Development of a Lean Implementation Strategy in a South African Dependency of an International Automotive Supplier

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Abstract:

Implementing a lean strategy within a South African plant has its own benefits and pitfalls. This case study takes place at Donaldson Filtration Systems, a high volume, low mix automotive parts supplier in South Africa.

This case study is performed within the framework of action science, aiming to highlight an implementation strategy that seeks to create a sustainable initiative that goes beyond the standard top-level-down implementations while still seeing the gains lean implementations have come to expect. A lean seed initiative is introduced to create a lean culture and develop the necessary tools relevant to creating a continuous improvement environment within the seed's defined boundary. The strategy makes use of an improvement loop to introduce known lean tools to the system in question to generate buy-in and sustainability. The research showed that the lean seed provides a capable platform for companies to launch an effective lean implementation by following the strategy developed at Donaldson. The strategy confirmed that a sustainable implementation was possible provided the culture was created to introduce the known lean tools available to the continuous improvement movement. A step-by-step improvement loop guide to facilitate the introduction of the culture was developed to ensure practicable outcomes are always made relevant. Management drive, willingness to change company infrastructure, a capable seed team and the freedom to focus on sustainable solutions were key factors found during the implementation that are necessary considerations for a South African manufacturer or facility looking to implement the lean seed strategy.

The main objectives of this study were to determine whether a lean seed implementation strategy could develop the necessary culture and understanding to create a successful and sustainable lean implementation.

Keywords: Lean Manufacturing, Implementation, South Africa, Manufacturing, Lean Culture, Continuous Improvement, Case Study

Declaration

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

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Heath Hartle

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Contents

List of Figures

Figures from Appendices

List of Tables

Tables from Appendices

List of Terms

5S	A system to ensure work areas are kept clean, organized and functional
6S	A 5S initiative with safety as an included focus
AMT	Advanced Manufacturing Technology, a department within the process development and advancement group, responsible for in-house design of machinery used for processing Donaldson product
C/O	Denotes a change-over
DPS	Donaldson Production System, Donaldson's own interpretation of the Toyota Production System
EDF	Brand name for a urethane dosing machine used on a Donaldson trademark product called radial seal
IE	Industrial Engineer, or Industrial Engineering department
ISIR	Initial Sample Inspection Report, a quality conformance check and requirement when introducing new product to the plant
ISO	Chemical component of polyurethane
ISO	International Organization of Standards
JDE	J.D. Edwards, ERP accounting software used in the Donaldson plants, used to integrate external and internal management requirements
PDCA	Plan, Do, Check, Act: an iterative four-step management method used in problem solving
Pleater	a machine used to score and fold media to a specific geometry for use in filter packs
Radial Seal	A trademark Donaldson product that makes use of potted urethane end caps that seal radially
Red Tag	A label used during a 6S study to identify items that are not needed or are placed in the wrong area

Acronyms

EHR	Earn Hour Rate
ERP	Enterprise Resource Planning
JIT	Just-In-Time
KPI	Key Performance Indicator
LAI	Lean Advancement Initiative
LESAT	Lean Enterprise Self-Assessment Tool
MRP	Manufacturing Resource Planning
OEE	Overall Equipment Effectiveness

PPM	Pleats per minute
POL	Chemical component of polyurethane
QLI	Quality Line-Inspector
RSL	Radial Seal (production) Line
SAE	Society of Automotive Engineers
SOP	Standard Operating Procedure
SWI	Standard Work Instruction
TPM	Total Productive Maintenance
TPS	Toyota Production System
TS	Technical Specifications
VSM	Value Stream Map
WIP	Work-In-Progress
WO	Work Order

1 Introduction

This case study takes place at Donaldson Filtration systems, an international automotive parts manufacturer seeking to implement a lean culture of continuous improvement through their global initiative, the Donaldson Production System (DPS), a modified version of the Toyota Production System (TPS) created by their international team assigned to implementing lean. DPS would be part of a top-down implementation strategy to ensure that Donaldson's various subsidiaries across the world were able to conform to the new international requirements set out by DPS. Many implementation strategies making use of the top-down strategy fail without the proper local support structures in place to ensure sustainability.

Continuous improvement strategies allow companies to select tools that allow them to engage their markets, processes and customers better. The lean philosophy is a collection of tools developed originally by Toyota to ensure a culture of continuous improvement was created that focussed on customer derived value.
The philosophy has grown into a global manufacturing enigma, where companies all over the world seek to implement the tools to attain the same system success that Toyota reports, but end up chasing strategies that achieve very little in the way of a lean culture.

With these concerns in mind, the Donaldson facility in Epping, Cape Town sought to create a local lean implementation to coincide with an upgrade to its main production line. The upgrade would be integrated as a new line defined by the local continuous improvement system and would comprise of a new system that had the potential to double the line's current capacity.

A new implementation strategy would be used to introduce lean culture to the line making use of a seed initiative to drive the culture from the grassroots of the facility. Introducing a grassroots strategy for introducing lean in South Africa is relevant due to the state of the current SA financial climate. Companies already have the infrastructure, machinery and nous to run a manufacturing facility, and have managed to do so for years without needing to introduce change until recently.
With greater exposure to international markets, companies with manufacturing facilities

needed to start looking at improvement activities, to begin solving minor details that could yield large gains.

Making the move towards a new lean system with a new line needs to be handled with care. One has to consider:

- The implications of bringing in new machinery
- Training and staffing either with a completely new team or an experienced one used to old values and existing habits, good and bad
- The layout of the line and any changes required to make the most of any lean improvements, and finally
- Factory morale.

Furthermore, in line with implementing a new lean strategy, the focus needs to redefine sustainability within the program. Sustainability needed to be incorporated into the actual implementation strategy to ensure that the continuous improvement system itself was creating an approach to problem solving that could be replicated.

This approach raises the question whether or not implementation strategies can or should be standardised. This report does not make a point of implementing lean tools and calling the implementation complete. The case study assumes that the reader has an understanding of the basic lean tools available to an implementation and why they are applicable.
Many documented instances of implementing lean indicate an introduction of lean through the use of tools to generate the culture.
The lean seed aims to create the culture first to develop the continuous improvement tools necessary for that implementation. While the tools are still the same, the understanding of the system from a grassroots perspective is more fundamental.

Implementing a lean seed in a South African automotive manufacturing plant requires a lean team to get the lay of the land in terms of politics and conditions, analyze the system within a defined scope, solve issues found within that scope and implement sustainable solutions. This simple improvement loop is used in conjunction with a lean seed and is used to select and develop specific lean tools as required once the issues are understood.

Within that seed, specific metrics will be assigned to showcase the level of improvements made within the seed boundaries. Each improvement loop would seek to be redefining irrelevant key performance indicators (KPIs). KPIs would be selected to relate to the improvements created to showcase gains or losses made by the system.

There are endless permutations governing a plant or facility's unique set of issues as they have evolved within that microcosm and grown in an environment specifically nurturing with those conditions. That may be insurmountable even before adding South Africa's own problematic history and culture issues when it comes to change, good or bad. The minute you seek to understand a specific microcosm, let alone try to change it, the predetermined reaction is to attack the new approach or methodology and maintain the status quo. Hence, implementing change that sticks and is sustainable is a key calling for those implementing lean strategies. By implementing change immediately before or without forming a unique strategy to facilitate your lean implementation, you set up for failure any changes and strategies because your solutions are not tailor-made to suit that system. While not all solutions need to be tailor-made, the understanding and knowledge gained through the development of that solution strengthens the training and morale of the seed initiative. Lean indicates that standardization is critical; solutions, however, are not one-size-fits-all. By implementing something that has worked somewhere else without specific tweaking, planning, associating and making that initiative personal to the culture, has the potential to fail without policing. Understanding this concept is the first step to achieving buy in and initiating a sustainable continuous improvement program.

1.1 Objectives

This case study was used to reflect that there exists no specific method to introduce a lean culture and all that it entails. To be able to introduce a method with which to combine the performance benefits of lean and be able to use the standard lean toolset sustainably, an implementation method was introduced at an automotive facility in South Africa. The strategy set out to define the characteristics of successful implementations and apply them to a repeatable method that could be applied to other facilities within the same environment.

The main objective would be for the lean seed to be proven as a viable option as an implementation strategy for manufacturing facilities. In creating a strategy guideline that can be used to facilitate the implementation of lean, practitioners making use of it can easily expand it to suppliers at other facilities within the same performance metrics laid out by the original initiative.

A body of work exists to demonstrate that the value of lean and the sustainability therein is derived from the facility's human element, not just the tools used by the philosophy. That said, creating an implementation strategy around the training of that element is critical to introducing the understanding necessary to solve problems and create the flow that lean espouses. As a South African implementation strategy, it speaks to the development and future of a company that their primary investment is in their workforce to perform at a higher level.

A lean implementation was initiated at Donaldson based on the lean seed implementation laid out in this case study. As the champion of the initiative, the researcher used the case study research methodology to ascertain the direct and indirect effects of such an implementation strategy within the culture and how to go about making the initiative stick. Improvement loops were introduced to take a lean team through the required phases to create a lean culture and further develop the continuous improvement environment.

Limitations in the research for the seed implementation strategy come as a result of it being introduced within an automotive manufacturing facility, where many standards and quality procedures would already exist. The implementation strategy outlined by this report is limited to the automotive industry as a result of this. The strategy is geared towards production and process steps found in a manufacturing environment, as such the guide may not translate into a successful implementation strategy for another industry. An introduction to the lean philosophy would be required before trying to introduce lean tools using this implementation strategy. Beyond the introduction, process studies would need to be carried out to understand the current state, this is not always easy in non-manufacturing environments as mapping the customer value and flow is not immediately apparent. The work to understand these systems and their potential intricacies is not highlighted in this guide but is vital in moving the implementation forward. Beyond capturing the current state, another obstacle is found when considering the advanced data capture that manufacturing facilities have over their service industry or other soft product counterparts in non-manufacturing environments, these systems should effectively be installed to showcase change, but do not necessarily require the sophistication seen in the automotive industry.

The case study was performed on site at Donaldson's Epping facility, starting in March 2010 through to June 2012. The facility functions with a staff complement of over 300 workers and does not retain any specifically unique traits that set it apart from other automotive suppliers beyond its global brand dominance.

1.2 Overview of Chapters and Appendices

This thesis began with an introduction to the case study at Donaldson Filtration and the need for a grassroots lean implementation strategy. Chapter 2 follows and presents a review of the relevant literature. Chapter 3 details the methodology to introduce a lean seed and the critical considerations that need to be taken into account for a South African manufacturing facility looking to implement a lean culture. Chapter 4 introduces Donaldson Filtration systems. Chapter 5 presents the case study methodology. Chapter 6 follows with a discussion of the observations and findings. Chapter 7 concludes this case study highlighting considerations for implementing a lean seed and makes presentation on further study.

2 Literature Review

2.1 Overview

The face of lean in today's international industry is one of consultancies offering implementation strategies and methods for a company to introduce lean immediately. It has moved from the open forums that used to exhibit and broadcast how effective it was for industry to being touted as a one-for-all solution to any and all problems within a company struggling through the recession. Lean has been developed with varying degrees of success, to be implemented in other industries looking to see similar gains, the latest being software development in IT and healthcare. Successful lean implementation is an industry in itself and ensuring that a system can be implemented in multiple industries would allow for greater growth of the philosophy.

This literature review covers lean as it is today in terms of implementing it, reviewing case-studies that outline methods of implementation. This chapter introduces lean production and goes on to discuss considerations when introducing it to a facility and the implications of certain implementation strategies. It then highlights the principles that an implementation should strive for and how other implementations are measured in terms of performance before introducing some common lean tools reflected on in this study.

2.2 Lean Production

In the book "The Machine That Changed the World" (Womack, et al., 1990), a new philosophy towards manufacturing was envisaged based purely on the Japanese manufacturing industry, specifically on TPS. The Japanese outclassed the Western industries, using fewer resources to produce cars of higher quality than that of their American and European competitors.
It stepped away from the standard mass production mindset that many manufacturing entities were using and focussed on waste reduction and creating customer value.

The philosophy was showcased around the world as an alternative to the standard batch processing manufacturing standards that were based on Ford's mass manufacturing principles (Towill, 2010) as a result of the primary focus of creating flow of customer-defined-value and reducing wasteful activities to reduce the time between a customer order and delivery. Many tried to implement this new philosophy in other industries with varied success (Lander & Liker, 2007), but failed to create a sustainable initiative as the lean tools were seen as a means to an end rather than as part of a bigger picture that involved setting up the culture and understanding to develop a continuous improvement environment (Shingō, 1989).

2.3 Introducing Lean to Facilities

The global realisation (Womack, et al., 1990) that lean is a tool to enable businesses to reprioritise their focus to make them more relevant to their intended markets has not been lost on South African companies. While a greater number of published lean implementations in SA emanate from the health and civil fields, manufacturing facilities have been quietly trying to gain some of the professed gains in overall productivity by using the lean systems developed through Womack's early automotive implementations (Womack, et al., 1990). The international benefits of implementing a lean strategy ensure that the company is able to supply to international customers that require lean initiatives to stay competitive. The standardised work practices that lean espouses, among other things, allow local subsidiaries to bring a global company's product to new markets by enabling them to produce to the same quality and standard the customer expects.

The local benefits of implementing lean in South Africa exist as a result of plant facilities around SA operating at the lowest labour productivity rate thus far (Klein, 2012; Mahadea, 2012), leaving room for improvement that ensures short term as well as long term gains. The infrastructure in many production facilities exists but is operating at a predominantly lower efficiency than what the facility is capable of. This can be attributed to a number of different factors, including education and training and poor management of said facilities.

With education and training being a fundamental issue for a young democracy (Selassie, 2011), changes to the way companies create and build in quality and sustainability are crucial benefits when implementing lean. The development of training strategies to improve workforce understanding, be it in skilled or unskilled tasks, ensure that companies are able to ride out the effects of recession or market fluctuations (Rockwell Collins, 2003) with a workforce able to survive the changes as a result of their inherent value to the company. This plays directly into a lean implementation, as the culture derives the ultimate benefit in creating a learning environment that initiates autonomous problem-solving. This positive investment into the workforce ensures that sustainability of the programme is built into the initiative from the start. This would ultimately mean that the facility has a better chance of continuing on in its lean journey having instilled such a culture (Bhasin & Burcher, 2006).

Introducing tools that have not been made relevant to the implementation means that they are not necessarily actively practiced which then gives way to unfamiliarity that can eventually collapse the initiative. This is supported by various lean pioneers (Sheridan, 2000; Liker, 2004) who profess that a definitive culture needs to be able to look at the entire value stream and actively practice building and improving the implementation to see sustainable success.

While many are adamant that there needs to be a culture present to ensure a lean implementation is successful (Bhasin & Burcher, 2006; Repenning & Sterman, 2002), with others presenting a common theme laid out by (Womack, et al., 1990) of focussing on creating value for the customer and eradicating waste (Bicheno, 1999; Hines, 1999; Lewis, 2001), the actual guidelines to creating an initiative is not forthcoming. Allen (2000) and Nanni *et al.* (1995) tend toward there being no defining guideline to explaining how to go about a lean implementation, with a lot of effort by practitioners to emphasise the journey the company or facility must take to become lean (Karlsson & Åhlström, 1996) being just as important as developing the culture to make use of lean tools. Pullin (2002) showcased the importance of adapting lean and the tools within context of the facility the culture was placed in, highlighting improved performance under a standard TPS-type system that was redefined for local conditions at a European plant.

For an implementation to be successful there must be a focus on a culture shift within the facility to secure sustainable change within the lean philosophy. There is not necessarily a guide laid out for this shift but it is paramount that the lean tools are introduced within a lean culture to create the continuous improvement focus required to generate flow and reduce waste.

2.4 Implementation Strategies

Implementing lean is thought of as straight forward: find a facility, introduce the tools, look at the issues, install the culture and initiate a continuous improvement environment. This falls flat once a consultant or champion leaves and the impetus behind the initiative is gone. The lack of a polished and whole implementation strategy that can be repeated is present across all industries, healthcare, construction and manufacturing (Rooke, et al., 2012)

The basis for an implementation is for improved responsiveness and flexibility; increased workforce skills, more effective problem-solving and improved quality (Ross & Francis, 2003). These fundamentals are core benefits as a result of a lean implementation. Case studies of previous implementations have made use of a step-by-step program, namely, form a dedicated team, select a project and perform continuous improvement (Muslimen, et al., 2011).

The skills base that SA is able to call on is limited (Department of Education, 2009), the level of training required to ensure that operators on the shop-floor have the skills and understanding necessary for production precludes any training needed to facilitate their input to a continuous improvement strategy while still being required to produce. The implementation strategies espoused by many lean consultants do not seek to take this into account; this critical flaw ensures that sustainability within the implementation is doomed because the shop-floor operators have not been trained to understand the system, but rather just to use the system. In doing so, the inherent value in continuous improvement is lost as the system is seen as additional work that needs to be done over and above the production tasks.

The transformation roadmap developed by the Lean Advancement Initiative (LAI) at Massachusetts Institute of Technology indicates that the Lean Enterprise Self-Assessment Tool (LESAT), can be used as a tool to gain insight into the maturity ranking of an enterprise (Nightingale, 2009), the roadmap endeavours to take a system and implement lean using a top-down approach after having done significant analysis and planning within the confines of an overall strategic plan. While a ranking of that nature is relevant when comparing implementation strategies, the difference between the lean seed and the enterprise is defined by the focus of the implementation, where the enterprise is an overall impression of the system while the lean seed approach seeks to understand and implement at shop-floor level.

A side-effect of implementing lean from an enterprise perspective is the creation of islands of success. These exist when lean tools and strategies for problem solving are implemented as a top-down strategy without understanding the effect they will have on the system (Lander & Liker, 2007). There is limited success within the system as fundamentals that limit the tools' effectiveness are not properly understood by the perspective provided by the enterprise approach (Casey, 2007). Lean exists at a strategic level as well as an operational level (Hines, et al., 2004) but by introducing a culture as part of the implementation, the initiative creates an improvement environment that understands where lean tools need to be applied and when a paradigm shift in strategy is required to solve the issues at hand. Often an implementation is introduced without this understanding and the tools are left separate to the philosophy. Other tools, not necessarily lean based, can be used to add value to the implementation, though they too must be included in a learning culture to make the tools valuable to the implementation for them to be used successfully.

2.5 Lean Thinking Principles

The underlying fundamental concepts of lean production, including just-in-time (JIT) manufacturing and TPS, were well established in Japan as an inherent culture (Ohno & Mito, 1988; Cusumano, 1985; Sugimori, et al., 1977), while not necessarily being documented as such (Holweg, 2007). The lean philosophy has ultimately remained unchanged since it was discovered by the West after WWI (Towill, 2010), but, even today, is still pointing towards developing the culture to truly reap the benefits that the first Western translation of the TPS way espouses. When Womack *et al.* (1990) disseminated the concept for markets beyond Japan, it was necessary to define an approach to create lean production and highlight principles under which lean thrived. These principles are listed below

Specify Value

Within the current economic climate, especially considering the automotive manufacturing industry, the lead indicators of a successful enterprise are those associating value derived directly by the customer (Holweg & Pil, 2005). For an implementation to reduce waste and create flow, a fundamental understanding of what the customer derives as value must be present.

Observe the Value Stream

This critical aspect of visualising the value stream, what happens between order and delivery to the final customer, allows for the implementation to immediately see flow and waste produced by the process in question. It allows for those developing and working within the process to physically acknowledge value and non-value adding activities. The mapping exercise creates the inherent understanding necessary to make changes and improvements that are sustainable (Hines, 1999; Womack, et al., 1990)

Create Flow

To create flow, as defined by Womack, *et al.* (1990), this is to develop value adding process steps to process raw material and inventory to final product pieces one piece at a time. Thus reducing waiting time between process steps and diminishing the requirement for inventory and buffer stock. Obstructions to flow are immediately apparent due to waste no longer being hidden as defects between processes (Lathin & Mitchell, 2001).

Create Customer pull

Pull systems allow for companies to provide customers with product when and where they want it in the right quantities (Ohno, 1988). The ultimate format of this system allows for the customer to pull product through its value stream only when they require it. It places focus on the lean realisation that the consumer is only handing over money for when the product is delivered, the value is not in keeping inventory but rather in ensuring the shortest point-to-point delivery created by customer pull to generate income.

Reduce Waste

The reduction of waste is the endless pursuit of perfection (Ohno, 1988). Waste reduction is the removal of non-value adding process steps in the value stream. To reduce waste, solutions need to be implemented and continuously improved to ensure that value is at the forefront of each process in question.

Instil the Lean Culture

Creating a continuous improvement culture requires for the implementation team to possess a champion that possesses strong communication skills, problem-solving ability and the focus to lead a team in bringing about the understanding required for a lean manufacturing environment (Philips, 2002). Without the culture, the initiative is a collection of tools without the drive to ensure there is buy-in, which may allow for the solutions to fall flat and allow the workers to revert back to old habits (Sugimori, et al., 1977). The focus on the human aspect of lean is often overlooked, but there is consensus that adequate implementation cannot be achieved without taking it into account (Allen, 2000; Lathin & Mitchell, 2001; Chung, 1996). The introduction of this culture allows for the tools relevant to the implementation to be introduced and developed as required, creating the positive lean performance improvements companies have come to expect (Scherrer-Rathje, et al., 2009).

2.6 Metrics

Metrics define how the implementation reports success and issues. A system with an ill-defined performance monitor will not see the required gains expected from a lean culture. The introduction of effective metrics to a continuous improvement system is vital in determining whether a system is creating effective solutions or not. They determine whether the implementation focus is achievable, if the metrics are not relevant to the strategic focus of the implementation, the system is not implementing the culture or the change necessary to create buy-in from management (Hauser & Katz, 1998).

There is no one definable metric that indexes lean implementations to a rank. The culture requires for each implementation to report and use metrics that govern the application, trying to create a common metric for any and all industries would water down or boost rankings by using various assumptions and generalisations. To graph the progress of a lean initiative, the metrics defined by the initial understanding of the improvement system should be able to display any improvement effectively.
If the metric becomes irrelevant, the system should redefine a new metric to allow a traceable means to highlight any improvements made. More research is required to determine relationships to indicators presented by (Sánchez & Pérez, 2001) to actual lean success.

Of the many implementation strategies espoused by various firms, the basic premise is to analyze a system and focus on waste reduction. (Womack, et al., 1990)

This allows the philosophy the flexibility it requires to be implemented in various industries. When it comes to implementation in automotive facilities, there are defined methods that have been repeated (Bicheno, 1999), with a focus on reducing defects, reducing inventories and reducing costs, but these methods are rather a collection of instructions on how to implement the tools, not necessarily a structured implementation strategy to create a lean culture within a continuous improvement system.

2.7 Application of Lean Tools

The lean philosophy espouses the use of certain tools to create the single-piece-flow and focus on customer value required by a lean enterprise.
Those tools are often used ad-hoc or disjointedly, as mentioned previously, much to the detriment of the implementation (Liker, 2004). The intent behind these tools is that they are used to enhance the implementation of lean in a facility, not as the be all and end all when it comes to the installation of the new mind-set.

There is often an over-emphasis and expectation on these tools to carry the entire lean eco-system, and while they are useful, one must keep in mind that without the careful guidance of an implementation strategy their capacity to create sustainable solutions within the company is reduced. Their inclusion as tools is invaluable to a healthy lean initiative, but should be dutifully introduced when the culture is perceptive enough for them to be useful (Scherrer-Rathje, et al., 2009). A brief description of relevant tools is provided below (Ohno & Mito, 1988; Shingo, 1992; Rich, et al., 2006; Sugimori, et al., 1977).

2.7.1 Just-In-Time (JIT)

JIT manufacturing focusses on reducing inventory, to make and allow for the autonomous design of inventory flow to a process. Its ultimate form is a logistics system that reacts naturally as issues or problems arise. JIT allows for the overall design of a cell to be focused on processing with lower inventory as a means of waste reduction which relates directly to the cost of inventory for those processes.

2.7.2 One-Piece-Flow

One-piece flow is a fundamental in lean in determining how your product perceives normal and value adding tasks. It seeks to reduce work-in-progress (WIP) by ensuring that each process is connected in such a way that each process advances the product’s path to completion.

By creating processes that reduce batch size, there is less product waiting to be loaded/unloaded, thus reduced inventory when running that process, therefore no buffer between processes, therefore reduced running costs and shorter lead times associated with making that product. In essence, processes are designed to sequence product one by one instead of in batches.

2.7.3 Introducing Metrics

2.7.3.1 Process Study

Ascertaining whether a system can improve or not will be defined by how well the processes are mapped, individually as well as the branched interconnectivity.

By fully understanding the processes step-by-step, the system can be listed and understood within a one-piece-flow philosophy and balanced to allow for specific processes with a long lead time or large batch sizes to be highlighted as critical issues that must be tackled before one-piece-flow can be achieved. While process studies aren't necessary, they inform value stream maps.

2.7.3.2 Value Stream Mapping (VSM)

It follows almost immediately that there needs to be a more visual way of displaying the process studies done on the line/facility in question.

By displaying it out in the open, the waste is immediately apparent when it comes to showcasing the various transport, additional processing, and incorrect handling or as yet unaccounted for systems that have hidden bigger problems that need to be tackled. VSMs intend to inform observers using a standard format of icons and symbols to indicate familiar processes what is happening at a particular stage of the cell or line.

2.7.4 Waste Reduction

The term waste reduction shows up in many lean texts, but is misunderstood. Waste reduction intends to highlight the value that is already being placed into the product or service. The focus on any lean implementation is to reduce the waste (or muda, defined by its Japanese term) from the system:

- Waste of overproduction (largest waste)
- Waste of time on hand (waiting)
- Waste of transportation
- Waste of processing itself
- Waste of stock at hand
- Waste of movement
- Waste of making defective products

All this considered, by reducing the waste, the percentage of value added time instilled in the product increases. Lean systems must ensure that they are continuously applying a waste-reduction mind-set when seeking solutions.

2.7.5 Total Productive Maintenance (TPM)

TPM is a tool developed in Japan with a view to increasing machine productivity and uptime. The benefits of this tool are twofold, in production an increase in uptime would see that time being used to produce quality product, and in maintenance, where unplanned maintenance can often be a critical factor due to spare part inventory or lead times. The focus becomes the responsibility of a dedicated forward thinking maintenance programme as well as implementing operator based maintenance strategies. This creates a team based approach to the upkeep of the machinery or workstations and allows for the operators to be knowledgeable about solutions that would aid in removing the recurring problems.

2.7.6 Standardised Work

Creating standardised work across a facility is vital in creating a work force that understands various concepts and can apply them to different workstations when required to troubleshoot issues. The visual impact of standard work allows for work deviating from the standard to be immediately apparent to the operator or observer.

2.7.7 Kaizen

Although much of the work done up to the point of introducing kaizens into the Donaldson case study can be considered improvements, it must be noted that the kaizen event is not just a stand-alone event held to attain a significant solution, it is an event that should invigorate a team to create the change solutions necessary to perpetuate the lean culture.

The kaizen must create the continuous improvement mind-set required to solve issues at the production level. It is meant to focus on improving efficiency and effectiveness of processes through the result of continued analysis and process changes.

2.7.8 *6S*

6S is a system that makes use of many quality management tools to determine the functionality of processes or issues, with the ultimate goal of reducing defects within a process. In this case, the focus was more on an effective housekeeping strategy that aligned the system with effective and repetitive quality standards that were required of processes and product. An update to the standard 5S mantra of sort, set-in-order, shine, standardize and sustain, 6S adds “Safety” as the 6th S to focus on. A description of each follows below (Chapman, 2005):

- **S**ort: Sort needed and unneeded items;
- **S**et-in-order: Arrange and put things in the proper place;
- **S**hine: Clean up the workspace;
- **S**tandardize: Standardize the first 3 Ss
- **S**ustain: Make 5S part of the job
- **S**afety: Make safety inherently part of the task

3 Creating a Lean-seed: What Is Required?

3.1 Overview

This thesis's intent is to assist an organisation in a South African manufacturing environment to implement an effective and sustainable lean culture by using a consistent approach to problem solving, continuous improvement and systems engineering.

While many systems in the industrial or manufacturing environment claim to be uniquely unable to implement lean either because of cost implications or a non-belief in the philosophy, this strategy allows for the company to create a small lean initiative and use continuous improvement loops to grow the seed. This thesis aims to cut through the initial red tape often seen by many continuous improvement projects by making use of a devised implementation strategy to create a lean seed-initiative. Using small seed projects allow for critical role-players to contemplate a lean initiative in their facility without the inhibitive culture clash that companies struggle to overcome when investigating lean alternatives and deconstructing them to force the implementation thereof.

Creating a sustainable and repeatable implementation structure allows companies the freedom to create a platform to develop lean from within. The case study research methodology (Yin, 1994) was used to determine whether an implementation strategy as defined by this section could be used to implement a lean culture. It placed the researcher within the framework of investigation allowing for direct observations to be frank and contextualised.

A qualitative approach was used to investigate the implementation strategy to allow for a systematic overview of the relationships investigated (Miles & Huberman, 1994) during the implementation of the lean seed. Interviews and sampling of the environment were replaced by observational lean tools, like process studies and VSMs to understand the dynamics at play within the implementation. Qualitative research is conducted in a natural setting and involves a process of building a complex and holistic picture of the phenomenon of interest (Stake, 1995). It allows for the lean seed to be measured within a defined boundary and the performance thereof reported through metrics introduced by the seed team.

The research took place at Donaldson Filtration's Epping manufacturing facility over the course of 24 months, starting in March 2010. The lean seed was initiated by a selected team familiar with the facility and its processes and championed by the researcher.

The introduction of a lean seed detailed below sought to create an environment, through the use of continuous improvement loops, that espouses the lean culture and makes use of the standard lean tools repertoire. In measuring the performance of the seed itself, metrics would be introduced through each continuous improvement loop to create a before and after state to highlight the change in the system within the scope of the loop. These key performance indicators (KPIs) allow the seed to quickly ascertain progress and updates within the initiative.

Performance data was monitored and compared within the production facility and analyzed with respect to gains and improvements made within the seed team's defined boundary and improvement loop scope. Process studies were used to create a timed insight into what was physically happening in the seed, VSMs were used to highlight an overview of material flow and manning and various capability studies were used to ascertain whether a process was capable of performing its role repeatedly and without defect. Each analysis made use of a before-state and proposed-state for comparison, which would then evolve into an actual state when change was finally implemented.

The lean seed provides an implementation strategy that seeks to include the lean culture as part of the introduction to lean tools. It seeks to create a bespoke system wherein it defines itself within the facility as a positive driver to initiate change for the better while making use of the standard lean philosophy.

A guide follows that lays out why introducing lean at a grassroots level is advantageous and what a company needs to be aware of before introducing a lean seen and the understanding necessary to produce effective results. It highlights where the seed implementation will be most beneficial and what factors to look out for when investigating it as a strategy to introduce the lean philosophy to a new facility.

3.2 Lean at a Grassroots Level

Introducing lean at a grassroots level at a plant and enforcing it from an international base is tricky.

Most companies, especially in South Africa, are not familiar with the lean principles or have been introduced to it without fully grasping why the implementation is so important, this will generally happen when smaller start-ups are bought and included in a company that has an on-going lean initiative or when a lean strategy is being driven from a top-down perspective, i.e. an international company seeking to see gains from implementing its own defined lean system in a local subsidiary.

One may then be left with a very able company trying to use tools it may not understand or worse, only be able to see the short term benefits. In the latter case, the international company can send a team to implement lean at its new subsidiary facility and watch it work initially, but see the initiative fall flat once they leave because the team they trained were located too high in the company hierarchy above actual operators to instil any value into the processes driving production of product that the customer is inherently looking for.

There are many factors that influence today's manufacturing environments, especially in a South African context. While some international companies have successfully instilled local content into their systems to allow better and sustainable results, the reality is that they still needed to change their systems with the intent of making them personal to the character and environment of the local venture.

Many companies with a link to a global partner or controlling entity often miss the fact that when implementing a lean philosophy in the initial phases, the onus is on the company to enhance the sustainability by moulding the required system to fit the company requirements. South African manufacturing facilities are moving into an interesting territory where, as suppliers, they need to adhere to standards and systems developed with lean as an end-goal to allow them to enter into partnerships with European, American and Asian markets.

By introducing the lean implementation at a grassroots level, the lean initiative is owned by the key role-players who are being physically measured by the initiative's KPIs. The implementation is hinged on their running of the system.

Hence the best way to facilitate this kind of paradigm shift within a company is to create a small cell, where the value of such an initiative can be showcased against the existing system, to essentially drive positive change with change.

3.3 Lean Seed-Initiative

There are many examples of failed improvement strategies that have been lifted from other companies looking to see similar gains. They are generally copy-and-paste exercises that have no undertaking to understand the complexities involved and often fail once the system loses key champions or drive. Examples include initiatives where a cell no longer produces quality product at a required rate or the facility installs new machinery to increase capacity and it becomes a new monument, unused, under-utilised or impedes the plant from even attaining previous output figures. These implementations sometimes do not even reach a place where the company sees the change, often discarding the system before showcasing positive results and purely not understanding the underlying issues having ploughed through a checklist.

By setting up a cell fully espousing the principles of lean, within a facility, with the freedom to develop, it becomes naturally aware of the environment it is working in. The lean seed initiative is a strategy that allows for a company to create a trend within a facility whereby the inherent value of a system and its processes, is projected beyond the seed by showcasing a new way to go about making customer product.

The initiative makes use of the continuous improvement loops, discussed later, using their core team to solve problems. The seed is defined by the initial boundaries of the cell. This allows for the cell to function as a unit and discover various implications their developed solutions have on the metrics the team defined as KPIs. The solutions are inherently part of the system's boundaries and seek to improve the seed's overall performance.

The growth of the seed comes into play when solutions require suppliers supporting the cell. By involving the suppliers, the inherent lean structure of the cell will require for the supplier to supply the cell using a more lean-oriented format, i.e. Just in time, smaller batches, etc. For the seed to prove that the solution is viable, it must incorporate the supplier in its metrics. Further growth is then achieved by having the supplier have its own core team trained to develop solutions within their own boundaries, thus propagating the loop.

3.4 Considerations for South African Manufacturers

As with any new development at a company, depending on the scale of the project, critical factors, often unique to the South African market, need to be taken into consideration. Common issues are highlighted below.

3.4.1 Culture Clash

The South African manufacturing industry is well established. As with many entrenched cultures, the thinking towards other cultures, especially ones seeking to change the production philosophy, is somewhat pessimistic. Change management is inherently seeking to bring about improvements in the overall company, but trying to get a consistent message of positive change across various languages and nuances requires a cultural understanding of the company and its people.

When seeking to implement a continuous improvement strategy, the defining features of the project must take into account methods of how to go about mediating between the often high-brow culture that espouses Japanese lean tools and the shop-floor training of South African operators by manufacturers (Department of Education, 2009). This is further hindered by the fact that school leavers vying for shop-floor roles are predominantly illiterate or are of a low reading standard (Sheppard, 2009, p. 9).

Without defining effective terminology that directly translates into the host’s language and understood as intended the initiative comes across as another strategy that has been patched together as a second thought. A common terminology must be developed and incorporated in the training to ensure that understanding and value is gained. By not creating this level of understanding, the initiative will be left in a high management level, unable to communicate with the shop-floor level, where the majority of effective production solutions will be developed.

3.4.2 Financial Implications

Africa is at the forefront of economic growth despite global financial uncertainty (IMF, 2012).

With the global recession showing signs of subsiding, companies on the international scale are looking to increase their relative market share in South Africa (Marais, 2009; Institute of Justice and Reconciliation, 2009; Marais, 2011).
South Africa has had issues with exposure to this interest in African investment and funding for capital expenditure (Selassie, 2011) in the past. These relate to labour and product market policies that inhibit growth as well as the anti-competition practices involved in some industries, like the provision of electricity by parastatal companies. Globalisation, coupled with democracy and the concomitant legislative and policy changes have opened up South African markets to international industry (Maritz, 2000, p. 68), with the added requirement of local companies needing to adapt and supply internationally to companies that expect evidence of environmental and lean initiatives and practices.

This has required many local manufacturers to implement lean as an incentive when vying for international partnerships and customers, often requiring the company to rethink its stand on change management and improvement strategies. South African manufacturers generally have erred on the side of caution when it comes to new continuous improvement strategies, often writing them off as passing fads and cost-intensive projects that show no short term gains. While this may be true for certain projects, limiting one's possible improvement choices due to lack of financial freedom will often see a company tackling issues that run against the Pareto principle (Pareto, 1927), which states, in part, that 80% of one's problems are a result of 20% of the causes. As many manufacturing facilities in SA have been established for some time, many lean initiatives can be applied without having to invest further capital expenditure because the machinery and infrastructure already exist, and often the system just needs to be tweaked to see gains through an effective lean strategy.

3.4.3 Management discord

The politics within a South African company's management structure are complex and beyond the scope of this thesis. Unfortunately there are legacies that are still apparent that can affect the implementation to a greater degree, but the discord seen by international companies when implementing lean is a common complaint and should be expected (Maccoby, 1997).

Many initiatives that are implemented by top-level management generally fall to middle management to implement at shop-floor level. This leaves middle management to be the change facilitators and often bear the brunt of any negativity towards a forced implementation (Clutterbuck & Kernaghan, 1994, p. 108) .

It does need to be noted that the failings of the management team to successfully support a lean initiative is a result of the champion not having enough top-tier support within the company. This can create division between the production management and those who interact directly with customers. Managers not familiar with the lean philosophy or, managers who are familiar with it but don't support it, will look at a standard initial lean implementation, see the change but regard the change as not significant to their department, often leaving the initiative without the support it requires to showcase the positive results necessary to create further buy-in. Should this be a distracting influence for the introduction of a lean initiative, the champion needs to address this accordingly and ascertain how to achieve buy-in on a management level.

While a lean seed attempts to avoid this and creates buy in by building the quality into the inherent system, ascertaining whether the management, as a team, are in support of creating a lean system is critical to the success of a lean implementation regardless. By introducing metrics that they, as a collective, understand as critical, the flaws or potential gains a system may see after the application of a lean system can be highlighted before the team undertakes a lean seed initiative.

3.4.4 Top-down Lean Implementation

Competitive companies tend to have common manufacturing processes to stay relevant. In an international company, product families are shared across plants, leading to common processes that are necessary to produce on the large scale required by the customer base. This will lead to a situation where, to ensure the local subsidiaries are conforming to the quality requirements of those common processes, the global lean strategy of the parent company is required.

Reinventing the wheel when it comes to improvement projects is a common mistake many companies still make today. Many companies will either create a team internally or bring in a consultant that develops a system based on the lean improvement principles and publish it as the company's answer to implementing lean. With a lot of the top-down lean implementations, there are single paths that make use of common processes that can be similarly mapped out and have problems highlighted that have been dealt with before. While this is the reason why companies follow a top-down approach, not assessing whether the strategy is sustainable for the local subsidiary could be detrimental to the overall implementation.

A lean implementation must be aware of the local pressures, implementation issues and other factors to ensure an effective implementation, and while a global initiative can be used as is, when it comes to sustainability, the outlook is less positive without continuously policing the system.

3.4.5 Low-Tech vs. High-Tech Strategies

Companies developing their systems in First World facilities will, at times, take their processes and administrative systems for granted, and often times are overlooked as key requirements of a system when porting them to other facilities. When moving to implement said global strategy in South Africa, it stands the risk of falling flat by trying to apply high-tech processes or plans to a low-tech system. Examples include computer databases controlling stock in a European facility to limit WIP on the floor. While the system works fine in the design phase at the European plant, moving to an African plant not using any electronic equipment in the warehouse for tracking stock may well present some issues with regard to implementing that system. This is more apparent in facilities where lean has been initiated as a top-down approach, and the fundamental differences that exist between headquarters and the South African subsidiary have not been understood.

3.4.6 State of Personnel and Training Systems

The Us vs. Them mentality created by the politicisation of worker's unions to oppose the Apartheid government of the 1970s (Moody, 1997, pp. 208-212) has created an incredibly tight space for employers to move with regard to change and perceived value from a worker's perspective. South Africa has traditionally had a cheap unskilled-labour market (Golub, 2000). While this has been seen as a benefit to constructing new manufacturing facilities and bringing in international investment, the shortcomings of hiring unskilled labour is often a hindrance to continuous improvement that is only fully realised months or even years later when an improvement strategy is introduced.

Training requirements for staff at manufacturing facilities are minimal and specific aptitudes are not sought out when it comes to low-level repetitive tasks. This is largely due to the high turn-over rate of staff seen at plants in SA, where companies would seek to protect themselves from this by using contractors or labour brokers (Kenny & Webster, 1998). This allows a company to keep shop-floor workers at arm’s length until they have showcased significant initiative and positive work ethic to be made permanent. Legal implications of labour brokers are controversial from the perspective of the South African government and of organised labour federation the Congress of South African Trade Unions, while many companies are of the view that they protect the employer from placing staff that have not proven themselves capable. Essentially, staffing within a company needs to be properly invested in to attain the buy-in to develop the shop-floor as a resource that a continuous improvement strategy requires to be successful.

When implementing a lean initiative, where staffing, as a resource, is a fundamental in achieving a sustainable continuous improvement environment, the training and selection criteria for any operators or key role-players must be with this in mind. With South Africa having just hit its lowest labour productivity rating (Klein, 2012) (Muthethwa, 2012), the state of the labour force would require for a company to make the most effective use of training strategies, personnel investment platforms, team input and overall efficiency improvements. A company cannot hope to function in a lean environment without achieving an effective relationship with the shop-floor team.

3.4.7 Exposure to Global Standards

South African companies newly exposed to global economies, or subsidiaries of international corporations need to adhere to the standards the company has been elevated to. Specifically in the automotive industry, where there are requirements to ensure the effective production and quality control measures are conforming to. These include:

- ISO/TS 16949:2009,
- ISO 14000, for environmental management
- Various Society of Automotive Engineers (SAE) requirements

While these requirements are often in line with attaining effective standards for quality in terms of lean, where poor quality is no longer acceptable for multi-nationals, it must not be allowed to derail a lean implementation without merit. The lean initiative must be well understood and supplemented accordingly to create compliance to these standards to bring any benefit to the company. A collection of best practices does not make a successful production system. (Maccoby, 1997)

3.4.8 System Commonalities

When a lean implementation is envisaged, it is often brought up as a result of a neighbour's or competitor's lean strategy seeing positive gains. When looking at various lean implementations, however, no two systems are alike. One cannot use the waste reduction initiatives implemented by another company and expect to see the same gains they expect or the same sustainability their initiatives achieved. There are many factors that brought about the success of the original system, often these are not tangible to the observer, or missed when the theories the system is based on are copied. While there are strong commonalities between various companies looking to implement lean, like product suppliers, management systems and processes, factors not immediately apparent must be taken into account to select an effective continuous improvement strategy

3.4.9 Prohibitive Culture: Philosophy of Change

Change in any facility that has a legacy assigned to it is complex and often requires an immense amount of effort on the part of the implementation team as well as the management behind the initiative. There are many factors that require consideration when implementing lean philosophy, namely staffing, machinery, admin systems and the procedures within the plant.

3.4.9.1 Staffing

The psychology surrounding the introduction of change within a jaded team does not allow for the successful implementation of any change strategy purely because of the legacy systems inherently left behind by the older strategies that have failed or been left unattended. The wisdom the team has learnt over time is invaluable, but it comes at the price of incorporating it into anything newly developed. This allows for bad habits and negativity towards change to propagate through any implementation. When this is the case, the only option is one to engage the team from within. The team is required to rediscover their creativity around solving problems under a framework that is self-sustaining.

3.4.9.2 Machinery

Machinery can easily avert change by physically being in the way, being prohibitively expensive to change, dangerous, being a critical system that the facility cannot do without or it suffers from a negative perception in terms of functionality or maintenance. South African machinery can be notoriously old. In the same sense, the connotations attributed to machinery that is old, large or difficult to maintain can prove to be a considerable burden to change purely because it stands as a reminder of the management vs. operator mind-set.

Creating a changed mind-set around new machinery also bears the same pitfalls as older machinery, as operators who have been introduced to new machinery before expect the same strategy and eventual outcome based on what has happened in the past. When introducing new machinery as a result of a lean solution, management can often fear that the expense of having the machine fail at the hands of the lean implementation must be taken into account. There tends to be undue pressure on the initiative as suddenly there is a greater investment than initially expected and a greater expectancy for it to do well. Should results not be forthcoming, or not immediately positive, the project could be discarded and handed over to the existing system. This potential outcome could lead to the champions of the implementation to be more conservative than they should be to the detriment of the strategy.

3.4.9.3 Admin Systems

Administration within a company can be the main culprit when it comes to holding up a change initiative by requiring processes and forcing specific systems to interact with each other that shouldn’t be required to interact or requiring familiarity with the existing system to gather any information regarding metrics relating to the performance of the line in question.

When it comes down to actually getting any information out, the integrity of that data will also be in question purely due to a poorly understood or the fraudulent capturing of data that can hide performance issues, stock loss or fraud.

Steps must be taken to ensure that if the system is used to showcase flaws or gains, that the reporting is consistent and transparent so that the integrity of the data does not come into question.

3.4.9.4 Procedures

Dealing with new machinery and ensuring it does not become the new monument in the way of continuous improvement is often required when introducing a capacity solution relieving bottlenecks. This requires procedures to ensure effective training is done and managed. Machinery not locally produced or available can often be complicated to install or maintain and cost you more in the long run in terms of time and complexity than a local solution would. Be that as it may, it will require a team that is willing to engage in active solutions to understand the risks during the design and offer optimised systems and determine whether they will be capable of trouble-shooting should a problem arise with machinery, local or not. Existing procedures, generally financially related, that control certain processes and functions can also be considered monuments when it comes down to issues with implementing solutions. It is one of the few cases where additional support is required from management to create the change necessary to get around these issues.

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Considering any of the above factors can often point to a key issue holding up the implementation of an efficient solution. It is the task of the lean champion to keep abreast of these issues and contemplate their impact when it comes to changing the culture. This is discussed further in the implementation case study.

3.5 Sustainability within a Company

The lean philosophy has often been called a fad that will pass along with all the other improvement strategies that have come along. When Toyota implemented their system in the late 40s (Towill, 2010) there was no end goal in site, the critical function of the implementation was to develop a system that looked at existing systems within Toyota and improve on their ability to react to the market and build product customers wanted to pay for. The sustainability in their programme was inherently built into the system because the end goal was a company that was constantly at the forefront of delivering value to their customers by reducing waste and focussing on process improvements.

The incentive to improve was part of their product, each improvement driving the next because the lean philosophy was such a fundamental part of getting Toyota back on track.

Creating a sustainable implementation requires for the inherent system to be built within itself, i.e., it creates and repurposes itself whenever it needs to change. To paraphrase an interpretation of Darwin (Megginson, 1963), the system most adaptable to its environment is most likely to survive. So creating a sustainable lean initiative is about ensuring lasting change and improvement solutions.

Sustainability can take on a number of guises, be it in terms of infrastructure, the hard systems in place that will exist until changed, or the soft systems, like staffing or processes that use the infrastructure. Evaluating whether those systems are robust enough to handle changes requires an internal knowledge of the system in question as well as the overall structure it exists within, where structure is not necessarily the physical structure, but rather the environment it exists within.

It is vital that the continuous improvement strategy makes use of this thinking in every application of their lean principles. Creating solutions that do not take into account the vital value-adding processes forces other requirements at a later stage to solve issues of maintaining that solution. Any staffing or infrastructure changes will require retraining or a reintroduction of the solution. It is far better to develop a solution that incorporates the value added processes, the machine/operator and the required quality to the extent that the outcome is consistently the same regardless of how much the overall system requires the solution to change.

Approaching the issues that arise with this in mind will result in effective solutions that are able to adapt and foresee restrictions to the value adding processes. This allows for the sustainability to be a by-product of the value-adding processes, and why Toyota is still successfully able to relate their product to their customer base.

3.6 Implementation Loops: Introducing a Seed Initiative

The South African automotive industry is jaded by existing management strategies, solutions that are no longer current, ever changing market requirements and a work-force without any passion (Barnes, 2009). The lean philosophy strives to keep a company at the edge of consumer requirement and the ability to provide a quality product. This achievement is something any company, let alone just in the South African industry, would benefit hugely from.

Introducing a lean seed as a means to introduce a lean culture is aimed at the South African market because it attempts to initiate the lean culture and create buy-in by showcasing the problem solving tools available to the strategy within real world issues. Creating this platform allows for the lean seed to create the culture within the initial boundary and develop tools that will help the implementing team to gain confidence in solving problems moving forward. This is also a critical learning step for the initiative as it is made aware of any difficulty holding the implementation back from growing. These issues need to be brought to light and investigated effectively before the seed can look beyond the boundary created when it was introduced.

Once the impetus to create a lean seed is able to initiate a seed in a plant or system, there is need for an implementation strategy to go about the effective handling of the seed and how to go about continuous improvement. A continuous improvement loop guideline is detailed below that can be used, once the loop's scope is defined, to implement a solution within the lean seed that is scalable and repeatable.

3.6.1 Implementation loops

The continuous improvement loop is a tool that the seed makes use of to define its role and objectives within its boundary. It is a reporting tool that identifies with a specific scope and the environment and metrics that the solutions need to overcome and satisfy. The loop makes use of 6 phases, and repeats itself until the issues brought up by the iterations have been solved or initiated into other loops. By focussing on building quality into the processes and product, the loop doesn't define the implementation or the sustainability therein; it rather is just a recording measure to ensure the closure of the improvement loops.

The phases used in the loop as shown in Figure 1 are:

- Assessing the plant
- Analyzing the system
- Selecting targets/issues to tackle
- Applying the implementation
- Creating sustainability
- Review

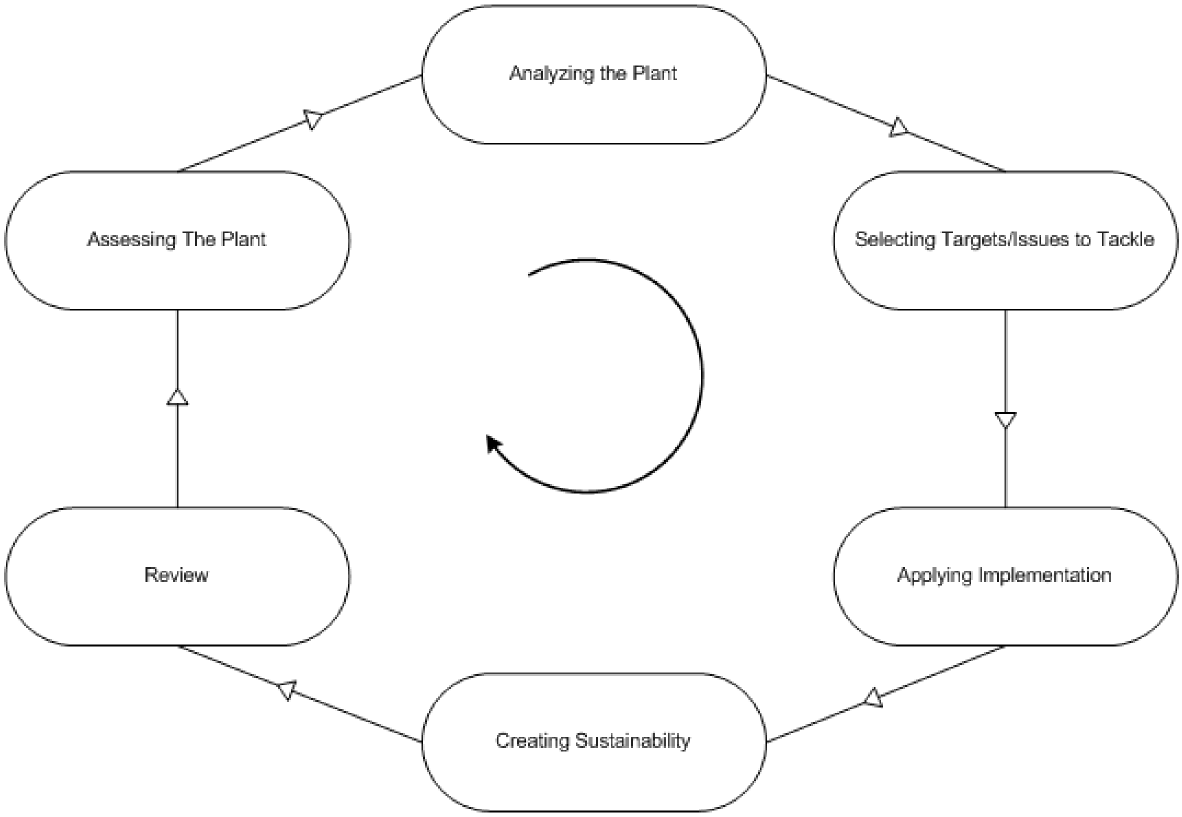

Figure 1: The 6 Phases of the Continuous Improvement Loop

Each phase opens up to various other considerations required within that phase before moving through to the next phase within the loop.

3.6.2 Assessing the Plant

This is not necessarily assessing a plant, but more the overall system that houses the seed. This phase must make the team aware of the current climate within the plant environment and what internal politics or corporate culture are informing the current state. It must essentially define the potential status that the seed will be exposed to once the loop is underway.

This phase should also make the team immediately aware of the management initiative behind the seed and what kind of solution type is being sought out: a quick fix or band-aid will not solve underlying issues, while a long term solution is perceived to not yield results soon enough. The plant manager must be made aware of potential changes to the floor and how they may possibly affect production, by bringing the awareness forward; the transparency of this change allows foresight into future developments.
In the same vein, foresight at management level is invaluable to the team, this will ensure that solutions are not applied to a dying system, i.e. the lifespan of the product will not outlast the system seeing improvements. The time limits alone for ensuring that the system stays alive will affect many phases and will not see an effective application for the initiative. The emphasis must be on 'continuous' improvement, if during this phase it becomes apparent that the solution will be held up due to politics, future planning or jaded decision making, those issues need to be solved before moving forward.

Once the team has completed this phase, they should be aware of any existing conditions, be it from another improvement loop or not, the plant or company status, possible changes to the plant that could affect their implementation and the scope of this particular loop. The improvement loop is now defined by this scope and its performance is rated accordingly within that scope.

3.6.3 Analyzing the System

This phase is used to introduce the metrics required for defining what is being affected within the scope of the loop. Various tools should be used to create an effective understanding of what the line/cell is actually doing. These include, but are not limited to:

- Process studies. These must take into account the system within the scope broken down to the step-by-step processes, this will include capturing time studies and inter-dependencies and WIP. A more advanced visual view of the processes can be made using a value stream map (VSM) and can often allow a different perspective on the system;
- Staffing status, the state of personnel & training in terms of ability and aptitude. Is the area within the scope operator-friendly and ergonomic?
- Machine/task capability. Is the process defined by a machine, what are the critical factors involved in its effective operation, reliability, maintenance and change-over times?
- Process complexity. How complex is the process, what is currently present in the process?
- Admin system status. What procedures in terms of admin are required for the processes to take place?

Once these factors are understood, various issues will become apparent, if not previously defined by the improvement loop's scope. It is important at this stage to define potential issues that will require solving and the associated KPIs that inform them. These KPIs must highlight the issue, or they must be made relevant to a specific issue to showcase improvements. Data must be used to showcase flaws or gains in the system where it is available. The metrics that the seed focuses on are defined by their KPIs, so it is in the seed's interest to introduce metrics related to performance that is relevant to the initiative.

Once this view of the cell is created, with the allocated performance figures, the team should be immediately aware of the overall line/cell status and the underlying issues. It is important to mention at this point that during the first improvement iteration, the status of the line may require many improvements. The team should not be overwhelmed, it is the nature of this phase to highlight many issues, and they should select the most apparent and move to the next phase. They should not get into a state of analysis paralysis, should an issue still be present after an iteration, if it is still relevant to the scope, a second or third iteration should provide an effective solution.

3.6.4 Selecting Targets/Issues to Tackle

This is the problem-solving phase of the loop. The impetus on the team would be to select an issue informed by the various tools and KPIs, once selected, a root cause analysis must be done to ensure that the team is going after the correct issue and tackling it accordingly. It can be frustrating if a problem arises as the result of a solution because the issue was poorly understood. The lean six sigma method of driving down to the root cause of the problem is relevant to this phase, as are other tools intended to be used within that framework to facilitate problem solving.

Local companies tend to look at very fine points when it comes to fielding for solutions from their international counterparts. It is the fall back of many new implementations, especially when it comes to machinery, as a solution is not correctly researched as to why it may work, what tends to fail and general upkeep requirements. So any solution fielded by entities not within the boundary of the seed must be wholly understood before being considered. The important point to note is that there must be foresight towards the affects the solution will have on solving the issue, with an inherent Plan, Do, Check, Act (PDCA) initiative it can be easy to highlight any risks and mitigating systems that need to be factored into the solution. These include training strategies, awareness of other systems that this solution should also be applied to and any change broadcasting that needs to be done beyond the seed. This will inform on the solution's planning and will ensure that there is an undertaking to implement the solution as effectively as possible.

Once this phase is completed, the team should have selected issues that are within the scope, adequately defined the root cause, are aware of any mitigating factors the solution will have on the system and have planned and are able to implement effectively and showcase any risks associated with the solution. As indicated previously, should a more pressing issue not be selected, the metrics defined as KPIs will inform whether the scope is fulfilled or whether further iteration is required. Should another iteration of the loop be required, the previous issues will still be up for selection.

3.6.5 Applying Implementation

This phase may sound straight forward, but it relies on how well the other phases up to this point have been done. The solution must be applied to the system as per the plan laid out by the previous phases, it must be within the scope of the loop and it should continue to showcase the KPIs that were apparent before its inception.

If there are multiple solutions, that are necessary, it may be required to implement all in one implementation. This does not detract from how effective that specific solution was individually, the point of this exercise is not to showcase the problem-solving abilities of the team, but rather the fact that the improvement loop was successful by applying those solutions as effectively as possible.

The completion of this phase will see the team having implemented the solutions and that the line/cell is able to provide data to showcase any flaws or gains within the KPIs. Applying the solution should have immediate effects, but it is not without reason to apply a time limit to determine whether the implementation has been effective.

3.6.6 Creating Sustainability

Having performed the process studies in the second phase, it is informative to use this phase to showcase whether the solution has improved on the relationship between lead time and value added time if not already made apparent by the defined KPIs. Solutions built around the value added processes automatically instil a sense of sustainability because the process now creates a quality outcome based on the product. This generates a continuous requirement for the solution to be applied, i.e. If a machine has required a change to produce better quality product, and the quality is now a required outcome for the process, the process is no longer completed correctly if that quality is not present, meaning that the process can go no further if the solution on that machine has not been maintained,

There are other mechanisms to ensure that sustainability is a by-product, these include standardising the work, processes and the instructions thereof, ensuring that effective training strategies have been implemented that showcase the use of the solution and maintenance structures (as required) to maintain the solution(s).
This is often benefitted further by change broadcasting. A change broadcast is brought

about when the issue does not only affect the cell within the scope, but other areas within the plant/system. By broadcasting the solution and the effects thereof, it is required for the solution to be able to handle being applied beyond the lean boundary created by the seed. The solution becomes a stand-alone product of the loop.

The completion of this phase requires that the team is aware of the sustainability of the implemented solutions and has made efforts to ensure that the system is able to maintain the solution effectively. This ensures that the solution is a stand-alone system that can stand up to the rigours of industry without the positive focus of the seed driving it to function correctly.

3.6.7 Review

This phase allows for the improvement loop to be registered as a success or not. It seeks to identify how well the scope was met and what needs to be further taken into account before the loop is closed. It looks at the defined KPIs, the solutions implemented and whether the issues identified but not pursued require investigation within the loop or whether a new loop is required.

This review section will inform the assessing of the plant phase when it ascertains whether any previous issues are present and what recommendations were previously suggested but not implemented. This is useful in the foresight of a solution as the next improvement loop that is issued with solving that problem may be hampered from investigating interdependencies by the scope and may miss these recommendations. Should the review find that the scope has not been met effectively; the loop goes into another iteration through each phase. The phases are then informed by the previous loop. Only once the scope has been satisfactorily met can the loop be closed.

Once the team have completed the review phase, they should be able to associate the issues found in the problem solving phase with effective solutions, and showcase the gains seen in that system along with any further recommendations that are apparent to the system. The team will then need to make a decision on whether to follow these recommendations up by creating a new improvement loop.

These improvement loops can be applied to existing systems once a champion and lean team have been selected to work within a defined boundary, but there are obviously cases where there is a requirement to start a lean initiative during the introduction of a new line/cell, further considerations follow. In the Donaldson case study, the loop was used to identify the need for a lean seed on their new line.

3.7 Considerations for Introducing Lean with a New System

While introducing lean to an existing system can have its own complications, a lean implementation on a new line/cell/system is sometimes more difficult to realize due to the learning curve that the champion as well as the team members and line operators need to go through to gain familiarity. The team goes through a transition phase, and, more often than not, that transition is not fluid, meaning that the metrics you are using to measure performance are forever changing as the understanding develops. This requirement can be so demanding that it often takes the focus away from implementing the gross changes required to get your line to produce at any rate, let alone the design rate. The reality is such that this exposure phase of introducing a new line, along with the learning curve to operate it, must be done to ensure complete understanding of the line to where it needs to be before entering into problem solving. Often the issues experienced during the learning curve will go away as time and experience weed themselves out.

3.7.1 Backing

It is obviously important to ensure that the initiative has the backing necessary when it comes to upper-level management. The team needs to have the understanding that they are going to change things for the better with the support of the management team.

3.7.2 Application and Scope

With a seed initiative, it is important to define the boundary that the initial seed will operate within; this can either be done by the authority that requested the seed (management) or the champion looking to implement. It is important for the single reason that it creates the focus necessary to highlight metrics and set up the seed for effective development.

It is wise to select a boundary that is contained by the team; this allows for anything within the boundary to be maintained by the seed's team and does not require any input from the shop-floor beyond the boundary. Communication that must take place will still take place, but the decisions taken within the cell do not need to have buy-in from anyone beyond the seed.

3.7.3 Manning

As the lean champion for the seed, apart from needing to be prepared for as many eventualities as possible in terms of issues within the cell, processes and maintenance issues, the team in your cell must come to grips with their understanding of the line. Getting the level of competency up on a line requires for your operators to understand the technical specifications of their work. Predominantly operators, especially contract workers, are not able to see or perhaps explain what it is they are experiencing in the process. So you are left with a weak appraisal of the contentment of the line because the operators that cannot express themselves will seed to the more expressive/strong characters in the team.

The first critical step is ensuring they understand what it is they are actually doing. There is a tendency, particularly with older product, to pick up that they are doing meaningless tasks that have been passed down during the hand-down training done by previous operators who also never understood, or perhaps did but already didn't see a use for it so glanced over it. This also exists with old procedures that are in circulation purely for administration reasons or because they've always done it

This single step is critical for the entire team. In South Africa, a matriculant can mean a much distorted baseline of what you'd expect from a school leaver, but having your team on the same level and able to teach, coach and explain to each other why a specific task needs to happen is invaluable.

3.7.4 Infrastructure

Once a seed has been created, it can become apparent that the existing infrastructure available to the team is not conducive to a lean cell. Changes to this system can result in modified systems that conform to the team requirements; an endeavour must be made such that any new additions or modifications are modular. By creating these as modular systems, the ability to move and change and tweak as the cell moves towards implementing lean solutions is vital.

Infrastructure doesn't only refer to workspaces, and existing systems. It can also refer to the soft systems that are there to sustain the cell. Total Productive Maintenance (TPM) aims to create standard processes for maintenance that run under a scheduled system to ensure reliability and unplanned maintenance are KPIs for the cell.

3.8 Summary

In summary, a method to introduce a lean culture through the use of a lean seed is laid out in this chapter. It explains why introducing a lean seed initiative is an alternative to the standard top-down approach and the benefits of allowing it to grow within the existing culture within a facility. It indicates that there are some considerations for managers to take into account before selecting this implementation method as well as possible issues that are present when introducing the seed to an entirely new cell or facility.

It makes use of a continuous loop to indicate the status of the implementation with regard to which issues the team is tackling at any one stage. The loop allows for the standard performance status of the seed to be reported in a consistent manner that becomes specific to the seed within the facility. The strategy defined in this chapter is used in the case study carried out at Donaldson Filtration Systems to implement a lean philosophy to coincide with a line upgrade.

4 Presentation of Donaldson Filtration

4.1 Background

Donaldson Filtration Systems is a global company that seeks to gain capital market share in the filtration industry by creating innovative filtration products that are derived from diverse customer requirements.

The company was founded in America in 1915 by Frank Donaldson Sr. after developing a simple air cleaner to solve a farmer's tractor problems. The longevity of the company is testament to the forward thinking required to solve customer issues and innovate where necessary to stay ahead of what the customer is looking for.
This perpetuated a gradual diversification that led from just agricultural equipment, to a broad spectrum of products spanning the construction, mining, transport and industrial markets.

By continuously creating effective products, Donaldson had established a worldwide sales and distribution network by the 1950s through various licensing agreements with overseas manufacturers, with the eventual set up of facilities internationally in 1958 with operations in England to support Caterpillar. By 2012, Donaldson serves the needs of its customer base through operations in 19 countries. This includes the operations in South Africa, from which a broad service footprint extends into Sub-Saharan Africa. The rest of Africa is currently serviced by various European plants, with the aim for South African operations to extend upwards to gain further exposure to the developing markets. The Europe, Middle East and Africa region currently accounts for 31% (Donaldson Website, 2012) of Donaldson's total revenue.

The company became synonymous with quality and value for the customer by providing solutions the customer wanted while still being able to showcase the inherent value of their product over the competition. This allowed for Donaldson to become a stalwart in the filtration industry behind a reputable market share in the various international markets.

The global drive has ensured an enviable presence in many countries with state of the art production facilities for the local customer demand and supplier networks to ensure they are accessible.

4.2 Radial Seal Elements

While axial seal filtration elements are still used today, the new generation of filters make use of a urethane end-capped product that seals on an engine clean air duct along the outer rim of the end cap, i.e. radially. Radial seal product performance is equivalent to axial seal elements, but do not require the metal end-caps the latter require, making them lighter, and by default, the first choice for customers looking to reduce weight in their designs.

4.3 Culture

In 2010, Donaldson headquarters implemented a global lean initiative called the Donaldson Production System (DPS) to bring all of its facilities up to the same level in terms of work process and capability. DPS was largely based on the Toyota Production System, using the tools developed within TPS to create a system whereby the Donaldson values of integrity, value and respect are built into the product.

With a view to springboard Donaldson South Africa further into Africa and develop a larger market share within Sub-Saharan Africa, the Epping plant was selected to increase production capacity in line with the global strategic plan of becoming the market leader in the growing African market.

With an increase in capacity required due to demand increasing for radial seal elements, a state of the art production machine was selected to increase overall line output. The Radial Seal Line (RSL) was assigned as the pilot programme to create a sustainable, lean line that made use of single piece flow to support the new system. Epping facility management brought on the author to facilitate a local implementation, as the top down approach was seen as unsustainable once the implementation was left to its own devices. This created the opportunity to develop a lean implementation strategy that was common to many South African manufacturers looking to implement lean.

A case report follows, showcasing the use of the loop and the implementation strategy used to implement a lean seed at Donaldson Filtration's Epping facility in Cape Town. The report makes use of showcasing the findings generated by the improvement loops explained previously. As explained earlier, one can either start a new iteration of the current loop or start a new project requiring a new scope with which to ascertain the success of the improvement loop.

5 Case Study Research

Lean implementation strategies in automotive or manufacturing facilities are generally a collection of instructions on how to use the tools with a lean mindset and do not necessarily present a structured implementation strategy to create a lean culture within a continuous improvement system. This chapter details the introduction to lean and reports on the method for implementation used at Donaldson Filtration. It discusses, at length, the loops used to create a lean seed at the Donaldson Epping facility.

5.1 Donaldson Loop

5.1.1 Assessing the Plant: The Legacy of the EDF

Donaldson required an improvement strategy that would introduce lean through a defined initiative.

The initiative was earmarked for implementation on the RSL. The product produced by the line was slowly becoming the plant's peak customer demand, and there was a need to improve the line to prepare it for the expected increases.

Donaldson sought to bring new machinery in, replacing a monument and its required infrastructure (polyol (POL) and isocyanate (ISO) lines, spares, scheduled outsourced maintenance) to cope with capacity requirements that would lead the plant into the next 15 years of effective production of filtration products. The Advance Manufacturing Technology (AMT) dispense was selected with a limiting line rate, effectively double the speed of the EDF. The intention for the new machine was for it to be used as a driver of one-piece-flow onto the shop-floor bringing the plant in line with international best practices.

EDF

The EDF polyurethane machine was once the driving force in the Epping plant, and had served the line for approximately 15 years. The infrastructure it required determined the layout of any lines in the vicinity and set up for a job required a machine setter to be on call whenever the line operators were changing over. This was somewhat mitigated by having a number of operators unofficially able to perform this task.

Maintenance of the EDF was its downfall, without a standard maintenance guide, the fitters and technicians assigned to the line had free reign on short-cuts and inferior quality parts. This would lead to the plant requiring external contractors to perform regular services to keep the system functional. Critical parts with extremely high lead times and significant unplanned maintenance were key issues inhibiting the line from producing at rate.

Manning

Complacency within the workforce assigned to the RSL was highlighted as being critical after reviewing the previous issues. These included a shop-floor team project created for problem-solving and to drive effective management at an operator level.

With the previous staffing project, only 2 of the 14 seals team were still on the line, with the understanding that they were the most experienced, but would also bring the most resistance to change due to their previous training. That being said, plant management expressed an interest in returning to the former status that the RSL seals team enjoyed.

Quality

Defective product on the RSL was raised as a critical issue as the line relied on the experience of a handful of operators to ascertain whether the elements produced were saleable product. Some visual gauges and go-no-go charts were used but it was an inherently unstable function.

The controls in place were not enforced as the system was easy to get around, using previous values for good product runs and only doing essential checks when the EDF-produced product did not conform to final inspection. Quality was essentially an after-thought to the product where the operators did not understand the critical interdependencies each process relied on.

Plant/Company status

Donaldson seeks to bring in a new polyurethane dispense system, replacing the EDF monument and its required infrastructure (POL, ISO lines, spares, scheduled outsourced maintenance) to cope with capacity requirements that will lead the plant into the next 15 years of Radial Seal filtration products. This is in line with the move to develop and increase market share in Africa as production will need to adhere to higher production output requirements.

With the dispense machine ordered, the company also wanted to be in line with the production capabilities the parent plants in the US have had developed with their in-house process manufacturing team AMT. The AMT designs were often iterations of their original machinery with a goal for continuous improvement of the overall systems, essentially allowing AMT to source issues from other international plants, troubleshoot with engineers on site and weed them out in future projects. Strategically this was a functional aspect as the dispense and support systems (engineers and maintenance) would have a knowledge base for troubleshooting issues, as well as a support base for any potential maintenance problems the dispense would see.

The Drive to a Lean initiative

With the above factors, management made the executive decision to introduce lean using the installation of the new AMT dispense as the catalyst to drive a larger lean implementation across the line and eventually the plant. This would mean that the lean seed at the Epping facility would be initiated using the radial seal line.

Scope

The implementation loop would create a lean seed that would be rated according to the introduction of one-piece-flow to the line, standardizing operations and an overall waste reduction over the current system. The implementation would need to focus on creating the culture that the lean tools required, an engaging culture towards change, the training strategies required to create a sustainable system and the infrastructure that the line needed to conform to the Epping plant expectations.

The infrastructure changes would require the overhaul of the Upstream, dispense and end-of-line areas to facilitate one-piece flow and general ergonomics updates to machinery. A positive lean outlook for the RSL shop-floor staff would be critical for the culture and implementation.

5.1.2 Analyzing the System: RSL

Critical processes on RSL were immediately apparent during the first overview of the processes happening on the line itself due to the haphazard nature they were occurring in. Machines were set up to their own pace, operators were able to operate various parts of the line disjointedly and the line management, while present, was autocratic, meaning that if unavailable, the line would grind to a halt without instruction. The critical processes are discussed below.

Pleater

The pleater is a critical machine that required a six month apprenticeship under the technical expert to allow a trainee operator to undergo in-house qualification to run the machine unsupervised. It is shown below in Figure 2, from media roll to final pleated media.

Figure 2: Critical Process, Pleated Media

It is used to pleat media by making a slight impression on the media, based on the media depth required, which is then compressed on that impression into a fold to create the pleat. The machine itself was capable of running at a pleat speed of 400 to 1400 pleats per minute

(PPM). Once the media had been pleated, it was then put through a steamer and blower system via a short conveyor to compress the pack and make the media easier to handle. The pleated media was then cut manually and checked at the light-check table, a quality control to ensure there were no holes in the media from the pleating process. The media was then packed into a bin that was delivered to the seam-seal station further down the line, provided they were running the relevant works order. Since the pleater was capable of running media at higher rates than what the RSL could handle, it was often used to run ahead of schedule to relieve capacity on other lines

Seam-seal Area

The seam-seal area was used to assemble media packs. This consisted of media being delivered in bins to the cell, shown below in Figure 3, with a lot of excessive movement and handling, to be glued and joined before being bundled and inserted into a liner.

Figure 3: Critical Process, Seam-Seal

The pleated media was not often run in-line with what the rest of the line was doing, hence the disjointed process step of packing and storing media in bins.

The media was then bundled by the operator, lifted off the table and placed into an outer liner, using a plastic guide as shown above in Figure 3. Once the media was in the liner, the inner liner was inserted and flared to ensure that the pack was tight. A finished media pack is shown in Figure 4 with the inner and outer liner surrounding the media**.** A tight pack ensured that the liners did not fall through the pack and create defective product.

Figure 4: Critical Process, Tight Media Pack

Both the inner and outer Liners would be welded at their respective spot welders and placed on a ramp as shown in Figure 5 that allowed the liners to roll down the slope to the operator performing media pack assembly.

Figure 5: Critical Process, Inner and Outer Liner Spot Welders with Liner Ramp

The immediate impression of this cell was that it was considerably ungainly for the operators from an ergonomics perspective and required wasteful movement and handling to assemble a media pack. The seam-seal station structure was integrated with the line's power supply to the spot welders, pack ovens and conveyors.

It was also noted that the operator flaring the pack controlled the conveyor for the media oven via a dual control, with the other control located at the EDF machine. Should the EDF be on a break down or stopped for whatever reason, the seam-seal operator would be unable to load the media pack conveyor. Packs were then placed on a pallet and stored until the EDF was operational again, creating unnecessary WIP. The cell would often finish a works order and continue to set up and run for the next job while waiting on the EDF.

Polyurethane Potting

Once the packs arrived at the potting station, having been flared and sent through a media drying process, the EDF, once set up, required an operator to place a mould on a rotating disk and begin the dispense. An additional operator then placed the media pack in the mould, otherwise known as potting, and transferred it to the carousel. It would then effectively do one loop of the carousel to allow for the polyurethane to gel, so the pack could be handled again, and then be potted in the opposite mould and transferred to the curing oven conveyor. Essentially the potting operator would continually be potting packs in an alternating fashion, i.e., open cover mould, closed cover mould, open cover mould, where the element itself would be potted open end-cover first, transferred to the carousel, sequenced and then have the closed end-cover potted before being transferred to the curing conveyor.

End-of-line Area

Once the elements have been potted and have gone through the curing cycle, the moulds need to be returned to the heating circuit that lead to the potting station for the EDF. The end-of-line area was therefore responsible for demoulding the elements, returning the moulds to the circuit, and then performing a final inspection of the element, including a height check and inkjet printing before being either boxed and palletized or forwarded to the hotmelt station for additional processing.

It was noted that at any one time, there could be as many as five works orders at the end-of-line area due to either supply issues like cartons or labels, line shortages or breakdowns, defects, over-runs or ISIRs waiting on engineering input from the industrial engineering department (IE).

Supplied Product

Product is supplied to the line in raw or 'finished' status. This supplied product was not always accounted for in the bill of materials, or scheduled appropriately to ensure it arrived on time. See Table 1 for the complete list of components delivered to the line as supplied parts for various products.

Table 1: List of Components Delivered to RSL, in Raw or Finished States

	Raw	Finished
Media	X	X
Cartons		X
Liners	X	X
Media sleeves	X	X
Plastic closed cover caps		X
Moulds		X
Bags		X

Quality

The quality functions on the line were more of a reactive nature. This could be directly related to the relationships that had developed over the years between the line's operators and the quality line-inspectors (QLIs). Should a problem arise, the line's experience allowed issues to be resolved relatively quickly, but with the EDF developing a wide array of new issues, the lack of a troubleshooting guide for the EDF was costing the line in terms of output, defects and unplanned downtime.

Changing Conditions

With the EDF machine on its last legs in terms of efficiency, the move was to ensure the machine would continue to produce equitable product until the arrival of the new dispense. That being said, when the machine was running, the run's batch size would be anything between 30 elements to 1000 elements. Average output per normal shift was 600-800, up to 1200-1300 depending on the number of changeovers and routine maintenance.

Table 2: Comparison of EDF and the Expected AMT dispense

	EDF	AMT Dispense	
Design Output (rate/hour)	100	300 or 180*	*depending on mould size
Design Flow Rates (g/s)	0-30	0-60	
Design C/O Times	25-30 mins**	10-15 mins	**depended on material flow rate

The AMT dispense is capable of a much higher dispensed flow rate, meaning it could theoretically double the output seen on the EDF in its current state. A summary comparison of both the machines' design parameters is shown in Table 2. Where the EDF had a manual sequencing of alternately potted packs, i.e. it was controlled by the potting operator, the AMT dispense automated the process, an open-cover mould would have polyurethane dispensed and be released to be potted by the operator and transferred onto an electronically-sequenced pre-gel table, once the element has made a full revolution, the machine then dispenses into the closed-cover mould and releases it to be potted and transferred once again to the pre-gel table. On the element's second revolution, the system discharges it into the curing circuit without any further operator intervention.

Staffing Status

The staffing on the RSL before the upgrade was officially 14 operators including a cell leader, with the pleater cell as a separate supply cell with an additional 3 operators. Tasks existed that could only be done by the technical experts on the line, running the pleater, setting up the EDF for a job, spot welding, etc.

Operator responsibilities were not specifically allocated and relied on the causal reactions (something needs to be done, change a drum, and go back to working) memory of either the cell-leader or maintenance personnel to ensure the line ran according to schedule. The cell leader was an integral part of the line, as a result of her seals team experience, and understood, critically, how to make the line run.

There was no formalized training system that allowed for a schedule of modular training to be done across the line. New operators were selected as necessary and placed ad hoc based on the cell leader's preference. While a training matrix was being utilised, the upgrading of operator skills was done as necessary. The actual training was being done using the standard operating procedures (SOPs) developed for the machines used in the process and not geared for the physical process and was essentially a hands-off process that was done in a training room; competency was not accounted for.

Admin System

The Donaldson admin system, JDE, is an ERP system used to account for various internal and external management requirements like stock handling, scheduling and accounting on the shop-floor. While it is a robust system, it is inherently a manufacturing resource planning (MRP) system.

The schedule is run using this system, based on sales demand and other logistic factors. While the schedule existed, line administrators or cell leaders could work outside the system to ensure supply or close off a works order (WO) as required based on line issues seen on the floor. It further reiterated the “garbage in, garbage out” adage

Output Gathering: Current Output and WIP

With the line operating as separate cells, often at times without proper communication, the line rate would not directly reflect the rate at which product flow was coming through the line. As an example, the pleater was a wholly separate entity if it was running ahead of the line, meaning the seam-seal station would be assembling packs for a different WO onto a pallet while the EDF was running reworks for the balance of another WO that was urgent.

The pleater was set up according to the drawing and run at the whim of the operator, while the ability to change the EDF pour times meant that there was no standard consumption rate that the seam-seal station could work to. The number of WOs open on the line was indicative of the level of controlled chaos present on the line.

The amount of time it took for an element to be processed on the line varied for innumerable reasons. To get a sense of the WIP beyond a merely visual metric, the number of WOs open on the RSL at any one time would indicate that there is unfinished work on the line.

The line's output in terms of the amount of physical elements produced can be seen from Figure 6. Recorded data only exists beyond March when the system was automated, it is indicative from the trend line that the output was on a downward trend as a result of continuous downtime that the EDF saw in the year before being decommissioned.

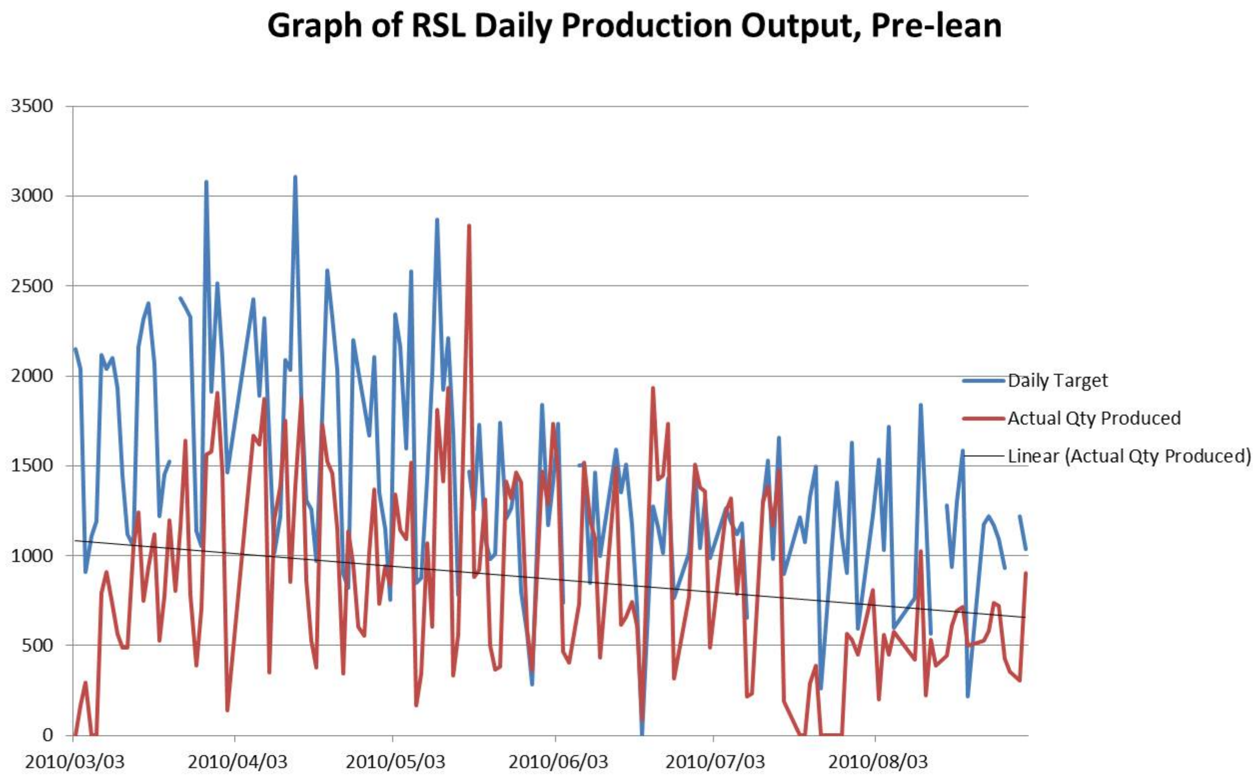

Figure 6: Output Gathering: Graph Showcasing the RSL Production Output, Pre-lean

Maintenance Downtime

It should be noted that the data indicating 0 output in Figure 6 is a result of unscheduled maintenance. The data is based on the production reporting done by the line; the maintenance system was non-existent in terms of recording data and downtime at that stage.

In terms of a running statistic, with the machine capability changing, this metric is only noted as a reference in the argument for the requirement of a TPM programme

Process Study: RSL

Please refer to Appendix A.1 for this loop's process study.

The physical steps taken to produce RSL elements as well as the set-up tasks required for specific workstations are shown.

Identifying Similar Product Streams

Highlighting interdependencies of product on a manufacturing line allow for the creation of standardized processes and showcase non-uniform product that may substantially affect the overall product time. There were two process streams identified as relevant to the scope of the loop, simply whether product was uniform and non-uniform.

The Pareto principle, i.e. the 80/20 law is evident when reviewing the composition of RSL product in Table 3. Here, non-conformances are where the product requires an additional processing step or operator function to be performed beyond those already specified by RSL. The normal stream includes steps as defined by Appendix A.1, additional steps an element may require are also listed in Table 3.

Table 3: RSL product composition comparing uniform and non-uniform product

	Number of Elements	Percentage of RSL product stream
Standard RSL processing	281	84.00%
Oil-treated media	1	00.30%
Polyester sleeve	18	06.00%
Plastic end cap	2	00.60%
Metal end cap	3	01.00%
Ultrasonic welding	12	04.00%
CAT spec liner clip	16	05.00%

To confirm the line's one-piece-flow capability, time studies were done using product that were within the identified process streams. These process cycle times needed to be within the new AMT dispenser's designed flow rate limitation of a maximum and minimum potting process time for both end caps of 20 seconds and 12 seconds respectively, this equated to a line rate of 300 or 180 elements/hour.

Notes: large amount of WIP seen, no physical way to track it as yet.

VSM

Please refer to Appendix B.1: Value Stream Maps for this loop's initial VSM of the RSL.

Since the dispense process was already changing, the focus in terms of issues to tackle was directed at integrating one-piece-flow into the entire line.
From the initial VSM we can confirm the additional non-value-adding activities that the current state is seeing on similar product streams identified in the process study.

With the dispense changing as a matter of course the next ideal state would need to incorporate one-piece-flow while removing the waste highlighted through analyzing the line. The potential future states with the updated process steps are shown in Appendix B: Value Stream Maps.

Reiterate the KPIs

With the line preparing for a drastic culture and infrastructure change, the success or failure of the lean seed implementation loop would be rated according to the potential future state shown in Appendix B.1: Initial VSM via the key performance indicators highlighted earlier in the scope of the loop. They are listed in Table 4 on page 56, by metric and description. The overall equipment effectiveness (OEE) is a measure of the equipment utilization and takes into account the loading, availability, performance and quality.

Table 4: Table Referencing the KPIs for the Donaldson Loop

Metric	Description
Unplanned maintenance downtime	Installation of new infrastructure and plant would require minimum effect on the line
Planned maintenance downtime	Installation downtime, planned vs. actual
Line rate (output)	Physical daily line output
Conformance to rate	Whether the line was conforming to machine design rate
OEE (AMT dispense)	OEE for the dispense, based on capability numbers generated in the US plants
Safety	Number of safety incidents recorded during shifts

As with each loop, the champion and team must ask: Are the current metrics valid and relevant to the changes we would like to see and are they within the scope of the loop? Is what we're measuring now going to be critical once we've implemented change?

5.1.3 Select/Target issue to tackle: Upstream, Dispense and End-of-Line

The critical issue that the analysis of the line highlighted was the need to prepare the line for one-piece-flow and introduce standard work. The new dispense was essentially a heart transplant for the line, replacing the EDF with the potential to double the output. The line upgrade would need to facilitate the heart-of-the-line update as well as create a pull culture in the support cells that supplied product to the dispense in line with one-piece-flow.

To ensure that each developed solution would be effective, the team must drill deep, and drill wide, meaning they must have drilled as far down to the root of the problem and solve it effectively at the root cause and then ensure that the same solution is applied to other issues that are caused by similar problems, or be aware of how the solution affects other areas within the scope.

One-piece-flow

The flow of the line would be determined by the new dispense's recipe database of the product currently running at the Epping facility according to two defined rates. These rates are linked to the mould type used across the Donaldson urethane-capable plants. The moulds are injection moulded in the US, with two sizes locally available for polyurethane end-caps, 10.5" (266.7 mm) and 16.5" (400 mm).

The dispense's flow rate capabilities allow for it to dispense PU in the 10.5" and 16" moulds at 300 elements/hr and 180 elements/hr respectively. These rates boil down to a potting process cycle time for both open and closed end-caps of 12 seconds for the 10.5" and 20 seconds for the 16". Provided the line runs a job that uses these moulds, the line rate will be limited to these two rates. To attain one-piece-flow, the upstream and downstream processes needed to be balanced to adhere to a minimum cycle time of 12 seconds for smaller packs and 20 seconds for larger packs.

Tackling the line as one to attain this goal was perceived as too ambitious. It was feared that the downtime the installation would cause by shutting down the line and installing the machine as well as moving all the line's new peripheries would extend to weeks or months. To avoid this, the line was split into three zones: upstream (now including the pleater and media pack drying oven), the new dispense and end-of-line. Removing the obstacles to one-piece-flow showcased in the line analysis would require that the solutions be looked at individually.

Each zone had unique issues which required significant strategic planning and problem solving to implement one-piece-flow. These are detailed in the sections below.

Upstream

The layout of the seam-seal area during the initial process study (viewed in Appendix A.1: Process Studies) can be seen to include a media bin delivery point, the liner manufacture and an integrated flare tool. It was a batch-work cell that swallowed staffing resources depending on the size of the job or whether the EDF was running or not.
The pleater was, as yet, not included in the zone.

The proposed state, sought to link the pleater and the seam-seal station into one upstream unit supplying completed media packs to the new dispense. The process steps comparison between current and proposed can be seen in Table 5.

Table 5: Table Showcasing the Current State vs. the Proposed State

Process Steps: Current State	Process Steps: Proposed State
Pleat Media	Pleat Media
Light Inspect Media	Light Inspect Media
Cut Media	Cut and Glue Media
Place Media in Bin	Seam-seal Media
Store Media Bin in Inventory Bay	Media-to-Liner Assembly
Retrieve Media Bin	Transfer to Flare Tool
Locate Media Bin at Seam-seal Station	Flare Pack
Pick up Media	Place Pack on Media Pack Oven Conveyor
Glue Media (Join if necessary)	
Seam-seal Media	
Bundle Media	
Pick up Media	
Transfer Media to Liner	
Insert Inner Liner	
Flare Pack	
Place Pack on Pack Conveyor	
Total Steps: 16	**Proposed Steps: 9**

Media delivery

For RSL product, the critical factor is the media and is seen as the most value adding activity by the customer, treating the pleater as the anchor that the rest of the line had to be built around was a necessity, securing it as an in-line supplier was vital to creating flow. As an immediate supplier to the line for the most critical component, incorporating it directly into the line to enable just-in-time supply of product was critical to cutting the transport waste and WIP seen during the process study. It was necessary when it played such a pivotal role in creating flow along the line. As a process however, the pleater could produce media at the minimum required rate of 12 seconds across the RSL product range, the only limiting factor during production was the fact that the operator checking the media had to cut and pack it into a bin, creating WIP and other waste.

The current process study had an operator checking and cutting the media; this led to a shortfall on the light check process as the operator was not at the workstation 100% of the time.

In terms of cycle times for those processes (refer to Appendix A.1: Process Studies) one can see that while the baseline time constraint of 20 seconds was met for larger packs, the time was not consistent with the operator having to step away from the workstation to pack the media away. The proposed state for this solution ensures that the light check media and the cut media processes are separate with staffing assigned to both to ensure the task is done competently and within the minimum cycle time required.

Media cutter

Cutting the media was a sticking point for the plant manager who stated it was always a tough pill to swallow when he had to take guests on a plant tour of his world-class facility and operators were cutting media with a pair of scissors. Cutting the media was not a cycle-time critical change requirement. Looking ahead however, in terms of safety and repeatability, only a handful of operators had the knack of doing it quickly and effectively. With it being a manual process, the consistency of the cut was questionable and it was requested that the process be mechanized.

To accomplish this, we looked at how other Donaldson plants were tackling the issue and incorporated a local solution based on their knowledge base.

The machine would cut the media from the underside, this would mean that the glue process and seam-seal assembly method would need revision, but it would mean that the blades could be effectively shrouded, thus protecting the operator from harm, fulfilling the new safety requirements laid out for the plant by the operational director.

Quick change-over tools

With the media cutting being mechanized, and the change to the cut location, the seam-seal process would require a change to the orientation of the blades used to press and seal the media to be able to use media cut on the machine. The downside of this would be that it necessitated the use of different blades depending on the various pleat depths used for jobs on the line. The stipulated set up time for the new line was 15 minutes, the new press needed to be designed with this in mind.

As the major constraint was the bottom blade, the top blade was designed to be permanent with the line only being required to change the bottom blade to set up for a change in media depth as shown in Figure 7. Set up time was now accomplished in 60-90 seconds, well within the time limit.

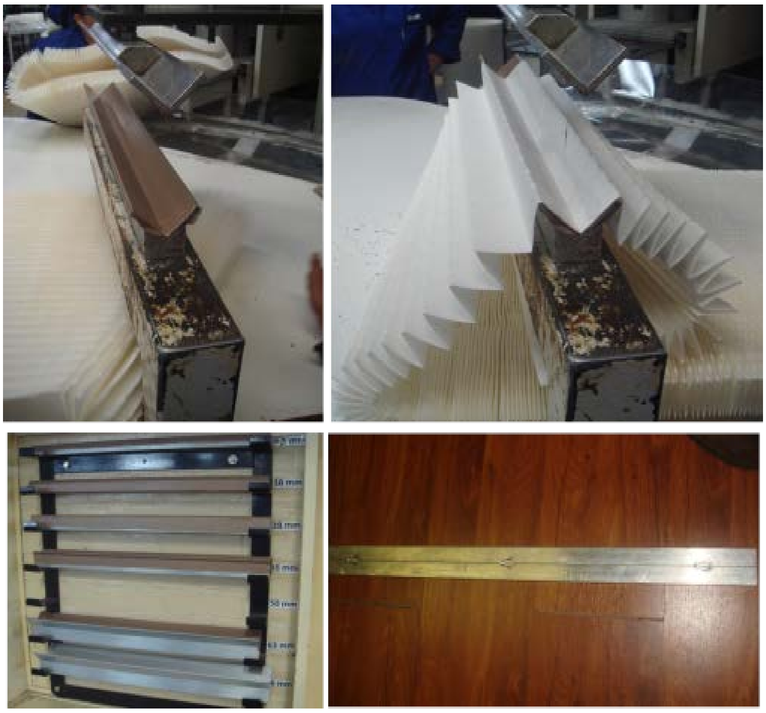

Figure 7: Quick Change-over VEE Design Seam-Seal Blades, Highlighting Slots and Storage Cupboard

WIP – liners, packs, media

The line was extremely cluttered, with the introduction of one-piece-flow, the number of WOs on the line would be dramatically reduced from the working norm of having up to 5 or 6 flooding inventory bays as the line saw fit. The introduction of current and next WO inventory bays would seek to solve the WIP present with liners and packs waiting to be potted.

The biggest change would be incorporating the spot welders, pleater and seam-seal station into one upstream supply, producing media packs. For the media and liners to arrive at the seam-seal station required a kanban pull-system for the inner and outer liners. The spot welders were located away from the smaller proposed seam-seal area for safety reasons, with the liners conveyed to the area as needed. The conveyor would serve as a buffer inventory.

Layout – manning, ergonomics and planning ahead

It was clear that the line layout would need to change to effectively merge the pleater into the seam-seal area, which already incorporated the spot welding and flaring of liners for the media packs. In defining a layout to build around the processes to create flow, there was a substantial restructuring required to advance the various areas.

Beyond that, the workstations were redesigned during their standardisation to be split per process, allowing the line the ease of modularity for when processes needed to be upgraded for whatever reason or needed maintenance. Each workstation was designed to sequence into the next process without any buffer stock or inventory between each process. For planning and buy-in the workstations needed to be designed and optimised with the team to ensure that all of the expected risks had been mitigated. There was concern, as a result of the time study, that the stuffing of the media into the liners was not going to be able to keep up. This process on the old seam-seal station required the operator to bundle the pack correctly and manually lift it to the height of the liner, and squeeze the media into the pack. This would require a drastic change to create an easier workflow. The team looked at what was being done elsewhere, in other Donaldson plants and looked to incorporate their designs.

It goes without saying that the workstations would look to improve on the ergonomics of the previous generation of those cells, while still ensuring the product conformed to the process requirements. The seam-seal station would be designed around the new seam-seal blades and the stuffing of the media such that the table would act like a sieve to collect the media and guide it into the outer liner; this was seen as a large improvement ergonomically for the operators. The main health and safety complaint on the line in that area was lower back pain. To ensure this method was viable, a local liner ring needed to be developed to prevent the media from catching on the liner itself when the media was being placed into the liner. An example of the liner ring developed can be seen in use in Figure 8.

Figure 8: Locally Developed Liner Ring

The staffing this required meant that each workstation was now a dedicated supply point that would feed the next process, meaning each process needed an operator assigned to it to ensure that the line could run consistently at rate.

With the complexity that this staffing requirement generated, process redundancy was introduced on the line to ensure that the line could cope and run should there be an issue, like unplanned maintenance or non-uniform processing required. This entailed that processes with inconsistent time studies were doubled up or had built in redundancies to handle any issues

Dispense

The dispense was coming in as a complete unit, requiring the direct input of media packs and moulds, outputting potted packs to a heated curing circuit defined by conveyors. This circuit would also be used to recirculate moulds. As the heart transplant that it was, it would be directly responsible for dictating an increase in capacity by defining the line rate. All the processes feeding into it needed to conform to the required rates.

The curing circuit would need direct integration with the dispense as potted elements would require a smooth transfer to the demoulding station to ensure that the product had cured sufficiently, approximately 8 minutes. The existing ovens leading into and away from the

EDF made use of heating elements and fans to ensure that the packs were dry and able to cure at a consistent temperature, this led to an extremely poor efficiency and inconsistent temperatures seen by the final product. In terms of an environmental perspective, it was highlighted as low hanging fruit to ensure that the ovens required for integration with the dispense would make use of recirculating the hot air within the oven to create a consistent heat profile while being an energy-saving improvement on the existing ovens.

End-of-line

Once the potted packs exit the curing oven, under the initial process study, the element would be manually demoulded, with the element placed on another conveyor for final inspection and boxing while the moulds would return to the EDF through a mould-release application and a heating tunnel to ensure they maintained a consistent heat profile. The dispense would work on a similar principle, with the only required change being the upgrade of the final inspection conveyor, as well as the mould release station.

Each process remained as is due to line rate conformance during the time study done initially, with only rearrangement for them to be in-line to conform to single-piece flow. Staffing for each process was formalised to ensure process conformance for each product. To reduce WIP on the shop-floor at the end of line, it was proposed that the system only have inventory locations for the current WO, any product not falling under that identity would be defected and placed on hold.

Looking Ahead – Infrastructure, Maintenance and Standardised Work

While the issues regarding upgrading the line had been outlined in the line analysis, the planning phase needed to look beyond just upgrading the workstations and processes. Key areas that required standardising included infrastructure changes and upgrades (Main power supply and lighting), air and water lines and the overall standard regarding how these services were delivered to the workstations.

From the process study and VSM for the RSL, it was apparent that the majority of the product sees all of the processes required for Radial Seal elements. By structuring the line process by process, one can assign the manning, machinery and TPM instructions to a single process and create a benchmark that can be used to introduce standardised work to the line. A template was created that provided all of the information required for a single process, including start up, shut down and the actual running of product through the workstation. A sample is shown in Figure C.1 in Appendix C.

Selected Issues: Summary

In summary, the following items were selected to provide effective solutions that ensured the scope for this loop was fulfilled, these solutions are listed below:

- Process modifications defined by one-piece flow, including process balancing to the line rate and overall output conformance to the AMT machine;
- Infrastructure clean-up;
- Upstream, including layout changes and seam-seal redesign;
- Upstream, including integration with curing circuit;
- End-of-line, process reshuffle.

With the line running as it was observed during the initial process study, the solutions created to initiate one-piece flow would need to be implemented and merged with existing systems that did not need to be changed. While individual solutions have been discussed, they cannot all be implemented at the same time at the cost of shutting down the line, as per the KPI defined by the loop to ensure that planned and unplanned downtime be kept to a minimum.

This required an effective and planned implementation of the changes to the line. Team meetings were held to discuss the staged roll-out of machine installation and line changes. While this is beyond the scope of the topic, it is useful to showcase the amount of work required to implement the flow required, the sample planning notes can be found in Appendix D: Planning Documentation.

To ensure that the planned installation did not affect the KPIs, installation work needed to overlap to minimise the effect on the line that was still required to run production, along with the development of training strategies to minimise the effect of downtime due to the installation.

5.1.4 Applying Implementation: Devil is in the details

The implementation of one-piece flow was the main aim to ensure the successful addition of the new AMT dispense system. Each solution required careful integration into the existing line to minimise downtime and further introduce lean tools to benefit processes. This was done by implementing the changes in stages. This had the added benefit of introducing flow and creating buy-in and familiarity with the shop floor. Each stage would require closely sticking to the planned and expected outcomes defined in the previous phase.

5.1.4.1 Stages

Please refer to Appendix D: Planning Documentation for this section

This stands as a brief guide to each stage, it briefly discusses any implementation that happened over the course of the stage. Any insight relevant to the loop will be noted but the overall physical installation is beyond the scope of this thesis.

Stage 1

The RSL made use of many inventory bays and various locations for moulds and WIP. This cluttered the floor and would create chaos once any change was implemented should they need to locate anything. This stage made use of a pseudo-red tag event, where the team did a walk with the RSL team-leader on the line and noted any items (tools, moulds, equipment, WIP and waste) for removal. It allowed the team-leader to remove anything that was deemed unnecessary by his or her own means, with the understanding of the shop-floor and it highlighted the requirement for an effective housekeeping strategy.

Stage 2

At the time, the EDF made use of a shared raw material pump location housed in a temperature controlled room. The room was installed during a time when the plant had material issues that required critical temperature control and agitation before any material was introduced to the line. As these material issues would cease to exist with the new dispense, the conditioning room was removed to clear space and relocate some of the room’s required infrastructure (Pumps, stirrers).

Stage 3

This stage was loosely used to prepare the line for installing infrastructure. It required the overhead preparation or removal of ducting, bus-bars and water or air lines. The main changes to this infrastructure would be seen in the new upstream area.

Stage 4

With the coupling of the pleater to the seam-seal station for the upstream area, the pleater's unused take-away conveyor was removed. This cleared the 8m of floor space necessary for installing the new integrated seam-seal workstation. This was a useful exercise for the shop-floor to see as it was their initiative to highlight the conveyor as being unnecessary. It showcased their input in a positive light and created a positive buzz around the new installation because of their inherent participation.

Stage 5

The spot welders and the glue gun for the media were common elements between the new and old layout for the seam-seal. This meant that the team needed to prepare the new seam-seal area to allow the old seam-seal area to continue to operate until the spot welders and glue gun could be moved. The area was prepared for the new upstream layout, so the new media cut machine was located, along with the new seam-seal station. This preparation included plotting new power, air and water lines to points for the new upstream layout.

Stage 6

With the line preparation done, the line shut down early on a Friday to begin the shuffle into the new layout. This required for the spot welders to be relocated from the old seam-seal station.

Stage 5 and 6 were far enough apart for the shop-floor team to have had some experience working with the new layout. These changes included:

- The new media cutter;
- The packing method using the liner rings shown in Figure 8 and the 'upside-down' (SIC) seam-seal blades and the table to guide the media;
- Spot welder integration, including the new liner conveyor using pull kanban.

Some ergonomic teething issues were found that required tweaks, but the overall impression was positive. The line would continue to use the new layout with the older equipment further down the line until the dispense arrived.

Stage 7

The first of the new recirculating ovens arrived and was installed to free up the area where the old media pack oven was located.

Stage 8

Move the EDF carousel. This step was merely done while there was still fork truck access to this part of the line.

Stage 9 – 12

These stages were used to decommission the old media pack oven, relocate and reuse the conveyor as the first part of the curing circuit and to set up a temporary conveyor to deliver media packs from the new media pack oven to the EDF until the dispense arrived.

Stage 13

The new curing conveyor and oven were assembled off line and moved into place. This required for the line to be down for a brief period while the conveyor was installed. This was the first planned downtime for the line.

Stage 14

The mould oven was shortened to ensure the complete curing circuit was contained within a manageable area. The new automated mould release station was located on the retrofit conveyor.

Stage 15

AMT dispense pre-assembly on the shop-floor. The line was still in operation until the system was physically located into its permanent position. Once located, the machine was fully assembled. The space created upstream allowed for the new dispense to be fully functional while the EDF was still running. This was a contingency built into the installation plan should any issues be found on the new dispense before it was qualified. Once it was cleared, the EDF carousel was removed. The line was now operating through the new dispense. This initiated the final decommissioning of the EDF and its removal from the line.

Stage 16

Once the EDF was cleared, the mould oven and curing oven were moved into place, essentially completing the final location preparation for the curing circuit to be installed.

Stage 17-18

The packaging line was now free to be relocated further up the line. This allowed for the final placement of the end-of-line and the hand-over to production signifying the end of the installation phase of the loop.

Actual recorded downtime for the installation was well within the planned-for allocated downtime of 7 shifts. Actual figures are reported in the review phase.

5.1.5 Creating Sustainability: Building Processes by Reducing Waste

The introduction of one-piece-flow to the line was critical in terms of sustainability. It required for each process to be reviewed and replaced or modified to create single-piece-flow. This inherently deconstructed the necessary processes and highlighted the waste within those processes.

In creating flow, the inventory between the processes upstream were seen as hugely wasteful and was removed to ensure that the line operated using the one-piece-flow required to conform to the new line rate. The newly introduced processes, singled out as stand-alone workstations now, were standardised, introducing a different understanding by the shop-floor operators of training required to run the machines. The operators were now responsible for their own defects, and immediately accountable by the next process. The RSL layout is shown in Figure 9 with operator-workstations indicated by orange dots.

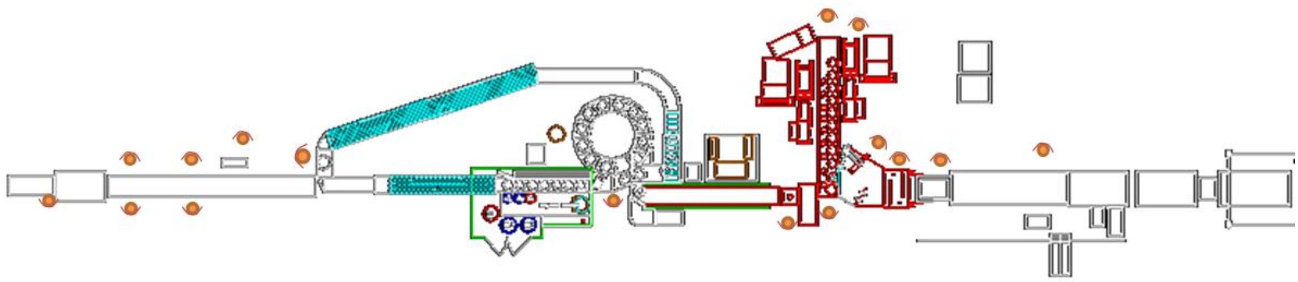

Figure 9: New RSL Line Layout

With this workstation layout, it was also immediately apparent to the shop-floor team where the critical functions were and how to achieve line output should one fail. The line was now divided into different training tiers as shown close-up in Figure 10, Figure 11 and Figure 12. The new dispense, tier 3, upstream, including the pleater, tier 2 and the end-of-line, tier 1.

Each tier represented the level of training an operator needed to be to be able to perform tasks in that area. Figure 10 is a close-up of the upstream section, encompassing the pleater and seam-seal station feeding directly to the new dispense. Should an upstream operator be absent, it is a tier 2 problem, meaning that only operators trained to work in the 2nd tier could be used to solve the problem otherwise their line rate would suffer.

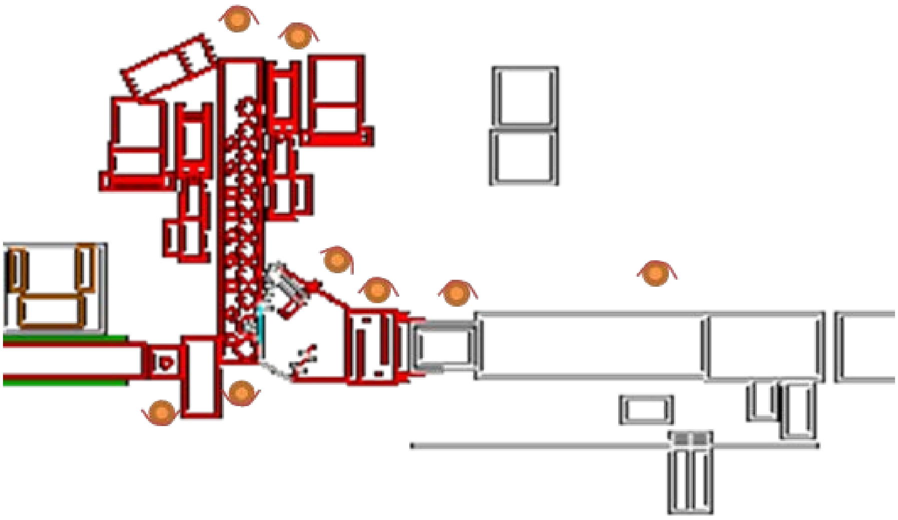

Figure 10: Upstream, Tier 2 Training Requirement

Tier 3, the new dispense workstation shown in Figure 11 is only available as a training option for an operator once they are qualified to work on the lower tiers. It allows for operators to rise to the top through their performance in the other tiers.

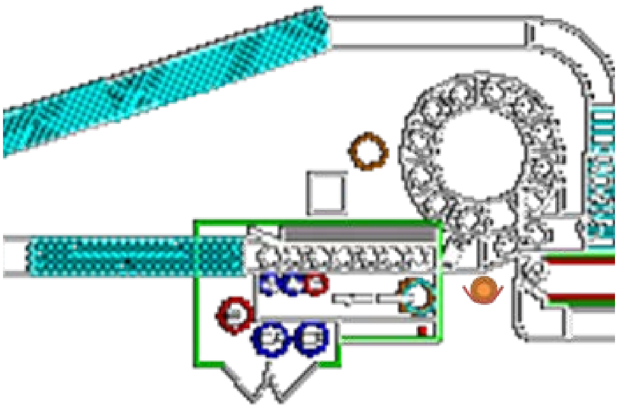

Figure 11: Dispense, Tier 3 Training Requirement

Tier 1, located at the end-of-line shown up close in Figure 12, has less critical process steps unique to the line, allowing for the line to rotate operators or introduce new operators based on training level when issues like absenteeism are present.

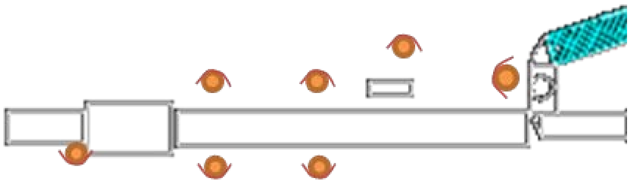

Figure 12: End-of-Line, Tier 1 Training Requirement

5.1.6 Review: Understanding the Line

With the installation successful, output stats from the line trickled in slowly. A definite improvement with regards to the overall line rate was noted with the added requirement of one-piece-flow now finally realised.

Teething issues

New machinery, generally prototypes that are, as yet untested by industry, struggle to be integrated to a team used to other practices without effective guidance and training. The seed team must be able to make a call when it comes down to this learning curve. Understanding the process is crucial to know when to push and when to allow the team to grow and develop ownership of their own understanding of a concept.

Set-up procedures with new machinery are also tricky. The first weeks working with new machinery, before TPM was introduced, required the team to familiarise themselves with the systems. It followed that machine specialists on the line had the added advantage over normally trained operators during set up. The introduction of standard work instructions (SWIs) and training reduced this significantly.

Loop KPIs

Apart from achieving one-piece-flow, some loop performance metrics are reported below. Table 6 compares the planned downtime for the implementation loop to the actual downtime recorded. Effective planning of this stage allowed the team to be ahead of schedule and able to react to any issues arising during the loop's implementation.

Table 6: Unplanned vs. Planned Maintenance Downtime

Allowable Unplanned Downtime	Actual Unplanned Downtime
16 hours (2 shifts)	3.5 hours
Maximum Planned Downtime	**Actual Planned Downtime**
40 hours (5 shifts)	24 hours (3 shifts + weekend overtime)

The line rate can be seen in Table 7. While the numbers have been rounded up, it is apparent that the rate/hour increased in terms of planned output as well as actual. The similar daily outputs can be attributed to the fact that the line was now required less hours per shift to run the same daily output.

Table 7: Table Showcasing the Line Comparison between the EDF and the Dispense

	EDF	Dispense
Daily Output	1000-1100	1000
Rate/hour Planned	120	170
Rate/hour Actual	57	98

See Figure 13 for EDF data during March/April and Figure 14 for dispense data during October/November.

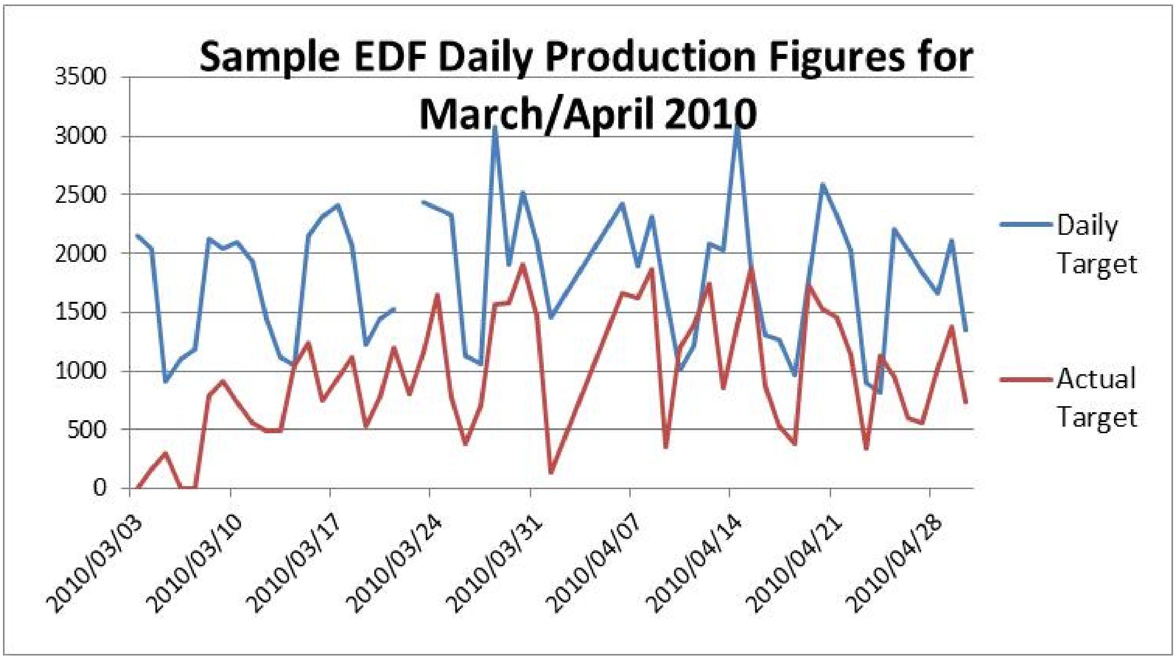

Figure 13: Sample of EDF Production Figures

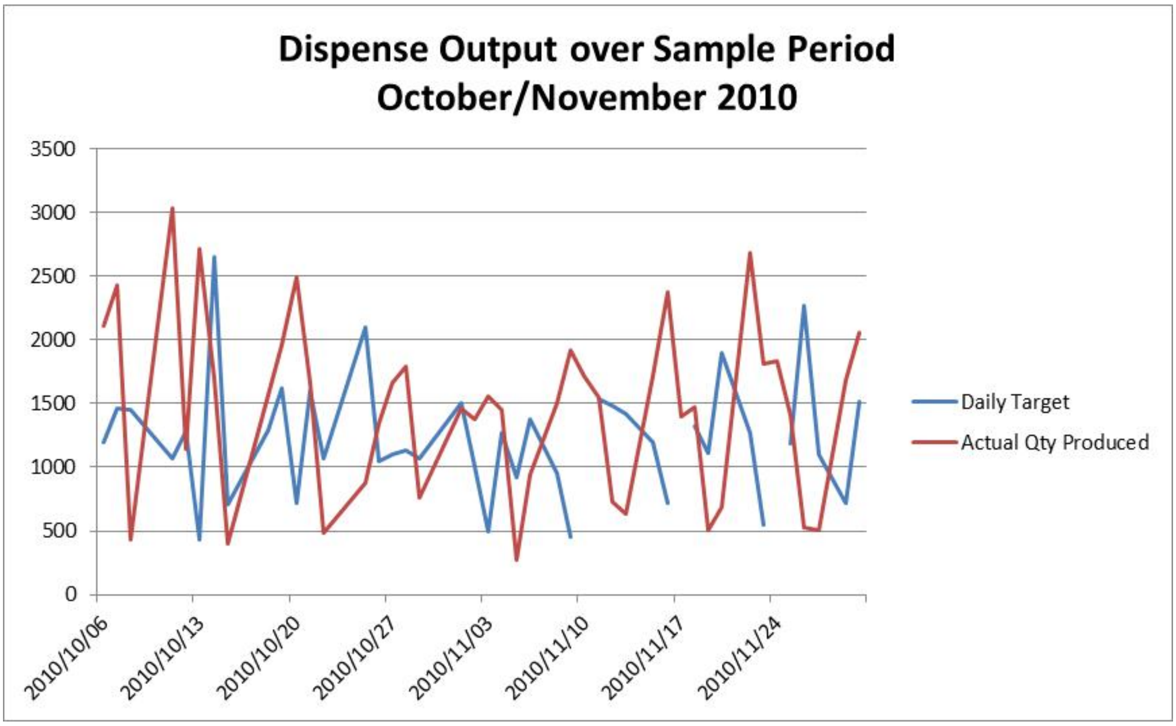

Figure 14: Sample of RSL Production Figures after Dispense Installation

It should be noted that the projected target for the new dispense is more in line with the actual output reached by the machine when compared to the EDF data. The EDF suffered from extremely long lead times for spare parts, when they failed, the spares coming in to replace them were still in the process of being shipped.

The expected OEE of the installed system compared favourably to the EDF data as shown in Figure 15 and Figure 16 respectively on page 75. The average OEE for the EDF hovered between 0.6 and 0.8, compared to the installed system running at an improved range between 0.8 and 1.2. The OEE calculation was modified to take the two rates that the dispense operated at into account.
Further Data for the RSL over the course of the loop period can be seen in Appendix E: Loop Data.

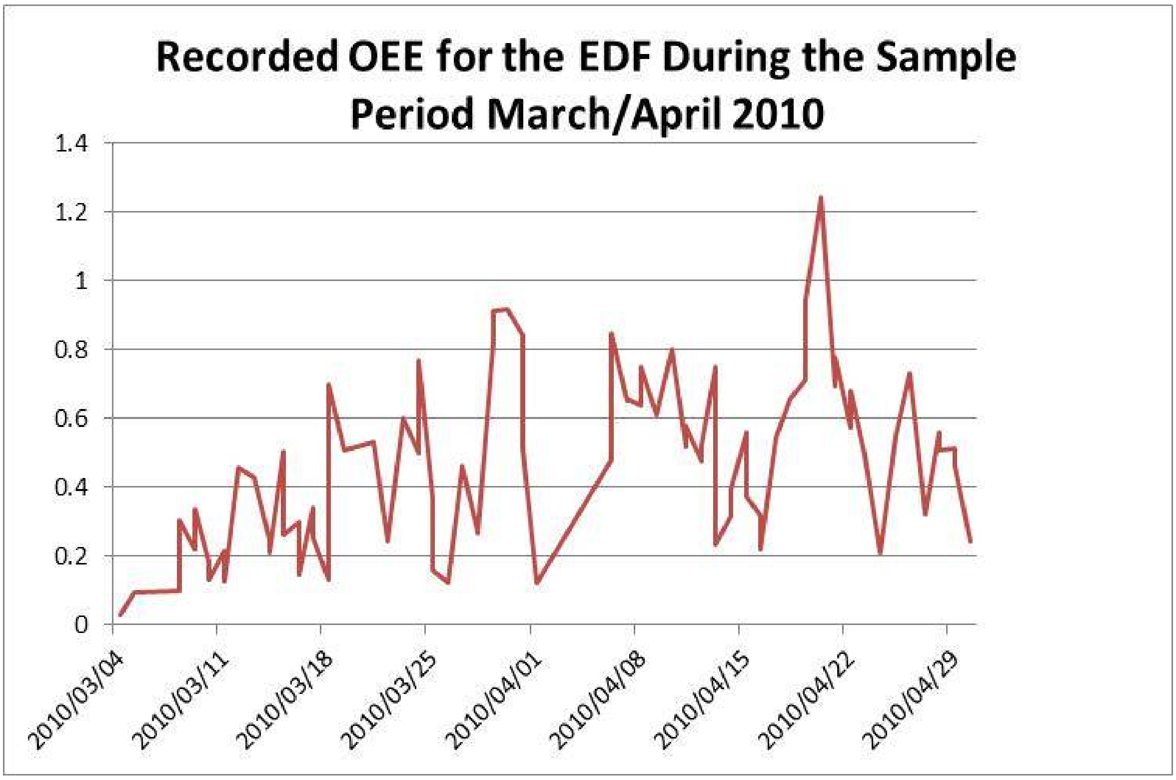

Figure 15: Graph of the OEE for the EDF during a Sample Period

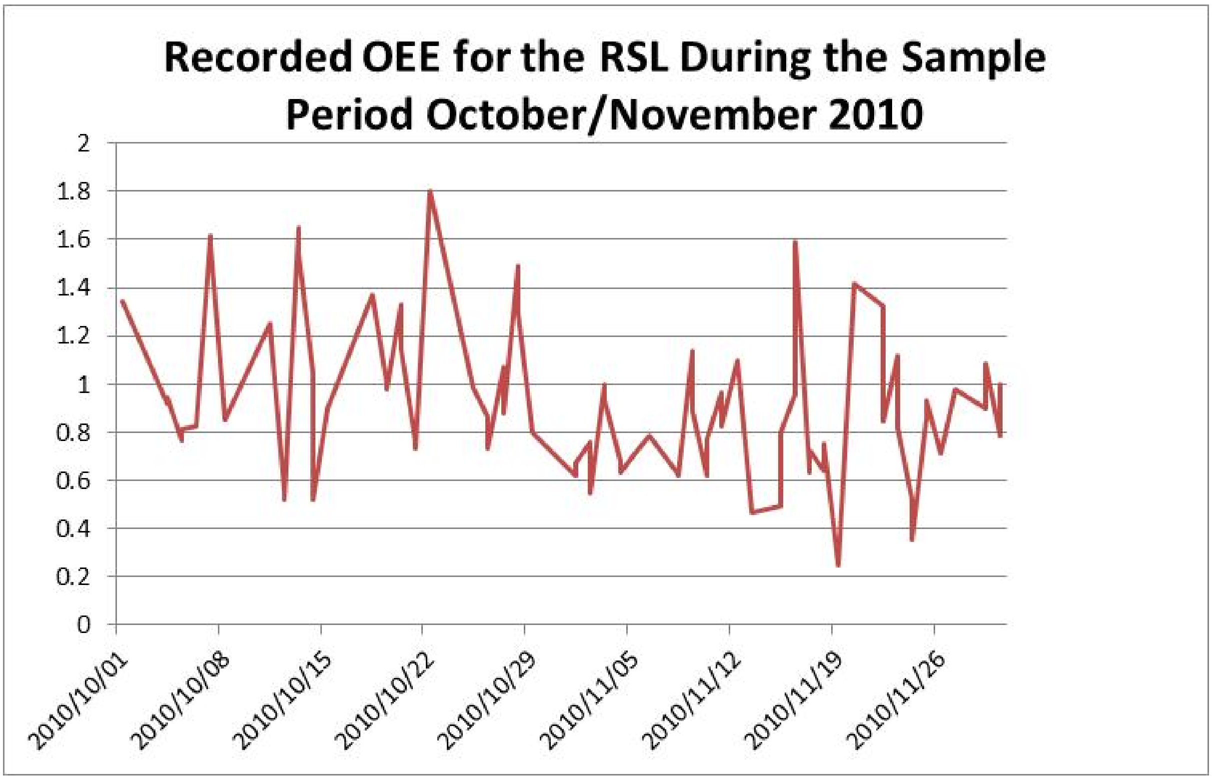

Figure 16: Graph of the OEE for the Dispense During a Sample Period

In terms of this improvement loop's scope set out in the analyse phase, the loop has satisfied the required outcomes which included creating one-piece-flow, integrating the pleater into the new upstream area and increases in the overall line performance, with favourable OEE figures for comparison.

Observations

These were observations during the implementation and the sustainability review phases that were beyond the loop scope, but needed to be seen to. In these cases, the champion must determine whether the current scope was relevant or whether a new improvement loop needed to be created to solve them within a redefined scope.

Set up times were extravagant, but this was attributed to the shop-floor staff familiarising themselves with the machinery, it was hoped that this would diminish over time. The upstream area also struggled with the pleat speed coming off the pleater. Where before, the pleater ran uncoupled to the line and the seam-seal station was able to work at its own pace and define their output, this was no longer the case. The pleater no longer had an inventory buffer that it could run into should there be processing issues further down the line. Upstream now needed to supply at the rate the dispense consumed packs; once the pleater had acclimatised itself to the required rate, this issue subsided with time.

It was made apparent by the seed team that there was no designated system to control improvement projects. There was no information available or system present when it came down to tracking how improvements were done and how they were documented to showcase any quality or process improvements.

Interference

Management often had a disturbing side view of issues and would circumvent previous statements and move other pieces into play to either limit or indirectly cause chaos unintentionally or without the full understanding of the effect. For example, a new demould machine had been commissioned for end-of-line, this had been done beyond the seed team's knowledge, so when it came down to changing the end-of-line, there was a new requirement to integrate an untested prototype as a replacement process. When push comes to shove, should all the information not be available to the implementation team at the planning stage, the entire project can be derailed by being forced to implement an unplanned-for strategy with low priority due to lack of information or it being missed by the team. Full disclosure and transparency needs to be understood by the management team and a scope must be signed off on to ensure this cannot take place. The team was able to adapt accordingly by being ready and flexible to the changing conditions, and by being aware of all of the affected processes and implementation changes upfront that this required.

5.1.7 Outcome

This section is included as an out of loop insight, i.e. what happened after the actual implementation

Recommendations:

Having fulfilled the requirements of the initial Donaldson loop, there were a few observations seen during the line changes that showcased a need for improvements. It was noted that the issues raised by the team and management needed to be handled by a single system run as a kaizen-structured problem solving event. By implementing this system it was thought that many issues could be weeded out by pushing this strategy forward and would also help drive continuous improvement projects across the rest of the plant.

This strategy would mean that any future lean initiatives in the plant would make use of the system developed by the team. A new loop would be required to introduce a kaizen system to the seed.

5.2 Introducing Kaizens into the System

5.2.1 Assessing the system: New System, Same Performance

With the installation of the new AMT dispense complete, and the initiation of one-piece flow fully realised, the production reports were used to ascertain a mean of what the line performance was peaking at. Issues highlighted by the previous improvement loop needed to be dealt with, with a main requirement being a continuous improvement template that could be applied to the line sustainably that ensured the tracking of solutions and the value behind them.

Having witnessed the installation of the new dispense, management were not seeing the expected results. The loose opinion was that the line was still operating at the level that the EDF was operating at.

While the seed team could apply a loop to develop a solution to the root cause of the line deficiencies, the continuous improvement template would allow for the RSL shop-floor team to be introduced to a kaizen strategy to ensure that the team were able to implement their own developed solutions.

Scope

Therefore a system to track continuous improvement would inform the next loop, with a sustainable template that could be used by the shop-floor team to generate solutions via continuous improvement was required. It was hoped that this system would be used to drill down to the root cause of the issues affecting the line output.

5.2.2 Analyzing the system: Soft Metrics

The RSL was able to produce elements on the line as designed. The system, however, was not generating effective output to the expected daily requirement. Somewhere the line was not operating like it was supposed to.

There was no system to track where improvements were required on the shop-floor and why. The line relied on the line engineer or management to generate change. There was also no data to showcase that any improvements were active, and no definable metric beyond a comparison of key KPIs to indicate significant change, especially when not directly linked to production.

The seed therefore needed to introduce soft metrics, metrics that were not directly related to production output, those that involved checking that the shop-floor was content, that the operators were seeing their suggestions come into play and that the system implemented was sustainable.

To showcase flaws/gains for this loop, the KPIs would be based on whether the system was able to successfully repeat itself, without intervention and that it could be used across the plant.

A process study of the plant procedures indicated that there was no official process to initiate continuous improvement in the plant (refer to Table A. 2: Process Study). One would need to be created for the Epping facility.

5.2.3 Select/target issues to tackle: Top-Down Relevance

A Continuous Improvement System

Naturally, the continuous improvement system would need to take into account how the line was designed, how the operators felt about the line in an open forum and involve them in problem solving and the implementation of the solutions. In looking ahead, the seed team needed the system to be relevant throughout the company, so that when the seed was mature enough to expand, tracking the kaizens in the company was consistent and straight forward. Further, the Donaldson Production System, in its infancy, would be making use of such a system in ensuring their international facilities were keeping up with their top-down implementation targets, it would be an easy win to integrate their requirements with the seed's requirements.

It wasn't a case of "Top-Down Implementation is wrong," more of a case that for the system to function sustainably, the local factors unique to Epping needed to be understood before blindly implementing.

The team needed to understand why there wasn't a continuous improvement system in place already. Interviews held on the shop-floor and other non-production departments indicated the lack of awareness of what kaizens and the need for continuous improvement meant. On the shop-floor, specifically, the understanding and culture that they were just there to operate and that there were other people there to solve issues was also indicative of a problem.

One of the inherent issues with top-down implementation is the awareness of the requirements beyond certain levels is not always accessible to the team, let alone the shop-floor, due to the tiered training approach and the understanding that upper management should be able to carry the responsibility of instilling the new culture in their subordinates. As the system did not exist in a form accessible to the seed team or the shop-floor operators, one needed to be developed. This system needed to showcase:

- Observation strategies that allowed the kaizen team to highlight issues;
- An effective description of the issues seen during the kaizen;
- An understanding of how to arrive at the root cause for the issues investigated;
- A selection criteria to ensure an integrated team was present and able to make decisions involving solutions;
- A standardised way to use the system such that there were repeatable outcomes;
- A successful implementation of solutions and any support structures they required to function;
- Compatibility with DPS requirements.

At the base of it, DPS just required that there be proof of continuous improvement events and participation. A template procedure was developed using the requirements above and used for mini-events to simulate how the system would work before training. This would be the standard that all continuous improvements to production would be done to. It follows the standard kaizen strategy defined by TPS, using the shop-floor team to highlight issues on the line and initiate problem solving. The exercise is defined by solutions that:

- Standardize operations and activities;
- Measure the standardized operation (find cycle time and amount of WIP);
- Gauge measurements against solution requirements;
- Innovate to meet requirements and increase productivity;
- Standardize the new, improved operations.

5.2.4 Applying implementation: Testing for Understanding

A test session was held for the seed to raise awareness of continuous improvement on the shop-floor with the RSL team. The majority of the time was spent training the team and testing their understanding of the concepts used within the kaizen itself. The review session with the team showcased how important understanding for the shop-floor team was in terms of training. It was a vital fundamental.

5.2.5 Creating Sustainability: Redefining the Procedural Customer

Building sustainability into a procedure that is not adding any value to the product from a customer standpoint could be seen as a waste of time. Certainly the end customer does not directly benefit from any value provided within that system because there isn’t any. But the reality is, the customer, when evaluating this system, is not defined as the end-user. The customer is the seed. The seed’s task is to showcase the value of making use of an effective system that advances the overall process of creating continuous improvement. The seed has KPIs that will see an improvement with the implementation of the kaizen system.

Creating sustainability would require that the output of a kaizen be something the line required. This ensured that the output from an event in terms of a solution was something tangible, allowing it to be captured in a SWI. As SWIs were mandated in the Epping facility to require an awareness session, each kaizen event generating a solution would require an awareness session for the solution to be implemented. This ensured that a team-developed solution was implemented immediately and broadcast to the relevant people on the line. Should a solution not be found in the session, a standard kaizen newspaper, owned by the kaizen in question would be used to track the status until the kaizen could be closed. To ensure events were being initiated, the events would need to be scheduled, at least initially.

5.2.6 Review: Can't Prove Longevity

The RSL team had been cultured into trying to run their line as fast as possible, and make do with machinery or processes that were more hindrance than aid. This goes against the culture of creating a value adding environment. The value of reporting issues and sorting them out immediately was not lost on the team after their kaizen events.
It was also clear that there needed to be a maintenance system in place at a higher level than what was available at the time.

With the longevity of the system in question, not necessarily the system, it fell to the sustainability of the system to highlight any weakness in ensuring that the system was used effectively and continuously. Ensuring that any and all improvement activities go through a similar, if not the same process would make the need to create a kaizen schedule redundant.
The loop scope has been fulfilled with the initiation of a continuous improvement system that is able to track implemented team-developed solutions for issues observed during a scheduled session.

5.2.7 Outcome

The first official kaizen session, held in March 2011 by the team, sought to:

- Increase OEE from 50% to 65%;
- Improve overall daily line output, target was above 1200 elements per shift;
- Eliminate any waste observed during the observation session;
- Highlight any actions that stop the new dispense from running.

The observation session revealed the issues that follow, among others that were solved within the confines of the kaizen. The first kaizen newspaper is shown in Appendix C: Donaldson Sample Documentation.

Set-up Procedures

Where initially it was thought that the shop-floor staff would come to grips with machinery set-ups over time, it was clear during the kaizen process observation that a set-up procedure was required. The line was not adhering to the standard set-up times laid out when the line was first installed due to various issues. These included miscommunication, raw material issues and ill-defined operator responsibility. These issues had to be manually resolved and were often only apparent once the line had begun running the next job and required a stop because a process was not set up correctly.

Coupled to this was the issue of the 1st off procedure. It was a legacy procedure that was carried over from the EDF system, where a product run needed to be checked to ensure that the EDF had been set up correctly and that the product being demoulded was what was required. Once a recipe was set on the dispense and has been running for a certain period, the recipe parameters would have settled into a permanent requirement that would only really change under seasonal ambient temperature changes.

The first-off procedure itself was long and tedious, requiring the product the full 8 min cure cycle. Because our new machine was capable of tracking the system and ensuring that it delivered consistently good product (we were only seeing issues if the SWIs were not followed for changing the mixer, POL handling procedure not followed, potting errors of operators) we were able to ask whether it was now necessary to check each element for conformance if we were running it on a regular basis. Our schedule was also adjusted so that similar parts were in the run, meaning that recipes on the machine did not need to change as the moulds were often the same, this entailed zero set-up required on the machine itself, or the line for that matter should that product be new. Each time a change-over occurred, it meant having to wait a further 15 minutes for the next product to be given the all clear to run over and above the standard change-over time to set up for the line.

Upstream Issues Affecting the Dispense

There was an existing media procedure to save media when the pleater created scrap. Instead of throwing the entire piece away, the legacy was such that, when the pleater needed to stop to change settings to avoid the scrap, the seam-seal operators would use that time to cut out the scrapped media and try to use it. While this was acceptable in the EN specifications, it was no longer a relevant solution as the time taken to cut out and save this 'scrap' media was affecting the seam-seal's processing of the actual media. The constant stopping and starting of the upstream area meant that there was an inconsistent supply of packs to the dispense. The more the dispense needed to stop, the less time it was able to run before requiring a mixer change. The nature of the urethane dispensing required for this stopping and starting to be kept to a minimum to prevent a build-up of cured urethane forming on the mixer and affecting end cap quality.

Housekeeping

The level of housekeeping on the line was abysmal, there was no structure to police it and the TPM was not being checked. It was a requirement of the kaizen that the line have a housekeeping checklist developed to ensure that the team-leader was able to work through the line systematically

We can now close the 'Kaizen' improvement loop off, the critical system has been realised and is now a relevant tool that the plant seed can use to gain improvements. That action will then leave the next loops open, set-up procedure, first-off procedure and housekeeping

Update: KPI Reporting

KPIs as a result of the closing of the loops generated by the kaizen are shown in Figure 17. You'll note OEEs are reported as having values greater than 1. The system makes utilisation assumptions in an attempt to factor in the EDF to generate a rating comparable to the new dispense running at different rates. These assumptions result in cases where the line was producing greater amounts than the planned output and running an additional shift and is reflected in the OEE being greater than 1 (i.e. above 100%).

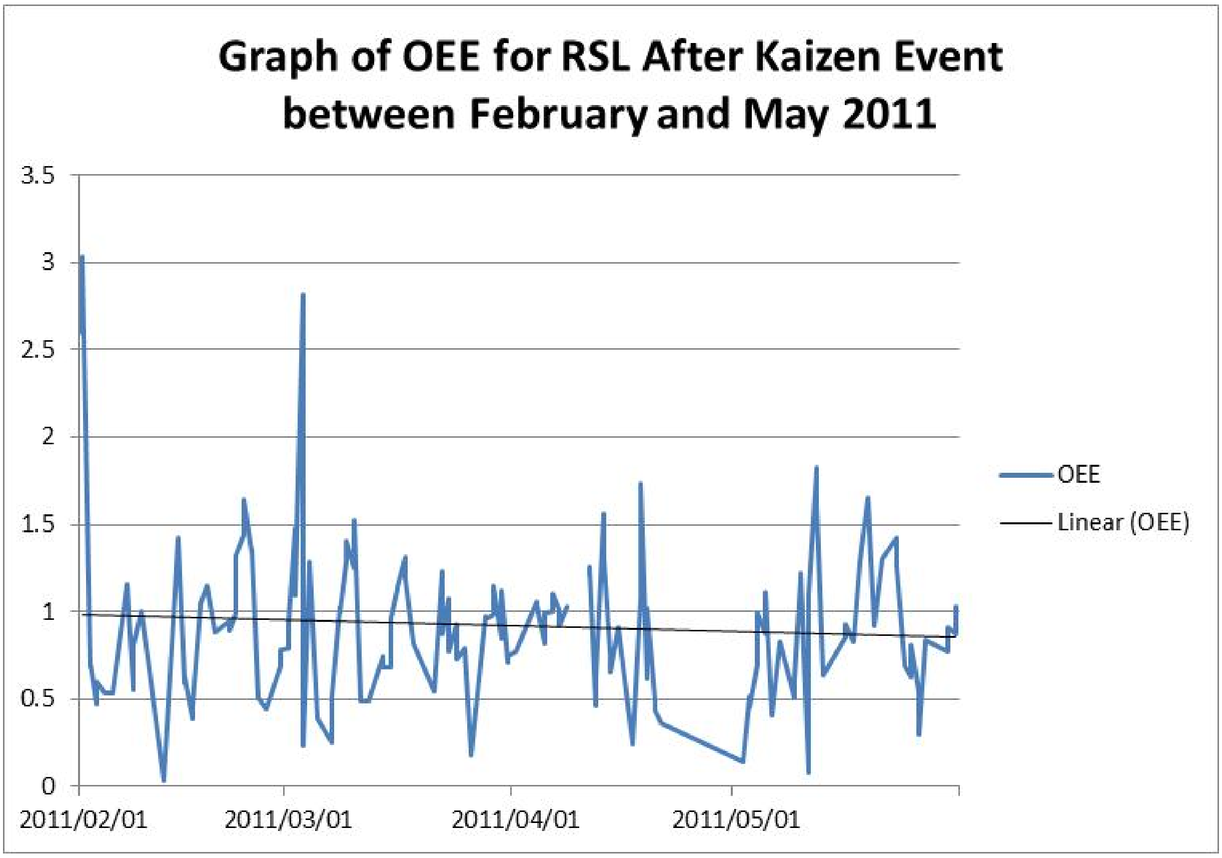

Figure 17: Graph of OEE for RSL after Kaizen Event

5.3 Set-up Procedure

5.3.1 Assessing the system: Making Things Easier

As a result of the kaizen activity on the line, various set-up procedures were required to ensure that the SWIs were easy to follow the set-up, that they fell within the set up time allocated to the line (15 minutes) and that the operator responsible for that set up was well defined.

As this was the result of the kaizen, the previous conditions are still relevant.

5.3.1.1 Scope

It was hoped that these procedures would be implemented to ensure an OEE improvement and an overall increase in output due to the increase in production time. A decrease in actual set-up time was expected.

5.3.2 Analyzing the system: Economies of Repetition

The main culprits in terms of set-up, incorrect or otherwise were the pleater, the flare tool, the dispense and the demould tool.

While the demould tool did not directly stop the line and affect the running of the dispense, it still suffered for a lack of a standard set up procedure.

The line set-up time was defined by the longest set-up procedure, namely the pleater, with the quickest change standing at 12 minutes. What made it even longer was that there was no indicator for the line to ensure a changeover happened at the same time. So essentially what would occur was that the pleater would finish its run and begin setting up for the next job, by the time it was done, the final packs would be going through the dispense and the pleater would need to wait while the dispense was allocated its changeover time. This staggered effect is visualised in Figure 18 on page 87.

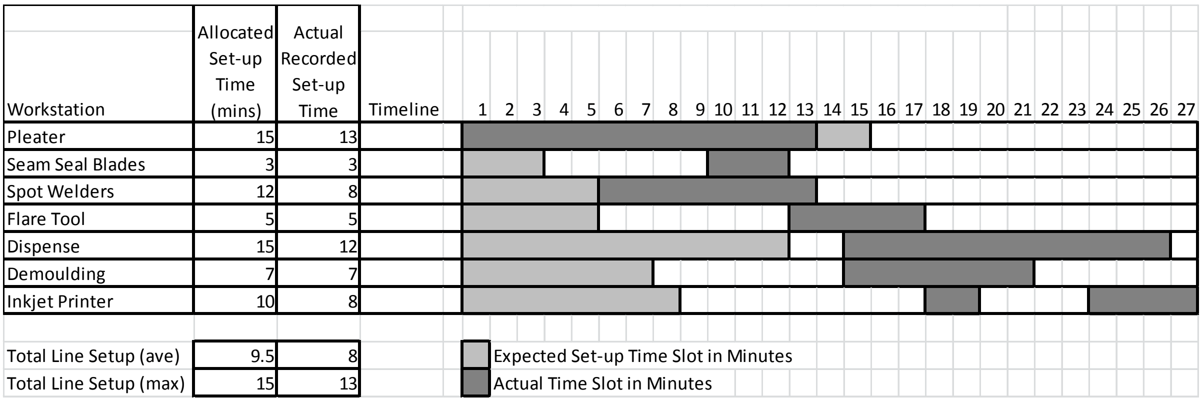

Figure 18: Diagram of Staggered Set-up Times on RSL

Each system was quite capable of being set-up to run well within the allocated time, the issue was training and creating a repeatable process that could be qualified without having the product available to test. The adage, “Economies of Repetition” (Glenday, 2007, p. 16) is perhaps applicable. The easier the process is to repeat, the more it will be done consistently and correctly, hence providing systems that could be set-up quickly to produce quality product within the allocated set-up times. Overall OEE would be used as a KPI to showcase an improvement in available production time, as well as actual set up time vs. planned.

5.3.3 Select/target issue to tackle: Change-overs

It was selected to further improve the standard SWI layout by including set-up and shut-down operations, to ensure that any operator reading the instructions could set-up and shut-down the system. Each machine/process SWI was developed with the operators to ensure that the tasks operators were performing were actually relevant to the process.

Operator functions were now called out on the SWI themselves to ensure that each operator was aware of their responsibility when assigned to that workstation. An allocated roving operator allowed for tasks not necessarily assigned to a workstation to be performed without allowing other tasks to go undone. A standard line changeover procedure was then initiated to allow the team-leader to check along the line that product and WIP was clear before signalling that the line could begin changing over to the next job.

Training for these tasks was made easier by developing training strategies that made use of the SWI itself. The training would be theoretical at first, with a physical component requiring that all tasks noted on the SWI be showcased to the training facilitator before being

accredited to operate at that workstation.
The scheduled kaizen SWI awareness session would be used to train the shop-floor operators on the new instructions.

5.3.4 Applying Implementation: SWI Development

With all of the SWIs developed with the operators working on the machines/workstations, all that was left to implement correct set-up procedures was to broadcast the change to the rest of the line. Training material as well as all the SWIs developed was published for use after the kaizen awareness session.

5.3.5 Creating sustainability: New Standards

To create the sustainability to ensure that set-up procedures were done, the SWI template was revised to include set-up, running and shut-down steps on any published SWI. By changing the training and operator acceptance on the line to work at a specific workstation, the qualifying criteria now required for the training operator to be able to set-up, run and shut-down the machine. By ensuring that each workstation had this training requirement, each training document, and by proxy each SWI used for it, needed to incorporate it. The Donaldson SWI now conformed to a new standard.

5.3.6 Review: Change Broadcasting

As the kaizen event was used to publish and train the relevant operators on their new SWI, the buy-in was immediate because they had, as a team, developed their insight into assumed legacy that was visible on the line itself. See Table 8 for the expected set-up times.

Table 8: Expected Set-up Times for RSL Workstations after Kaizen Event

	Existing Set-up Time	New Set-up Time Achieved
Pleater	22 mins (Including media roll changes)	14 mins (process responsibility defined better)
Seam-seal Station	12 mins	6 mins
Spot Welders	8 mins each	8 mins
Flare Tool	15 mins	6 mins
Dispense	15+ mins depending on product	9 mins standard
Demould Tool	5 mins	5 mins
Inkjet	10 mins	6 mins

KPIs reported as part of the “KPI Reporting” in the Outcome section for “Introducing Kaizens”.

This loop can be closed as there is a built in set-up procedure ensuring that all SWIs are required to include set-up, running and shut-down instructions.

5.3.7 Outcome

In a production environment, it is not always effective to pull shop-floor operators away from production to analyze the system. To generate buy-in more efficiently, have the team whose sole purpose is to create the improvement analyze the system from the outset; the information is on the shop-floor. Once the vital information has been captured, arrange to have the operators check how accurately you are mapping the issue.

The SWI plays a supportive role to production, it allows for other operators to produce consistent results using the knowledge of other operators. The champion cannot be allowed to think that he/she is above the shop-floor, away from where the value, as perceived by the customer, is being generated. Creating this dialog between the operator and the team means that the line can still function during the planning and implementation phases, while still creating effective buy-in.

5.4 Handling First-offs

5.4.1 Assessing the system: Legacy Procedures

Plant/company Status

International quality issues were found, requiring the introduction of new CAT quality control requirements. These issues caused ripples in the company as the spotlight was suddenly on the dispense to ensure that the line was running as the system was designed and not allowing for scrap to be sent off the shop-floor.

Previous issues

The kaizen observed that the line was down during set-up at the dispense due to a long 1st off procedure. The first product needed to have both end caps potted and signed off after the full 8 min cure cycle. This was a legacy procedure that needed updating as the new machine was capable of much tighter parameter control.

Scope

To reduce the time necessary for new product to be introduced to the line as well as standardizing the 1st off process itself.

5.4.2 Analyzing the system: Recipe Control

Line Status

Quality issues were being blamed on poor performance – in this scenario, the system needed to be able to hold role-players accountable; to maintain employee investment in continuous improvement you cannot throw the book at them if there is no book to throw at them.

Process Study

The process study indicated that recipes were not in a controlled state. The operator selected a recipe, if that day, for instance, the pack was tighter than normal, the operator would then adjust the recipe and pot a 1st off. The system would then have to wait for the 8 min cure cycle before being able to check that the recipe was producing a quality end cap, which required a complete seal, no protrusion into the cover and a good surface finish. Should any of these not be to the required specification, the recipe needed to be tweaked, either more or less material depending on what the end cap was failed on, resulting in another 8 min cycle to determine whether the change to the recipe worked for the element to pass final inspection.

This also highlighted that there was no troubleshooting method for recipe design. The longer you were on the line, the more likely you were making an educated guess at which way to tweak the recipe.

Setup times have come down as a result of integrated set-up procedures. Any time lost during a first-off procedure would be written off and not recorded accurately; it would just be noted on the production report as time lost to set-up. New product was not seen often, hence the occurrence was seldom, so in terms of averages it wasn't easy to track.

5.4.3 Select/target issue to tackle: 1st off SWI

Looking Ahead

QC requirement is of huge importance, but removed from the SA market as issues have not been apparent locally, it is however a new international requirement from a substantial client which must be undertaken immediately to ensure product remains untainted. That being said, it would also enable the local implementation system to move one step closer to the newly updated global DPS standard. A SWI would be used to create a standard way to set-up for a brand new element with an unknown recipe as well as implementing the quality requirements seen in the other global plants to ensure conformance to the DPS standards.

Planning

A first-off recipe book would be used as a template governing all the recipe input parameters used at the dispense. It would record various parameters to enable the better tracking of how they affect the system, like temperature, accuracy of the pumps. Changes to the software would ensure operators were able to make running changes to the recipe, but not save them. Training required to implement this SWI would be limited to cell-leaders, dispense operators and the line artisans.

5.4.4 Applying Implementation: Software Changes

Recipe lockdown required a simple change to operator access. The benefits of having a system with the necessary support, essentially a solution tailored to the requirement.

The recipe book template can be seen in Appendix C: Donaldson Sample Documentation4. It should be noted that the recipe control sheet was not a quality mechanism, the SWI developed for 1st offs had built in quality requirements to ensure that the dispense was producing the correct density required by the line. The recipe control sheet however, was to allow the operator and engineer to make a more educated guess when it came to creating new recipes.

While the recipe would still take more than 15 minutes to be run to check that the element would pass final inspection, it would only need to do that procedure once before having the recipe signed off by all involved parties, the team-leader, line artisan and engineer. Once the software updates were made to the machine, training took place to ensure that the operators were aware of the changes.

5.4.5 Creating sustainability: Lockdown

By creating accountability, operators are limited by the selected recipe, they can make changes in the run; changes, however, are logged by the machine. If there are defects that develop during the run, there must be a justification why the system is not running as per the signed-off recipe. By instilling the relevant control guidelines into the process, the process cannot progress without effectively fulfilling these quality roles.

The process can only run if the line accepts and signs-off the recipe. If the recipe was not correctly assigned, the recipe cannot be run under normal conditions, hence the system cannot run. The sign-off must happen, and the recipe must undergo testing to ensure it can be run on the machine.

5.4.6 Review: Iteration Required

The lockdown of the recipes allowed for the line to remove the 1st off procedure for existing, signed-off product completely. The change enabled quick change-over times to be performed with known product runs.

Issues

It was found in the process study that there was no controlled troubleshooting method for the line, so that while the first off procedure would be well defined once a recipe was designed for the system, should a recipe not exist at all, the initial stages of creating a recipe could not be competently repeated by an operator not experienced on the dispense machine.

The loop is therefore required to undergo further iterations as it fails the review of the scope.

While the new first-off process does allow the line to immediately run a new job without the normal set-up times and quality checks, the actual recipe definition to ensure the recipe can be signed-off still requires considerable production time to be lost, often times at least 4 passes equating to 60 minutes if the recipe has been created by an operator with little experience with polyurethane.

5.4.7 2nd Iteration of 'Handling 1st Offs' Loop:

5.4.7.1 Troubleshooting Method for Line

5.4.7.1.1 Assessing the system

This section stays unchanged, as the scope has remained unchanged.

5.4.7.1.2 Analyzing the system

In this phase, the analysis of the system is still relevant; the waiting time attributed to running a first off was prohibitive. Should an operator not know how to run a job for the first time, the trial and error issues found during the 1st iteration's process study will still be present.

5.4.7.1.3 Select/target issue to tackle

The issue is the time allocated to finding out how to introduce new product to the line. When new product is being introduced to the line, an operator will make use of the new SWI to ensure that that product recipe is created as closely as possible to be signed off. During the 1st off phase, the engineer, line artisan and the team-leader must be present. The operator will generate a new recipe as per the SWI as close to the new mould size as possible.

Once the recipe has a loose recipe requirement, packs must be potted to ascertain whether it passes final inspection. The iteration will repeat as soon as possible should it not pass inspection.

Once the product is given the clear to run, the recipe must be saved and locked down.

5.4.7.1.4 Applying Implementation

The new SWI was added to the existing dispense SWI. Training and awareness was done for all operators qualified to work at the workstation.

5.4.7.1.5 Creating sustainability

To run any new product, and to save the recipe on the system, there must be evidence of this process. For an operator to be certified to work at the dispense, he/she needs to be able to acceptably repeat the creation of a recipe for a new product. This ensures that the operator is ready for such an eventuality.

5.4.7.1.6 Review

The SWI for new product recipes require for any operator working at the dispense to be able to functionally create a recipe for a new product. This fulfils the loop requirement of reducing the time required to run 1st offs to within the allocated 15 minute set-up period, meaning a 3rd iteration is not required.

5.4.8 Outcome

Having created the handling 1st off loop, the line has dramatically reduced the set up time requirement. The system can now be allowed to change-over quicker provided it performs the required quality checks put in place as a result of the CAT product requirements.

5.5 6S Implementation

5.5.1 Assessing the plant: Flexibility to Conditions

Change in conditions

The critical change during this period came with the indication that the plant was to receive a crucial visit from the global CEO, who, as global CEO, had last visited nearly 10 years ago. Throughout an initial implementation, you will be assessed on many soft metrics, not generally accounted for in a standard audit process. When such a high ranking official's opinion of the system comes into play, the politics of the plant will throw your activities into sharp light. As with all new installations that do not appear to adhere to specific standards, your seed will undergo criticism that has not been pivotal before. It is important at this stage to ascertain the critical performance factors that need to be achieved. Should you not be able to do this, the resulting efforts may take the drive away from the seed initiative, with the possible side effects thereof derailing the initiative because the focus has shifted away from the initial purpose of the seed: To implement lean.

The trick is to build contingencies into the system that allow for growth and massive changes to be implemented without affecting the overall project. This is achieved by making the components of your implementation strategy as modular as possible.

Plant Status

Full plant resources were thrown at the line housekeeping to ensure that the visitors would be able to envisage the future of the plant by looking at the plant's new flagship line. The plant management wanted to score high with the visiting official who would define the next 10 years of capital investment in the plant. There was to be zero disparity between international and local systems as we wanted to implement the global 6S system.

Previous Issues

Kaizen mapping of the processes showed workstation clutter as well as a lack of designated areas. An ad hoc housekeeping system was in use that made use of generic checklists, but there was not definitive system in place tracking any improvements.

The requirement for 6S is stressed as one of the top-down strategies required by DPS. It was a good starting point to initiate a housekeeping system on the line

Scope

The team needed to implement a line-wide audit system that runs low level and high level audits, with valid output data, i.e. develops checklists to achieve better scores within the audit and is driven by a scored assessment. This score would be used to drive the often hidden flaws into the limelight by giving operators a platform to showcase them. Implementing a 6S standard system will allow many issues, the space and input required to solve them effectively.

5.5.2 Analyzing the system: Rating Systems

The global 6S assessment tool introduced a neat score to the system. As it is inherently a rating metric, we can indicate that the system has had an initial rating of zero and was improved upon, i.e. we would deem this loop a success should the review showcase that the rating has been improved upon. If not improved, at least a generated list of issues that would be solved under the 6S audits or the tools made available by the seed, like an improvement loop requirement or a kaizen event. The overall output of the line would not necessarily see a direct change, positive or negative. A possible outcome could highlight a workstation's need for TPM bringing down the downtime for planned maintenance which would eventually reflect in a higher OEE, but this is beyond the scope of this loop.

Monitored KPIs

Apart from the 6S rating that the audit will generate, another KPI would be to see the number of items on the audit checklist being reduced gradually, essentially indicating an improvement of awareness in terms of housekeeping.

Operator awareness - soft metric, is the operator aware of machine problems, ergonomics deficiencies, training, tools required at workstation? In terms of a high level audit compared to a shop-floor level audit, will the same issues be picked up?

Process study

In the process study for the line, the original procedure was to end the line's shift early and do housekeeping.

5.5.3 Select/Target issue to tackle: Drill Wide, Drill Deep

Look ahead

The 6S strategy was being rolled out plant wide, as part of the top-down DPS requirement, tying in with this as an early adaptor would allow for any improvements to the implementation and training to be done on a plant wide scale. Standardization is inherently part of the 6S programme, apart from eliminating physical waste it would highlight WIP.

Planning – drill wide, drill deep

This loop required a soft install, i.e. the effect on production would be minimal in terms of output. This meant that the system could be implemented in the background as a supplement to the line once the two shifts had received training

Using the DPS template was a necessity to allow the RSL 6S programme to be later implemented without having to modify it to the plant specifications as the seed was pre-empting the need for it as a result of the kaizen requirement for a housekeeping checklist. Once the template was applied to RSL, the graphs were developed and the SWI written up to allow for it to be sustainably audited, monitored and displayed without an engineer's input.

In terms of implementation, two levels were initiated, high level and low level. The high level audit would deal with infrastructure changes, machinery capabilities, line artisan insights, engineer tasks and quality aspects, while the low level would deal with the everyday enforcing of the housekeeping tasks, checklists developed by the operator and the engineer, tools required, housekeeping implements.

Initially both would be controlled by the line engineer and audited accordingly with the view that the high level 6S requirements would be phased out over time and replaced by the weekly walks, eventually the low level would be run entirely by the line as a sustainable entity

5.5.4 Applying implementation: Action Lists

An initial audit was done at the high level to attain an audit score as well as initial action list to drive a higher score for the next update. Refer to Figure C.3 for an example of the 6S audit score and action list. The initial score was more conservative than that of the line, but once the audits were underway, the shop-floor were allowed to implement their own checklists for housekeeping to ensure a general improvement for the next audit.

5.5.5 Creating Sustainability: Operator Accountability

To ensure that the housekeeping tasks were made easier, it was suggested that the operators be instructed to clean during change-over or whenever there was a change of workstations.

By ensuring that the operator would not change to a messy workstation when swapping as they would be newly responsible for cleaning it, there was accountability to ensure that the previous operator was working in a clean environment. Additional housekeeping tasks were added to the SWI for various workstations.

5.5.6 Review: Tracking

Beyond training and the addition to the SWI, the only external input that will affect the sustainability of the system is the scheduled review times of the audits.

Issues

Having more than one level of audits complicates the overall tracking of the system when it comes to actioning the items required to update the audit scores. The immediate recommendation is to incorporate both levels into one system where the line artisan, engineer and team are fully aware of what issues are being dealt with and seen to.

Training for both shifts was completed in parallel with the initial implementation phase, meaning the line could initiate their own audits in line with the DPS requirements once they were ready. This loop can be closed as the scope has been fulfilled by the implementation of a 6S system.

5.5.7 Outcome

Once the high level audits were phased out, the line was solely responsible for their own housekeeping tasks. The 6S rating done by the shop-floor itself is shown in Appendix C: Donaldson Sample Documentation after the initial high level audit scores.
It shows an upward trend with a marked awareness of line issues shown by the reduction of the action plan requirements.

5.6 Summary

The sections above highlight the use of a lean-seed implementation strategy within Donaldson Filtration's Epping manufacturing facility. The strategy made use of continuous improvement loops on the shop-floor to introduce a lean culture within the plant. The seed introduced one-piece flow, standard work, 6S housekeeping and Kaizen events on their new radial seal line by introducing lean tools to the shop-floor as the system required it.

The strategy sought to install a lean culture at grassroots level by initiating a cell that was empowered by selected lean tools to solve issues that prevented efficient production activity. In creating the seed, continuous improvement loops were used to assess the plant, analyze the system, select targets or issues to tackle, plan and solve them through a lean understanding and with a sustainable backing to ensure an effective result that was repeatable.

6 Discussion

This report sought to highlight a way to implement a lean culture through the use of a lean seed.

Facilities seeking to make use of the lean philosophy are often able to implement some change using the lean tools available to them, but are not able to create a sustainable culture that does not need to be enforced to expand their success.

The case study method was used to follow the implementation strategy outlined by this report to showcase how a South African manufacturer would go about creating a lean seed within his or her facility. The method outlined made use of a team creating a cell, or a seed, that is allowed to grow within its defined boundary, introducing the lean culture of effective problem-solving, product flow and reducing waste through the use of continuous improvement loops within a controlled environment.

The researcher was brought in to create a lean environment using a new line upgrade as the catalyst to create a lean culture. The continuous improvement loops introduced allowed for the step-by-step introduction of lean tools and problem-solving skills to ensure that the team was able to successfully implement solutions.

The seed introduced one-piece-flow during the Radial Seal Line upgrade and endeavoured to make use of more ergonomic workstations, quality designed into the process, better control of processes themselves and improved overall output. This was accomplished through the use of continuous improvement loops, the creation of a problem solving environment, reduction in set-up times and the introduction of a 6S housekeeping programme.

An overview of the RSL processes and cycle times can be seen in Table 9. It shows significant improvement over the course of the implementation, with the latest iteration cutting the time taken from raw material to final boxed product in half (51% reduction). This reduction in setup and processing time allows the line to react quickly to market changes and customer demand.

Table 9: Comparison of Loop Iterations in Terms of Steps and Process Times

Loop Description	**Process Steps**	**Value Creating Steps**	**Total Time (s)**	**Value Create Time (s)**
EDF Machine	23	16	25236	350
Dispense Install	20	16	20900	828.5
Kaizen Events	20	16	20660	828.5
Setup Procedure	20	16	16760	765.5
First-off Procedure	20	16	13100	214

A summary of the production output on RSL seen over the course of the improvement loops and the lean seed implementation can be seen in Figure 19. The early drop off is a reflection of the EDF maintenance issues, but there is an improvement in total output of 8–20% reflected by the end of the observation study trending upwards. The flatter curve should be noted, with the RSL able to react to customer demand pressure more readily, the planned targets were not as greatly affected by fluctuations in demand and were adjusted as necessary.

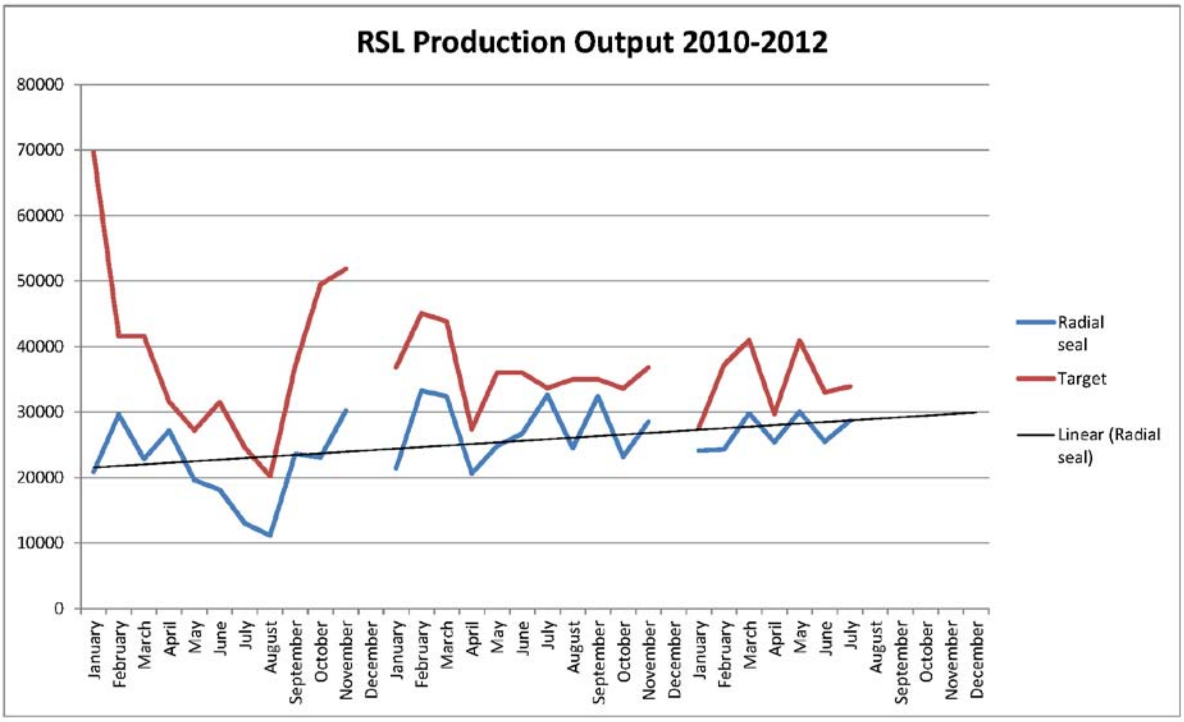

Figure 19: RSL Production Output between 2010 and 2012

A reflection of the two states of the line, before and after the lean seed implementation is shown in Figure 20 and Figure 21 on page 105. Both figures report on the OEE and the earn hour rate (HER). The EHR is an indicator used to indicate the rate at which income is recovered against the line's availability and the hours billed. It should decrease the more efficient the line is. The OEE is seen to increase of the course of the implementation while the EHR is shown to decrease, specifically after the EDF is removed in September 2010.

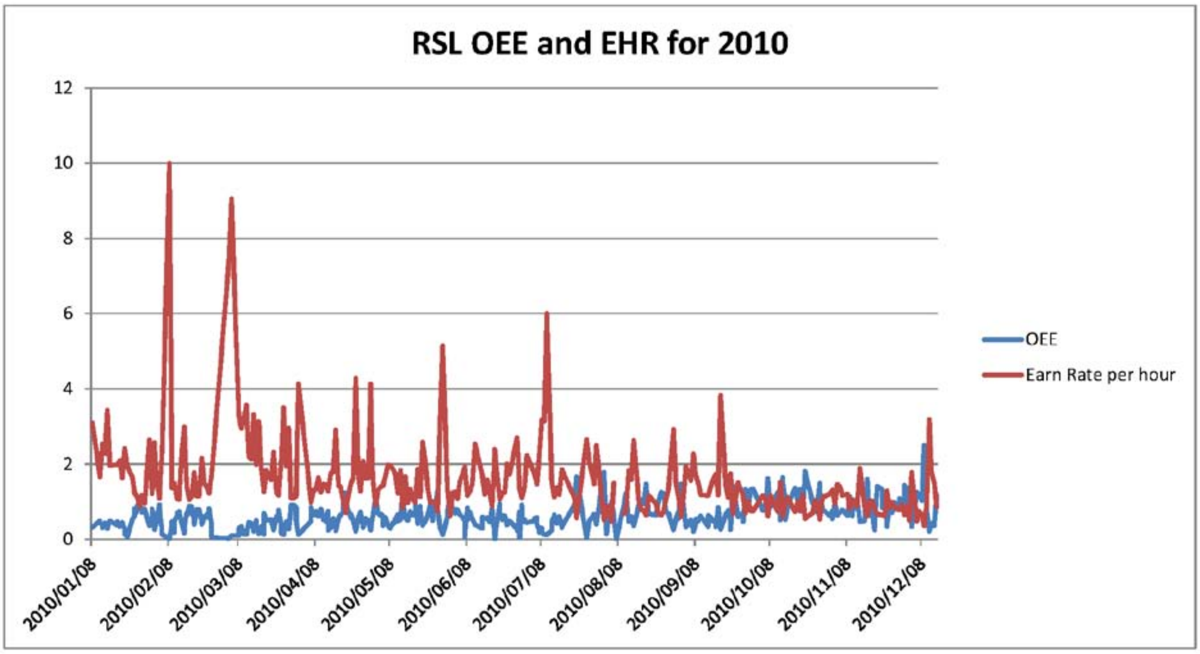

Figure 20: RSL OEE and EHR for 2010

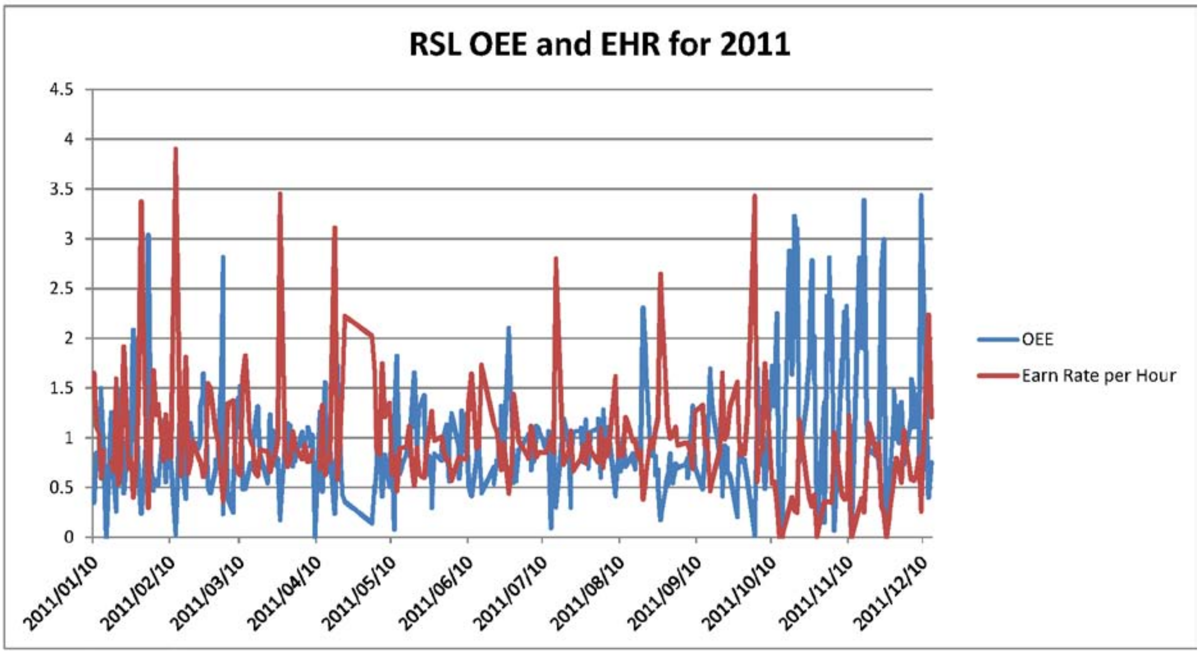

Figure 21: RSL OEE and EHR for 2011

The implementation allowed for the introduction of lean, and the tools required, at a pace that allowed for sustainable solutions to be sought out. The strategy created a safe environment to carry out a more controlled PDCA system that facilitated a greater grasp and understanding of lean tools and their effect on the issues with the improvement loops.

This study highlights the need for an effective implementation strategy that can be rolled out as a bespoke system for implementation while still making use of the standard toolset that lean espouses. The strategy has been shown to create buy-in by creating the culture first and then focusing on the issues at hand using the created environment to solve them. In solving the issues presented to the seed, the team is able to gain momentum and skills to tackle other issues before expanding the seed. This effect creates the drive to seek out better performance within the seed to the benefit of the facility it was started in, as well as the knock-on effect of creating hype in other cells or divisions that have seen the success.

Where other implementation strategies seek to solve the issues presented with lean tools, the culture is not installed correctly to maintain the solution and the entire initiative stands to fail should the champion of the lean drive move on to other projects as occurs when using consultants or the system changes with regard to operators, management or machinery.

As the culture evolves, the seed evolves and expands to tackle other issues and problems within its defined boundary. This is in stark contrast to a top-down implementation where the entire company or facility is forced to buy in through various efforts by management or shareholders. These implementations generally resort to window-dressing and making it appear as though they are seeing the positive effects of lean, but in reality are only going through the motions until the upper tiers of the implementation lose steam or consider their introduction of their lean culture complete.

While other implementations strategies exist, the creation of a lean seed allows for the culture to be made a critical part of the initiative that creates a bespoke platform around which to use lean tools and create an effective roadmap for a facility or company to use that will outline their lean journey. Instead of introducing lean tools and enforcing their use, the seed team is allowed the vision and foresight to select issues to approach, select tools that will be effective within its confines and solve the problem at hand in a sustainable and repeatable fashion.

7 Conclusions & Recommendations

This case study sought to ascertain whether implementing the lean culture through the use of a lean seed and standard lean tools to facilitate buy-in in the Donaldson Filtration Epping facility. This was followed by the development of a continuous improvement loop to outline the direction that the lean seed needed to follow and which lean tools to introduce to solve the issues it was presented with.

The lean seed ideology is in line with the concept of unifying the lean tools that companies have available to them. Many expect to see the same success that other implementations have seen purely by mimicking the use of the tools. A strategy that creates sustainability within that implementation allows for each tool to be introduced within the boundary of the seed as a method of furthering the continuous improvement implementation and creating understanding.

When it comes to lean strategies a lot of them fall short on the basic requirements that all systems eventually suffer from, effective management of the system, introducing complexity and sustainability when there is a high level of personnel turnover. The seed theory aims to start a fully lean seed cell that instils a lean culture and uses a complete implementation strategy to select and develop lean tools that are relevant to the facility the seed has been placed in.

The lean seed was successfully introduced as an implementation strategy that saw similar improvements as to those seen in other lean implementations where lean tools are used to create a lean culture. The internal DPS assessment to ascertain the development of various lean observations is presented in Figure C.5 in Appendix C. The audit was performed by an objective member of Donaldson, external to the seed and the Epping facility. It showcases the seed implementation's development of the lean culture in 2012

7.1 Critical Requirements for a Lean Seed

For a company to achieve similar results to those showcased in plants where lean has been implemented, certain key indicators must be present to make the initiative a possibility. Examples of these are discussed below.

7.1.1 Management Drive

As stated previously, there are different phases of management drive, these will often have nothing to do with the progress of the lean initiative, and be a purely external influence, but as they go, this is the most important one to be aware of. For a company to look into implementing a lean system, it would mean that some tier of the management levels is motivated to see the gains proposed by such an implementation.

However, if the tier is not capable of making critical decisions that will influence the outcome of lean initiatives on the shop floor, the success of the implementation hinges on the decision. Suffice to say, creating buy in on a management level needs to be done effectively. The seed allows the team to showcase improvements and generate buy-in using KPIs that are relevant to management, but there must be a platform to springboard the initiative into the plant.

7.1.2 Willingness to Change Company Infrastructure

For a new plant or a brand new facility, it goes without saying that the cell needs to be designed with lean thinking behind it, i.e. if something is not working, it is easy to change and adapt. With an existing plant however, it is easy to get lost in what can be moved and what can't be moved. This thinking can be overcome once the initial lean seed potential has been realised, but if the initial lean seed was planted trying to incorporate a monument, it then becomes very hard to motivate for greater improvements after the fact.

Having the company backing to ensure that there is no holy cow when it comes to plant machinery, processes or staffing, from the outset, is beneficial when making larger improvement changes. This backing will also drive the approach to expanding the seed, as the lessons learned in upgrading infrastructure can be directly applied to other brownfield applications.

7.1.3 Capable champions

For the company to be driven in the right direction, it is critical to select a champion that is familiar with the goals of the company and how to bring them in line with a lean philosophy.

This champion should understand the role he is playing, and be able to identify and showcase any potential gains or flaws using process studies, VSMs and cross flow diagrams. The champion's personality is critical. He or she must be able to facilitate and drive role-players in various departments to ensure that root causes and solutions are being fully understood.

It is counter-productive to implement a lean initiative where management is not fully behind the champion. While politics will always play a role on the shop-floor, he/she must be able to showcase the vision using the team-developed lean tools, with relevant data, to managers and operators that will create buy-in towards a more sustainable initiative.

The champion must be passionate and engaging to ensure that the application of lean tools towards a lean system is not hindered by people unwilling to change their philosophies. The champion must be able to inspire and direct change and encourage the team to look ahead to see the bigger picture beyond the immediate improvement loop

7.1.4 Hands-on Approach

When implementing anything new, the first instinct is to look to a resource with experience of a similar system to ascertain what is required to make the new system capable. When it comes to implementing a lean seed with the intent for it to showcase a change and improvement culture, the seed and those within its boundary must understand that the change must be necessary and immediate. The seed must be empowered to make the change happen, this can only happen using a team that is hands-on.
By ensuring that the solutions developed in a loop are implemented immediately, it showcases how serious a company’s investment is in dealing with issues, finding the root-cause and creating an effective solution.

7.1.5 Focus on sustainability

A manufacturing cell requires repeatable and consistent results, if the cell is unable to achieve these critical tasks within the production environment, the customer, be it an internal or external one, will seek to find a more stable alternative.

Ensuring that a system that has been implemented is still working and attaining the same output or better, through experience, requires your cross-functional team to be aware of the fall backs and create intuitive solutions that allow for the system to be self-sustaining.

Not all sustainability solutions are an easy fit, and the company needs to have the team focus on sustainability by building in quality or the value adding processes to ensure that the product relies on those systems to be produced effectively. By ensuring that the company is ready to fulfil these requirements, the lean seed stands as a viable implementation strategy to create a lean culture within a seed that can trial and develop solutions relevant to that facility or plant and showcase the real significant gains the manufacturing industry has come to hope for rather than expect.

7.2 Current Status

Day to day running of the line within the facility has now just resolved to producing elements, and problem solving any issues that arise. The seed culture has reached a point where the line is able to react quickly to plant changes, like internal and external supplier issues, schedule changes and staffing disruptions.

The sustainability created by standardising work processes and the training thereof allow for any new RSL product to be quickly introduced to the line and produced at rate. The use of an experiential training strategy, along with the tiered operator structure of the line ensures that operators required for critical processes are always available. This means that the top tiers, 2 and 3, are always populated with operators that have trained with the most relevant SWIs and are able to perform set-up and shut-down tasks efficiently along with normal production tasks.

The ability of the line to handle routine continuous improvement exercises using the system developed within the seed helps embed the lean tools into the culture. The seed is able to drive change through programmes developed for the shop floor, implementing solutions that have the inherent buy-in of operators before the solution hits the floor.

The 6S audit structure forms parts of the DPS production requirements, among various performance reporting that needs to happen on the line.
By ensuring that the systems the seed implemented were relatable to DPS, they were still

creating relevant outputs that could be used once the plant was being audited for compliance to DPS. As far as the global company was concerned, the top-down implementation was successful because the plant was able to showcase compliance to DPS on the line, but what made the system able to sustain the continuous improvement was understanding what lean tools were relevant to the plant and how to go about maximising their usability during improvement exercises.

The seed can be deemed successful once the implementation has reached a level of maturity where it will only see gains by expanding the initial boundary to include suppliers in its continuous improvement exercises. With the kaizen system beginning to show awareness of various supply issues involving liners and media during line set-up, the RSL seed was well on its way to showcasing the need to initiate a new improvement loop, requiring the expansion of the seed to bring in other department resources to solve issues.

7.3 Looking Beyond

Expanding the seed beyond its initial boundary is the point of the implementation. The seed is used to create and develop the lean culture that will be present in that facility. The seed acts as a pilot programme to showcase the best-of that the facility is capable of, and is a necessity to enable lean growth beyond the initial gains and to realise its potential future state. The beauty of creating a seed initiative is that it allows for a direct comparative showcase of the old vs. the new, but at some point, the seed initiative will point toward improving the connections that it often shares with systems using a non-lean philosophy. With Donaldson, the seed team was made aware of issues that required changes to supply lines, supply paths and frequency those paths were replenished

7.3.1 Supply to the line

In general, quality and quantity are critical to a line running at a standard rate, one of the shortcomings of running a seed initiative is that once operational as the initial seed, various improvement solutions will see it running with a different expectation of the warehouse and its delivery capabilities. I.e. the seed cell expects product components to be consumed at the design rate in one piece flow, but the store only supplies half the quantity because the delivered bin was not restored to the minimum stocking policy.
Any other line in the plant would just order a balance amount once discovered, and carry

on. Beyond the seed boundary, cells work in batch flow, so essentially the impact on the line is minimal. On the line making use of one-piece-flow, the operator is focussed on producing, he expects the bin to have the quantity ordered, once he runs out, he has to stop, check whether he has fulfilled the WO and go fetch the correct quantity as required. As each process is interrelated, the upstream cell has to stop as it has nothing to work with. Should the issue affect the dispense during the run, the dispense needs to stop. The preventative maintenance of the dispense machine requires for a mixer and nozzle change after 3 no-pack related stops, with this maintenance downtime allocated as 10 minutes of production time, this accounts for substantial downtime should it happen during more than one WO per shift.

These supply issues are mainly present in the correct quantity and quality of liners delivered for the RSL spot welders. An improvement loop would require for the expanders, responsible for supplying liners to the line, to be involved for the root-cause analysis and solution implementation to be done, to do this, the seed would need to expand the boundary to include them.

By expanding the seed to cells that directly affect the original cell, the sustainability is further enforced because the line requires the expanded cells to conform to the original seed's expectations.

7.3.2 Final Integration with DPS

For obvious reasons, once your system has been proven and the seed initiative is being implemented beyond the original system, the complete integration with the international requirements set out by the parent company is a necessity.

While the international system was put aside because the outputs were somewhat out of sorts with the requirements of the local subsidiary, now that the cell is functioning in terms of international standards, it is easier to look at what the DPS needs to be fully implemented accordingly.

As the base system is in place, it is a simple case of reviewing it against the international requirements and initiate a loop to implement any required changes sustainably to show due diligence.

7.3.3 Implementing Levelled Scheduling

Creating ways to minimise the planned downtime required for change-overs and set-ups are crucial to maximising the time available for production. By introducing a schedule that reduced the amount of change-overs necessary or created a defined and repeatable programme that the line could operate on that fulfilled customer requirement, the line further reduce lead time and inventory.

7.3.4 Design Engineering

Introducing new product to the line is a role played by the internal design department after a sales request has been initiated by a customer. This process adds a considerable lead time to the end product delivery to the customer. This issue was made relevant by the "Handling 1st offs" loop. By the time the product gets down to the line, the engineer involved in ensuring it was able to conform to the available processes needs to re-familiarise themselves with the project.

Integrating the design and engineering support departments is something that would see product development move to greater heights. With that step a job-shop capable polyurethane machine would be necessary to allow the plant to take on otherwise low volume jobs, but because the two support departments are integrated, the customer to end-product lead-time, including design, is so much shorter because the engineering team assigned to each product is capable of ascertaining immediately how to standardize the product, in terms of moulds, jigs and tools available and presenting the product to the customer's specifications.

The control of tools and jigs then becomes an inherent part of the engineering drawings assigned to the product, should either be lost or damaged, it is a simple case of finding the drawings and ordering the tool.

This is similar to expanding the seed to a supplier, where in this case, the supplier is supplying information as a support department.

7.4 Further Research

The limitations surrounding this research revolved around the strategy having been implemented within an automotive facility. As a result the implementation strategy was surrounded by individuals, both skilled and unskilled, that were familiar with the lean movement and culture, but were not necessarily able to practise the skills required to make a difference. Their enthusiasm drove the system at an accelerated rate as a result of this exposure.

Further research within the context of the lean seed implementation could involve the development of a strategy to map the current state within the service or other non-manufacturing industries. It would be a compelling study to introduce this implementation strategy within the ranks of a non-engineering fraternity like a government service department or health institute to ascertain what further input would be required in the continuous improvement loop to ensure that the correct tools are chosen and developed to ensure a smooth introduction of a lean culture using the lean seed as an implementation strategy.

Beyond that, would the champion and the lean seed team need to be exclusively familiar with the engineering discipline or lean fraternity to implement a successful lean culture using the lean seed? If not, what would need to be tweaked to facilitate these factors? A study of these indicators would be useful when deciding on an implementation strategy venturing into other industries.

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Appendix A: Process Studies

Task is done in parallel

Physical Actions Required to Create a Radial Seal Element

Proposed Solution Reference	Total Steps		Value Creating Steps	Total Time	Value Create Time
	1 Reconcile WO			300	
2	Pleat media		1	120	120
		2.1 Fetch media from media warehouse			
		2.2 Load media bale(s) for pleater			
		2.3 Set up pre-heater			
		2.4 Set up pleater as per drawing requirement			
		2.5 Set up take away conveyor speed			
		2.6 Turn on light table			
	2 Light check media			15	
3	Cut media		2	6	6
		3.1 Clean media cut-off		25	
	4 Store media			22	
	5 Fetch media bin from inventory			720	
		5.1 Locate bin			
		5.2 Move to seam seal station			
	6 Load media at seam seal table			20	
7	Glue media		3	6	6
		7.1 Fetch glue from store		900	
		7.2 Set up glue gun		300	
		7.3 Bleed gun (Fridays)		1260	
	8 Seam seal media		4	10	4
		8.1 Set up seam seal blade		300	
	9 Spot weld inner liner	10	5	15	8
		9.1 Fetch liners from expanders ---> inspect & accept (quality & quantity)		1200	
		9.2 Set up roller table		120	
		9.3 Set up spot welder		300	
		9.4 Roll inner liner		4	
11	Spot weld outer liner		6	15	8
		11 Fetch liners from expanders ---> inspect & accept (quality & quantity)		1200	
		11.2 Set up roller table		120	
		11.3 Set up spot welder		300	
		11.4 Roll outer liner		4	
12	Media into liner		7	20	18
		12.1 Set up media guides		120	
		12.2 Fetch media ring		120	
13	Flare pack		8	17	12
		13.1 Fetch flare tool		120	
		13.2 Set up flare tool		300	
	14 Dry media		9	-	120
		14.1 Set up media pack oven		120	
		14.2 Set up curing oven and conveyors		120	
		14.3 Set up mould oven and conveyor		120	for larger elements
15	EDF	15.1 Dispense PU into open cover	10	23	18
		15.2 Dispense PU into closed cover	11	24	18
		15.3 Mix POL drum on high speed mixer		3900	
		15.4 Fetch POL drum from PU store		960	
		15.5 Fetch ISO frum from ISO room		1200	
		15.6 Check density and cupshots		300	
		15.7 Set up for run		1140	
		15.8 First offs (slabs, open cover)		120	

Table A.1: Initial EDF RSL Process Study (1/2)

	15.9 Monitor warnings and pressures		10	Ongoing	
	15.10 Change nozzle and/or mixer		1020		
	15.11 Cure element		600		600
16 Manual Demould			20		
17 Height check element		12	5	3s	
	17.1 Set up height gauge		300		
	17.2 Calibrate		600		
18 Inkjet print element		13	5	4s	
	18.1 Set up inkjet printer		1200		
19 Sign off element			38		
20 Hotmelt element		14		non-uniform	
	20.1 Transfer element to element line				
	20.2 Transfer element to RSL				
21 Bag element		15	20	12s	
	21.1 Fetch bags from store		900		
22 Box element		16	20	10s	
	22.1 Fetch cartons from carton line ---> inspect & accept (quality & quantity)		540		
	22.2 Set up boxing machine		300		
23 Palletize					
	23.1 Fetch pallet		120		
	23.2 Set up stretchwrap machine		300		

Table A.1: Initial EDF RSL Process Study (2/2)

Task is done in parallel

Physical Actions Required to Create a Radial Seal Element

Proposed Solution Reference

Total Steps		Value Creating Steps	Total Time	Value Create Time
1 Reconcile WO			300	
2 Pleat media		1	120	120
	2.1 Fetch media from media warehouse			
	2.2 Load media bale(s) for pleater			
	2.3 Set up pre-heater			
	2.4 Set up pleater as per drawing requirement			
	2.5 Set up take away conveyor speed			
	2.6 Turn on light table			
3 Cut media		2	6	6
	3.1 Clean media cut-off		25	
4 Glue media		3	6	6
	4.1 Fetch glue from store		900	
	4.2 Set up glue gun		300	
	4.3 Bleed gun (Fridays)		1260	
5 Seam seal media		4	10	4
	5.1 Set up seam seal blade		300	
6 Spot weld inner liner	7	5	15	8
	6.1 Fetch liners from expanders ---> inspect & accept (quality & quantity)		1200	
	6.2 Set up roller table		120	
	6.3 Set up spot welder		300	
	6.4 Roll inner liner		4	
7 Spot weld outer liner		6	15	8
	7.1 Fetch liners from expanders ---> inspect & accept (quality & quantity)		1200	
	7.2 Set up roller table		120	
	7.3 Set up spot welder		300	
	7.4 Roll outer liner		4	
8 Media into liner		7	20	18
	8.1 Set up media guides		120	
	8.2 Fetch media ring		120	
9 Flare pack		8	17	12
	9.1 Fetch flare tool		120	
	9.2 Set up flare tool		300	
10 Dry media		9	120	120
	10.1 Set up media pack oven		120	
	10.2 Set up curing oven and conveyors		120	
	10.3 Set up mould oven and conveyor		120	
				for larger elements
11 Dispense PU	11.1 Dispense PU into open cover	10	20	8
	11.2 Dispense PU into closed cover	11		9.5
	11.3 Mix POL drum on high speed mixer		3900	
	11.4 Fetch POL drum from PU store		960	
	11.5 Fetch ISO frum from ISO room		1200	
	11.6 Check density and cupshots		300	
	11.7 Set up for run		600	
	11.8 First offs (slabs, open cover)		120	
	11.9 Monitor warnings and pressures		10	Ongoing
	11.10 Change nozzle and/or mixer		600	
	11.11 Cure element		480	480
12 Demould element			20	
	12.1 Set up demould system		660	
13 Height check element		12	5	3
	13.1 Set up height gauge		300	
	13.2 Calibrate		600	
14 Inkjet print element		13	5	4

Table A.2: Proposed Process Steps for RSL (1/2)

	14.1 Set up inkjet printer		1200	
15 Sign off element			38	
16 Hotmelt element		14		non-uniform
	16.1 Transfer element to element line			
	16.2 Transfer element to RSL			
17 Bag element		15	20	12
	17.1 Fetch bags from store		900	
18 Box element		16	20	10
	18.1 Fetch cartons from carton line ---> inspect & accept (quality & quantity)		540	
	18.2 Set up boxing machine		300	
19 Palletize				
	19.1 Fetch pallet		120	
	19.2 Set up stretchwrap machine		300	
20				

Table A.2: Proposed Process Steps for RSL (2/2)

Task is done in parallel

Physical Actions Required to Create a Radial Seal Element

Proposed Solution Reference	Total Steps		Value Creating Steps	Total Time	Value Create Time
	1 Pleat media		1	300	120
		1.1 Fetch media from media warehouse			
		1.2 Load media bale(s) for pleater			
		1.3 Set up pre-heater			
		1.4 Set up pleater as per drawing requirement			
		1.5 Set up take away conveyor speed			
		1.6 Turn on light table			
		1.7 Light check media			
	2 Cut media		2	6	6
		2.1 Clean media cut-off		25	
	3 Glue media		3	6	6
		3.1 Fetch glue from store		900	
		3.2 Set up glue gun		300	
		3.3 Bleed gun		1260	
	4 Seam seal media		4	10	4
		4.1 Set up seam seal blade		300	
	5 Spot weld outer liner	6	5	15	8
		5.1 Fetch liners from expanders ---> inspect & accept (quality & quantity)		1200	
		5.2 Set up roller table		120	
		5.3 Set up spot welder		300	
		5.4 Roll outer liner		4	
	6 Spot weld inner liner		6	15	8
		6.1 Fetch liners from expanders ---> inspect & accept (quality & quantity)		1200	
		6.2 Set up roller table		120	
		6.3 Set up spot welder		300	
		6.4 Roll inner liner		4	
	7 Media into liner		7	20	18
		7.1 Set up media guides		120	
		7.2 Fetch media ring		120	
	8 Flare pack		8	17	12
		8.1 Fetch flare tool		120	
		8.2 Set up flare tool		300	
	9 Dry media		9	-	120
		9.1 Set up media pack oven		120	
		9.2 Set up curing oven and conveyors		120	
		9.3 Set up mould oven and conveyor		120	
					for larger elements
	10 Dispense PU	10.1 Dispense PU into open cover	10	20	8
		10.2 Dispense PU into closed cover	11		9.5
		10.3 Load POL drum onto high speed mixer		3900	
		10.4 Fetch POL drum from PU store		960	
		10.5 Fetch ISO frum from ISO room		1200	
		10.6 Check density and cupshots		300	
		10.7 Set up for run		600	
		10.8 First offs (slabs, open cover)		120	
		10.9 Monitor warnings and pressures		10	Ongoing
		10.10 Change nozzle and/or mixer		600	
		10.11 Cure element		480	480
	11 Demould element			20	
		11.1 Set up demould system		660	
	12 Height check element		12	5	3
		12.1 Set up height gauge		300	
		12.2 Calibrate		600	
	13 Inkjet print element		13	5	4
		13.1 Set up inkjet printer		1200	

Table A.3: 1st Iteration (1/2)

14 Sign off element				38	
15 Hotmelt element			14		non-uniform
	15.1	Set up hot melt			
	15.2	Transfer element to element line			
	15.3	Transfer element to RSL			
16 Bag element			15	20	12
	16.1	Fetch bags from store		900	
17 Box element			16	20	10
	17.1	Fetch cartons from carton line ---> inspect & accept (quality & quantity)		540	
	17.2	Set up boxing machine		300	
18 Palletize					
	18.1	Fetch pallet		120	
	18.2	Set up stretchwrap machine		300	
20					
			16	20660	828.5

Table A.3: 1st Iteration (2/2)

Task is done in parallel

Physical Actions Required to Create a Radial Seal Element

Proposed Solution Reference	Total Steps		Value Creating Steps	Total Time	Value Create Time
	1 Line Setup for run				
		1.1 Ensure lights/fans are on			
		1.2 Ensure media roll is on line			
		1.3 Ensure liners are on line (quantity and quality)			
		1.4 Ensure media sleeves are on line			
		1.5 Ensure POL/ISO drum is on line			
		1.6 Ensure additional POL drum is being mixed			
		1.7 Ensure moulds are on line (70 in tray)			
		1.8 Ensure cartons are on line (quantity and quality)			
		1.9 Ensure additional plastisol drum is on line			
		1.10 Ensure recipe is on dispense			
		1.11 Check/order for consumables cupboard			
	2 Pleat media		1	300	120
		2.1 Fetch media from media warehouse			
		2.2 Load media bale(s) for pleater			
		2.3 Set up pre-heater			
		2.4 Set up pleater as per drawing requirement			
		2.5 Set up take away conveyor speed			
		2.6 Turn on light table			
		2.7 Light check media			
	3 Cut media		2	6	6
		3.1 Clean media cut-off		25	
	4 Glue media		3	6	6
		4.1 Fetch glue from store		900	
		4.2 Set up glue gun		300	
		4.3 Bleed gun		1260	
	5 Seam seal media		4	10	4
		5.1 Set up seam seal blade		300	
	6 Spot weld outer liner	7	5	15	8
		Fetch liners from expanders ---> inspect & accept			
		6.1 (quality & quantity)		1200	
		6.2 Set up roller table		120	
		6.3 Set up spot welder		300	
		6.4 Roll outer liner		4	
	7 Spot weld inner liner		6	15	8
		Fetch liners from expanders ---> inspect & accept			
		7.1 (quality & quantity)		1200	
		7.2 Set up roller table		120	
		7.3 Set up spot welder		300	
		7.4 Roll inner liner		4	
	8 Media into liner		7	20	18
		8.1 Set up media guides		120	
		8.2 Fetch media ring		120	
	9 Flare pack		8	17	12
		9.1 Fetch flare tool		120	
		9.2 Set up flare tool		300	
	10 Dry media		9	-	60
		10.1 Set up media pack oven		120	
		10.2 Set up curing oven and conveyors		120	
		10.3 Set up mould oven and conveyor		120	
				for larger elements	
	11 Dispense PU	11.1 Dispense PU into open cover	10	20	8
		11.2 Dispense PU into closed cover	11		9.5
		11.4 Fetch POL drum from PU store		960	
		11.5 Fetch ISO frum from ISO room		1200	
		11.6 Check density and cupshots		300	
		11.7 Set up for run		600	
		11.8 First offs (slabs, open cover)		120	
		11.9 Monitor warnings and pressures		10	

Table A.4: 2nd Iteration (1/2)

		11.10 Change nozzle and/or mixer		600	Ongoing
		11.11 Cure element		480	
					480
12	Demould element			20	
		12.1 Set up demould system		660	
13	Height check element		12	5	
		13.1 Set up height gauge		300	
		13.2 Calibrate		600	
14	Inkjet print element		13	5	4
		14.1 Set up inkjet printer		1200	
15	Sign off element			38	
16	Hotmelt element		14		non-uniform
		16.1 Set up hot melt			
		16.2 Transfer element to element line			
		16.3 Transfer element to RSL			
17	Bag element		15	20	12
		17.1 Fetch bags from store		900	
18	Box element		16	20	10
		18.1 Fetch cartons from carton line ---> inspect & accept (quality & quantity)		540	
		18.2 Set up boxing machine		300	
19	Palletize				
		19.1 Fetch pallet		120	
		19.2 Set up stretchwrap machine		300	
20					
				16760	765.5

Table A.4: 2nd Iteration (2/2)

Appendix B: Value Stream Maps

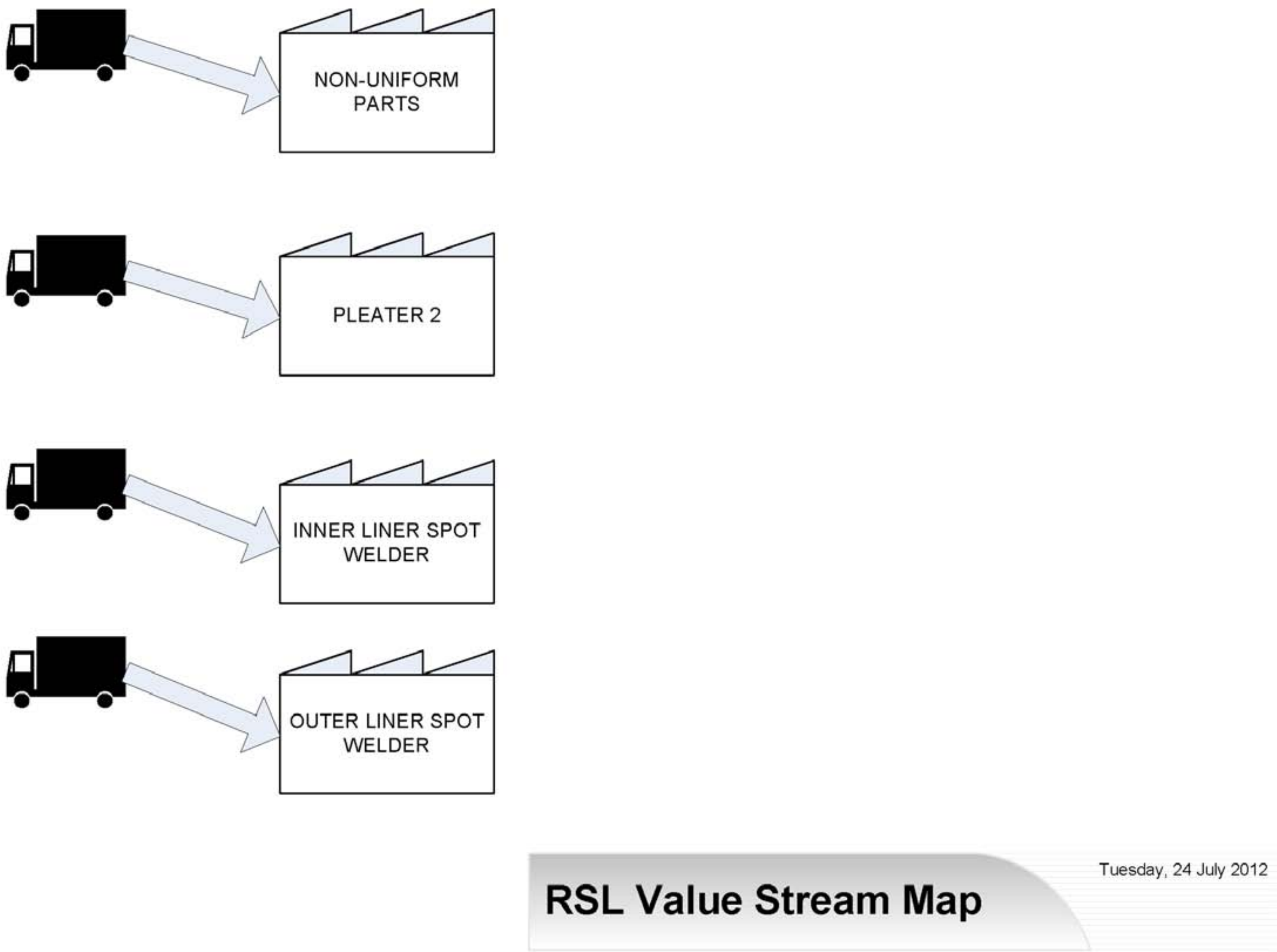


Figure B.1: Initial VSM (1/5)

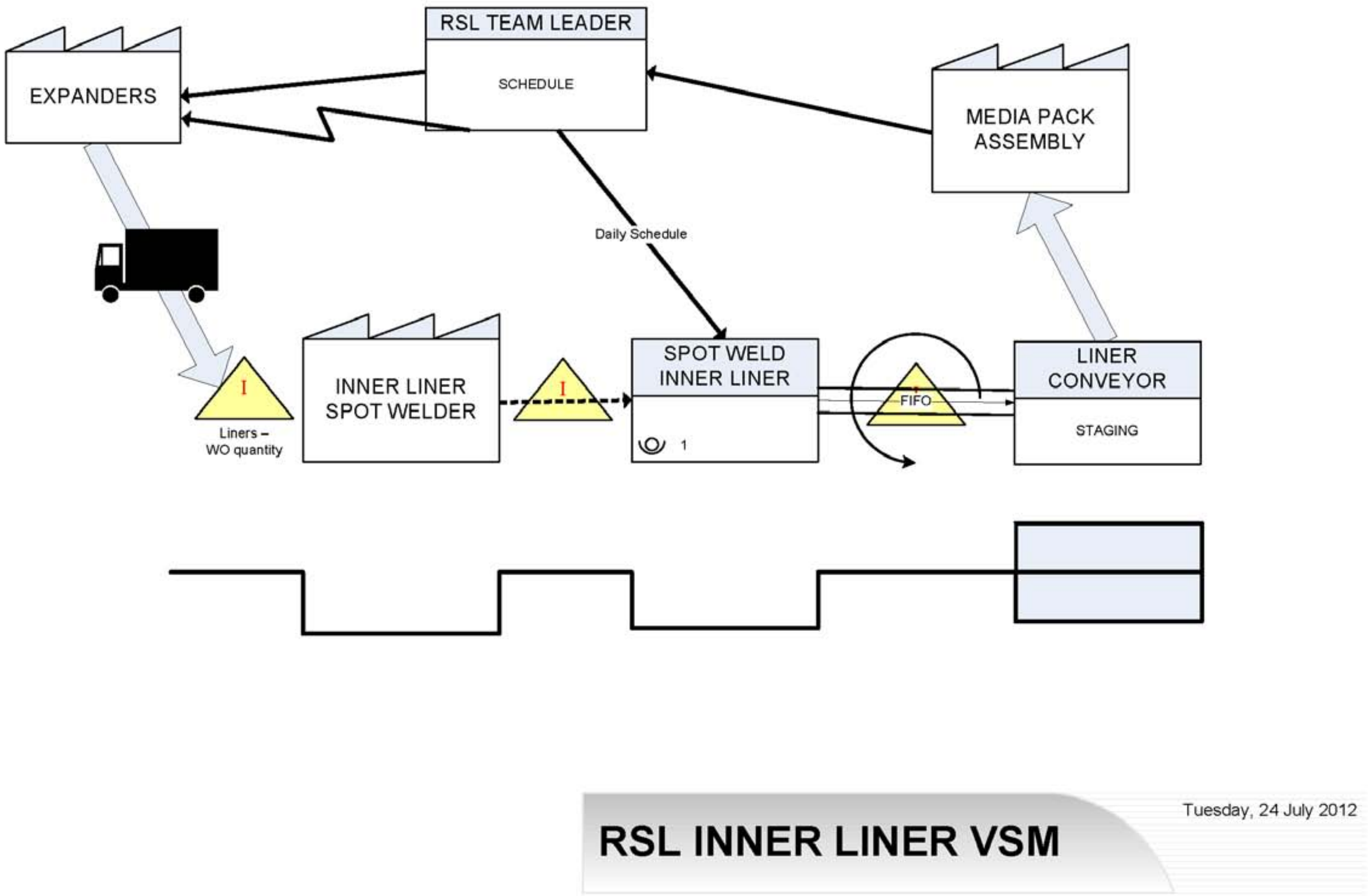


Figure B.2: Initial VSM (2/5)

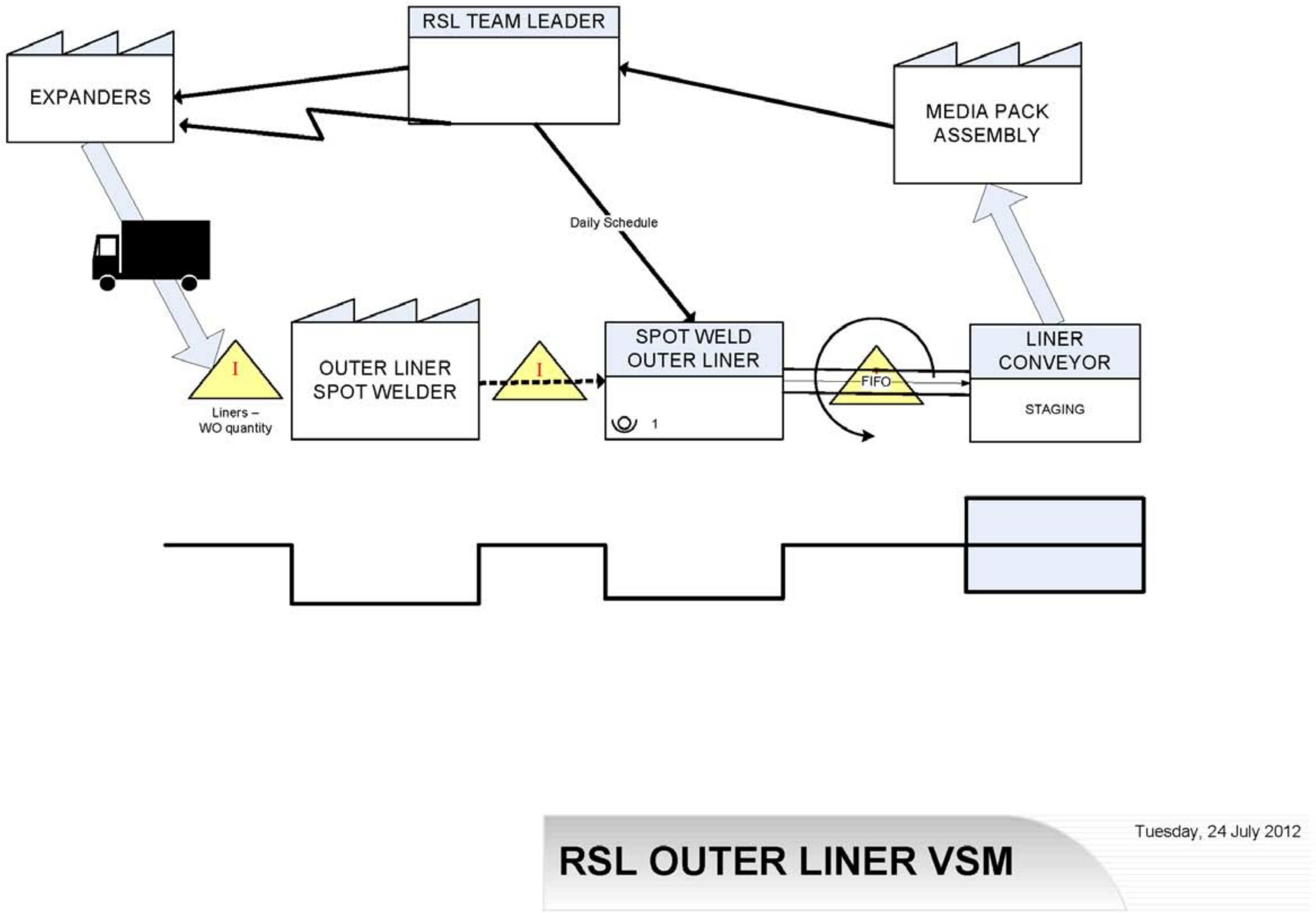


Figure B.3: Initial VSM (3/5)

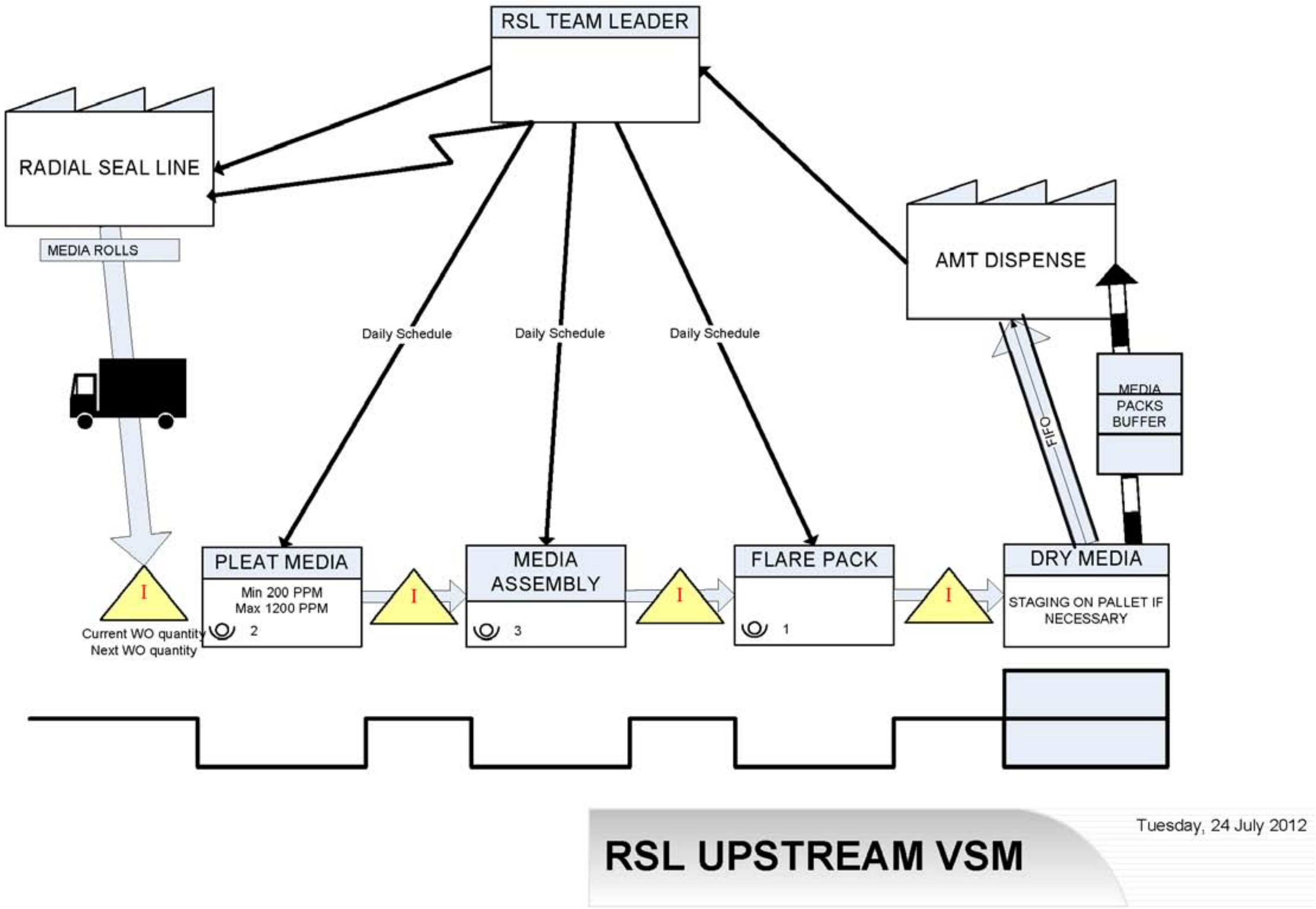


Figure B.4: Initial VSM (4/5)

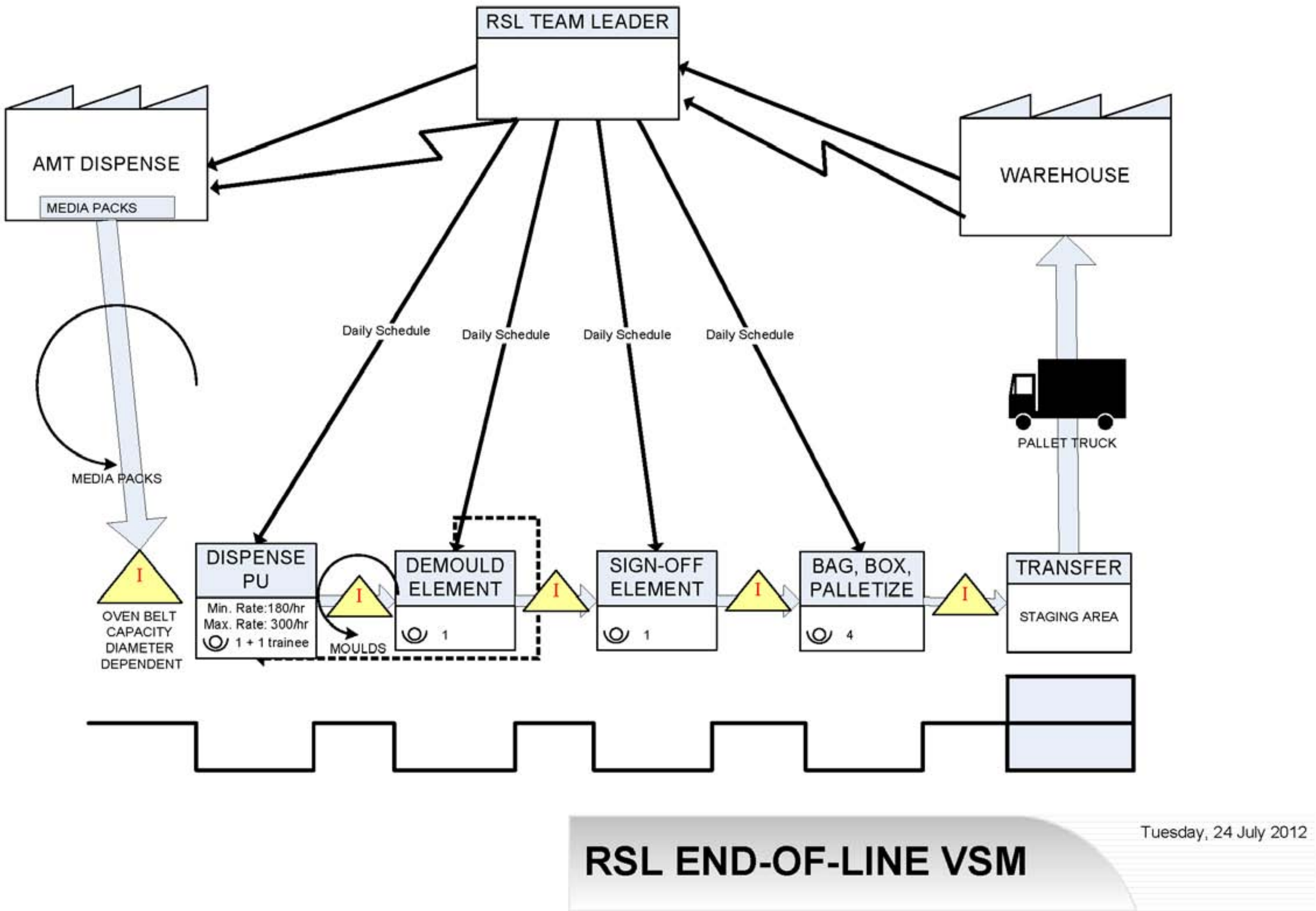


Figure B.5: Initial VSM (5/5)

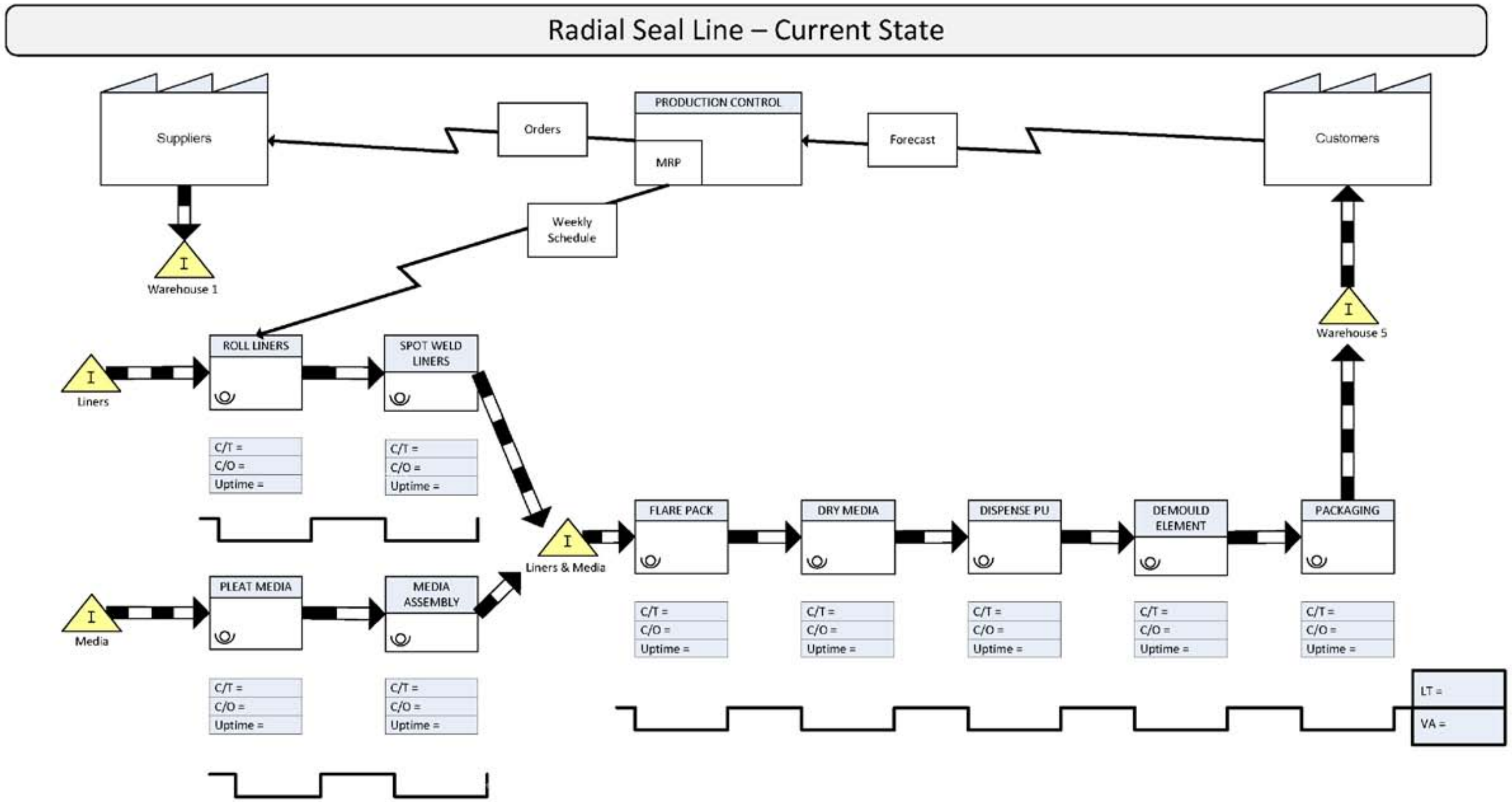


Figure B. 6: Team Developed VSM

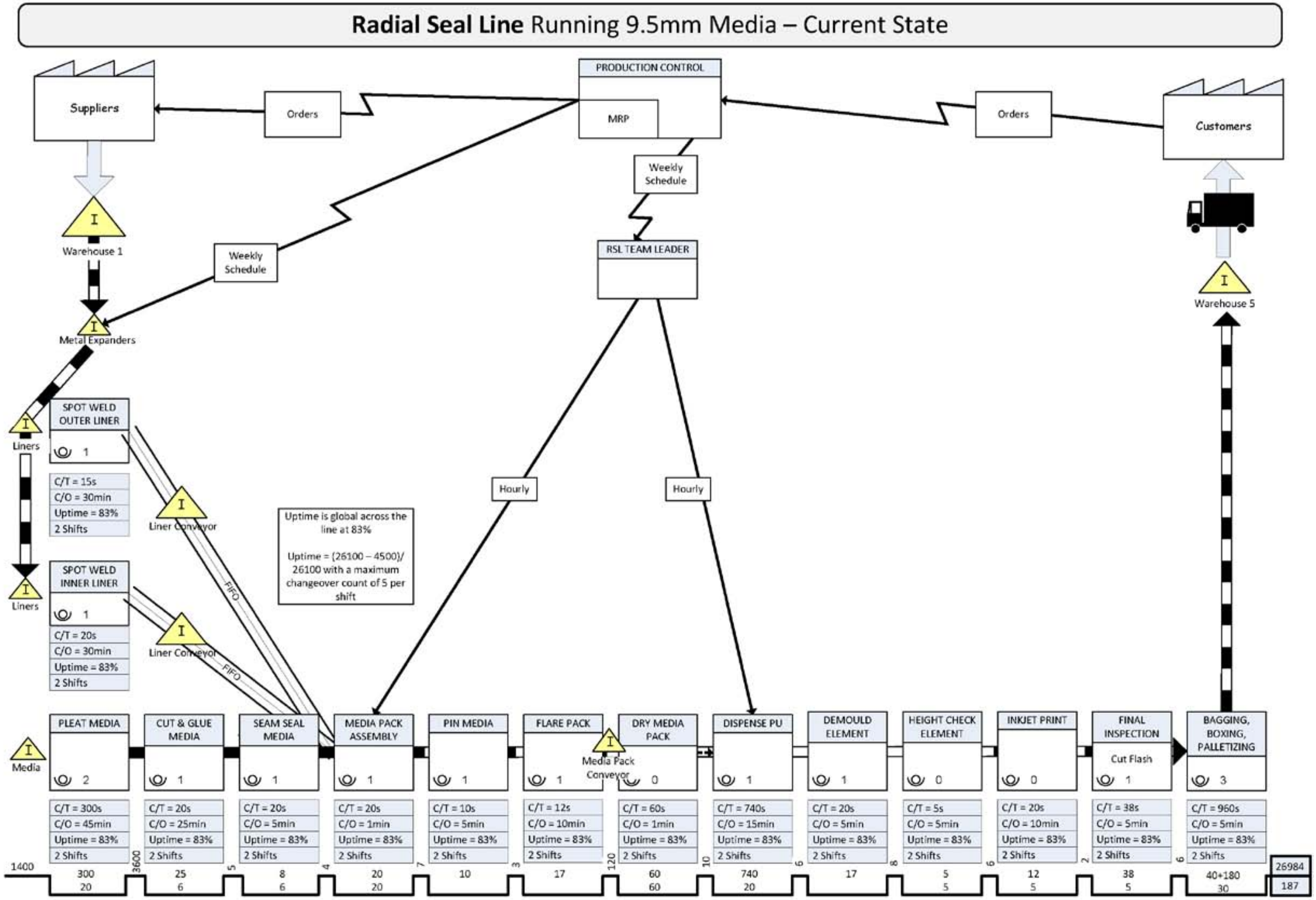


Figure B.7: VSM Sample from Kaizen Event (1/2)

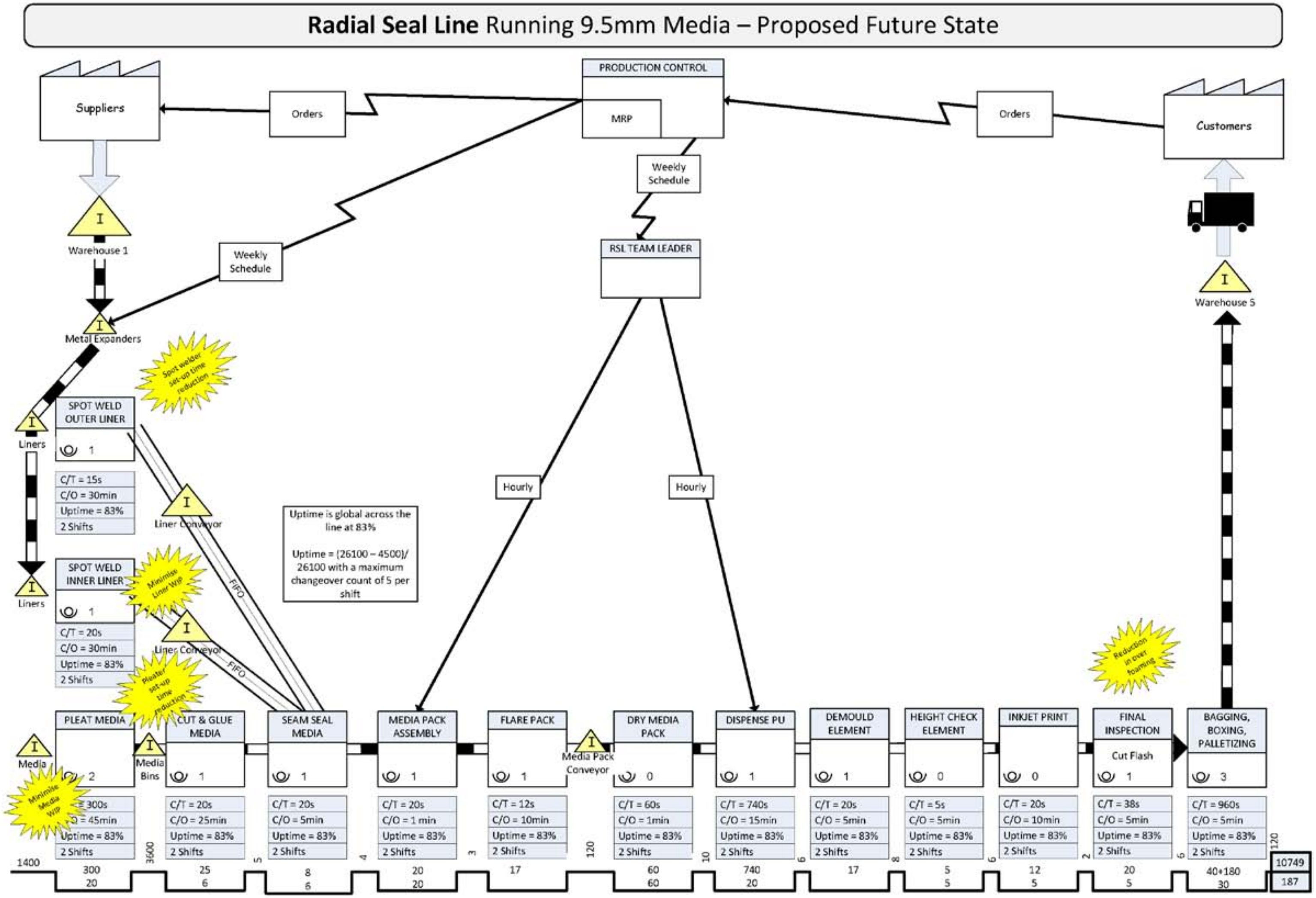


Figure B.8: VSM Sample from Kaizen Event (2/2)

Appendix C: Donaldson Sample Documentation

Type	Prod or Gen	RS020
Rev	1	
#	Revision Detail	

(1) Media-to-Liner

Donaldson. Filtration Solutions

Part/Model Name	Uniform RSL product	Work Center Description:	RSM-031	Prepared By:	H.Hartle		
Part/Model Number	Standard RSL	Dept #:	TAKT Time: min	Date:	15 November 2010		

WIP	PCS OF WIP	CYCLE TIME
▲	#	0

Step	Elemental Description	Time Element
1	Media-to-Liner	
1.1	S1 ✚ Place media ring on outer liner	
1.2	Bundle the media as shown	
1.3	Transfer the media from the table into the	
	ring opening	
1.4	Push the media through the ring into the pack	
1.5	Remove ring	
1.6	Insert inner liner	
1.7	Transfer to spool table	

1.2

1.2

1.3

1.6

Maintenance/

✚	SAFETY ITEMS
S1	KEEP HANDS CLEAR
	DO NOT OPERATE IF AREA NOT CLEAR

Housekeeping/

◆	QUALITY ITEMS
Q1	

Standard Work - RSL - Media-to-Liner (1) Media-to-Liner

Figure C.1: Sample of a SWI Developed by Donaldson

30 Day Kaizen Newspaper	Event	Owner	K
	Process Center/Department # Business Unit/Department	Radial Seal	EVENT Type
Title		Leader	
	Radial Seal Kaizen	Event Leader	

Directions:

1) Fill rows with EVENT Implemented items that your team completed during the week.
2) At the end of EVENT week, add items that must be completed in the next 30 days that affect your goals.
3) Fill in the "Plan to Close" dates (X) for the next 30 working days after the EVENT is over.
4) Perform cell audit every Friday for 30 days, Indicate if items are done and working (Y)
5) Event leader & Process Owner must update weekly the NEWSPAPER until ALL actions are completed

	Kaizen Week End	5-Day	10-Day	15-Day	20-Day	30-Day	
Total Items	13	13	13	13	13	13	13
Plan to Close	10	20	30	41	52	63	63
% Plan/week	77%	154%	231%	315%	400%	485%	485%
Score (Y=1pt.):	10	20	30	41	52	63	63
% Complete:	77%	154%	231%	315%	400%	485%	485%

Continuous Improvement EVENT Objectives: Note: 100% action completion signifies that ALL the EVENT objectives are achieved

1 -
2 -
3 -
4 -

Item #	Problem	Action	Date: / Who?	Kaizen Week End	5-Day	10-Day	15-Day	20-Day	30-Day	Are these items really OPPORTUNITIES?
1	Liner cut length inconsistency	Establish metal expander capability	QC	N	N	N	Y	Y	Y	
2	Media bailing by seam seal operator	Implement roving operator	Team PC	Y	Y	Y	Y	Y	Y	
3	Producing media to bin, not INLINE	SWI and implementation of manning to accomodate it	Team PC	Y	Y	Y	Y	Y	Y	
4	Operator not doing standard work per SWI	Train and implement SWI through out the line for all operators	Team HH	Y	Y	Y	Y	Y	Y	
5	Pleater stop to empty media trim bin	Propose "Klasterec Plant" like system	RD	N	N	N	N	N	N	
6	Seam seal blade has to be cleaned often (± every 10 minutes)	Seal blade with teflon tape	HH	Y	Y	Y	Y	Y	Y	
7	On last media on the bin, operator has to count pleat to join media	Implement standard work for more than 1 ink mark on media	Team HH	Y	Y	Y	Y	Y	Y	
8	2 Different flaring tool for to accomodate different WO	Upgrade flare tool	HH DD	N	N	N	N	N	N	
9	RS flaring tool foot pedal loose - unsafe operation	Place rubber mat under foot pedal and have new foot pedal	DD	Y	Y	Y	Y	Y	Y	
10	Rework after finish WO	Implement new rework procedure	Team HH & Quality	Y	Y	Y	Y	Y	Y	
11	Untrained operator on the line	Implement procedure for training request and skill development for operators	Team HH & Team Leader	Y	Y	Y	Y	Y	Y	
12	1st off approval procedure ±15 minutes	Implement 1st off approval for new recipe and for old recipe	Team HH & Team Leader	Y	Y	Y	Y	Y	Y	
13	General 6S	6S audit and competition	Team HH & Team Leader	Y	Y	Y	Y	Y	Y	
Op										
Op										

Lean Newspaper - RS Kaizen\Kaiz News

Printing Date: 04/07/2012

Figure C.2: Sample of Newspaper from Kaizen Event in March 2012

"Everything has a place, and everything is in its place"

Donaldson.
Filtration Solutions

Scoring Criteria
0 = Many occurances found (3+)
1 = A few occurances found (1-2)
2 = NO occurances found

RADIAL SEAL
Byron/Danielle
03/04/2012

		Score each item 0, 1, or 2 — Audit Date	March	APRIL	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	Ap/12	Feb	
Sort	1	Only required items for the workcell/zone are present. (Not equipment)	0	1	1	1	1	1	2	2	1	2	2	0	1S
	2	There are no broken, unused, or unnecessary **equipment** located in the workcell/zone.	2	1	2	2	2	2	2	2	2	2	1	2	
	3	Scrap/non-conforming materials are segregated & clearly identified.	2	1	1	1	2	1	1	2	2	2	2	2	
	4	Shelving, racking, and cabinets are not used for storing or hiding junk?	1	1	1	1	2	2	2	2	1	1	1	1	
	5	All aisles and walkways are free of materials and obstructions.	2	0	1	1	1	1	2	2	1	0	2	2	
		Red = 0 - 3, Yellow = 4 - 7, & Green = 8 - 10	7	4	6	6	8	7	9	10	7	7	8	7	
Set	6	**Tools** are properly stored so they can be used and returned easily (ex. shadow boards).	2	1	1	1	1	1	2	2	2	2	2	2	2S
	7	All **movable** items, **drop zones**, & **aisles** are labeled and clearly marked with tape/paint.	2	0	1	1	1	1	2	2	2	2	1	2	
	8	All items in area are clearly identified or labeled, including inventory items.	2	1	1	1	1	1	1	2	1	2	1	2	
	9	All air hoses and electrical cords are the correct length or tied up neatly.	2	1	2	2	1	2	0	0	0	0	1	1	
	10	All items are sorted and prioritized by frequency of use.	2	1	1	1	1	1	2	2	0	2	2	2	
		Red = 0 - 3, Yellow = 4 - 7, & Green = 8 - 10	10	4	6	6	5	6	7	8	5	8	7	9	
Shine	11	Cleaning checklists are established for the area.	2	0	2	2	2	2	2	2	2	2	2	2	3S
	12	Machines, tools, & flat surfaces in area are kept clean.	1	1	1	1	1	1	2	2	1	1	0	2	
	13	Floors are clean including areas under and around equipment and furniture.	1	1	1	1	1	1	2	2	1	1	1	2	
	14	Cleaning materials (brooms, dust pans, fluids) are easily accessible and designated.	2	1	0	0	0	0	2	1	2	2	1	2	
	15	No outdated, torn, or soiled documents are displayed in workcells.	2	0	1	1	2	2	1	2	0	2	1	2	
		Red = 0 - 3, Yellow = 4 - 7, & Green = 8 - 10	8	3	5	5	6	6	9	9	6	8	5	10	
Standardize	16	Current processes are documented (schedules, production boards, work instructions).	2	0	0	0	2	2	2	2	2	2	1	2	4S
	17	Cleaning checklists are being followed.	2	1	1	1	0	2	2	2	0	1	1	2	
	18	A training matrix is developed for each area.	2	1	1	1	1	1	2	2	2	2	2	2	
	19	A Red Tag process is in place to identify unused or outdated materials.	2	0	0	0	0	0	0	2	2	2	2	2	
	20	Items are returned to their proper location after their use.	2	1	1	1	1	1	2	2	2	2	2	2	
		Red = 0 - 3, Yellow = 4 - 7, & Green = 8 - 10	10	3	3	3	4	6	8	10	8	9	8	10	
Sustain	21	Display boards and other documents are current and being used.	2	1	1	1	2	1	2	2	2	2	1	2	5S
	22	A corrective action plan is being utilized to improve overall 6S.	2	1	1	1	0	2	2	2	1	2	1	2	
	23	6S corrective actions completed or initiated from last audit.	1	1	1	1	0	2	2	0	2	2	0	2	
	24	Overall performance has sustained a minimum score or better from previous month.	2	0	0	0	2	2	2	2	1	0	0	2	
	25	6S level has been documented and posted in the work area.	2	0	2	2	2	2	2	2	2	2	2	2	
		Red = 0 - 3, Yellow = 4 - 7, & Green = 8 - 10	9	3	5	5	6	9	10	8	8	8	4	10	
Safety	26	All proper personal protective equipment (PPE) is worn at all times.	2	2	2	2	2	2	2	2	2	2	2	2	6S
	27	All equipment is working properly with no leaks. Electrical/air cords are not torn and neatly tied.	1	2	2	2	1	1	0	0	2	2	1	1	
	28	Emergency routes, aisles, and exits are clear and posted.	2	2	2	2	2	2	2	2	2	2	1	2	
	29	No trip hazards are present anywhere in the area.	2	1	1	1	2	1	2	2	2	2	1	2	
	30	All equipment is properly guarded and have lockout/tagouts.	2	1	1	1	2	2	1	2	2	2	1	2	
		Red = 0 - 3, Yellow = 4 - 7, & Green = 8 - 10	9	8	8	8	9	8	7	8	10	10	6	9	
		Red = 0 - 24, Yellow = 25 - 48, & Green = 49 - 60 **TOTAL SCORE**	53	25	33	33	38	42	50	53	44	50	38	55	

rev 8/5/09

Figure C.3: 6S Audit Sheet for 2012 Showcasing Monthly Progression

Recipe Lockdown Sheet

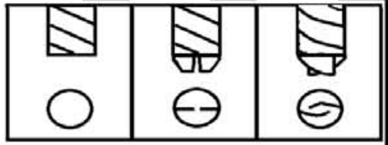
Part Number:

As of:		Next update:	

AMT Dispense 10773

Donaldson.
Filtration Solutions

Recipe Name:				
Dispense Flow Rate	g/s			
ISO Pressure	Psi	**POLY Pressure**		Psi
Mix Rotor Speed	rpm			
Rotor Pre-run	s	**Rotor After-run**		s
Mould Diameter	mm	**Mixer Type**		
Dispense Delay	s	Flat	Straight	Helix
Infeed Conv. Speed	%			
Infeed Clamp Delay	s			
Auto-flush Timeout	s			



Temperature values are for both POL & ISO

Variable Values	Head		Day Tank	
Temperature Range	24-27	°C	24-27	°C
Pressure Range	± 5	Psi	5	Psi

OPEN END mould			**CLOSED END mould**		
Mould Number			**Mould Number**		
Dispense Time		s	**Dispense Time**		s
Mould Rotation		rpm	**Mould Rotation**		rpm
X Dispense Position		mm	**X Dispense Position**		mm
Z Dispense Position		mm	**Z Dispense Position**		mm

			Head Temp.		Day Tank Temp.		Open cover				Closed Cover			
	Run Date	Ambient Temp.	ISO	POL	ISO	POL	Dispense Time	Mould Rotation	X-position	Z-position	Dispense Time	Mould Rotation	X-position	Z-position
1														
2														
3														
4														

(Print name and sign)
Engineer reviewed: QC Reviewed: Production Reviewed:

Standard Work - RSL - First-off Spreadsheet Recipe Lockdown Sheet

Figure C.4: Recipe Lockdown Sheet Developed During Kaizen to Reduce Setup Times

Donaldson Lean Assessment Rev 3.0 11/07/2011						
Site / Location Name:		Cape Town, South Africa			Date:	30-Jul-12
Category	Lean Culture	VSM / Lean Planning	Material Management	Quality and Process Design	6S	Total Productive Maintenance
4	The entire plant uses lean as a part of daily life.	The entire plant effectively uses value stream maps to drive continuous improvements.	World class material flow through-out entire value stream with replenishment systems based on customer demand.	Sophisticated approaches are used to prevent, detect and correct defects. Results are at world class levels and quality and customer satisfaction are pervasive in the culture.	The plant is a "high performance" workplace which indicates 6S is part of the culture. Sources of mess contributors are eliminated and mess is never caused.	Total Productive Maintenance
3	All departments and managers are involved in lean (including office and support functions).	The plant is using multiple value stream maps throughout their lean journey indicating future state of achievement.	Pull and flow are evident internally between cells. Replenishment systems drive inventory reduction to be "on the fairway". Culture of "pull and flow" is becoming internalized. The basic SIOP system is up and running.	Isolating defects and using tools to predict and prevent defects. Formal processes are being used to solve problems and eliminate recurrence. Metrics are driving action in the organization	Evidence of an effective 6S program is in place throughout entire facility (including grounds, operations, and office areas).	Predictive maintenance system
2	Some managers and employees are involved in lean	Cross functional teams develop value stream maps with detailed improvement plan and tracking mechanism in place to measure sustainability. All plant processes are part of improvement plan.	Some advanced inventory and supply chain management techniques are being actively deployed.	Detecting defects and solving problems through more formal methods. Quality systems are being formalized. Customer requirements are being considered and suppliers are contributing to improving results.	Evidence of a 6S program is in place in entire production area	Preventive maintenance system
1	Pockets of involvement are evident in the plant	The facility has value stream maps and an improvement plan.	Provides for the fundamental foundation of a solid inventory and supplier management systems in a lean environment.	Basic system controls emerging. Tools are being understood and deployed. Problems are being identified and solved.	A 6S program is in place with a tracking mechanism to monitor progress.	Basic maintenance system.
Category Score	1.83	2.63	0.86	1.50	2.33	2.00
Average Score	1.86	Bronze	= Assessment Level			

Figure C.5: DPS Lean Assessment Audit for Plant (1/3)

Lean Culture	1	2	3	4
	Pockets of involvement are evident in the plant	Some managers and employees are involved in lean	All departments and managers are involved in lean (including office and support functions).	The entire plant uses lean as a part of daily life.
Lean Training/Certification	☒ Individual(s) dedicated to lean, full- or part-time. (Lean certification not required)	☐ Full or part-time lean individual(s) are training employees on lean tools - Bronze = 25%, Silver = 1% (Audit training records)	☐ Full or part-time lean individual and plant leaders are involved with training and implementation of lean. Bronze = 40%, Silver = 10%, Gold = 1% or 2 minimum(Audit training record and event participation)	☐ All levels of the plant have been trained, understand and use lean as a part of daily life. Bronze = 60%, Silver = 20%, Gold = 5% or 4 minimum(Audit training records, event participation, individual interviews)
Visual Management	☒ Basic control boards have been established and implemented in the plant.(Audit control boards are present)	☒ Standard control boards outlined in the DPS are created and implemented for all departments and employee training has been conducted. (Audit departments for control boards present and interview employees for understanding of the boards)	☐ Countermeasures/Corrective actions have been added to control boards to address underperformance and/or value stream issues and concerns. (Audit boards for measures that are under performance; identify countermeasures/corrective actions posted on board including metrics of no recurrence of the issue and/or closure to value stream issues and concerns)	☐ Strategy Deployment is posted in a location that is available to all employees at the plant. Training on the Strategy Deployment process has been conducted for all employees. (Audit area for presence of Strategy Deployment, verify training records, interview for location of Strategy Deployment documents and understanding of Strategy Deployment)
Communication	☒ All employee meetings occur once/quarter. One of the topics must be a lean topic. (Audit employee meetings agenda and meeting occurrence)	☒ Regular group communication meetings (floor cell meetings, office staff meetings, tool box meetings, etc) reviewing lean and continuous improvement opportunities. (Audit both manufacturing floor and office staff for group meetings, review agendas, documented improvement opportunities.)	☐ An employee suggestion system is implemented with 100% of the suggestions receiving a response. The employee suggestion system may be part of the control board documentation. (Audit system suggestion system/control boards and evidence of responding to employee suggestions.)	☐ Regular team meetings using the value stream map, creating action items, and problem resolution. (Audit interview for team meetings, VSM, action items and problem resolution.)
Improvement Events	☒ Kaizen events happen informally (Audit event documentation)	☒ Kaizen events are regularly planned. (Audit formalize event schedule)	☐ The kaizen improvement plan and strategy deployment are integrated and events are conducted based on the plan. (Audit schedule, action plans, bowling charts to determine integration of planned events)	☐ Events are no longer exclusively used to drive improvements - kaizens are a part of daily operating. (Audit interview team leaders at cells)
Visual Standard Work	☒ Standard work (Work Instruction) elements, format, and training is in use by plant lean leaders. (Audit documents)	☒ Every Kaizen event must include Standard Work knowledge training, revision or development of standard work, and then training and implementation of the new standard work.(Audit standard work revision/development, training records and Kaizen events documents)	☐ Standard work is implemented cross-functionally to include targeted areas of the entire plant value stream and metrics implemented. (Audit by reviewing metrics, visual standard work and targeted areas of value stream)	☐ All areas of the plant have implemented visual standard work and improvement targets have been established. (Audit by sampling areas for std. work and targets)
Leadership	☒ All employees perceive leaders as delegating (know it) the support of lean initiatives in the plant. (Audit by interviewing, possible question "Tell me how XXX is involved in lean.")	☒ All employees perceive leaders as understanding and supporting (live it & talk it) lean initiatives in the plant. (Audit- same question in level 1 answer will provide information for each level 2, 3, 4.)	☐ All employees perceive leaders as advocating (measure it) planning and improvement and performance evaluations include lean and leaders participate on daily Gemba walks (review performance evaluations for lean components & Gemba assessment by talking to employees; look for verbal evidence that the managers are asking how they can help)	☐ All employees perceive leaders as highly participative (insist on it) in planning and improvements and performance evaluations include lean at all levels(review several functional areas performance evaluations)
Totals	6	5	0	0
Possible	6	6	6	6
Score	1.00	0.83	0.00	0.00
Comments	C: Quarterly all-employee meetings by Rob. Recommend all-employee meeting more regularly by plant mgmt. team. Continue to communicate lean examples and principles during all-employee meetings.			

Figure C.6: DPS Lean Assessment Audit for Plant (2/3)

VSM / Lean Planning	1	2	3	4
	The facility has value stream maps and an improvement plan.	Cross functional teams develop value stream maps with detailed improvement plan and tracking mechanism in place to measure sustainability. All plant processes are part of improvement plan.	The plant is using multiple value stream maps throughout their lean journey indicating future state of achievement.	The entire plant effectively uses value stream maps to drive continuous improvements.
Map Creation	☒ Evidence of current value stream maps exists for at least one of the following: business level, product family, or process.	☒ Current and future state value stream maps are created with an improvement plan for targeted value streams.	☐ Multiple revisions of the value stream and process maps have been used in the lean journey.	☐ Plant value stream maps created from Customer to Supplier. (Audit both current and future state maps.)
Visual	☒ VSM are posted in at least one area represented on VSM.	☒ Most recent VSM are posted in area represented. (Audit by reviewing rev. levels and/ or ask employees "what is the latest improvement done on the line?" Walk the line with the VSM that is posted)	☒ Most recent VSM are posted in 75% of the plant. (Audit same as level 2; base 75% on volume, sales, lines, etc. Understand the plant logic detailing 75%)	☐ Most recent maps are posted in 100% of the plant. (Audit same as level 2)
Kaizens	☒ Kaizen events are being conducted. (Audit event documentation)	☒ The improvement plan is used to determine Kaizen events. Current and Future state maps are created during events. (Audit event documentation for use of improvement plan, map creation, standard work, and metrics. Walk the line to review sustainability).	☒ Same as level 2 ☒ Non manufacturing cell kaizen has been conducted. (Audit same as level 2)	☐ Same as level 2 ☐ Non manufacturing cell and external group (corporate, supplier, customer, etc.) kaizen has been conducted. (Audit same as level 2, verify attendance)
Material & Machine Change Over (SMED/QCO	☒ Change over time is beginning to be measured and understood. (Audit documentation and interview)	☒ Material and/or machine change over is being reduced to optimize productivity based on the value stream (removed takt time).	☒ Material and/or machine change over time shows an improving trend.	☐ Work area change over is within takt time. (Audit by a visual review and documents)
Leadership	☒ Evidence exists for employee participation in kaizen events.	☒ Evidence of staff participation in creation of VSM.	☐ Plant leadership drives facility improvement planning activity. (Audit - who drives strategy deployment)	☐ Plant leadership drives facility improvement planning activity. (Audit Strategy Deployment monthly review meetings and interviews)
Communication	☒ Kaizen final report out communicated with management members and stakeholders from Kaizen event area not in the event present. (Audit event report outs and conduct interviews)	☒ Kaizen is being communicated by the team members to the entire area(s) affected. (Audit by interviewing areas for Kaizen awareness)	☒ Employees can identify improvement plans and locate and explain value stream maps. (Audit by interview and "show me" and ask for explanation for value stream.)	☐ Employees from all areas of the plant can identify improvement plans and locate and explain value stream maps. (Audit by interview and "show me" and ask for explanation for value stream.)
Metrics/Countermeasure	☒ All kaizen events have a newspaper/action plan developed. (Audit documentation newspaper/action plan)	☒ Kaizen newspaper tracked. (Audit documentation)	☐ Newspapers are tracked and countermeasures implemented where necessary. (Audit documentation newspapers, countermeasures available)	☐ Tracking system developed for newspaper completion percentage (Audit tracking system for action items and % completed)
Totals	7	7	5	0
Possible	7	7	8	8
Score	1.00	1.00	0.63	0.00
Comments		L: Marshall area event had mgmt team participation.		

Figure C.7: DPS Lean Assessment Audit for Plant (3/3)

Appendix D: Planning Documentation

NEW RADIAL SEAL LINE INSTALL STAGES.
(AS OF 15.02.2010):

STAGE 1: CLEAN AREAS.

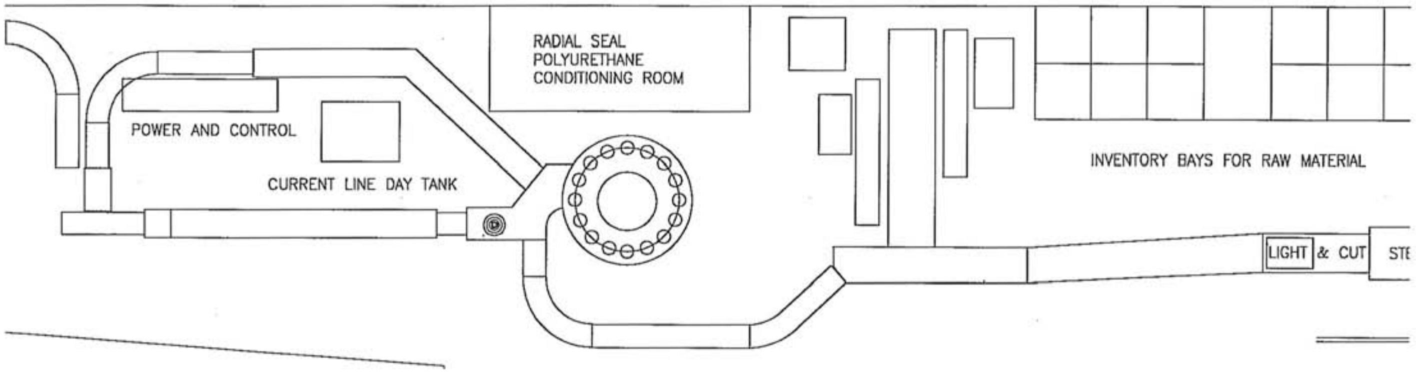


Figure D.1: Stage 1

STAGE 2: CONDITIONING ROOM REMOVAL

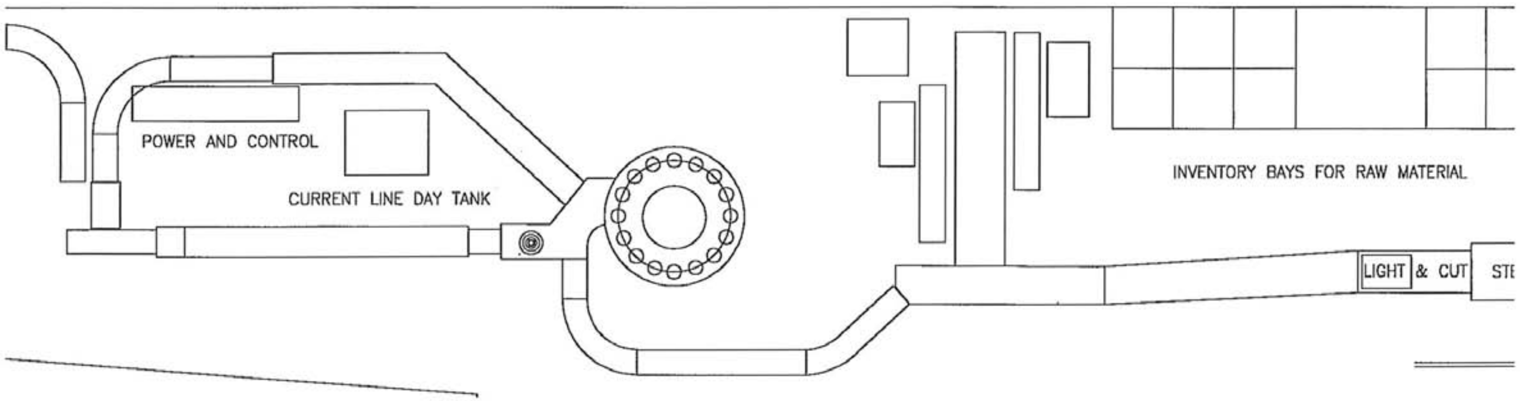


Figure D 2: Stage 2

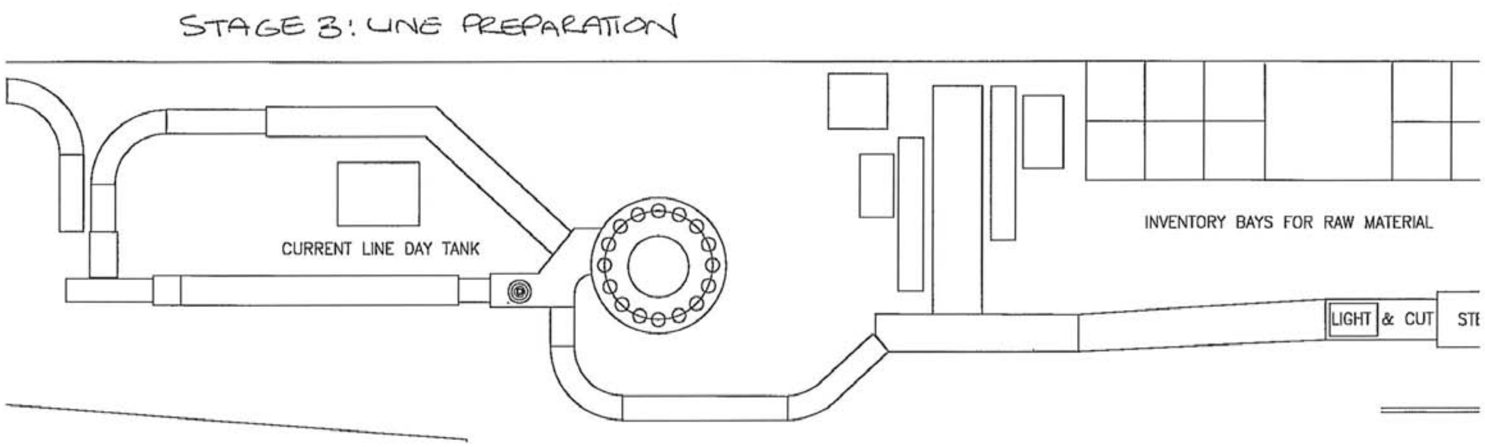


Figure D.3: Stage 3

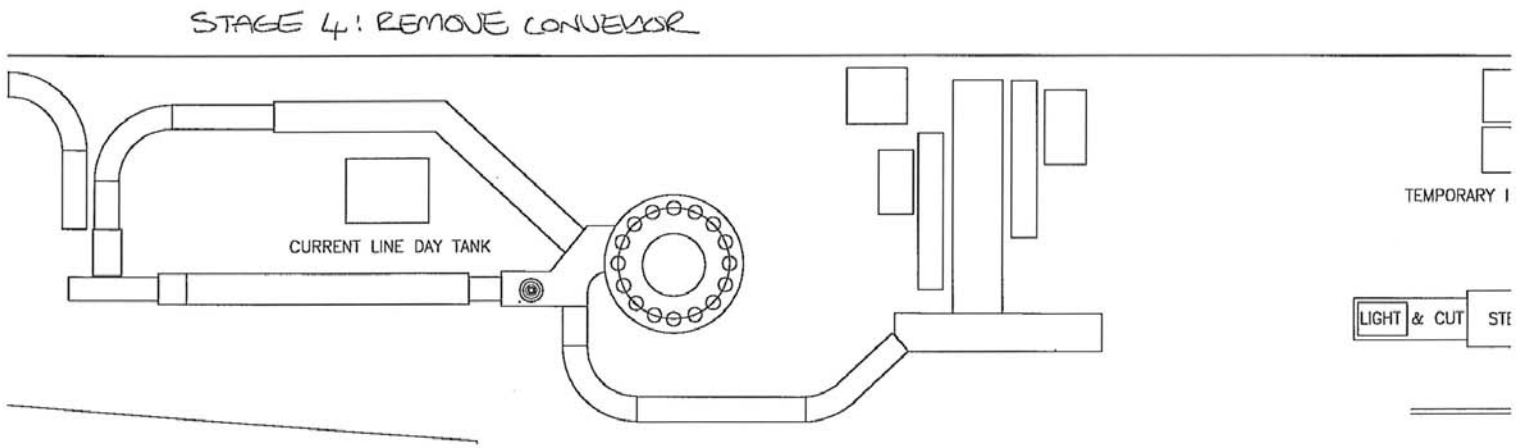


Figure D. 4: Stage 4

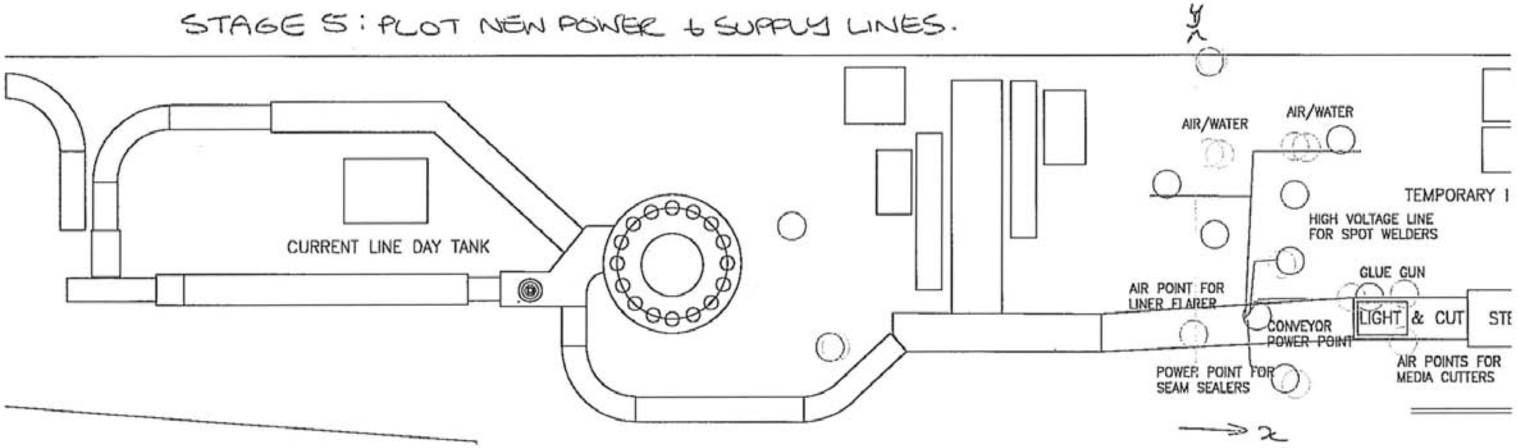


Figure D.5: Stage 5

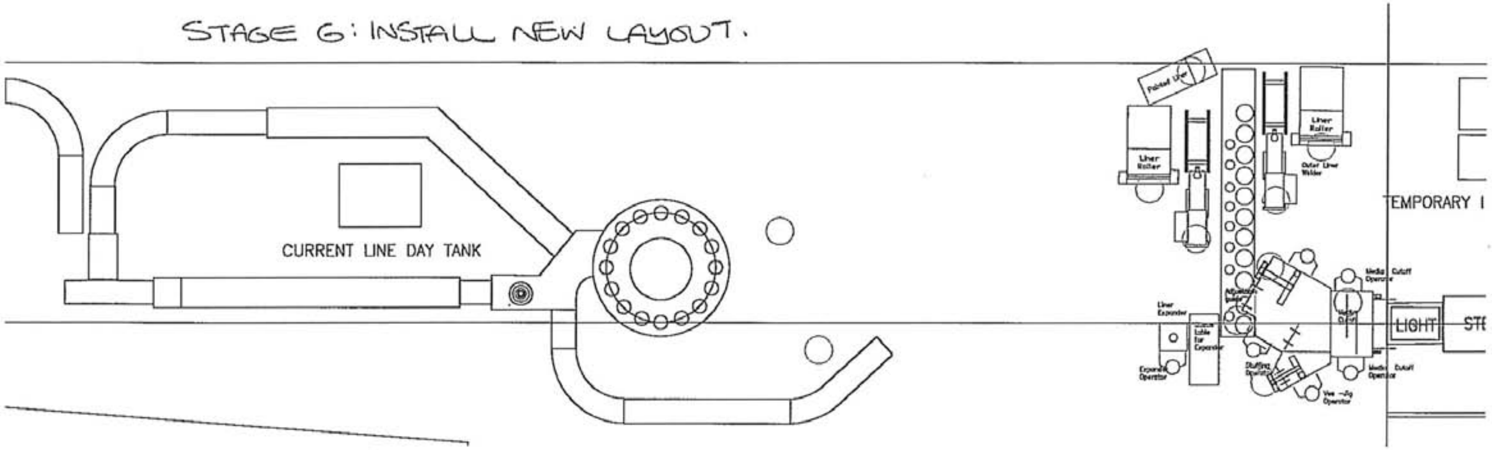


Figure D.6: Stage 6

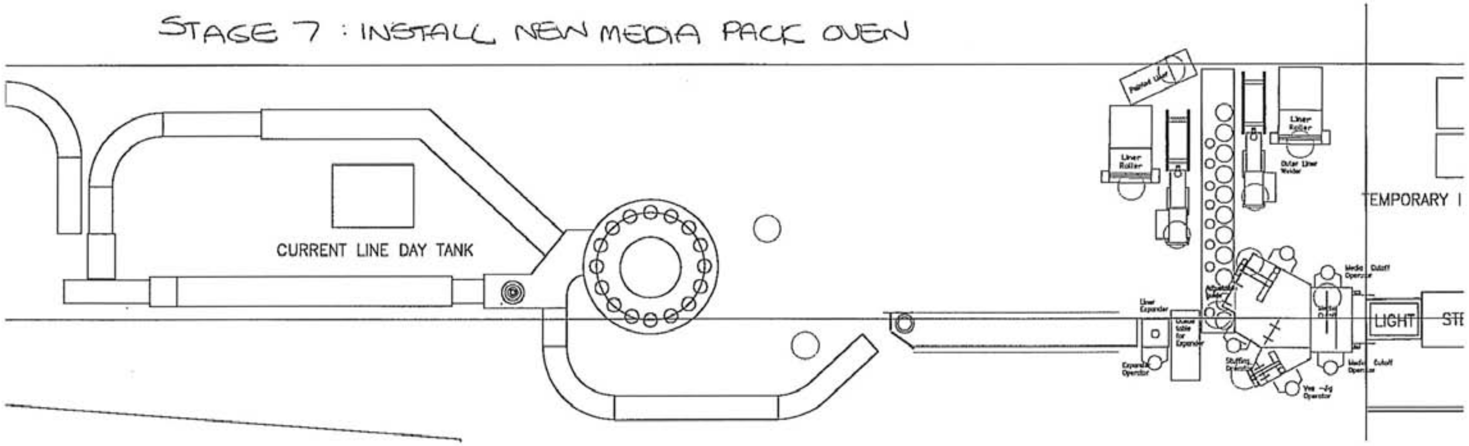


Figure D.7: Stage 7

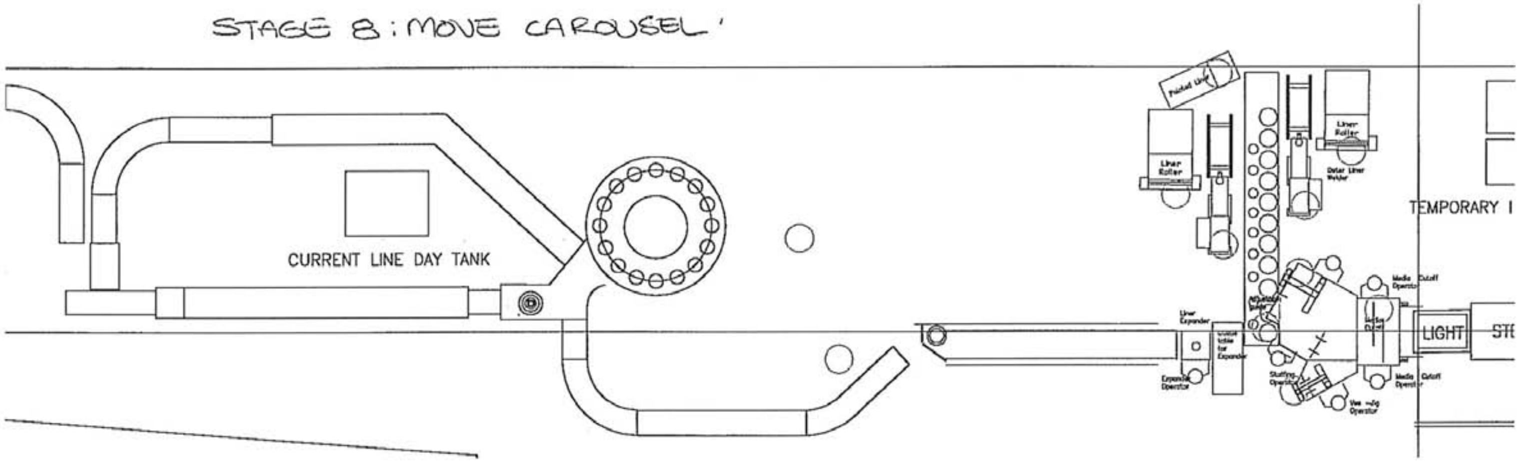


Figure D.8: Stage 8

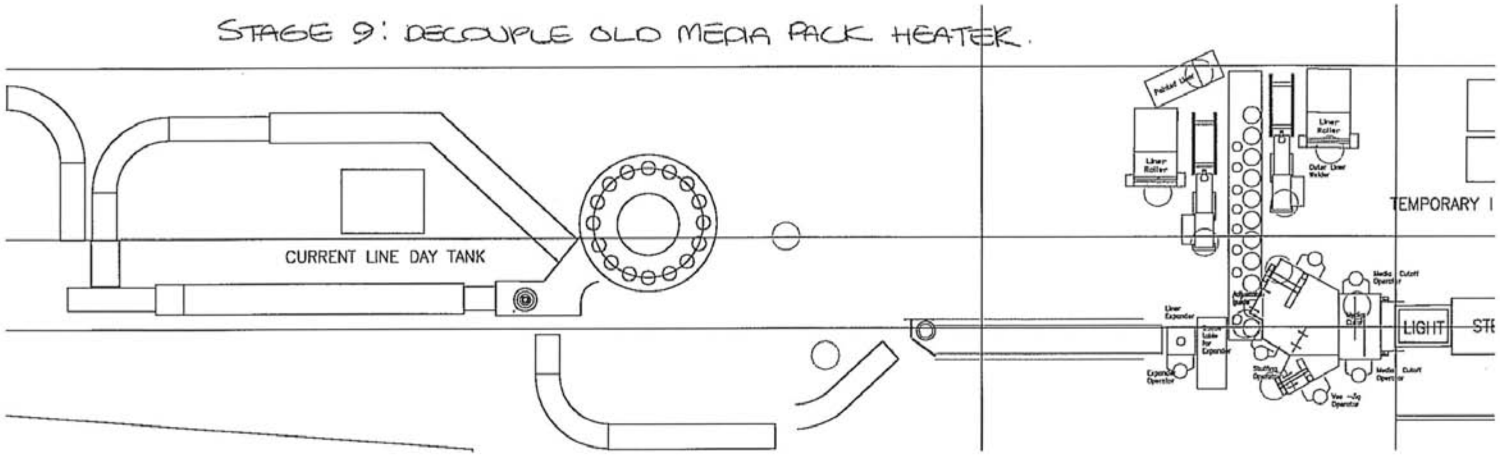


Figure D.9: Stage 9

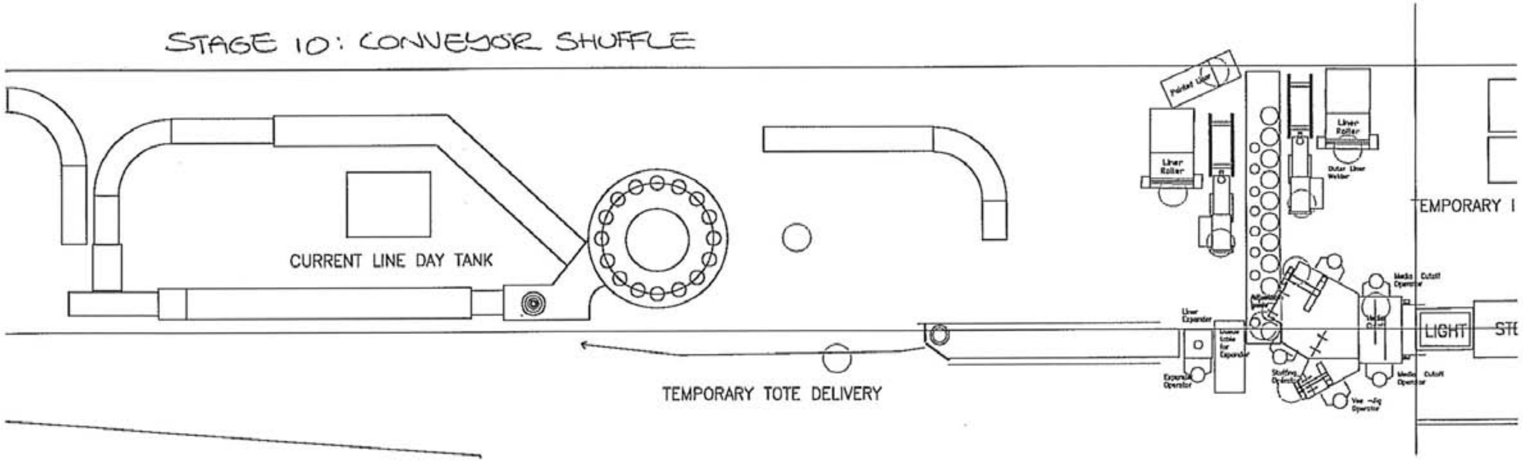


Figure D. 10: Stage 10

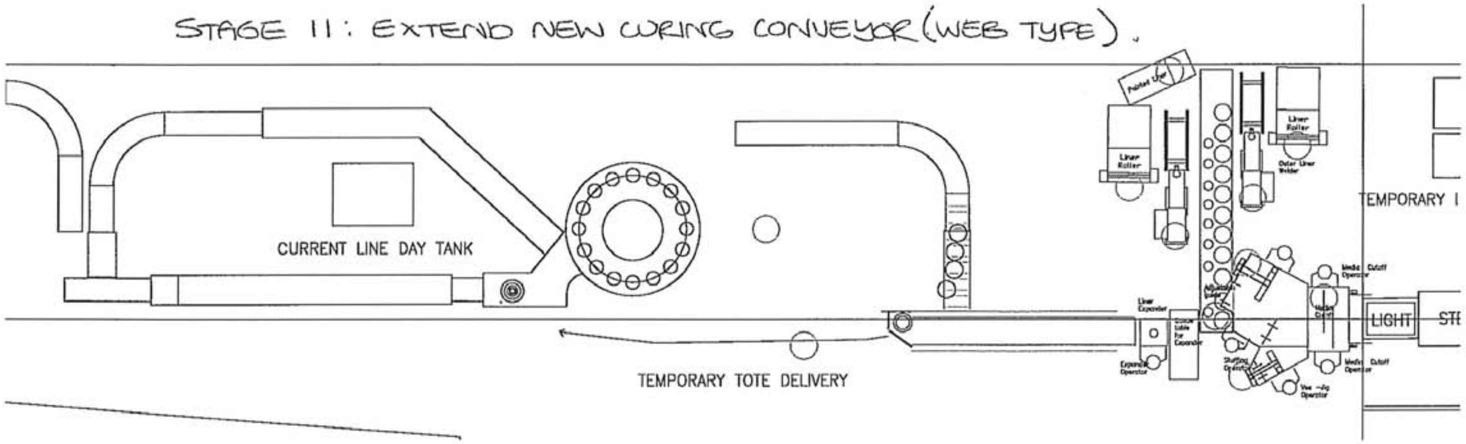


Figure D.11: Stage 11

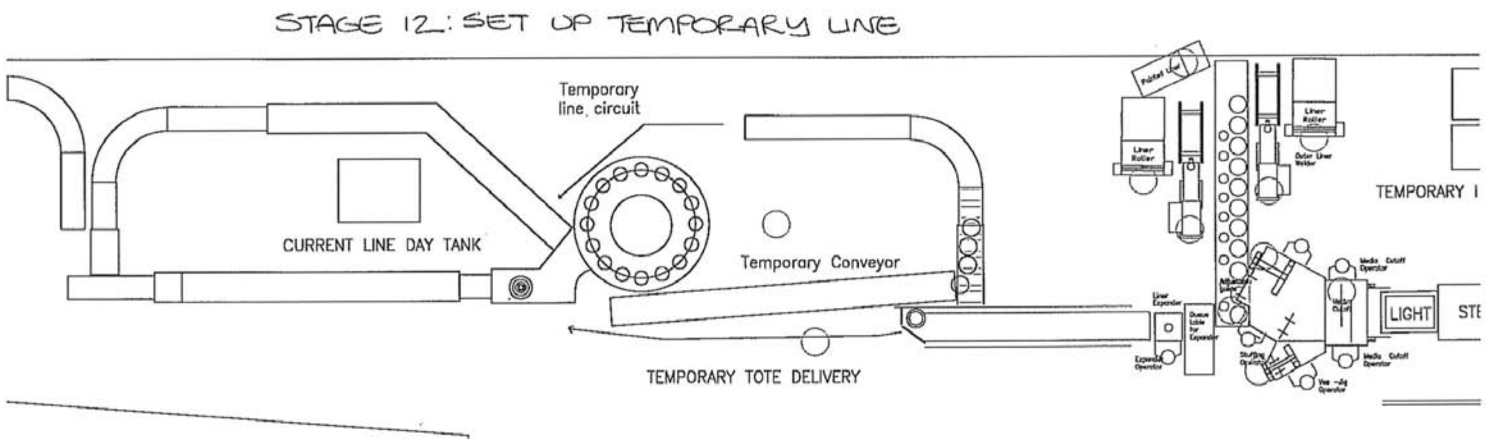


Figure D.12: Stage 12

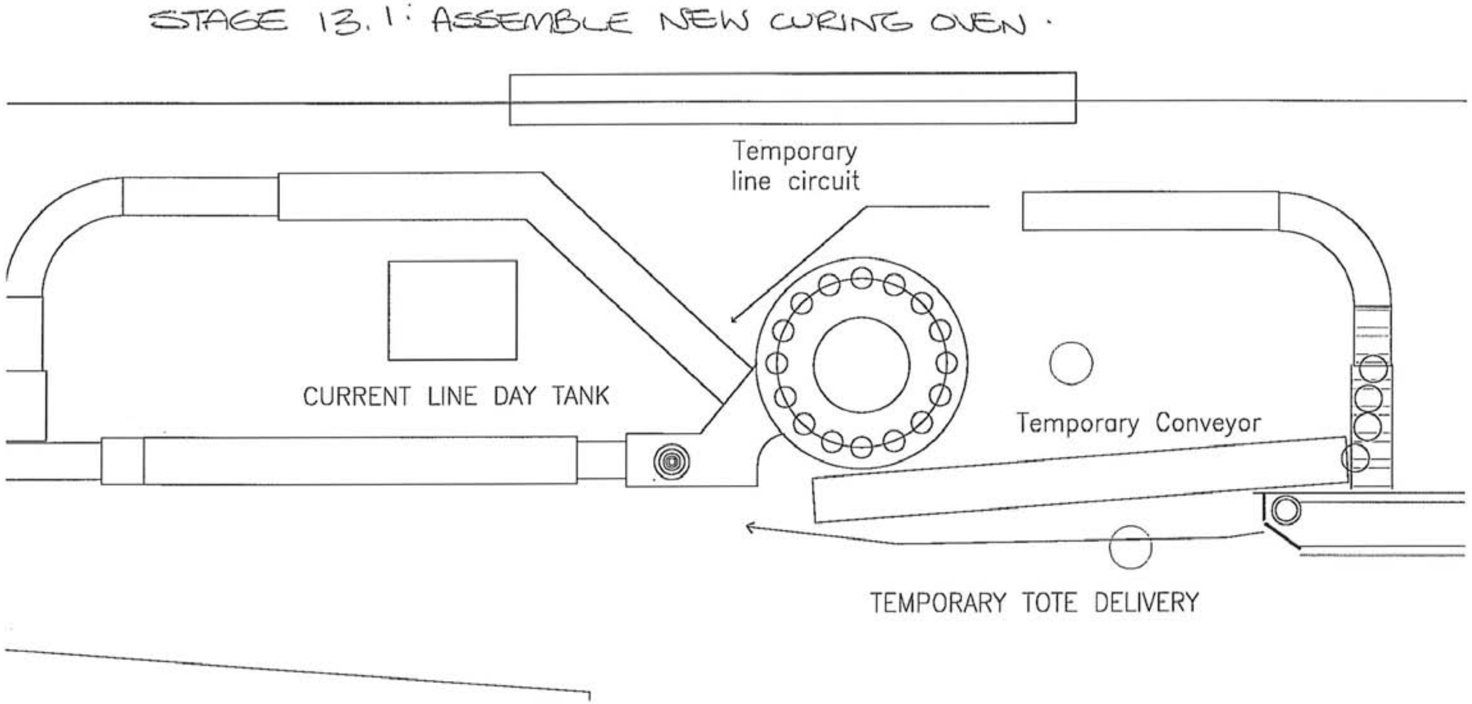


Figure D.13: Stage 13.1

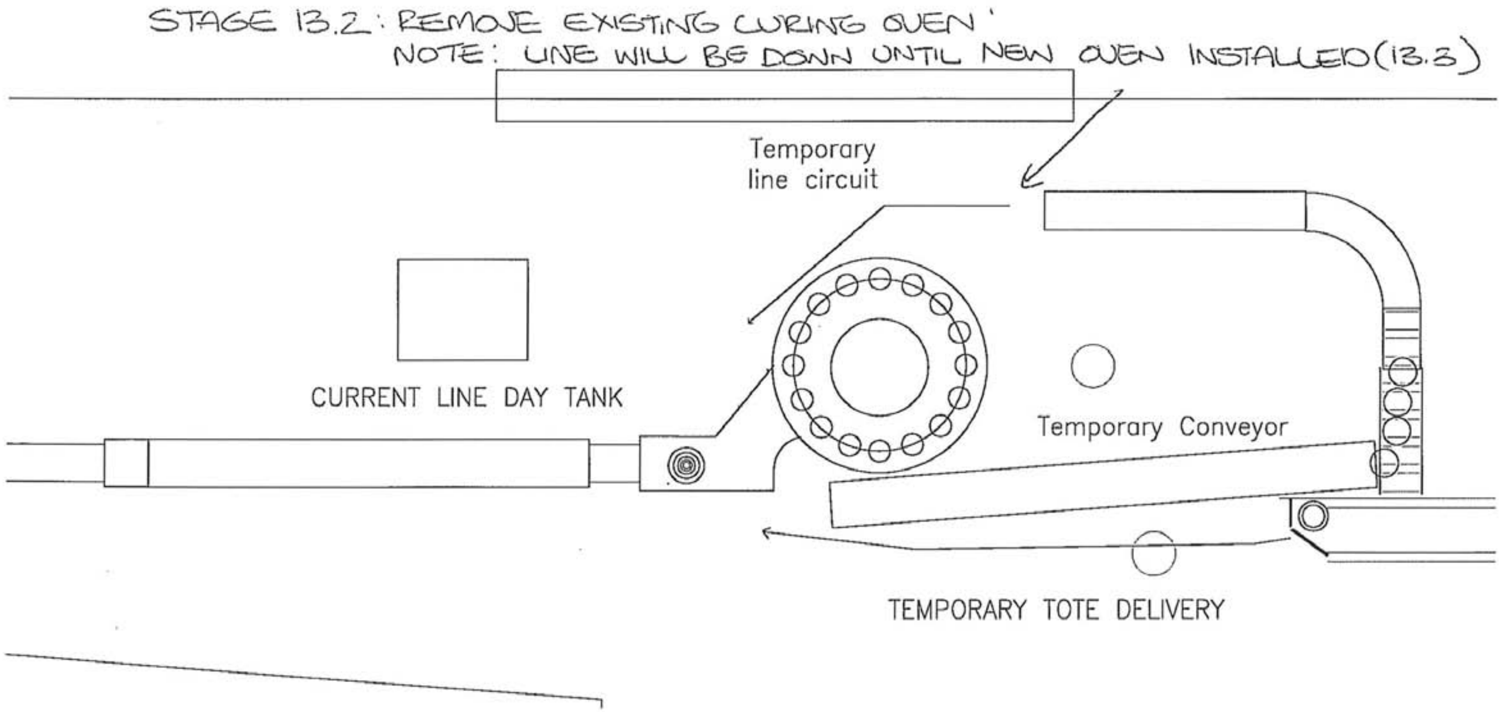


Figure D.14: Stage 13.2

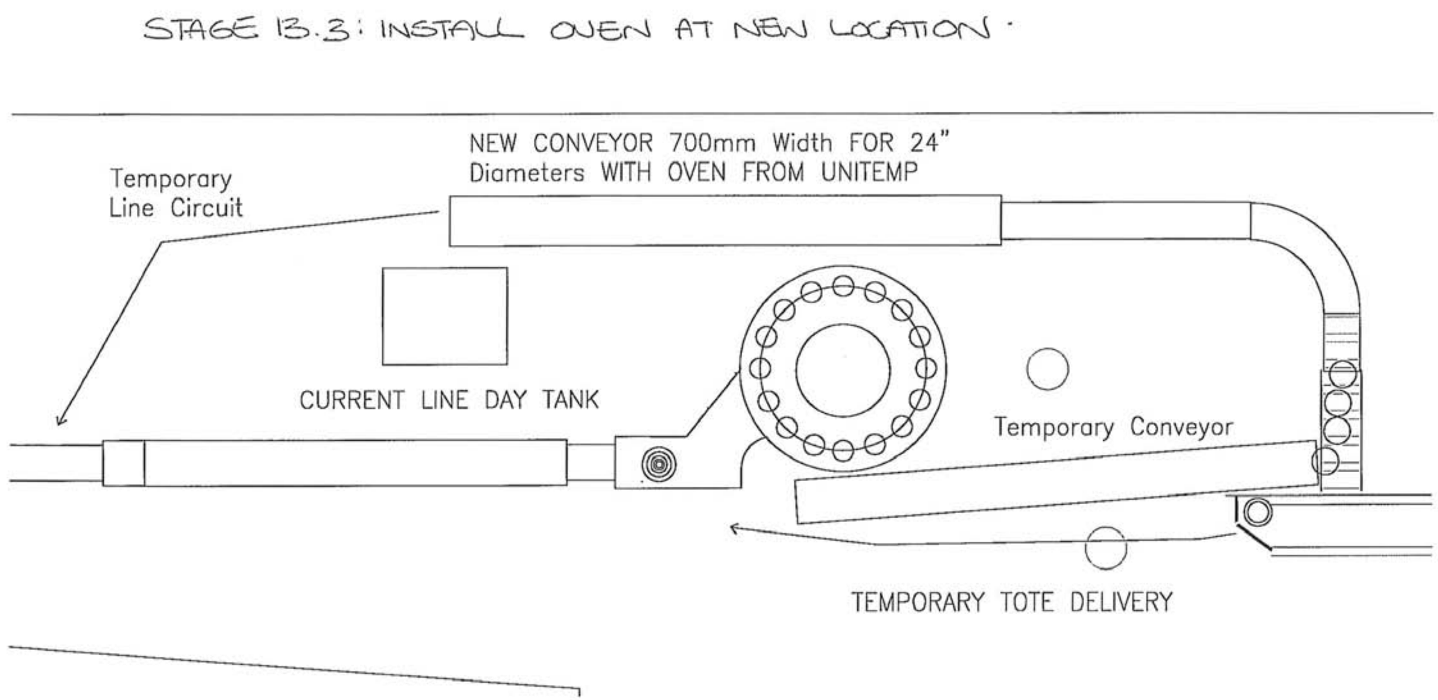


Figure D.15: Stage 13.3

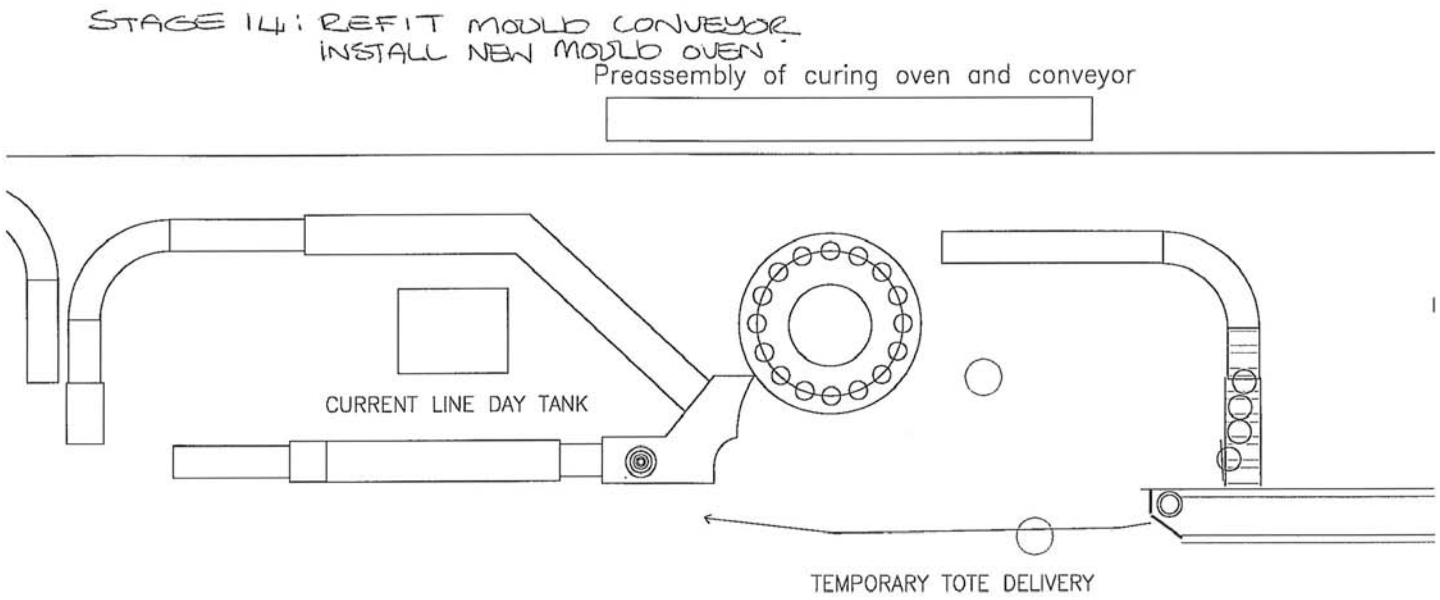


Figure D. 16: Stage 14

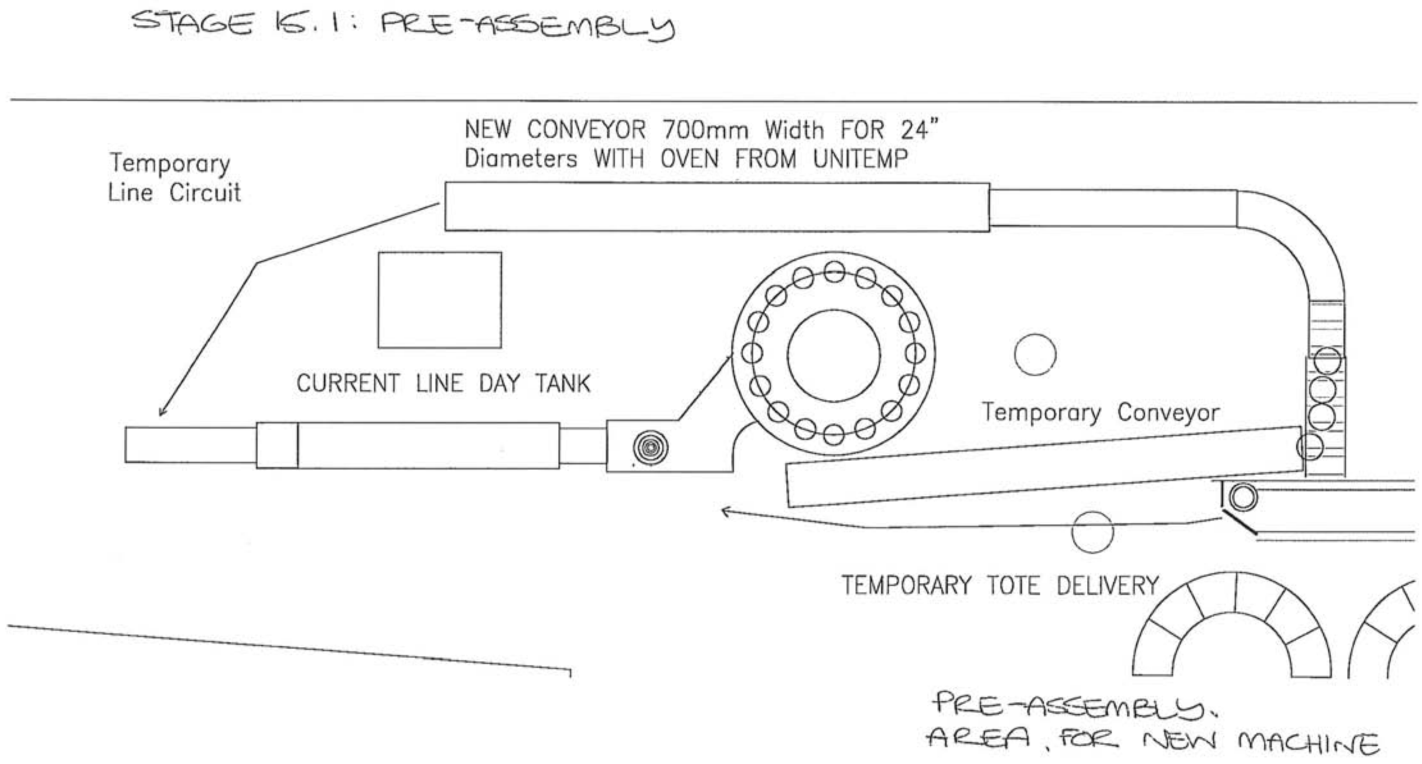


Figure D.17: Stage 15.1

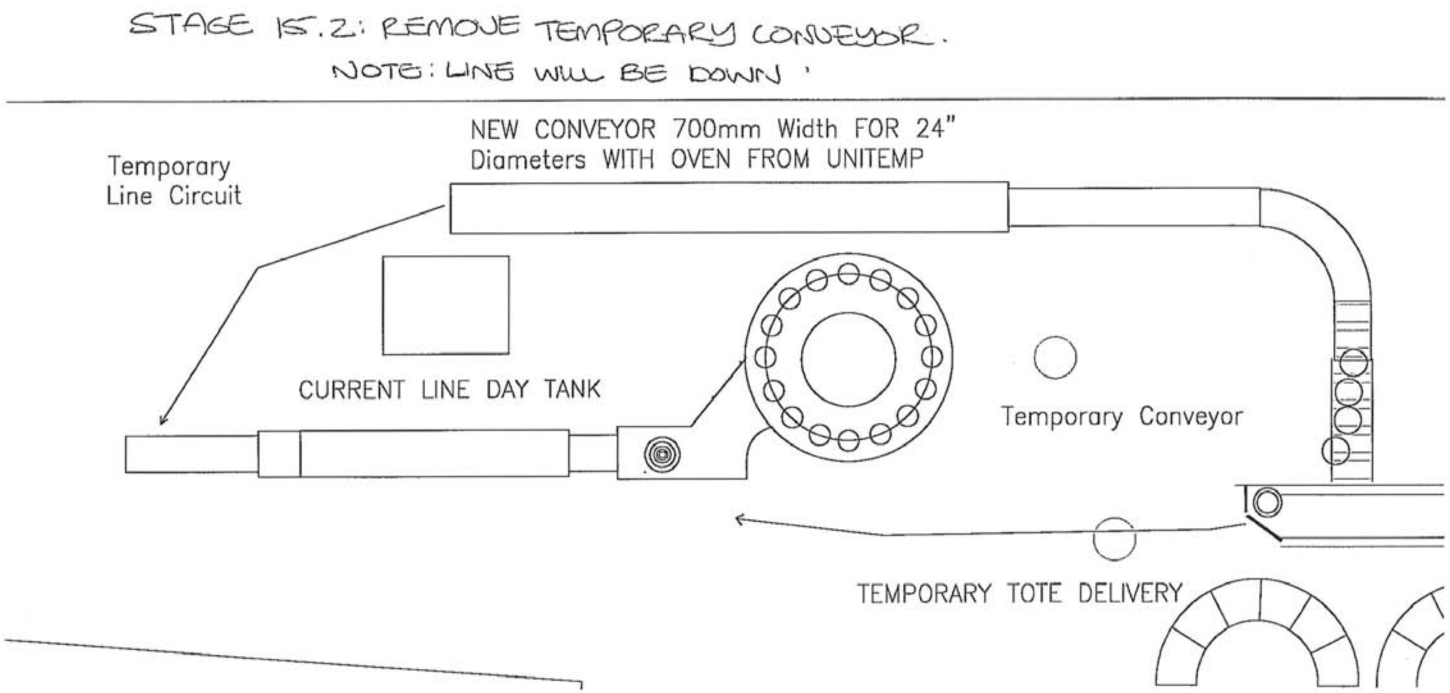


Figure D.18: Stage 15.2

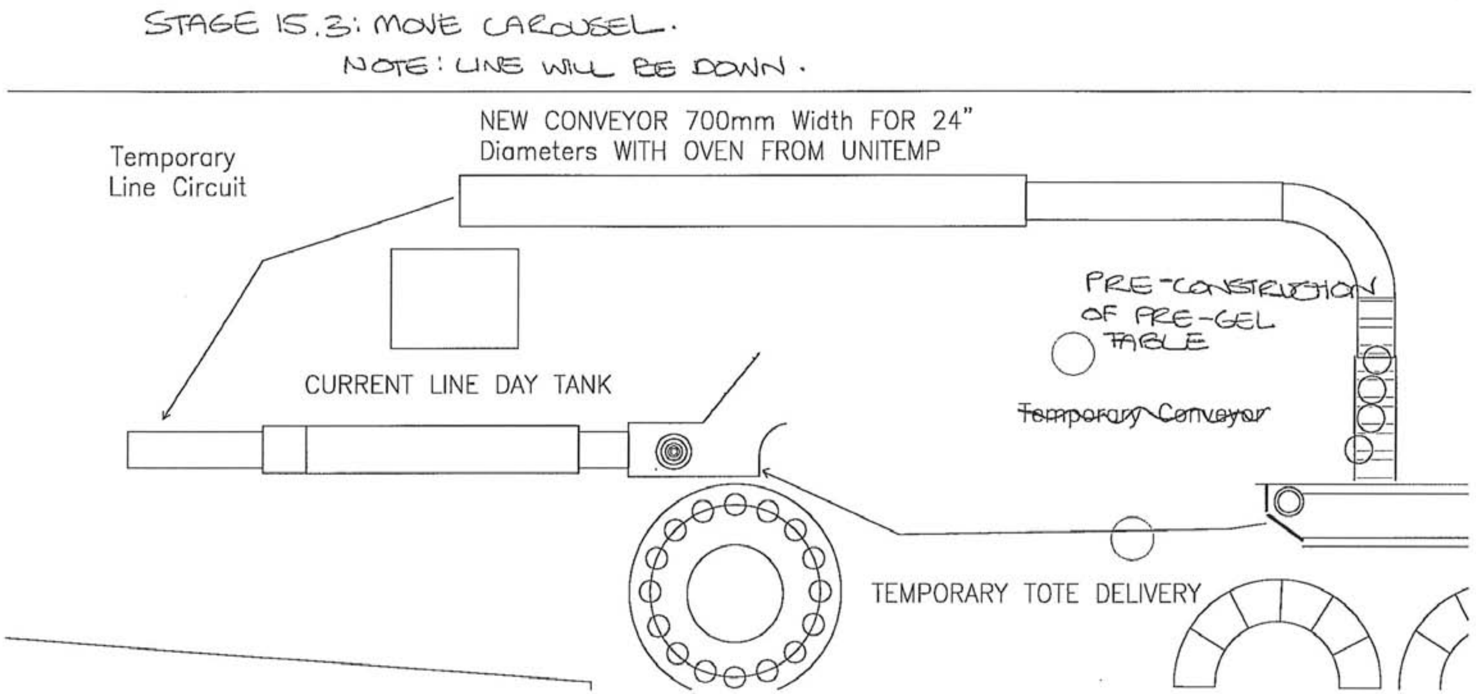


Figure D.19: Stage 15.3

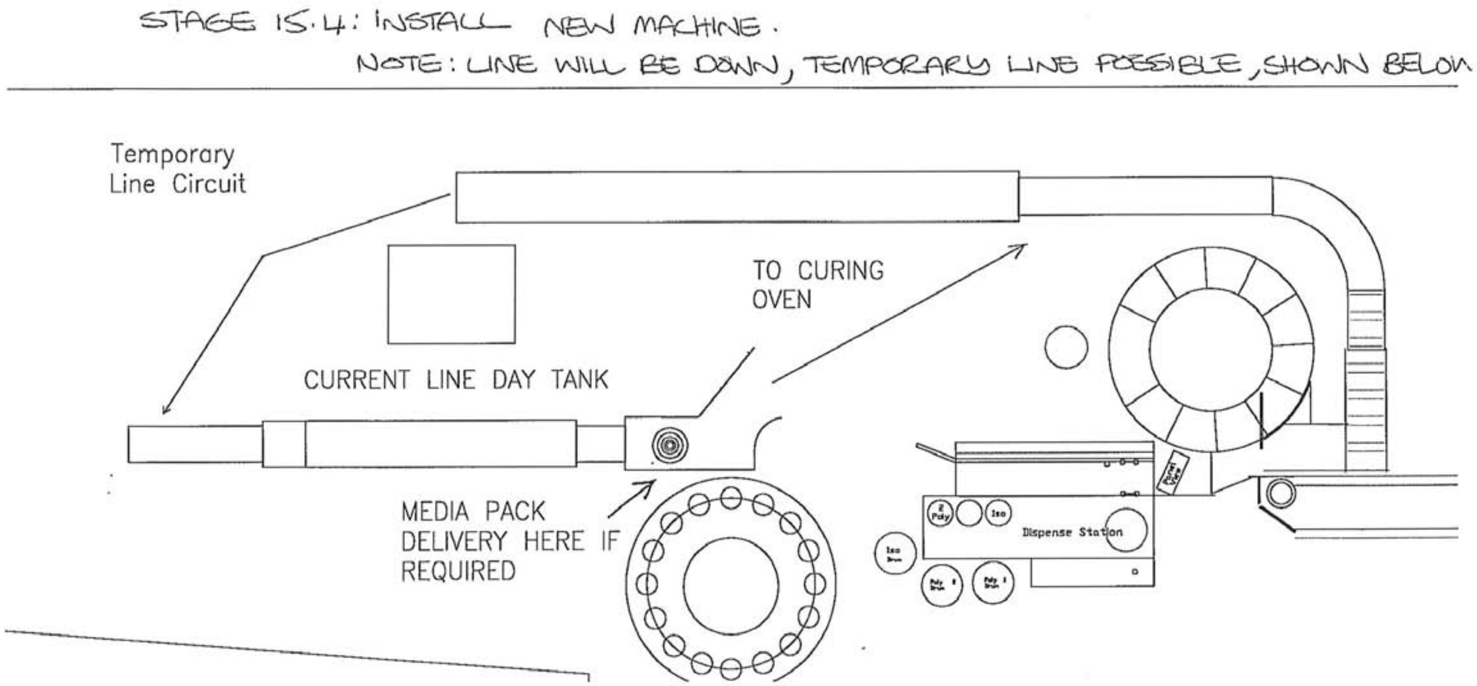


Figure D.20: Stage 15.4

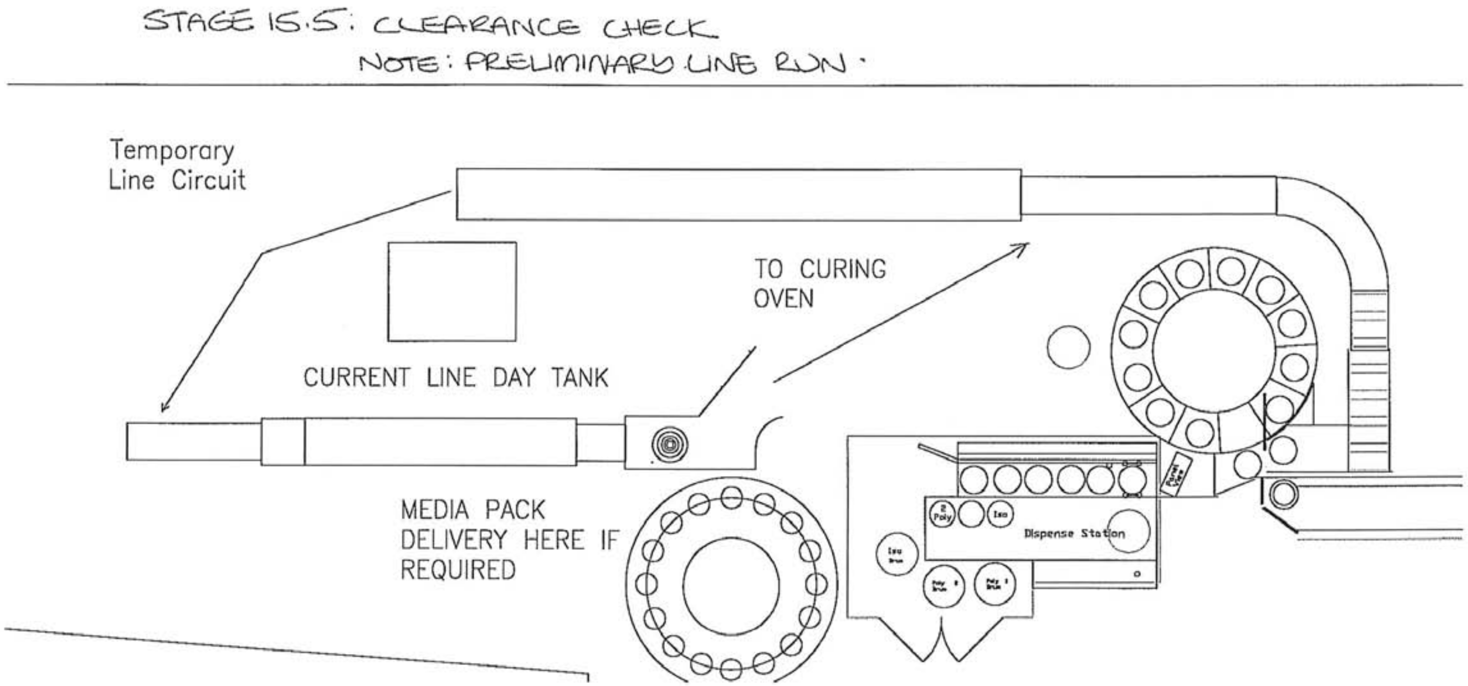


Figure D.21: Stage 15.5

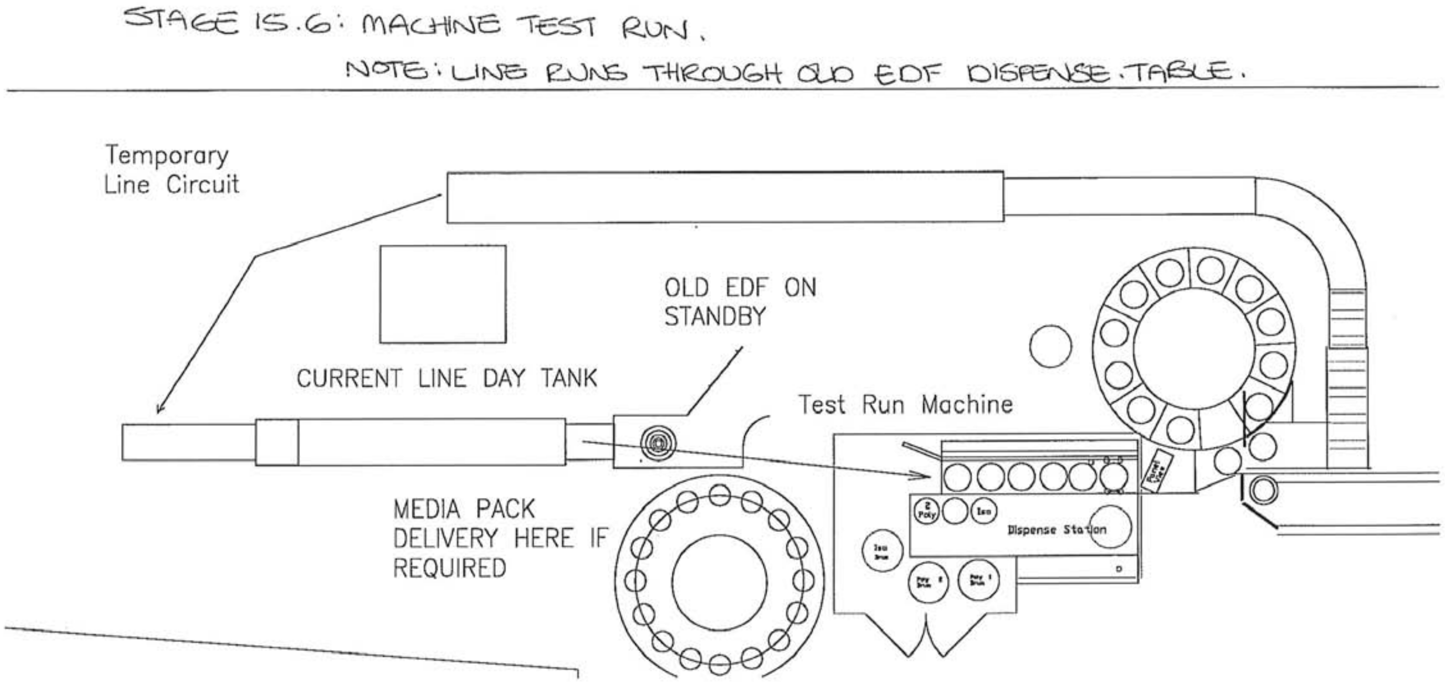


Figure D.22: Stage 15.6

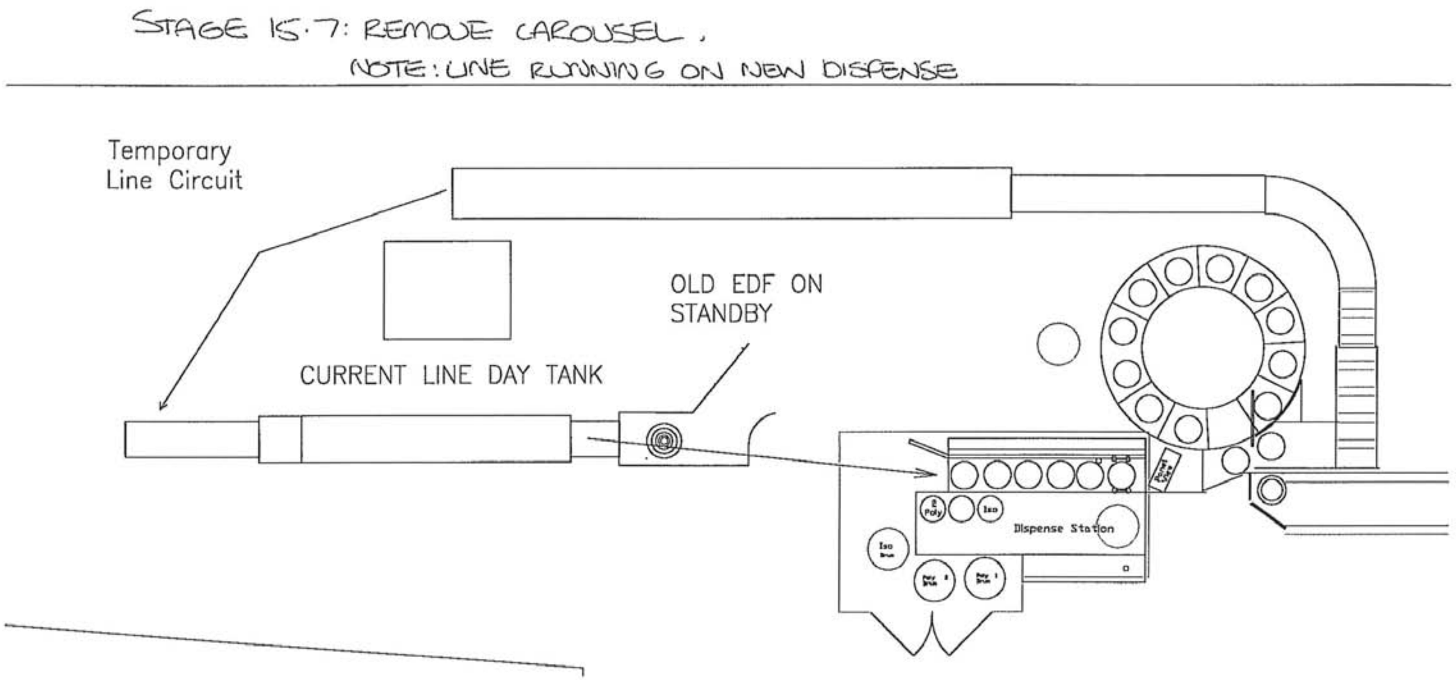


Figure D.23: Stage 15.7

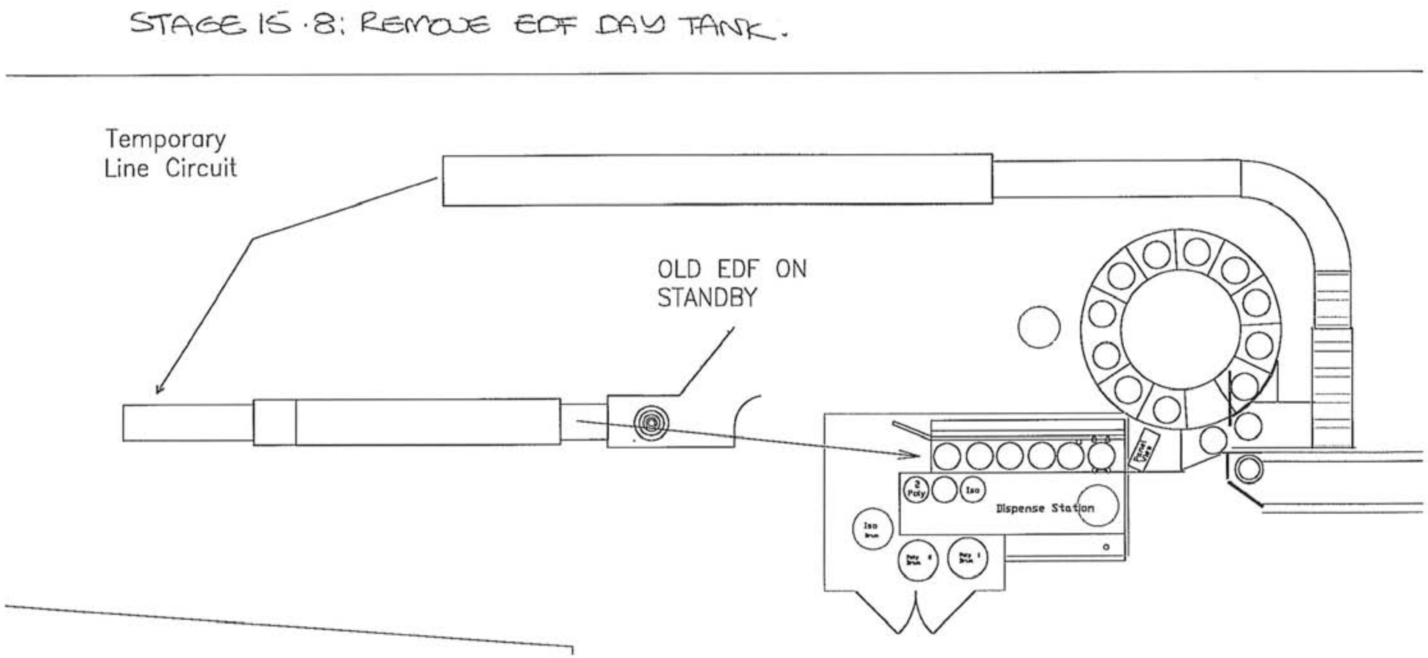


Figure D.24: Stage 15.8

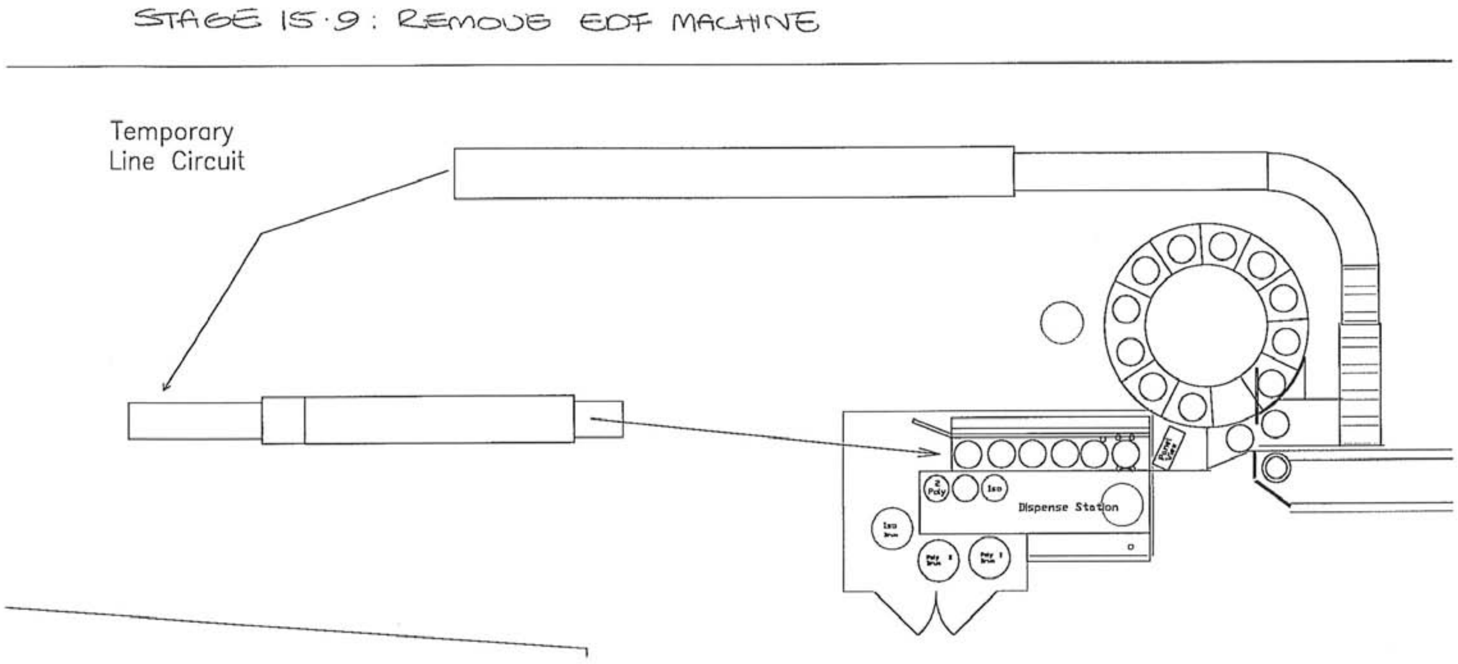


Figure D.25: Stage 15.9

STAGE 15.10: MOVE MOULD OVEN TO FINAL LOCATION.

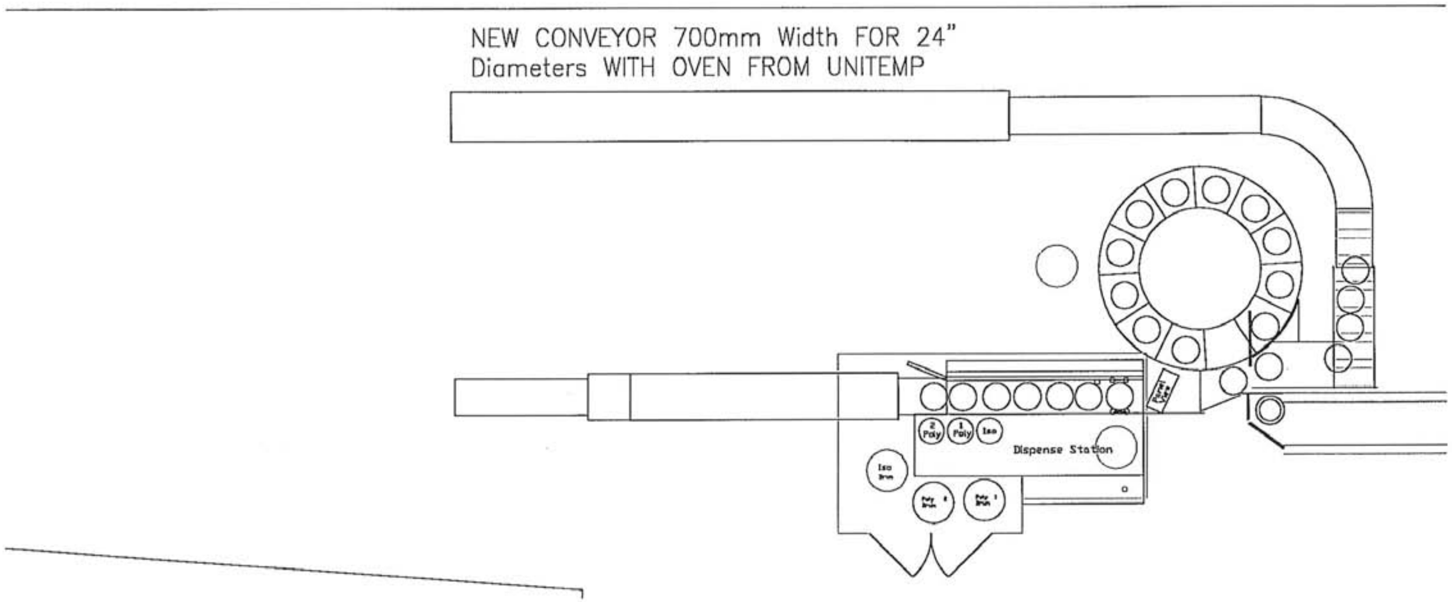


Figure D.26: Stage 15.10

STAGE 16: MOVE CURING OVEN TO FINAL LOCATION

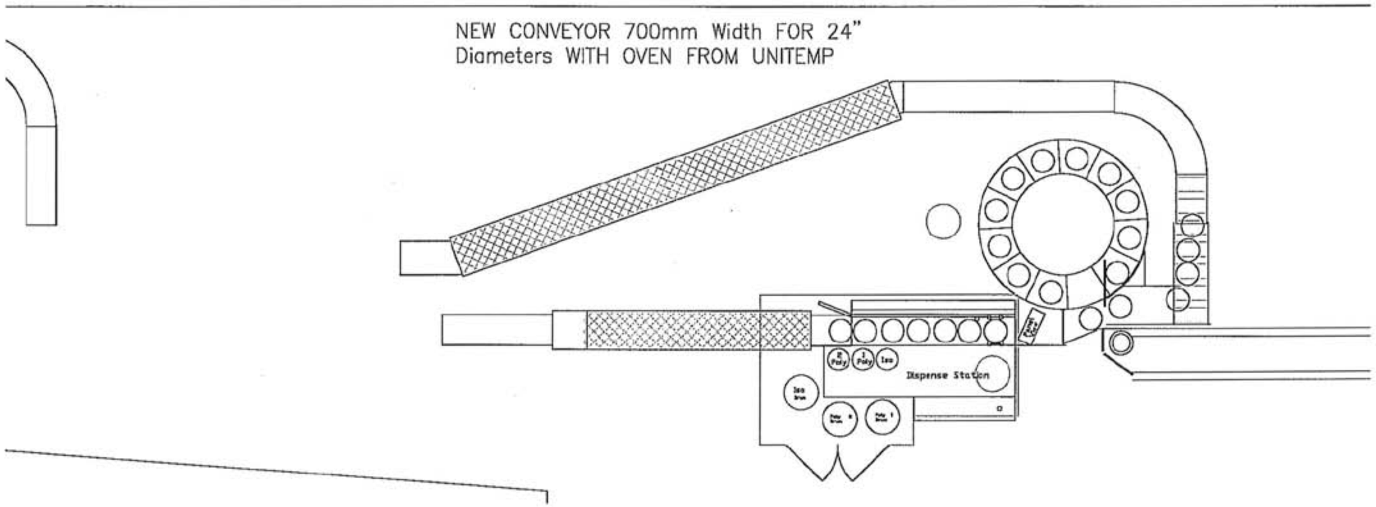


Figure D.27: Stage 16

STAGE 17: SHIFT UP PACKAGING LINE

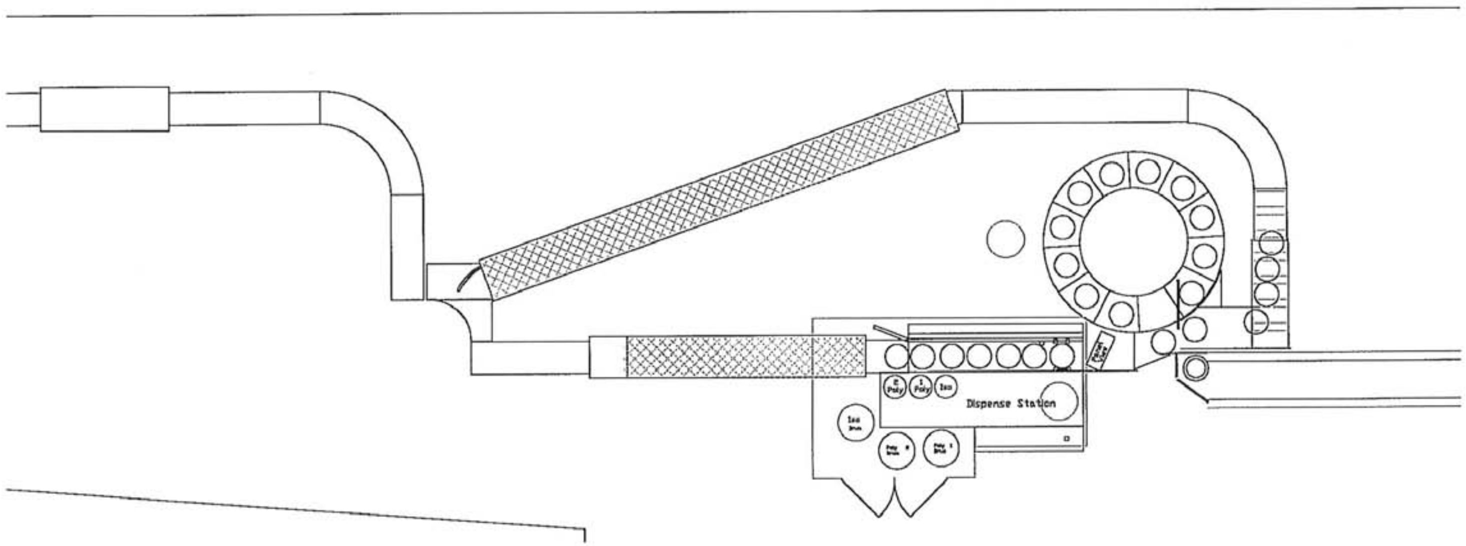


Figure D.28: Stage 17

STAGE 18: HAND OVER LINE.

STAGE 18:

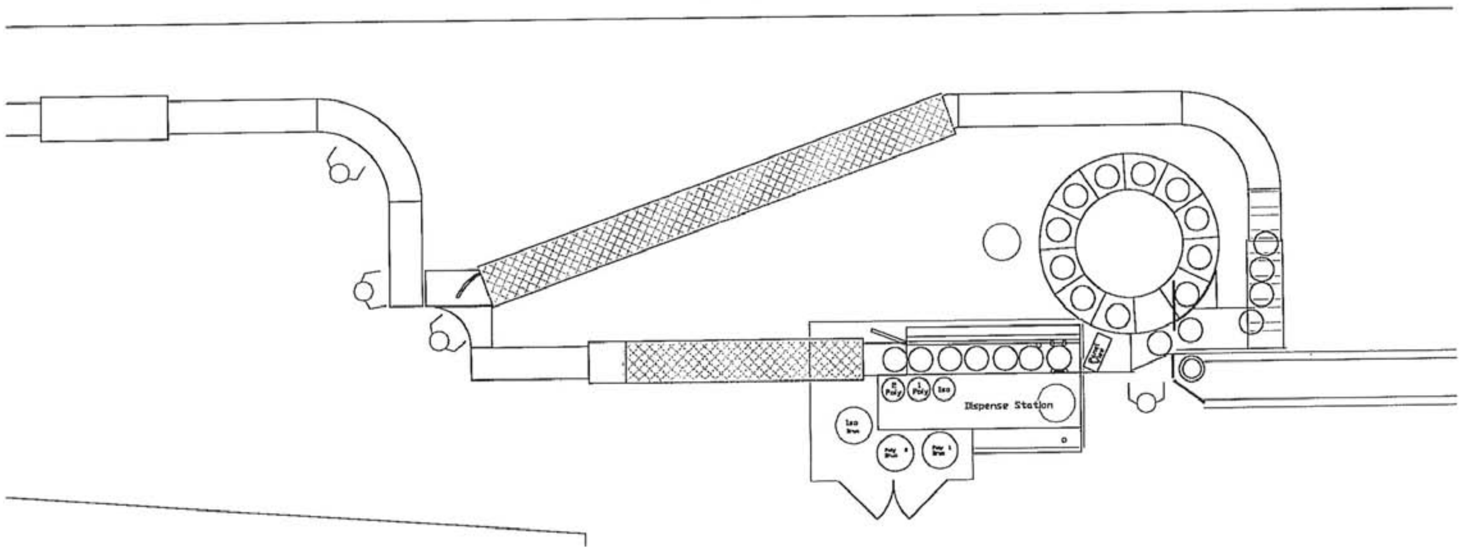


Figure D.29: Stage 18

Appendix E: Loop Data

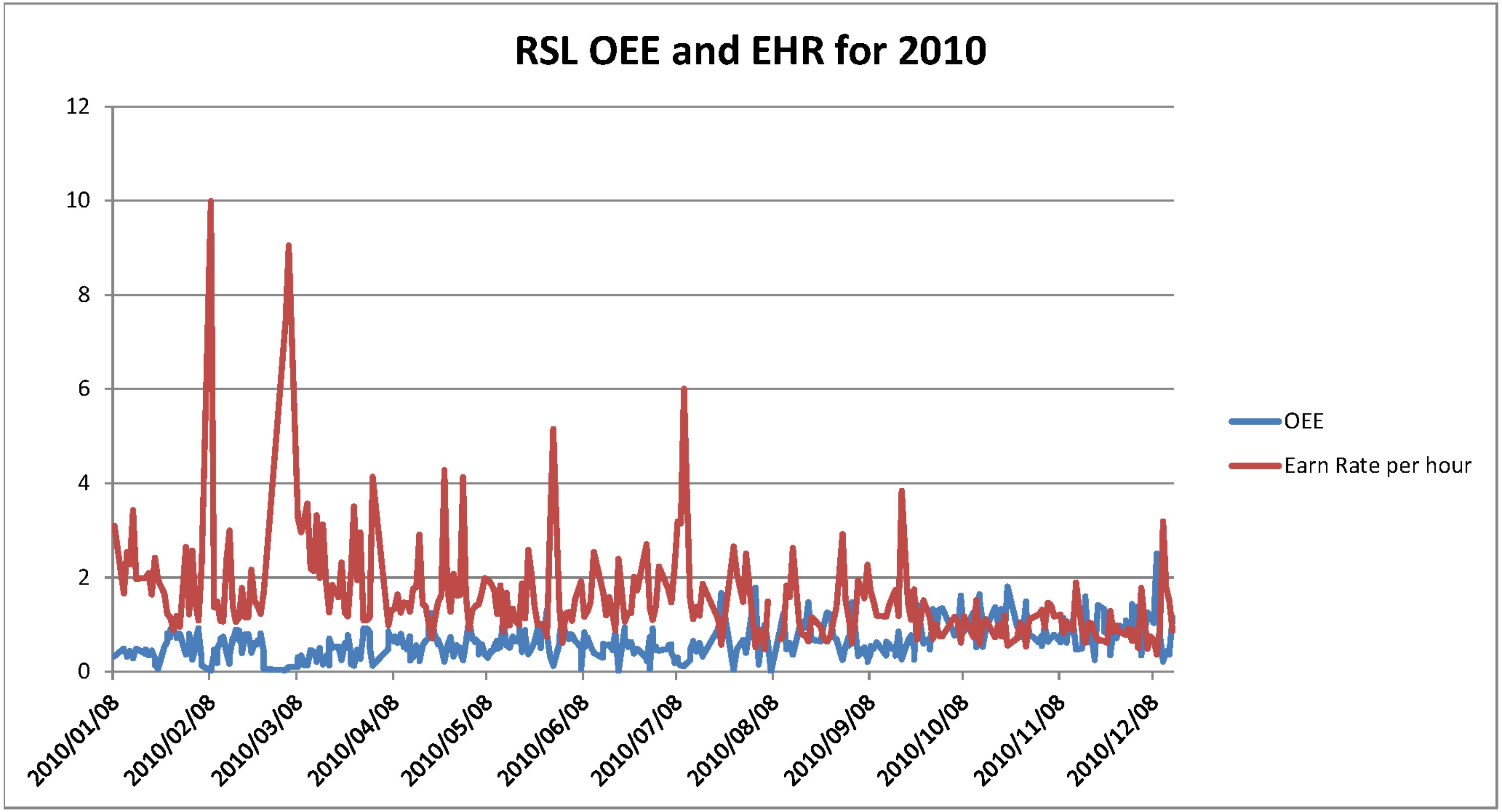


Figure E.1: RSL OEE and EHR data for 2010

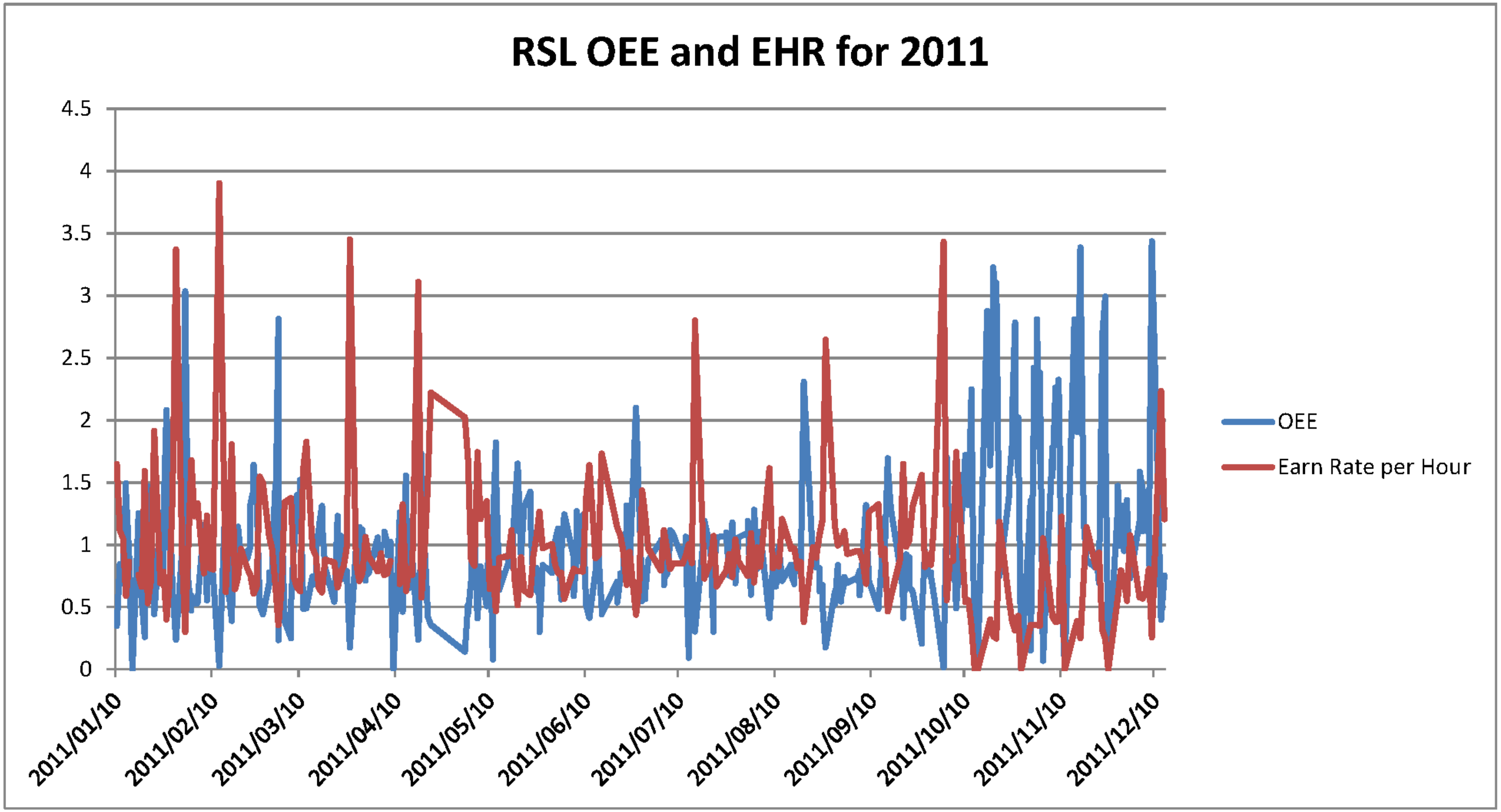


Figure E.2: RSL OEE and EHR Data for 2011

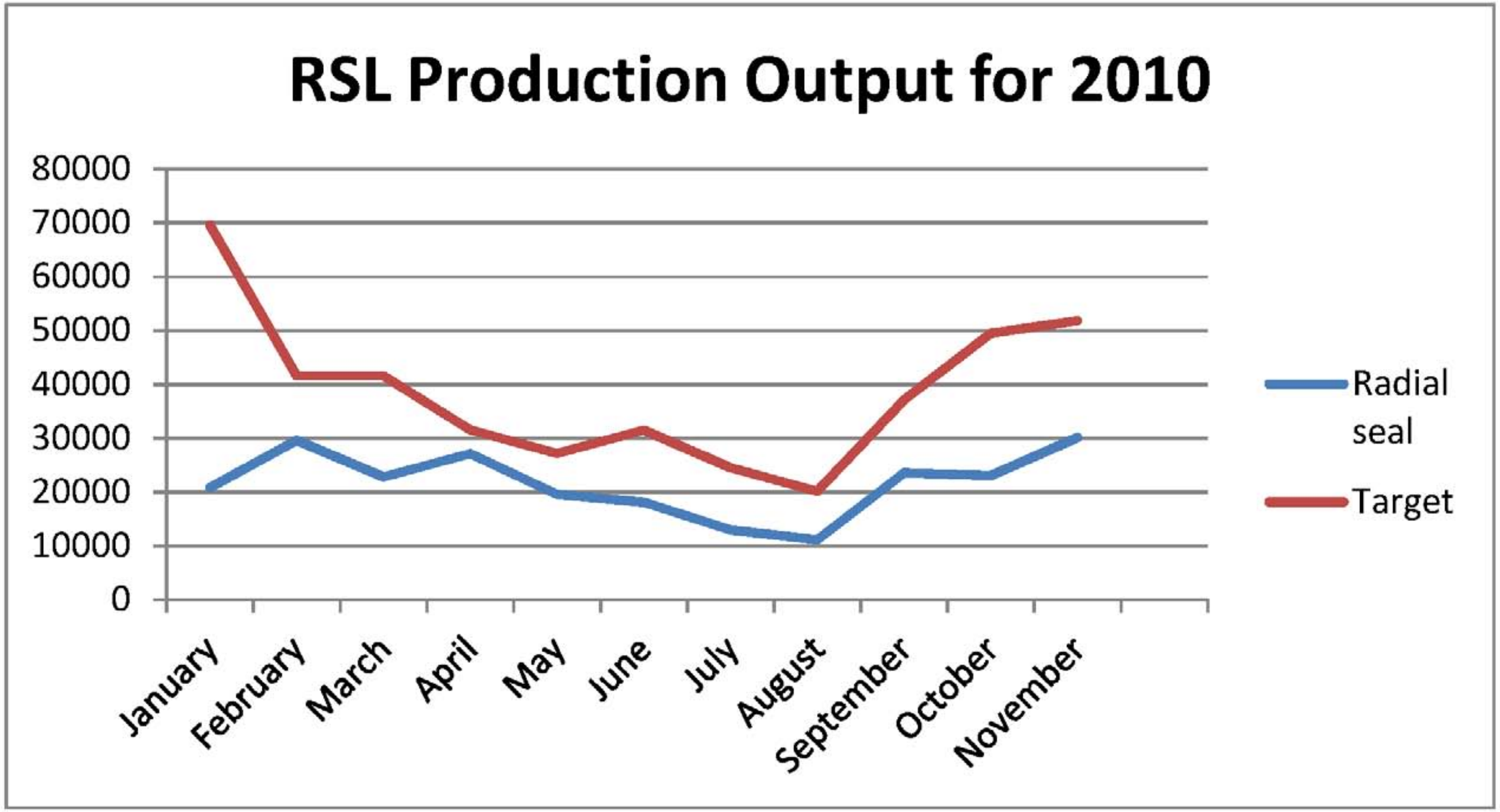


Figure E.3: RSL Production Data for 2010 (Dispense installed August 2010)

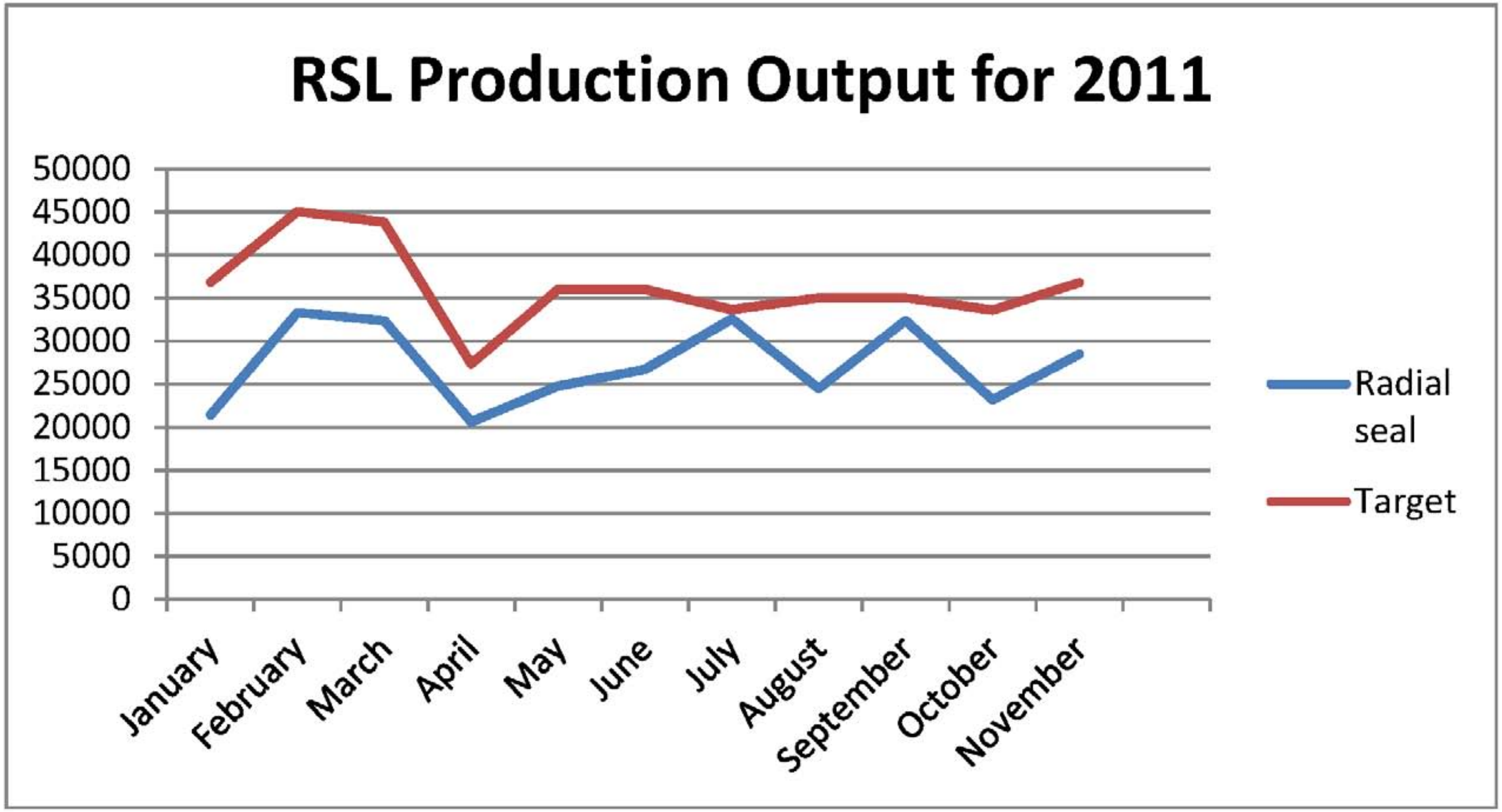


Figure E.4: RSL Production Data for 2011

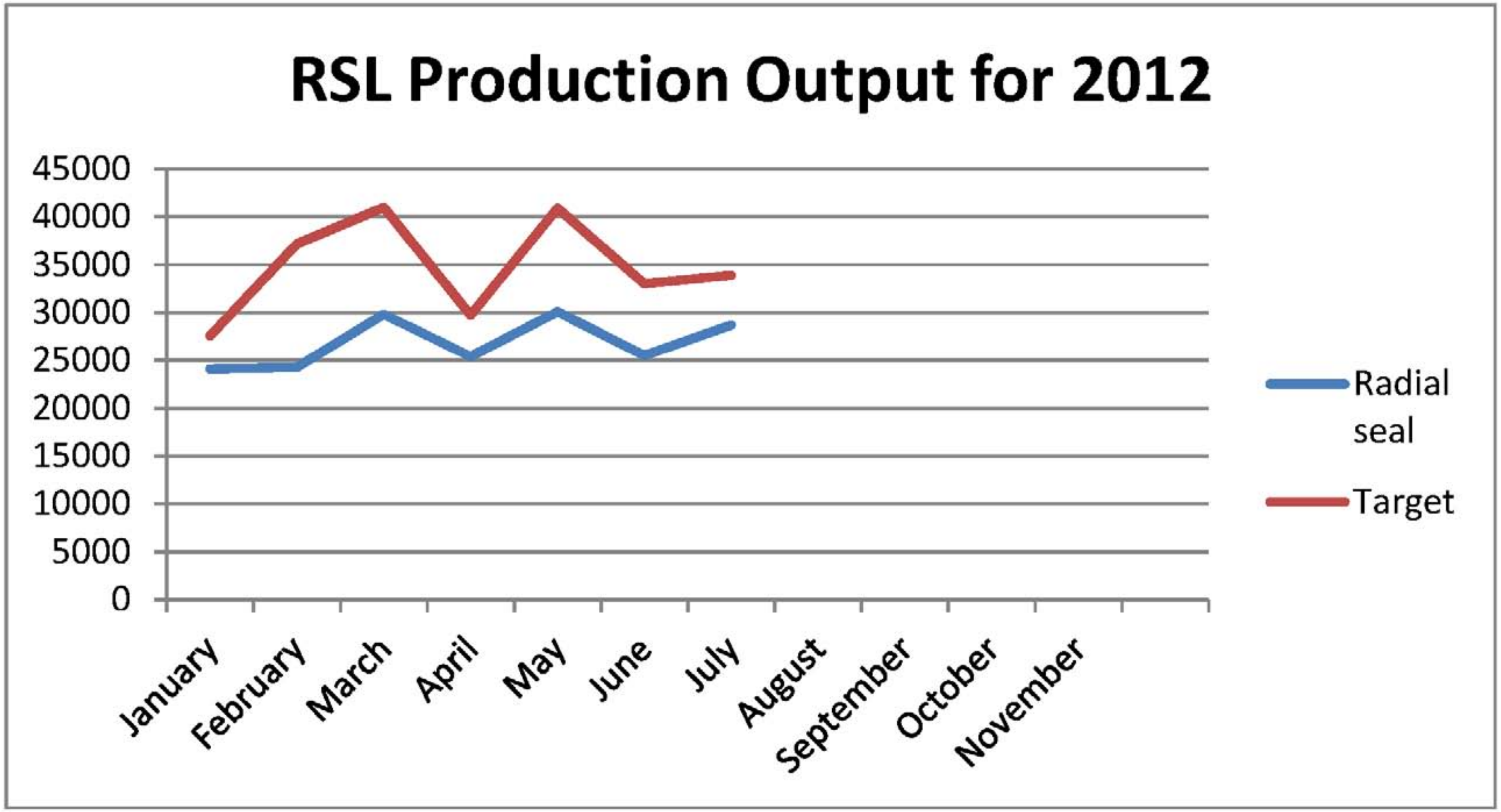
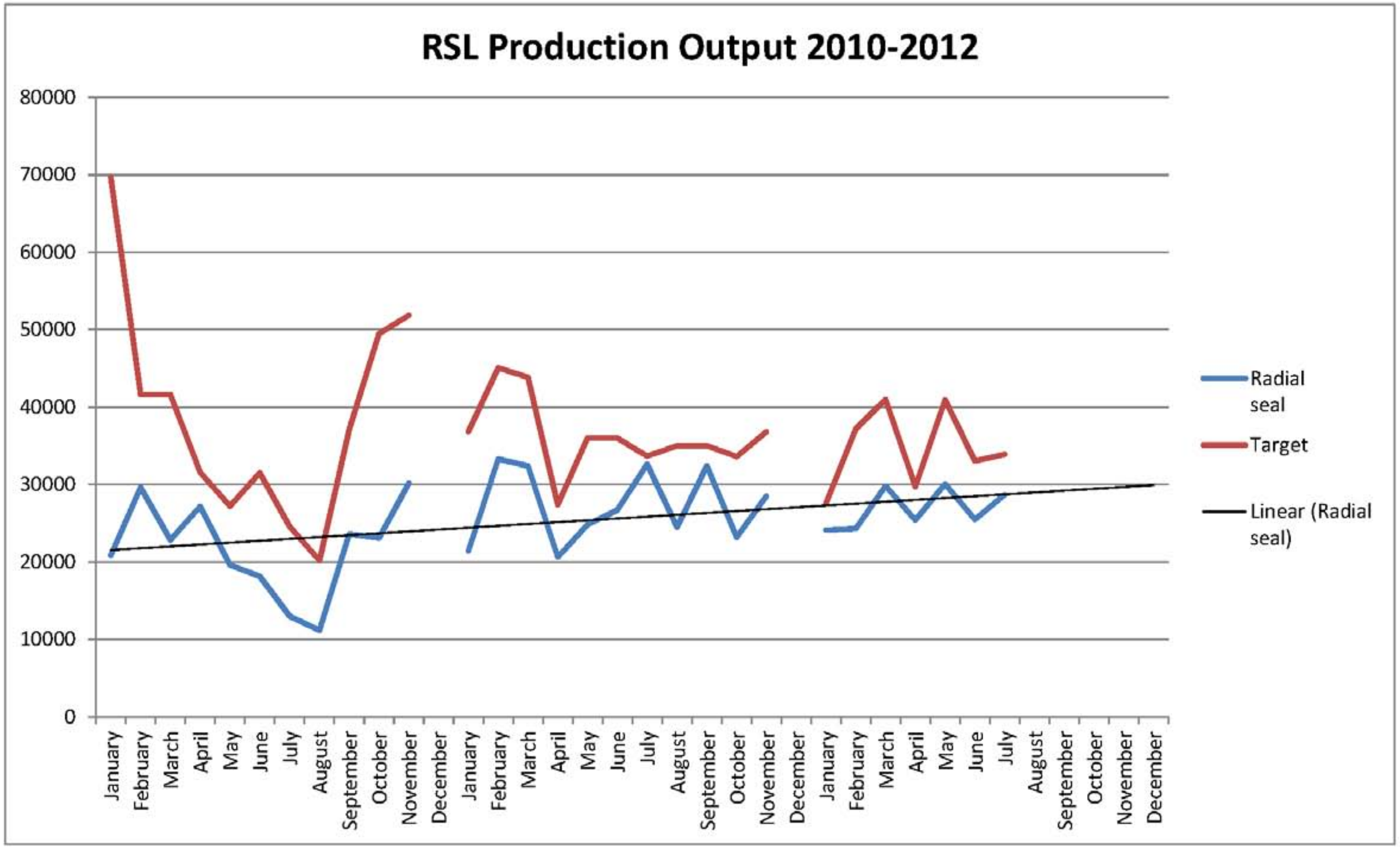


Figure E.5: RSL Production Data for 2012



Loop initiation January 2010

Figure E.6: Combined RSL Production Data Over the Course of the Implementation 2010-2012

(red)	Critical Process
(orange)	Task is done in parallel

Physical Actions Required to Create a Radial Seal Element

Proposed Solution Reference	Total Steps			Value Creating Steps	Total Time	Value Create Time
	1 Line Setup for run					
			1.1 Ensure lights/fans are on			
			1.2 Ensure media roll is on line			
			1.3 Ensure liners are on line (quantity and quality)		540	
			1.4 Ensure media sleeves are on line		540	
			1.5 Ensure next POL/ISO drum is ready for line			
			1.6 Ensure additional POL drum is being mixed			
			1.7 Ensure moulds are on line (70 in tray)			
			1.8 Ensure bags are on line (quantity and quality)		900	
			1.9 Ensure cartons are on line (quantity and quality)		540	
			1.10 Ensure additional plastisol drum is on line		900	
			1.11 Ensure recipe is on dispense			
			1.12 Check/order for consumables cupboard			
			1.13 Reconcile works order			
	2 Pleat media			1	300	20
			2.1 Fetch media from media warehouse			
			2.2 Load media bale(s) for pleater			
			2.3 Set up pre-heater			
			2.4 Set up pleater as per drawing requirement			
			2.5 Set up take away conveyor speed			
			2.6 Turn on light table			
			2.7 Light check media			
	3 Cut media			2	6	6
			3.1 Clean media cut-off		25	
	4 Glue media			3	6	6
			4.1 Set up glue gun		300	
			4.2 Bleed gun		1260	
	5 Seam seal media			4	10	6
			5.1 Set up seam seal blade		300	
	6 Spot weld outer liner	7		5	15	10
			Fetch liners from expanders ---> inspect & accept			
			6.1 (quality & quantity)		600	
			6.2 Set up roller table		120	
			6.3 Set up spot welder		300	
			6.4 Roll outer liner		4	
	7 Spot weld inner liner			6	15	9
			Fetch liners from expanders ---> inspect & accept			
			7.1 (quality & quantity)		600	
			7.2 Set up roller table		120	
			7.3 Set up spot welder		300	
			7.4 Roll inner liner		4	
	8 Media-to-liner			7	20	20
			8.1 Set up media guides		120	
			8.2 Fetch media ring		120	
	9 Flare pack			8	17	17
			9.1 Fetch flare tool		120	
			9.2 Set up flare tool		300	
	10 Dry media			9	-	60
			10.1 Set up media pack oven		20	
			10.2 Set up curing oven and conveyors		20	
			10.3 Set up mould oven and conveyor		20	
	11 Dispense PU		11.1 Dispense PU into open cover	10	20	20
			11.2 Dispense PU into closed cover	11		
			11.6 Check density and cupshots		300	
			11.7 Set up for run		300	
			11.8 First offs (slabs, open cover)		120	
			11.9 Monitor warnings and pressures		10	Ongoing

Table E.1: Latest Iteration of RSL Process Study (1/2)

	11.10 Change nozzle and/or mixer		300	
	11.11 Cure element		480	
12 Demould element			20	
	12.1 Set up demould system		660	
13 Height check element		12	5	5
	13.1 Set up height gauge		300	
	13.2 Calibrate		600	
14 Inkjet print element		13	5	5
	14.1 Set up inkjet printer		1200	
15 Sign off element			38	
16 Hotmelt element	(Not in-line)	14		
	16.1 Set up hot melt			
	16.2 Transfer element to element line			
	16.3 Transfer element to RSL			
17 Bag element		15	20	15
18 Box element		16	20	15
	18.1 Set up boxing machine		120	
19 Palletize				
	19.1 Fetch pallet		60	
	19.2 Set up stretchwrap machine		60	
20				
			13100	214

Table E.1: Latest Iteration of RSL Process Study (2/2)