotates on a weekly basis and is designated as A, B and C Shift based on the General Foreman operating in the shifts.

The key people associated with core shop heavy duty flow line are Manager (Core shop), Engineer (Core shop), General Foreman (HD Flow Line A, B and C shifts), Team Leader (HD Flow Line A, B and C shifts), Senior Operator (HD Flow Line A, B and C shifts) and Operators (HD Flow Line A, B and C shifts). The layout of core shop heavy duty flow line is shown in Figure 6.



Stations and Operators of Core Shop Heavy Duty Flow Line

The core shop heavy duty flow line consist of 16 stations and 27 operators

- Machine 100 : Produce End core - 1 Operator
- Machine 120 : Produce Water Rail - 1 Operator
- Machine 350 : Produce End Core - 1 Operator
- Machine 135 : Produce Crank Case 1,2,3 - 2 Operators
- Machine 140 : Produce Crank Case 4,5,6 - 2 Operators
- Machine 150 : Produce 6 Port - 1 Operator
- Machine 365 : Produce 2 Port, Timing Insert - 1 Operator
- Machine 320 : Produce 3 Port, Bypass - 2 Operators
- Assembly Deck : Core Assembly - 4 Operators
- 6 Port Assembly - 1 Operator
- 2 & 3 Port Assembly - 1 Operator
- Water Rail Assembly - 2 Operators
- Oven Dip Station - 2 Operators
- Oven Take off Station - 2 Operators
- Drilling Station - 2 Operator
- Quality Inspection Gate - 2 Operators

Figure 6: Layout of Core Shop Heavy Duty Flow Line

4.2 Value Stream Mapping - Core Shop Heavy Duty Flow Line

Value stream mapping is an enterprise improvement tool to assist in visualizing the entire production process, representing both material and information flow required to bring a product or service to a consumer. Value stream mapping of core shop heavy duty flow line is shown in Figure 7. Here the total lead time is 3 days 44 minutes and value added time is 1 hour 11 minutes.

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Value Stream Mapping - Core Shop Heavy Duty Flow Line

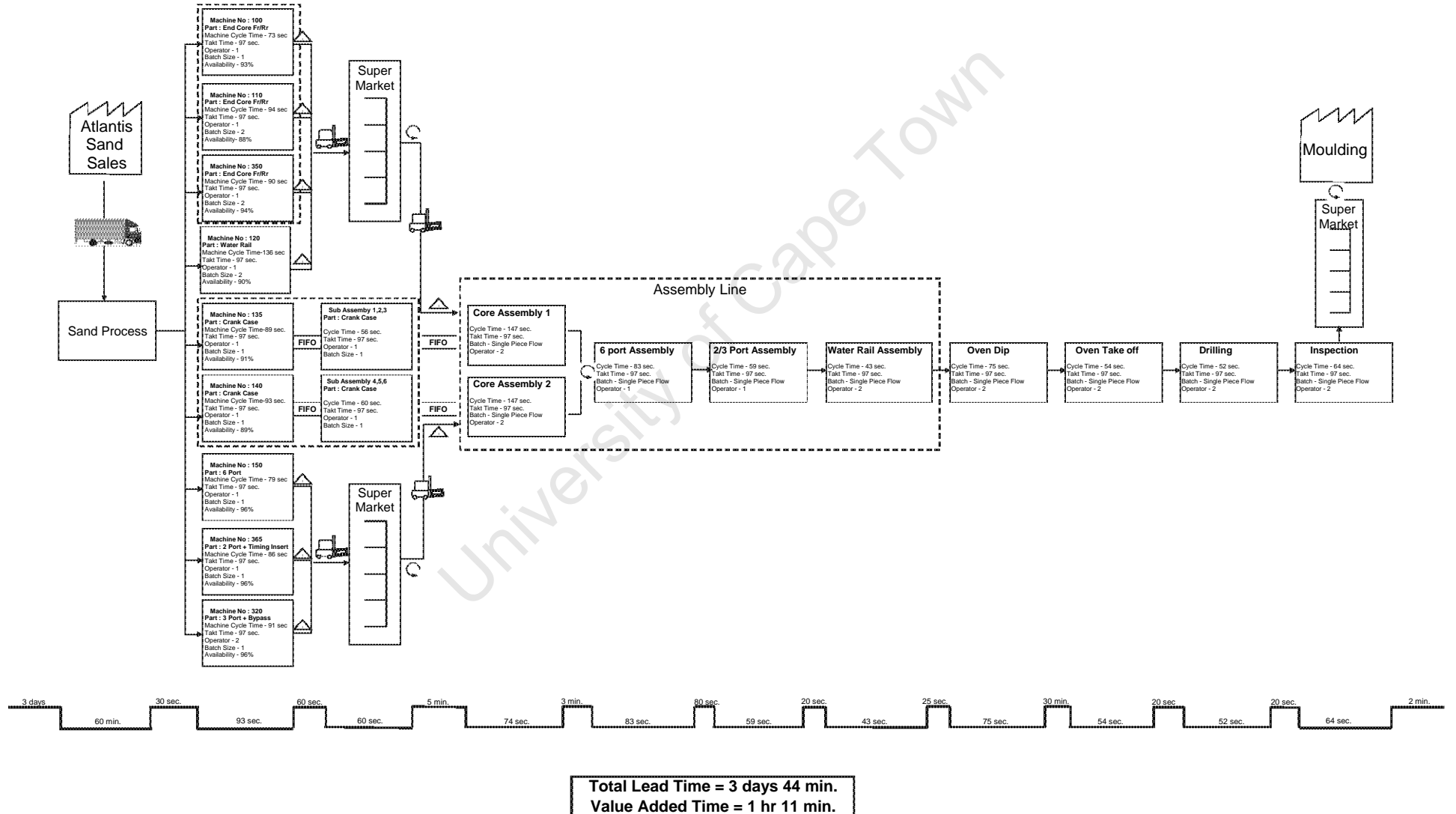


Figure 7: Value Stream Map

4.3 Generation of Standard Work Instruction (SWI)

Standard work instructions are specific instructions that allow processes to be completed in a consistent, timely and repeatable manner. For generating standard work instruction, the operating procedures of operators working on each station per shift were analysed. The entire process of operation performed by operators on a station was divided into various job elements. Job elements provided by operators on a particular station in a shift were compared with the job elements provided by operators working on the same station in other two shifts. The difference in work sequence was analysed and the difference in operating procedure were investigated with reasons from the operators in three shifts. After investigation, unnecessary operations (job elements) were eliminated and required operations were added in consultation with operators of three shifts. Each job element was then compiled in steps to make the operator aware of the step by step standard procedures followed to perform the process. Thus a total of 27 standard work instructions were generated.

4.4 Generation of Job Element Sheet (JES)

Job element sheet defines in detail the elements of the process operations as established in standard work instruction. By means of visual aids/images, job element sheet gives a better understanding to the operator why a particular job element is performed for completing the process. It provides information regarding the necessity of a particular job and the outcome if that job is not performed. Job element sheet was prepared in consultation with operators of three shifts.

4.5 Generation of Skills Training Matrix

Skills training matrix is a table showing the skills held by individuals in a team and the skills gap within a team. It was prepared to check the number of operators capable of operating on more stations and also for analysing the progress in training of core shop operators. On the basis of this table, tasks can be rotated and workers can fill in for each other.

4.6 Generation of 5 Cycle Check Observation Form (Layered Process Audits)

Redundant process checks that verify five parameters namely work sequence, safety of operators, quality, tools/equipment's, design of work place. 5 Cycle check observation form is used for the validation of standardised work. 5 Cycle check observation form at Atlantis Foundries is audited by general foreman, engineer and senior management.

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CHAPTER FIVE

RESULTS AND DISCUSSION

5.1 Introduction of Standardised work

Standardized work was introduced at Atlantis Foundries with the generation of standard work instruction, job element sheet, skills training matrix and layered process audits. Standard work instruction and job element sheet were generated in consultation with operators. Skills training matrix was prepared to check the number of operators capable of operating on more stations and also for analysing the progress in training of operators. Layered process audit (5 Cycle check observation form) was used for the validation of standardised work.

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5.1.2 Job Element Sheet

Job element sheet generated for the project is shown in Figure 9.


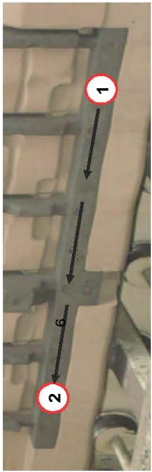
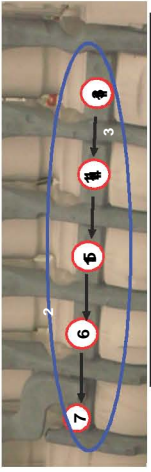
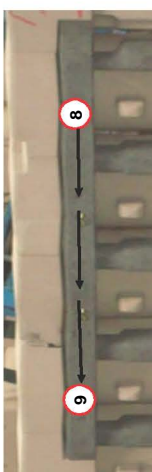
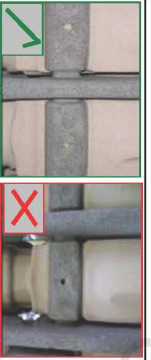
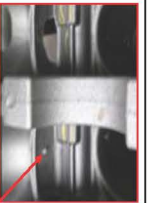
 JOB-ELEMENT-SHEET (JES)		JES-471/472-053 Details to Job Element		Station No.: 6 Port Assembly Name of Station: Assembly Product-Name: 6 Port Product-Type: 471 / 472		Workstep-No.: 10 Base / Option: ??? Revision-Date: 16/3/2012 Revision-No.: V002	
Pictures & Drawings JES-No.: Workstep:		Assembly of the 6 Port onto Assembly		Key Point		Key Point Reason	
  <p>Tighten the 5 middle screws NOT TOO DEEP into the 6 Port.</p> 	1	First tighten the two screws at the bottom of the 6 Port from right to left.	To prevent movement and keep the 6 Port in place.	To prevent movement and keep the 6 Port in place.	To prevent movement and keep the 6 Port in place.	To prevent movement and keep the 6 Port in place.	To prevent movement and keep the 6 Port in place.
	2	Then tighten the five middle screws also from right to left not too deep into the 6 Port.	To keep the 6 Port in Place and to avoid any movement and casting defects.		If screws are tightened deeper than the 6 Port core surface it will cause a metal lump on the casting.		If screws are tightened deeper than the 6 Port core surface it will cause a metal lump on the casting.
	3	Finally tighten the two top screws also from right to left.	To prevent any core movement and keep the 6 Port in place.	To prevent any core movement and keep the 6 Port in place.	To prevent any core movement and keep the 6 Port in place.	To prevent any core movement and keep the 6 Port in place.	To prevent any core movement and keep the 6 Port in place.
Approval of JES Process Engineer: Quality Engineer: Teamleader: Foreman: Manager:							

Figure 9: Job Element Sheet

5.1.5 Major improvements on introduction of standardised work

- Layout of Machine 120 (Water Rail manufacturing machine) was modified and hence transportation was reduced.
- Trolley concept was introduced at Machine 150 (6 Port manufacturing machine). Hence manufactured 6 Port was transported to 6 Port assembly station by means of fork lift trucks, thereby reducing the unwanted movement of 6 Port station operator.
- Operators were able to work within takt time.

5.1.6 Figures of Core Shop Heavy Duty Flow Line on introduction of standardised work

- Rate of scrap per day was reduced from 1.04% to 0.67% making an average daily reduction in scrap from 4 to 2 heavy duty cores (refer Figure 12).
- Rate of rework per day was reduced from 2.07% to 1.19% making an average daily reduction in rework from 8 to 4 heavy duty cores (refer Figure 13).
- Average weekday production of heavy duty cores was increased from 1981 to 2130 making an average daily increase in production from 396 to 426 cores.
- Operating shifts required per week for meeting the required weekly target was reduced from 21 to 20 shifts.

These figures are obtained by comparing the average values before and after the introduction of standardised work. Before standardised work refers to the period between 16th January 2012 and 20th March 2012 and after standardised work refers to the period between 21st March 2012 and 17th June 2012.

Scrap Rate of Core Shop HD Flow Line

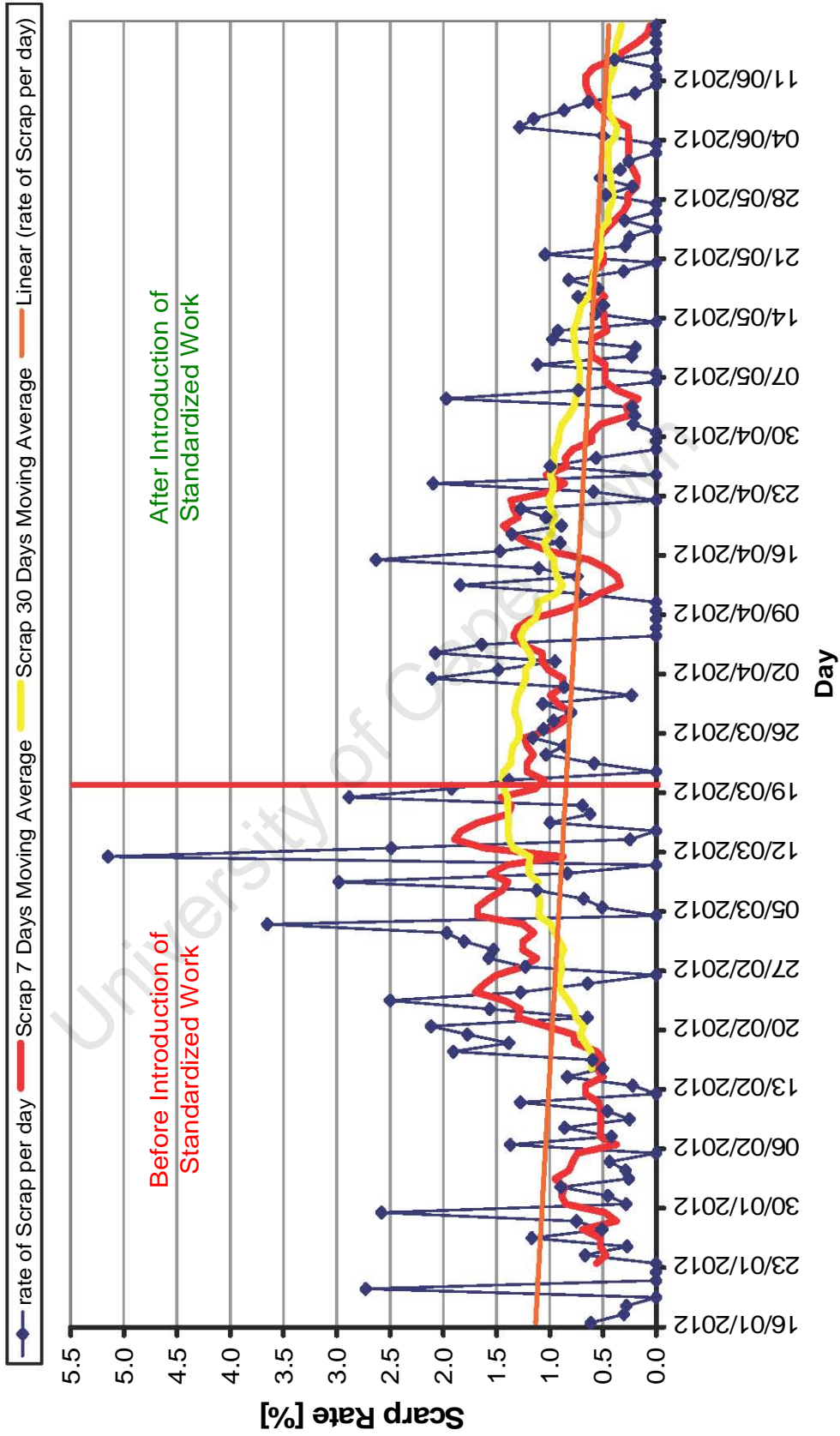


Figure 12: Chart showing reduction in Rate of Scrap from 16th January 2012 to 17th June 2012.

Rework Rate of Core Shop HD Flow Line

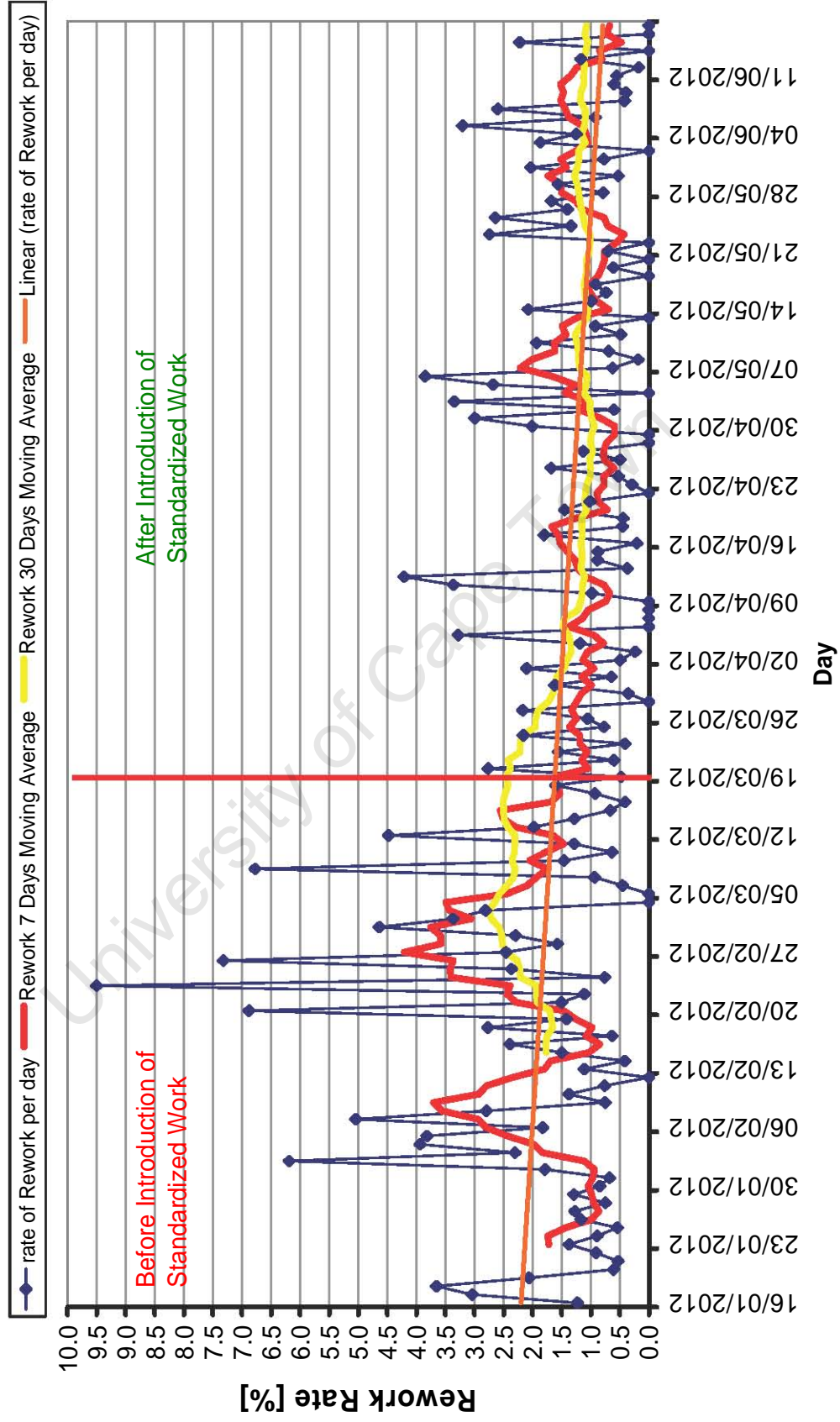


Figure 13: Chart showing reduction in Rate of Rework from 16th January 2012 to 17th June 2012.

5.2 Analysis of Employee Behaviour, Personal and Training Development, 5S & the Seven Wastes

Acceptance and rejection of standardized work by the employees is a major area of concern in manufacturing industries. In order to get an understanding about how the employees accept the introduction of standardised work, it is essential to diagnose the employee behaviour. Employee behaviour can be analysed with the help of a structured standardized questionnaire (Robbins, 2006; Kothari, 2003) with specific focus towards the introduction of standardised work in the foundry.

Skills of employees are the asset of any company. Analysing the skills gained by there employees is a major step towards a company's success. Hence it is essential to analyse the personal and training development of employees. This can be found out with the help of a structured standardized questionnaire.

Structuring of the work environment is one of the basic foundations of lean manufacturing (Liker, 2004). Implementation of lean tools cannot be considered perfect if the employees do not structure their work environment. So it's essential to check whether the employees structure their work environment.

The wasteful activities occurring in an organization, identified as "Seven Wastes" by Toyota's chief engineer Taiichi Ohno are transportation, inventory, motion, waiting, over-processing, over-production and defects. An activity that does not add value is unproductive and wasteful. Therefore, it's necessary to check the existence of the seven wastes in the company. This can be found out with the help of a structured standardized questionnaire.

5.2.1 Respondent Profile

The respondents include all employees of core shop heavy duty flow line namely Manager (Core shop), Engineer (Core shop), General Foreman (HD Flow Line A, B and C shifts), Team Leader (HD Flow Line A, B and C shifts), Senior Operator (HD Flow Line A, B and C shifts) and Operators (HD Flow Line A, B and C shifts).

5.2.2 Population

Population taken for the analysis included all the employees of core shop heavy duty flow line and the size of population was 92. This included the employees of 3 shifts and 16 stations.

5.2.3 Sample Size

For greater reliability of results, the whole population was included as the sample size (Kothari, 2003). Out of the 92 employees interviewed, 10 employees refused to respond. The responded number of employees was thus 82 and the valid questionnaire taken for analysis was 82.

5.2.4 Method of Data Collection

Primary data was collected with a structured standardized questionnaire generated on five point Likert scale (Kothari, 2003) on the basis of direct interview with the employees of core shop heavy duty flow line. Secondary data was collected from company records and company database.

The questionnaire on five point Likert scale provided the employees to make decision from the five available options; strongly disagree, disagree, neutral, agree and strongly agree. For analysis all responses were coded as follows; Strongly Disagree – 1, Disagree – 2, Neutral – 3, Agree – 4, Strongly Agree – 5.

The questionnaire consisted of four parts;

Part A – Lean Tools and Employee Behaviour

Part B – Personal and Training Development

Part C – Methodologies for Structuring Work Environment (5S)

Part D – Existence of the Seven Wastes

5.2.5 Inferences of Pilot Study

Before doing elaborate questionnaire survey, a pilot study was conducted for testing the questionnaire. Pilot study is the replica and rehearsal of the main questionnaire survey. Pilot study brings to light the weakness of the questionnaire and also the survey techniques (Kothari, 2003).

For doing the pilot study, interview were conducted with 3 operators of B Shift. It was found that few questions were not arranged in an orderly sequence, as orderly arrangement of questions reduces the chances of ambiguity among the respondents. Based on this, questions were arranged in a sequential manner and were used for interviewing the employees of all 3 shifts.

5.2.6 Tools for Data Analysis

Statistical Package for Social Sciences (SPSS) version 10 was utilized to analyze and present the data in this research, with frequency tables and graphical illustrations to provide information on variables of research (Field, 2006). The variables of this research are lean tools and employee behaviour, personal and training development, methodologies for structuring work environment (5S) and existence of the seven wastes. The statistical tools used include tabulation and descriptive statistics. Descriptive statistics gives the mean of the different variables under consideration and the maximum and minimum value the variable has achieved in the research.

5.3 Statistical Analysis and Interpretation

Here, the demographic variables used in the questionnaire and the questions related to lean tools and employee behaviour, personal and training development, methodologies for structuring work environment (5S) and existence of the seven wastes are statistically analysed and interpreted.

5.3.1 Analysis of Demographic Variables

The demographic variables used in the questionnaire are analysed from Table 2 to Table 8. The demographic variables include gender of respondents (refer Table 2), age group of respondents (refer Table 3), educational qualification of respondents (refer Table 4), designation of respondents (refer Table 5), length of employment of respondents at Atlantis Foundries (refer Table 6), operating station of respondents (refer Table 7) and shift wise details of respondents (refer Table 8).

Table 2: Gender of respondents

		Gender			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	78	95.1	95.1	95.1
	Female	4	4.9	4.9	100.0
	Total	82	100.0	100.0	

Inference: Majority of the respondents were males (95%) and only 5% of the respondents were female respondents.

Table 3: Age Group of Respondents

		Age Group			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Below 25 Years	13	15.9	15.9	15.9
	25 to 35 Years	26	31.7	31.7	47.6
	36 to 50 Years	38	46.3	46.3	93.9
	above 50 Years	5	6.1	6.1	100.0
	Total	82	100.0	100.0	

Inference: 16% of the core shop HD flow line employees were below 25 years of age. 32% of the employees were between the age group of 25 to 35 years. 46% of the employees were between the age group of 36 to 50 years and 6% of the employees were above 50 years of age. Hence majority of the employees interviewed were between the age group of 36 to 50 years.

Table 4: Educational Qualification of Respondents

		Educational Qualification			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Below Matric	44	53.7	53.7	53.7
	Matric	35	42.7	42.7	96.3
	Diploma	3	3.7	3.7	100.0
	Total	82	100.0	100.0	

Inference: 54% of the employees interviewed were below matric, 43% of the employees were matric and 4% of the employees were diploma holders. None of the employees from operators to manager holds a bachelors or masters degree.

Table 5: Designation of Respondents

		Designation			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Operator	73	89.0	89.0	89.0
	Senior Operator	2	2.4	2.4	91.5
	Team Leader	2	2.4	2.4	93.9
	General Foreman	3	3.7	3.7	97.6
	Engineer	1	1.2	1.2	98.8
	Manager	1	1.2	1.2	100.0
	Total	82	100.0	100.0	

Inference: 89% of the respondents were operators, 2% of the respondents senior operators, another 2% team leaders, 4% of the respondents include general foreman and the remaining respondents include core shop engineer and core shop manager. Hence majority of the respondents were operators.

Table 6: Length of Employment at Atlantis Foundries

		Length of Employment			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 to 2 Years	18	22.0	22.0	22.0
	3 to 5 Years	18	22.0	22.0	43.9
	6 to 10 Years	17	20.7	20.7	64.6
	11 to 15 Years	14	17.1	17.1	81.7
	16 to 20 Years	11	13.4	13.4	95.1
	Above 20 Years	4	4.9	4.9	100.0
	Total	82	100.0	100.0	

Inference: 22% of the respondents had been in Atlantis Foundries for 2 years, another 22% from 3 to 5 years and 21% from 6 to 10 years. Employees with 11 to 15 years of work experience were 17%, 15 to 20 years were 13% and above 20 years of work experience were 5%.

Table 7: Analysis of Respondents based on Operating Stations

		Station operating			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Machine 100	3	3.7	3.7	3.7
	Machine 120	3	3.7	3.7	7.3
	Machine 350	3	3.7	3.7	11.0
	Machine 135	6	7.3	7.3	18.3
	Machine 140	6	7.3	7.3	25.6
	Machine 150	3	3.7	3.7	29.3
	Machine 365	3	3.7	3.7	32.9
	Machine 320	6	7.3	7.3	40.2
	Core Assembly Station	11	13.4	13.4	53.7
	6 Port Assembly Station	3	3.7	3.7	57.3
	2 & 3 Port Assembly Station	3	3.7	3.7	61.0
	Water Rail Assembly Station	4	4.9	4.9	65.9
	Oven Dip Station	6	7.3	7.3	73.2
	Oven Take off Station	5	6.1	6.1	79.3
	Drilling Station	4	4.9	4.9	84.1
	Quality Inspection Station	5	6.1	6.1	90.2
	Supervision	8	9.8	9.8	100.0
	Total	82	100.0	100.0	

Inference: Majority of the respondents interviewed were operating at core assembly station (13%). Supervision refers to the supervisory respondents like senior operators, team leaders, general foreman, core shop engineer and core shop manager who do not operate on any specific station.

Table 8: Shift wise details of Respondents

		Shift			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	B Shift	29	35.4	35.4	35.4
	C Shift	26	31.7	31.7	67.1
	A Shift	25	30.5	30.5	97.6
	All Shift	2	2.4	2.4	100.0
	Total	82	100.0	100.0	

Inference: Majority of employees responded were from B Shift (35%). All shifts refer the core shop engineer and core shop manager.

5.3.2 Lean Tools and Employee Behaviour

Analysis of Employee Behaviour

A total of 17 questions were formulated so as to analyse the behaviour of employees on introduction of standardised work. All the questions related to employee behaviour were structured in a positive manner. Among the 82 employees interviewed, majority of the employees responded positively to the entire 17 questions. All questions related to employee behaviour are analysed from Table 9 to Table 25.

Table 9: Understand what is meant by lean & participated in its implementation

Understood lean & participated in implementation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	7	8.5	8.5	8.5
	Neutral	2	2.4	2.4	11.0
	Agree	70	85.4	85.4	96.3
	Strongly Agree	3	3.7	3.7	100.0
	Total	82	100.0	100.0	

Inference: Majority of employees agree that they understood lean and participated in lean implementation and introduction of standardized work (85%).

Table 10: Understand the need to implement lean techniques in the foundry

Understood need to implement lean in foundry

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	4	4.9	4.9	4.9
	Neutral	4	4.9	4.9	9.8
	Agree	69	84.1	84.1	93.9
	Strongly Agree	5	6.1	6.1	100.0
	Total	82	100.0	100.0	

Inference: Majority of employees agree that they understood the need to implement lean techniques in the foundry (84%).

Table 11: Standard work instruction was developed together with employees

SWI developed along with employees

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	10	12.2	12.2	12.2
	Neutral	2	2.4	2.4	14.6
	Agree	65	79.3	79.3	93.9
	Strongly Agree	5	6.1	6.1	100.0
	Total	82	100.0	100.0	

Inference: Majority of employees agree that standard work instruction (SWI) was developed together with employees (79%).

Table 12: Trained to work on the basis of standard work instruction (SWI)

Trained to work based on SWI

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	6	7.3	7.3	7.3
	Neutral	4	4.9	4.9	12.2
	Agree	68	82.9	82.9	95.1
	Strongly Agree	4	4.9	4.9	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agree that they were trained to work on the basis of standard work instruction (83%).

Table 13: Satisfied with the training procedure

Satisfied with training

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	6	7.3	7.3	7.3
	Neutral	6	7.3	7.3	14.6
	Agree	66	80.5	80.5	95.1
	Strongly Agree	4	4.9	4.9	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agree that they were satisfied with the training procedure (81%).

Table 14: Standard work instruction made work easier

SWI made my work easier

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	1	1.2	1.2	1.2
	Disagree	6	7.3	7.3	8.5
	Neutral	11	13.4	13.4	22.0
	Agree	59	72.0	72.0	93.9
	Strongly Agree	5	6.1	6.1	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agree that standard work instruction (SWI) made work easier (72%).

Table 15: Prefer to work based on standard work instruction over previous instructions

Prefer to work on SWI over previous instruction

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	1	1.2	1.2	1.2
	Disagree	10	12.2	12.2	13.4
	Neutral	7	8.5	8.5	22.0
	Agree	61	74.4	74.4	96.3
	Strongly Agree	3	3.7	3.7	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agree that they prefer to work based on standard work instruction (SWI) over previous instructions (74%).

Table 16: Able to complete operation within takt time as displayed in standard work instruction

Able to complete operation within takt time

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	3	3.7	3.7	3.7
	Agree	76	92.7	92.7	96.3
	Strongly Agree	3	3.7	3.7	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agree that they are able to complete operation within takt time as displayed in standard work instruction (93%).

Table 17: Overall satisfied with the standard work instructions (SWI)

		Satisfied with SWI			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	2	2.4	2.4	2.4
	Neutral	5	6.1	6.1	8.5
	Agree	71	86.6	86.6	95.1
	Strongly Agree	4	4.9	4.9	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agree that they are satisfied with the standard work instructions (87%).

Table 18: Job element sheet helped in implementation of standard work instruction (SWI)

		JES helped in implementing SWI			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	1	1.2	1.2	1.2
	Neutral	3	3.7	3.7	4.9
	Agree	74	90.2	90.2	95.1
	Strongly Agree	4	4.9	4.9	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agree that job element sheet (JES) helped in implementation of standard work instruction (90%).

Table 19: Job element sheet provided the significance of each work element

		JES provided significance of work element			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	1	1.2	1.2	1.2
	Neutral	5	6.1	6.1	7.3
	Agree	72	87.8	87.8	95.1
	Strongly Agree	4	4.9	4.9	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agree that job element sheet (JES) provided the significance of each work element (88%).

Table 20: Satisfied with the information provided in job element sheet (JES)

Satisfied with JES

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	2	2.4	2.4	2.4
	Neutral	5	6.1	6.1	8.5
	Agree	70	85.4	85.4	93.9
	Strongly Agree	5	6.1	6.1	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agree that they are satisfied with the information provided in job element sheet (85%).

Table 21: 5 Cycle check observation form help in validation of standardised work

5CC help to validate Standardized work

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	74	90.2	90.2	90.2
	Agree	4	4.9	4.9	95.1
	Strongly Agree	4	4.9	4.9	100.0
	Total	82	100.0	100.0	

Inference: Majority of employees were neutral regarding whether 5 Cycle check observation form (5CC) help in validation of standardized work (90%) as 5CC are not filled by operators but by supervisory employees - general foreman and above.

Table 22: 5 Cycle check observation form helps to convey my concern of work sequence, safety, quality, tools and workplace design to my supervisor

5CC help to convey concerns to supervisor

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	74	90.2	90.2	90.2
	Agree	3	3.7	3.7	93.9
	Strongly Agree	5	6.1	6.1	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees were neutral regarding whether 5 Cycle check observation form (5CC) helps to convey my concerns to supervisor (90%) as 5CC are not filled by operators but by supervisory employees - general foreman and above.

Table 23: Satisfied with the implementation of 5 cycle check observation form

Satisfied with 5CC observation form

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	75	91.5	91.5	91.5
	Agree	4	4.9	4.9	96.3
	Strongly Agree	3	3.7	3.7	100.0
	Total	82	100.0	100.0	

Inference: Majority of employees were neutral regarding whether they are satisfied with implementation of 5 cycle check observation form (92%) as 5CC are not filled by operators but by supervisory employees - general foreman and above.

Table 24: Commitment to the organization increased with lean implementation and introduction of standardised work

Commitment to company increased

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	1	1.2	1.2	1.2
	Disagree	6	7.3	7.3	8.5
	Neutral	7	8.5	8.5	17.1
	Agree	66	80.5	80.5	97.6
	Strongly Agree	2	2.4	2.4	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agree that commitment to the organization increased with lean implementation and introduction of standardised work (81%).

Table 25: Overall, satisfied with lean implementation and introduction of standardised work

Overall, satisfied with standardised work

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	3	3.7	3.7	3.7
	Neutral	8	9.8	9.8	13.4
	Agree	68	82.9	82.9	96.3
	Strongly Agree	3	3.7	3.7	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agree that they are satisfied with lean implementation and introduction of standardised work (83%).

Table 26: Descriptive Statistics using SPSS

Descriptive Statistics

	N	Minimum	Maximum	Mean
Lean Tools and Employee Behaviour	82	47	85	63.54
Valid N (listwise)	82			

Inference: Table 26 shows the minimum value, maximum value and mean value achieved for the 17 questions related to lean tools and employee behaviour. This was obtained by analysing the response of 82 employees of core shop heavy duty flow line using SPSS.

Table 27: Measurement of Employee Behaviour

Lean Tools and Employee Behaviour	Minimum Scale Value	Neutral Scale Value	Maximum Scale Value
	17	51	85

Inference: Table 27 gives the extent of employee behaviour of employees. On knowing the mean value from SPSS (refer Table 26) and also the minimum scale value, neutral scale value and maximum scale value of the questionnaire (refer Table

27), the extent of employee behaviour can be inferred. Since all the questions related to employee behaviour in the questionnaire were positive questions and as the mean value is greater than the neutral scale value it can be inferred that the core shop heavy duty flow line employees are satisfied with the introduction of standardised work.

5.3.3 Personal and Training Development

Analysis of Personal Development and Training Development of employees

A total of 12 questions were formulated so as to analyse the personal development and training development of employees after standardized work. Among the 12 questions, only 10 questions were formulated on five point Likert scale and the remaining two questions were open questions for analysing the feedback of employees from standardised work. All the 10 questions on five point Likert scale were structured in a positive manner. Among the 82 employees interviewed, majority of the employees responded positively to the entire 10 questions. All questions related to personal and training development are analysed from Table 28 to Table 37.

Table 28: Lean implementation provided way for personal growth and development in company

Lean help in personal growth & development

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	8	9.8	9.8	9.8
	Neutral	8	9.8	9.8	19.5
	Agree	61	74.4	74.4	93.9
	Strongly Agree	5	6.1	6.1	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agree that lean implementation provided way for personal growth and development in company (74%).

Table 29: Lean implementation provided way for growth and development of technical skills

Lean help in improving technical skills

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	15	18.3	18.3	18.3
	Neutral	6	7.3	7.3	25.6
	Agree	56	68.3	68.3	93.9
	Strongly Agree	5	6.1	6.1	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agree that (68%) lean implementation helped in growth and development of technical skills but a small major portion (18%) disagrees to this.

Table 30: Whether employees like to work on more than one station

Like to work on more than one station

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	1	1.2	1.2	1.2
	Disagree	1	1.2	1.2	2.4
	Neutral	8	9.8	9.8	12.2
	Agree	71	86.6	86.6	98.8
	Strongly Agree	1	1.2	1.2	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agree that they like to work on more than one station (87%).

Table 31: Whether employees were given training to work on more than one station

Given training to work on more stations

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	5	6.1	6.1	6.1
	Neutral	9	11.0	11.0	17.1
	Agree	68	82.9	82.9	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agree that they were given training to work on more than one station (83%).

Table 32: After training able to work on new station without assistance

Able to work on stations without assistance

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	2	2.4	2.4	2.4
	Neutral	13	15.9	15.9	18.3
	Agree	67	81.7	81.7	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agree that after training they are able to work on new station without assistance (82%).

Table 33: Whether employees were trained to work on two or more stations

Trained to work on two or more stations

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	3	3.7	3.7	3.7
	Neutral	8	9.8	9.8	13.4
	Agree	71	86.6	86.6	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agree that they were trained to work on two or more stations (87%).

Table 34: Whether employees were trained to work on five or more stations

Trained to work on five or more stations

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	18	22.0	22.0	22.0
	Neutral	8	9.8	9.8	31.7
	Agree	56	68.3	68.3	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agrees (68%) that they were trained to work on 5 or more stations but a small major portion (22%) disagrees to this.

Table 35: Whether able to train other employees to work on two or more stations

Able to train employees on 2 or more station

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	7	8.5	8.5	8.5
	Neutral	8	9.8	9.8	18.3
	Agree	67	81.7	81.7	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agrees that they can train other employees to work on two or more stations (82%).

Table 36: Whether able to train other employees to work on five or more stations

Able to train employees on 5 or more station

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	33	40.2	40.2	40.2
	Neutral	8	9.8	9.8	50.0
	Agree	41	50.0	50.0	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agrees (50%) that they can train others to work on five or more stations but a major portion (40%) disagrees to this.

Table 37: Overall satisfied with the implementation of training matrix

Satisfied with Training matrix

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	1	1.2	1.2	1.2
	Neutral	6	7.3	7.3	8.5
	Agree	74	90.2	90.2	98.8
	Strongly Agree	1	1.2	1.2	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agrees that they were satisfied with the implementation of training matrix (90%).

Table 38: Descriptive Statistics using SPSS

	N	Minimum	Maximum	Mean
Personal and Training Development	82	29	40	36.84
Valid N (listwise)	82			

Inference: Table 38 shows the minimum value, maximum value and mean value achieved for the entire 10 questions related to personal and training development. This was obtained by analysing the response of 82 employees of core shop heavy duty flow line using SPSS.

Table 39: Measurement of Personal and Training Development

Personal and Training Development	Minimum Scale	Neutral Scale	Maximum Scale
	Value	Value	Value
	10	30	50

Inference: Table 39 gives the extent of personal and training development of employees. On knowing the mean value from SPSS (refer Table 38) and also the minimum scale value, neutral scale value and maximum scale value of the questionnaire (refer Table 39), the extent of personal and training development can be inferred. Since all the questions related to personal and training development in the questionnaire were positive questions and as the mean value is greater than the neutral scale value it can be inferred that the core shop heavy duty flow line employees had personal development and are working on more than one station.

Positives of employees with introduction of standardised work

- Standard work instruction made work easier.
- After the introduction of standardised work employees know exactly what to do.
- Standard work instruction increased product quality.

- Standard work instruction is easy to understand.
- Standard work instruction made work more productive.
- Now there is a definite sequence for doing operations.
- After the introduction of standardised work, work environment is better.
- Not much strain to work after the new procedures.
- Standard work instruction made work faster.
- After the introduction of standardised work there is consistency in work.
- Now less time is required for work and spare time is present between work.
- Introduction of standardised work made to learn more and thereby more growth.
- Now the problem solving is easy.
- None is required to teach work as standard work instruction and job element sheet are there.
- The quality of work increased.
- Gained skills and knowledge.
- Better work flow and takt time.
- Standard work instruction simplified work.
- There is no need for hurry after the introduction of standardised work.

Negatives of employees with introduction of standardised work

Employees do not provided any negatives for the introduction of standardised work.

5.3.4 Methodologies for Structuring Work Environment (5S)

Analysis of 5S

A total of five questions were formulated so as to analyse whether the employees structure their work environment. All the questions related to the structuring of work environment were framed in a positive manner. Among the 82 employees interviewed, majority of the employees responded positively to the entire five

questions. All questions related to structuring of work environment are analysed from Table 40 to Table 44.

Table 40: 5S – Sorting

5S - Sorting

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	1	1.2	1.2	1.2
	Neutral	16	19.5	19.5	20.7
	Agree	65	79.3	79.3	100.0
	Total	82	100.0	100.0	

Inference: Majority of employees agrees that they sort their work environment (79%).

Table 41: 5S - Stabilizing/ Straightening out

5S - Stabilizing/ Straightening out

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	1	1.2	1.2	1.2
	Neutral	15	18.3	18.3	19.5
	Agree	66	80.5	80.5	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agrees that they stabilize their work environment (81%).

Table 42: 5S - Sweeping/ Shining

5S - Sweeping/ Shining

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	2	2.4	2.4	2.4
	Neutral	17	20.7	20.7	23.2
	Agree	63	76.8	76.8	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agrees that they clean their work environment (77%).

Table 43: 5S – Standardizing

5S - Standardising

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Disagree	1	1.2	1.2	1.2
Neutral	15	18.3	18.3	19.5
Agree	66	80.5	80.5	100.0
Total	82	100.0	100.0	

Inference: Majority of employees agrees that the work practices are standardized (81%).

Table 44: 5S – Sustaining

5S - Sustaining

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Disagree	1	1.2	1.2	1.2
Neutral	15	18.3	18.3	19.5
Agree	66	80.5	80.5	100.0
Total	82	100.0	100.0	

Inference: Majority of the employees agrees that they sustain the practice of structuring their work environment (81%).

Table 45: Descriptive Statistics using SPSS

Descriptive Statistics

	N	Minimum	Maximum	Mean
Structuring Work Environment	82	10	20	18.90
Valid N (listwise)	82			

Inference: Table 45 shows the minimum value, maximum value and mean value achieved for the entire five questions related to structuring work environment. This was obtained by analysing the response of 82 employees of core shop heavy duty flow line using SPSS.

Table 46: Measurement of 5S

Structuring Work Environment	Minimum Scale	Neutral Scale	Maximum Scale
	Value	Value	Value
	5	15	25

Inference: Table 46 gives the extent of employees structuring their work environment. On knowing the mean value from SPSS (refer Table 45) and also the minimum scale value, neutral scale value and maximum scale value of the questionnaire (refer Table 46), the extent of 5S can be inferred. Since all the questions related to structuring work environment in the questionnaire were positive questions and as the mean value is greater than the neutral scale value it can be inferred that the core shop heavy duty flow line employees structure their work environment.

5.3.5 Existence of the Seven Wastes at Atlantis Foundries

Analysis of the Seven Wastes

A total of seven questions were formulated so as to analyse the existence of seven wastes at the core shop heavy duty flow line. All the questions related to the existence of seven wastes were structured in a negative manner. Among the 82 employees interviewed, majority of the employees responded positively to the entire seven questions. All questions related to the existence of seven wastes are analysed from Table 47 to Table 53.

Table 47: Existence of transportation at core shop heavy duty flow line

Seven Wastes - Transportation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	72	87.8	87.8	87.8
	Agree	9	11.0	11.0	98.8
	Strongly Agree	1	1.2	1.2	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees disagrees to the existence of transportation at core shop heavy duty flow line (88%).

Table 48: Existence of inventory at core shop heavy duty flow line

Seven Wastes - Inventory

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	78	95.1	95.1	95.1
	Neutral	1	1.2	1.2	96.3
	Agree	3	3.7	3.7	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees disagrees to the existence of inventory at core shop heavy duty flow line (95%).

Table 49: Existence of motion at core shop heavy duty flow line

Seven Wastes - Motion

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	55	67.1	67.1	67.1
	Neutral	1	1.2	1.2	68.3
	Agree	25	30.5	30.5	98.8
	Strongly Agree	1	1.2	1.2	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees disagrees (67%) to the existence of motion at core shop heavy duty flow line but a small major portion (31%) agrees to this.

Table 50: Existence of waiting at core shop heavy duty flow line

Seven Wastes - Waiting

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	35	42.7	42.7	42.7
	Agree	45	54.9	54.9	97.6
	Strongly Agree	2	2.4	2.4	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees agrees (55%) to the existence of waiting at core shop heavy duty flow line and only a small portion (43%) disagrees to this.

Table 51: Existence of over processing at core shop heavy duty flow line

Seven Wastes - Over processing

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	1	1.2	1.2	1.2
	Disagree	80	97.6	97.6	98.8
	Neutral	1	1.2	1.2	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees disagrees to the existence of over processing at core shop heavy duty flow line (98%).

Table 52: Existence of over production at core shop heavy duty flow line

Seven Wastes - Over production

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	1	1.2	1.2	1.2
	Disagree	76	92.7	92.7	93.9
	Neutral	2	2.4	2.4	96.3
	Agree	3	3.7	3.7	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees disagrees to the existence of over production at core shop heavy duty flow line (93%).

Table 53: Existence of defects at core shop heavy duty flow line

Seven Wastes - Defects

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	1	1.2	1.2	1.2
	Disagree	69	84.1	84.1	85.4
	Neutral	5	6.1	6.1	91.5
	Agree	6	7.3	7.3	98.8
	Strongly Agree	1	1.2	1.2	100.0
	Total	82	100.0	100.0	

Inference: Majority of the employees disagrees to the existence of defects at core shop heavy duty flow line (84%).

Table 54: Descriptive Statistics using SPSS

Descriptive Statistics

	N	Minimum	Maximum	Mean
Existence of 7 Wastes	82	14	26	16.49
Valid N (listwise)	82			

Inference: Table 54 shows the minimum value, maximum value and mean value achieved for the entire seven questions related to existence of seven wastes at core shop heavy duty flow line. This was obtained by analysing the response of 82 employees of core shop heavy duty flow line using SPSS.

Table 55: Measurement of the Seven Wastes

Existence of 7 Wastes	Minimum Scale	Neutral Scale	Maximum Scale
	Value	Value	Value
	7	21	35

Inference: Table 55 gives the extent of the existence of seven wastes at core shop heavy duty flow line. On knowing the mean value from SPSS (refer Table 54) and also the minimum scale value, neutral scale value and maximum scale value of the questionnaire (refer Table 55), the extent of the existence of seven wastes can be inferred. Since all the questions related to the existence of seven wastes in the questionnaire were negative questions and as the mean value is lesser than the neutral scale value it can be inferred that there are not much issues related to the existence of seven wastes at core shop heavy duty flow line.

The Seven Wastes identified at Core Shop Heavy Duty Flow Line

Transportation

- Transportation for collection of timing chain insert at Machine 100.
- Transportation for collection of tie rods at Machine 100.

- Transportation for collection of rubber air pipe at Machine 100.
- Scrap bin at Machine 120 is too far making unnecessary transportation for operator working at Machine 120.

Inventory

- Higher amount of buffer stock of front/ rear end cores, 2 Port's, 3 Port's and 6 Port's.

Waiting

- Waiting for sand at Machine 100, 120, 350, 135, 140, 150, 365 and 320.
- Waiting for fork lift truck at Machine 100, 120, 350, 150, 365, 320, assembly deck and quality inspection gate.
- Waiting for bin during change over at Machine 120.
- Long waiting in front of Howden oven.

Motion

- Bending at Machine 150, 320, quality inspection gate, assembly deck and drilling station.

5.4 A3 Practical Problem Solving

A3 Practical problem solving report is used in the project for analysing the root cause of production defects, thereby reducing the increase in rework occurred in the core shop HD flow line after a break in production.

5.4.1 Figures showing the increase in Rework Rate

Rate of rework per day was increased from 1.19% to 2.60% making an average daily increase in rework from 4 to 9 heavy duty cores (refer Figure 14).

The figures are obtained by comparing the average values of the period between 21st March 2012 to 17th June 2012 (period after introduction of standardised work) and the period between 18th June 2012 to 26th June 2012 (period after a break in production).

Rework Rate of Core Shop HD Flow Line

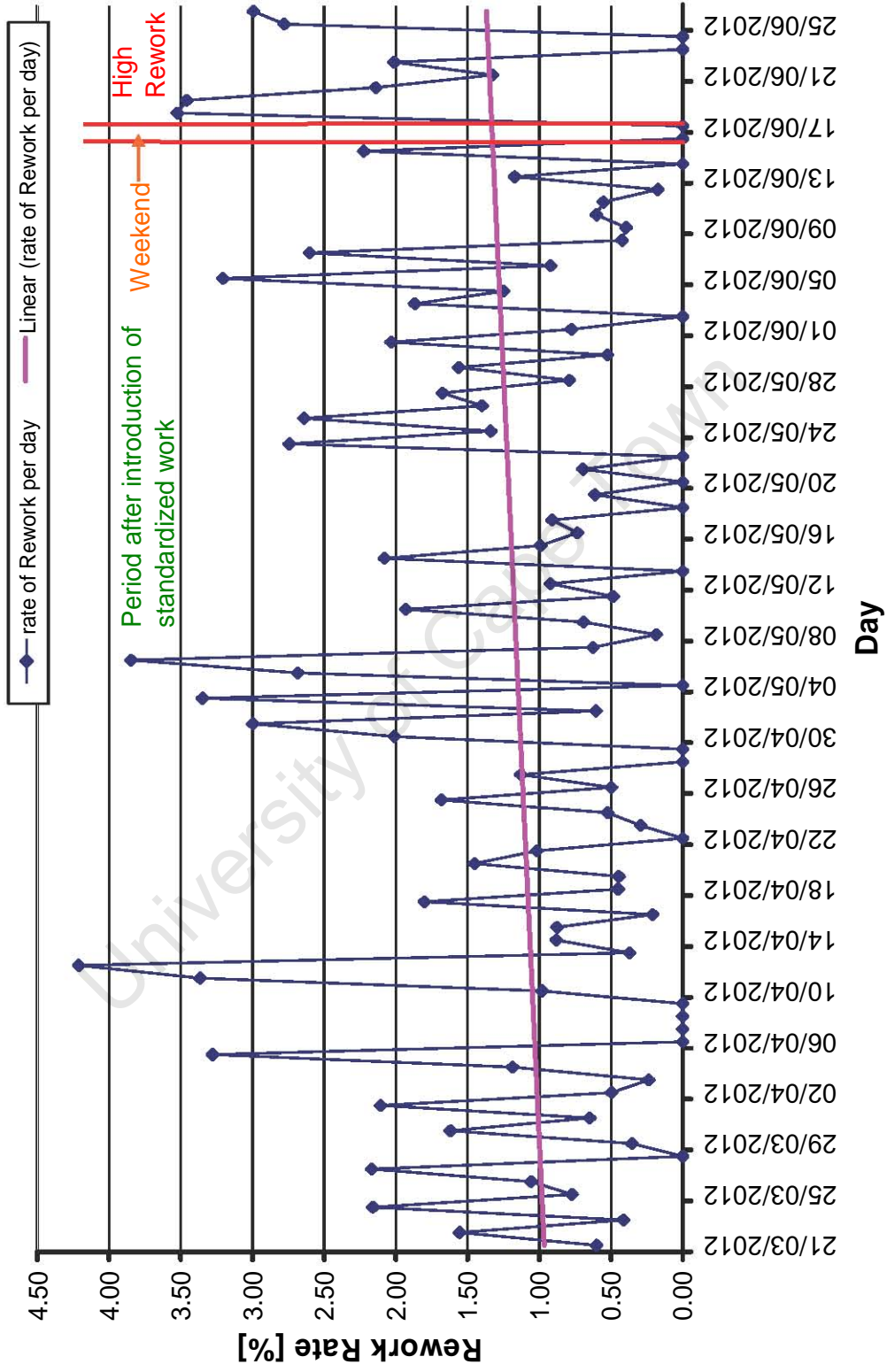


Figure 14: Chart showing the Rework Rate from 21st March to 26th June 2012.

5.4.2 A3 Practical Problem Solving Report

A3 Practical problem solving report (PPS) was used for solving the problem (refer Figure 15).


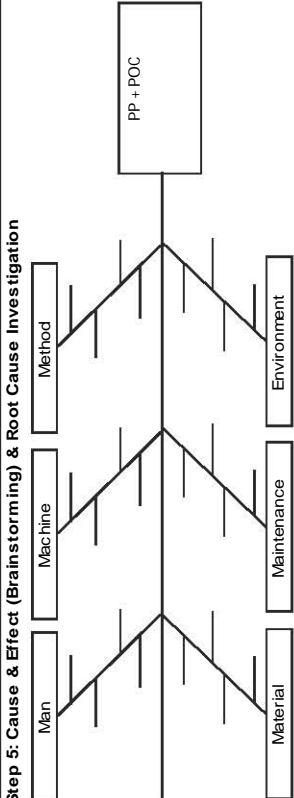
 <p>ATLANTIS FOUNDRIES A Product Center of Mercedes-Benz Trucks</p>	<h2 style="margin: 0;">A3 Practical Problem Solving Report</h2>	Project Leader Manager Senior Manager	Date Reference																														
<p>Step 1: Initial Problem Perception</p> <p>Team Members</p>																																	
<p>Step 2: Problem Identification (Size and Scope)</p> <p>Prioritised Problem (PP)</p>																																	
<p>Step 3: Locate the Point of Cause</p> <p>Point of Cause (POC)</p>																																	
<p>Step 4: Goal Setting (Set target(s) to take care of Prioritised Problem at Point of Cause)</p> <table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th>No</th> <th>Progress</th> <th>Activity Identified</th> <th>Activity in Place</th> <th>Activity Confirmed</th> <th>Activity Effective</th> </tr> </thead> <tbody> <tr> <td></td> <td><input type="checkbox"/></td> <td></td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> </tr> <tr> <td></td> <td><input type="checkbox"/></td> <td></td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> </tr> <tr> <td></td> <td><input type="checkbox"/></td> <td></td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> </tr> <tr> <td></td> <td><input type="checkbox"/></td> <td></td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> </tr> </tbody> </table>				No	Progress	Activity Identified	Activity in Place	Activity Confirmed	Activity Effective		<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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<p>Step 5: Cause & Effect (Brainstorming) & Root Cause Investigation</p> <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>Man Machine Method</p>  </div> <div style="width: 45%;"> <p>Material Maintenance Environment</p> <p>5 Why Investigation</p> <p>Why? Why? Why? Why? Why?</p> </div> </div> <p>Cause Investigation</p> <p>Direct Cause Potential/Direct Cause Ok - Not related to this problem</p> <p> <input type="checkbox"/> Direct Cause <input type="checkbox"/> Potential/Direct Cause <input type="checkbox"/> Ok - Not related to this problem </p> <table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th>Item</th> <th>Investigation Method</th> <th>Result</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> </tbody> </table>				Item	Investigation Method	Result																											
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<p>Step 6: Countermeasure Action Plan</p> <table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th>Serial/Part#</th> <th>Who</th> <th>When</th> <th>Status</th> </tr> </thead> <tbody> <tr> <td> </td> <td> </td> <td> </td> <td><input type="checkbox"/></td> </tr> <tr> <td> </td> <td> </td> <td> </td> <td><input type="checkbox"/></td> </tr> <tr> <td> </td> <td> </td> <td> </td> <td><input type="checkbox"/></td> </tr> <tr> <td> </td> <td> </td> <td> </td> <td><input type="checkbox"/></td> </tr> </tbody> </table>				Serial/Part#	Who	When	Status				<input type="checkbox"/>				<input type="checkbox"/>				<input type="checkbox"/>				<input type="checkbox"/>										
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<p>Step 7: Follow-Up and Check Results</p>																																	
<p>Step 8: Standardize and Share Success (Yokoten)</p>																																	

Figure 15: A3 Practical Problem Solving Report

5.4.3 Analysis with A3 Practical Problem Solving Report (PPS)

Step 1: Initial Problem Perception

Increasing rework rate for the heavy duty cores.

Team Members

Project leader, core shop manager, core shop engineer and all general foreman of core shop heavy duty flow line.

Step 2: Problem Identification

Figure 16 shows the rate of rework per day for heavy duty cores from 18th June 2012 to 26th June 2012. The rework rate is zero on 23rd and 24th June as there was no production, as the company strategize to stop weekend production for three months from 16th June 2012 onwards. The period from 18th June to 26th June 2012 was chosen for analysing the increase in rework rate occurred after the break in production. On analysis, the average rate of rework after break in production was found to be 2.60% (indicated by red line in Figure 16) which was 0.75% higher than the target value of 1.85% (indicated by green line in Figure 16).

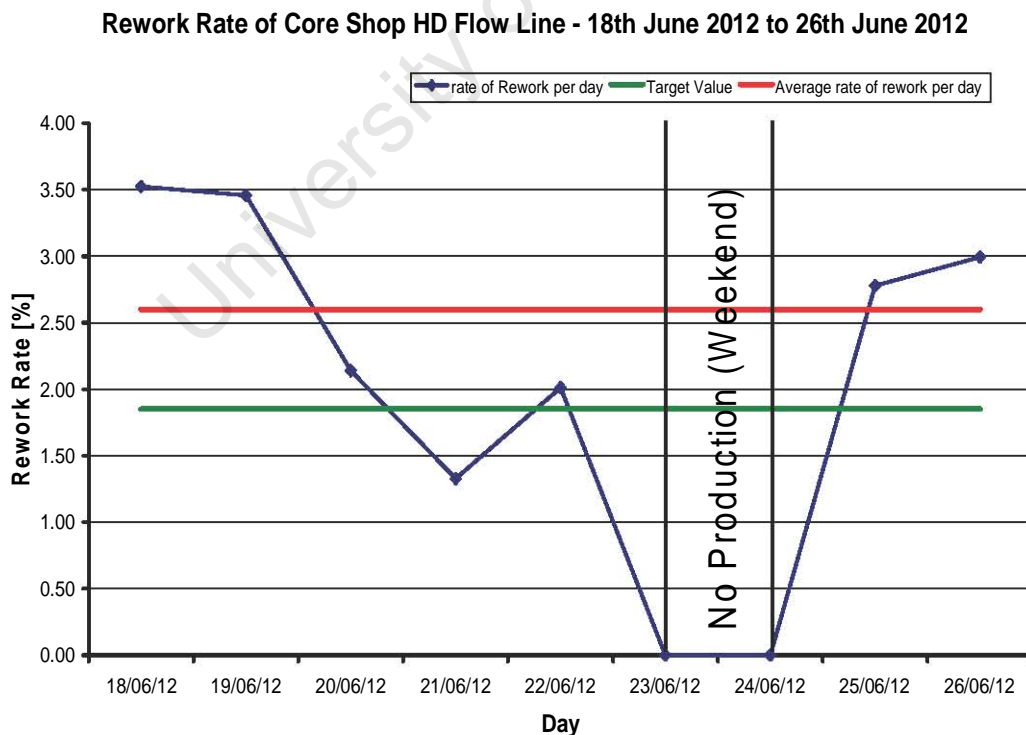


Figure 16: Chart showing the Rework Rate of heavy duty cores from 18th June 2012 to 26th June 2012.

For analysing the problem further, it is necessary to find out the reasons for rework. The major reasons for rework are:

- Loose tie rods – 471 EPA 10, 472 EPA 10
- Sand blown off on package – 471 EPA 10, 472 EPA 10
- Porosity on core – 471 EPA 10, 472 EPA 10
- Damage – 471 EPA 10, 472 EPA 10
- Cracked water rail - 471 EPA 10, 472 EPA 10
- Cracked 6 Port - 471 EPA 10, 472 EPA 10
- Cracked 2 Port - 471 EPA 10, 472 EPA 10
- Cracked 3 Port - 471 EPA 10, 472 EPA 10
- Damaged bypass core – 471 EPA 10, 472 EPA 10

Since 471 EPA 10 is the major product manufactured on core shop heavy duty flow line, reduction of rework was targeted towards 471 EPA 10. Once the major reasons for rework of 471 EPA 10 is known, it is essential to diagnose the problem based on the current major contributors. The current major contributors of rework were known by collecting the rework figures based on the above reasons, followed by plotting them on a Pareto chart (refer Figure 17).

471 EPA 10 - Rework Pareto Chart - 18th June 2012 to 26th June 2012

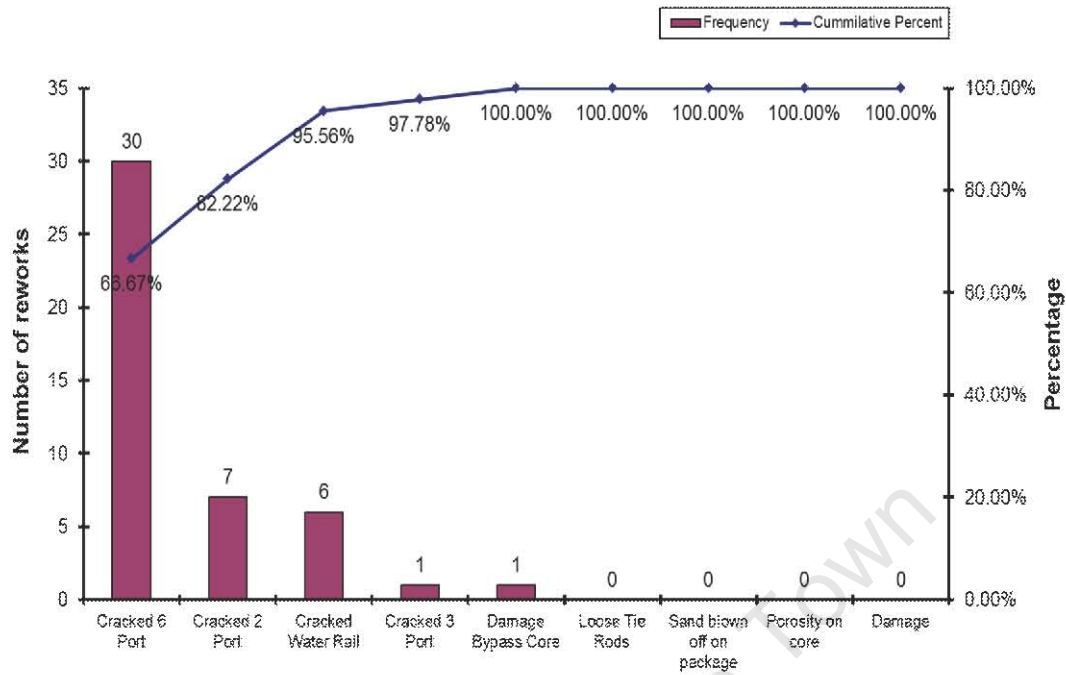


Figure 17: Pareto chart showing reasons for Rework from 18th June 2012 to 26th June 2012.

From the Pareto in Figure 17, it is evident that cracked 6 Port is the major reason for rework as it constitutes 67% of the total rework occurred to 471 EPA 10. Knowing this, it's necessary to diagnose the problem based on grid reference for identifying the exact point of occurrence. Rework figures of cracked 6 Port was thus collected based on grid reference and was drawn on a Pareto chart (refer Figure 18).

471 EPA 10 - Cracked 6 Port Grid - 18th June 2012 to 26th June 2012

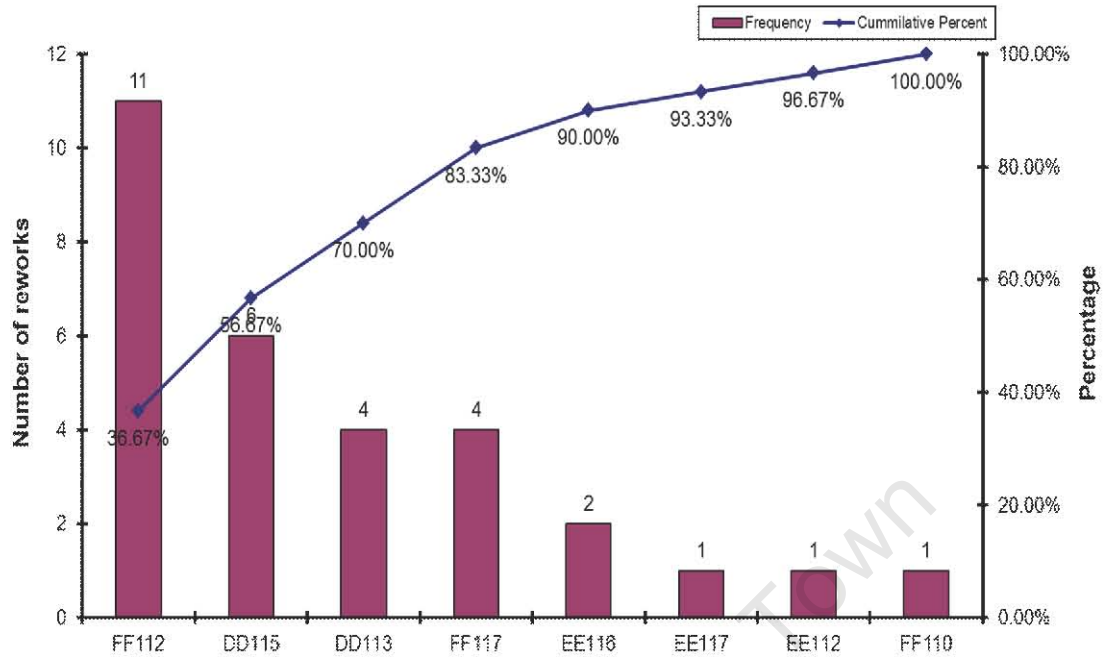


Figure 18: Pareto chart indicating Cracked 6 Port Grid Reference

From the Pareto in Figure 18, it is evident that grid reference FF112, DD115, DD113 and FF117 are the major areas where 6 Port is being cracked as these four constitute 83% of the total rework caused by 6 Port.

For analysing the problem at grid reference FF112, DD115, DD113 and FF117 different PPS must be used as point of cause of the problem varies with grids. Here the point of cause of cracked 6 Port at grid reference FF112 and FF117 were found same. Therefore FF112 and FF117 were solved together on a PPS. Hence, the prioritized problem is 471 EPA 10 cracked 6 Port at grid reference FF112 & FF117 (refer Figure 20).

For locating the grids, grid reference is shown in Figure 19.

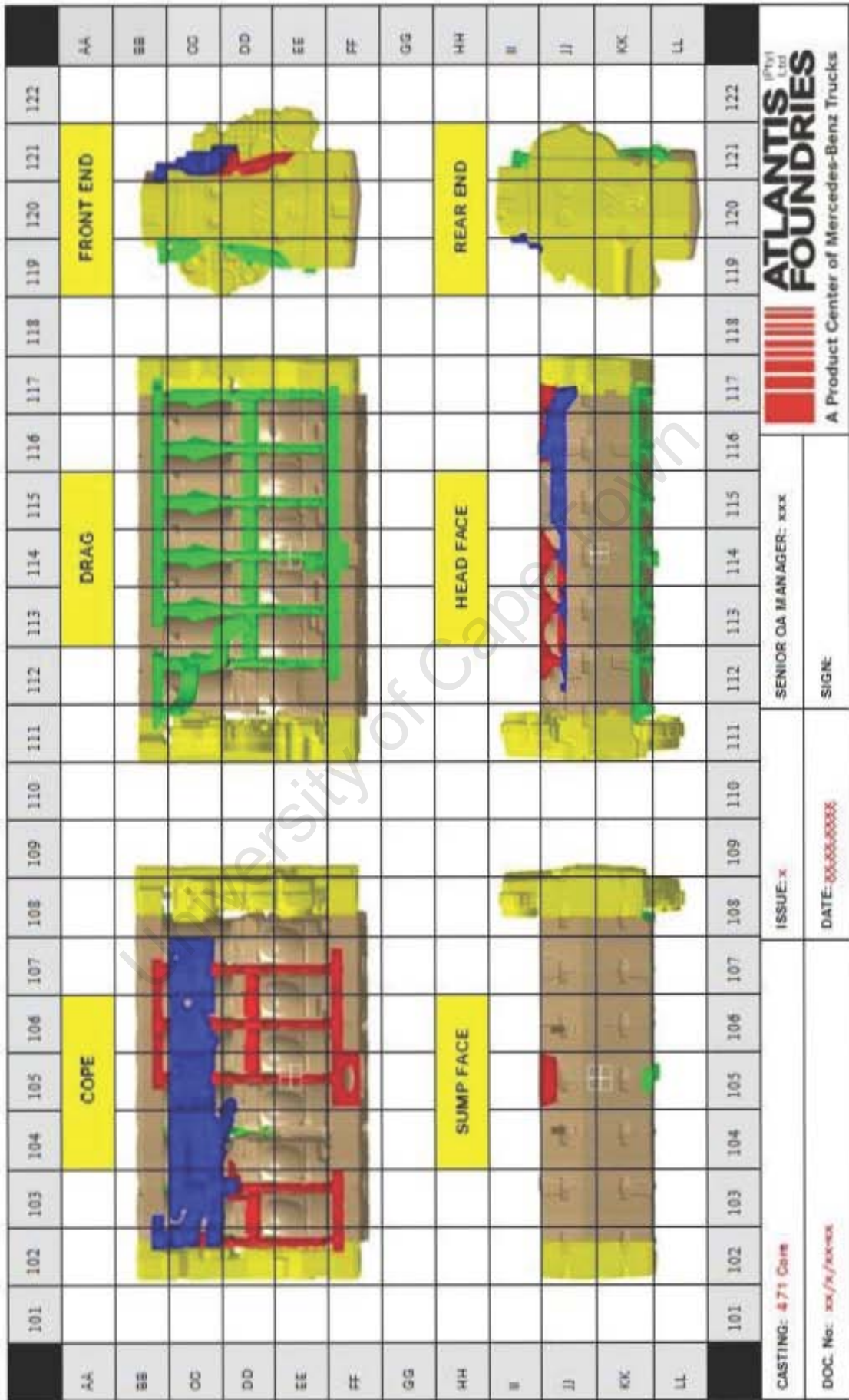


Figure 19: Grid Reference of 471 EPA 10

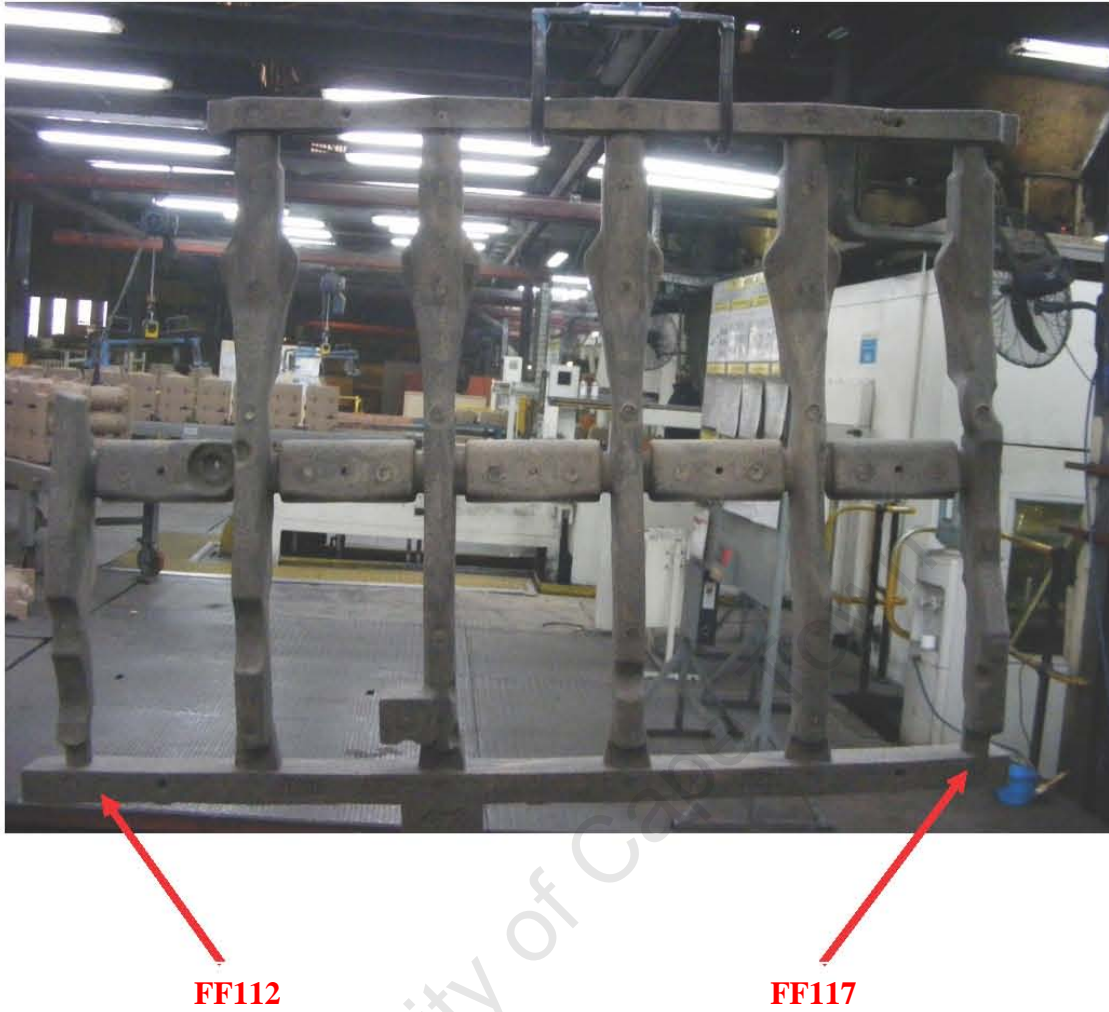


Figure 20: Location of Grid Reference FF112 & FF117 on 6 Port.

Prioritised Problem: 471 EPA 10 cracked 6 Port at grid reference FF112 & FF117.

Step 3: Locate the Point of Cause

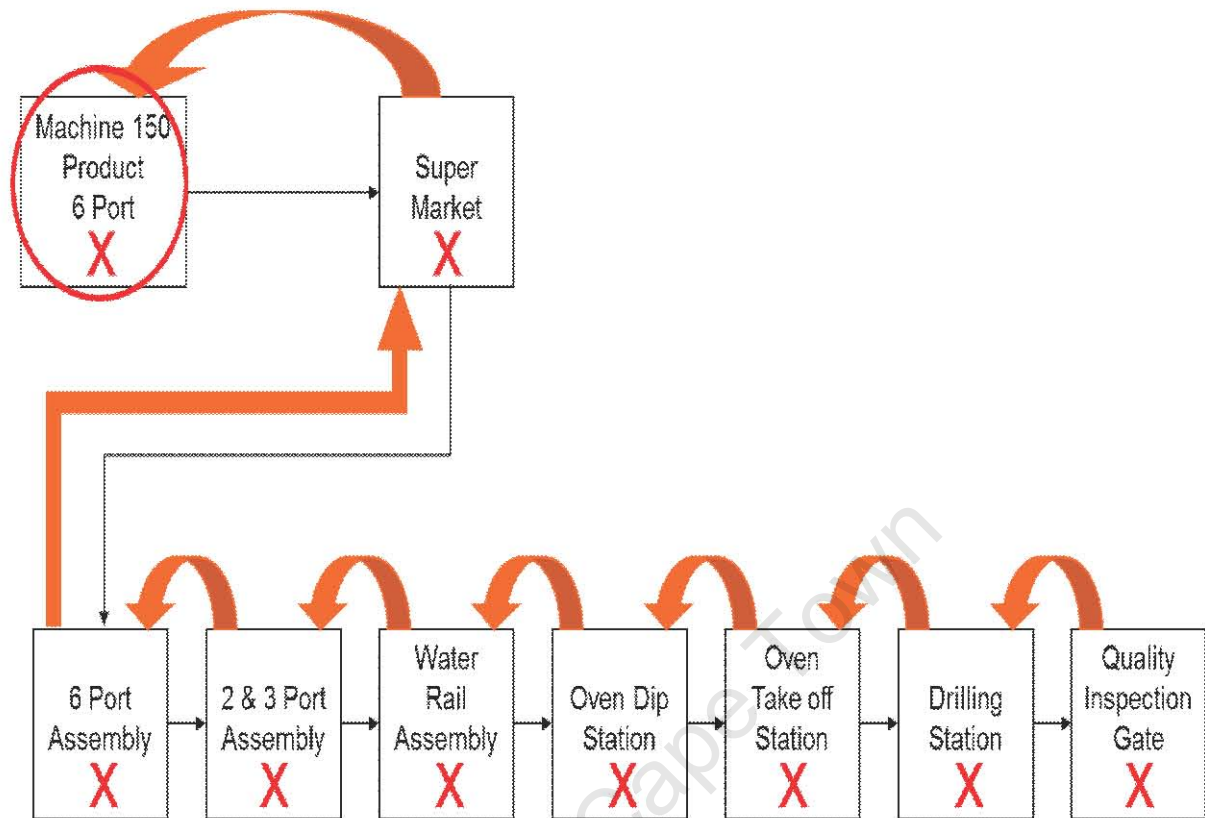


Figure 21: Point of Cause

Figure 21 indicates the flow of 6 Port from Machine 150 to the quality inspection gate. 6 Port's manufactured at Machine 150 are stored at the super market, before arrival at the 6 Port assembly station. 6 Port assembly station, assembles 6 Port to the semi-finished heavy duty core coming through the heavy duty flow line. 2 & 3 Port assembly station assembles 2 Port and 3 Port respectively and water rail assembly station assembles water rail to the semi-finished heavy duty core. At the oven dip station the heavy duty core is dipped in paint and is transported into the oven for baking. The baked heavy duty core is taken off from the oven at the oven take off station and it moves to the drilling station where the core is drilled to allow gases to escape. The drilled heavy duty core then moves to the quality inspection gate where the quality of heavy duty core is inspected before transporting to the moulding line.

471 EPA 10 cracked 6 Port at grid reference FF112 & FF117 was first detected at quality inspection gate. Therefore, the point of detection (indicated by red coloured cross in Figure 21) was quality inspection gate. For locating the point of

cause, check sheets were provided to operators at all stations starting from back to front (from drilling station till Machine 150). On analysis of check sheets, cracked 6 Port was detected from drilling station till Machine 150 (indicated by red coloured cross in Figure 21) and the point of cause was Machine 150, the 6 Port manufacturing machine. Therefore, the point of cause was due to Machine 150 (refer Figure 22) at grid reference FF112 and FF117.

Point of Cause: Machine 150 at grid reference FF112 and FF117.

Table 56: Containment action plan

Containment Action Plan	Serial/ Part#	Who	When	Status
Adjust upper bars and lower ejectors (refer Figure 23 and 24)	471 EPA10	General Foreman	27/06/2012	Activity effective
Lubricating top and bottom of tooling (refer Figure 26 and 27)	471 EPA10	General Foreman	27/06/2012	Activity effective
Introducing lifting hook (refer Figure 28)	471 EPA10	General Foreman	27/06/2012	Activity effective
Tool change dowl and fork (refer Figure 29 and 30)	471 EPA10	General Foreman	27/06/2012	Activity effective
Cent percent inspection of stock	471 EPA10	Core Shop Engineer	27/06/2012	Activity effective



Figure 22: Machine 150 Overview



Figure 23: Upper Bars in Machine 150



Figure 24: Lower Ejectors



Figure 25: Lower Ejectors holding 6 Port



Figure 26: Lubricating Top of Tooling



Figure 27: Lubricating Bottom of Tooling



Figure 28: Lifting Hook holding 6 Port



Figure 29: Dowl inside Machine 150



Figure 30: Fork

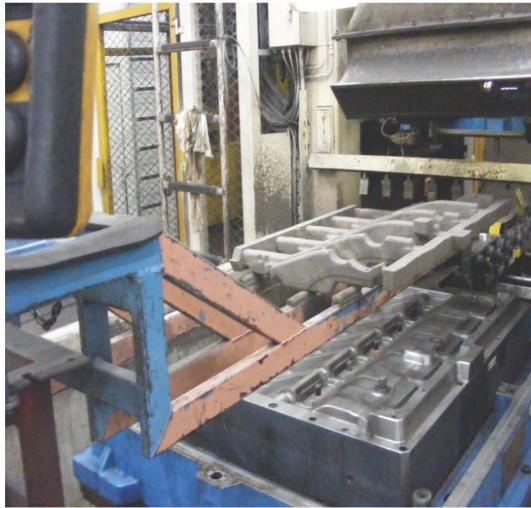


Figure 31: Fork holding 6 Port

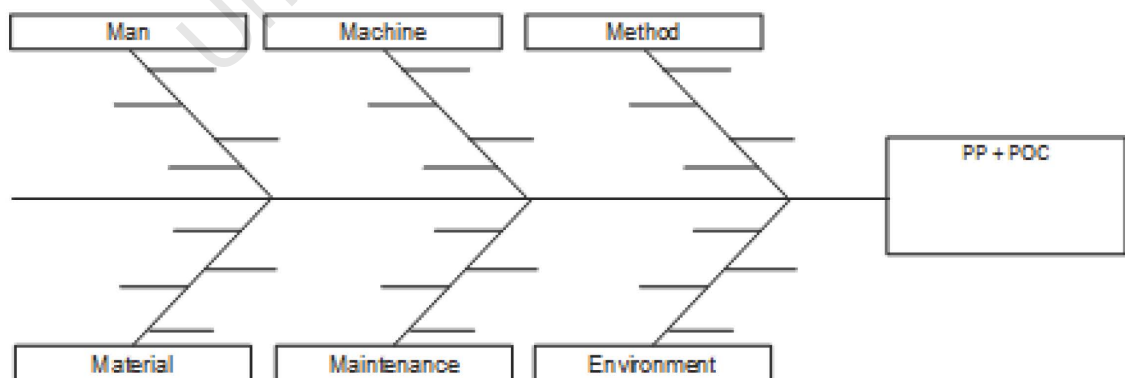


Figure 32: Stripping Mechanism

Step 4: Goal Setting

From the Pareto chart in step 2 (refer Figure 18), it is clear that rework at grid reference FF112 and FF117 constitutes 50% (15 reworks out of total 30 reworks) of the total reworks due to cracked 6 Port. Therefore, if rework at FF112 and FF117 are eliminated, it reduces the rework due to cracked 6 Port by 33.5% thereby reducing the total rework of heavy duty cores from 2.6% to 1.73% which is 0.12% lesser than the target value of 1.85%.

Step 5: Cause & Effect and Root Cause Investigation



- Cause Investigation
- X Direct Cause
 - ▲ Potential Direct Cause
 - Ok - Not related to this problem

Figure 33: Fishbone diagram

In the fish bone diagram in Figure 33, Prioritised Problem (PP) at the Point of Cause (POC) is cracked 6 Port at Machine 150, grid reference FF112 and FF117. Therefore PP + POC refer to cracked 6 Port at grid reference FF112 & FF117 + Machine 150 at grid reference FF112 and FF117.

In order to solve the prioritised problem at the point of cause (PP + POC), factors related to man, machine, method, material, maintenance and environment were brainstormed. Each of the factors brainstormed were investigated based on the three cause investigation parameters; direct cause, potential direct cause and not related to this problem. The factors brainstormed and investigation results are discussed below.

Man

- Handling 6 Port – Not related to this problem
- Pick up from machine - Not related to this problem
- Training – Not related to this problem

Machine

- Hard pieces in blow hood - Not related to this problem
- Stripping mechanism (refers to opening and closing of tooling, refer Figure 32) - Potential direct cause
- Ejection - Direct cause
- Settings - Not related to this problem
- Lubrication - Potential direct cause
- Porosity - Not related to this problem
- Fork speed - Potential direct cause
- Dowl - Potential direct cause

Method

- Tooling clean - Not related to this problem
- Transportation - Not related to this problem

Material

- Bench life of sand - Not related to this problem
- Viscosity of resin mix - Not related to this problem

Maintenance

- Deep cleaning of tooling - Not related to this problem
- Diaphragms - Not related to this problem
- Total productive maintenance - Potential direct cause
- Blow chamber - Not related to this problem

Environment

- Climate, seasonal change - Not related to this problem

Cause Investigation

Among the factors investigated, those factors which were found as potential direct cause and direct cause were taken for cause investigation.

For cause investigation, the team visually inspected each of the factors. After visual inspection, each factors were further analysed based on the three cause investigation parameters; direct cause, potential direct cause and not related to this problem. Further analysis of the factors and results are shown in Table 57.

Table 57: Cause investigation

Item	Investigation Method	Result
Stripping mechanism (refer Figure 32)	Visually inspected	Potential direct cause
Ejection (refer Figure 24, 25)	Visually inspected	Direct cause
Lubrication (refer Figure 26)	Visually inspected	Potential direct cause
Fork speed (refer Figure 31)	Visually inspected	Potential direct cause
Dowl (refer Figure 29)	Visually inspected	Potential direct cause
Total productive maintenance	Visually inspected	Potential direct cause

From Table 57, it's clear that after visual inspection, ejection was identified as the direct cause.

Direct Cause: Top ejection of Machine 150.

5 Why Investigation

Problem: Top ejection of Machine 150.

Why? Upper bar setting is incorrect.

Because: Bushes are worn.

Why? Bushes are worn.

Because: There is no frequent checking or maintenance method.

Why? There is no frequent checking or maintenance method.

Because: There is no standardised process.

Why? There is no standardised process.

Because: It is not included in TPM activities.

Why? It is not included in TPM activities.

Because: Problem never occurred when TPM documentation was formulated.

Root Cause: No Total Productive Maintenance (TPM) Check in place.

Table 58: Step 6: Countermeasure Action Plan

Countermeasure Action Plan	Serial/ Part#	Who	When	Status
Upper bar setting to be checked after every change over	471 EPA 10	Core Shop Manager	05/07/12	Activity effective
Add check to TPM activities	471 EPA 10	Core Shop Manager	09/07/12	Activity effective

Step 7: Follow-Up and Check Results

After the containment and countermeasure action plans, rate of rework per day was reduced from 2.60% to 1.15% making an average daily reduction in rework from 9 to 4 heavy duty cores (refer Figure 34).

The figures are obtained by comparing the average values of the period between 18th June 2012 to 26th June 2012 (problem identification period) and the period between 27th June 2012 to 15th July 2012 (problem solving period).

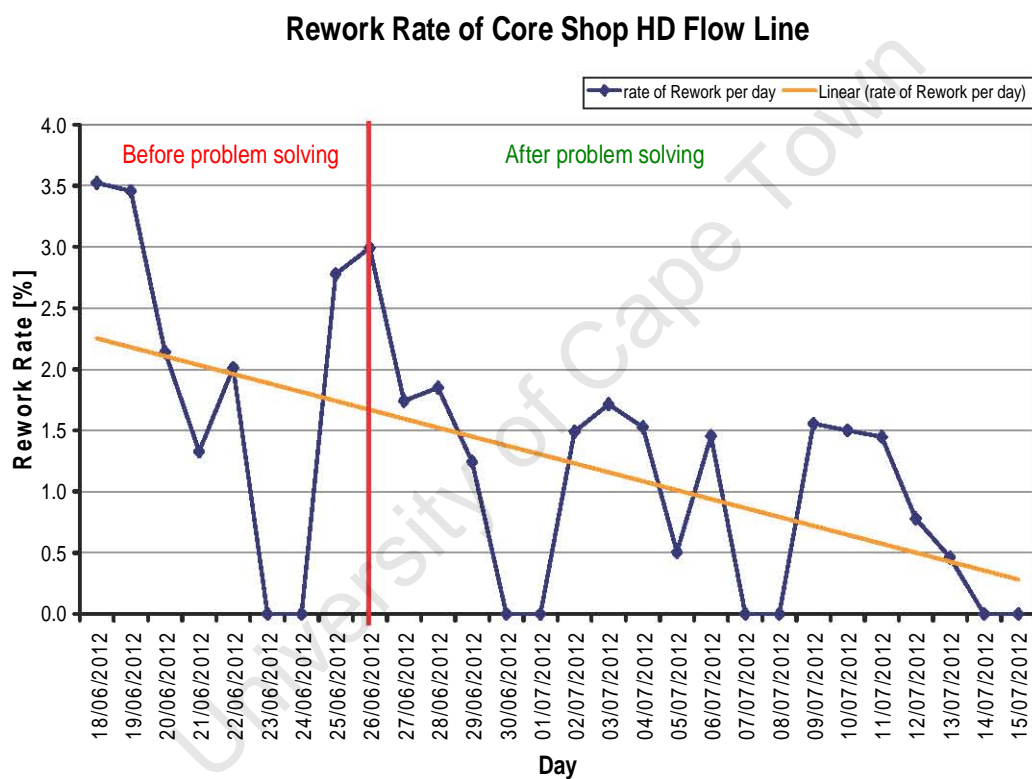


Figure 34: Chart showing the reduction in Rework Rate from 18th June 2012 to 15th July 2012.

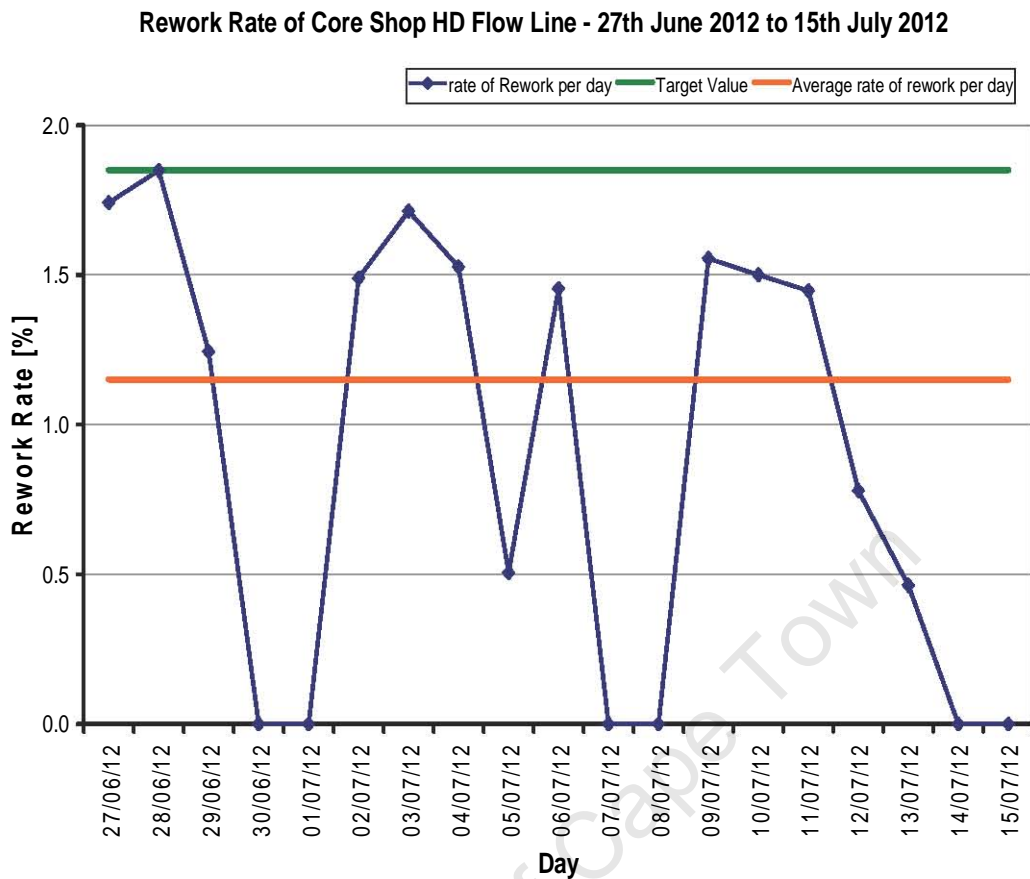


Figure 35: Chart showing the Rework rate of core shop heavy duty cores from 27th June to 15th July 2012.

Figure 35 shows the rate of rework per day for heavy duty cores from 27th June 2012 to 15th July 2012. On analysis, the average rate of rework from 27th June to 15th July was found to be 1.15% (indicated by orange line in Figure 35) which was 0.70% lesser than the target value of 1.85% (indicated by green line in Figure 35).

Step 8: Standardise and Share Success

Checking of upper bar setting after every change over was included in change over procedures. Moreover, check was also included into TPM activities. Thereby, the process was standardised.

The problem solved with PPS was shared with other departments within the company.

5.5 Summary of the results

The introduction of standardized work with the generation of standard work instruction, job element sheet, skills training matrix and layered process audits help to reduce scrap rate, reduce rework rate and to increase production (refer Table 59). The scrap rate per day was reduced from 1.04% to 0.67% making an average daily reduction in scrap from 4 to 2 heavy duty cores (refer Figure 12) and the rework rate per day was reduced from 2.07% to 1.19% making an average daily reduction in rework from 8 to 4 heavy duty cores (refer Figure 13). Average weekday production of heavy duty cores were increased from 1981 to 2130 making an average daily increase in production from 396 to 426 cores. Operating shifts required per week for meeting the required weekly target was reduced from 21 to 20 shifts.

Table 59: Core shop figures after the introduction of standardized work

Name	Target value	Before introduction of standardised work	After introduction of standardised work	Inference
Scrap rate in core shop per day	0.9%	1.04%	0.67%	Reduction in scrap rate
Rework rate in core shop per day	1.85%	2.07%	1.19%	Reduction in rework rate
Cores produced in core shop per day	550	396	426	Increase in production
Shifts required per week	15	21	20	Reduction in working shifts

During the introduction of standardised work, transportation waste was identified at Machine 120, the water rail manufacturing machine. Therefore, layout of

Machine 120 was modified and thereby transportation waste was reduced. Transportation waste was identified at Machine 150, the 6 Port manufacturing machine. Hence trolley concept was introduced at Machine 150 and manufactured 6 Port's were transported to 6 Port assembly station by means of fork lift trucks, thereby reducing unwanted movement of 6 Port station operator.

As acceptance and rejection of standardised work by employees is a major area of concern, it was essential to diagnose the employee behaviour. 17 questions were formulated on questionnaire for the analysis of employee behaviour. On analysis, it was known that employees were satisfied with the introduction of standardised work (refer Table 25). Moreover, the 17 questions were analysed separately for specific results. Majority of the employees responded that they participated in the introduction of standardized work (refer Table 9) and they know the need of introducing lean techniques in the company (refer Table 10). The employees admit that standard work instructions were developed in consultation with them (refer Table 11) and they prefer to work based on standard work instruction over their previous instructions (refer Table 15). The employees were trained to work based on standard work instruction (refer Table 12) and were satisfied with the training procedure (refer Table 13). Standard work instruction made work easier for employees (refer Table 14); they were able to complete operations within takt time as displayed in standard work instruction (refer Table 16) and they were satisfied with the introduction of standard work instruction (refer Table 17). Job element sheet helped employees in the implementation of standard work instruction (refer Table 18) as it provided the significance of each work element (refer Table 19). The employees were satisfied with the job element sheet (refer Table 20). The employees admit that their commitment to the company increased with the introduction of standardized work and lean techniques (refer Table 24).

Personal development and training development of employees with the introduction of standardized work were analysed by means of 12 questions (10 closed questions and 2 open questions) on questionnaire. On analysis, it was known that the introduction of standardised work helped in the personal development of employees and employees were trained to work on more stations. Moreover, the 12 questions were analysed separately for specific results. Majority of the employees responded that the introduction of standardized work provided way for their personal growth and

development in the company (refer Table 28) and for the growth and development of their technical skills (refer Table 29). The employees like to work on more than one station (refer Table 30) and were given training to work on more than one station (refer Table 31). The employees were trained to work on two or more stations (refer Table 33) and a major portion of them were trained to work on five or more stations (refer Table 34). Majority of the employees are able to train other/ new employees to work on two or more stations (refer Table 35) and a considerable portion are able to train employees to work on five or more stations (refer Table 36). The employees admit that their training procedures have improved with the introduction of standardized work and are satisfied with the generation of skills training matrix (refer Table 37).

Two open questions were used to analyse the positives and negatives of employees with the introduction of standardized work. Employees do not provide any negatives for the introduction of standardised work. Employees admit that standard work instruction made work easier, faster and more productive. Standard work instruction is easy to understand; it increased product quality and simplified work. Moreover, the employees admit that there is better work flow and takt time with the introduction of standard work instructions.

Structuring of work environment (5S) by employees were analysed by means of five questions on questionnaire. On analysis, it was known that the employees structure their work environment. Moreover, the five questions were analysed separately for specific results. Majority of employees responded that they sort (refer Table 40), stabilize (refer Table 41) and clean (refer Table 42) their work environment. The work practices are standardized (refer Table 43) and the employees sustain the practice of structuring the work environment (refer Table 44).

Existence of the seven wastes were analysed by means of seven questions on questionnaire. On analysis, it was known that the existence of seven wastes were less. Even though, the existences of the seven wastes were less, wastes were identified at stations. Transportation with respect to timing chain insert, rubber air pipe and tie rods were identified at Machine 100. Existence of buffer stock with respect to end core, 2 Port, 3 Port and 6 Port were identified. Waiting for sand was identified at Machine 100, 120, 350, 135, 140, 150, 365 and 320. Moreover, waiting for fork lift trucks was identified at Machine 100, 120, 350, 150, 365, 320, assembly deck and

quality inspection gate. Excessive bending of operators was identified at Machine 150, 320, quality inspection gate, assembly deck and drilling station.

Rate of rework of heavy duty cores increased after a break in production. On analysis, the average rate of rework was found to be 2.60% which was 0.75% higher than the target value of 1.85% (refer Figure 14). A3 Practical problem solving report (PPS) was used for reducing the increase in rework rate (refer Figure 15). From the analysis, based on the reasons for rework on Pareto chart, it was known that 471 EPA 10 cracked 6 Port was the major reason for rework (refer Figure 17). On further analysis, it was found that grid reference FF112 and FF117 are the areas where the 6 Port is cracked (refer Figure 18). For locating the point of cause, check sheets were provided to operators at all 6 Port flowing stations starting from the 6 Port manufacturing machine. It was found that the point of cause was at Machine 150, 471 EPA 10 grid reference FF112 and FF117 (refer Figure 19).

On locating the point of cause, containment actions like adjusting upper bars (refer Figure 23) and lower ejectors (refer Figure 24), lubricating top and bottom of tooling (refer Figure 26, 27), introducing lifting hook (refer Figure 28), tool change dowl (refer Figure 29) and fork (refer Figure 30) and cent percent inspection of stock were taken. After goal setting, factors related to man, machine, method, material, maintenance and environment were brainstormed and were investigated based on the three cause investigation parameters; direct cause, potential direct cause and not related to this problem. After investigation, top ejection of Machine 150 was found as the direct cause for cracked 6 Port at grid reference FF112 and FF117 at Machine 150. Five why investigation was done for locating the root cause of the problem. It was found that top ejection of Machine 150 was due to incorrect upper bar setting which was due to worn bushes of Machine 150. Moreover, there were no frequent checks for worn bushes as it was not included in TPM activities because the problem never occurred when TPM documentation was formulated. Therefore the root cause of the problem was found to be no total productive maintenance (TPM) check in place. As the root cause of the problem was identified, the checks for worn bushes of Machine 150 were included in change over procedures and total productive maintenance activities. After the countermeasure action plan, the average rate of rework was found to be 1.15% which was 0.70% lesser than the target value of 1.85% (refer Figure 34). The problem solved with PPS was shared with other departments within the company.

CHAPTER SIX

CONCLUSION

The research carries evidences that the introduction of standardized work helped to reduce scrap rate, reduce rework rate and to increase production. The employees were satisfied with the introduction of standardised work and the lean tools helped in the personal and training development of employees. Analysis of 5S led to the conclusion that the employees structure their work environment. The existence of the seven wastes at the core shop heavy duty flow line was found lesser. Root cause analysis of increased rework rate of heavy duty cores led to the conclusion that higher rework rate was due to the absence of TPM checks for worn bushes at Machine 150. Hence, the checks for worn bushes of Machine 150 were included in change over procedures and total productive maintenance activities.

The research suggests that lean tools like standard work instruction, job element sheet, skills training matrix and layered process audits need to be introduced at each department of the company as this result in reduced rework rate, reduced scrap rate and increased production. Standard work instructions need to be introduced for changeover as well as for total productive maintenance checks. Moreover, TPM checks must be done regularly at all stations of core shop heavy duty flow line.

Due to increased customer expectations and severe global competition, the automotive component manufacturing companies are desperately trying to improve productivity at lower cost and still retain excellent product and service quality. Under these circumstances, the implementation of lean principles improves the production environment with moderate investment. This research carries evidence of genuine advantages when applying lean principles to the manufacturing shop floor. Furthermore, the benefits of lean are evident from the reduced scrap rate, reduced rework rate and improved production output.

CHAPTER SEVEN

OUTLOOK

Lean tools like standard work instruction, job element sheet, skills training matrix and layered process audits need to be introduced at each department of the company as this results in reduced rework rate, reduced scrap rate and increased production.

Standard work instructions need to be introduced for changeover's as well as for total productive maintenance checks, as the current operating procedures are not standardised. TPM checks must be done regularly at all stations of the core shop heavy duty flow line.

Fork lift trucks are currently used to transport core parts to assembly stations. Hence, operator's waiting for fork lift truck is identified at majority of the stations. Therefore, fork lift trucks need to be replaced by conveyers, thereby; waiting for fork lift trucks can be eliminated.

Sand drier currently used is only capable of drying 10 tonnes of sand in an hour but the actual requirement of sand is 12 tonnes per hour. Therefore, the sand drier need to be replaced by an efficient drier capable of meeting demand and thus waiting for sand can be eliminated.

Existence of higher amount of buffer stock of front/ rear end cores, 2 Port's, 3 Port's and 6 Port's must be reduced as this is a major inventory waste. Transportation waste at Machine 100 with respect to timing chain insert, rubber air pipe and tie rods must be eliminated. Current Howden oven must be replaced by a small and efficient oven. Thereby excessive waiting in front of oven can also be reduced.

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APPENDIX A

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University of Cape Town

A.1 Questionnaire for analysis of employee behaviour, personal and training development, 5S and the seven wastes



ANALYSIS OF EMPLOYEE BEHAVIOUR, PERSONAL AND TRAINING DEVELOPMENT, 5S AND THE SEVEN WASTES

Biographical Information

Gender	Male	Female
---------------	------	--------

Age	Below 25yrs	25 -35yrs	36- 50yrs	above 50yrs
------------	-------------	-----------	-----------	-------------

Educational qualification	Below Matric	Matric	Diploma	B.Sc.	M.Sc.	Ph.D.
----------------------------------	--------------	--------	---------	-------	-------	-------

Designation	Operator	Senior Operator	Team Leader	General Foreman	Engineer	Manager	Senior Manager
--------------------	----------	-----------------	-------------	-----------------	----------	---------	----------------

Length of Employment at Atlantis Foundries	0- 2 yrs	3-5yrs	6-10yrs	11-15yrs	16-20yrs	Above 20yrs
---	----------	--------	---------	----------	----------	-------------

Machine/ Station operator currently operating	
--	--

Date		Current Shift	A	B	C	M	A	N
-------------	--	----------------------	---	---	---	---	---	---

A) Lean Tools and Employee Behavior

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1) I understand what is meant by lean and participated actively in its implementation					
2) I understand the need to implement lean techniques in the foundry					
3) Standard Work Instruction was developed together with employees					
4) I was being trained to work on the basis of Standard Work Instruction					
5) I am satisfied with the training procedure					
6) Standard work instruction made my work easier					
7) I would prefer to work based on standard work instruction over previous instructions					
8) I am able to complete my operation within takt time as displayed in SWI					
If not, reasons for not being able to complete operations within takt time					

9) Overall I am satisfied with the new procedure					
10) Job element sheet helped in implementation of standard work instruction					
11) Job element sheet provided the significance of each work element					
12) I am satisfied with the information provided in Job Element sheet					
13) 5 Cycle Check Observation form help in the validation of standardized work					
14) 5 Cycle Check Observation form helps to convey my concern related to work sequence, safety, quality, equipment/ tools and workplace design to my supervisor					
15) I am satisfied with the implementation of 5 cycle check observation form					
16) My commitment to the organization increased with lean implementation					
17) Overall, I am satisfied with the changes and lean implementation					

B) Personal and Training Development

18) Lean implementation provided way for my personal growth and development in company					
19) Lean implementation provided way to growth and development of my technical skills					
20) I would like to work on more than one station					
21) I was given training to work on more than one station					
22) After training I am able to work on new station without assistance					
23) I am trained to work on 2 or more stations					
24) I am trained to work on 5 or more stations					
25) I am able to train other employees to work on 2 or more stations					
26) I am able to train other employees to work on 5 or more stations					
27) Overall I am satisfied with the implementation of training matrix					

28) My positives from lean implementation and standardized work

29) My negatives from lean implementation and standardized work

C) Methodologies to Structure Work Environment

a) Sorting					
b) Stabilizing/ Straightening out					
c) Sweeping/ Shining					
d) Standardizing					
e) Sustaining					

D) Existence of 7 Wastes at Atlantis Foundries

a) Transportation					
Example					
b) Inventory					
Example					
c) Motion					
Example					
d) Waiting					
Example					
e) Over processing					
Example					
f) Over production					
Example					
g) Defects					
Example					

Your feedback is appreciated. Thank you

APPENDIX B



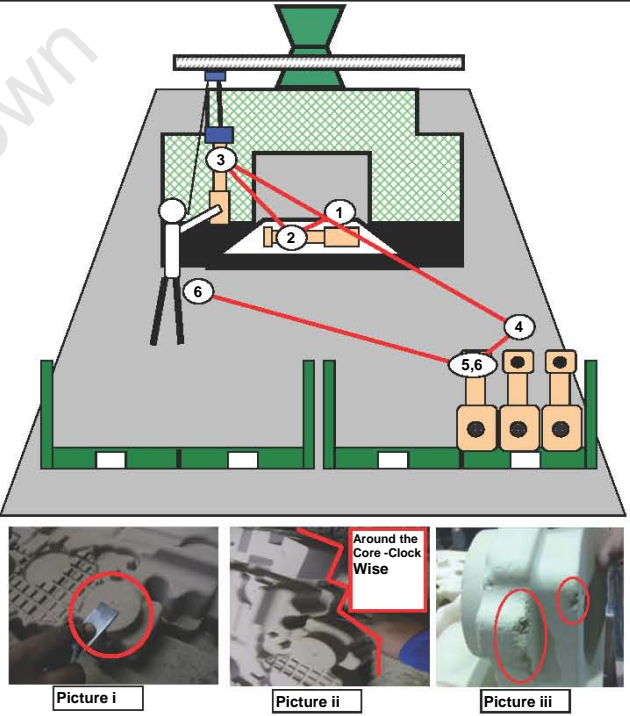
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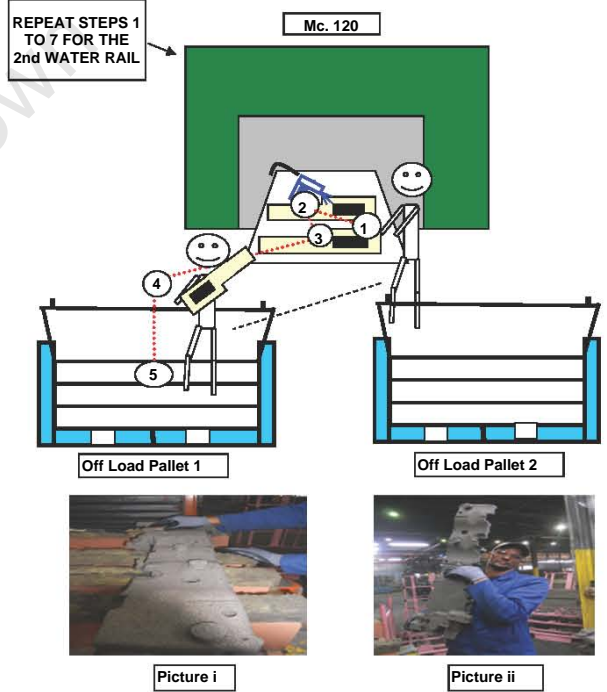
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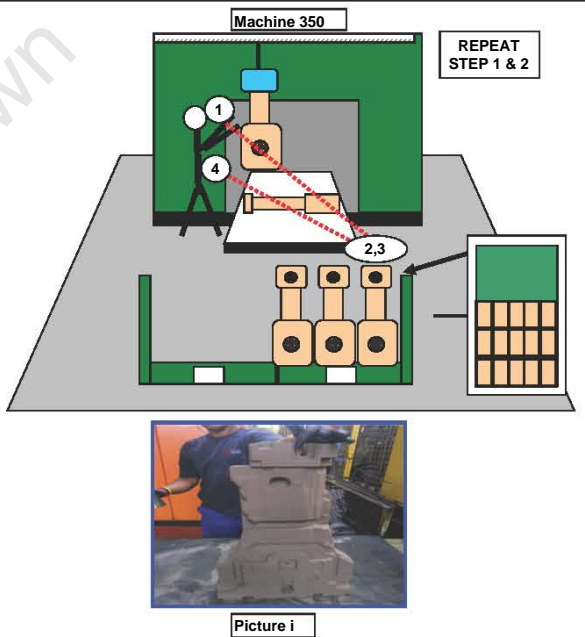
B.1 Standard Work Instruction of Machine 100

 Atlantis Foundries <small>A Product Center of Mammoet-Buss Trucks</small>		Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>				Rear End Core - Core Making							
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg.Cycle Time [min]				Base Model	SWI-No.	Rev. Date	Page (x / y)
Atlantis Foundries	Core Shop	14111	HD Line - Mc.100	471 / 472	1.62						SWI-CS-030-471/472-001	07/03/12	1 / 1
No.	Job Element ("Verb - Object ")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)				
					total	A	B	C					
1	Cleaning the End Core	Cleaning the End Core with a Steel Plate and remove all ejector marks on top of the Core (Q - Pic.j)	471 / 472		6		x						
2	Dressing the Sides E/C	Dressing the side of the End Core starting @ 3o'clock moving clockwise around the core & end @ starting point	471 / 472		18		x						
3	Off Loading of E/C from conveyor of Mc.	Take the crane & open fixture & hooks in the core, close fixture, lift crane.	471 / 472		13		x						
4	Push Button	Push the start button to let the conveyor go in.	471 / 472										
5	Off Loading of E/C	Move the Jig towards the Off loading pallets to stack the End Core.	471 / 472		21		x						
6	Set Core	Set the Core on pallet, Open Jig & Remove the Jig from the Core.	471 / 472				x						
7	Fix insert into E/C	Fix the Insert Core into the headbank of the Rear End Core	471 / 472		4	x							
8	Insert Tie Rods & Rubber Hose	Insert the Tie Rod and the Rubber Hose between the End Cores	471 / 472		21		x						
9	Waiting	Step back and wait for machine to complete the cycle	471 / 472				x						
10													
11	Cleaning Schedule												
12	1	Stop Machine after every 20 Blows	471 / 472										
13	2	Insert safety bars onto machine.	471 / 472										
14	3	Clean Joint Lines of the Core Box	471 / 472										
15	4	Opens vents where needed	471 / 472										
16	5	Clean Core Box with a Copper Plate	471 / 472										
17	6	Apply Redwax Crayon if needed	471 / 472										
18	7	Apply Release agent.	471 / 472										
19	7	Remove the Safety Bars from the Machine	471 / 472										
20	8	Restart Machine	471 / 472										
21	9	Book into Shopware	471 / 472										
22													
23													
24													
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks											
Mark the appropriate time type with "X":		Assembly: A/B/C =Value added / Non value added but necessary / Non value added			Max / Min-Time due to variants:						Safety Equipment:		
		Machining: A/B/C = Manual work time / Auto cycle time / Walk time									Reference Material		
Created by (Name & Date)		Production Approval (Name, Date)			Engineering Approval (Name, Date)								
		Foreman (A Shift):			Teamleader (A Shift):								
Version-No. (V47-AF)		Foreman (B Shift):			Teamleader (B Shift):								
V005		Foreman (C Shift):			Teamleader (C Shift):								



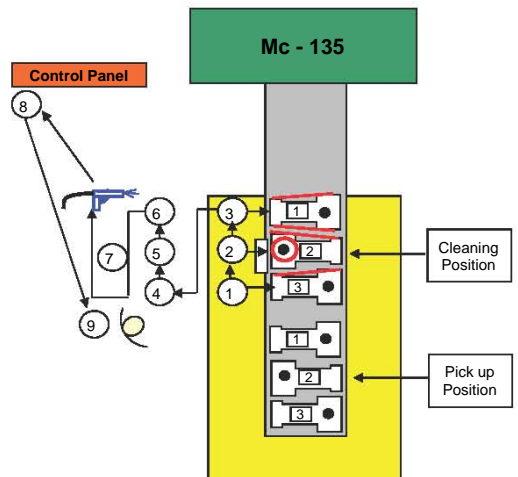
B.2 Standard Work Instruction of Machine 120

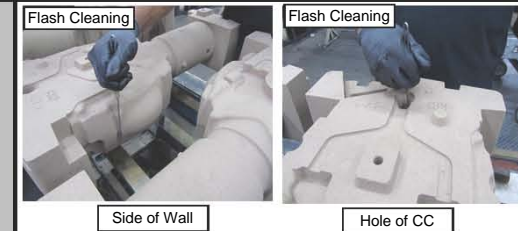
 Atlantis Foundries <small>A Product Center of Mercedes-Benz Trucks</small>		Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>				Water Rail - Core Making								
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg. Cycle Time [min]				Base Model	SWI-No.	Rev. Date	Page (x / y)	
Atlantis Foundries	Core Shop	14111	HD Line - Mc.120	471 / 472	1.62						SWI-CS-030-471/472-004	16/03/12	1 / 1	
No.	Job Element ("Verb - Object")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)					
					total	A	B	C						
1	Remove ejector marks of 1st W/R	Dress the core with a Filter and remove all the ejector marks on top of the first Water Rail core	471 / 472		15			x						
2	Remove ejector marks of 2st W/R	Dress the core with a Filter and remove all the ejector marks on top of the second Water Rail core	471 / 472		16			x						
3	Blow off sand	Take the Airgun and blow off all loose sand on the Water Rail Core.	471 / 472		6			x						
4	Flip W/Rail once 180°	Flip the Water Rail Core once at 180° (See H - Pic. i)	471 / 472		4			x						
5	Lift W/R from Fetcher	Lift the Core from the fetcher to take to Pallet	471 / 472		2			x						
6	Stacking on Pallets	Take the Water Rail Core to pallet and stack it (See H-Pic ii)	471 / 472		5			x						
7	Flip W/Rail once 180°	Flip the Water Rail Core once at 180° (See H - Pic. i)	471 / 472		4			x						
8	Lift W/R from Fetcher	Lift the Core from the fetcher to take to Pallet	471 / 472		2			x						
9	Stacking on Pallets	Take the Water Rail Core to pallet and stack it (See H-Pic ii)	471 / 472		5			x						
10	Waiting	Step back and wait for machine to complete the cycle	471 / 472						x					
11														
12														
13	Quality	Every 32 Blow	1. Stop Machine	471 / 472										
14			1. Clean Joint Lines of the Core Box	471 / 472										
15			2. Opens vents where needed	471 / 472										
16			3. Clean Core Box with a Copper Plate	471 / 472										
17			4. Apply Redwax Crayon if needed	471 / 472										
18			5. Apply Release agent.	471 / 472										
19			6. Restart Machine	471 / 472										
20			7. Book into Shopware	471 / 472										
21														
22														
23														
24														
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks												
Mark the appropriate time type with "X":		Assembly: A/B/C =Value added / Non value added but necessary / Non value added			Max / Min-Time due to variants:									
		Machining: A/B/C = Manual work time / Auto cycle time / Walk time												
Created by (Name & Date)		Production Approval (Name, Date)			Engineering Approval (Name, Date)				Reference Material					
		Foreman (A Shift):			Teamleader (A Shift):									
Version-No. (V47-AF)		Foreman (B Shift):			Teamleader (B Shift):									
V006		Foreman (C Shift):			Teamleader (C Shift):									

B.3 Standard Work Instruction of Machine 350



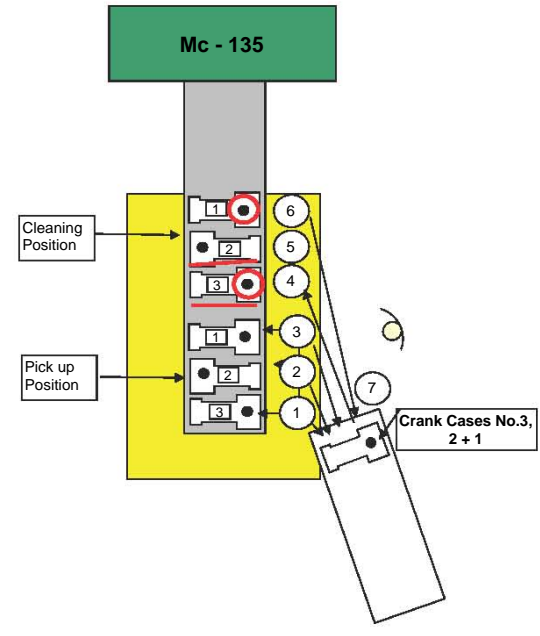


 Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>		Front End Core - Core Making								
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg.Cycle Time [min]	Base Model	SWI-No.	Rev. Date	Page (x / y)
Atlantis Foundries	Core Shop	14111	HD Line - Mc.350	471 / 472	1.62			SWI-CS-030-471.472-003	07/03/12	1 / 1
No.	Job Element ("Verb - Object ")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)	
					total	A	B	C		
1	Remove End Core No.1	Take the crane & open fixture & hook the first end core, close fixture, lift crane & move core to pallet to be stacked	471 / 472		25	x				
2	Remove End Core No.2	Take the crane & open fixture & hook the second end core, close fixture, lift crane & move core to pallet to be stacked	471 / 472		27	x				
3	Insert Tie Rod	Insert the Tie Rod into End Cores after each 8 has been stacked onto pallet	471 / 472		13		x			
4	Waiting	Step back and wait for the machine to complete cycle.	471 / 472				x			
5										
6										
7	Cleaning Cycle	Clean the Machine after every 40th blow								
8	1	Push the emergency stop button @ the Machine	471 / 472							
9	2	Open the Safety Gate .	471 / 472							
10	3	Insert the safety bars onto the machine	471 / 472							
11	4	Clean the Joint Lines of the Core Box.	471 / 472							
12	6	Clean the resin built up with a Copper Plate.	471 / 472							
13	6	Open the vents with vent cleaner where needed.	471 / 472							
14	7	Apply Red Wax Crayon were needed.	471 / 472							
15	8	Apply Release agent @ Core Box.	471 / 472							
16	9	Remove the Safety Bars from the Machine	471 / 472							
17	9	Close the Safety Gate.	471 / 472							
18	10	Restart the Machine	471 / 472							
19	11	Book into Shopware	471 / 472							
20								Important Tools Used, Auxiliary Material & Devices, Testing Equipment:		
21										
22										
23										
24										
Key to Symbols: S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks Mark the appropriate time type with "X": Assembly: A/B/C =Value added / Non value added but necessary / Non value added; Machining: A/B/C = Manual work time / Auto cycle time / Walk time				Max / Min-Time due to variants:				Safety Equipment:		
Created by (Name & Date)		Production Approval (Name, Date)			Engineering Approval (Name, Date)			Reference Material		
Version-No. (V47-AF) V008		Foreman (A Shift): Foreman (B Shift): Foreman (C Shift):		Teamleader (A Shift): Teamleader (B Shift): Teamleader (C Shift):						

B.4 Standard Work Instruction of Machine 135 Operator A



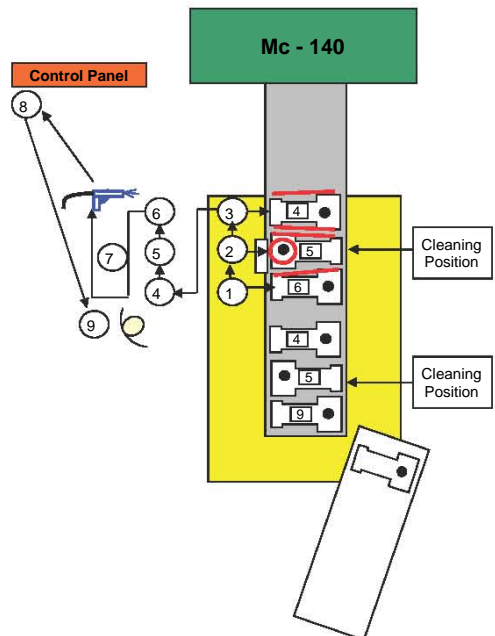
 Atlantis Foundries <small>A Product Center of Mammoet-Buss Trucks</small>		Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>				Operator (cleaning) @ machine 135				
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg.Cycle Time [min]	Base Model	SWI-No	Rev. Date	Page (x / y)
Atlantis Foundries	Heavy Duty	14111	Machine 135	471 / 472	1.62			SWI-CS-030-471/472-005-A	08/03/12	Page 1 / 1
No.	Job Element ("Verb - Object ")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)	
					total	A	B	C		
1	Crank Case Cleaning	Clean the Crank Case (CC) with Scrapper - CC 3	471 / 472		8		x			
2	Crank Case Cleaning	Clean the Crank Case (CC) with Scrapper - CC 2	471 / 472		8		x			
3	Crank Case Cleaning	Clean the Crank Case (CC) with Scrapper - CC 1	471 / 472		8		x			
4	Flash Cleaning	Remove the Core Flash with a Wire Rod on the Right Hand side of CC. No.3 (H - Pic.i)	471 / 472		7		x			
5	Flash Cleaning	Remove the Core Flash inside the hole and the Left Hand side of CC. No.2 (H - Pic.ii)	471 / 472		9		x			
6	Flash Cleaning	Remove Core Flash both sides of CC. No.1	471 / 472		14		x			
7	Sand Cleaning	Take the Air Gun and blow of loose sand on Crank Cases No. 3, 2, 1.	471 / 472		6		x			
8	Push Button	Push the operating Blue button "Photo Electric Barrier"	471 / 472		5		x			
9	Waiting	Step off the Safety Mat until the Crank Case is placed in Cleaning and Transfer Position	471 / 472					x		
10										
11	Cleaning Schedule	Every 30 Blow	471 / 472							
12	1	Stop Machine	471 / 472							
13	2	Clean the Top Plate	471 / 472							
14	3	Clean Joint Lines of the Core Box (Op A & B)	471 / 472							
15	4	Opens vents where needed	471 / 472							
16	5	Clean Core Box with a Copper Plate	471 / 472							
17	6	Apply Redwax Crayon if needed (Op. A & B)	471 / 472							
18	7	Apply Release agent. (Op.A & B)	471 / 472							
19	8	Restart Machine	471 / 472							
20	9	Book into Shopware	471 / 472							
21										
22										
23										
24										
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks								
Mark the appropriate time type with "X":		x Assembly; A/B/C =Value added / Non value added but necessary / Non value added; Machining: A/B/C = Manual work time / Auto cycle time / Walk time			Max / Min-Time due to variants:				Safety Equipment:	
Created by (Name & Date)		Production Approval (Name, Date)			Engineering Approval (Name, Date)		Reference Material			
		Foreman (A Shift):			Teamleader (A Shift):					
Version-No. (V47-AF)		Foreman (B Shift):			Teamleader (B Shift):					
V006		Foreman (C Shift):			Teamleader (C Shift):					

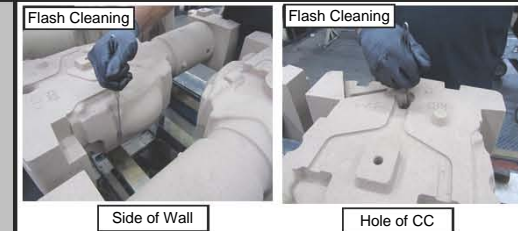


B.5 Standard Work Instruction of Machine 135 Operator B



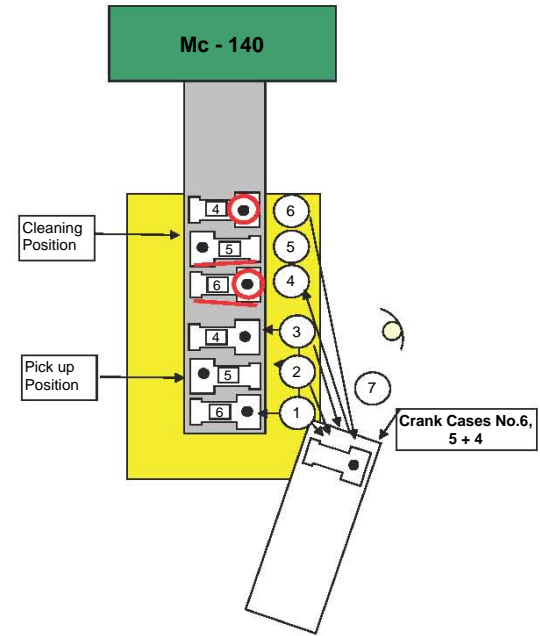
 Atlantis Foundries <small>A Product Center of Mercedes-Benz Trucks</small>		Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>				Transfer @ machine 135							
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg.Cycle Time [min]				Base Model	SWI-No	Rev. Date	Page (x / y)
Atlantis Foundries	Heavy Duty	14111	Machine 135	471 / 472	1.62						SWI-CS-030-471/472-005-B	23-Feb-12	Page 1 / 1
No.	Job Element ("Verb - Object ")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)				
					total	A	B	C					
1	Crank Case Transfer	Pickup the Crankcase (CC) No. 3 & Load it on the conveyor Belt	471 / 472		15		x						
2	Crank Case Transfer	Turn the hoist by 180° & pickup the CC No. 2, turn the hoist 180° while moving & locate onto CC No. 3	471 / 472		16		x						
3	Crank Case Transfer	Pickup the CC No. 1 & Locate onto CC No. 2	471 / 472		15		x						
4	Flash Cleaning	Remove Core Flash with a Wire Rod - Left hand Side of CC. 3 and inside the Hole of CC's No. 3	471 / 472		9		x						
5	Flash Cleaning	Remove Core Flash with a Wire Rod - Right hand Side of CC. 2	471 / 472		7		x						
6	Flash Cleaning	Remove Core Flash with a Wire Rod inside the Hole of CC. 1	471 / 472		3		x						
7	Waiting	Step off the Safety Mat until the Crank Cases is placed in Pick up Position	471 / 472					x					
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													
24													
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks							Important Tools Used, Auxiliary Material & Devices, Testing Equipment:  				
Mark the appropriate time type with "X":		x Assembly: A/B/C =Value added / Non value added but necessary / Non value added Machining: A/B/C = Manual work time / Auto cycle time / Walk time			Max / Min-Time due to variants:								
Created by (Name & Date)		Production Approval (Name, Date)			Engineering Approval (Name, Date)				Reference Material				
		Foreman (A Shift): _____ Teamleader (A Shift): _____											
Version-No. (V47-AF)		Foreman (B Shift): _____ Teamleader (B Shift): _____											
V003		Foreman (C Shift): _____ Teamleader (C Shift): _____											

B.6 Standard Work Instruction of Machine 140 Operator A

 Atlantis Foundries <small>A Product Center of Mammoet-Buss Trucks</small>		Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>				Operator (cleaning) @ machine 140				
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg.Cycle Time [min]	Base Model	SWI-No	Rev. Date	Page (x / y)
Atlantis Foundries	Heavy Duty	14111	Machine 140	471 / 472	1.62			SWI-CS-030-471/472-006-A	08/03/12	Page 1 / 1
No.	Job Element ("Verb - Object ")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)	
					total	A	B	C		
1	Crank Case Cleaning	Clean the Crank Case (CC) with Scrapper - CC 6	471 / 472		8		x			
2	Crank Case Cleaning	Clean the Crank Case (CC) with Scrapper - CC 5	471 / 472		8		x			
3	Crank Case Cleaning	Clean the Crank Case (CC) with Scrapper - CC 4	471 / 472		8		x			
4	Flash Cleaning	Remove the Core Flash with a Wire Rod on the Right Hand side of CC. No.6	471 / 472		7		x			
5	Flash Cleaning	Remove the Core Flash inside the hole and the Left Hand side of CC. No.5	471 / 472		9		x			
6	Flash Cleaning	Remove Core Flash both sides of CC. No.4	471 / 472		14		x			
7	Sand Cleaning	Take the Air Gun and blow of loose sand on Crank Cases No. 6, 5, 4.	471 / 472		6		x			
8	Push Button	Push the operating Blue button "Photo Electric Barrier"	471 / 472		4		x			
9	Waiting	Step of the Safety Mat until the Crank Case is placed in Cleaning and Transfer Position	471 / 472							
10										
11	Cleaning Schedule	Every 30 Blow	471 / 472							
12	1	Stop Machine	471 / 472							
13	2	Clean the Top Plate	471 / 472							
14	3	Clean Joint Lines of the Core Box (Op A & B)	471 / 472							
15	4	Opens vents where needed	471 / 472							
16	5	Clean Core Box with a Copper Plate	471 / 472							
17	6	Apply Redwax Crayon if needed (Op. A & B)	471 / 472							
18	7	Apply Release agent. (Op.A & B)	471 / 472							
19	8	Restart Machine	471 / 472							
20	9	Book into Shopware	471 / 472							
21										
22										
23										
24										
Key to Symbols: S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks Mark the appropriate time type with "X": x Assembly; A/B/C =Value added / Non value added but necessary / Non value added Machining; A/B/C = Manual work time / Auto cycle time / Walk time				Max / Min-Time due to variants:						
Created by (Name & Date)		Production Approval (Name, Date)			Engineering Approval (Name, Date)			Reference Material		
Version-No. (V47-AF)		Foreman (A Shift):			Teamleader (A Shift):					
V006		Foreman (B Shift):			Teamleader (B Shift):					
		Foreman (C Shift):			Teamleader (C Shift):					



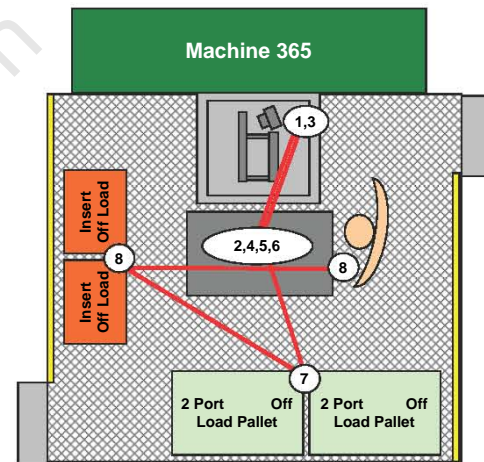




B.7 Standard Work Instruction of Machine 140 Operator B



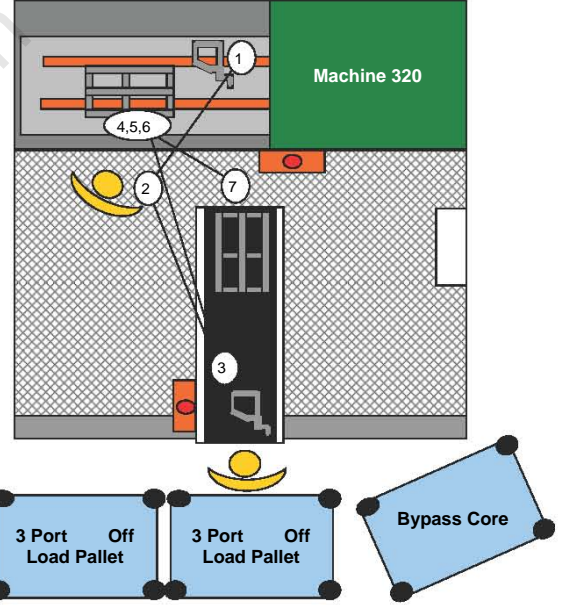
 Atlantis Foundries <small>A Product Center of Mercedes-Benz Trucks</small>		Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>				Transfer @ machine 140							
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg.Cycle Time [min]			Base Model	SWI-No	Rev. Date	Page (x / y)	
Atlantis Foundries	Heavy Duty	14111	Machine 140	471 / 472	1.62					SWI-CS-030-471/472-006-B	23-Feb-12	Page 1 / 1	
No.	Job Element ("Verb - Object ")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)				
					total	A	B	C					
1	Crank Case Transfer	Pickup the Crankcase (CC) No. 6 & Load it on the conveyor Belt	471 / 472		18			x					
2	Crank Case Transfer	Turn the hoist by 180° & pickup the CC No. 5, turn the hoist 180° while moving & locate onto CC No. 6	471 / 472		20			x					
3	Crank Case Transfer	Pickup the CC No. 4 & Locate onto CC No. 5	471 / 472		18			x					
4	Flash Cleaning	Remove Core Flash with a Wire Rod - Left hand Side of CC 6 and inside the Hole of CC 6	471 / 472		9			x					
5	Flash Cleaning	Remove Core Flash with a Wire Rod - Right hand Side of CC. 5	471 / 472		7			x					
6	Flash Cleaning	Remove Core Flash with a Wire Rod inside the Hole of CC. 4	471 / 472		3			x					
7	Waiting	Step off the Safety Mat until the Crank Cases is placed in Pick up Position	471 / 472						x				
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
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21													
22													
23													
24													
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks			Max / Min-Time due to variants:						Safety Equipment:		
Mark the appropriate time type with "X":		Assembly: A/B/C =Value added / Non value added but necessary / Non value added									Reference Material		
		Machining: A/B/C = Manual work time / Auto cycle time / Walk time											
Created by (Name & Date)		Production Approval (Name, Date)			Engineering Approval (Name, Date)								
		Foreman (A Shift):			Teamleader (A Shift):								
Version-No. (V47-AF)		Foreman (B Shift):			Teamleader (B Shift):								
V003		Foreman (C Shift):			Teamleader (C Shift):								



B.9 Standard Work Instruction of Machine 365

 ATLANTIS FOUNDRIES <small>A Product Center of Mammoet-Buss Trucks</small>		Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>				Timing Insert & 2 Port							
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg.Cycle Time [min]				Base Model	SWI-No.	Rev. Date	Page (x / y)
Atlantis Foundries	Heavy Duty	14111	Machine 365	471 / 472	1.62						SWI-CS-030-471/472-009	06/03/12	Page 1 / 1
No.	Job Element ("Verb - Object ")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)				
					total	A	B	C					
1	Pick up Core	Pick up the Timing Insert & 2 Port from the Machine	471 / 472		13	x			  				
2	Place Core	Place the Timing Insert & 2 Port on the Table	471 / 472		2	x							
3	Blow off core box	Blow off core box by using the Airgun	471 / 472		7	x							
4	Clean Core	Clean the 2 Port with a Scraper	471 / 472		12	x							
5	Open Holes	Ensure the screw location holes are open with wire.	471 / 472		9	x							
6	Clean Core	Clean the Timing insert with a Scraper	471 / 472		1	x							
7	Store core	Place the 2 Port on a Clean Storage Pallet (H - Pic.ii)	471 / 472		3	x							
8	Insert Core	Place the Timing Insert in a Tray (H - Pic.i)	471 / 472		1	x							
9	Waiting	Step back and wait till machine provides cores for pick up	471 / 472					x					
10													
11	Cleaning Schedule		471 / 472										
12	1	Stop Machine after every 42 Blows	471 / 472										
13	2	Clean Joint Lines of the Core Box	471 / 472										
14	3	Opens vents where needed	471 / 472										
15	4	Clean Core Box with a Copper Plate	471 / 472										
16	5	Apply Redwax Crayon if needed	471 / 472										
17	6	Apply Release agent.	471 / 472										
18	7	Restart Machine	471 / 472										
19	8	Book into Shopware	471 / 472										
20													
21													
22													
23													
24													
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks											
Mark the appropriate time type with "X":		[Assembly: A/B/C =Value added / Non value added but necessary / Non value added Machining: A/B/C = Manual work time / Auto cycle time / Walk time			Max / Min-Time due to variants:						Safety Equipment:		
Created by (Name & Date)		Production Approval (Name, Date)			Engineering Approval (Name, Date)				Reference Material				
		Foreman (A Shift):			Teamleader (A Shift):								
Version-No. (V47-AF)		Foreman (B Shift):			Teamleader (B Shift):								
V006		Foreman (C Shift):			Teamleader (C Shift):								

B.10 Standard Work Instruction of Machine 320 Operator A

 Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>		Cleaning of Bypass & 3 Ports (A)								
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg.Cycle Time [min]	Base Model	SWI-No.	Rev. Date	Page (x / y)
Atlantis Foundries	Heavy Duty	14111	Machine 320	471 / 472	1.62			CS-030-471/472-	06/03/12	Page 1 / 1
No.	Job Element ("Verb - Object ")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)	
					total	A	B	C		
1	Pick up core	Pick up the Bypass Core from the Machine (H - Pic.i)	471 / 472		1		X			
2	Clean Core	Remove all ejector marks from the Bypass Core with a scrapper. (Q - Pic.i)	471 / 472		13		X			
3	Clean Core	Remove all Core Flash from the Bypass Core by using a scrapper.	471 / 472		3		X			
4	Place Core	Place the Bypass Core on the Conveyor Belt	471 / 472		3		X			
5	Clean Core	Remove all ejector marks from the 3 Port Core with a scrapper.	471 / 472		7		X			
6	Clean Core	Remove all Core Flash from the 3 Port by using a scrapper.	471 / 472							
7	Pick up Core	Pick up the 3 Port Core from the Machine	471 / 472		1		X			
8	Open Holes	Ensure screw location holes are open (use wire rod when necessary)	472 / 472		5		X			
9	Set 3 Port	Place the 3 Port on the Conveyor Belt (H - Pic.ii)	471 / 472		3		X			
10	Blow Off Sand	Blow off the Cores with Airgun	471 / 472		3		X			
11	Waiting	Wait on Machine to finish the next cycle	471 / 472					X		
12										
13	Cleaning Schedule	Every 48 Blows	471 / 472							
14	1	Stop Machine	471 / 472							
15	1	Clean Joint Lines of the Core Box	471 / 472							
16	2	Opens vents where needed	471 / 472							
17	3	Clean Core Box with a Copper Plate	471 / 472							
18	4	Apply Redwax Crayon if needed	471 / 472							
19	5	Apply Release agent.	471 / 472							
20	6	Restart Machine	471 / 472							
21	7	Book into Shopware	471 / 472							
22										
23										
24										
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks								
Mark the appropriate time type with "X":		[Assembly: A/B/C =Value added / Non value added but necessary / Non value added; Machining: A/B/C = Manual work time / Auto cycle time / Walk time]			Max / Min-Time due to variants:				Safety Equipment:	
Created by (Name & Date)		Production Approval (Name, Date)			Engineering Approval (Name, Date)		Reference Material			
		Foreman (A Shift): _____ Teamleader (A Shift): _____								
Version-No. (V47-AF)		Foreman (B Shift): _____ Teamleader (B Shift): _____								
V006		Foreman (C Shift): _____ Teamleader (C Shift): _____								



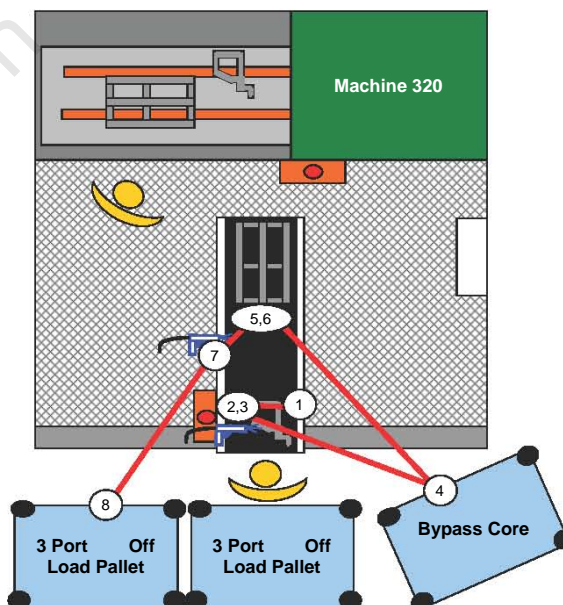




Picture i





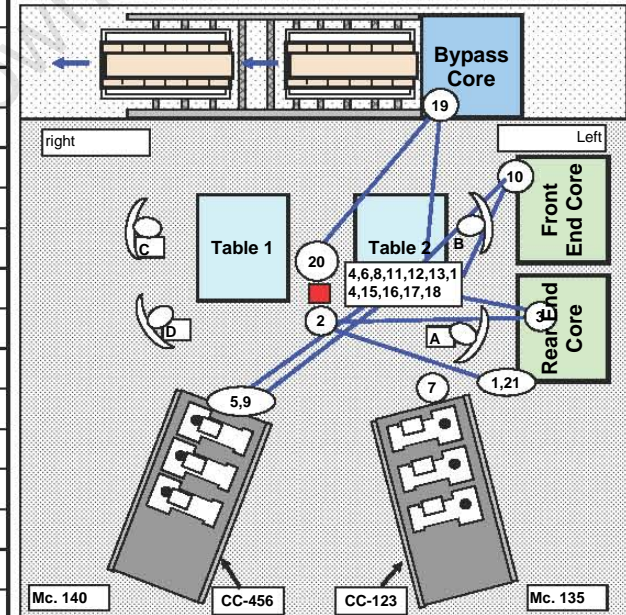
Picture ii

B.11 Standard Work Instruction of Machine 320 Operator B

 ATLANTIS FOUNDRIES <small>A Product Center of Mercedes-Benz Trucks</small>		Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>				Cleaning of Bypass & 3 Ports (B)				 <small>TOS - Truck Operating System</small>			
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg.Cycle Time [min]				Base Model	SWI-No.	Rev. Date	Page (x / y)
Atlantis Foundries	Heavy Duty	14111	Machine 320	471 / 472	1.62						CS-030-471/472-	06/03/12	Page 1 / 1
No.	Job Element ("Verb - Object ")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)				
					total	A	B	C					
1	Open 1 Hole in Bypass Core	Open the 1 hole in the bypass core	471 / 472		2		X						
2	Blow Off with Airgun	Blow off all loose sand from the Bypass Core with an Airgun	471 / 472		3		X						
3	Pick up Bypass Core	Pick up the Bypass Core from the Conveyor	471 / 472		1		X						
4	Storage Rack	Place the Bypass Core onto a Clean Storage Rack	471 / 472		9		X						
5	Remove Core Flash	Remove all Core Flash from the 3 Port	471 / 472		4		X						
6	Open 5 Holes	Open the 5 Holes on the 3 Port with a Wire Rod	471 / 472		7		X						
7	Blow Off with Airgun	Blow off all loose sand from the 3 Port Core with an Airgun	471 / 472		6		X						
8	Pick up 3 Port Core	Pick up the 3 Port Core	471 / 472		1		X						
9	Stacking	Place the 3 Port Core on a clean Storage Pallet.	471 / 472		10		X						
10	Waiting	Wait for the machine to finish the next cycle	471 / 472					X					
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													
24													
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks			Max / Min-Time due to variants:						Important Tools Used, Auxiliary Material & Devices, Testing Equipment:		
Mark the appropriate time type with "X":		Assembly: A/B/C =Value added / Non value added but necessary / Non value added									  Picture i Picture ii		
Created by (Name & Date)		Production Approval (Name, Date)			Engineering Approval (Name, Date)						Reference Material		
		Foreman (A Shift): _____ Teamleader (A Shift): _____											
Version-No. (V47-AF)		Foreman (B Shift): _____ Teamleader (B Shift): _____											
V006		Foreman (C Shift): _____ Teamleader (C Shift): _____											

B.12 Standard Work Instruction of Assembly Deck Operator A

 Atlantis Foundries <small>A Product Center of Mercedes-Benz Trucks</small>		Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>				Assembly Deck Table 2 - Operator A				
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg.Cycle Time [min]	Base Model	SWI-No.	Rev. Date	Page (x / y)
Atlantis Foundries	Core Shop	14111	HD Line - Assembly Deck Table 2 (Operator A)	471 / 472	3.24			SWI-CS-040-471/472-001-A	23/03/12	1 / 1
No.	Job Element ("Verb - Object ")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)	
					total	A	B	C		
1	Wait For Table 1	Wait to start till Table 1 is further than Front End Core (FEC).	471 / 472							
2	Push Middle Button	Push the middle Button of the table remote to lower table to starting position.	471 / 472		3					
3	Carry REC together	Carry the Rear End Core (REC) together with operator B with your hands at right hand side of the core.	471 / 472		6					
4	Set REC on Table	Set the REC on the table with bottom & outside surface to table	471 / 472		1	x				
5	Insert Jig	Insert the Jig on Crank Cases 4 - 6	471 / 472		3					
6	Transfer CC	Transfer Crank Cases 4 - 6 to Assembly Table and put the Crank Cases on the Rear End Core	471 / 472		10	x				
7	Insert Jig	Insert the Jig on Crank Cases 1 - 3	471 / 472		12					
8	Wright Shift	Wright shift onto Crank Case of No. 1 on bottom of right-hand side of CC1 with wire rod	471 / 472		5					
9	Transfer CC	Transfer Crank Cases 1 - 3 to Assembly Table and put the Crank Cases on No. 4.	471 / 472		11	x				
10	Move Jig	Move the Jig towards Crank Cases 4 - 6 @ waiting position.	471 / 472		12					
11	Carry FEC	Carry the FEC at right-hand side of core together with Operator B	471 / 472		8					
12	Set FEC	Set FEC on Table 2 with bottom & inside surface onto CC 1 together with Op. B	471 / 472		1	x				
13	Insert Tie Rod	Take 1 Tie Rod by Operator B & insert Tie Rod into Top of Assembly.	471 / 472		9					
14	Close Clamp	Close clamp on Left Hand side of Table 2	471 / 472		3					
15	Fetch 2 Nuts & Impact Wrench	Fetch 2 Nuts, Impact Wrench out of Holders and Tighten Tie Rod from Top to Bottom.	471 / 472		18	x				
16	471 Only	471 Only: Take Torque - Wrench and Torque both nuts with 10NM	471	Q - 048	9	x				
17	Wait for Operator B	Wait for Operator B to handle Jig	471 / 472							
18	Placement of Jig	Assist Operator B with Placement of Assembly Jig onto Assembly.	471 / 472		5					
19	Wait for Loading	Wait till Op.B puts Assembly onto Flow Line	471 / 472							
20	Take 1 Bypass Core	Take 1 Bypass Core out of Container and Place onto Assembly.	471 / 472		9					
21	Push Button	Push Button on Control Panel to Move Main Assembly.	471 / 472		3					
22	Wait For Table 1	Wait till Progress at Table 1 is Further than the Front E/C Transfer.	471 / 472							
		NOTE: After 4 hours Rotate for Position of Operator C at Table 1								
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks								
Mark the appropriate time type with "X":		Assembly: A/B/C =Value added / Non value added but necessary / Non value added Machining: A/B/C = Manual work time / Auto cycle time / Walk time		Max / Min-Time due to variants:						
Created by (Name & Date)		Production Approval (Name, Date)		Engineering Approval (Name, Date)		Reference Material				
Foreman (A Shift):		Teamleader (A Shift):								
Foreman (B Shift):		Teamleader (B Shift):								
Foreman (C Shift):		Teamleader (C Shift):								
Version-No. (V47-AF) V005										

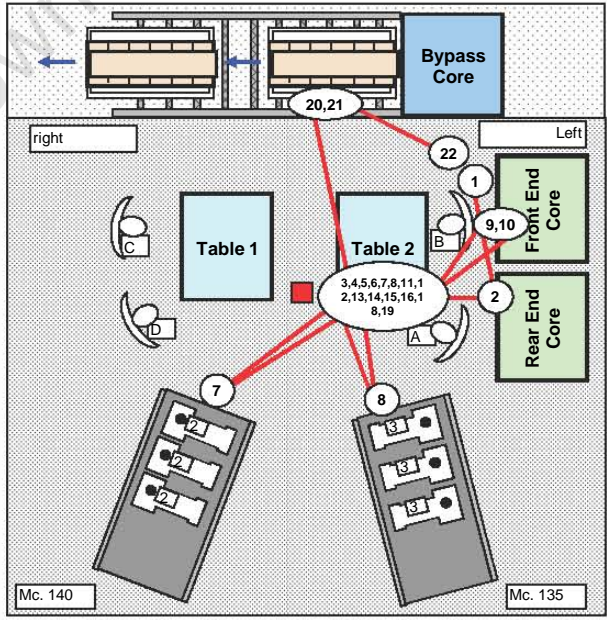


Important Tools Used, Auxiliary Material & Devices, Testing Equipment:

Safety Equipment:

B.13 Standard Work Instruction of Assembly Deck Operator B

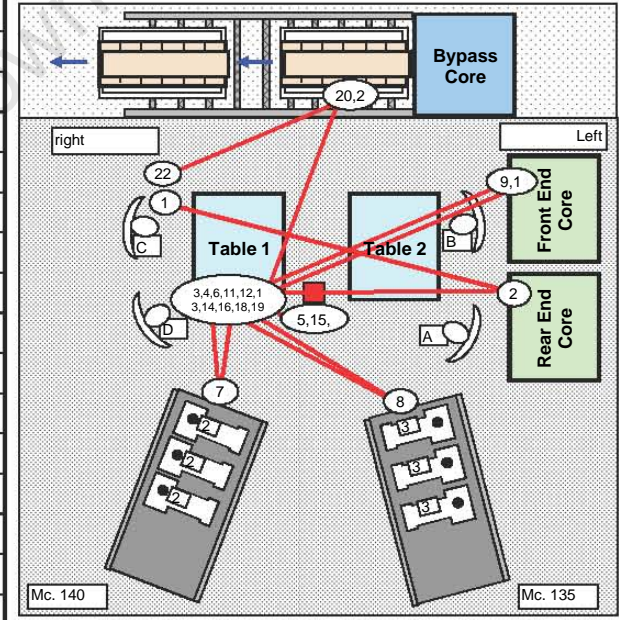
Plant/Center		Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg. Cycle Time [min]	Base Model	SWI-No.	Rev. Date	Page (x / y)	
Atlantis Foundries		Core Shop	14111	HD Line - Assembly Deck Table 2 (Operator B)	471 / 472	3.24			SWI-CS-040-471/472-001-B	23/03/12	1 / 1	
No.	Job Element ("Verb - Object")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)			
					total	A	B	C				
1	Wait for Table 1	Wait to start till Table 1 is further than Front End Core (FEC).	471 / 472									
2	Prepare Take Off of Rear End Core	Prepare Take Off of Rear End Core (REC) at container & check for any defects & if the Timing Insert is Inserted.	471 / 472	Q - 049	7			x				
3	Carry REC together	Carry the REC together with operator A with your hands at left-hand side of the core.	471 / 472		6			x				
4	Set REC	Set the REC on the table with bottom & outside surface.	471 / 472		2	x						
5	Lower Table	Lower Table with Remote to the Lowest Position.	471 / 472		3			x				
6	Blow Off sand	Blow Off loose sand of REC with Air Gun	471 / 472	Q - 050	5			x				
7	Assist Op. A & Blow	Assist Operator A to Lower Crank Cases 4-6 onto Rear End Core, take the Air Gun & blow of loose sand of CC	471 / 472		6			x				
8	Assist Op. A & Blow	Assist Operator A to Lower Crank Cases 1-3 onto Rear End Core, take the Air Gun & blow of loose sand of CC	471 / 472		6			x				
9	Prepare Take Off of FEC	Prepare Take Off of Front End Core.	471 / 472	Q - 051	7			x				
10	Carry FEC	Carry the FEC with op. A at left-hand side of the core	471 / 472		8			x				
11	Set FEC	Set FEC with bottom & inside surface onto CC 1 together with Op. B	471 / 472		2	x						
12	Take 2 Tie Rods	Take 2 Tie Rods out of holder, hand over 1 to Op. A & insert 1 Tie Rod into Bottom of Assembly	471 / 472		9			x				
13	Close Clamp	Close Clamp on right hand side of Table 2.	471 / 472		2			x				
		The next step needs to be done for First 10 Assemblies of Shift, then every 10th Assembly.										
14	Check Height	Check if the Height of the Assembly is Correct with the Gauge fitted onto Table 2.	471 / 472	Q - 052	6			x				
15	471: Tilt the Table	Tilt the Table to 45 Degrees	471		9			x				
15	472: Tilt the Table	Tilt the Table to Take Off Position	472		11			x				
16	Wait for Operator A	Wait until Operator A fits the Tie Rod	471 / 472									x
17	471: Tilt the Table	Tilt the Table to Take Off Position.	471		3			x				
18	Place Assembly Jig	Place Assembly Jig onto Assembly.	471 / 472		18			x				
19	Open Clamps	Open Clamps at Table 1.	471 / 472		2			x				
20	Set Assembly	Take Assembly out of Table by Operating Crane Remote, Transfer & Fit Assembly onto Skid of Flow Line.	471 / 472		18			x				
21	Remove Jig	Remove Jig from Main Assembly and higher it 0,5 m above the Main assembly	471 / 472		7			x				
23	Wait till Progress	Wait till Progress at Table 1 is Further than FEC Transfer.	471 / 472									x
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks			Max / Min-Time due to variants:					Safety Equipment:		
Mark the appropriate time type with "X":		x Assembly: A/B/C=Value added / Non value added but necessary / Non value added										
		Machining: A/B/C= Manual work time / Auto cycle time / Walk time										
Created by (Name & Date)		Production Approval (Name, Date)			Engineering Approval (Name, Date)			Reference Material				
Version-No. (V47-AF)		Foreman (A Shift):			Teamleader (A Shift):							
V008		Foreman (B Shift):			Teamleader (B Shift):							
		Foreman (C Shift):			Teamleader (C Shift):							





Important Tools Used, Auxiliary Material & Devices, Testing Equipment:

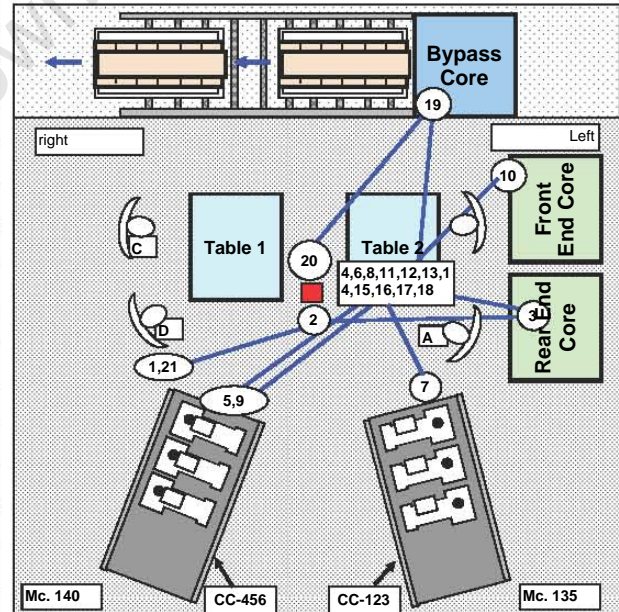
B.14 Standard Work Instruction of Assembly Deck Operator C

Plant/Center		Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg. Cycle Time [min]	Base Model	SWI-No.	Rev. Date	Page (x / y)	
Atlantis Foundries		Core Shop	14111	HD Line - Assembly Deck Table 1 Operator C	471 / 472	3.24			SWI-CS-040-471/472-001-C	23/03/12	1 / 1	
No.	Job Element ("Verb - Object")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)			
					total	A	B	C				
1	Wait for Table 2	Wait to start till Table 2 is further than Front End Core (FEC)	471 / 472									
2	Prepare Take Off of Rear End Core	Prepare Take Off of Rear End Core (REC) at container & check for any defects & if Timing Insert is Inserted	471 / 472	Q - 049	7			x				
3	Carry REC together	Carry the REC together with operator D with your hands at left-hand side of the core	471 / 472		7			x				
4	Set REC	Set the REC on the table with bottom & outside surface	471 / 472		2	x						
5	Lower Table	Lower Table with Remote to the Lowest Position	471 / 472		3			x				
6	Blow Off sand	Blow Off loose sand of REC with Air Gun	471 / 472	Q - 050	5			x				
7	Assist Op. D & Blow	Assist Operator D to Lower Crank Cases 4-6 onto Rear End Core, take the Air Gun & blow of loose sand of CC	471 / 472		6			x				
8	Assist Op. D & Blow	Assist Operator D to Lower Crank Cases 1-3 onto Rear End Core, take the Air Gun & blow of loose sand of CC	471 / 472		6			x				
9	Prepare Take Off of FEC	Prepare Take Off of Front End Core	471 / 472	Q - 051	8			x				
10	Carry FEC	Carry the FEC with op. A at left-hand side of the core	471 / 472		9			x				
11	Set FEC	Set FEC with bottom & inside surface onto CC 1 together with Op. D	471 / 472		2	x						
12	Take 2 Tie Rods	Take 2 Tie Rods out of holder, hand over 1 to Op. D & insert 1 Tie Rod into Bottom of Assembly	471 / 472		9			x				
13	Close Clamp	Close Clamp on right hand side of Table 1	471 / 472		2			x				
		The next step needs to be done for First 10 Assemblies of Shift, then every 10th Assembly										
14	Check Height	Check if the Height of the Assembly is Correct with the Gauge fitted onto Table 1	471 / 472	Q - 052	6			x				
15	471: Tilt the Table	Tilt the Table to 45 Degrees	471		9			x				
16	472: Tilt the Table	Tilt the Table to Take Off Position	472		11			x				
16	Wait for Operator D	Wait until Operator D fits the Tie Rod	471 / 472									x
17	471: Tilt the Table	Tilt the Table to Take Off Position	471		3			x				
18	Place Assembly Jig	Place Assembly Jig onto Assembly	471 / 472		18			x				
19	Open Clamps	Open Clamps at Table 2	471 / 472		2			x				
20	Set Assembly	Take Assembly out of Table by Operating Crane Remote, Transfer & Fit Assembly onto Skid of Flow Line.	471 / 472		23			x				
21	Remove Jig	Remove Jig from Main Assembly and higher it 0,5 m above the Main assembly	471 / 472		7			x				
22	Wait till Progress	Wait till Progress at Table 2 is Further than FEC Transfer.	471 / 472									x
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks			Max / Min-Time due to variants:					Safety Equipment:		
Mark the appropriate time type with "X":		x Assembly: A/B/C=Value added / Non value added but necessary / Non value added										
		Machining: A/B/C= Manual work time / Auto cycle time / Walk time										
Created by (Name & Date)		Production Approval (Name, Date)			Engineering Approval (Name, Date)			Reference Material				
Version-No. (V47-AF)		Foreman (A Shift):			Teamleader (A Shift):							
V010		Foreman (B Shift):			Teamleader (B Shift):							
		Foreman (C Shift):			Teamleader (C Shift):							



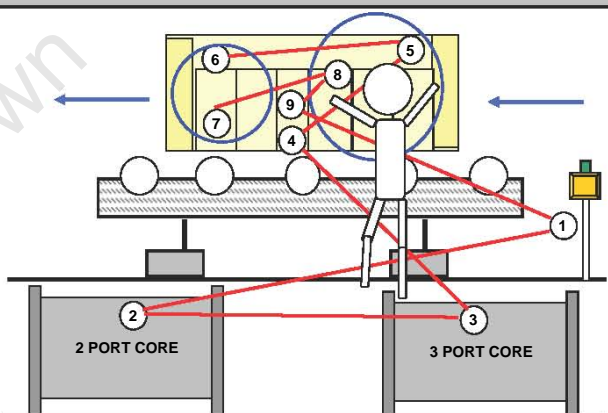


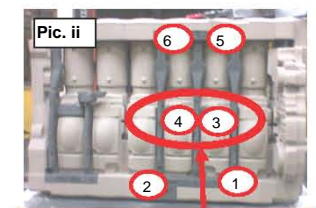
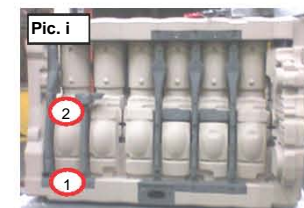
B.15 Standard Work Instruction of Assembly Deck Operator D

 Atlantis Foundries <small>A Product Center of Mercedes-Benz Trucks</small>		Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>				Assembly Deck Table 1 - Operator D							
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg. Cycle Time [min]			Base Model	SWI-No.	Rev. Date	Page (x / y)	
Atlantis Foundries	Core Shop	14111	HD Line - Assembly Deck Table 1 (Operator D)	471 / 472	3.24					SWI-CS-040-471/72-001-D	23/03/12	1 / 1	
No.	Job Element ("Verb - Object")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)				
					total	A	B	C					
1	Wait For Table 2	Wait to start till Table 2 is further than Front End Core (FEC).	471 / 472										
2	Push Middle Button	Push the middle Button of the table remote to lower table to starting position.	471 / 472		3			x					
3	Carry REC together	Carry the Rear End Core (REC) together with operator C with your hands at right hand side of the core.	471 / 472		6				x				
4	Set REC on Table	Set the REC on the table with bottom & outside surface to table	471 / 472		2	x							
5	Insert Jig	Insert the Jig on Crank Cases 4 - 6	471 / 472		3				x				
6	Transfer CC	Transfer Crank Cases 4 - 6 to Assembly Table and put the Crank Cases on the Rear End Core	471 / 472		8	x							
7	Insert Jig	Insert the Jig on Crank Cases 1 - 3	471 / 472		12				x				
8	Wright Shift	Wright shift onto Crank Case of No. 1 on bottom of right-hand side of CC1 with wire rod	471 / 472		5				x				
9	Transfer CC	Transfer Crank Cases 1 - 3 to Assembly Table and put the Crank Cases on No. 4.	471 / 472		13	x							
10	Move Jig	Move the Jig towards Crank Cases 4 - 6 @ waiting position.	471 / 472		5				x				
11	Carry FEC	Carry the FEC at right-hand side of core together with Operator C	471 / 472		7				x				
12	Set FEC	Set FEC on Table 1 with bottom & inside surface onto CC 1 together with Op. C	471 / 472		1	x							
13	Insert Tie Rod	Take 1 Tie Rod by Operator C & insert Tie Rod into Top of Assembly.	471 / 472		6				x				
14	Close Clamp	Close clamp on Left Hand side of Table 1	471 / 472		3				x				
15	Fetch 2 Nuts & Impact Wrench	Fetch 2 Nuts, Impact Wrench out of Holders and Tighten Tie Rod from Top to Bottom.	471 / 472		4	x							
16	471 Only	471 Only: Take Torque - Wrench and Torque both nuts with 10NM	471	Q - 048	9	x							
17	Wait for Operator C	Wait for Operator C to handle Jig	471 / 472										x
18	Placement of Jig	Assist Operator C with Placement of Assembly Jig onto Assembly.	471 / 472		8				x				
19	Wait for Loading	Wait till Op.C puts Assembly onto Flow Line	471 / 472										x
20	Take 1 Bypass Core	Take 1 Bypass Core out of Container and Place onto Assembly.	471 / 472		3				x				
21	Push Button	Push Button on Control Panel to Move Main Assembly.	471 / 472		3				x				
22	Wait For Table 2	Wait till Progress at Table 2 is Further than the Front E/C Transfer.	471 / 472										x
23		NOTE: After 4 hours Rotate for Position of Operator B at Table 1.											
24													
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks		Max / Min-Time due to variants:						Important Tools Used, Auxiliary Material & Devices, Testing Equipment:			
Mark the appropriate time type with "X":		Assembly: A/B/C = Value added / Non value added but necessary / Non value added								Safety Equipment:			
		Machining: A/B/C = Manual work time / Auto cycle time / Walk time											
Created by (Name & Date)		Production Approval (Name, Date)		Engineering Approval (Name, Date)		Reference Material							
		Foreman (A Shift):		Teamleader (A Shift):									
Version-No. (V47-AF)		Foreman (B Shift):		Teamleader (B Shift):									
V007		Foreman (C Shift):		Teamleader (C Shift):									





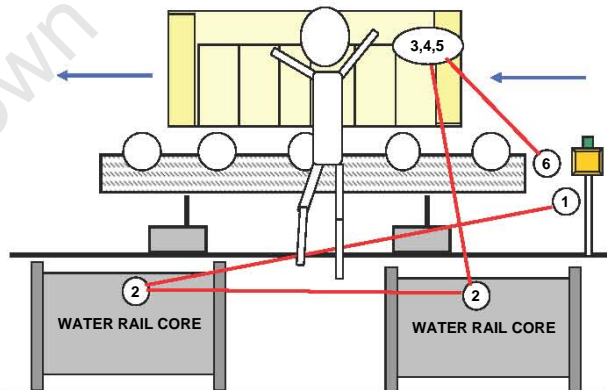
B.16 Standard Work Instruction of 2 Port and 3 Port Assembly

 Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>			2 & 3 Port Assembly							
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg.Cycle Time [min]	Base Model	SWI-No.	Rev. Date	Page (x / y)
Atlantis Foundries	Core Shop	14111	HD Line - 2 & 3 Port Assembly	471 / 472	1.62			SWI-CS-040-471/472-003	19/03/12	Page 1 / 1
No.	Job Element ("Verb - Object ")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)	
					total	A	B	C		
1	Push Button	Push the Operating Button	471 / 472		3					
2	Pick up 2 Port	Take the 2 Port out of the container & insert it into the Main Assembly	471 / 472		6	x				
3	Pick up 3 Port	Take the 3 Port out of the container & insert it into the Main Assembly	471 / 472		6	x				
4	Drill 1 Hole	Drill one hole into 3 Port next to Down Sprue.	471 / 472		7	x				
5	Insert 6 Screws	Insert 6 screws into 3 Port from right to left, from bottom to top	471 / 472		15		x			
6	Insert two screws	Insert 2 screws into 2 Port from bottom to top.	471 / 472		3			x		
7	Tighten 2 Port	Tighten the two screws into the 2 Port:- Bottom to Top	471 / 472	Q - 054	4	x				
8	Tighten 3 Port	Tighten the 6 screws into the 3 port :- from Right to Left, from Bottom to Top	471 / 472		16	x				
9	Tighten 3 Port	Tighten the 2 middle of the 3 Port Core from right to left not deeper than the core surface.	471 / 472	Q - 055	4	x				
10	Waiting	Step back and wait for the next Main Assembly	471 / 472							
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks								
Mark the appropriate time type with "X":		Assembly: A/B/C =Value added / Non value added but necessary / Non value added			Max / Min-Time due to variants:					
		Machining: A/B/C = Manual work time / Auto cycle time / Walk time								
Created by (Name & Date)		Production Approval (Name, Date)			Engineering Approval (Name, Date)			Reference Material		
		Foreman (A Shift):			Teamleader (A Shift):					
Version-No. (V47-AF)		Foreman (B Shift):			Teamleader (B Shift):					
V007		Foreman (C Shift):			Teamleader (C Shift):					
								Important Tools Used, Auxiliary Material & Devices, Testing Equipment:		
								Safety Equipment:		

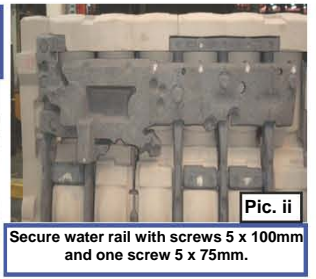
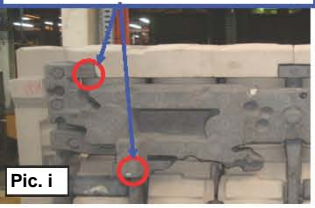


Q Do not tighten the 2 middle screws deeper than the core surface!

B.17 Standard Work Instruction of Water Rail Assembly Operator A



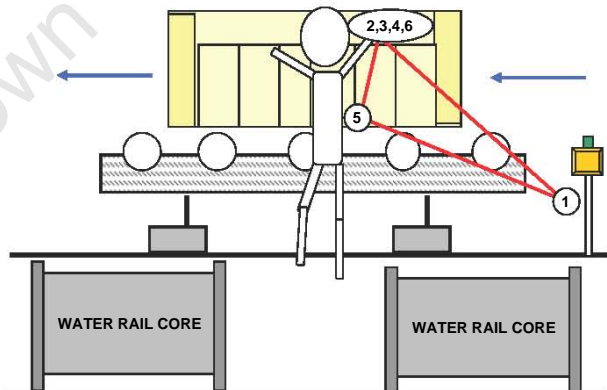
 ATLANTIS FOUNDRIES <small>A Product Center of Mercedes-Benz Trucks</small>		Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>				Watrerrail Assembly							
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg.Cycle Time [min]				Base Model	SWI-No	Rev. Date	Page (x / y)
Atlantis Foundries	Heavy Duty	14111	Water Rail Assembly (Operator A)	471/472	1.62						SWI-CS-040-471/472-004-A	16/03/12	Page 1 / 1
No.	Job Element ("Verb - Object ")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)				
					total	A	B	C					
1	Push Button	Press the Conveyor Button, Step back and wait for the next Main Assembly	471 / 472		3		x						
2	Visually Inspect	Visually inspect the Water Rail Core	471	Q - 056			x						
3	Drill Water rail	Drill 4 holes into Water Rail	471	Q - 057			x						
4	Drill Water rail	Drill 6 holes into Water Rail (H - Pic.i)	472	Q - 058	17		x						
5	Pick up & Set Water rail	Pick up & Set Water Rail to Main Core Assembly	471 / 472		11	x							
6	Drill Water rail	Drill 2 Holes on the Left Side of the Water Rail (Q - Pic.i)	471 / 472	Q - 059	9		x						
7	Insert Screws	Insert 1 Short Screw (5x75mm) & 5 Long Screws (2x100mm) From left to Right	471				x						
8	Insert Screws	Insert 1 Short Screw (5x75mm) & 7 Long Screws (2x100mm) From left to Right (H - Pic.ii)	472		14		x						
9	Waiting	Step back and wait for the start of next cycle						x					
10									<p>Important Tools Used, Auxiliary Material & Devices, Testing Equipment:</p>				
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													
24													
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks											
Mark the appropriate time type with "X":		Assembly: A/B/C =Value added / Non value added but necessary / Non value added			Max / Min-Time due to variants:						Safety Equipment:		
		Machining: A/B/C = Manual work time / Auto cycle time / Walk time									Reference Material		
Created by - Date		Production Approval (Name, Date)			Engineering Approval (Name, Date)								
		Foreman (A Shift):		Teamleader (A Shift):									
Version-No. (V47-AF)		Foreman (B Shift):		Teamleader (B Shift):									
V006		Foreman (C Shift):		Teamleader (C Shift):									

During assembly of the 472 Water Rail Core, Drill 2 holes on the left side of the water rail as indicated in the Picture below.



Secure water rail with screws 5 x 100mm and one screw 5 x 75mm.



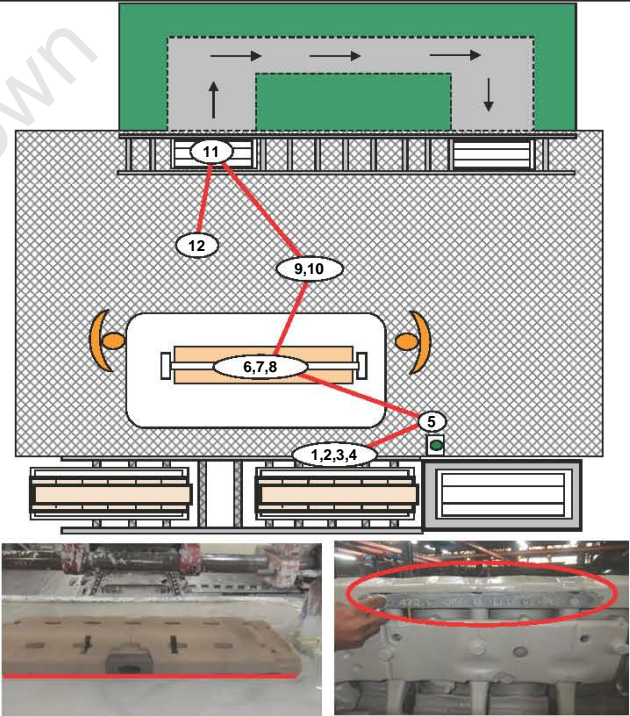
B.18 Standard Work Instruction of Water Rail Assembly Operator B

 Atlantis Foundries <small>A Product Center of Mercedes-Benz Trucks</small>		Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>				Watrerrail Assembly							
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg.Cycle Time [min]				Base Model	SWI-No	Rev. Date	Page (x / y)
Atlantis Foundries	Heavy Duty	14111	Water Rail Assembly (Operator B)	471/472	1.62						SWI-CS-040-471/472-004-B	16/03/12	Page 1 / 1
No.	Job Element ("Verb - Object ")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)				
					total	A	B	C					
1	Push Button	Press the Conveyor Button, Step back and wait for the next Main Assembly	471 / 472		3		x						
2	Jig Setting	Set Jig to the Water Rail (H - Pic.i)	471 / 472		6		x						
3	(471) Tighten Screws	Tighten the (six) 6 screws from Left to Right	471	Q - 060	22	x							
4	(472) Tighten Screws	Tighten the (eight) 8 screws from Left to Right	472	Q - 061	24	x							
5	Length Gauge Check	(Q - Check to be done every 10 Core) Measure the Core Length with a Length Jig (Q - Pic.ii)	471 / 472	Q - 062	6		x						
6	Remove Jig	Remove the Jig	471 / 472		2		x						
7	Waiting	Step Back and Wait till next cycle can start	471 / 472					x					
8													
9													
10													
11													
12													
13													
14													
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16													
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24													
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks											
Mark the appropriate time type with "X":		Assembly: A/B/C =Value added / Non value added but necessary / Non value added			Max / Min-Time due to variants:						Safety Equipment:		
Created by - Date		Production Approval (Name, Date)			Engineering Approval (Name, Date)						Reference Material		
		Foreman (A Shift):			Teamleader (A Shift):								
Version-No. (V47-AF)		Foreman (B Shift):			Teamleader (B Shift):								
V005		Foreman (C Shift):			Teamleader (C Shift):								



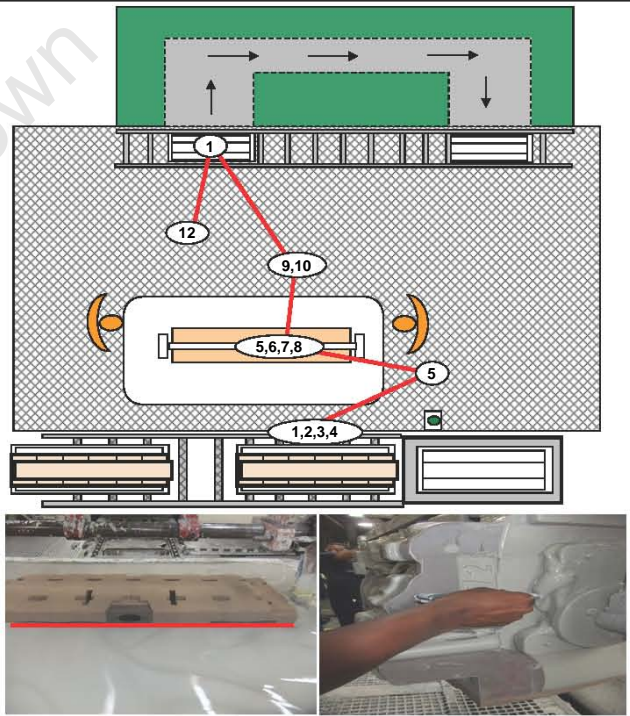



Important Tools Used, Auxiliary Material & Devices, Testing Equipment:



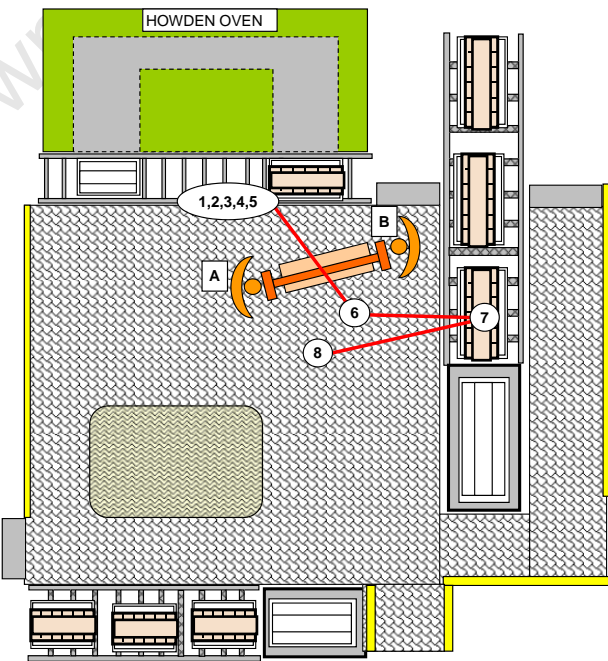


B.19 Standard Work Instruction of Dipping Station Operator A

 Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>			Dipping - Core Assembly (REMOTE)							
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg.Cycle Time [min]	Base Model	SWI-No.	Rev. Date	Page (x / y)
Atlantis Foundries	Core Shop	14111	HD Line - Dipping Operator A(Remote)	471 / 472	1.62			SWI-CS-040-471/472-005-A	19/03/12	1 / 1
No.	Job Element ("Verb - Object ")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)	
					total	A	B	C		
1	Move Jig Together	Move Jig towards Main Assembly together	471 / 472		5		x			
2	Locate Jig	Locate the Jig to the Main Assembly	471 / 472		4		x			
3	Wait for Readiness	Wait for readiness and then operate the cycle switch	471 / 472		5		x			
4	Operating Remote	Operating the remote to lift the Main Assembly together	471 / 472		3		x			
5	Push Button	Push the Push Button to release an empty skid	471 / 472		10		x			
6	Transfer Core	Transfer the Main Assembly to the Dipping Station together	471 / 472		7		x			
7	Dipping Core	Dipping the Main Assembly the just below the Filter hole together.	471 / 472	Q - 063	9	x				
8	Lift & Operate Lock	Lift the Main assembly, Operate the Locking Lever & wait for Operator B	471 / 472		10		x			
9	Move Core	Move the Main Assembly to Cleaning position together	471 / 472		5		x			
10	Clean 3 Port	Clean the 3 Port with a Rubber Scrapper	471 / 472	Q - 064	10		x			
11	Load onto Skid	Load the Main Assembly onto an empty skid and release the cylinder switch of the dipping jig	471 / 472		8		x			
12	Home position of Jig	Move the jig to the home position together	471 / 472		5		x			
13	Waiting	Wait for next core	471 / 472				x			
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks								
Mark the appropriate time type with "X":		Assembly: A/B/C =Value added / Non value added but necessary / Non value added			Max / Min-Time due to variants:				Safety Equipment:	
		Machining: A/B/C = Manual work time / Auto cycle time / Walk time							Reference Material	
Created by (Name & Date)		Production Approval (Name, Date)			Engineering Approval (Name, Date)					
		Foreman (A Shift):		Teamleader (A Shift):						
Version-No. (V47-AF)		Foreman (B Shift):		Teamleader (B Shift):						
V005		Foreman (C Shift):		Teamleader (C Shift):						



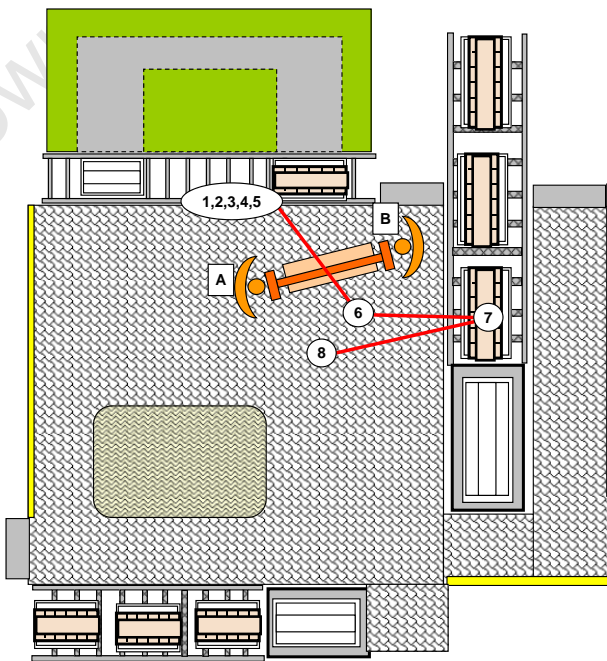

B.20 Standard Work Instruction of Dipping Station Operator B

 ATLANTIS FOUNDRIES <small>A Product Center of Mammoet-Buss Trucks</small>		Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>				Dipping - Core Assembly (WHEEL)							
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg.Cycle Time [min]				Base Model	SWI-No.	Rev. Date	Page (x / y)
Atlantis Foundries	Core Shop	14111	HD Line - Dipping Operator B(Wheel)	471 / 472	1.62						SWI-CS-040-471/472-005-B	19/03/12	1 / 1
No.	Job Element ("Verb - Object ")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)				
					total	A	B	C					
1	Move Together	Move towards Main Assembly together	471 / 472		5		x						
2	Locate Jig	Locate the Jig to the Main Assembly	471 / 472		4		x						
3	Align clamp position	Align clamp position and signal readiness to operator A	471 / 472		5		x						
4	Lift & Align Core	Lift the Assembly in alignment with Operator A	471 / 472		4		x						
5	Turn & Blow Off	Turn the Main Assembly 180° anti - clockwise than take the Airgun and blow off all loose sand on Core	471 / 472	Q - 065	7		x						
6	Transfer Core	Transfer the Main Assembly to Dipping position together towards the righthand side of propeller	471 / 472	Q - 066	8		x						
7	Dipping of Core	Dipping the Main Assembly to under the Filter Hole together (JES)	471 / 472	Q - 067	9	x							
8	Lift & Rotate Core	Lift & Rotate the wheel first 135 degrees clock wise, 270 anti clockwise and than to 305 degrees clockwise (JES)	471 / 472	Q - 068	10		x						
9	Cleaning Position of Core	Move the Main Assembly to the Cleaning position	471 / 472		8		x						
10	Clean End Core	Clean the End Core with a Rubber Scrapper (JES)	471 / 472	Q - 069	8		x						
11	Off Load onto Skid	Load the Main Assembly onto an empty Skid of the oven and wait for release	471 / 472		7		x						
12	Home position of Jig	Move the Dipping Jig to Home position together	471 / 472		4			x					
13	Wait	Waiting for next Core	471 / 472					x					
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													
24													
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks							Important Tools Used, Auxiliary Material & Devices, Testing Equipment: 				
Mark the appropriate time type with "X":		Assembly: A/B/C =Value added / Non value added but necessary / Non value added Machining: A/B/C = Manual work time / Auto cycle time / Walk time			Max / Min-Time due to variants:								
Created by (Name & Date)		Production Approval (Name, Date)			Engineering Approval (Name, Date)				Safety Equipment:				
		Foreman (A Shift):			Teamleader (A Shift):								
Version-No. (V47-AF)		Foreman (B Shift):			Teamleader (B Shift):								
V004		Foreman (C Shift):			Teamleader (C Shift):								



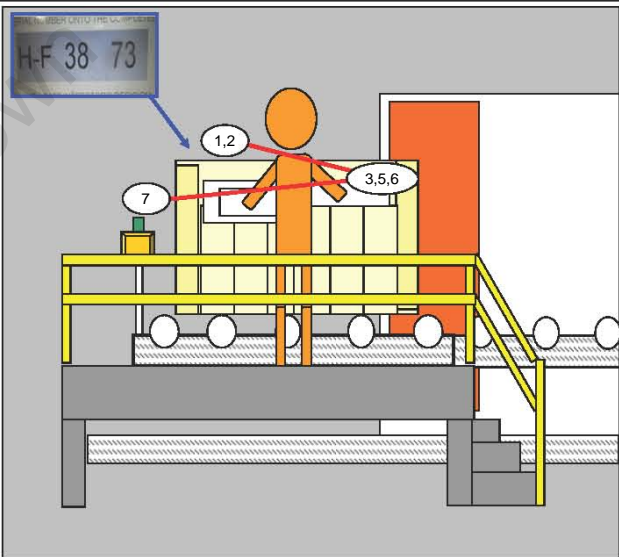


B.21 Standard Work Instruction of Oven Take off Station Operator A

 Atlantis Foundries <small>A Product Center of Mercedes-Benz Trucks</small>		Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>				HD - Oven Take Off							
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg.Cycle Time [min]				Base Model	SWI-No.	Rev. Date	Page (x / y)
Atlantis Foundries	Heavy Duty	14111	Oven Take Off - Operator A	471/472	1.62						SWI-CS-040-471/472-006-A	19/03/12	Page 1 / 1
No.	Job Element ("Verb - Object ")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)				
					total	A	B	C					
1	Torque bolts	Torque the two Bolts in the Main Assembly	471	Q - 070	10	x							
2	Clean core	Clean the Rear End Core with Steel Wool	471 / 472	Q - 071	6		x						
3	Move Jig	Move the Hoist Jig towards the Main Assembly	471 / 472		6		x						
4	Set Jig	Set the hoist Jig to the Main Assembly	471 / 472		4		x						
5	Hold hoist	Support and hold the hoist until clamping of Main Assembly position are reached.	471 / 472		5		x						
6	Move hoist	Move the Hoist towards the OFF Line tray	471 / 472		9		x						
7	Align Core	Align the Main Assembly on Off Line tray and Load	471 / 472		2		x						
8	Move hoist	Move the hoist back to Home position	471 / 472		6			x					
9	Waiting	Waiting for the next available Assembly	471 / 472					x					
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													
24													
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks											
Mark the appropriate time type with "X":		Assembly: A/B/C =Value added / Non value added but necessary / Non value added			Max / Min-Time due to variants:								
		Machining: A/B/C = Manual work time / Auto cycle time / Walk time											
Created by (Name & Date)		Production Approval (Name, Date)			Engineering Approval (Name, Date)				Reference Material				
		Foreman (A Shift):			Teamleader (A Shift):								
Version-No. (V47-AF)		Foreman (B Shift):			Teamleader (B Shift):								
V005		Foreman (C Shift):			Teamleader (C Shift):								
									Important Tools Used, Auxiliary Material & Devices, Testing Equipment:  				
									Safety Equipment:				



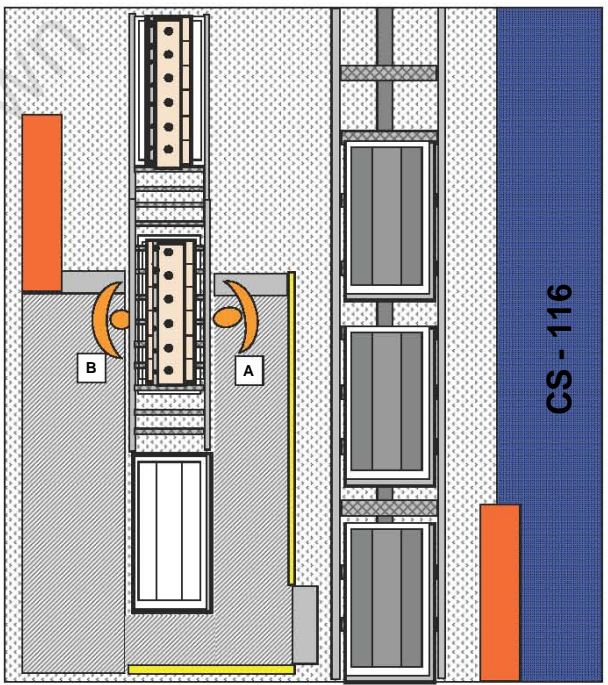





B.22 Standard Work Instruction of Oven Take off Station Operator B

 Atlantis Foundries <small>A Product Center of Mercedes-Benz Trucks</small>		Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>				Oven Take Off							
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg.Cycle Time [min]				Base Model	SWI-No.	Rev. Date	Page (x / y)
Atlantis Foundries	Heavy Duty	14111	Oven Take Off - Operator B	471/472	1.62						SWI-CS-040-471/472-006-B	19/03/12	Page 1 / 1
No.	Job Element ("Verb - Object ")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)				
					total	A	B	C					
1	Clean 3 Port	Clean the 3 Port Core with Steel Wool.	471 / 472	Q - 072	6		x						
2	Move Jig	Move the Hoist Jig towards the Main Assembly	471 / 472		6		x						
3	Set Jig	Set the hoist Jig to the Main Assembly	471 / 472		4		x						
4	Lock Jig	Push the Cylinder Switch and Lock the Jig	471 / 472		2		x						
5	Lift Jig	Lift the hoist Jig up by using an Overhead Crane.	471 / 472		2		x						
6	Press Button	Press the Push Button	471 / 472		2		x						
7	Move Jig	Move the Hoist towards the OFF Line tray	471 / 472		9		x						
8	Align Core	Align the Main Assembly on Off Line tray and Load	471 / 472		2		x						
9	Move Jig	Move the hoist back to Home position	471 / 472		6			x					
10	Waiting	Waiting for the next operation	471 / 472					x					
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													
24													
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks			Max / Min-Time due to variants:						Important Tools Used, Auxiliary Material & Devices, Testing Equipment: 		
Mark the appropriate time type with "X":		Assembly: A/B/C =Value added / Non value added but necessary / Non value added											
		Machining: A/B/C = Manual work time / Auto cycle time / Walk time									Safety Equipment:		
Created by (Name & Date)		Production Approval (Name, Date)			Engineering Approval (Name, Date)		Reference Material						
		Foreman (A Shift):			Teamleader (A Shift):								
Version-No. (V47-AF)		Foreman (B Shift):			Teamleader (B Shift):								
V005		Foreman (C Shift):			Teamleader (C Shift):								



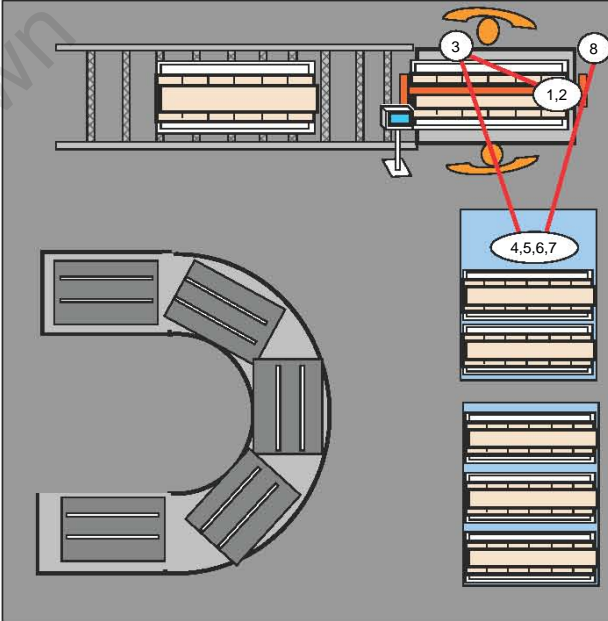
B.23 Standard Work Instruction of Drilling Station Operator A

 Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>			HD - Drilling										
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg.Cycle Time [min]				Base Model	SWI-No.	Rev. Date	Page (x / y)
Atlantis Foundries	Heavy Duty	14111	Flow Line Drilling	471/472	1.62						SWI-CS-040-471/472-007	19/03/12	Page 1 / 1
No.	Job Element ("Verb - Object ")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)				
					total	A	B	C					
1	Write on Package	Write the Date, time on the Main Assembly using Shopware Numbering System	471 / 472		10		x						
2	Drill Package	Drill the 9 holes ontop of the Main Assembly	471 / 472	Q - 073	9		x						
3	Set Jig	Set the Water Rail Jig to Main Assembly (H - Pic.ii)	471 / 472		3		x						
4	Drill Core	Drill 5 Holes in the Main Assembly Core	471 / 472	Q - 074	5		x						
5	Remove template	Remove the drilling template from Main Assembly	471 / 472		1		x						
6	Ready @ Scissors	Check when next Assembly is on Skid & Ready @ Scissors	471 / 472										
7	Push Button	Push the Push Button	471 / 472		1		x						
8													
9													
10													
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24													
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks							Important Tools Used, Auxiliary Material & Devices, Testing Equipment:  				
Mark the appropriate time type with "X":		Assembly: A/B/C =Value added / Non value added but necessary / Non value added Machining: A/B/C = Manual work time / Auto cycle time / Walk time			Max / Min-Time due to variants:								
Created by (Name & Date)		Production Approval (Name, Date)			Engineering Approval (Name, Date)				Reference Material				
Version-No. (V47-AF)		Foreman (A Shift):			Teamleader (A Shift):								
V007		Foreman (B Shift):			Teamleader (B Shift):								
		Foreman (C Shift):			Teamleader (C Shift):								

B.24 Standard Work Instruction of Drilling Station Operator B

 ATLANTIS FOUNDRIES <small>A Product Center of Mercedes-Benz Trucks</small>		Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>				Drilling							
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg.Cycle Time [min]				Base Model	SWI-No.	Rev. Date	Page (x / y)
Atlantis Foundries	Heavy Duty	14111	Flow Line Drilling - Operator B	471 / 472	1.62						SWI-CS-040-471/472-007-B	02-May-12	1 / 1
No.	Job Element ("Verb - Object ")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)				
					total	A	B	C					
1	Visually inspect Package	Visually inspect the Bypass & 6 Port Cores for any unacceptable defects	471 / 472										
2	Drilling Bypass Core	Drill the 2 Holes on top of the Bypass Core by using a Straight Drill fitted with a 4mm drill bit	471 / 472										
3	Drilling 6 Port Core	Drill the 5 Holes on top of the 6 Port Core by using a Straight Drill fitted with a 4mm drill bit	471 / 472										
4	Blow off	Blow off the package by using an Airgun	471 / 472										
5	Waiting	Wait for the next available package	471 / 472										
6													
7													
8													
9													
10													
11													
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14													
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16													
17													
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19													
20													
21													
22													
23													
24													
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks							Important Tools Used, Auxiliary Material & Devices, Testing Equipment:  				
Mark the appropriate time type with "X":		Assembly: A/B/C =Value added / Non value added but necessary / Non value added Machining: A/B/C = Manual work time / Auto cycle time / Walk time			Max / Min-Time due to variants:								
Created by (Name & Date)		Production Approval (Name, Date)			Engineering Approval (Name, Date)				Safety Equipment:				
		Foreman (A Shift): Foreman (B Shift): Foreman (C Shift):			Teamleader (A Shift): Teamleader (B Shift): Teamleader (C Shift):				  & / OR 				
Version-No. (V47-AF)									Reference Material				
V001													

B.25 Standard Work Instruction of Quality Inspection Station Operator A

 Atlantis Foundries <small>A Product Center of Mercedes-Benz Trucks</small>		Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>				Heavy Duty Inspection								
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg.Cycle Time [min]				Base Model	SWI-No.	Rev. Date	Page (x / y)	
Atlantis Foundries	Heavy Duty	14111	472 Inspection Operator A	471/472	1.62						SWI-CS-040-471/472-008-A	19/03/12	Page 1 / 1	
No.	Job Element ("Verb - Object ")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)					
					total	A	B	C						
1	Set Hoist	Set the Hoist Jig to the Main Assembly Core	472 / 471		8		x							
2	Push Button	Push the Cylinder lock button to secure the Hoist Jig to Main Assembly	472 / 471		1		x							
3	Inspect Package	Visually inspect the Drag side (6 Port Area) of the Main Assembly for any thick paint and cracks.	472 / 471	Q - 075	22		x							
4	Lift Jig	Lift up the hoist Jig & move it towards the off loading Pallet	472 / 471		13		x							
5	Load the Main Assembly	Load the Main Assembly on a Clean Blue Storage Pallet (H - Pic.iii)	472 / 471		3		x							
6	Unlock Cylinder	Once the Main Assembly is Load onto the Storage Pallet unlock the cylinder lock.	472 / 471		1		x							
7	Lift Jig	Lift up the Hoist Jig (H - Pic.iv)	472 / 471		2		x							
8	Waiting	Wait for the next Core Package	472 / 471					x						
9														
10														
11														
12														
13														
14														
15														
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18														
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Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks												
Mark the appropriate time type with "X":		Assembly: A/B/C =Value added / Non value added but necessary / Non value added			Max / Min-Time due to variants:						Safety Equipment:			
Created by (Name & Date)		Production Approval (Name, Date)			Engineering Approval (Name, Date)				Reference Material					
		Foreman (A Shift):			Teamleader (A Shift):									
Version-No. (V47)		Foreman (B Shift):			Teamleader (B Shift):									
V006		Foreman (C Shift):			Teamleader (C Shift):									



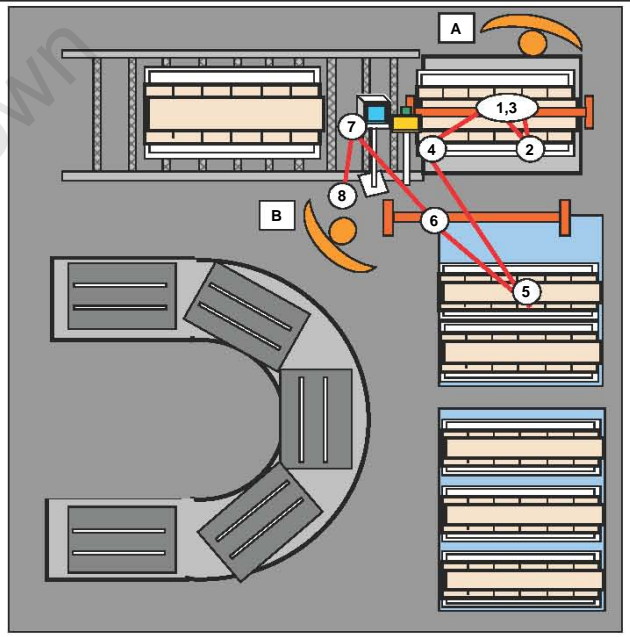


Picture i



Picture ii

B.26 Standard Work Instruction of Quality Inspection Station Operator B

 ATLANTIS FOUNDRIES <small>A Product Center of Mercedes-Benz Trucks</small>		Standard Work Instruction (SWI) <small>(Form 022 Issue A 13/02/2012)</small>				Heavy Duty Inspection								
Plant/Center	Department	Cost Center	Group, Line, Station / Operation or Machine	Model / Type	Takt Time [min]	Avg.Cycle Time [min]				Base Model	SWI-No.	Rev. Date	Page (x / y)	
Atlantis Foundries	Heavy Duty	14111	472 Inspection Operator B	Inspection	1.62						SWI-CS-040-471/472-008-B	19/03/12	Page 1 / 1	
No.	Job Element ("Verb - Object ")	Details to Job Element	Variants	Symbol & JES-No.	100% Times [sec]				Layout / Spaghetti Diagram (descriptions / pictures optional)					
					total	A	B	C						
1	Set jig	Set the Hoist Jig to the Main Assembly Core	472 / 471		8		x							
2	Inspect assembly	Visually inspect the Cope Side (W/Rail) of the Main Assembly for any thick paint, cracks and Core Flash	472 / 471	Q - 076	15		x							
3	Lift Jig	Lift up the hoist Jig & move it towards the off loading Pallet	472 / 471		13		x							
4	Push Button	Press the Push Button for an empty Off Bay Flowline Tray	472 / 471		5		x							
5	Load the Main Assembly	Load the Main Assembly on a Clean Blue Storage Pallet (H - Pic.i)	472 / 471		3		x							
6	Lift Jig	Lift up the Hoist Jig (H - Pic.ii)	472 / 471		2		x							
7	Push Button	Push the accept button on the Shopware Monitor	472 / 471		2		x							
8	Waiting	Waiting for next operation	472 / 471					x						
9														
10														
11														
12														
13														
14														
15														
16														
17														
18														
19														
20														
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24														
Key to Symbols:		S=Safety / Ergonomics; Q=Quality; H=Hints & Tricks												
Mark the appropriate time type with "X":		Assembly: A/B/C =Value added / Non value added but necessary / Non value added			Max / Min-Time due to variants:						Safety Equipment:			
Created by (Name & Date)		Production Approval (Name, Date)			Engineering Approval (Name, Date)				Reference Material					
		Foreman (A Shift):			Teamleader (A Shift):									
Version-No. (V47-AF)		Foreman (B Shift):			Teamleader (B Shift):									
V005		Foreman (C Shift):			Teamleader (C Shift):									



Picture i



Picture ii