UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

FRONT PAGE FOR FINAL PROJECT DOCUMENT (BPJ 420) - 2012	
Information with regards to the mini-dissertation	
Title (e.g. A Contingency framework for the after-sales inventory at Xxxxx Part Distribution Centre)	A Changeover Reduction Project on line 7 SAB-Alrode
Author (Last name, Initial(s) e.g. Botha, P.J.)	Groenewald, E
Student number	29467595
Supervisor/s (Last name, Initial(s) e.g. Botha, P.J.)	Breytenbach, W
Date (year/month/day) e.g. (2012/10/08)	2012/10/17
Keywords (Provide keywords from your project (for searching purposes). The first word of two words must always have a capital first letter and the rest of the words following must be lower case. In the event of an abbreviation, use as it is known. E.g. Economic recession, ABSA, ERP, Simulation modelling)	Changeover reduction, Lean manufacturing, Sixsigma, DMAIC, Training template, Statistical process measures, Best practices, FMEA, Cause and effect, Process maps
Abstract (Provide an abstract of the mini-dissertation. An abstract is a short summary of the contents covered in the item.)	SAB Alrode sets various operational targets, amongst others; changeover time. Currently, Brand Pack changeover time on Line7 is inconsistent and needs to be reduced to an absolute minimum in order to ensure maximum production and profitability. A Data Analysis is conducted in order to understand the process and redefine the problem statement. Thereafter, a Literature study is conducted to identify possible tools in reducing the changeover inconsistency. Tools such as Process Maps, Cause & Effect diagrams and a Failure Mode and Effect Analysis will be completed following the DMAIC structure. Relevant improvements are recommended, verified and a conclusion is reached.
Category (Enter the category in which the project was done. E.g. Operations Research, Simulation, Logistics…)	Quality assurance and lean manufacturing

Declaration

1. I understand what plagiarism is and I am aware of the University's policy in this regard.
2. I declare that this is my own original work
3. Where other people's work has been used (either from a printed source, internet or any other source) this has been carefully acknowledged and referenced in accordance with departmental requirements
4. I have not used another student's past work to hand in as my own
5. I have not allowed and will not allow, anyone to copy my work with the intention of handing it in as his/her own work

Signature	

Changeover Reduction Project on Line 7 SAB Alrode

by

ETRECIA GROENEWALD
29467595

Submitted in partial fulfilment of the requirements for the degree of

BACHELORS OF INDUSTRIAL ENGINEERING

in the

FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION TECHNOLOGY

UNIVERSITY OF
PRETORIA

October 2012

Executive Summary

SAB Alrode sets various operational targets, amongst others; changeover time. Currently, Brand Pack changeover time on Line7 is inconsistent and needs to be reduced to an absolute minimum in order to ensure maximum production and profitability. A Data Analysis is conducted in order to understand the process and redefine the problem statement. Thereafter, a Literature study is conducted to identify possible tools in reducing the changeover inconsistency. Tools such as Process Maps, Cause & Effect diagrams and a Failure Mode and Effect Analysis will be completed following the DMAIC structure. Relevant improvements are recommended, verified and a conclusion is reached.

Contents

List of Figures

List of Tables

Glossary of Abbreviations

BW	-	Bottle Washer
CO	-	Change Over
Depal	-	Depalletiser
EBI	-	Electronic Bottle Inspector
LCL	-	Lower Control Limit
Lab	-	Labeller
PrePal	-	Pre-palletiser
PFBI	-	Preliminary Full Bottle Inspector
UCL	-	Upper Control Limit

1. Introduction and Background

1.1 Company Background

Founded in 1895, the South African Breweries Ltd (SAB) is the South African home and birthplace of SABMiller, one of the world's largest brewers. SABMiller produces more than 200 brands and distributes beer in 75 countries across six continents.

SAB is South Africa's leading brewer and primary distributor of beer and soft drinks.For over 115 years SAB has been a central part of the community and country and carries on to play a vital role in the national economy.

The company runs seven breweries and 40 depots in South Africa with an annual brewing capability of 3.1 billion litres. Its collection of beer brands includes five of the country's six most common beer brands – namely Carling Black Label, Hansa Pilsner, Castle Lager, Castle Lite and Castle Milk Stout. In total SABMiller produces ten beers and five flavoured alcoholic beverages.

The soft drinks division, Amalgamated Beverage Industries (ABI), is one of the largest producers and distributors of Coca-Cola brands in the southern hemisphere. There are a total of five advanced manufacturing plants in South Africa.

SAB also boasts a hop production company, The South African Breweries Hop Farms (Pty) Ltd; a barley farming corporation, The South African Breweries Barley Farms (Pty) Ltd; a barley malting firm, The South African Breweries Malting's (Pty) Ltd; and a 60% share in Coleus Packaging (Pty) Ltd, a metal crown manufacturer.

1.2 Project Background

This project is planned to be executed at the Alrode brewery in Gauteng. Built in 1965, this brewery is the largest in the Southern Hemisphere and produces 1.9million litres of beer each day. The changeover reduction project is planned on Line7 in Alrode, specifically focussing on the change over time between different Brand Packs. Line7 is a Multi-Pack line and produces only returnable bottles.

A pallet of bottles will arrive at the start of the production line, these bottles are shifted onto a conveyor belt and the process is started. The bottles move towards the De-crowner where left over crowns are removed. Next, the bottles make their way through to the Uncaser, this is where the cases and bottles split into different lines. The bottles move towards the Bottle Washer followed by the Electronic Bottle Inspector. The Filler then fills the bottles with the

given beer and the bottles are crowned. Just before the bottles leave the Filler they go through the Preliminary Full Bottle Inspector (PFBI). This is followed by the Pasteuriser and Labeller. The bottles and crates meet up again at the Packer. Lastly, the crates are palletised and sent to the warehouse

1.3 Types of Changeovers

Two types of changeovers are found on Line 7, Brand and Size changeovers.

1.3.1 Brand Changeover

A brand changeover takes place between the 750ml bottles;

- Castle Larger
- Hansa Pilsener
- Castle Milk Stout

Brand changeovers imply that the label and the crown will change. Thus, there is only a raw material change and most of this will take place at the Labeller. Also, the “old” beer must be flushed and the containers must be replaced with the “new” beer. The flush takes about 10min.

1.3.2 Size Changeover

A size changeover is for any changes between 750ml, 660ml and 500ml;

- 750ml (Castle Milk Stout, Castle Lager, Hansa Pilsner)
  - 660ml Castle Light
  - 500ml Castle Draught
  - 660ml Miller Genuine Draught
- 660ml (Castle Lite)
  - 750ml*
  - 500ml Castle Draught
  - 660ml Miller Genuine Draught
- 500ml (Castle Draught)
  - 750ml*
  - 660ml Castle Lite
  - 660ml Miller Genuine Draught
- 660ml (Miller Genuine Draught)
  - 750ml*
  - 660ml Castle Lite
  - 500ml Castle Draught

(750ml* = Castle Milk Stout, Castle Lager, Hansa Pilsner)

2. Problem Statement

SAB Alrode sets various operational targets, amongst others; changeover time. Line7 is a Multi-Pack line producing different bottle sizes and also different brands. Currently, Brand Pack changeover time on Line7 is inconsistent and needs to be reduced to an absolute minimum to ensure maximum production and profitability. It is also important to eliminate any waste in the form of time. These Brand Pack changeover times are also used as part of the lines Efficiency Calculation which currently have a severe negative impact on the Packaging Halls Daily Efficiency results.

The changeover is limited to returnable bottles and the process involves the change from one Brand Pack to another Brand Pack with quality as the counter balance. Brand Pack changeover time directly upsets Alrodes's ability to accomplish its complete Brand Pack Reliability of 100%. Reducing the variability in these changeover times would contribute to Alrodes's overall goal.

3. Project Aim

The aim of this project is to successfully reduce the Brand Pack change over time on line 7, at Alrode SAB. Currently, the target value of 90min per Filler and Labeller needs to be reduced to a new entitlement if possible.

Benefits will include, but are not limited to, the following;

- Internal customer: will benefit by achieving Efficiency targets.
- External customers: will benefit through more Brand Pack reliability.

4. Project Scope

Project scope is limited to Brand Pack changeover on Alrode line7 with the process ranging from the Depalletiser to Palletiser. The data used for analysis purposes in this project is from the last "good" bottle of one Brand Pack to the first "good" bottle of the next Brand Pack. Line7 is limited to returnable bottles including; 750ml Castle Larger/Hansa Pilsner/Castle Milk Stout, 660ml Castle Light, 660ml Miller Genuine Draft and 500ml Castle Draft.

Certain aspects excluded from this scope are raw materials and warehouse, other than the supply interfaces. It is assumed that raw materials such as bottles, labels and crowns will be available. The changeover also excludes breakdowns during brand change. Full machine setup though, is included in the changeover. Also, any downtime at any machine downstream from the fillers (resulting in the filler stopping or slowing down) due to changes made for a new Brand Pack should be added to the Brand Pack change over time.

Major changeovers are investigated at the Filler and the two Labellers as these processes require most of the line operators and take the longest.

Process Flow

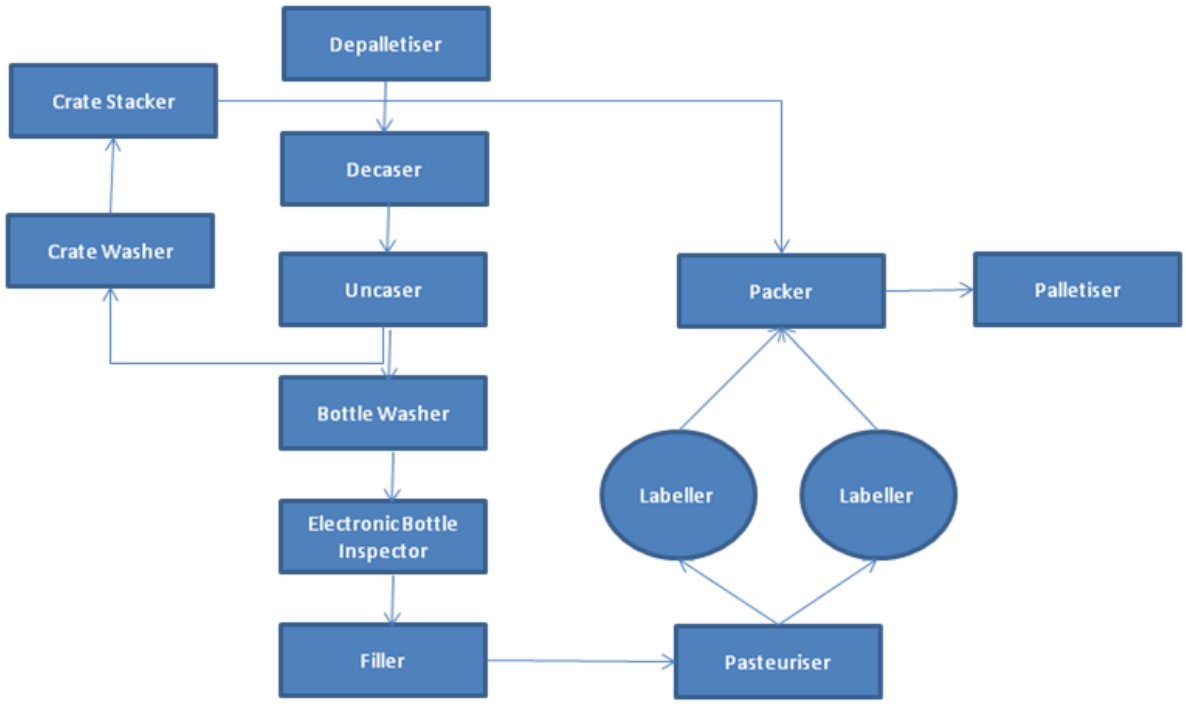


Figure 1 - Process Flow Diagram

5. Problem definition

5.1 Historical Data

Historical changeover times of both the Filler and the Labeller was collected and is shown in Appendix A. Unfortunately, only historical data points were available for the Filler, while several missing times regarding Labeller 1 & 2 are noted. Also, only mixed Size Changeover times were made available.

5.2 Data Analysis

To define the AS-IS process performance, the data is analysed against Xbar- and MRbar-Charts, given the data is variable data in the form of single readings.

MRbar Chart

This chart is relatively straightforward. The range between all the data points is calculated, in other words; X2-X1= range point. This new set of data is then plotted against the average range line (MRbar) the Upper Control Limit (UCL) and the Lower Control Limit. The average

line depicts the average of all the data points, whereas the upper and lower control limits are three times the standard deviation above and below the average line, or as theory states;

UCL = (3.267)*MRbar
LCL = (0)*MRbar
(The answer is more or less the same)

Xbar Chart

This is a basic chart that plots the changeover times. These times are then analysed against the average (Xbar), upper control limit (UCL) and the lower control limit (LCL). The Xbar line is the average of all the data points whereas the UCL and LCL are calculated as follows;

UCL = Xbar + (2.66)*MRbar

LCL = 0

5.2.1 Filler

Date	2011/11/14	2011/11/21	2011/12/06	2012/01/17	2012/02/03
Target	90	90	90	90	90
Time	147	131	180	57	90
Range		16	49	123	33
UCL(Rbar)	180.50175	180.50175	180.50175	180.50175	180.50175
Mrbar	55.25	55.25	55.25	55.25	55.25
LCL(Rbar)	0	0	0	0	0
UCL(Xbar)	267.965	267.965	267.965	267.965	267.965
Xbar	121	121	121	121	121
LCL(Xbar)	0	0	0	0	0

Table 1 - Filler Changeover Times

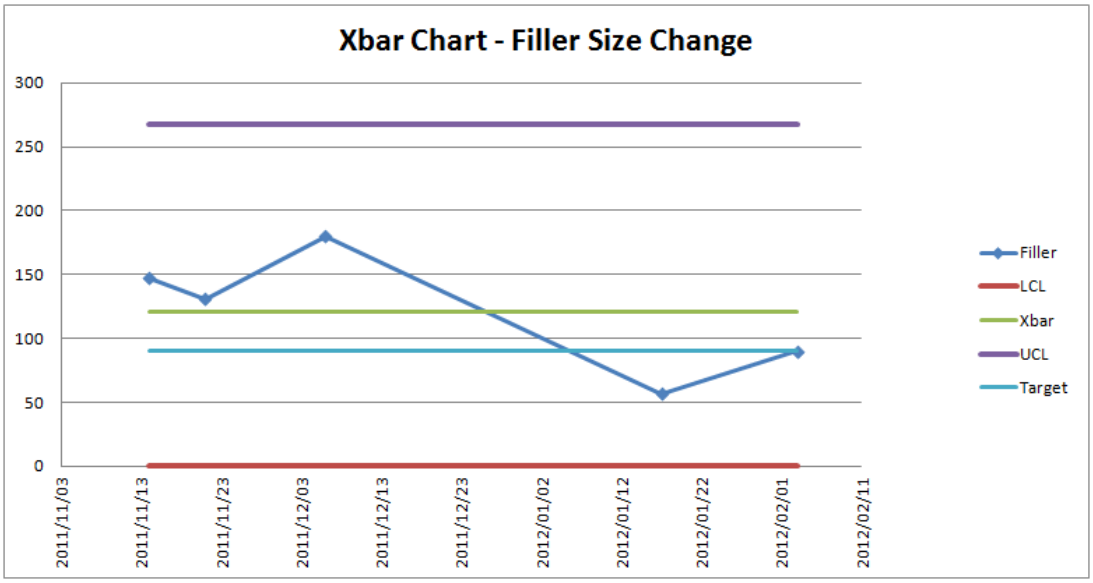


Figure 2 - Xbar Chart Filler Size Change

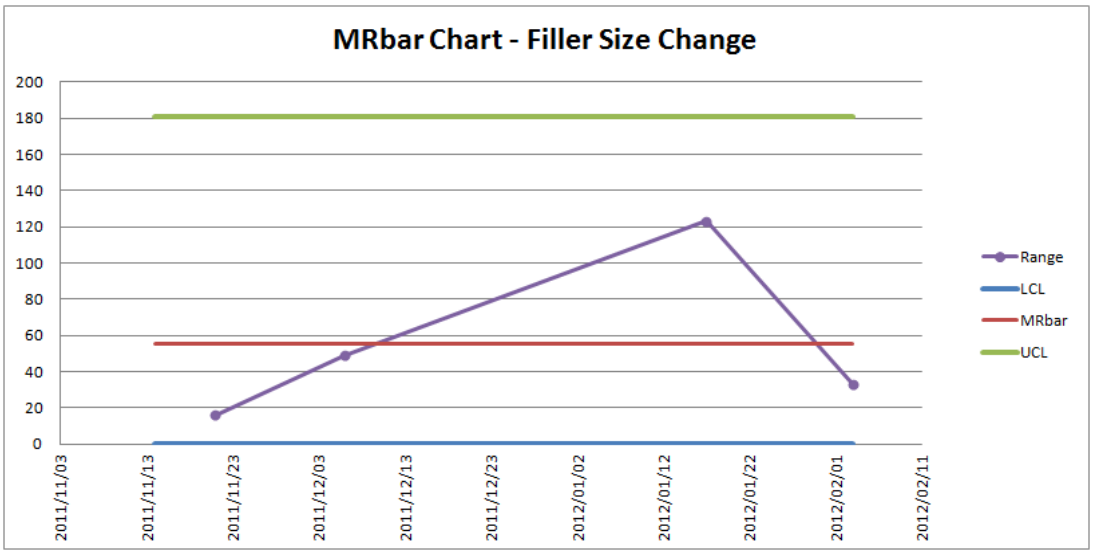


Figure 3 - MRbar Chart Filler Size Change

Interpretation

The MRbar-Chart, figure 3, shows huge variation. Changeover times differ with as much as 120mins and are very inconsistent. The Xbar-Chart, figure 2, depicts some good points with a low of 57mins, but the process is still inconsistent with an average larger than 90mins.

5.2.2 Labeller 1

Reading	1	2	3	4	5	6	7	8	9	10
Target	90	90	90	90	90	90	90	90	90	90
Time	209	204	60	220	240	90	180	90	30	100
Range		5	144	160	20	150	90	90	60	70
UCL(Rbar)	286.407	286.407	286.407	286.407	286.407	286.407	286.407	286.407	286.407	286.407
Mrbar	87.6667	87.6667	87.6667	87.6667	87.6667	87.6667	87.6667	87.6667	87.6667	87.6667
LCL(Rbar)	0	0	0	0	0	0	0	0	0	0
UCL(Xbar)	375.493	375.493	375.493	375.493	375.493	375.493	375.493	375.493	375.493	375.493
Xbar	142.3	142.3	142.3	142.3	142.3	142.3	142.3	142.3	142.3	142.3
LCL(Xbar)	0	0	0	0	0	0	0	0	0	0

Table 2 – Labeller1 Changeover Times

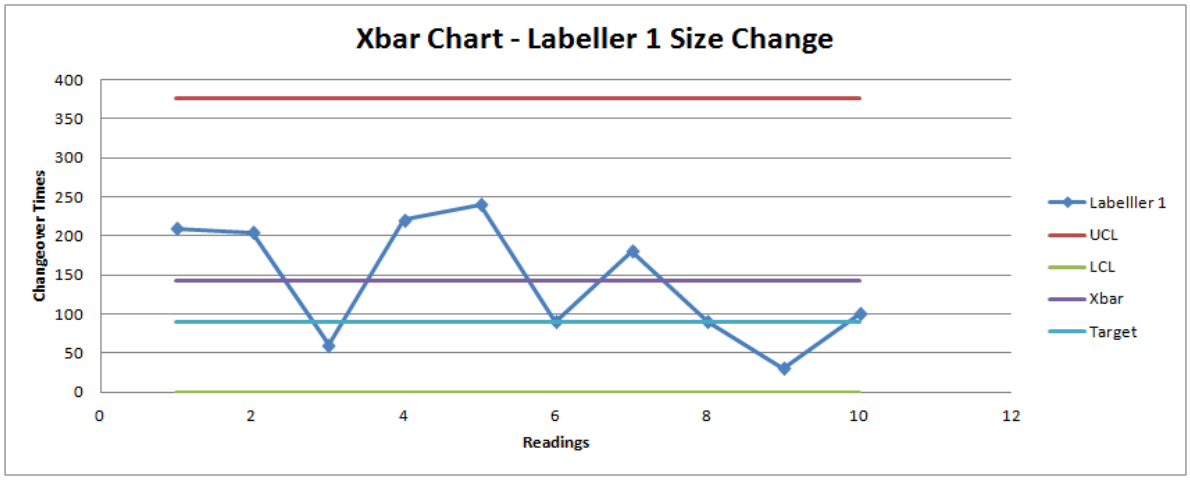


Figure 4 - Xbar Chart Labeller 1 Size Changeover

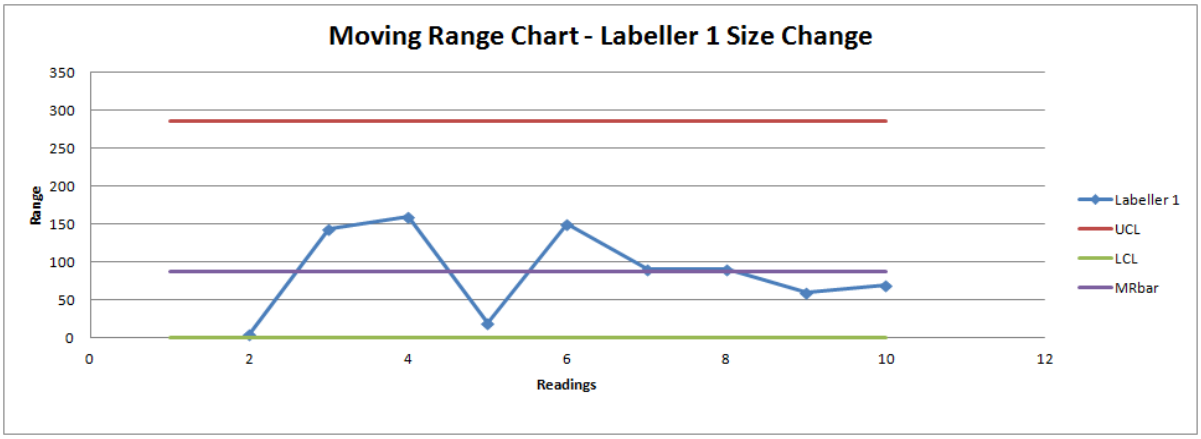


Figure 5 - MRbar Chart Labeller 1 Size Change

Interpretation

When analysing Labeller 1 it is seen from the Xbar Chart, figure 4, that a process low of 30min has been reached in the past. The process also depicts a stable tendency and has an average of about 142mins.

5.2.3 Labeller 2

Reading	1	2	3	4	5	6	7	8	9	10	11
Target	90	90	90	90	90	90	90	90	90	90	90
Time	180	68	115	160	125	110	180	100	100	30	110
Range		112	47	45	35	15	70	80	0	70	80
UCL(Rbar)	180.992	180.992	180.992	180.992	180.992	180.992	180.992	180.992	180.992	180.992	180.992
Mrbar	55.4	55.4	55.4	55.4	55.4	55.4	55.4	55.4	55.4	55.4	55.4
LCL(Rbar)	0	0	0	0	0	0	0	0	0	0	0
UCL(Xbar)	263.546	263.546	263.546	263.546	263.546	263.546	263.546	263.546	263.546	263.546	263.546
Xbar	116.182	116.182	116.182	116.182	116.182	116.182	116.182	116.182	116.182	116.182	116.182
LCL(Xbar)	0	0	0	0	0	0	0	0	0	0	0

Table 3 - Labeller2 Changeover Times

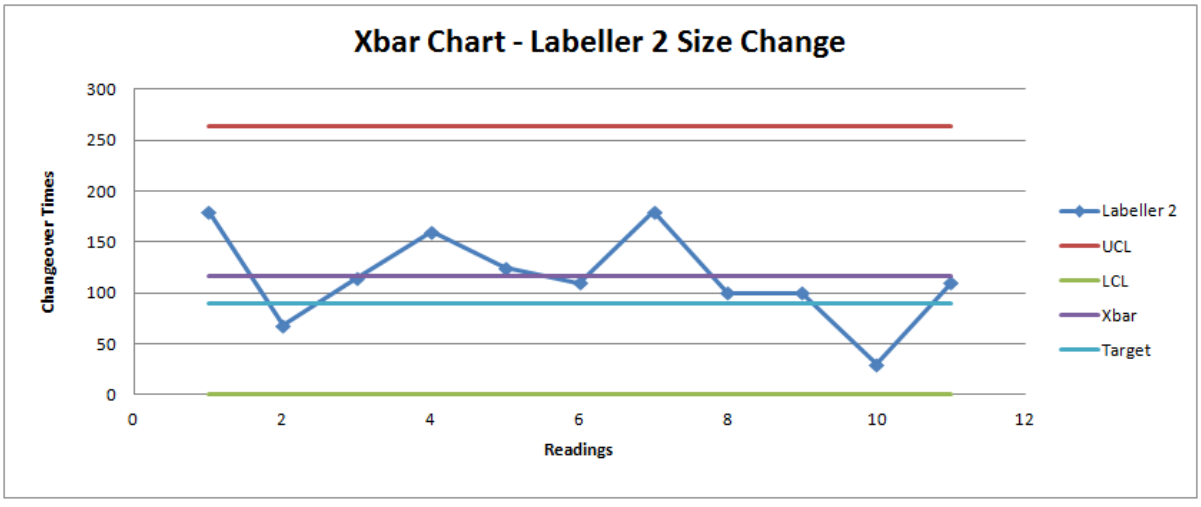


Figure 6 - Xbar Chart Labeller2 Size Change

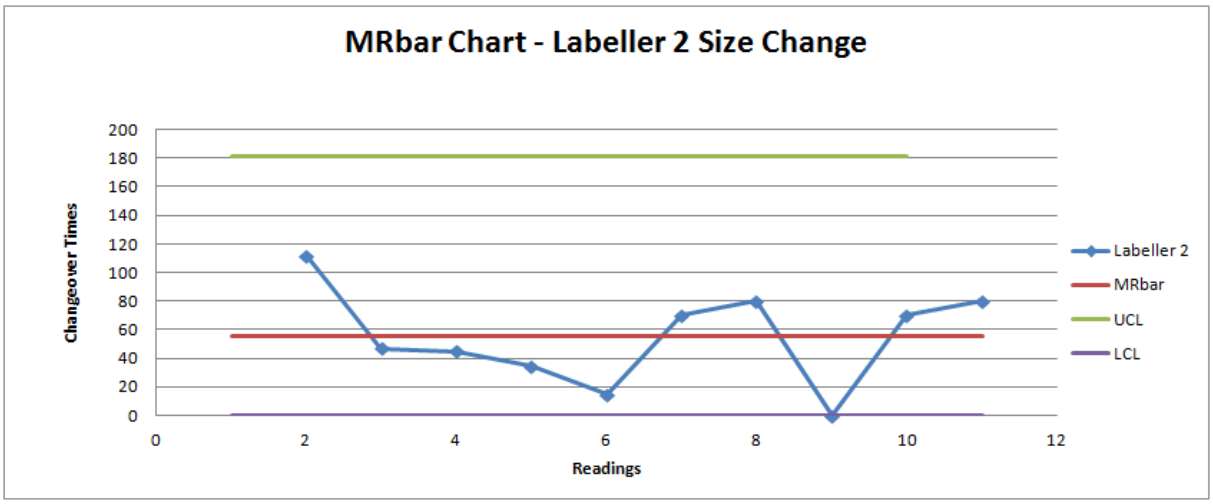


Figure 7 - MRbar Chart Labeller2 Size Change

Interpretation

Once again, according to figure 6, the process is stable and has reached a minimum of 30mins. An average line of about 116mins exists.

5.2.4 Labeller 1&2

A further analysis of Labeller 1 & 2 is made. When the complete process of the two labellers is taken into account, it might be meaningful to combine the data of both Labeller 1&2. This is because the process can't continue without both the labellers working. In essence, they have to "work together as one".

(Data is found in Appendix B)

Thus, the following Xbar Chart and MRbar Chart were created:

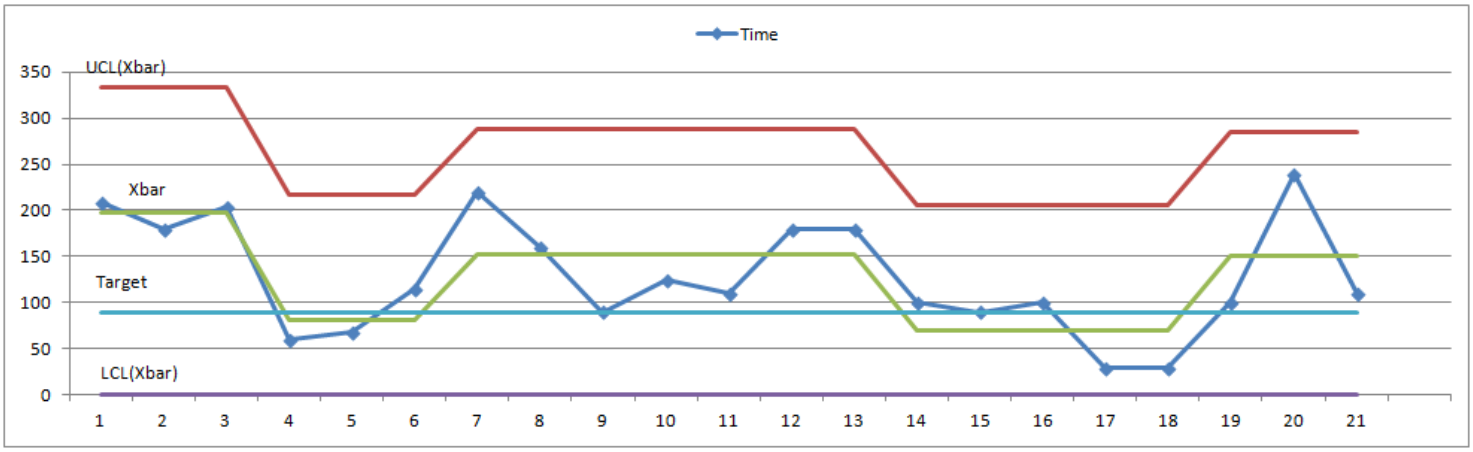


Figure 8 - New Xbar Chart

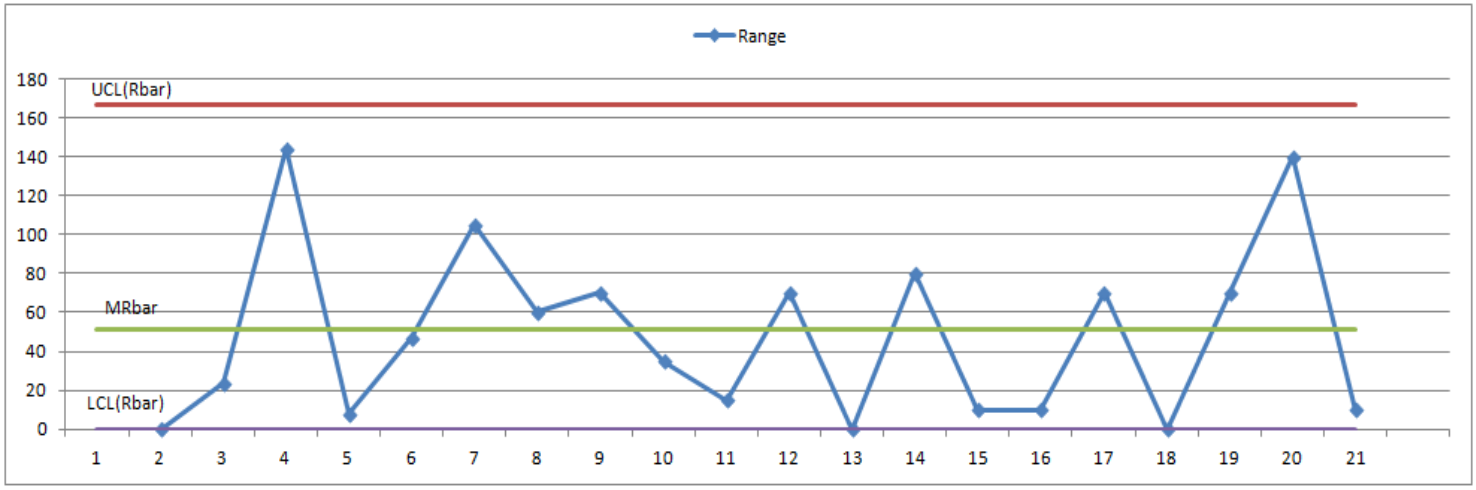


Figure 9 - New MRbar Chart

Interpretation

It must be noted that with the new Xbar Chart, figure 8, the Xbar line, UCL and LCL are adapted each time the complete process reaches a 'new best'. Thus, each time the process performs according to a new low; these data points are group into subgroups and plotted according to their own new average and control limits.

By analysing these charts, the process low is still at 30mins.

5.3 Targets

By analysing each process on its own a good representation of each individual process is clearly depicted. In order to complete the data analysis a final comparison of the Averages and process Best Evers must be made. These values must be compared to each other due to the fact that the total changeover will only take as long as the longest process. In the same way, it can be measured according to the shortest process if controlled in the correct manner.

	Best ever	Average
Filler	57	121
Labeller 1	30	142
Labeller2	30	116
Labeller 1&2	30	200

Table 4 - Comparison Data

Thus, by making this simple comparison and comparing it to the voice of the customer (90min), it is found that the Best Ever of 30min is reachable. But, it must also be noted that in each case the Average is very far from the Best Ever. Thus, the new entitlement will still follow the voice of the customer and be 90mins.

5.4 Analysis Conclusion

By analysing the historical data, it is clearly seen that there is a lot of room for improvement. Process improvements can rather be focussed on minimising the variation in the total process and identifying and eliminating the process constraints.

A literature study will reveal the best possible technique to use in order to identify the problem areas.

6. Literature study

6.1 Introduction

When analysing the problem at Alrode Breweries, it is clear that the appropriate methods and problem solving techniques concerned with changeover reduction must be studied. A changeover, also referred to as a set-up, can be defined as the time elapsing from the last manufactured product leaving the line all the way to the first new manufactured product coming out. Various techniques can be used in order to optimise these elements such as Six Sigma, SMED, Lean Manufacturing and Quick Changeover Technology.

6.2 Six Sigma

Six Sigma is a business managing approach related to the current system that seeks to improve all areas of quality. The output worth is achieved by eliminating and identifying the specific causes of faults or defects and also by reducing the inconsistency in the process. Six Sigma includes both the manufacturing and business processes.
From the statistical viewpoint, the term six sigma is defined as achieving a success rate of 99.9997% or by having an average of 3.4 defects per million opportunities. Sigma is a term used to signify the inconsistency or variation around the process average (Antony and Banuelas, 2002).

Six sigma is a methodical, data-driven approach that uses the define, measure, analysis, improve, and control (DMAIC) process and utilizes design for six sigma technique (DFSS) (GE, 2004).

6.2.1 The DMAIC Process

DMAIC is a closed-loop practice that identifies and eliminates fruitless steps by focusing on new measurements and applying technology for constant improvement (Kwak and Anbari, 2006). Firstly, the project boundaries and scope is defined with regards to the customer. The process is then measured and the correct data is collected, defects and causes of variation are then identified. Lastly, the process is improved and controlled.

Each phase has various techniques that apply to it; these techniques differ in each organisation.

Techniques that typically apply:

Define

- Meet up with the customer
- Develop the problem statement
- Propose a project charter
- Best State
- Identify resources
- Develop the budget

Measure

- Develop the AS-IS Map
- Develop Process Map Hi
- Develop Process Map Low
- Create a Cause and Effect diagram
- Initial data and gathering plan
- Measure System Analysis
- Basic Stats
- Continuous Capability study

Analyse

- Conduct Failure Mode and Effect Analysis
- Set-up Multi-Vari Plan
- Selection of tests

Improve

- Conduct Experiments
- Implement improvements
- Develop Should Map

Control

- Develop control plan
- Hand off training
- Conduct final capability

6.2.2 The DFSS Process

This process is comparable to the DMAIC Process and is short for Design for Six Sigma. Unlike the DMAIC style, the steps or phases of DFSS are not generally acknowledged or defined (Hallowell,2010). Many businesses will define their own DFSS to suite their business environment. Generally, the DMADV approach is used, including the five steps of define, measure, analyze, design, and verify. Figure 10 depicts the five step process.

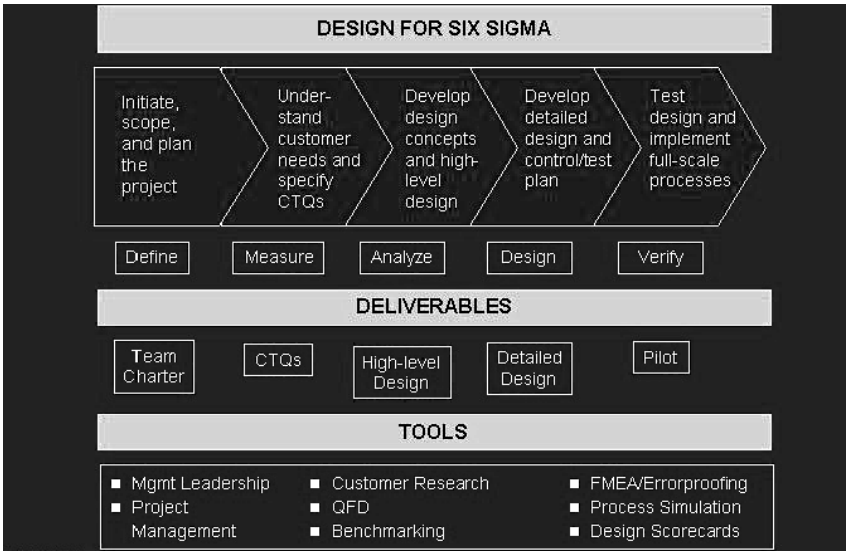


Figure 10 - 5Step DFSS Process (adapted from de Feo and Bar-El, 2002).

Six Sigma is also used together with Lean Manufacturing; this is known as Lean Six Sigma.

6.2.3 Lean Six Sigma

Lean Six Sigma plays an immense role in combining the results from the use of Lean Manufacturing, effective and efficient set-ups, with the quality improvement that is achieved by the use of Six Sigma (SixSigmaOnline, 2007).

Six Sigma is known for its data driven methods that identify and eliminate faults. As mentioned, this method runs from manufacturing through to business viewpoints. Lean Manufacturing's goal is speeding up the performance of a process and also eliminating unwanted steps that do not add value. The combination of these two produces one distinct process flow that consolidates factors that help in improving the quality of an organisation.

(*further explanation of Lean Manufacturing is found later in the paper)

6.2.4 Benefits of Six Sigma

Various case studies have shown the success of implementing Six Sigma. As a division of an improvement program, Motorola was the first institute to use the expression Six Sigma for the use of performance measurement (Kwak and Anbari, 2006). Six Sigma can be implemented in a range of organisational sectors such as financial, research and development, engineering and healthcare. Table 5 summarises reported benefits and savings in the manufacturing sector.

Company/project	Metric/measures	Benefit/savings
Motorola (1992)	In-process defect levels	150 times reduction
Raytheon/aircraft integration systems	Depot maintenance inspection time	Reduced 88% as measured in days
GE/Railcar leasing business	Turnaround time at repair shops	62% reduction
Allied signal (Honeywell)/laminates plant in South Carolina	Capacity Cycle time Inventory On-time delivery	Up 50% Down 50% Down 50% Increased to near 100%
Allied signal (Honeywell)/bendix IQ brake pads	Concept-to-shipment cycle time	Reduced from 18 months to 8 months
Hughes aircraft's missiles systems group/wave soldering operations	Quality/productivity	Improved 1,000%/improved 500%
General electric	Financial	$2 billion in 1999
Motorola (1999)	Financial	$15 billion over 11 years
Dow chemical/rail delivery project	Financial	Savings of $2.45 million in capital expenditures
DuPont/Yerkes plant in New York (2000)	Financial	Savings of more than $25 million
Telefonica de espana (2001)	Financial	Savings and increases in revenue 30 million euro in the first 10 months
Texas instruments	Financial	$ 600 million
Johnson and Johnson	Financial	$ 500 million
Honeywell	Financial	$1.2 billion

Table 5 - Reported benefits from Six Sigma (adapted from Kwak and Anbari, 2006)

The basis of this project must be formed around the Six Sigma DMAIC Methodology. Certain aspects of DMAIC have already been completed, such as this Literature Study and Basic Stats (Data Analysis). Further incorporation of aspects such as Process Map HI & LOW, Cause & Effect and FMEA will be used in order to identify possible problems that occur at the Filler and the labeller.

6.3 Lean Manufacturing

This is a process of eliminating waste along the overall value stream while providing the ultimate value or worth to the customer. Lean manufacturing means that your facilities are operating at the best efficiency with the smallest amount of waste, the least amount of assets on hand and the least potential number of employees, the maximum state of quality, the shortest order and deliver cycle of the completed products by not over or under producing, and that the goods are delivered to the customer just on time (Bodek, 2005). The process of Lean Manufacturing was first designed and implemented in the early 1940's by Toyota, Japan. Toyota decided to produce according to the customer demands, unlike the mass production philosophies of Henry Ford.

Quatermann Lee (2005) recommends six steps to implementing a Lean Manufacturing system:

1. Assess the existing system.
2. Develop the future-state workflow.
3. Recognize future-state infrastructures.
4. Identify your own lean techniques and elements.
5. Identify the priorities and precedents for the chosen technique.
6. Develop the strategy.

Every business will eventually use different elements and techniques to suite their own specific problem. No one methodology can be applied to every business environment, thus step 4 will differ in every situation.

Melton explains a few of these techniques:

- Kanban—a visual warning sign to sustain flow by 'pulling' products through the manufacturing process as demanded by the customer.
- 5 S's—a visual maintenance technique; Sort, Standardise, Set-in-order, Sustain and Shine.
- Poka yoke—a mistake proofing technique.
- SMED (single minute exchange of dies)—a changeover reduction practice.

(adapted from Melton, 2005)

6.3.1 SMED

Single minute exchange of dies is one of the Lean Manufacturing methods for reducing and eliminating waste in a manufacturing process. It provides a quick and efficient way of converting a manufacturing process from one product to the next.

There are seven basic steps to the SMED system:

1. Study the current line.
2. Part the internal and external activities. Internal activities are those that can only be completed when the process has stopped, external activities can be done while the process is still busy.
3. Convert internal activities into external activities (where possible).
4. Streamline the left over internal activities by simplifying them.
5. Streamline the external activities.
6. Document the new process.
7. Do it all again, continuing in this manner numerous times will ultimately cross the "single minute" line.

Three types of waste area also identified during changeovers; setup, replacement and adjustment waste, which refers to any unnecessary activities performed during these phases that waste time, energy and ultimately money. This must be kept in mind when identifying all the internal and external activities.

If changeovers at the Filler and the Labeller are not done with best practices in mind, this could be a possible cause of variation. Both changeovers must be studied and if they are not efficient SMED must be used in order to develop best practices.

6.4 Quick Changeover Techniques

The 'quality' of a changeover is mainly influenced by three primary elements: technical aspects of the tools and equipment, the organisation or administration of the work ('who does what when') and the technique or method followed (Goubergen and Landeghem,2002). These three elements have to work in correspondence with each other.

6.4.1 Equipment Design

The designer is the only one who can control set-up times in advance, before real set-ups are conducted (Goubergen and Landeghem,2002). It is much cheaper to implement changes on the equipment in the design phase than in the actual product production phase. Also, it is important for the designer to create equipment that requires little physical effort and adjustments. The designer must be aware of all the aspects of the changeover in order to design 'set-up friendly' equipment.

Table 6 depicts a few important rules for designing equipment to suite changeovers.

1. Less weight
1.1 Use lighter materials
1.2 Use less material
2. Simplification
2.1 Reduce number of mechanisms
2.2 Eliminate the need to remove non changeover parts
2.3 Eliminate the need to remove complete assemblies
2.4 Eliminate pipe connections or use quick release couplings
2.5 Reduce the number of hand/powertools required
2.6 Reduce the total number of components in a tool
2.7 Simplify control procedures such as timing diagrams
2.8 Use short power drive connections
3. Standardization
3.1 Use the same size shut heights for presses
3.2 Use the same size securing bolts
3.3 Use the same type of electrical motors
4. Securing
4.1 Use the minimum number of fasteners consistent with strength
4.2 Eliminate manually operated clamps
4.3 Use $\frac{1}{4}$ turn devices
5. Location and adjustment
5.1 Eliminate on-machine adjustments
5.2 Provide intelligent adjustment and monitoring
5.3 Eliminate the use of spacers and shims
5.4 Provide dead stop positioning
6. Handling
6.1 Eliminate the need for or ensure easy cleaning/purging
6.2 Eliminate the need to handle hot items
6.3 Eliminate the need to handle awkward items
6.4 Provide power aids
6.5 Provide remote actuation
6.6 Ensure easy delivery of tools etc. to the machine
6.7 Provide good access

Table 6 - Design rules adapted from Mileham et al.

These rules can also be linked to the ergonomics of work and equipment design. By designing a machine with the correct ergonomics, it is much easier for the worker to operate the machine. Also, the strain of performing repetitive will be less which promotes a friendlier working environment.

6.4.2 Work Method

Several cases in diverse industries have revealed that without a effective work method, very well-designed equipment can still present a timely changeover (Goubergen and Landeghem,2002). Many designers assume that the workers are knowledgeable enough to complete an efficient set-up. Accompanied with the maintenance and operation manuals should be set-up instructions and this is the responsibility of the equipment designer. When an organisation buys a new piece of equipment they must request for set-up instructions, this will prevent the workers from developing their own work method, which is not always efficient and effective.

Table 7 depicts a few rules that equipment designers should keep in mind, these rules should be used in order to monitor the set-up phase of the equipment. The equipment designer can then generate a complete set-up guide.

1	Separate on-line and off-line set-up activities.
2	Optimize the order in which the activities are performed to minimize movements and walking distance
3	In a line situation with more than one operator, divide the work on the different stations between the operators so that the machine on which the most activities need to be performed is not waiting
4	Balance the workload between the available operators and make separate instruction sheets per person
5	Use the Kipling questions on every activity of the set-up for critical review (What, where, when, who, how, why)
6	Provide set-up sets with all necessary tools and parts, determine the exact location where the tools and parts have to be placed before the actual set-up starts
7	Provide set-up instruction guides

Table 7- Design rules for efficient work method adapted from Goubergen and Landeghem

Rule 1 links to the SMED methodology and rule 2 can be used together with a routing diagram. In order to create a balanced work load, rule 3 and 4 should be accompanied by multi-activity charts. Rule 7 is the most important rule that combine all the previous steps. The set-up instructions should include complete instructions for each individual worker in optimal order, an ideal routing map for each worker, mutli-activity charts to depict the relationship between different operations and lastly, a complete tool checklist stating were all the tools are used and placed. Also, a list with all the parameter values is important.

6.4.3 Organisation

When working with a large production line that has an intricate work method and expensive equipment, it is only understandable that well skilled workers are an absolute necessity. It is important to have specialised workers that are trained in only a limited areas of the production line but still have a broad understanding of the complete process. This will eliminate the possibility of confusion arising between different tasks.

Maintenance is also very important. It is better and cheaper for an organisation to prevent accidents and breakdowns from happening than having to replace broken components.

Finally, a ‘good quality’ set-up is not complete without the positive motivation of the people performing the set-up. Appropriate training, gear and working clothes is strongly linked to this aspect. The working environment must be comfortable complete with all the necessary benefits such as a cafeteria and first aid.

6.5 Conclusion

From all the information collected about quick changeovers and reduction cases, it is clear that the initial problem areas will have to be identified. As stated earlier, the DMAIC Methodology will be used in order to do this. Only then, when the problem is identified, can one incorporate aspects such as SMED and Quick Changeover Technology.

Lastly, during the analysis of the process, it was noted that SAB Alrode Line7 struggles with data capturing and that this problem should also be properly addressed. Statistical Process Control measures can be implemented.

7. Process map HI

A High-Level Process Map describes all of the core processes within an organisation. This process map will elaborate on the Process Flow diagram, illustrating process at each stage of the changeover.

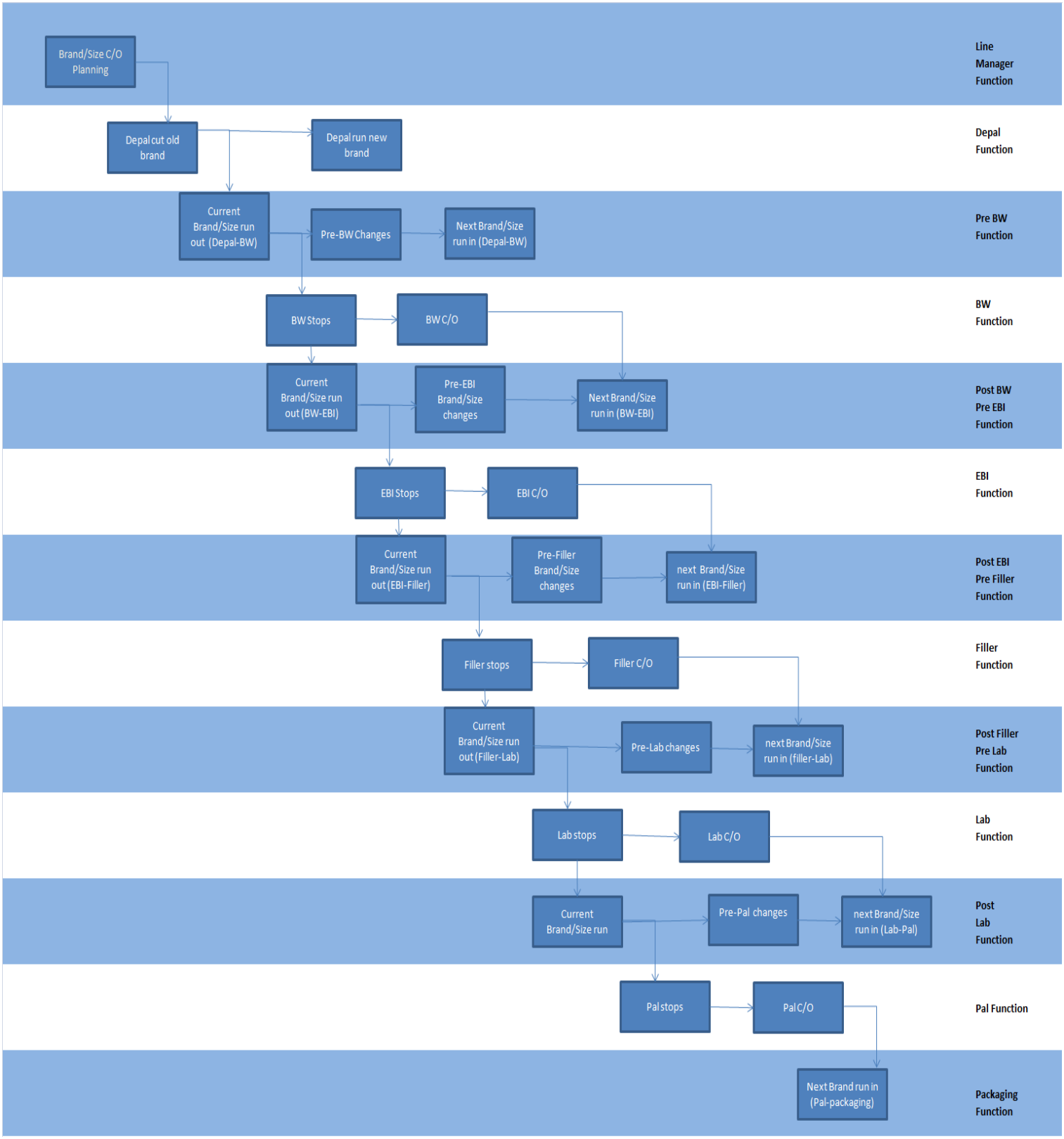


Table 8 – Process Map Hi

8. Process Map LOW

This process map will provide input to the Causse&Effect and the FMEA. The process are identified and liked to their inputs and customer outputs.

***All machines must have output of changed over machine**

Process Map - Low level (SIPOC - Supplier Input Process Output Customer)

Inputs	C/U	Steps	C/U	Outputs
Empty Bottles in Crates		**Depal Changeover**		New Brand Empty Bottles in Crates
Depalletiser Operator		**Depal Changeover**		Old Brand Empty Bottles in Crates
Wharehouse forklift driver		**Depal Changeover**		
Forklift		**Depal Changeover**		
Crates		**Depal Changeover**		New Brand Crates
Changeover Work Instructions		**Depal Changeover**		Gap between old and new bottles
New Brand Empty Bottles in Crates		**Uncaser Changeover**		Old Bottles
Old Brand Empty Bottles in Crates		**Uncaser Changeover**		New Bottles
Gap between old and new bottles		**Uncaser Changeover**		Old Brand Crates
Uncaser Operator		**Uncaser Changeover**		New Brand Crates
Changeover Work Instructions		**Uncaser Changeover**		Gap Between Old and New Bottles
Washer Operator		**Washer Changeover**		New Brand Clean Bottles
Changeover Work Instructions		**Washer Changeover**		Old Brand Clean Bottles
Old Bottles		**Washer Changeover**		Gap Between New and Old Bottles
New Bottles		**Washer Changeover**		
Gap Between Old and New Bottles		**Washer Changeover**		
NaOH Strength		**Washer Changeover**		
Washer Temperature		**Washer Changeover**		
Detergent		**Washer Changeover**		
Process Artizen		**EBI Changeover**		Last Good Inspected Old Brand Bottle
Filler Operator		**EBI Changeover**		First Good Inspected New Brand Bottel
EBI - Control Panel + Software		**EBI Changeover**		Gap Between Old and New Bottles
Bottle Type		**EBI Changeover**		Changed Parts
Changeover Work Instruction		**EBI Changeover**		
New Brand Clean Bottles		**EBI Changeover**		
Old Brand Clean Bottles		**EBI Changeover**		
Gap Between New and Old Bottles		**EBI Changeover**		
Starwheel		**EBI Changeover**		
Dead Plate		**EBI Changeover**		
Side guides		**EBI Changeover**		
EBI Test Bottles		**EBI Changeover**		
Cleaning tools (Brooms, Rags & water)		**EBI Changeover**		
19' Spanner		**EBI Changeover**		
Process Artisan		**Filler Changeover**		
Process Operator		**Filler Changeover**		
Filler Operators		**Filler Changeover**		
Team Leader		**Filler Changeover**		
Changeover Work Instructions		**Filler Changeover**		Changed Parts
Filler - Control Panel + Software		**Filler Changeover**		Settings on Filler
Beer type		**Filler Changeover**		
BBT		**Filler Changeover**		
Height settings		**Filler Changeover**		
Conveyor Control Panel		**Filler Changeover**		
Last Good Inspected Old Brand Bottle		**Filler Changeover**		Last Good Filled Bottles Old Brands
First Good Inspected New Brand Bottel		**Filler Changeover**		First Good Filled Bottles New Brands
Gap Between Old and New Bottles		**Filler Changeover**		Gap Between Old and New Bottles
New Crowns		**Filler Changeover**		New brand crowns in hopper
Old Crowns		**Filler Changeover**		
Water		**Filler Changeover**		
Filler Test Bottle		**Filler Changeover**		
Bin for the old vent tubes		**Filler Changeover**		bin filled with old vent tubes
Rinser Infeed Guide		**Filler Changeover**		
Rinser Infeed Worm		**Filler Changeover**		
Filler Infeed Guide		**Filler Changeover**		
Filler Discharge Guide		**Filler Changeover**		
Crowner Infeed Guide		**Filler Changeover**		
Crowner Discharge Guide		**Filler Changeover**		
Vent Tubes		**Filler Changeover**		
9/10/13/22 Spanner + Shifting and Bobbejaan spanner		**Filler Changeover**		
17' Spanner		**Filler Changeover**		
19' Spanner		**Filler Changeover**		
Hammer		**Filler Changeover**		
LN Key		**Filler Changeover**		
Vent tube Puller		**Filler Changeover**		
Punch		**Filler Changeover**		
Detergent (F7, Topax)		**Filler Changeover**		
Ster-bac (Ammonium Sanitiser)		**Filler Changeover**		
Spectak-G (Heavy duty caustic detergent)		**Filler Changeover**		
High Pressure Water Sprayer		**Filler Changeover**		
High Pressure Detergent Sprayer		**Filler Changeover**		

Process Artisan		PFBI Changeover		
Changeover Work Instruction		PFBI Changeover		
Control Panel + Software		PFBI Changeover		Changed settings according to height
Last Good Filled Bottles Old Brands		PFBI Changeover		Gap Between Old and New Bottles
First Good Filled Bottles New Brands		PFBI Changeover		Old Brand Inspected Bottles
Gap Between Old and New Bottles		PFBI Changeover		New Brand Inspected Bottles
Process Artisan		Pasteuriser Changeover		
Pasteuriser Operators		Pasteuriser Changeover		
Control Panel + Software		Pasteuriser Changeover		Changed settings according to brand
Gap Between Old and New Bottles		Pasteuriser Changeover		Gap Between Old and New Bottles
Old Brand Inspected Bottles		Pasteuriser Changeover		Old Pasteurised Beer Brand Bottles
New Brand Inspected Bottles		Pasteuriser Changeover		New Pasteurised Beer Brand Bottles
Changeover Work Instructions		Pasteuriser Changeover		
Push & Pull Tool		Pasteuriser Changeover		
Filled Bottles		Pasteuriser Changeover		
Process Artisan		Labeller Changeover		
Labeller Operator		Labeller Changeover		
Team Leader		Labeller Changeover		
Labeller Control Panel + Software		Labeller Changeover		changed settings
Gap Between Old and New Bottles		Labeller Changeover		Gap Between Old and New Bottles
Old Pasteurised Beer Brand Bottles		Labeller Changeover		Old Labelled Brand Bottles
New Pasteurised Beer Brand Bottles		Labeller Changeover		New Labelled Brand Bottles
Start Position		Labeller Changeover		
Camera 1&2 height		Labeller Changeover		
Fill Height		Labeller Changeover		
Changeover Work Instructions		Labeller Changeover		
Body Label		Labeller Changeover		
Back Label		Labeller Changeover		
Neck Label		Labeller Changeover		
Foil (CL & KL)		Labeller Changeover		
Infeed guide		Labeller Changeover		
Discharge Guide		Labeller Changeover		
Labeller Infeed Worm		Labeller Changeover		
Starwheel Infeed		Labeller Changeover		
Starwheel Discharge		Labeller Changeover		
Brush Set		Labeller Changeover		
Centering Bell		Labeller Changeover		
Bottle Platform		Labeller Changeover		
Gripper Cylinder		Labeller Changeover		
Pallets		Labeller Changeover		
Magazine		Labeller Changeover		
Trace		Labeller Changeover		
Lable Follower		Labeller Changeover		
Lable Gard		Labeller Changeover		
WAP machine		Labeller Changeover		clean parts

Table 9 - Process Map Low

*note: At Low Level the team decided that the following tools for analysis are limited to the end of the Labellers due to CCR's between Filler and Labeller changeover.

9. Cause and Effects Matrix

This is a simplified Quality Function Deployment Matrix that highlights customer importance. Key outputs are scored for their importance to the project and key inputs are scored based on their relationship to the key outputs. The key outputs are defined as Changeover time and Product Quality.

	Rating of Importance to Customer	5	9	
	9	High	High	
	3	Medium	Medium	
	1	Low	Low	
	0	None	None	
process step	**Process Inputs**	**Primary Y = Line 7 Brand/Pack Change Over Time**	**Procuct Quality**	**Total**
Depal Changeover	Empty Bottles in Crates	3	9	96
Depal Changeover	Depalletiser Operator	9	3	72
Depal Changeover	Wharehouse forklift driver	9	3	72
Depal Changeover	Forklift	9	3	72
Depal Changeover	Crates	9	9	126
Depal Changeover	Changeover Work Instructions	3	1	24
Uncaser Changeover	New Brand Empty Bottles in Crates	3	9	96
Uncaser Changeover	Old Brand Empty Bottles in Crates	3	1	24
Uncaser Changeover	Gap between old and new bottles	1	3	32
Uncaser Changeover	Uncaser Operator	9	**3**	72
Uncaser Changeover	Changeover Work Instructions	3	**3**	42
Washer Changeover	Washer Operator	9	9	126
Washer Changeover	Changeover Work Instructions	3	3	42
Washer Changeover	Old Bottles	3	1	24
Washer Changeover	New Bottles	9	3	72
Washer Changeover	Gap Between Old and New Bottles	9	3	72
Washer Changeover	NaOH Strength	3	9	96
Washer Changeover	Washer Temperature	3	9	96
Washer Changeover	Detergent	3	9	96
EBI Changeover	Process Artizen	3	9	96
EBI Changeover	Filler Operator	9	3	72
EBI Changeover	EBI - Control Panel + Software	9	3	72
EBI Changeover	Bottle Type	3	9	96
EBI Changeover	Changeover Work Instruction	3	9	96
EBI Changeover	New Brand Clean Bottles	9	3	72
EBI Changeover	Old Brand Clean Bottles	3	3	42
EBI Changeover	Gap Between New and Old Bottles	9	3	72
EBI Changeover	Starwheel	9	9	126
EBI Changeover	Dead Plate	9	9	126
EBI Changeover	Side guides	9	9	126
EBI Changeover	EBI Test Bottles	3	9	96
EBI Changeover	Cleaning tools (Brooms, Rags & water)	3	3	42
EBI Changeover	19' Spanner	9	1	54
				0
Filler Changeover	Process Artisan	9	9	126
Filler Changeover	Process Operator	9	3	72
Filler Changeover	Filler Operators	9	9	126
Filler Changeover	Team Leader	9	9	126
Filler Changeover	Changeover Work Instructions	3	3	42
Filler Changeover	Filler - Control Panel + Software	9	9	126
Filler Changeover	Beer type	3	9	96
Filler Changeover	BBT	3	9	96
Filler Changeover	Height settings	3	9	96

Filler Changeover	Conveyor Control Panel	3	3	42
Filler Changeover	Last Good Inspected Old Brand Bottle	3	1	24
Filler Changeover	First Good Inspected New Brand Bottle	9	3	72
Filler Changeover	Gap Between Old and New Bottles	9	3	72
Filler Changeover	New Crowns	3	9	96
Filler Changeover	Old Crowns	3	3	42
Filler Changeover	Water	9	3	72
Filler Changeover	Filler Test Bottle	3	9	96
Filler Changeover	Bin for the old vent tubes	3	3	42
Filler Changeover	Rinser Infeed Guide	9	9	126
Filler Changeover	Rinser Infeed Worm	9	9	126
Filler Changeover	Filler Infeed Guide	9	9	126
Filler Changeover	Filler Discharge Guide	9	9	126
Filler Changeover	Crowner Infeed Guide	9	9	126
Filler Changeover	Crowner Discharge Guide	9	9	126
Filler Changeover	Vent Tubes	9	9	126
Filler Changeover	9/10/13/22 Spanner + Shifting and Bobbejaan spanner	9	3	72
Filler Changeover	17' Spanner	9	3	72
Filler Changeover	19' Spanner	9	3	72
Filler Changeover	Hammer	9	3	72
Filler Changeover	LN Key	9	3	72
Filler Changeover	Vent tube Puller	9	3	72
Filler Changeover	Punch	9	3	72
Filler Changeover	Detergent (F7, Topax)	3	9	96
Filler Changeover	Ster-bac (Ammonium Sanitiser)	3	9	96
Filler Changeover	Spectak-G (Heavy duty caustic detergent)	3	9	96
Filler Changeover	High Pressure Water Sprayer	3	3	42
Filler Changeover	High Pressure Detergent Sprayer	3	9	96
PFBI Changeover	Process Artisan	9	9	126
PFBI Changeover	Changeover Work Instruction	3	3	42
PFBI Changeover	Control Panel + Software	3	9	96
PFBI Changeover	Last Good Filled Bottles Old Brands	3	1	24
PFBI Changeover	First Good Filled Bottles New Brands	3	9	96
PFBI Changeover	Gap Between Old and New Bottles	9	3	72
Pasteuriser Changeover	Process Artisan	3	9	96
Pasteuriser Changeover	Pasteuriser Operators	9	9	126
Pasteuriser Changeover	Control Panel + Software	9	3	72
Pasteuriser Changeover	Gap Between Old and New Bottles	9	1	54
Pasteuriser Changeover	Old Brand Inspected Bottles	3	3	42
Pasteuriser Changeover	New Brand Inspected Bottles	9	3	72
Pasteuriser Changeover	Changeover Work Instructions	3	3	42
Pasteuriser Changeover	Push & Pull Tool	9	3	72
Pasteuriser Changeover	Filled Bottles	3	9	96
Labeller Changeover	Process Artisan	9	9	126
Labeller Changeover	Labeller Operator	9	9	126
Labeller Changeover	Team Leader	9	9	126
Labeller Changeover	Labeller Control Panel + Software	9	9	126
Labeller Changeover	Gap Between Old and New Bottles	9	3	72
Labeller Changeover	Old Pasteurised Beer Brand Bottles	3	1	24
Labeller Changeover	New Pasteurised Beer Brand Bottles	3	9	96
Labeller Changeover	Start Position	3	9	96
Labeller Changeover	Camera 1&2 height	3	9	96
Labeller Changeover	Fill Height	3	9	96
Labeller Changeover	Changeover Work Instructions	3	3	42
Labeller Changeover	Body Label	3	9	96
Labeller Changeover	Back Label	3	9	96
Labeller Changeover	Neck Label	3	9	96
Labeller Changeover	Foil (CL & KL)	3	9	96
Labeller Changeover	Infeed guide	9	3	72
Labeller Changeover	Discharge Guide	9	3	72
Labeller Changeover	Labeller Infeed Worm	9	3	72
Labeller Changeover	Starwheel Infeed	9	9	126

Labeller Changeover	Starwheel Discharge	9	9	126
Labeller Changeover	Brush Set	9	9	126
Labeller Changeover	Centering Bell	9	9	126
Labeller Changeover	Bottle Platform	9	9	126
Labeller Changeover	Gripper Cylinder	9	9	126
Labeller Changeover	Pallets	9	9	126
Labeller Changeover	Magazine	9	9	126
Labeller Changeover	Trace	9	9	126
Labeller Changeover	Lable Follower	9	9	126
Labeller Changeover	Lable Gard	9	3	72
Labeller Changeover	WAP machine	3	3	42

Table 10 – Cause and Effect Matrix

The inputs that scored high ratings, 126, are identified and investigated further in the FMEA.

10. Failure Mode and Effect Analysis

The FMEA identifies ways in which the process inputs can go wrong and determines what effect this has on the process outputs.

Failure Mode and Effects Analysis (FMEA)

Process Step	Key Process Input	Potential Failure Mode	Potential Failure Effects	S E V	Potential Causes	O C C	Current Controls	D E T	R P N	Actions Recommended
What is the process step	What is the Key Process Input?	In what ways does the Key Input go wrong?	What is the impact on the Key Output Variables (Customer Requirements) or internal requirements?	How Severe is the effect to the customer?	What causes the Key Input to go wrong?	How often does cause or FM occur?	What are the existing controls and procedures (inspection and test) that prevent either the cause or the Failure Mode? **Should include an SOP number.**	How well can you detect cause or FM?		What are the actions for reducing the occurrence of the Cause, or improving detection? **Should have actions only on high RPN's or easy fixes.**
Depal Changeover	Crates	not enough available	CO time longer	9	crate stacker too slow	3	manual labour	4	108	
Washer Changeover	washer operator	Not be available	Extended Change Over time	9	Lunch	3	Agreement to inform TL when going on lunch	4	108	No Lunch during Brand/Pack changes
EBI Changeover	EBI change parts- starwheel, deadplate, side guides		CO time longer	9	workers	5	CO instuction guide	4	180	
		starwheel not correctly put in	rejected bottles	9	workers	5	CO instruction guide	4	180	
		dead-plate not marked	CO time longer	9	workers	5	CO instuction guide	4	180	
Filler Changeover	Process Artisan	not knowing how to control problems with software panel	extended co time	9	auto to manual	7	CO instruction guide	5	315	retrain workers and review CO guides
		Not be available	Extended Change Over time	9	Lunch	3	Agreement to inform TL when going on lunch	4	108	No Lunch during Brand/Pack changes
	Filler Operators	not having parts available eg. vent tubes	extended co time	9	still waiting for order from planner	6	planner must make orders and machine specialist	3	162	
		Not be available	Extended Change Over time	9	Lunch	3	Agreement to inform TL when going on lunch	4	108	No Lunch during Brand/Pack changes
	Team Leader	not knowing how to control problem with software panel	extended co time	9	auto to manual	3	CO instuction guide	9	243	retrain workers and review CO guides
		Not be available	Extended Change Over time	9	Lunch	3	Agreement to inform TL when going on lunch	4	108	No Lunch during Brand/Pack changes
	Filler - Control Panel + Software	program freeze	extended co time	9	software	3	work from office on remote	9	243	investigate why the problem occurs and how to get system going
	filler change parts - rinser guide and worm, crowner guide, vent tubes	locking pin is missing	extended co time	6	workers misplaced them	4	must be kept on the changed parts	3	72	
		not available	Extended Change Over time	9	machine specialist must make sure parts are available	3	maintenance control	3	81	
	Vent Tubes	not available	Extended Change Over time	9	machine specialist must make sure vt are available	3	maintenance control	3	81	

PFBI Changeover	Process Artisan	adjusting the hight	beer loss	9	neglect	1	CO instuction guide	3	27	
		Not be available	Extended Change Over time	9	Lunch	3	Agreement to inform TL when going on lunch	4	108	No Lunch during Brand/Pack changes
Pasteuriser Changeover	Pasteuriser Operators	wrong brand type selected	freeze the shift, beer loss, time loss	9	neglect	1	CO instuction guide	3	27	
		Not be available	Extended Change Over time	9	Lunch	3	Agreement to inform TL when going on lunch	4	108	No Lunch during Brand/Pack changes
Labeller Changeover	Process Artisan	not available	extended co time	9	busy with filler	9	none	3	243	retrain workers and review CO guides
				9	Lunch	3	Agreement to inform TL when going on lunch	4	108	No Lunch during Brand/Pack changes
	Labeller Operator	parts not correctly installed	extended co time, waste	9	neglect	4	CO instruction guide	5	180	
		Not be available	Extended Change Over time	9	Lunch	3	Agreement to inform TL when going on lunch	4	108	No Lunch during Brand/Pack changes
	Team Leader	not knowing how to control problem with software panel	extended co time	9	auto to manual	3	CO instuction guide	9	243	retrain workers and review CO guides
		Not be available	Extended Change Over time	9	Lunch	3	Agreement to inform TL when going on lunch	4	108	No Lunch during Brand/Pack changes
	Labeller Control Panel + Software	program freeze	extended co time	9	software	3	work from office on remote	9	243	investigate why the problem occurs and how to get system going
	Guides (Change Parts) - Brushes + Starwheels 1-3 (Amber, 1-8 Amstel, 1-7 Caste lite	loose brush,	extended co time,	9	busy with other process	5	lab specialist	3	135	
		adjustments are loose on brush set	extended co time,	9	busy with other process	5	lab specialist	3	135	
		difficult to handle	extended co time,	7	heavy	9	none	3	189	

Table 11 - FMEA

It is seen from the FMEA that the main problem faced with is the Software Panel that causes trouble. Operators and artisans are unable to control the problem in most cases and this extends the changeover time. Actions recommended are that the Changeover guides (SAB Work Instruction 15) must be reviewed, workers must be retrained and the software problem must be investigated, this will be discussed in the Improvement plan.

11. Improvement Plan

The top five problems identified in the FMEA are clearly causing the constant variation in each the Fillers and the Labellers changeovers and general production. In order to make meaningful improvements, changeover guides must be reviewed and updated, workers must be retrained and the root cause of these software problems must be investigated.

11.1 Review Changeover Instruction Guides

The changeover guide used at the Filler and Labeller is bulky and out dated. It consists of many pages that make it difficult for a first timer to perform an effective changeover. Also, instructions regarding the Software Panel are not clear enough and the Best Practice for this part of the changeover must be documented.

Best Practices are developed in order to assist operators whilst they are performing a changeover. These new changeover guides are listed in the most effective and efficient manner and will ensure an easy changeover. These guides will also assist in changeover

problems related to the software panel, the steps are clearly stated and will ensure the correct settings being selected. Provision is also made for further improvements to be documented.

The new guides for the Filler and the Labeller can be found in Appendix D.

11.2 Retraining

Operators are not properly trained in order to identify and solve problems concerning the software panel and the rest of the changeover for that matter. Sufficient guides are available for the operators to use, but little effort is made to explain the whole process and discuss possible preventative maintenance. It is assumed that the other operators will give the new operators “on the job training”. This problem occurs throughout the whole line and not only at the Filler and Labeller.

Thus, a general training template is developed that can be used throughout the line on all the machines. A skilled operator or team leader must assist in training the candidate. The template incorporates classroom as well as hands-on training and includes an assessment sheet. Successful training will ensure a reduction in downtime and alleviate major breakdowns. This will contribute to the success of Line7 and eliminate the variation between changeovers. Operators will also know how to handle software problems with more knowledge.

The Training Template can be found in Appendix C.

11.3 Investigation

There is a built in function in the filler software panel that automatically changes the various height setting for each changeover according to the chosen beer. This automatic function can only work if the two height sensors are working and if the variance between the two is less than 5mm. As soon as the variance is greater, the system will not change automatically and the operators have to set the height of the filler manually. This problem takes about 15mins to solve, as the operators have to set the precise height to the last millimetre. The reason for the variance being greater than 5mm can be assigned to three parts not working; the motor (for the height adjuster), the gearbox and the clamp brakes. These parts seem to fail often due to the chlorine oxide corroding them. The chlorine oxide is used as a cleaning agent in the filler.

It is strongly advised that these parts be maintained every week, to check if they still work properly and be replaced every month, not every six months as currently decided. This change must be documented in the Maintenance Schedule. Sufficient stock must also be available at any given moment. As soon as a part is changed, a new one has to be ordered.

11.4 Further Recommendations

In almost every field, where repetitive work is concerned, it is your operators that sit with the most knowledge about the work. The operators should be encouraged to make suggestions that could possibly improve the production and changeover of the line. Unfortunately, on line7, only team leaders and process artisans sit in on daily production meetings. SAB has created an online system where any worker can make suggestions but this is a lot of effort and is a national system that is reviewed by a panel. Line7 needs their own system where suggestions can be made by operators without the effort of logging on to a website.

A basic solution, that is both easy to implement and easy to use, would be to get a white board for both the filler and the labeller. These boards will be right next to the machine, mounted against the wall. Operators can easily walk to the board and write down their solutions. This is a live system that will be reviewed every time there are enough solutions. This is also very cost effective and Line 7 can decide whether they what to reward the best solution with a prize of sorts, in order to motivate creative suggestions. In this manner, most of line7's production, maintenance and changeover problems can be eliminated, without having to investigate the entire system that could be costly and waste time.

11.5 Data Capturing System

Line 7 is becoming aware of the importance of documenting their changeover times in order to track performances and identify good and bad changeovers. A Statistical Process Control spread sheet is created in order to do this.

This spreadsheet will allow Line 7 to enter all their changeover times and specify whether it is a brand or size changeover. Furthermore, the spread sheet will automatically create changeover charts plotted against time.

11.5.1 Chart Design

Because each subgroup consists of only single variables values and the process variation is estimated on the basis of observation-to-observation changes, Individual (Xbar) and Moving Range (MRbar) charts are chosen to best represent Line 7's statistics.

Moving Range Charts

This chart will display the process variability where single measurements of variables are considered a subgroup size of one. An estimate of variability is based on the point-to-point difference in the arrangement of single values, measured by the moving range. An average of the moving ranges is used as the centreline for the moving range portion of the chart and as the basis of an estimate of the overall process variation.

MRbar line = average of moving range points

The estimate for the upper control limit is calculated by using the MRbar value multiplied by a standard value depending on the subgroup size. There is no lower control limit as process variation cannot be lower than zero. For subgroup size one:

UCL = MRbar x 3.267 (This is the approximate for the 3sigma line)

Individual Charts

This chart will display the process average for single measurements. An average of the single measurements is used to calculate the centreline.

Xbar = average of single measurement

The approximation for the Upper control limit is calculated by adding three times the standard deviation of the single measurements. There is no lower control limit because the lower the changeover the better. For subgroup size one, the following estimate is made:

UCL = Xbar + 2.66(MRbar)

11.5.2 Chart Usage

Charts and spread sheets for both the Size and Brand changeovers are produced. These charts must be updated every time there is a changeover and relevant comments must be made for both the filler and the two labellers. By analysing the charts, the process operators will be able to see if the changeover was out-of-control or not.

Reading in the data is very simple, only the date, changeover type and changeover time must be specified. Moving Range and Individual charts will automatically be generated that are measured according to each machines own target value (specified by Line 7).

Colour coordination on the charts is used in order to make a quick evaluation of the changeover. The red area indicates an out-of –control process whereas green indicates good changeovers.

Control limits, average lines and target lines must be used when an in depth analysis is made;

Out of control Patterns and the Rules of Thumb

The Xbar chart is used to detect out-of-control changeovers. The chart area above the BestAve line is divided up into three areas (zones) from dark red to light red.

1. Process exhibits a lack of control if any point is within Zone C (beyond the upper control limit).

2. Process exhibits lack of control if any two out of three points fall in Zone B on the same side of the centreline.
3. Process exhibits lack of control if four out of five consecutive point fall within Zone A or beyond on the same side of the centreline.

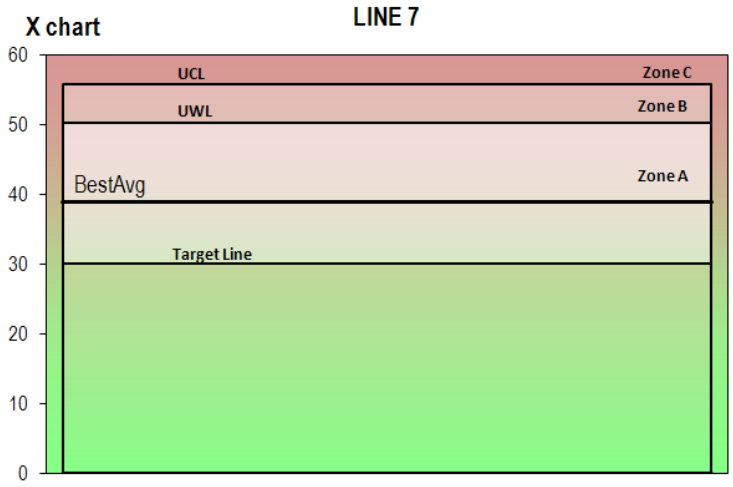


Figure 11 - Xbar Chart Example

The MRbar-charts looks very similar to the Xbar-charts. In this case the variability of the process is measured and thus the lower the point the better. High points indicate a big time difference between the current change over and the previous. Thus, the operators were not able to perform a changeover as good as their previous changeover.

The design of both size and brand changeover charts can be found in Appendix E.

12. Verification and Validation

As stated previously in the document, the goal is to reduce any aspect that causes variation in the changeover. Fields have been identified that cause possible variation and solutions are stated. Training, Best Practices and Maintenance being the main solutions.

12.1 Best Practices

The implementation of best practices will definitely improve variation to a great extent. Implementation of these guides will ensure that all the operators are working according to the same standard that is proven the most effective. This will also prevent operators from creating their own routine that does not correspond with the other operators.

It is currently estimated that the operators struggle with software problems at the filler and the labellers that last up to 15mins at each station. The best practices will decrease the time

spent with these problems and the changeover can possibly be reduced by 30mins (the total of the filler and the labellers)

12.1.1 Savings

With an estimated production capacity of 650 bottles per minute, 30minutes will equal 19500 bottles or 146 hectolitre. The average estimated cost in warehouse per hectolitre is R136, thus R19890 will be saved per changeover. Line 7 has an average of 48 changeovers per year, equalling a save of R895050.

If the changeover guides are updated on all the lines and not only at line7, SAB Alrode could save a considerable amount.

12.2 Training

It is strongly recommended to implement the new training template. The current operators do encompass the knowledge to perform a changeover and preventative maintenance, but their knowledge came with time. Line 7 must realise the importance of giving new operators proper training so that they start off with an equal amount of knowledge regarding the changeover as the current operators. This will lighten the strain on the current operators because they won't have to explain the procedure during a changeover. Thus, a changeover can be performed with the full cooperation of all the workers in an efficient and effective manner.

Also, with the implementation of the new best practices, all the operators must be retrained regarding the new changeover guides.

12.3 Maintenance

Preventative maintenance is not something that a company should underestimate. It is cheaper to maintain a machine more regularly than having to replace broken parts that could cause down time of up to two days.

12.3.1 Savings

Line 7 is estimated to have a capacity of 650 bottles per minute. Downtime of one day, 24 hours, equals 936000 bottles or 7020 hectolitre. The average estimated cost in warehouse per hectolitre is R136. This equals a loss of R954720 per day.

With these values stated, it is clear that Line 7 should update their maintenance schedule in order to keep the filler working at all times possible.

12.4 Statistical Process Control Charts

There are three main reasons why Line 7 should implement the Statistical Process Control measure.

Evaluating the past

This way Line 7 can determine whether or not their changeovers where in statistical control.

This is indicated by control chart points beyond the control limits.

This will indicate that there are certain problems that cause variation in their changeovers.

Evaluating the present

Control charts can be used to generate “special cause” signals during a process’s operation. Special causes in variation call attention to anything out of the ordinary during the changeover that requires intervention in the process. In this sense, control charts are useful in maintaining the current state of stability.

Predicting the future

Finally, Line 7 can use these charts to predict their future production rates based on process knowledge concerning future conditions that could affect the process stability.

12.5 Communication

There is no financial indication that staves this suggestion, but it will definitely promote better communication between the operators and the team leaders. The operators will also feel like they contribute to the process. In essence, they will also be more aware and concerned with the urgency of the complete process. Also, future problems will be addressed quicker and solutions will be motivated from the people with the most knowledge about the process. It is not a costly operation and can be used in many aspects of SAB Alrode’s production.

13. Conclusion

SAB Alrode has set various operational targets, amongst others; changeover time. Major changeovers were investigated at the filler and the labeller and it was found that the new entitlement must still follow the voice of the customer as the time difference between the average changeover and the target is too large. The changeover target for size changeovers was kept at 90min and for brand changeovers at 30min. Process improvements where focussed on minimising the variation in the total process and identifying and eliminating the process constraints. In order to make meaningful improvements, changeover guides were reviewed and updated, training templates where created and the root cause of software problems was investigated.

It is suggested that Line 7 consider these solutions. Reviewing the Changeover guides and retraining the operators will provide Line 7 with the necessary knowledge and skill to solve problems quicker and complete changeovers in a more efficient and effective manner. The Statistical Process Control Charts will enable Line7 to analyse and track their changeovers in an easier fashion. It will also highlight out-of-control changeovers. Using the control charts in correspondence with the recommendations-whiteboard will ease the course of searching for process constraints during out-of-control changeovers.

References

ANTONY, J. and BANUELAS, R., 2002. Key ingredients for the effective implementation of six sigma program. Measuring Business Excellence, 6 (4), 20–27.

BODEK, N., 2005. The keys to quick changeover [Online]. Available from: http://www.moldmakingtechnology.com/columns/the-keys-to-quick-changeover [Accessed 7 April 2012]

De FEO, J. and BAR-EL, Z., 2002. Creating strategic change more efficiently with a new design for six sigma process. Journal of Change
Management, 3 (1), 60–80.

GOUBERGEN, D. and LANDEGEHEM, H., 2002. Rules for integrating fast changeover capabilities into new equipment design. Robotics and Computer Integrated Manufacturing, 18 (2002) 205–214.

General Electric., 2004. What is six sigma: the roadmap to customer impact [online]. Available from: http://www.ge.com/sixsigma/SixSigma.pdfO
[Accessed 7 April 2012].

HALLOWELL, D.L., 2010. DMAIC and DFSS Roadmaps: How to Connect and Integrate[Online]. Available from: http://www.isixsigma.com/new-to-six-sigma/design-for-six-sigma-dfss/dmaic-and-dfss-roadmaps-how-connect-and-integrate/. [Accessed 8 April 2012].

HOON KWAK, Y. and ANBARI, F.T., 2006. Benefits, obstacles and future of six sigma approach. Technovation, 26 (2006) 708–715.

LEE, Q., 2003. Implementing Lean Manufacturing [online]. Available from: www.strategosinc.com/_downloads/implement.pdf [Accessed 7 April 2012].

MELTON, T., 2005. The benefits of lean manufacturing: What Lean Thinking has to Offer the Process Industries. Chemical Engineering Research and Design, 83(A6), 662–673.

MILEHAM, A.R. and CULLEY, S.J., 1999. Rapid Changeover: Fa pre-requisite for responsive manufacture. Int Journal Oper Prod Manage , 19:785–96.

SAB Limited., 2012. Overview [online]. Available from: http://www.sablimited.co.za/sablimited/content/en/sab-overview. [Accessed 21 March 2012].

SixSigmaOnline, 2007. Lean Six Sigma – 5 Reasons Your Organization Needs It[Online]. Available from: http://www.sixsigmaonline.org/six-sigma-training-certification-information/articles/lean-six-sigma-%E2%80%93-5-reasons-your-organization-needs-it.html. [Accessed 8 April 2012]

Appendix

Appendix A

Historical Data

	Date	2011/11/14	2011/11/21	2011/12/06	2012/01/17	2012/02/03
Filler - Size Change	Target	90	90	90	90	90
	Time	147	131	180	57	90

ave	stdev
121	48.25453

	Date	2011/11/14	2011/11/21	2011/11/22	2011/11/24	2011/12/06	2100/12/09	2011/12/13	2011/12/17	2011/12/20	2011/12/28	2011/12/30	2012/01/17	2012/02/09
Labeller 1 - Size Change	Target	90	90	90	90	90	90	90	90	90	90	90	90	90
	Time	209	204	60	x	220	240	90	x	x	180	90	30	100

ave	stdev
142.3	75.94157

	Date	2011/11/14	2011/11/21	2011/11/22	2011/11/24	2011/12/06	2100/12/09	2011/12/13	2011/12/17	2011/12/20	2011/12/28	2011/12/30	2012/01/17	2012/02/09
Labeller 2 - Size Change	Target	90	90	90	90	90	90	90	90	90	90	90	90	90
	Time	180	x	68	115	160	x	125	110	180	100	100	30	110

ave	stdev
116.1818	45.2699

Table 12 - Historical Data

Appendix B

Combinational Data

Reading	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Target	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
Time	209	180	204	60	68	115	220	160	90	125	110	180	180	100	90	100	30	30	100	240	110
Range			24	144	8	47	105	60	70	35	15	70	0	80	10	10	70	0	70	140	10

Reading	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Range		0	24	144	8	47	105	60	70	35	15	70	0	80	10	10	70	0	70	140	10
UCL(Rbar)	166.45	166.45	166.45	166.45	166.45	166.45	166.445	166.445	166.45	166.445	166.45	166.445	166.45	166.45	166.45	166.45	166.45	166.45	166.45	166.45	166.45
MRbar	50.947	50.947	50.947	50.947	50.947	50.947	50.9474	50.9474	50.947	50.9474	50.947	50.9474	50.947	50.947	50.947	50.947	50.947	50.947	50.947	50.947	50.947
LCL(Rbar)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Reading	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Time	209	180	204	60	68	115	220	160	90	125	110	180	180	100	90	100	30	30	100	240	110
UCL(Xbar)	**333.19**	333.19	333.19	**216.52**	216.52	216.52	**287.663**	287.663	287.66	287.663	287.66	287.663	287.66	**205.52**	205.52	205.52	205.52	205.52	**285.52**	285.52	285.52
Xbar	**197.67**	197.67	197.67	**81**	81	81	**152.143**	152.143	152.14	152.143	152.14	152.143	152.14	**70**	70	70	70	70	**150**	150	150
LCL(Xbar)	**0**	0	0	**0**	0	0	**0**	0	0	0	0	0	0	**0**	0	0	0	0	**0**	0	0
Target	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90

Table 13 - Combinational Data

Appendix C

Alrode Brewery Training Template			
Section	Packaging – Line7	Date created	../../2012
Sub Section			
Subject	Training Procedure	Page	1 of 6

Content

1. Safety, Health and Environment

Safety

- Correct PPE must be worn when working on the line.
- Always remember SAFETY FIRST when making any machine adjustments.
- All machine guards must be installed and secured before starting up the machine to avoid possible machine damage or personal injury.
- Inspect the machine for proper component performance prior to starting.
- Ensure all tools and cleaning equipment is moved away from the machine before start up.
- Never attempt to bypass any safety switches or devices.
- Be careful when handling glass bottles; always wear gloves and safety goggles.
- Be aware of wet and slippery floors.
- Be careful of bursting glass bottles.
- Be aware of moving conveyors.

Health

- Be aware of the noise; always wear earplugs when in the packaging hall.

Environment

- Follow the correct disposal procedures when working with chemicals.

2. Classroom Training

- Before classroom training begins, the trainer should give a brief introduction of his or her experience to demonstrate what students will face in their day-to-day jobs. Next, students should give brief introductions of themselves to give the trainer an idea of the skill levels.
- Discuss how Line 7 functions and name all the different subsections (depal, decrowner, uncaser, washer, crate packer, bottle washer, EBI, filler, Pasteuriser, labeller, packer, palletiser)
- Discuss what different brands are produced on Line7
- Explain the day-to-day functioning of the machine and what will be expected from the student. Also explain the use of any equipment.
- Also explain how the machine works together with its pre- and post-machines
- Hand the student a changeover guide and work through each step of the guide, also talk about problems that typically occur during changeovers and how they are solved.
- Explain how maintenance is completed on the machine and also explain preventative maintenance
- Give examples of typical problems that occur during production and how they are solved.
- Clearly state any hazards involved
- Give a breakdown of the team members of line 7
  Unit manager, team leaders, maintenance, operators, cleaners

make use of visual aids; draw a flow diagram of the line. Hand the student a copy of the changeover instructions together with health and safety tips.
this session should not take longer than about an hour.

3. On the Job Training

- This is the hands-on session.
- Trainees must assist in the day-to-day activities.
- They must also assist in preventative as well as repair maintenance.
- They must assist in a changeover.
- Be sure to give specific activities to the trainee and alternate these activities during the course of a week.
- Trainees must be encouraged to assist and not just observe.
- Show trainees how to correctly handle all the equipment.
- Show trainees where the equipment is stored.
- At the end of each day, demonstrate how the working environment is kept clean.

during the course of 1-2 weeks, the trainee should have assisted in at least one maintenance procedure and one changeover.

make sure the trainee is always wearing the correct PPE.

4. Assessment

Machine/Area:	Filler
Assessor:	
Candidate:	
Position :	Trainee
Date:	
Result:	Pass/Fail

Assessor's comments:

Alrode Brewery Training Template			
Section	Packaging – Line7	Date created	../../2012
Sub Section			
Subject	Training Procedure	Page	6 of 6

Performance Criteria		
The candidate must be able to perform the following:		
	Yes	**No**
Is the candidate able to perform day-to-day activities		
Is the candidate able to assist with maintenance		
Is the candidate able to assist with a changeover		
Is the candidate able to check the input and output quality of the machine		
Does the candidate maintain general housekeeping of the area		
Does the candidate understand the packaging plan		
Is the candidate aware of all the equipment and able to inspect them		
Does the candidate adhere to health, safety and environmental rules		
Is the candidate aware of all the hazards related to the machine and process		
Can the candidate differentiate between internal and external activities		
Is the candidate aware of the different raw materials used with the machine		
Is the candidate able to record quality results		

Appendix D

Alrode Brewery Best Practices			
Section	Packaging – Line7	Date created	../../2012
Sub Section	KHS Filler		
Subject	Changeover Guide	Page	1 of 14

AMENDMENTS			
Revision Date	**Details**		**Description of change**
	Page	**Paragraph**	

CONTENTS

1. INTRODUCTION

This document provides step by step instructions on how to effectively prepare for, and perform brand changes on the KHS Filler i.e. from clear beer to clear beer, stout to clear beer and clear beer to stout. This is aimed at assisting the front-end process crew to effectively prepare for and perform various brand changes within the allowed time whilst achieving quality and safety requirements, following the Best Operating Practices. Failure to adhere to this work instruction may result in lost time, poor quality product, injuries to personnel and/or damage to the Filler**.**

1.1 DEFINITIONS

PPE - Personal Protective Equipment
KHS - Klockner Holstein Seitz
BBC - Bright Beer Corridor
BBT - Bright Beer Tank
WOB - Water Ozonated Blended
Bph - Bottles per hour
QC - Quality Control
HLs - Hectolitres
pH - acidity or alkalinity of a solution

2. SAFETY, HEALTH AND ENVIRONMENT

Safety

To be adhered to as per Work Instruction 11. Eye protection, ear protection, Conti suit, safety gloves and safety shoes must be worn.

- Be careful when handling glass bottles.
- Be careful of wet and slippery floors.
- Be careful of bursting glass bottles from the Filler.
- Be aware of moving machinery and running conveyors.

Health

- Be aware of the noise and use specified ear protection at all times.
- Ensure that Burst Bottle Sprays are functional at all times.

Environment

- Ensure that all hazardous chemicals and materials are disposed of properly.

3. TASK DESCRIPTION

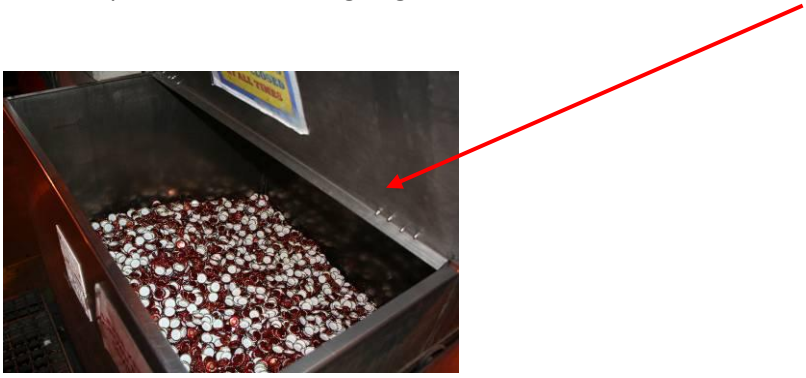
3.1 EXTERNAL CHANGEOVER TASKS

Ensure the line needs to do brand change by checking the following:

- HLS withdrawn on current brand versus production program.
- The BBT balance.

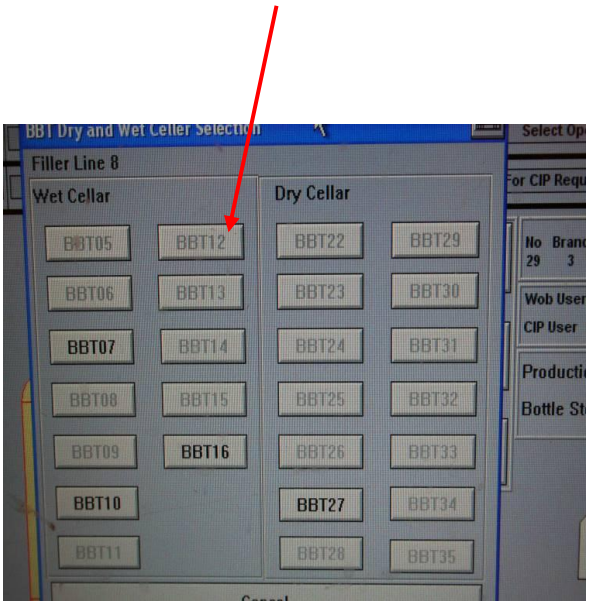
Thereafter do the following:

- Keep crowns of the outgoing brand to a minimum level in the crown bin.



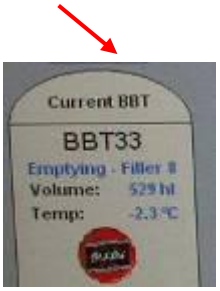
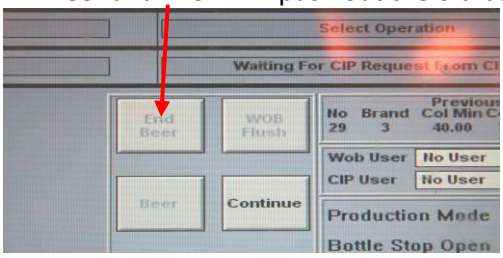
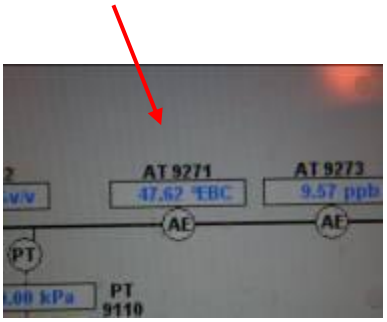
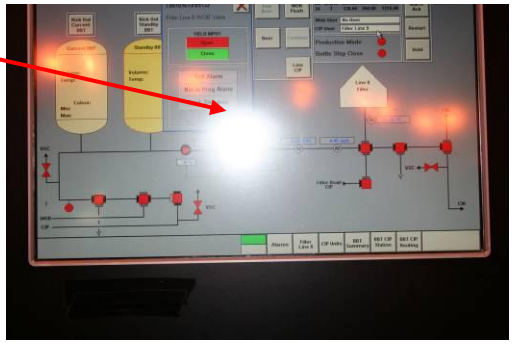
- Order enough crowns for the next brand.
- Communicate the intended brand change to everyone.
- Ensure **BBT availability** for the next brand and that it is entered as a standby on the BBC panel.

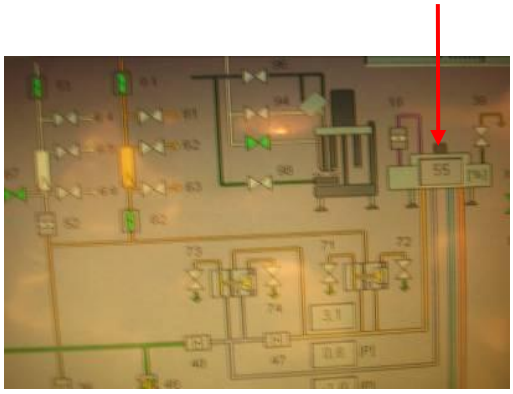
Available BBTs are highlighted

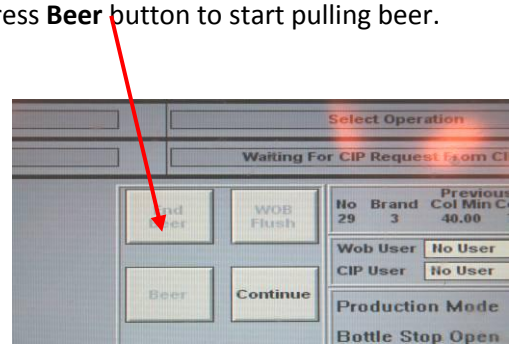
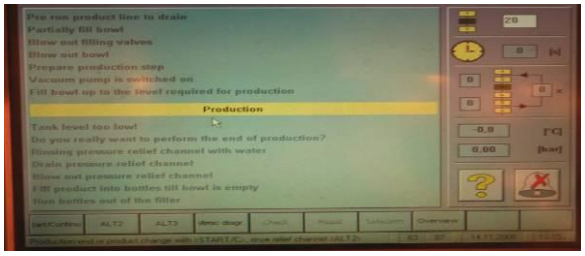


3.2 INTERNAL CHANGEOVER TASKS

a) Changing from light to light leaving no balance tank

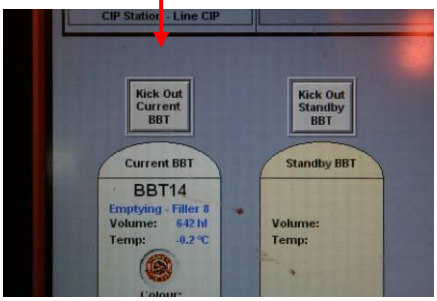
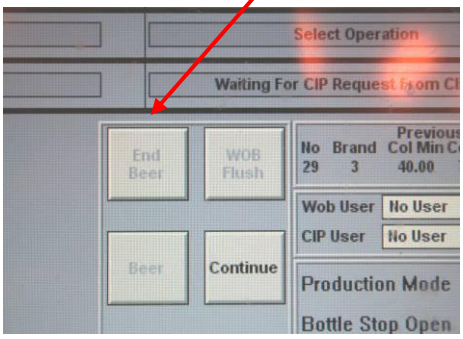
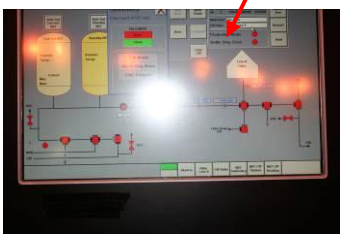
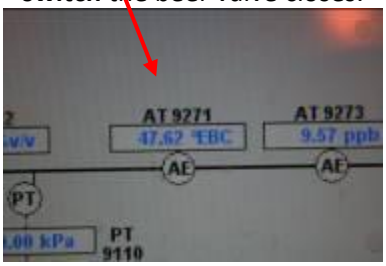
ACTIVITIES	COMMENTS
1. At a balance of 50 HLs: Monitor the BBT panel until the BBT runs empty. Enter the next tank into the **Current BBT tab.** 	
2. Once the tank runs empty the system will wait. Press **End Beer** and WOB will push out the old beer. 	All system valves will be automatically closed.
3. Once the Filler "sees" WOB at the **Colour switch** the beer **valve closes.**  	

ACTIVITIES	COMMENTS
4. The Filler will run until it detects **low level** in the bowl. 	The bowl level should not drop below 45% as the filler might produce some under fills.
5. Once low level has been detected, change to Step 26 - Run remaining bottles out of Filler until bowl is empty.	
6. Close **bottle stopper** at Filler Operator's panel when bowl level equals 30%. 	Bottle stopper will engage, stopping bottles from feeding into Filler.
7. Run remaining bottles through the Filler.	The bowl will run empty until about 3% of beer is left.
8. Take last bottle from Filler to QC to perform brand identity and dilution check.	Check if all quality parameters are in spec. as per AQCP82.

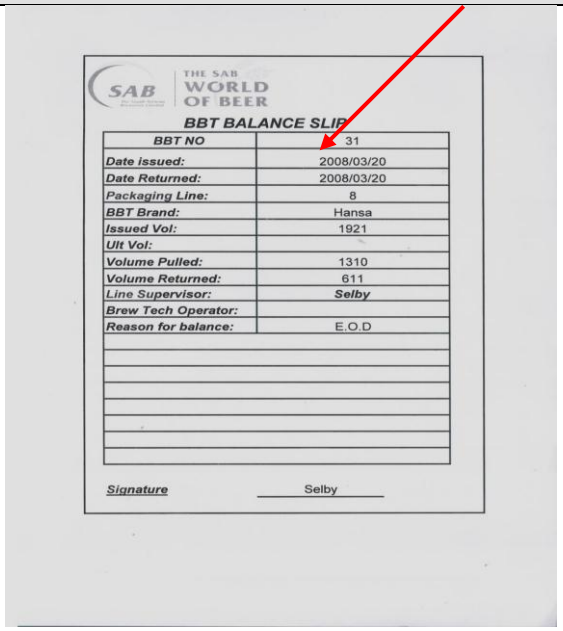
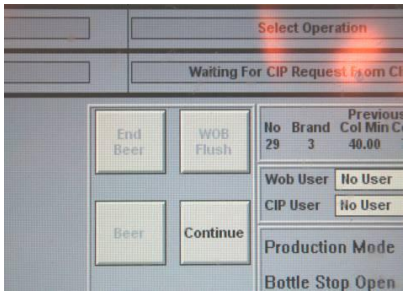
ACTIVITIES	COMMENTS
9. Do not forget to push the last bottles of outgoing brand into the pasteuriser. This will create +/- 20 min gap (or two windows) in the pasteuriser.	
10. Remove old brand crowns and put new brand crowns into bins and run them through to the hopper.	
11. Thoroughly clean out all broken glasses from Filler. These are broken glasses on the Star wheel, in feed / discharge, Crowner and Intermediate.	
12. Record the Filler counters and **reset** for next tank.	
13. Press **Beer** button to start pulling beer. 	The beer pushes WOB to drain until colour switch sees beer and the system goes into hold.
14. Once the Filler sees WOB at the colour switch the **beer valve closes** and drain opens until +/-25 HL has passed to drain or until colour switch detects beer.	System will then stop.
15. Start the Filler program from Step 10 – Request Product (Start/Continue). 	The Filler will go through all the flushing and pressurising steps using the new brand beer and not water. The system will now step through to Step 12 which is a wait step for sampling.

ACTIVITIES	COMMENTS
To select Step 10: press the **Selection** button , change the step number to 10, and press the **Select** button and press **Yes** button to confirm.	
16. The system will wait at Step 12.	Verify colour is within spec limits at the colour switch, if yes, press Start/Continue. If not, use manual draining buttons on side of conveyor until colour is within spec limits.
17. Process now steps through to Step 20 – Production Mode.	
18. Press **Bottle Stopper Open**. 	The **Bottle Stopper** will disengage.
19. Run the Filler at slow speed of ±30 000 bph until the beer temperature is between -1^{0}C to 0.8^{0}C.	The bottles will start running through, filled and sealed.
20. Check for dilution in Packaging Laboratory.	Take the first bottle off the line and check for dilution. Check that all parameters are in spec as per AQCP82. If yes, then carry out the rest of the Input/Output checks as per PIMS/POMS.
21. Return all old brand crowns to Raw Materials Store.	Only current brand crowns should be at the work station.

B) CHANGING FROM LIGHT TO LIGHT LEAVING A BALANCE TANK

ACTIVITIES	STANDARD
1. Check the Filler counters and convert to HL.	Ensure enough HL withdrawn as per program.
2. **Kick out Current BBT** when desired volume is reached. 	System is in hold. Select **End Beer** for WOB flush. 
3. Once the tank runs empty the system will wait. Press **End Beer** and WOB will push out the old beer.	All system **valves will be closed.** 
4. Once the Filler "sees" WOB at the **colour switch** the beer valve closes. 	

ACTIVITIES	STANDARD
5. The Filler will run until it detects low level in the bowl.	
6. Once low level has been detected, change to Step 26 - Run remaining bottles out of Filler until bowl is empty.	
7. Close bottle stopper at Filler Operator's panel when bowl level equals 30%.	Bottle stopper will engage, stopping bottles from feeding into Filler.
8. Run remaining bottles through the Filler.	The bowl will run empty until about 3% of beer is left.
9. Take last bottle from Filler to QC to perform brand identity and dilution check.	Check if all quality parameters are in spec as per AQCP82.
10. Do not forget to push the last bottles of outgoing brand into the pasteuriser. This will create +/- 20 min gap in the pasteuriser.	
11. Remove old brand crowns and put new brand crowns into bins and run them through to the hopper.	
12. Clean out all glass from Filler.	
13. Record the Filler counters and reset for next tank.	Ensure that Filtration receives a **BBT balance slip.**

ACTIVITIES	STANDARD
	
14. Press Beer button to start pulling beer. 	The beer pushes WOB to drain until colour switch sees beer and the system goes into hold.
15. Once the Filler sees WOB at the colour switch the beer valve closes and drain opens until +/- 25 Hl has passed to drain or until colour switch detects beer.	System will then stop.
16. Press **Continue** at BBC panel and valve opens to Filler.	
17. Start the Filler program from Step 10 – Request Product (Start/Continue) **See picture – Start / Continue button above**	The Filler will go through all the flushing and pressurising steps using the new brand beer and not water.

ACTIVITIES	STANDARD
To select Step 10: press **Selection** button , change the step number to 10, and press **Select** button and press **Yes** button to confirm.	The system will now step through to Step 12 which is a wait step for sampling.
18. The system will wait at Step 12.	Verify colour is within spec limits with colour switch, if yes, press Start/Continue. If not, use **manual draining buttons** on side of conveyor until colour is within spec limits.
19. Process now steps through to Step 20 - Production.	
20. Press **Bottle Stopper Open**	The **Bottle Stopper** will disengage.
21. Run the Filler at slow speed of ±30,000 bph until the beer temperature is between -1^0C to 0.8^0C.	The bottles will start running through, filled and sealed.
22. Check for dilution in Packaging Laboratory.	Take first bottle off line and check for dilution. Check that all parameters are in spec. If yes, then perform the rest of the Input/Output checks as per PIMS/POMS.
23. Return all old brand crowns to Raw Materials Store.	Only current brand crowns should be at the work station.

C) CHANGING FROM LIGHT TO DARK

This procedure is the same as changing from light to light above.

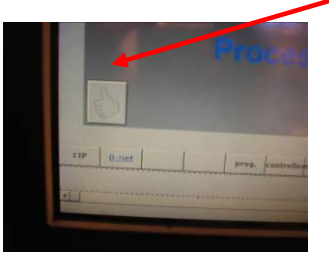
D) CHANGING FROM DARK (CMS) TO LIGHT

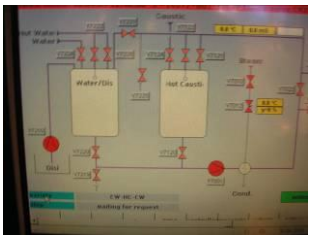
This procedure is exactly the same as the above two procedures (changing from light to light leaving no balance tank and leaving a balance tank) BUT do not enter the new BBT in the BBC system. As soon as the last Castle Milk Stout reaches the Color switch, the system will go into a hold condition and will wait for a command or action from the operator.

Press **End Beer** to call for more WOB. Run the Filler out and do cold and hot water flush from the CIP station. Proceed with the normal start-up as per Work Instruction 12.

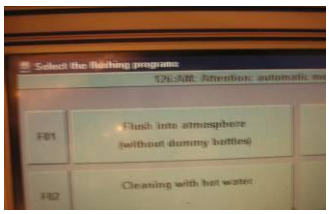
Procedure to do a hot flush using CIP station.

- While in normal operating screen, press arrow left to go to **CIP** screen **on AIO (Lauer / HMI)**.

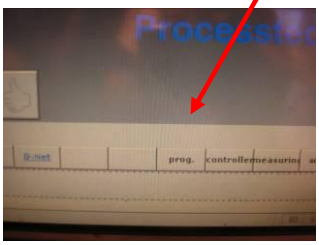


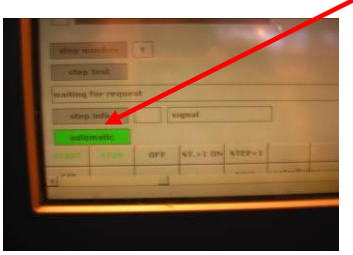


- Select **Flush into atmosphere without dummy bottles.**

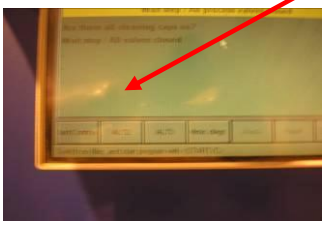


- Go to CIP station and select **program**, select CIP Filler and press **Start/Continue.**





- Go back to Filler AIO and press **Start/Continue.**



- CIP system runs and flushes Filler to drain two times. (Duration 35 minutes).
- When this finishes select bottom left hand side button on AIO. This takes you back to the filling program.
- Start up as described in your start up procedure.

Alrode Brewery Best Practices			
Section	Packaging – Line7	Date created	../../2012
Sub Section	Labeller		
Subject	Changeover Guide	Page	1 of 4

Content

1. Introduction

The reason for this document is to provide a step by step instruction on how to do a changeover and setup on the Krones Multimodal Labeller unit 7. To minimise the time taken to perform changeovers, this procedure is made up of internal and external tasks. The external tasks are those tasks that must be done before and after the actual changeover has taken place. The internal tasks are those performed during the changeover process.

2. Preparation

Check parts list for brand change.
Get rid of all re wash bottles and glass around labellers and glide liner.
Ensure that labels and glue for next brand is available
Move current brand labels to make space for next brand
When filler stop for brand change fill 4 trays with labels per label station
Bring trolleys to labeller for brand change
Load one tray per station with next brand labels
When bottles are at required position in pasteuriser insert the divider.
Empty out the conveyors and stop machine for change over
Prepare back station if it needs to be done
Get back station glue and glue pump ready for operation

3. Krones Cold Glue Aggregate Changeover

Remove the following:
Unlock and move back label station
Disconnect air and grease pipes to gripper cylinder
Remove the face guard.
Place the empty pallet holder on to AMB
Open up glue scraper and then top support.
Remove pallet support and place on AMB
Remove pallets and place them in holder.
Remove the pallet turret cover for cleaning.

Wipe dirt from gripper cylinder drive shaft
Remove gripper cylinder and put it next to pallets.
Put pallets on to trolley
Put gripper cylinder on to trolley.

Do the following:
Place the required pallets on to AMB
Place the gripper cylinder on to AMB
Fit the clean pallet turret cover
Rub some oil on to gripper cylinder shaft.
Fit required gripper cylinder & set up air blower
Put some oil in to hubs and fit required pallets.
Replace pallet support and put oil on bushes.
Close top cover and glue scraper.
Fit required Face guard.
Change to required label magazine.
Change to required spacers and label follower.
Change to required label tray guide.**(Not on Back station)**
Connect gripper cylinder air and grease pipes
Fit required neck brush at back station.
Fit required brushes
Set parameters as required on control pendant. Height & penetration.
Synchronize aggregates when all stations are changed over
Move in label station in to required position.
Run empty trays through to check operation.

Prime the glue roller to wet the pallets..
Fill 4 trays with required labels.
Jog 3 bottles through machine and check operation and quality.

4. Post Changeover Tasks

Continue to monitor the labelling process and check for any quality defects.
Clean the parts in the wash basin.
Once changed parts have been properly cleaned, store correctly in the change parts trolley and A-frame
Store the trolleys and A-frames in the dedicated space in the workshop.
Return previous brand remaining labels to the label store after size or brand change.

Appendix E

Statistical Process Control Charts for Brand Changeovers

			LINE 7			FILLER			LABELLER 1			LABELLER 2		
			Line 7: Brand Change Over Time			Filler: Brand Change			Labeller 1: Brand Change			Labeller 2: Brand Change		
Year	Month	Date	From	To	Longest Process	Target	Actual	Filler Change: Comments	Target	Actual	Labeller 1 Change: Comments	Target	Actual	Labeller 2 Change: Comments
2012	Jan	3	MS	KL	35	30	35		30	26		30	32	
		5	KL	HP	44	30	28		30	44		30	40	
		8	HP	MS	44	30	30		30	39		30	44	
		12	MS	KL	45	30	25		30	29		30	45	
	Feb	13	KL	HP	40	30	40		30	22		30	33	
		15	MS	KL	41	30	41		30	35		30	33	
		22	KL	MS	32	30	25		30	30		30	32	
		27	MS	HP	34	30	26		30	29		30	34	
	March	3	HP	KL	44	30	44		30	31		30	30	
		5	KL	MS	39	30	39		30	30		30	29	
		8	MS	HP	32	30	29		30	32		30	25	
		12	HP	KL	29	30	22		30	29		30	24	
	April	13	KL	MS	35	30	35		30	35		30	27	
		15	MS	HP	36	30	36		30	28		30	28	
		22	HP	MS	30	30	30		30	30		30	30	
		27	MS	KL	45	30	31		30	18		30	45	
	June	5	KL	HP	50	30	30		30	26		30	50	
		8	HP	MS	32	30	32		30	30		30	30	
		12	MS	KL	47	30	29		30	26		30	47	
					45	30	45		30	44		30	30	

Table 14 - Spread sheet for brand changeovers

Line 7: Brand Change Over Time												
CAPABILITY STUDIES			CONTROL LIMITS: X CHARTS					CONTROL LIMITS:MR CHARTS				
IX Pot	MR	MR Pot	LCLx	Target	BestAvg	UWLx	UCLx	LCL(R)	LWL(R)	MRbar(Pot)	UWL(R)	UCL(R)
35			0.0	30.0	39.0	50.2	55.8	0.00	0.00	6	15.9	20.6
44	9	9	0.0	30.0	39.0	50.2	55.8	0.00	0.00	6	15.9	20.6
44	0	0	0.0	30.0	39.0	50.2	55.8	0.00	0.00	6	15.9	20.6
45	1	1	0.0	30.0	39.0	50.2	55.8	0.00	0.00	6	15.9	20.6
40	5	5	0.0	30.0	39.0	50.2	55.8	0.00	0.00	6	15.9	20.6
41	1	1	0.0	30.0	39.0	50.2	55.8	0.00	0.00	6	15.9	20.6
32	9	9	0.0	30.0	39.0	50.2	55.8	0.00	0.00	6	15.9	20.6
34	2	2	0.0	30.0	39.0	50.2	55.8	0.00	0.00	6	15.9	20.6
44	10	10	0.0	30.0	39.0	50.2	55.8	0.00	0.00	6	15.9	20.6
39	5	5	0.0	30.0	39.0	50.2	55.8	0.00	0.00	6	15.9	20.6
32	7	7	0.0	30.0	39.0	50.2	55.8	0.00	0.00	6	15.9	20.6
29	3	3	0.0	30.0	39.0	50.2	55.8	0.00	0.00	6	15.9	20.6
35	6	6	0.0	30.0	39.0	50.2	55.8	0.00	0.00	6	15.9	20.6
36	1	1	0.0	30.0	39.0	50.2	55.8	0.00	0.00	6	15.9	20.6
30	6	6	0.0	30.0	39.0	50.2	55.8	0.00	0.00	6	15.9	20.6
45	15	15	0.0	30.0	39.0	50.2	55.8	0.00	0.00	6	15.9	20.6
50	5	5	0.0	30.0	39.0	50.2	55.8	0.00	0.00	6	15.9	20.6
32	18	18	0.0	30.0	39.0	50.2	55.8	0.00	0.00	6	15.9	20.6
47	15	15	0.0	30.0	39.0	50.2	55.8	0.00	0.00	6	15.9	20.6
45	2	2	0.0	30.0	39.0	50.2	55.8	0.00	0.00	6	15.9	20.6
			0.0	30.0	39.0	50.2	55.8	0.00	0.00	6.3	15.9	20.6

Table 15 - Control chart calculations for overall brand changeover

Filler: Brand Change												
CAPABILITY STUDIES			CONTROL LIMITS: X CHARTS					CONTROL LIMITS:MR CHARTS				
IX Pot	MR	MR Pot	LCLx	Target	BestAvg	UWLx	UCLx	LCL(R)	LWL(R)	MRbar(Pot)	UWL(R)	UCL(R)
35			0.0	30.0	32.6	44.7	50.8	0.00	0.00	7	17.2	22.4
28	7	7	0.0	30.0	32.6	44.7	50.8	0.00	0.00	7	17.2	22.4
30	2	2	0.0	30.0	32.6	44.7	50.8	0.00	0.00	7	17.2	22.4
25	5	5	0.0	30.0	32.6	44.7	50.8	0.00	0.00	7	17.2	22.4
40	15	15	0.0	30.0	32.6	44.7	50.8	0.00	0.00	7	17.2	22.4
41	1	1	0.0	30.0	32.6	44.7	50.8	0.00	0.00	7	17.2	22.4
25	16	16	0.0	30.0	32.6	44.7	50.8	0.00	0.00	7	17.2	22.4
26	1	1	0.0	30.0	32.6	44.7	50.8	0.00	0.00	7	17.2	22.4
44	18	18	0.0	30.0	32.6	44.7	50.8	0.00	0.00	7	17.2	22.4
39	5	5	0.0	30.0	32.6	44.7	50.8	0.00	0.00	7	17.2	22.4
29	10	10	0.0	30.0	32.6	44.7	50.8	0.00	0.00	7	17.2	22.4
22	7	7	0.0	30.0	32.6	44.7	50.8	0.00	0.00	7	17.2	22.4
35	13	13	0.0	30.0	32.6	44.7	50.8	0.00	0.00	7	17.2	22.4
36	1	1	0.0	30.0	32.6	44.7	50.8	0.00	0.00	7	17.2	22.4
30	6	6	0.0	30.0	32.6	44.7	50.8	0.00	0.00	7	17.2	22.4
31	1	1	0.0	30.0	32.6	44.7	50.8	0.00	0.00	7	17.2	22.4
30	1	1	0.0	30.0	32.6	44.7	50.8	0.00	0.00	7	17.2	22.4
32	2	2	0.0	30.0	32.6	44.7	50.8	0.00	0.00	7	17.2	22.4
29	3	3	0.0	30.0	32.6	44.7	50.8	0.00	0.00	7	17.2	22.4
45	16	16	0.0	30.0	32.6	44.7	50.8	0.00	0.00	7	17.2	22.4
			0.0	30.0	32.6	44.7	50.8	0.00	0.00	6.8	17.2	22.4

Table 16 - Calculations for filler brand changeover chart

Labeller 1: Brand Change												Labeller 2: Brand Change											
CAPABILITY STUDIES			CONTROL LIMITS: X CHARTS					CONTROL LIMITS:MR CHARTS				CAPABILITY STUDIES			CONTROL LIMITS: X CHARTS					CONTROL LIMITS:MR CHARTS				
IX Pot	MR	MR Pot	LCLx	Target	BestAvg	UWLx	UCLx	LCL(R)	LWL(R)	MRbar(Pot)	UWL(R)	UCL(R)	IX Pot	MR	MR Pot	LCLx	Target	BestAvg	UWLx	UCLx	LCL(R)	LWL(R)	MRbar(Pot)	UWL(R)	UCL(R)
26			0.0	30.0	30.7	42.6	48.6	0.00	0.00	7	16.9	22.0	32			0.0	30.0	34.4	45.4	50.9	0.00	0.00	6	15.6	20.3
44	18	18	0.0	30.0	30.7	42.6	48.6	0.00	0.00	7	16.9	22.0	40	8	8	0.0	30.0	34.4	45.4	50.9	0.00	0.00	6	15.6	20.3
39	5	5	0.0	30.0	30.7	42.6	48.6	0.00	0.00	7	16.9	22.0	44	4	4	0.0	30.0	34.4	45.4	50.9	0.00	0.00	6	15.6	20.3
29	10	10	0.0	30.0	30.7	42.6	48.6	0.00	0.00	7	16.9	22.0	45	1	1	0.0	30.0	34.4	45.4	50.9	0.00	0.00	6	15.6	20.3
22	7	7	0.0	30.0	30.7	42.6	48.6	0.00	0.00	7	16.9	22.0	33	12	12	0.0	30.0	34.4	45.4	50.9	0.00	0.00	6	15.6	20.3
35	13	13	0.0	30.0	30.7	42.6	48.6	0.00	0.00	7	16.9	22.0	33	0	0	0.0	30.0	34.4	45.4	50.9	0.00	0.00	6	15.6	20.3
30	5	5	0.0	30.0	30.7	42.6	48.6	0.00	0.00	7	16.9	22.0	32	1	1	0.0	30.0	34.4	45.4	50.9	0.00	0.00	6	15.6	20.3
29	1	1	0.0	30.0	30.7	42.6	48.6	0.00	0.00	7	16.9	22.0	34	2	2	0.0	30.0	34.4	45.4	50.9	0.00	0.00	6	15.6	20.3
31	2	2	0.0	30.0	30.7	42.6	48.6	0.00	0.00	7	16.9	22.0	30	4	4	0.0	30.0	34.4	45.4	50.9	0.00	0.00	6	15.6	20.3
30	1	1	0.0	30.0	30.7	42.6	48.6	0.00	0.00	7	16.9	22.0	29	1	1	0.0	30.0	34.4	45.4	50.9	0.00	0.00	6	15.6	20.3
32	2	2	0.0	30.0	30.7	42.6	48.6	0.00	0.00	7	16.9	22.0	25	4	4	0.0	30.0	34.4	45.4	50.9	0.00	0.00	6	15.6	20.3
29	3	3	0.0	30.0	30.7	42.6	48.6	0.00	0.00	7	16.9	22.0	24	1	1	0.0	30.0	34.4	45.4	50.9	0.00	0.00	6	15.6	20.3
35	6	6	0.0	30.0	30.7	42.6	48.6	0.00	0.00	7	16.9	22.0	27	3	3	0.0	30.0	34.4	45.4	50.9	0.00	0.00	6	15.6	20.3
28	7	7	0.0	30.0	30.7	42.6	48.6	0.00	0.00	7	16.9	22.0	28	1	1	0.0	30.0	34.4	45.4	50.9	0.00	0.00	6	15.6	20.3
30	2	2	0.0	30.0	30.7	42.6	48.6	0.00	0.00	7	16.9	22.0	30	2	2	0.0	30.0	34.4	45.4	50.9	0.00	0.00	6	15.6	20.3
18	12	12	0.0	30.0	30.7	42.6	48.6	0.00	0.00	7	16.9	22.0	45	15	15	0.0	30.0	34.4	45.4	50.9	0.00	0.00	6	15.6	20.3
26	8	8	0.0	30.0	30.7	42.6	48.6	0.00	0.00	7	16.9	22.0	50	5	5	0.0	30.0	34.4	45.4	50.9	0.00	0.00	6	15.6	20.3
30	4	4	0.0	30.0	30.7	42.6	48.6	0.00	0.00	7	16.9	22.0	30	20	20	0.0	30.0	34.4	45.4	50.9	0.00	0.00	6	15.6	20.3
26	4	4	0.0	30.0	30.7	42.6	48.6	0.00	0.00	7	16.9	22.0	47	17	17	0.0	30.0	34.4	45.4	50.9	0.00	0.00	6	15.6	20.3
44	18	18	0.0	30.0	30.7	42.6	48.6	0.00	0.00	7	16.9	22.0	30	17	17	0.0	30.0	34.4	45.4	50.9	0.00	0.00	6	15.6	20.3
			0.0	30.0	30.7	42.6	48.6	0.00	0.00	6.7	16.9	22.0				0.0	30.0	34.4	45.4	50.9	0.00	0.00	6.2	15.6	20.3

Table 17 - Calculations for Labellers brand changeover charts

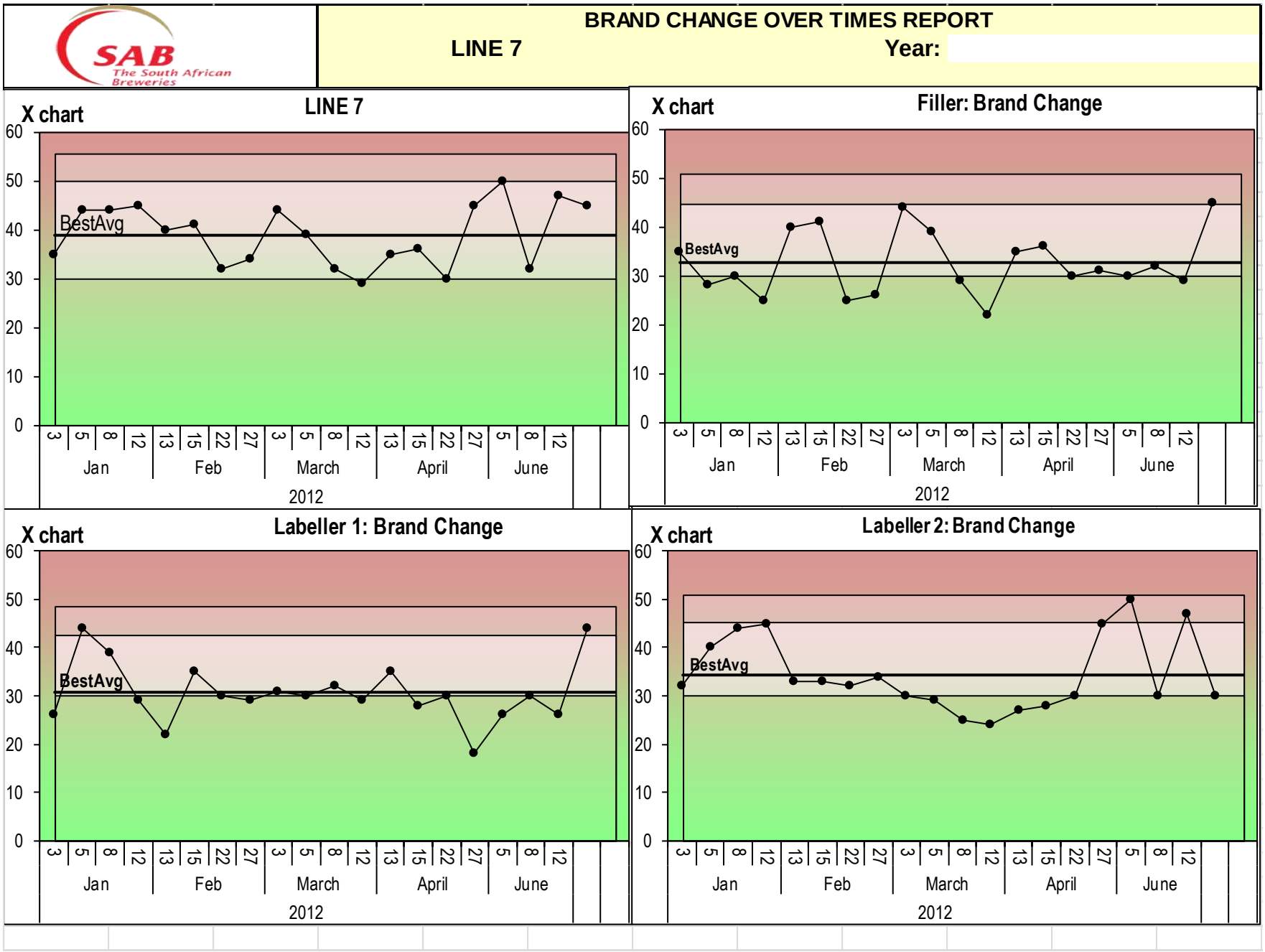


Figure 12 - Xbar control charts for brand changeover

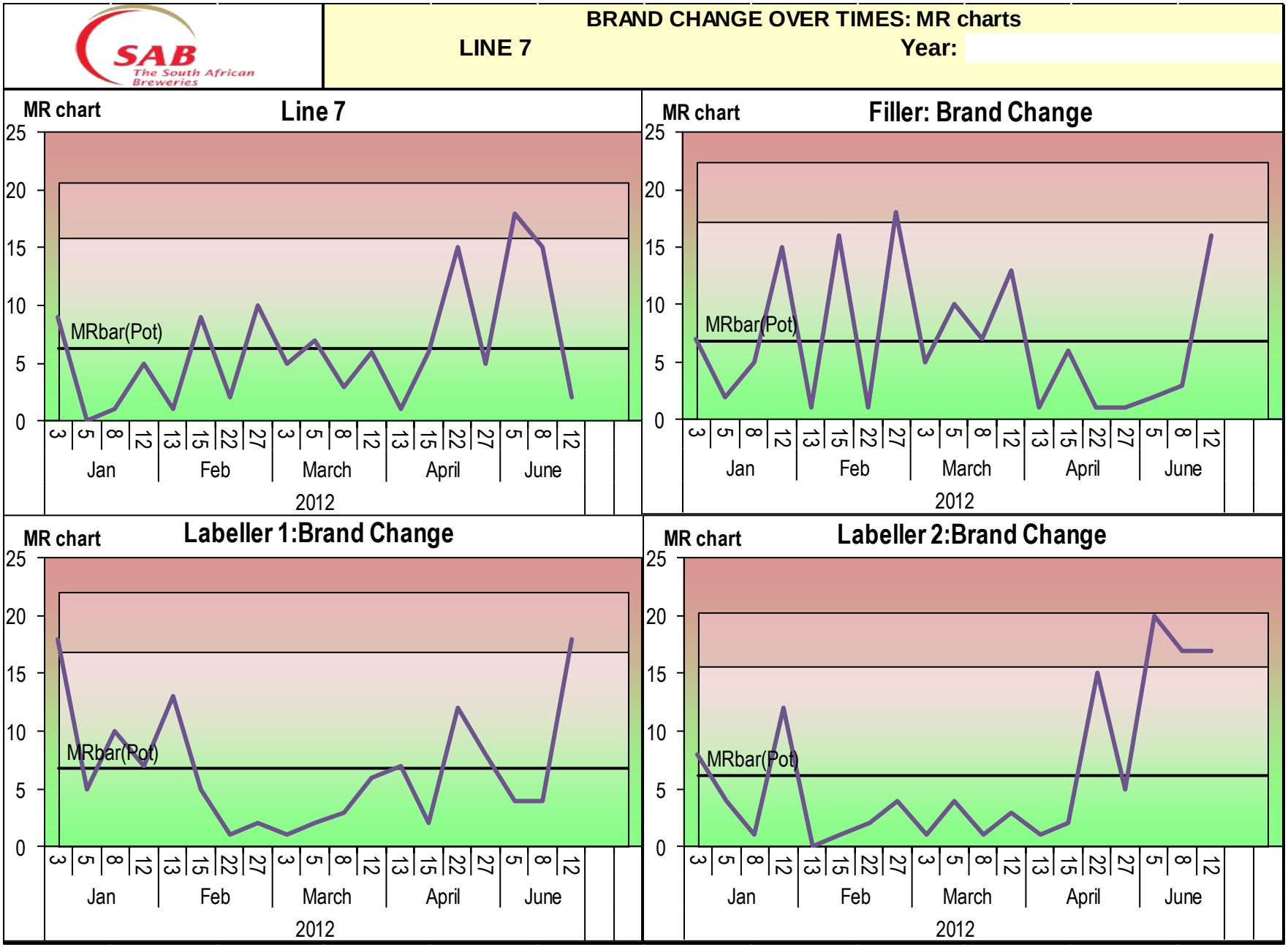


Figure 13 - MRbar control charts for brand changeover

Statistical Process Control Charts for Brand Changeovers

SAB The South African Breweries			LINE 7			FILLER			LABELLER 1			LABELLER 2		
			Line 7: Size Change Over Time			Filler: Size Change			Labeller 1: Size Change			Labeller 2: Size Change		
Year	Month	Date	From	To	Longest Process	Target	Actual	Filler Change: Comments	Target	Actual	Labeller 1 Change: Comments	Target	Actual	Labeller 2 Change: Comments
2012	Jan	3	HP	CL	100	90	100		90	88		90	90	
		5	CL	CD	110	90	110		90	90		90	79	
		8	CD	MS	98	90	98		90	95		90	75	
		12	MS	MGD	111	90	90		90	111		90	88	
	Feb	13	MGD	CL	95	90	89		90	95		90	90	
		15	CL	CD	95	90	80		90	80		90	95	
		22	CD	MGD	111	90	90		90	90		90	111	
		27	MGD	MS	95	90	79		90	89		90	95	
	March	3	HP	CL	80	90	75		90	80		90	80	
		5	CL	CD	90	90	88		90	90		90	90	
		8	CD	MS	90	90	90		90	79		90	79	
		12	MS	MGD	95	90	95		90	95		90	95	
	April	13	MGD	CL	111	90	111		90	80		90	80	
		15	CL	CD	95	90	95		90	85		90	95	
		22	CD	MGD	80	90	80		90	70		90	80	
		27	MGD	MS	90	90	85		90	76		90	90	
	June	5	HP	CL	89	90	70		90	79		90	89	
		8	CL	CD	80	90	76		90	75		90	80	
		12	CD	MGD	90	90	77		90	88		90	90	
					90	90	72		90	90		90	79	

Table 18 - Spread sheet for size changeovers

Line 7: Size Change Over Time												
CAPABILITY STUDIES			CONTROL LIMITS: X CHARTS					CONTROL LIMITS:MR CHARTS				
IX Pot	MR	MR Pot	LCLx	Target	BestAvg	UWLx	UCLx	LCL(R)	LWL(R)	MRbar(Pot)	UWL(R)	UCL(R)
100			0.0	90.0	94.8	112.5	121.4	0.00	0.00	10	25.1	32.7
110	10	10	0.0	90.0	94.8	112.5	121.4	0.00	0.00	10	25.1	32.7
98	12	12	0.0	90.0	94.8	112.5	121.4	0.00	0.00	10	25.1	32.7
111	13	13	0.0	90.0	94.8	112.5	121.4	0.00	0.00	10	25.1	32.7
95	16	16	0.0	90.0	94.8	112.5	121.4	0.00	0.00	10	25.1	32.7
95	0	0	0.0	90.0	94.8	112.5	121.4	0.00	0.00	10	25.1	32.7
111	16	16	0.0	90.0	94.8	112.5	121.4	0.00	0.00	10	25.1	32.7
95	16	16	0.0	90.0	94.8	112.5	121.4	0.00	0.00	10	25.1	32.7
80	15	15	0.0	90.0	94.8	112.5	121.4	0.00	0.00	10	25.1	32.7
90	10	10	0.0	90.0	94.8	112.5	121.4	0.00	0.00	10	25.1	32.7
90	0	0	0.0	90.0	94.8	112.5	121.4	0.00	0.00	10	25.1	32.7
95	5	5	0.0	90.0	94.8	112.5	121.4	0.00	0.00	10	25.1	32.7
111	16	16	0.0	90.0	94.8	112.5	121.4	0.00	0.00	10	25.1	32.7
95	16	16	0.0	90.0	94.8	112.5	121.4	0.00	0.00	10	25.1	32.7
80	15	15	0.0	90.0	94.8	112.5	121.4	0.00	0.00	10	25.1	32.7
90	10	10	0.0	90.0	94.8	112.5	121.4	0.00	0.00	10	25.1	32.7
89	1	1	0.0	90.0	94.8	112.5	121.4	0.00	0.00	10	25.1	32.7
80	9	9	0.0	90.0	94.8	112.5	121.4	0.00	0.00	10	25.1	32.7
90	10	10	0.0	90.0	94.8	112.5	121.4	0.00	0.00	10	25.1	32.7
90	0	0	0.0	90.0	94.8	112.5	121.4	0.00	0.00	10	25.1	32.7
			0.0	90.0	94.8	112.5	121.4	0.00	0.00	10.0	25.1	32.7

Table 19 - Calculations for overall size changeover chart

Filler: Size Change												
CAPABILITY STUDIES			CONTROL LIMITS: X CHARTS					CONTROL LIMITS:MR CHARTS				
IX Pot	MR	MR Pot	LCLx	Target	BestAvg	UWLx	UCLx	LCL(R)	LWL(R)	MRbar(Pot)	UWL(R)	UCL(R)
100			0.0	90.0	87.5	102.8	110.5	0.00	0.00	9	21.7	28.2
110	10	10	0.0	90.0	87.5	102.8	110.5	0.00	0.00	9	21.7	28.2
98	12	12	0.0	90.0	87.5	102.8	110.5	0.00	0.00	9	21.7	28.2
90	8	8	0.0	90.0	87.5	102.8	110.5	0.00	0.00	9	21.7	28.2
89	1	1	0.0	90.0	87.5	102.8	110.5	0.00	0.00	9	21.7	28.2
80	9	9	0.0	90.0	87.5	102.8	110.5	0.00	0.00	9	21.7	28.2
90	10	10	0.0	90.0	87.5	102.8	110.5	0.00	0.00	9	21.7	28.2
79	11	11	0.0	90.0	87.5	102.8	110.5	0.00	0.00	9	21.7	28.2
75	4	4	0.0	90.0	87.5	102.8	110.5	0.00	0.00	9	21.7	28.2
88	13	13	0.0	90.0	87.5	102.8	110.5	0.00	0.00	9	21.7	28.2
90	2	2	0.0	90.0	87.5	102.8	110.5	0.00	0.00	9	21.7	28.2
95	5	5	0.0	90.0	87.5	102.8	110.5	0.00	0.00	9	21.7	28.2
111	16	16	0.0	90.0	87.5	102.8	110.5	0.00	0.00	9	21.7	28.2
95	16	16	0.0	90.0	87.5	102.8	110.5	0.00	0.00	9	21.7	28.2
80	15	15	0.0	90.0	87.5	102.8	110.5	0.00	0.00	9	21.7	28.2
85	5	5	0.0	90.0	87.5	102.8	110.5	0.00	0.00	9	21.7	28.2
70	15	15	0.0	90.0	87.5	102.8	110.5	0.00	0.00	9	21.7	28.2
76	6	6	0.0	90.0	87.5	102.8	110.5	0.00	0.00	9	21.7	28.2
77	1	1	0.0	90.0	87.5	102.8	110.5	0.00	0.00	9	21.7	28.2
72	5	5	0.0	90.0	87.5	102.8	110.5	0.00	0.00	9	21.7	28.2
			0.0	90.0	87.5	102.8	110.5	0.00	0.00	8.6	21.7	28.2

Table 20 - Calculations for filler size changeover charts

Labeller 1: Size Change												
CAPABILITY STUDIES			CONTROL LIMITS: X CHARTS					CONTROL LIMITS:MR CHARTS				
IX Pot	MR	MR Pot	LCLx	Target	BestAvg	UWLx	UCLx	LCL(R)	LWL(R)	MRbar(Pot)	UWL(R)	UCL(R)
88			0.0	90.0	86.3	102.5	110.6	0.00	0.00	9	23.0	29.9
90	2	2	0.0	90.0	86.3	102.5	110.6	0.00	0.00	9	23.0	29.9
95	5	5	0.0	90.0	86.3	102.5	110.6	0.00	0.00	9	23.0	29.9
111	16	16	0.0	90.0	86.3	102.5	110.6	0.00	0.00	9	23.0	29.9
95	16	16	0.0	90.0	86.3	102.5	110.6	0.00	0.00	9	23.0	29.9
80	15	15	0.0	90.0	86.3	102.5	110.6	0.00	0.00	9	23.0	29.9
90	10	10	0.0	90.0	86.3	102.5	110.6	0.00	0.00	9	23.0	29.9
89	1	1	0.0	90.0	86.3	102.5	110.6	0.00	0.00	9	23.0	29.9
80	9	9	0.0	90.0	86.3	102.5	110.6	0.00	0.00	9	23.0	29.9
90	10	10	0.0	90.0	86.3	102.5	110.6	0.00	0.00	9	23.0	29.9
79	11	11	0.0	90.0	86.3	102.5	110.6	0.00	0.00	9	23.0	29.9
95	16	16	0.0	90.0	86.3	102.5	110.6	0.00	0.00	9	23.0	29.9
80	15	15	0.0	90.0	86.3	102.5	110.6	0.00	0.00	9	23.0	29.9
85	5	5	0.0	90.0	86.3	102.5	110.6	0.00	0.00	9	23.0	29.9
70	15	15	0.0	90.0	86.3	102.5	110.6	0.00	0.00	9	23.0	29.9
76	6	6	0.0	90.0	86.3	102.5	110.6	0.00	0.00	9	23.0	29.9
79	3	3	0.0	90.0	86.3	102.5	110.6	0.00	0.00	9	23.0	29.9
75	4	4	0.0	90.0	86.3	102.5	110.6	0.00	0.00	9	23.0	29.9
88	13	13	0.0	90.0	86.3	102.5	110.6	0.00	0.00	9	23.0	29.9
90	2	2	0.0	90.0	86.3	102.5	110.6	0.00	0.00	9	23.0	29.9
			0.0	90.0	86.3	102.5	110.6	0.00	0.00	9.2	23.0	29.9

Labeller 2: Size Change												
CAPABILITY STUDIES			CONTROL LIMITS: X CHARTS					CONTROL LIMITS:MR CHARTS				
IX Pot	MR	MR Pot	LCLx	Target	BestAvg	UWLx	UCLx	LCL(R)	LWL(R)	MRbar(Pot)	UWL(R)	UCL(R)
90			0.0	90.0	87.5	106.6	116.2	0.00	0.00	11	27.1	35.2
79	11	11	0.0	90.0	87.5	106.6	116.2	0.00	0.00	11	27.1	35.2
75	4	4	0.0	90.0	87.5	106.6	116.2	0.00	0.00	11	27.1	35.2
88	13	13	0.0	90.0	87.5	106.6	116.2	0.00	0.00	11	27.1	35.2
90	2	2	0.0	90.0	87.5	106.6	116.2	0.00	0.00	11	27.1	35.2
95	5	5	0.0	90.0	87.5	106.6	116.2	0.00	0.00	11	27.1	35.2
111	16	16	0.0	90.0	87.5	106.6	116.2	0.00	0.00	11	27.1	35.2
95	16	16	0.0	90.0	87.5	106.6	116.2	0.00	0.00	11	27.1	35.2
80	15	15	0.0	90.0	87.5	106.6	116.2	0.00	0.00	11	27.1	35.2
90	10	10	0.0	90.0	87.5	106.6	116.2	0.00	0.00	11	27.1	35.2
79	11	11	0.0	90.0	87.5	106.6	116.2	0.00	0.00	11	27.1	35.2
95	16	16	0.0	90.0	87.5	106.6	116.2	0.00	0.00	11	27.1	35.2
80	15	15	0.0	90.0	87.5	106.6	116.2	0.00	0.00	11	27.1	35.2
95	15	15	0.0	90.0	87.5	106.6	116.2	0.00	0.00	11	27.1	35.2
80	15	15	0.0	90.0	87.5	106.6	116.2	0.00	0.00	11	27.1	35.2
90	10	10	0.0	90.0	87.5	106.6	116.2	0.00	0.00	11	27.1	35.2
89	1	1	0.0	90.0	87.5	106.6	116.2	0.00	0.00	11	27.1	35.2
80	9	9	0.0	90.0	87.5	106.6	116.2	0.00	0.00	11	27.1	35.2
90	10	10	0.0	90.0	87.5	106.6	116.2	0.00	0.00	11	27.1	35.2
79	11	11	0.0	90.0	87.5	106.6	116.2	0.00	0.00	11	27.1	35.2
			0.0	90.0	87.5	106.6	116.2	0.00	0.00	10.8	27.1	35.2

Table 21 - Calculations for labeller's size changeover charts

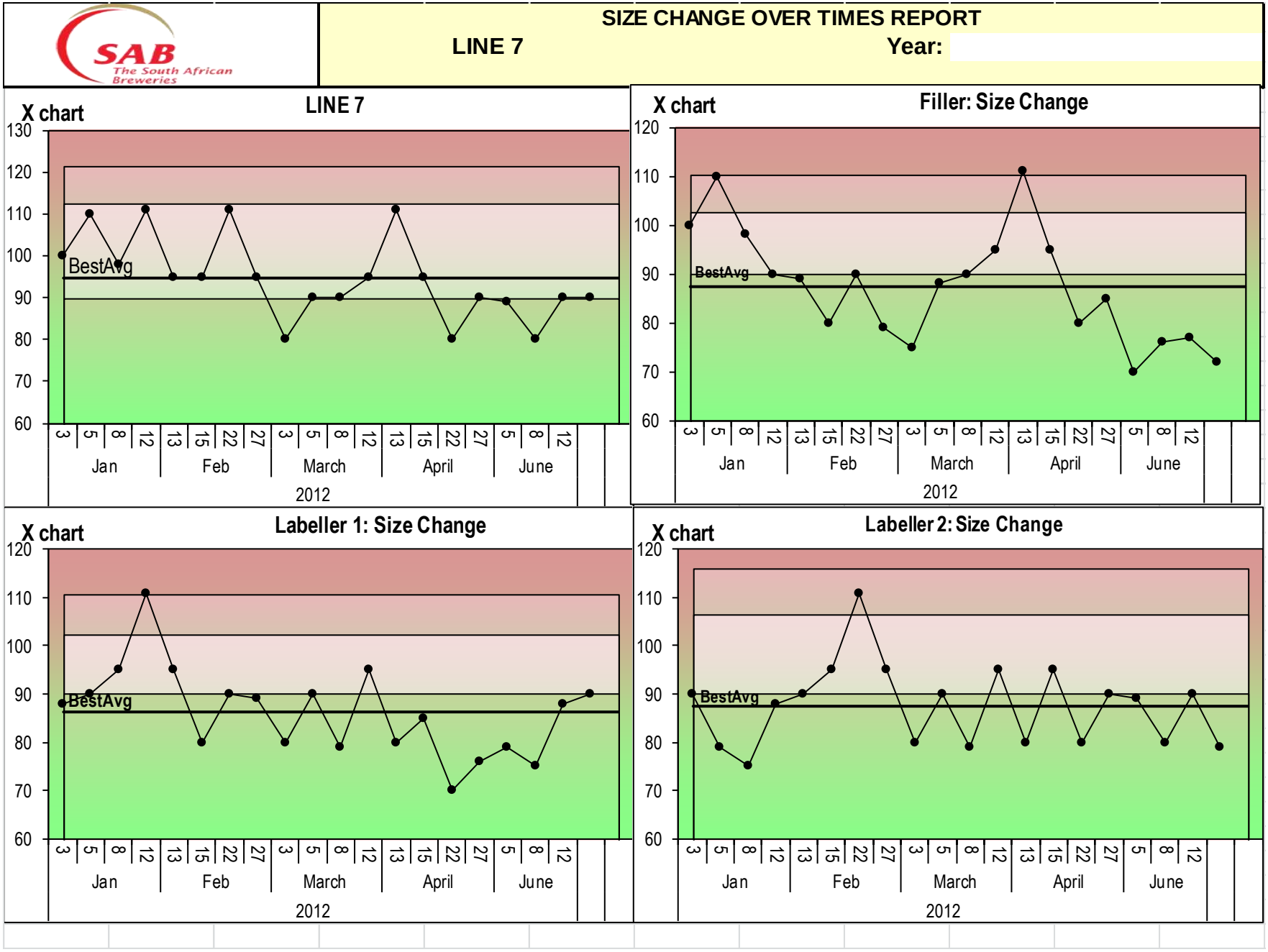


Figure 14 - Xbar control charts for size changeover

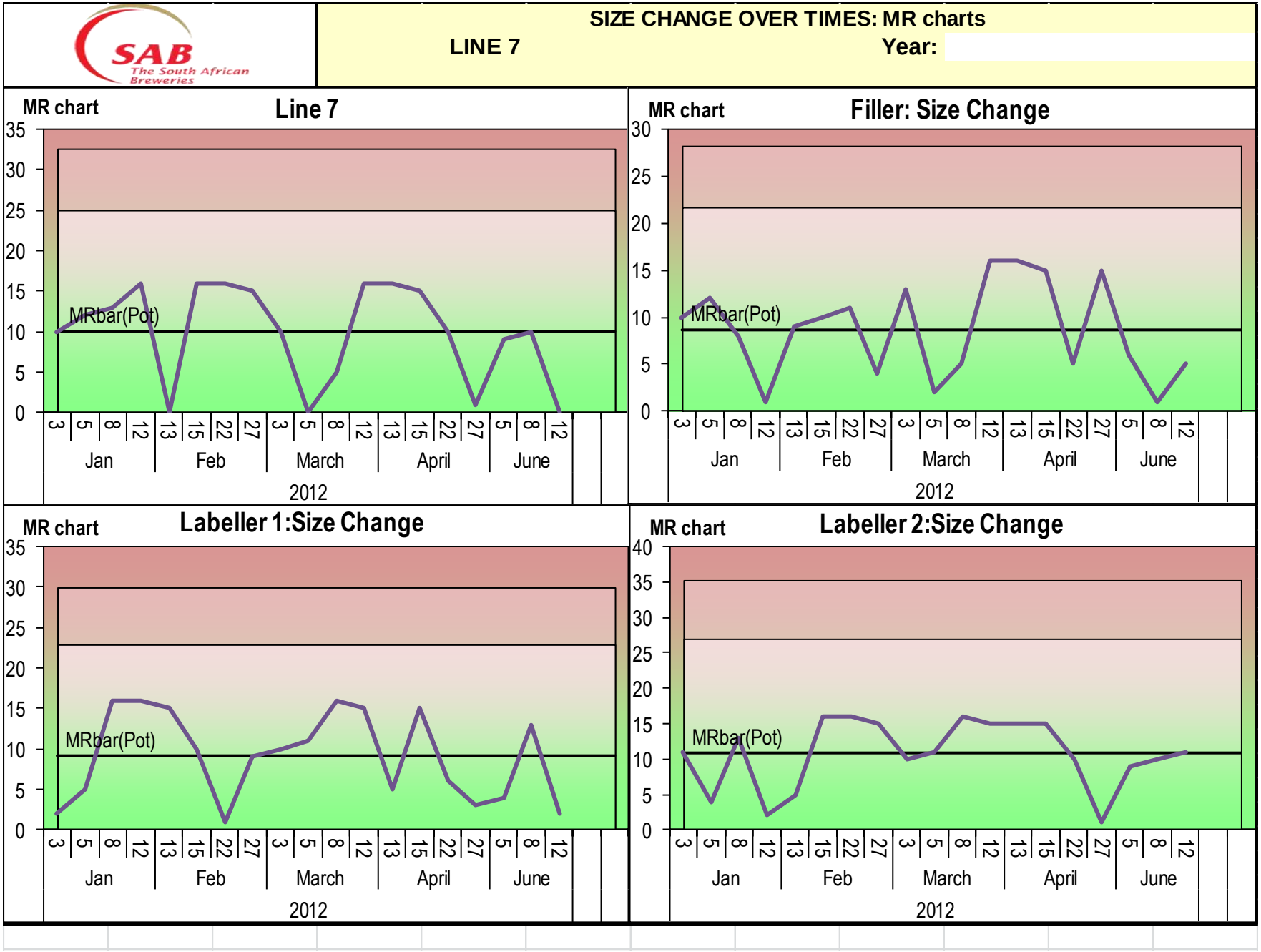


Figure 15 - MRbar charts for size changeover