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MAJOR PROJECT (M6X00417)

**TITANIUM METALS CORPORATION - MEMBRANE PRODUCTS FIRST STAGE
GRINDING DOWNTIME REDUCTION**

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DECLARATION OF AUTHENTICITY

This thesis is the result of the author's original research. It has been composed by the author and has not been previously submitted for examination which has led to the award of a degree.

Signed: A Curtis

Date: 16/05/20

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ABSTRACT

This project focuses on a significant loss to revenue sustained at TIMET Swansea Plant during year quarter two 2019. When, a miss of \$273,000 had been attributed to a constraint within the Membrane Products process route. The constraint, or bottleneck had been identified at the First Stage Grinding process. The objective of this project was to reduce this constraint by improving the reliability of the Hoffman filtration system, which had been found to be the major contributor. A potential project return of \$235,000 per annum was estimated at project launch, based on a conservative 75% improvement to the First Stage Grinding Filtration processes reliability.

The model chosen to structure this project was the DMAIC framework; which contains tools to drive problem-solving within Lean Six Sigma projects. The approach is frequently applied to existing processes that require an improvement in some way and provides tools to collect, analyse and present data. The processes Analyse phase, identified many potential causes for Hoffman filter failure. However, consensus from the project team established the root cause of the problem as a recent change of the metal working fluid (MWF) used within the process. The new type of MWF had altered the process requirements for the filtration system, possibly expanding these requirements outside that of the Hoffman filter's capability. The Hoffman filter could not reliably process the new MWF at the required flow rate after contamination. Following on through the DMAIC roadmap resulted in the final solution of the procurement of a new filtration system, which could be designed for the application and built in line with current technologies.

The project briefly outlines the successful Capital Appropriation Request for the new filters and follows the project through to taking delivery of the new filters. Unfortunately, The Covid-19 pandemic significantly impacted the project and any further work is on hold. The planned next steps for the project were for the new filter suppliers to attend site and complete the installation, comissioning and TIMET operator training. However, TIMET Swansea plant's prohibition of contractors has prevented this for the foreseeable future. Progress on the DMAIC Control Phase and any additional project work has been affected by a significant reduction in TIMET's engineering staff through furlough and sickness. The focus for the remaining engineering staff has now been realigned to statutory, legislation and essential plant requirements. The Oberlin filter project was deemed non-essential to TIMETs business needs at this current time.

PROJECT TIMING PLAN

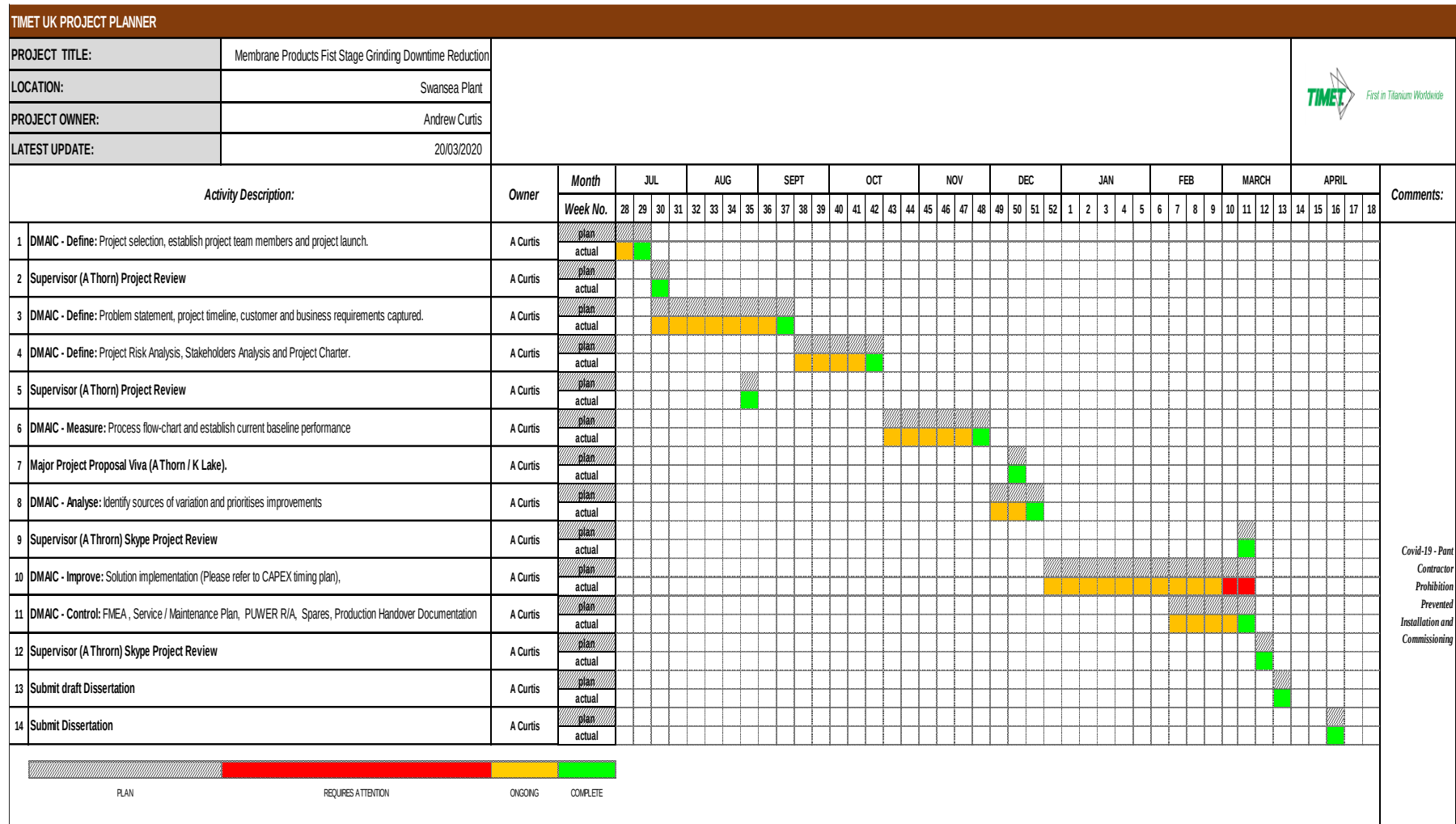


TABLE OF CONTENTS

DECLARATION OF AUTHENTICITY	1
ACKNOWLEDGMENTS.....	2
ABSTRACT	3
PROJECT TIMING PLAN	4
LIST OF FIGURES.....	7
LIST OF TABLES.....	8
CHAPTER 1 - INTRODUCTION.....	9
1.1 TITANIUM METALS CORPORATION.....	9
1.2 PROJECT OVERVIEW.....	9
1.2.1 Project Aims and Objectives.....	11
1.2.2 Project Relevance and Benefits.....	11
1.2.4 Model and Methodology.....	13
CHAPTER 2 – LITERATURE REVIEW.....	13
2.1 SIX SIGMA METHODOLOGY: AN OVERVIEW	13
2.2 METALWORKING FLUID FILTRATION: AN OVERVIEW	17
2.3 HOFFMAN FILTRATION SYSTEM CURRENT STATE: AN OVERVIEW	26
CHAPTER 3 - DEFINE	29
3.1 PROJECT SELECTION MATRIX	29
3.2 PROBLEM STATEMENT.	31
3.3 SIPOC PROCESS MAP	31
3.4 STAKEHOLDERS ANALYSIS	34
3.5 PROJECT RISK ANALYSIS	36
3.6 PROJECT CHARTER.....	38
3.7 TOLLGATE REVIEW:	41
CHAPTER 4 - MEASURE	41
4.1 PROCESS FLOW CHART	41
4.2 DETERMINE BASELINE PERFORMANCE AND KEY METRICS.....	43
4.2.1 Data Source.....	43
4.2.1 Graphical Analysis.....	43
4.2.3 Establishing Key Metrics	46
4.3 TOLLGATE REVIEW	48
CHAPTER 5 – ANALISE PHASE.....	48

5.1 FIX THE OBVIOUS	48
5.2 CAUSE AND EFFECT ANALYSIS	50
5.3 MULTI-VOTING (N/3) TECHNIQUE.....	52
5.4 PARETO ANALYSIS	52
5.5 FIVE WHY ANALYSIS	53
5.5 TOLLGATE REVIEW	58
CHAPTER 6 - IMPROVE PHASE.....	58
6.1 GENERATE POTENTIAL SOLUTIONS	58
6.1.1 Solution Selection Matrix	59
6.2 SOLUTION IMPLEMENTATION	63
6.2.1 Source, Install and Pilot Study an Alternative Vacuum System	63
6.2.2 Confirmation of Metalworking Fluid Flow Rates	64
6.3.3 Capital Acquisition of New Filtration Systems.....	65
4.3 TOLLGATE REVIEW	75
CHAPTER 7 - COVID-19 PROJECT IMPACT	75
CHAPTER 8 - CONTROL PHASE.....	76
8.1 TOLLGATE REVIEW	76
CHAPTER 9 - CONCLUSION	77
CHAPTER 10 - RECOMMENDED FOR FURTHER WORK.....	79
REFERENCE LIST	80
APPENDICES.....	83
APPENDIX 1: TIMET ENGINEERING STRUCTURE	83
APPENDIX 2: EFCO GRINDER PRE-USE INSPECTION	84
APPENDIX 3: OBERLIN FILTER EMAIL CORRESPONDENCE (MARTIN WILKINSON)	85
APPENDIX 4: OBERLIN FILTER EMAIL CORRESPONDENCE (JEREMIAH TRINONE).....	86
APPENDIX 5: OBERLIN FILTER CAPITAL APPROPRIATION REQUEST.....	87
APPENDIX 6: OBERLIN FILTER CAPITAL APPROPRIATION REQUEST - QUOTES.....	98

LIST OF FIGURES

FIGURE 1: FIRST STAGE GRINDING AND HOFFMAN FILTRATION KEY ATTRIBUTES	10
FIGURE 2: HOFFMAN FILTRATION TYPICAL BREAKDOWN AND COOLANT OVERFLOW EVENT	10
FIGURE 3: DMAIC PROCESS - PHASES, OBJECTIVES AND TOLLGATES (MONTGOMERY AND WOODALL, 2008).....	14
FIGURE 4: DMAIC PROCESS STATISTICAL TOOLS (HAHN, 2002).....	15
FIGURE 5: METHODS OF METALWORKING SOLID SEPARATION (ASTAKHOV AND JOKSCH, 2012).	18
FIGURE 6: TYPICAL SETTLING TANK ARRANGEMENT (BRANDT, 2006; ASTAKHOV AND JOKSCH, 2012)	21
FIGURE 7: TYPICAL HYDRO-CYCLONE ARRANGEMENT (BRANDT, 2006).....	21
FIGURE 8: TYPES OF DISPOSABLE MEDIA (BRANDT, 2006)	23
FIGURE 9: MULTIPLE CARTRIDGE HOUSING ARRANGEMENT (ASTAKHOV AND JOKSCH, 2012).....	23
FIGURE 10: GRAVITY SEPARATION DEVICE (ASTAKHOV AND JOKSCH, 2012).....	24
FIGURE 11: VACUUM SEPARATION DEVICE (ASTAKHOV AND JOKSCH, 2012).....	25
FIGURE 12: PRESSURE-DRIVEN SYSTEM (ASTAKHOV AND JOKSCH, 2012)	26
FIGURE 13: HOFFMAN FILTRATION PROCESS FLOW DIAGRAM (INTERFIL.COM., 2020).	27
FIGURE 14: HOFFMAN FILTRATION WORK FLOW DIAGRAM (INTERFIL.COM., 2020).....	27
FIGURE 15: HISTOGRAM CHART TO ILLUSTRATE PROJECT SELECTION MATRIX RESULTS.....	31
FIGURE 16: PROCESS FLOW CHART KEY (MICROSOFT.COM, 2020)	42
FIGURE 17: FIRST STAGE GRINDING PROCESS FLOW CHART (MICROSOFT.COM, 2020).....	42
FIGURE 18: EFCO ONE DOWNTIME ANALYSIS	44
FIGURE 19: EFCO TWO DOWNTIME ANALYSIS	44
FIGURE 20: FIRST STAGE GRINDING COMBINED DOWNTIME ANALYSIS	45
FIGURE 21: STRATEGICAL PLACEMENT OF INDIVIDUAL DRIP TRAYS	48
FIGURE 22: HOFFMAN FILTERS PRIOR TO DRIP TRAY INSTALLATION	49
FIGURE 23: HOFFMAN FILTER DRIP TRAY INSTALLATION	49
FIGURE 24: FIRST STAGE GRINDING FAILURE CAUSE AND EFFECT DIAGRAM (DOGETT, 2005; BROOK, 2014).....	51
FIGURE 25: FIRST STAGE GRINDING – HOFFMAN FILTER PARETO ANALYSIS (BROOK, 2014).	52
FIGURE 26: HISTOGRAM TO DISPLAY SOLUTION SELECTION MATRIX RANKING SCORE.....	62
FIGURE 27: RADAR CHART TO DISPLAY SOLUTION SELECTION MATRIX CRITERION RANKING	62
FIGURE 28: COMPATIBLE CENTRIFUGAL PUMP INSTALLATION AND TRIAL	63
FIGURE 29: CONTROLGEAR VACUUM SYSTEM INSTALLATION AND TRIAL.....	64
FIGURE 30: EFCO MWF FLOW METER.....	65
FIGURE 31: OBERLIN FILTER LTD FIELD TEST TRIAL	66
FIGURE 32: PROJECT PAYBACK PERIOD CHART (EFINANCIALMODELS.COM, 2020).....	68
FIGURE 33: HIGH-LEVEL CAPEx PROJECT PLAN	70
FIGURE 34: OBERLIN FILTER INSTALLATION PLAN AND DETAILED PRODUCTION IMPACT	71
FIGURE 35: PROPOSED LAYOUT OF OBERLIN FILTERS	73
FIGURE 36: OBERLIN FILTER LINEAR DRAINAGE INSTALLATION	74
FIGURE 37: OBERLIN FILTER DELIVERY AND OFFLOADING.....	74
FIGURE 38: OBERLIN FILTER PLACEMENT.....	74

LIST OF TABLES

TABLE 1: FIRST STAGE GRINDING DOWNTIME COST METRIC CALCULATION	11
TABLE 2: HOFFMAN FILTRATION DOWNTIME COST CALCULATION	12
TABLE 3: HOFFMAN FILTRATION BREAKDOWN – CONTRACT CLEANER COST	12
TABLE 4: HOFFMAN FILTRATION BREAKDOWN – ENGINEERING CRAFT LABOUR COST	12
TABLE 5: HOFFMAN FILTRATION – ADDITIONAL OPERATOR REQUIREMENT TO RECOVER CUSTOMER NEEDS COST.....	12
TABLE 6: HOFFMAN FILTRATION TOTAL BREAKDOWN COSTS SUMMARY	12
TABLE 7: PROJECT SELECTION MATRIX (SIGMAPRO, 2020).	30
TABLE 8: SIPOC DIAGRAM OF FIRST STAGE GRINDING PROCESS (SIGMAPRO, 2020).....	33
TABLE 9: PROJECT STAKEHOLDER COMMUNICATION PLAN (SIGMAPRO, 2020).	35
TABLE 10: PROJECT STAKEHOLDER ANALYSIS (SIGMAPRO, 2020).	36
TABLE 11: PROJECT RISK ANALYSIS (SIGMAPRO, 2020).	37
TABLE 12: PROJECT RISK MATRIX (SIGMAPRO, 2020).	38
TABLE 13: PROJECT CHARTER (SIGMAPRO, 2020).	39
TABLE 14: PROJECT CHART CONTINUED (SIGMAPRO, 2020).	40
TABLE 15: TIMET’S MAINTENANCE HISTORY REPORT SAMPLE (CURTIS, 2020).	43
TABLE 16: FIRST STAGE GRINDING PROCESS BASELINE KEY METRICS (CURTIS, 2020; EPSILONENGINEER.COM, 2020).	47
TABLE 17: FIVE WHY ANALYSIS - COOLANT TYPE CAUSE (BROOK, 2014; CARD, 2017).....	54
TABLE 18: FIVE WHY ANALYSIS - VACUUM SYSTEM CAUSE (BROOK, 2014; CARD, 2017).	55
TABLE 19: FIVE WHY ANALYSIS - COOLANT FLOW RATE CAUSE (BROOK, 2014; CARD, 2017).	56
TABLE 20: FIVE WHY ANALYSIS – MEDIA GRADE / MATERIAL CAUSE (BROOK, 2014; CARD, 2017).	57
TABLE 21: SOLUTION SELECTION MATRIX	61
TABLE 22: PROJECT RETURN ON INVESTMENT METRIC	68

CHAPTER 1 - INTRODUCTION

1.1 TITANIUM METALS CORPORATION

Titanium Metals Corporation, or more commonly known from the company trademark TIMET. Is a supplier of titanium and metal products, which has been operating since the 1950s and supplying nearly one-fifth of the world's titanium. TIMET was purchased for \$2.9 billion by Precision Castparts Corporation (PCC) in November 2012 and now operates under the PCC Metals Group Division. In January 2016, PCC became a subsidiary of Berkshire Hathaway and sells products directly from the United States and Europe, as well as through independent agents and distributors worldwide. The monthly average number of employees operating at TIMET UK is 627, which is inclusive of the directors. The turnover for the year ended 30 December 2018 was £227.2m, generating an operating profit of £6.7m. Which was a significant reduction from the previous year, when an operating profit of £41m was disclosed. This was justified through Companies House as being attributed to a fatal accident at the Witton Plant in 2017, which resulted in plant and machinery damage causing significant downtime. Consequently, the organisation had received support from other TIMET group companies during this period of reinstatement, which resulted in higher operating costs (Curtis, 2020; Timet.com, 2020; Companyhouse.gov.uk, 2020).

TIMET has two plants operating from within the United Kingdom, one based in the West Midlands at Witton and the second in South Wales at Swansea. The Witton Plant manufactures titanium base by melting the raw materials necessary for titanium ingot manufacture. Witton additionally forges these ingots into either billet or slab form, which are then transported to the Swansea Plant for processing. The Swansea Plant further processes the titanium base into mill products such as bar, sheet and plate; which is often further customised to near net shapes and finished components through secondary manufacturing processes. Titanium, has a combination of unique metallurgical properties such as strength, light weight and corrosion resistance; that are ideal for use in the chemical, aerospace, industrial and emerging application markets (Curtis, 2020; Timet.com, 2020).

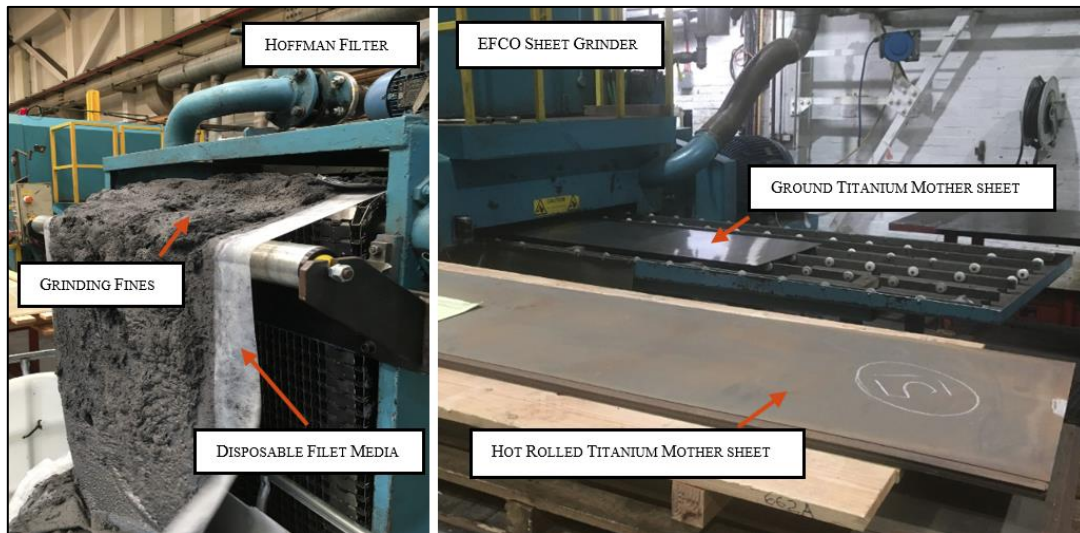
1.2 PROJECT OVERVIEW

This report details the analysis and actions undertaken in response to a significant loss to revenue sustained at TIMET Swansea Plant during year quarter two (Q2) 2019. When, a miss of \$273K had been attributed to a constraint within the Membrane Products process route. The constraint, or bottleneck within the process had been identified at the First Stage Grinding process.

The First Stage Grinding process at TIMET Swansea consists of two assets; EFCO Sheet Grinder One and Two, which are abrasive belt grinding machines. The function of each machine is to remove the bulk material and alpha scale from hot rolled titanium flats. The swarf produced during the grinding

process at these machines is in the form of fines, or often referred to as ‘sponge’. Which requires filtering from the metalworking fluid (MWF) used during the process. The MWF filtration is provided by two Hoffman filtration systems, which had been identified as the main cause of the lost productivity, and had been determined to have caused 57% of the downtime at First Stage Grinding from repeated failures.

Figure 1: First Stage Grinding and Hoffman Filtration Key Attributes



A Hoffman filtration failure would often result in the complete loss of the First Stage Grinding Cell. As a typical failure would result in an overflow event, where coolant would spill out from the top of the filter and flood the surrounding area. This event would often raise safety concerns, which had been escalated through the TIMET’s incident reporting procedure.

Figure 2: Hoffman Filtration Typical Breakdown and Coolant Overflow Event



1.2.1 PROJECT AIMS AND OBJECTIVES

The objective of this project was to reduce the constraint within the Membrane Process route caused by First Stage Grinding. The project's aim was to improve the reliability of the Hoffman filtration system and reduce the downtime sustained through repeated failures. Successful delivery of the project could potentially improve Membrane Products throughput and on time delivery by 57%. The deliverables established to ensure the success of the project and to meet the objectives can be summarised as follows:

- Implement an immediate short-term solution to mitigate the safety concerns or hazards, as a result of Hoffman filter failure and the associated MWF spillages.
- Implement immediate short-term solution to prevent or reduce the potential further loss to the organisation.
- Analyse and establish the root cause of the Hoffman Filtration repeated failures.
- Implement long-term solution to improve the reliability of the process.
- Capitalise on further opportunities presented throughout the development of the project, provided that the opportunities are within the project scope.

1.2.2 PROJECT RELEVANCE AND BENEFITS

The advantages and gains that will be delivered through the successful completion of this project have been determined by calculating the total cost of the Hoffman Filtration downtime. Table 1 through to Table 6 illustrates the calculations used to ascertain the costs associated to:

- Lost productivity
- Additional operator requirement to recover customer needs (labour at premium rates).
- Engineering craft labour requirement to repair and recover machines from breakdown.
- Contract Cleaner labour requirement to return the work area to a safe working environment (clean up coolant spillages).

Table 1: First Stage Grinding Downtime Cost Metric Calculation

FIRST STAGE GRINDING DOWNTIME COST METRIC			
RUN RATE = 1.25 / hr	AVG. PRICE PER PANEL	HOURLY LOST PRODUCTION COST	SHIFT LOST PRODUCTION COST (11.25hrs)
14	\$2,332.86	\$2,916.08	\$32,805.87

Table 2: Hoffman Filtration Downtime Cost Calculation

HOFFMAN FILTRATION DOWNTIME COST CALCULATED - WEEKS 1-24		
MACHINE	HOFFMAN FILTER DOWNTIME Hrs	LOST PRODUCTION
EFCO1	33.25	\$96,959.58
EFCO2	14.75	\$43,012.14
	TOTAL	\$139,971.72
	ANNUAL FORCASTED LOSS	\$303,272.06

Table 3: Hoffman Filtration Breakdown – Contract Cleaner Cost

HOFFMAN FILTRATION - CONTRACTOR COST (CLEANERS)				
CLEANER RATE / HOUR	AVG. OVERTIME CLEANER RATE / HOUR	NO. OF EVENTS x 2 MEN x 1 Hr	WEEK 1-24	ESTIMATED ANNUAL FORECAST
\$11.88	\$17.81	86	\$1,531.88	\$3,319.06

Table 4: Hoffman Filtration Breakdown – Engineering Craft Labour Cost

HOFFMAN FILTRATION - REPAIR LABOUR COST (ENGINEERING CRAFT)				
ENG CRAFT RATE / HOUR	AVG. OVERTIME ENG CRAFT RATE / HOUR	COMBINED DOWNTIME EFCO1 + EFCO2	WEEK 1-24	ESTIMATED ANNUAL FORECAST
\$23.13	\$34.69	48	\$1,665.00	\$3,607.50

Table 5: Hoffman Filtration – Additional operator requirement to recover customer needs Cost.

HOFFMAN FILTRATION - LOST PRODUCTION RECOVERY LABOUR COST (OPERATOR).				
AVG. OPERATOR RATE / HOUR	AVG. OVERTIME OPERATOR RATE / HOUR	COMBINED DOWNTIME EFCO1 + EFCO2	WEEK 1-24	ESTIMATED ANNUAL FORECAST
\$22.03	\$33.04	48	\$1,585.80	\$3,435.90

Table 6: Hoffman Filtration Total Breakdown Costs Summary

HOFFMAN FILTRATION DOWNTIME TOTAL COST SUMMARY	
DIRECT COSTS	ESTIMATED ANNUAL FORECAST
LOST PRODUCTIVITY	\$303,272.06
PRODUCTION OVERTIME COSTS TO RECOVER LOST SALES AND MEET CUSTOMER'S NEEDS	\$3,435.90
ENGINEERING CRAFT REPAIR LABOUR COST	\$3,607.50
CONTRACT CLEANING LABOUR COST	\$3,319.06
TOTAL	\$313,634.52

The evaluation of these costs has provided a means to establish a potential project return of \$235K per annum. This value is based on a conservative 75% improvement to the Hoffman Filtration process reliability, however, further opportunities from a reduction in filter media usage, coolant usage and waste disposal costs may be realised before project completion.

1.2.4 MODEL AND METHODOLOGY

The model chosen to structure this project was the DMAIC framework; often referred to as a roadmap, which contains tools to drive problem-solving within Lean Six Sigma projects. DMAIC is an acronym of define, measure, analyse, improve and control. The framework is a structured problem-solving methodology that builds on each sequential phase to provide long-term solutions to difficult problems. The define phase will determine what needs to be measured; the measure phase will identify what needs to be analysed; the analyse phase will highlight what needs to be improved and so forth. The approach is frequently applied to existing processes that require an improvement in some way and provides techniques to collect, analyse and present data (Theodore, 2019).

CHAPTER 2 – LITERATURE REVIEW

2.1 SIX SIGMA METHODOLOGY: AN OVERVIEW

Montgomery and Woodall (2008) describe Six Sigma as a disciplined, project-oriented, statistically based approach for reducing variability, removing defects, and eliminating waste from products, processes, and transactions. The Six Sigma methodology and the drive to produce higher quality products at lower prices was originated through necessity by Motorola because of competitive market conditions and the need to survive. The change happened when a Japanese organisation took over a Motorola factory in the United States during the 1970s. Under the new Japanese management, who promptly set about making drastic changes in the way the factory operated. The factory started producing television sets with 1/20th of the number of defects that were produced under the Motorola management. This was accomplished using the original workforce, technology and designs, and established that the problem was Motorola's management. Motorola's CEO during this time was Bob Galvin, who steered the organisation into the new quality path known today as Six Sigma and became a business icon as a result.

Since its origin, Six Sigma has evolved through three generations of implementations. Generation I focused on basic variability reduction and the elimination of defects, which was mainly in manufacturing and originated in Motorola. Generation II continued the emphasis on variability and defect elimination; however, these initiatives were aligned to projects and activities that improved business performance through cost reduction and improvements to product design. General Electric is often cited as the leader of the Generation II phase of Six Sigma. In Generation III an additional focus on creating value throughout the organisation and for its stakeholders (employees, suppliers, owners, customers, and society at large) is included. Creating this value within an organisation can involve

expanding markets, improving job retention, innovation and new product developments, increasing stock prices, or improving customer satisfaction levels (Srinivasan et al., 2016).

Most implementations of Six Sigma use a framework known as DMAIC for project management. However, DMAIC is not formally allied to SIX Sigma and can be a very useful approach to management of change and improvement. The framework is a generalisation of Walter Shewhart's Plan-Do-Check-Act cycle, which provides a roadmap to help people understand how to integrate various tools into an approach to quality improvement. DMAIC is an acronym for five interconnected phases: define measure, analyse, improve and control (Selvi and Majumdar, 2014).

Figure 3: DMAIC Process - Phases, Objectives and Tollgates (Montgomery and Woodall, 2008)

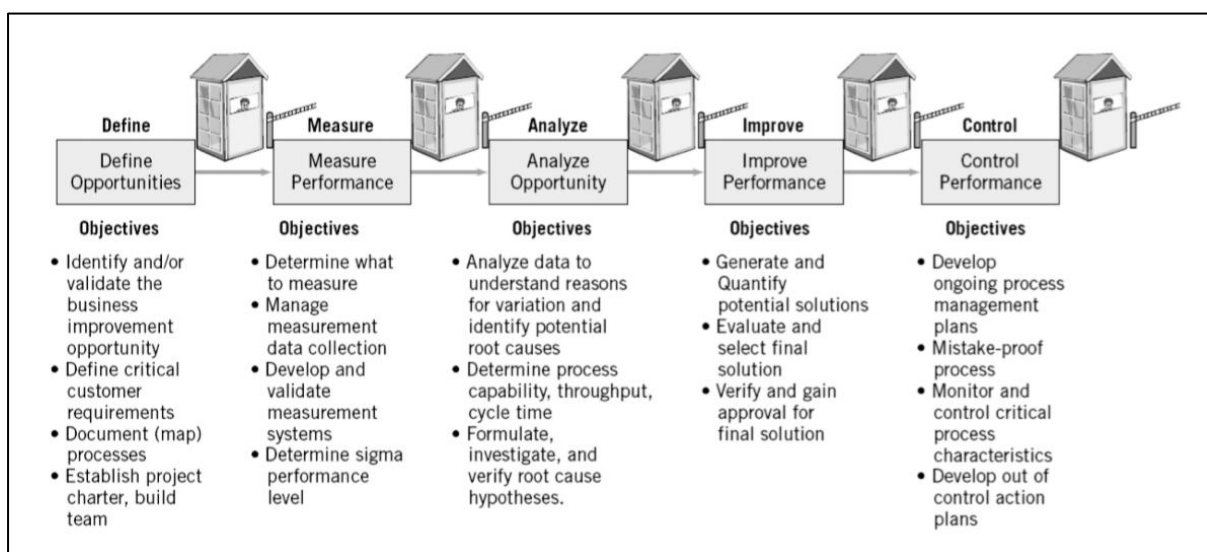


Figure 3 illustrates the DMAIC process and identifies a tollgate between each stage on the roadmap. The function of the DMAIC tollgate is to provide the project team with opportunities to present project findings and results to managers and process owners. The reviews can be used to evaluate whether the team can successfully complete the project on time and budget, and strategies for dealing with any organisational problems or barriers to success can be established. The tollgate also prevents the team from transitioning into the next phase before all the requirements of the current phase have been met (Montgomery and Woodall, 2008).

Contained within each DMAIC phase there is a selection of statistical tools which can be utilised based on their applicability to the project. Figure 4 illustrates the most prominent tools utilised within each phase. This list is not conclusive, and other tools, or different variations on the ones listed are occasionally used within DMAIC. Some books on Six Sigma have given useful overviews of many of these other tools; for example, see George (2002) and Snee and Hoerl (2005). Pande et al. (2002)

provided a full explanation of the non-technical aspects of the DMAIC process, while Hahn (2002) provided hands-on guidance.

Figure 4: DMAIC Process Statistical Tools (Hahn, 2002)

Tool	Define	Measure	Analyze	Improve	Control
Project charter	X				
Process maps & flow charts	X	X			
Cause and effect analysis		X			
Process capability analysis		X			
Hypothesis tests, confidence intervals			X		
Regression analysis, other multivariate methods			X		
Gauge R&R		X			
Failure mode & effects analysis			X		
Designed experiments			X	X	
SPC and process control plans		X	X		X

Define Phase: Srinivasan et al. (2016) states that the objective of this phase is to identify the project opportunity and validate that it represents legitimate breakthrough potential. The project must be important to both customers (critical to quality) and the business (core business process involved). A focused problem statement must be developed describing in measurable terms what the project will deliver. The project team will create a charter to identify team members, stakeholders and the scope of the project (project boundaries) will be agreed. This phase is completed when the team develops a process map that includes the process's inputs and outputs.

Measure Phase: The measure phase is used to evaluate and understand the current state of the process. This may involve collecting data on throughput, measures of quality, cost and so forth. Pande et al. (2002) describes the importance of developing a list of all the key process variables (KPIV) and the key process output variables (KVOV). These variables may have been identified tentatively during the Define phase, but must be verified and measured during the DMAIC Measure phase. Establishing key metrics and data collection are important tasks; there must be sufficient data to allow for a thorough analysis and understanding of current process performance with respect to key metrics. The data collected during this phase may be presented in various way such as histograms, run charts, scatter diagrams and Pareto charts.

Analyze Phase: The objectives of this phase are to use the data from the Measure phase to determine the cause-and-effect relationships in the process and to identify the sources of variability. Sources of variability can be separated into common causes and assignable causes. Removing a common cause of variability often involves changing a process in some way. Whilst removing an assignable cause involves eliminating a specific problem. Examples of common cause of variability are inadequate training or processing insurance claims, whereas an assignable cause could be a tool failure on a machine. The Analyze phase has many statistical tools that are potentially useful in determining

sources of variability. Amongst these are graphical data displays, control charts, hypothesis testing and confidence interval estimation, regression analysis, designed experiments, and failure modes and effects analysis. The purpose of the Analyse phase is to examine and understand relationships between process variables and to develop potential process improvements. A list of specific opportunities and root causes that are targeted for action in the Improve step should be developed. Improvement strategies will be further developed and actually tested in the Improve step (George, 2002).

Improve Phase: By transitioning through the previous phases; KPIVs and KPOVs have been identified, which data to collect and how it is to be displayed for analysis has been determined, and potential sources of variability and how to interpret the data has been established. In the Improve phase, the team use creative thinking to find specific changes that will positively influence the process and achieve the desired outcome. Again, a broad range of tools are available to help the team make the right decisions. Redesigning the process to improve work flow and reduce bottle necks and work-in-process, will make extensive use of flow charts and possibly value stream mapping. Often, mistake proofing can be advantageous to a process. Or, designed experiments can be used to determine which are the optimum factors to implement to influence the outcomes of a process. The objectives of the Improve step are to develop solutions to the problem and evaluate which solution or solutions to implement (Selvi and Majumdar, 2014; George, 2002).

Control Phase: The objectives of this phase are to complete all outstanding work and hand over the process improvement to the process owner. This phase focuses on establishing control measures to ensure all project gains are sustained. A process control plan is often used to outline the necessary procedures that need to be adhered to prevent the process from returning to the 'old ways'. The process owner should be provided with the before and after data on the key project metrics, operational and training documents, and updated process maps. The financial benefits to the improvement should be quantified and a process control plan to monitor the key metrics for periodic auditing needs to be implemented. Montgomery and Woodall (2008) emphasise the importance of auditing the process periodically, to ensure that the original results are still in place and stable so that the any financial benefits will be sustained. It is not unusual to find that something has gone wrong in the transition to the improved process. The ability to respond rapidly to unanticipated failures should be factored into the plan.

2.2 METALWORKING FLUID FILTRATION: AN OVERVIEW

The primary objective of metal machining within industry is to economically produce components to a customer specification by a controlled material removal process, known collectively as subtractive manufacturing. To facilitate the increasing demand on this market from industrial advancements, metalworking fluid (MWF) has evolved to meet greater performance requirements, for both direct metal removal and indirect functional attributes (Brandt, 2006). For these benefits to be realised, the metalworking fluid must be correctly maintained to prevent upsets in the fluid integrity which would impact performance. The properties of MWFs deteriorate in service, and effective maintenance preserves these properties, ensuring service time is maximised. Primary requirements of cutting fluids are:

- To cool the cutting tool (maximise tool life), and workpiece (prevent heat distortion/damage).
- To provide lubrication between the tool and workpiece during the cutting process.
- Chip flushing from the tool-workpiece interface.
- Chip transportation to a clarification or recirculation system.

Important secondary requirements are:

- Stability
- Resistance to microorganisms
- Protection against corrosion
- Safety
- Correct disposal (good cleavage properties for water-based cutting fluids)
- Filtration ability.

Astakhov and Jokschi (2012), state that effective maintenance of MWFs not only reduces the environmental impact but also increases the profitability of production. Therefore, importance for waste reduction must also be realised, along with the quality of the workpiece. With the correct choice and application of MWF, a high rationalisation potential can be released. An incorrect choice can generate high additional production costs

Metal working processes which utilise MWF often use a closed loop system, which involves collecting the used fluid in some way and then recirculating the fluid back to the tool-workpiece interface. Unfortunately, this recycling process subjects the metalworking fluid to a multitude of contaminants such as:

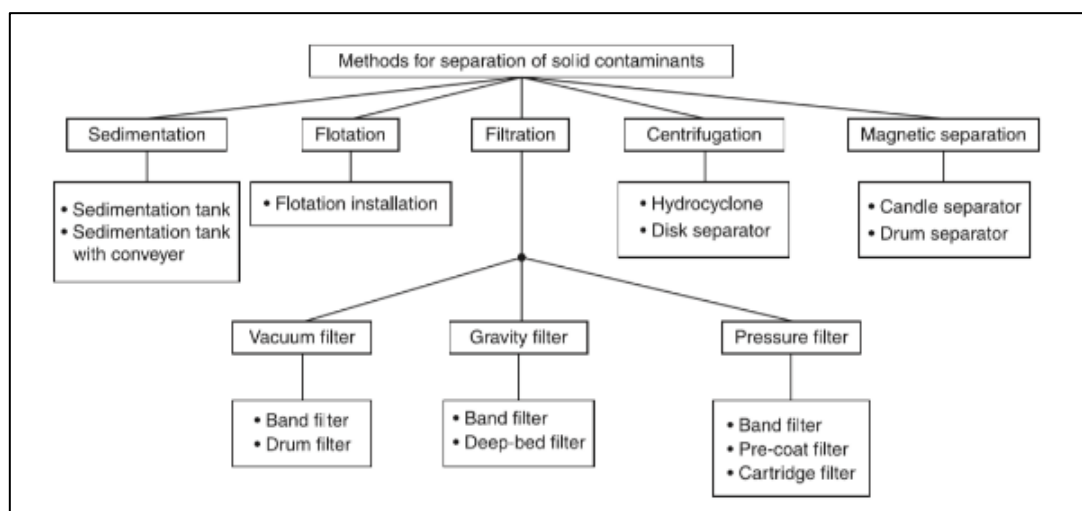
- Metal chips and fines from the process
- Airborne contamination from contact between a part and the machine

- Machine leakages
- Residues left on the part from previous operations
- Abrasive ingredients from tooling

Therefore, the recirculation process must also minimise these contaminants and deliver metalworking fluid of an acceptable operating condition back to the tool-workpiece interface. This is sometimes facilitated chemically by adding new concentrate or additives to the metalworking fluid. However, many contaminants such as metal chips, fines and free oil, will not be affected by additives or concentrate additions and will require removal through some means of separation or filtration whenever possible. Figure 5 illustrates the available methods for separation of solid contaminants from MWFs and the different types of hardware used. The block diagram demonstrates the difficulty in correctly selecting equipment for an application (Brandt, 2006).

The process of metalworking fluid separation and filtration needs to be carefully evaluated, selected and aligned to the process application. Various criteria for the system design will need to be established such as: material type, machining process, machine horsepower, type of metalworking fluid, metalworking fluid flow, and available space. Figure 5 illustrates some the methods often used for MWF solid separation. However, application of ultra-filtration, nano-filtration, or reverse osmosis is generally not applied to plant metalworking systems. These filtration technologies are used in processes such as water preparation and metalworking fluid waste treatment. The membrane systems used in these systems would have a harmful effect on the fluid by selectively removing wanted ingredients (Brinksmeier et al., 2015).

Figure 5: Methods of Metalworking Solid Separation (Astakhov and Joksch, 2012).



PARTICULATE EQUILIBRIUM

When designing metalworking fluid separators or filtration systems, the level of particulate cleanliness required for the process must be established. Particulate cleanliness is often given at an equilibrium level, as there is no absolute filtration in the metalworking fluid industry and a residual level of metal particulate will always be expected. The purpose of separation and filtration is to minimise the metallic contamination equilibrium by one or a combination of systems. An equilibrium of metal contaminate develops because a filtration device will not remove 100% of the metal removed during the process. Each filter system and process will require a different equilibrium level, the level is related to the fluid used, the maintenance of the fluid, the filter, and a host of other outside influences. To determine the equilibrium level which is reasonable and necessary, tests can be run on existing filtration systems and then correlated. These tests will provide a direction toward the particulate levels which should be maintained (Rahäuser et al., 2013); Brandt, 2006).

MECHANICAL / PHYSICAL METHODS OF SEPARATION OF SOLID CONTENTS

The separation of solid contents in MWFs can be conducted by mechanical/physical methods. The fundamental process involves utilising the difference in density between the solid content of the contaminant dispersed in the liquid phase and the liquid. It is also important to know what influence the viscosity has on the MWF; in the case of high viscosity the sedimentation speed and flow rate are clearly reduced compared to a MWF with low viscosity.

Best practice in cleaning MWFs ensures following benefits:

- Increased service life of the MWF
- Reduced skin irritation
- Reduced waste and waste-water volumes
- Reduced disposal costs
- Reduced tool costs
- Reduced machine downtimes
- Improved finish and surface quality
- Reduced maintenance effort and cost of MWF change.

(Astakhov and Jokschi, 2012).

TRANSPORTATION SYSTEMS

Transportation systems are required to recover the metalworking fluid after it has been delivered to the tool-workpiece interface. Where, the fluid flushes and collects the chips or fines produced during the operation and carries them away in suspension as part of the fluid flow. This fluid mixture flows

off the machine and into a variety of devices, which will transport the fluid and chips back to a point of separation or filtration. Brandt (2006) lists H-chain, chain and flight, push bar (harpoon), metalworking fluid, and in some cases, overhead troughs and sumps as methods used.

The contaminated metalworking fluid is then further processes by clarification through recirculating systems. Filtration is often used as a term to describe this process of metalworking fluid and particle separation, even when the process relies on a physical characteristic and does not contain a filter.

Recirculating systems receive the dirty fluid from the machine tool and after processing, send it continuously back to the machine in a circular flow with a continuous process of particle removal.

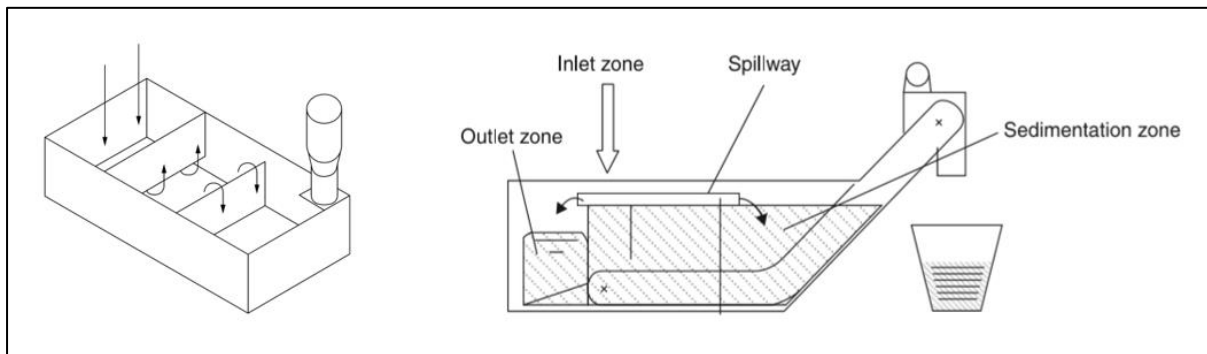
These recirculation systems are often divided into two groups; separation systems and filtration systems. These categories contain a variety of equipment developed to accomplish the same thing: cleaner fluid. The driving force found in these categories is either gravity, vacuum or pressure (ElBaradie, 1996).

SEPARATION SYSTEMS

The physical characteristics used in a separation processes are specific gravity differential, foam bubble inclusion, or ability to be magnetized. These various characteristics are put to use in a variety of equipment:

Settling Tanks; The basic separation device for the individual machine is the settling tank (see Figure 6). This unit is generally placed alongside a machine and receives liquid from the process. The fluid capacity of the tank provides for a retention time. The retention time is an indication of settling that will take place in the tank. The type of metal and size of chip or particulate formed in the metal removal process, as well as the fluid and retention time, will determine what equilibrium point will be reached. Typically, the retention time for the average tank is 5 min. Less retention time will usually mean a large quantity of fine recirculation. In large central systems where settling is the only method of particle removal, the retention time should not be less than 10 min and ranging up to 15 min. These settling devices are applied to cast iron machining, with some application to other non-cake forming particles, such as glass grinding and silicon sawing. The particles produced by grinding cast iron may also be separated by settling, but the retention time is customarily double that of machining. This is due to the fine nature of the particles produced and their lightness compared with the fluid used in the process. The application of settling systems to cast iron machining and grinding does not produce metalworking fluid clean enough for the requirements of most critical metal-removing processes. The settling system can provide primary separation of the larger chips and particles. However, separation processes can be added to the settling system in the form of centrifugal and magnetic devices (Brandt, 2006; Astakhov and Jokschi, 2012).

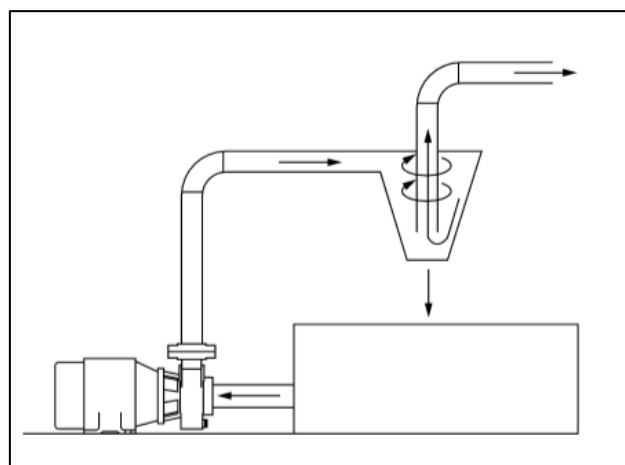
Figure 6: Typical Settling Tank Arrangement (Brandt, 2006; Astakhov and Jokschi, 2012)



Foam Separators; In some separation systems, particle removal has been reported as being enhanced by the occurrence of foam. The generation of foam or small air bubbles tends to entrap the fine particles causing them to float with the foam. The fines brought to the surface of the tank can be removed along with the foam by a conveyor or scraper system. The particle-filled foam is generally moved into a tank, which settles the fines when the foam breaks. This method has been used but is limited in application to metalworking fluids that can sustain a foam condition. For fines removal, this method has proved difficult to control in a consistent manner (Brandt, 2006).

Centrifugal Separators; Centrifugal separation systems can incorporate a hydro-cyclone and/or a centrifuge. Hydro-cyclones are devices which separate the fine particulate suspended in the metalworking fluid from the heavier coarse particulate. This is achieved by entering the fluid tangentially into the hydro-cyclone, where, heavier particulate falls through the bottom, and cleaner fluid moves back up and out of the top through a vortex action (see Figure 7).

Figure 7: Typical Hydro-cyclone Arrangement (Brandt, 2006)



Liquid processed in this manner reaches an equilibrium from the differential pressure across the hydro-cyclone and the specific gravity differences between the fluid and the particles. Under the same conditions, a smaller diameter hydro-cyclone can remove finer particulate than a larger diameter hydro-cyclone.

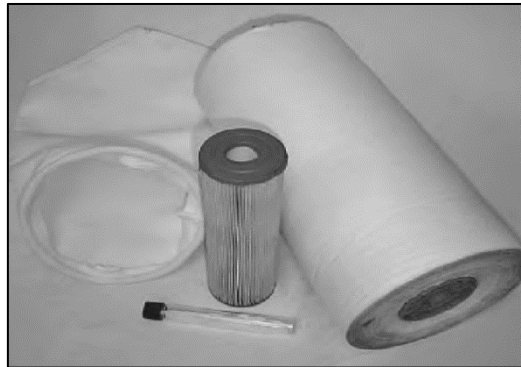
Another device which can be added to primary separation tanks is the solids-separating centrifuge. This unit is designed to remove particles by centrifugal force. A spinning bowl receives the particle-laden metalworking fluid. The force against the fluid and particles separates the particles by moving them to the side of the bowl. The bowl fills with particulate and eventually requires cleaning. It is customary to use one of these units on small flows and small dirt load systems. These conditions are usually found in individual machines and not large central systems (Brandt, 2006).

FILTRATION SYSTEMS

A filtration system can be described as particulate separation through the introduction of a media into a fluid stream. Filtration systems can use gravity, vacuum or pressure as the force required to transition the metalworking fluid through the media. As well as these three different options to provide the driving force, media is also available in many different forms and materials. Generally, the density of the fabric will determine the attainable filtration. This is valid in comparing fabric densities within the same family. There are a number of criteria used for the selection of filter materials, such as particulate level, type of metalworking fluid, driving force and so forth. As with the selection of fabric, the selection of hardware also varies and can be discussed in two categories: those units that use disposable media and those using permanent media (Brinksmeier et al., 2015).

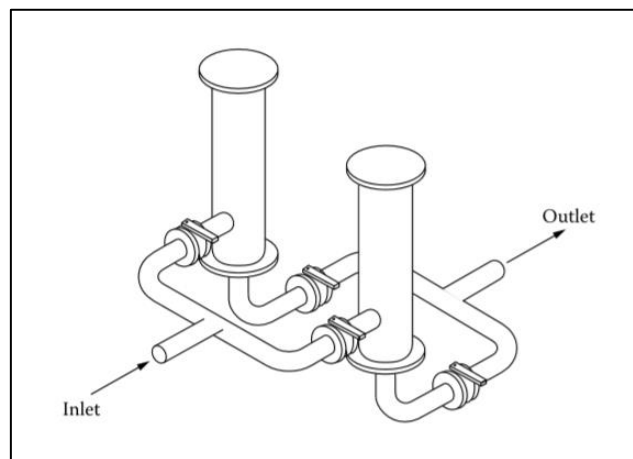
Disposable media systems can be produced in a number of different configurations to meet the desired process requirements. Types include bags, cartridges, rolled goods, chopped paper, and a multitude of materials referred to as precoat (see Figure 8). The operation can be manual or automatic. Bag filters are filter media in a bag form. The bag(s) may be suspended at the end of a discharge pipe with a special fitting or enclosed in a housing. The driving force is pressure: less than 103 kPa for the end-of-pipe assembly and up to 1034 kPa for housing units. The bag is selected to retain chips and particulate but allow a flow of metalworking fluid through the system. When a pressure drop is noted across the bag, indicating the bag is plugged or there is a significant reduction in flow, the bag filter is manually changed. The bag filters can be purchased in various sizes. This provides some flexibility in the square foot of filter area available. A wide range of micron retention bags are available providing additional flexibility. Typically, a flow rate of 1000 to 2000 l/min/m² can be obtained. However, type of dirt and viscosity of the fluid may modify those numbers downward. For selected applications: washers, individual machines, and recycling equipment, the bag filter has proven effective (Brinksmeier et al., 2015; Astakhov and Jokschi, 2012).

Figure 8: Types of Disposable Media (Brandt, 2006)



Cartridge Filter system; Cartridge filters are often used to provide a positive after-filter for other filtration systems. These units consist of individual cartridges or clusters contained in multiple cartridge housings (see Figure 9). The driving force for cartridge filtration is also pressure. Therefore, the housings for the cartridges are made for low 517 kPa to high 2068 kPa pressure. The flow rate for cartridge filtration is less than bag filters. The application of these units is not generally on large flow rate systems but as guard filters to prevent spurious particulate from entering a close tolerance area. This close tolerance area could be a through-the-drill supply of coolant, a tapping operation, or application to a fine finish machine (Astakhov and Joksch, 2012).

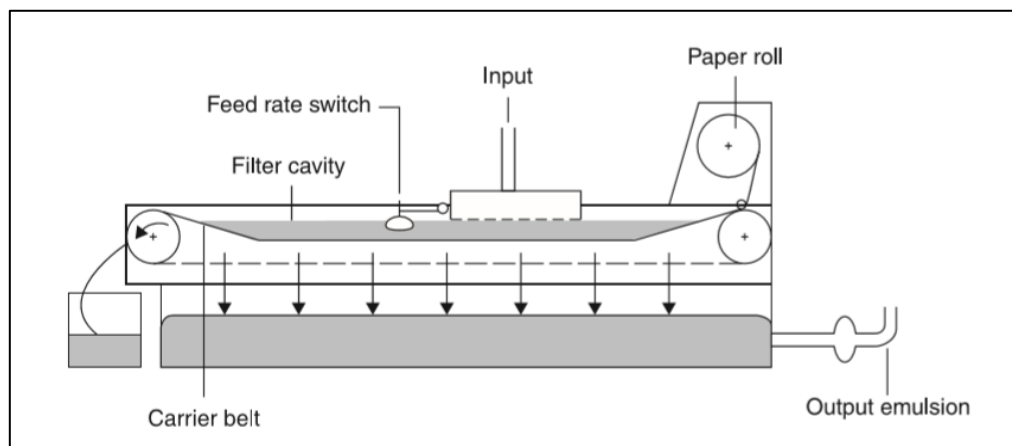
Figure 9: Multiple Cartridge Housing Arrangement (Astakhov and Joksch, 2012)



Filter Media Roll; Disposable media on a roll provides the maximum flexibility to a filtration design because it can be used for gravity, vacuum, or pressure separations. The basic use of the rolled media is in the gravity-driven system. In a gravity separation device, the metalworking fluid containing particulate flows or is pumped from the machine into an open container (see Figure 10). As the liquid level deepens, the head of liquid forces metalworking fluid through the media. The particulate is

trapped on the filter media and as more particulate is collected on the filter media, a greater resistance to flow is encountered. The metalworking fluid becomes deeper and a cycle-inducing device is activated. This control may be supplied by a float limit switch, conductivity probe, or another device. When the device is activated the filter media is indexed through the tank by means of a conveyor. This provides new filter media in the tank and results in recovery of the desired flow rate. The liquid level drops and filtration continues until the cycle repeats itself. The indexing and movement of the media can be achieved manually or can be driven with an electric motor (Astakhov and Jokschi, 2012; ElBaradie, 1996).

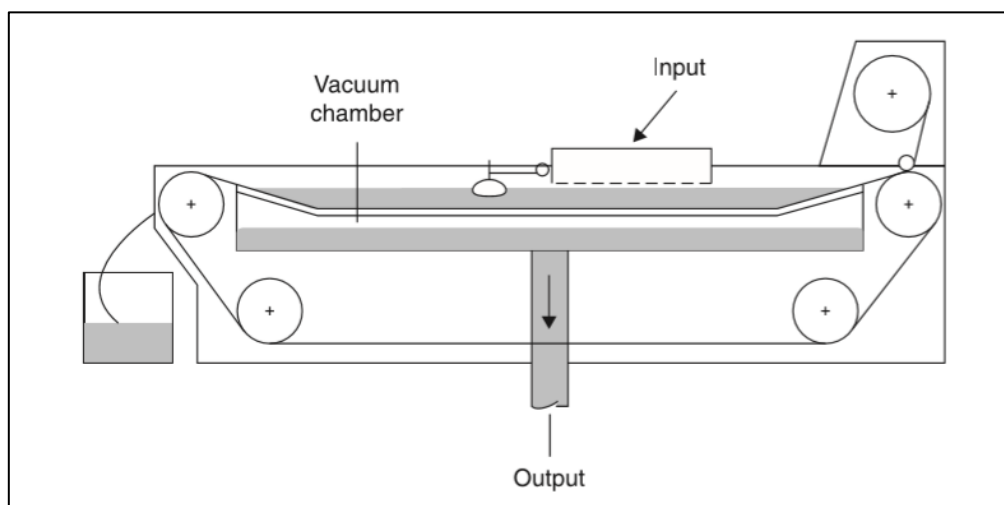
Figure 10: Gravity Separation Device (Astakhov and Jokschi, 2012)



Vacuum systems are similar to gravity systems except there is often an additional pump that is used to create a negative pressure under the media and its support structure (see Figure 11). The pump is used to evacuate a large volume of air from under a media and support system, which draws liquid through the filter media faster than gravity would normally allow. The use of a vacuum generator generally increases the time between indexes of the media. Typical vacuum conditions can reach 12 to 15 in. of mercury (41 to 51 kPa). Beyond 15 in. of mercury (51 kPa), justified benefit is low. Typical indexing methods for a vacuum media system include a mercury vacuum switch, differential pressure switch, or a timer. The first two index relative to the reduction in flow caused by the build-up of particulate on the filter media. This causes the vacuum pump to draw more vacuum and this is subsequently sensed by the switch. The timer is used on materials that do not cause a substantial decrease in flow rate or build-up in vacuum, such as steel or aluminium machining, or grinding. Since these chips and particles form a porous pile or cake, indexing on vacuum may not be adequate to keep ahead of the chip loading in the system. To ascertain the timer setting, a calculation is performed to determine the quantity of solid material removed. Based on an expansion factor, a volume of chips can be approximated from the solid stock removed. Knowing the capacity of the conveyor in the filtration system, the timer can be set for an interval which will prevent overloading of the system. This setting

has to be done for the worst condition, i.e., the most chips produced at maximum production. At any other condition which would make less chips, the indexing will be more frequent than necessary. When the vacuum system indexes, the filter media moves a short distance. Therefore, the media is never fully replaced. This changes the gallons per square foot passing through the new area. If a system is purchased to provide 10 gal/min/ft², this condition only occurs at start up. At any other time during operation, the filter's moderate indexing minimizes the new area and causes the gallons per minute per square foot to increase slightly. In fact, the only reason for large tanks with large filter areas is to provide physical flow volume of metalworking fluid (Brandt, 2006; Astakhov and Joks, 2012).

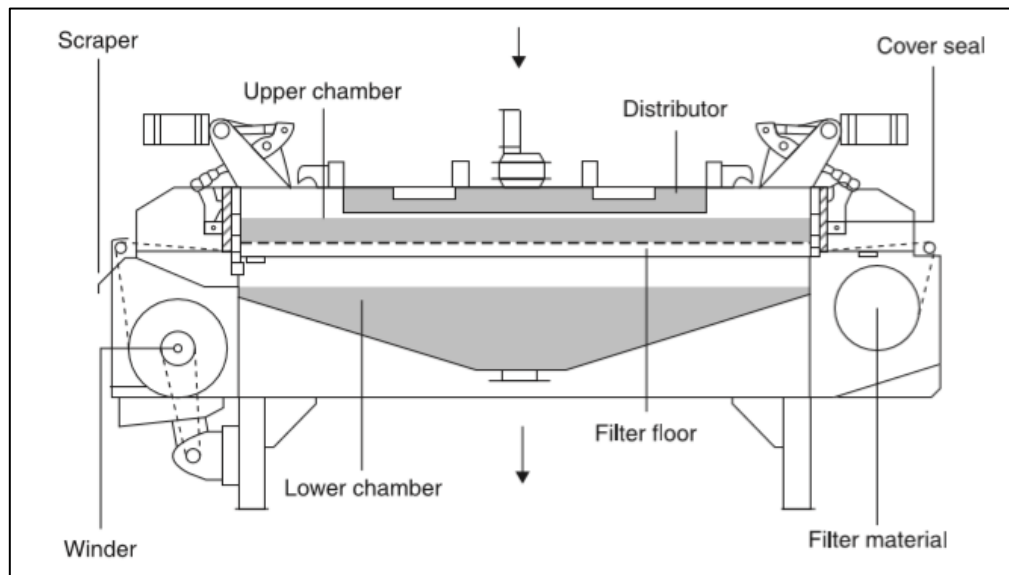
Figure 11: Vacuum Separation Device (Astakhov and Joks, 2012)



Another alternative is a pressure-driven system, in which the filter media is supported on a metal or cloth belt, slotted, or perforated plate. The support and filter media are enclosed between two enclosures. The contaminated metalworking fluid and are introduced into the cavity above the filter media and forced through the media. This process continues until the particulate builds a cake and the resistance causes an increase in pressure. When a pre-set pressure on a switch is reached, the filter supply pump is turned off, air is introduced into the cavity to remove the metalworking fluid and dry the particulate cake. After this process is complete, the two shells separate and the filter media is advanced entirely out of the system. The two shells close and the process begins again. The usual configuration is for the two shells to be in the horizontal position. Multiple horizontal shells can be used with multiple rolls of filter media. The pressure settings vary for each type. Indexing pressures for two-shelled units are usually 50 to 70 kPa, while multiple-shelled units can run to 240 kPa. The limitation for any of these systems is the mechanism which keeps the shells closed. The closing mechanism used is air pressure in conjunction with air bags or cylinders. The advantage of the pressure-driven unit is that a reasonably dry cake can be discharged from the system. With pressure

filtration, each time the filter indexes, a new complete filter media is introduced into the system. The disposable media filter material comes in a variety of retention capabilities. As the filtration process proceeds through its cycle, the particulate being deposited on the media is building up. This build-up in particulate forms a cake. In some cases, this cake is actually necessary in order to attain fine particle filtration. The filter media acts only as an initial barrier upon which the cake can build. This process is referred to as depth filtration (Brandt, 2006; Astakhov and Jokschi, 2012).

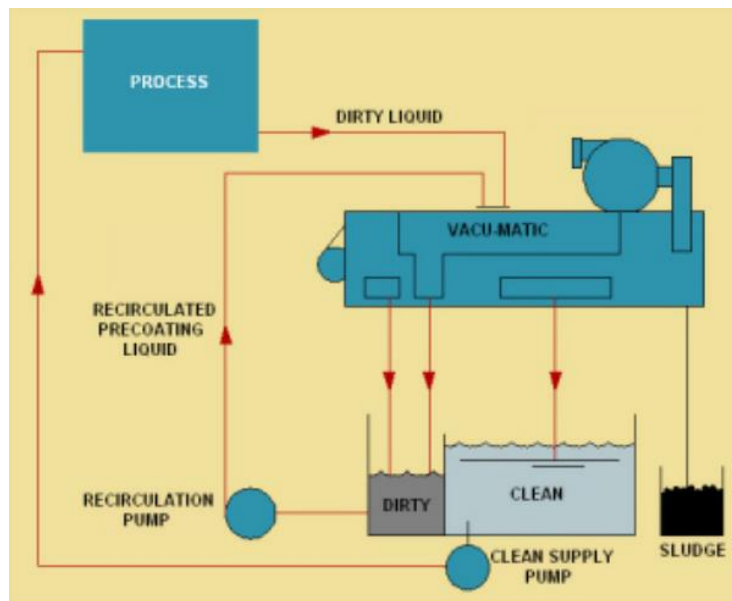
Figure 12: Pressure-driven System (Astakhov and Jokschi, 2012)



2.3 HOFFMAN FILTRATION SYSTEM CURRENT STATE: AN OVERVIEW

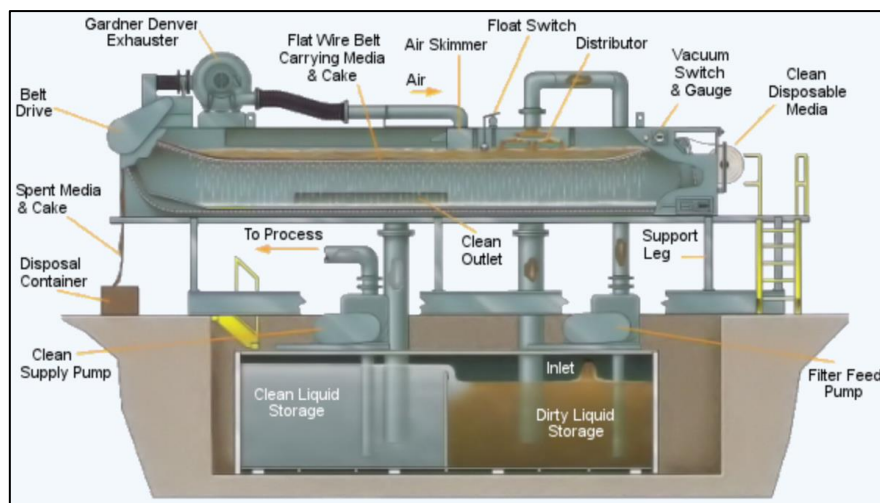
The process flow diagram in Figure 13 illustrates the fundamental stages contained within the closed loop MWF delivery system for each EFCO grinding machine. Where, contaminated MWF from the abrasive belt grinding process is gravity fed into a sublevel sump, often referred to as a 'dirty pit'. From the 'dirty pit', this MWF is then pumped to the Hoffman filtration system. The fluid is then filtered and gravity fed into a 'clean pit'. The processed clean coolant is then delivered back to the machine.

Figure 13: Hoffman Filtration Process Flow Diagram (Interfil.com., 2020).



The Work Flow Diagram in Figure 14 details the Hoffman Filtration system's components and their function.

Figure 14: Hoffman Filtration Work Flow Diagram (Interfil.com., 2020).



With reference to Figure 14, contaminated MWF is delivered into a distributor, located on top the filter system. The distributor reduces the velocity generated from the pump and distributes the MWF onto a disposable filter media. The filter media is supported by a continuous flat wire conveyor belt, which passes over the top of a vacuum chamber. The vacuum chamber creates a pressure differential that influences the coolant pooling on top of the filter media. This difference in pressure, accompanied by the weight of the liquid, draws the liquid down into the vacuum chamber through the filter media.

Solid particles remain on the media surface and accumulate to form a cake. This cake, together with the media, provides for very efficient filtration (Interfil.com., 2020).

As the filter cake increases in thickness, the openings between particles becomes smaller. When the cake reaches optimum thickness, airflow through the bed is reduced, the vacuum and the resistance to the coolant flow increases, and the pool level above the vacuum chamber increases. Both the vacuum and pool level have a pre-set maximum limit, each monitored respectively by a vacuum gauge and float switch. Upon reaching the pre-set maximum limit for the vacuum, the indexing controls automatically move the conveyor belt and filter media forward without interruption of the filtration process. Only enough clean media enters the filter to restore the vacuum and pool level below the pre-set maximum limits, thus optimising the amount of filter media used. The spent filter media and cake are expelled into a waste container at the discharge end of the filter (Interfil.com., 2020).

In applications where particle type and size would not allow sufficient vacuum levels to be reached for correct control of the filter cake and media indexing, the pool level can be monitored to introduce clean media into the filter. A float switch senses when the pool has reached its maximum pre-set limit and moves the conveyor belt forwards until the pool level drops below the pre-set value. A float switch is also commonly used in vacuum initiated indexing filters to actuate an alarm and warn of a possible overflow condition. In this case the float switch can be wired to the indexing controls to override the vacuum switch. Upon being filtered, the clean liquid is pumped back to the work area or a holding tank is ready for use (Interfil.com., 2020).

CHAPTER 3 - DEFINE

The first step on the roadmap defines the project goals and both external and internal customer deliverables. It focuses on the selection of high-impact projects with an understanding of which metrics will influence the project's success. The define phase identifies the customers, their requirements and expectations. Project boundaries are defined, and the process flow is mapped (Srinivasan et al., 2016).

3.1 PROJECT SELECTION MATRIX

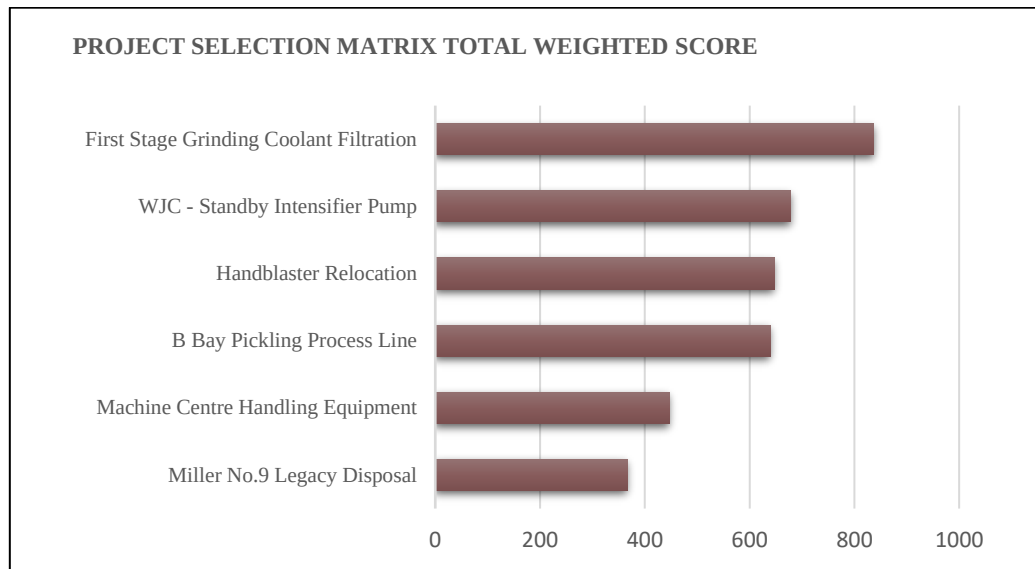
TIMET Swansea Plant is divided into three separate areas; Bar Products, Mill Products and Finishing. The engineering management team allocated to each section is illustrated in Appendix 1. Each area team's primary focus is to improve productivity and eliminate waste, which leads to the identification of problems requiring solutions with a disproportionate amount of time and resource. A list of projects and initiatives to improve the current state and drive towards efficiency can quickly accumulate. This problem exposure is a positive, however, there is a need to define what is important to the organisation and prioritise these projects. The Project Selection Matrix provides a solution to this eventuality and was utilised to prioritise such a list in March 2019. Key metrics were identified and weighted against business need (Table 7).

Table 7: Project Selection Matrix (Sigmapro, 2020).

PROJECT OWNER: ANDREW CURTIS		DATE: 15/03/19		SELECTION CRITERIA										
PROJECT SELECTION MATRIX				HSE Compliance	Quality	Throughput	Customer Impact OTD	Savings Potential	Strategic Alignment	Probability of Success	Team Availability	Speed of Delivery		
				WEIGHTING										
PROJECT				20	15	15	15	10	8	8	7	5	TOTAL	RANKING TOTAL
First Stage Grinding Coolant Filtration	Value			9	9	9	9	3	9	9	9	3	837	1
	Weighted Cal.			180	135	135	135	30	72	72	63	15		
Machine Centre Handling Equipment	Value			9	1	1	1	1	9	9	9	1	447	5
	Weighted Cal.			180	15	15	15	10	72	72	63	5		
WJC - Standby Intensifier Pump	Value			1	9	9	9	9	3	9	9	1	679	2
	Weighted Cal.			20	135	135	135	90	24	72	63	5		
Miller No.9 Legacy Disposal	Value			3	1	1	1	1	9	9	9	9	367	6
	Weighted Cal.			60	15	15	15	10	72	72	63	45		
Handblaster Relocation	Value			1	1	9	9	9	9	9	9	9	647	3
	Weighted Cal.			20	15	135	135	90	72	72	63	45		
B Bay Pickling Process Line	Value			3	9	9	9	1	9	3	9	1	639	4
	Weighted Cal.			60	135	135	135	10	72	24	63	5		
					KEY		1 = Low (Less Good)		3 = Medium		9 = High (Good)			

Figure 15 illustrates the results from the project selection matrix in graphical form. As can be observed, the greater the value or score obtained from the matrix, the greater the business priority. From this analysis the teams focus was directed to the First Stage Grinding Coolant Filtration project.

Figure 15: Histogram chart to illustrate Project Selection Matrix results



3.2 PROBLEM STATEMENT.

Between Q1 and Q2 2019, TIMET's Quarterly Membrane Products revenue plan sustained a loss totalling \$273K because of constraints within the process route at First Stage Grinding. Further analysis identified that 57% of the downtime which had caused the constraint was a result of repeated failures of the coolant filtration system at this process. These quarterly misses had affected the On-Time Delivery metric, presented missed opportunities and customer relationships had become strained.

3.3 SIPOC PROCESS MAP

A SIPOC diagram was built to summarise the inputs and outputs of the process from the beginning to end (Table 8). The diagram is a form of process mapping in table form, which illustrates the first controlled and organised view of the process to set the foundation for the DMAIC strategy. SIPOC is an acronym for suppliers, inputs, process, outputs and customers (Sigmapro, 2020). The tool is used to identify:

- **Suppliers:** Suppliers can be systems, people, organisations which provide resources or services to the process.

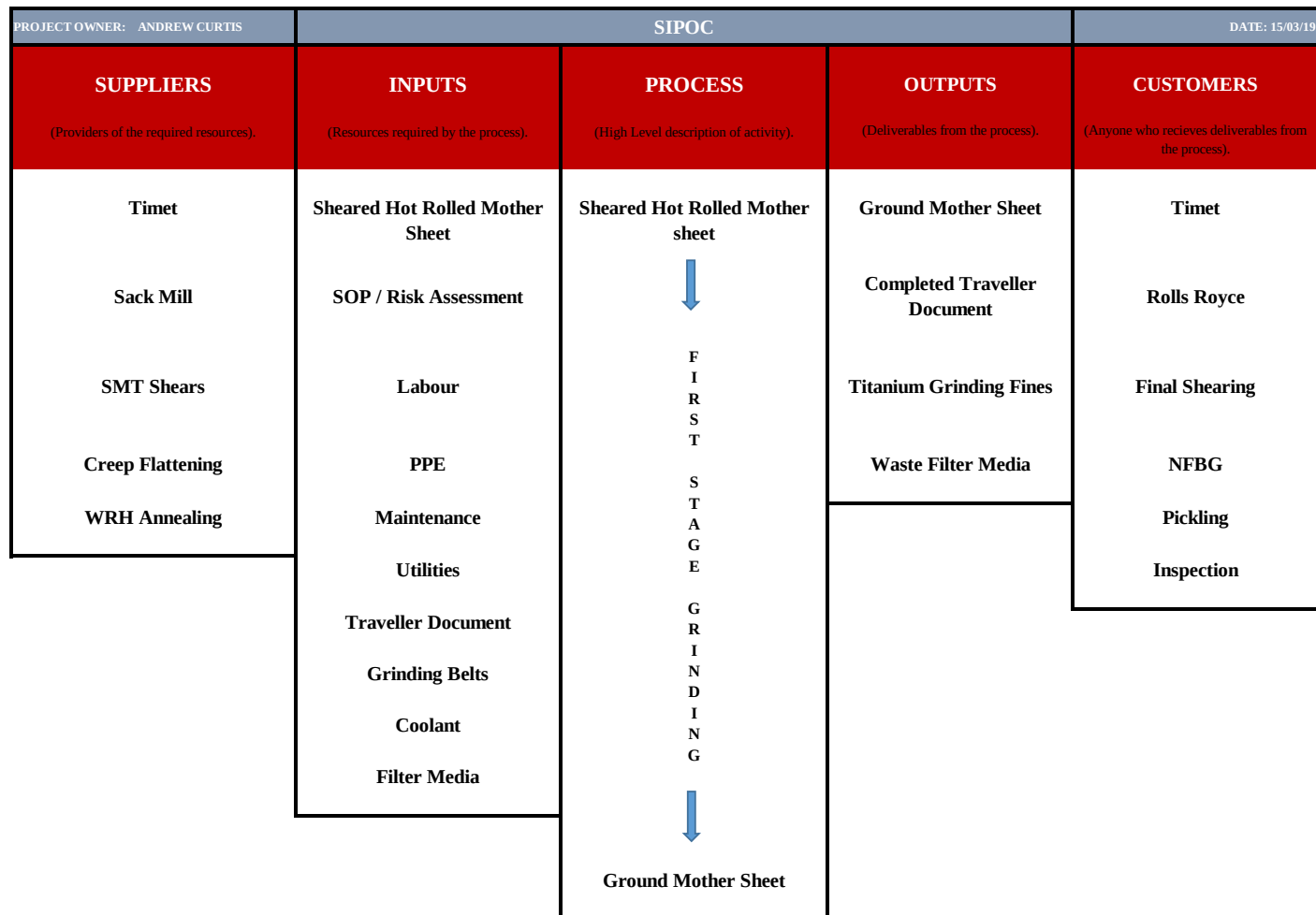
- **Inputs:** These can include information, materials and other resources that the suppliers provide, which are either consumed or transformed within the process.
- **Process:** The action and activities that transform the inputs into the outputs.
- **Outputs:** The products or services that are produced and the customer uses.
- **Customer:** The people, groups, systems and downstream processes that receive the outputs.

Through the successful development of SIPOC; the voice of the customer (VOC), the voice of the process (VOP), and the voice of the business (VOB) will all be determined.

- **Voice of the customer:** This can be described as the needs, wants and desires of the customer (customer requirements).
- **Voice of the process:** The process must meet the requirements of the customer by establishing the resources needed to complete the functional transfer of inputs to outputs.
- **Voice of the business:** This is the voice of profit and return on investment, to ensure the business survives, grows and meets the needs of the employees, investors and the community.

(Theodore, 2019).

Table 8: SIPOC Diagram of First Stage Grinding Process (Sigmapro, 2020).



3.4 STAKEHOLDERS ANALYSIS

Project stakeholders can generally be described as either single individuals, or entire organisations who have interest, or can be affected by the outcome of a project. Project stakeholders are typically members of the project team, customers, operators, maintenance personnel and so forth. These individuals must be identified along with the key project stakeholders. Who are people with authority, and the objectives set by these individuals must be met, as they have the influence to dictate whether a project is a success or not (Theodore, 2019).

Stakeholders are people who are invested in the project, anyone who will be affected by your project at any point along the way, and individuals whose input can directly impact the outcome. Therefore, stakeholder management and communication with them is essential in order to collaborate and succeed on a project. Table 9 identifies the stakeholders for this project and proposes a communication plan to update on progress. Table 10 illustrates the importance of each stakeholder and prioritises those with significant influence, the numerical labels are referenced to each stakeholder in Table 9 (Sigmapro, 2020).

Table 9: Project Stakeholder Communication Plan (Sigmapro, 2020).

PROJECT OWNER: ANDREW CURTIS		STAKEHOLDER ANALYSIS				DATE: 15/03/19
STAKEHOLDER		OBJECTIVE OF COMUNICATION	MESSAGE TO BE DELIVERED	MEDIA	MESINGER	FREQUENCY
1	Business Unit Manager (Champion).	Maintain executive engagement and support by identifying project value add.	Problem summary. Results to date. Sustain gains. Best practice.	1 Page Summary with visual aids.	Green Belt	Monthly
2	Area Manager	Maintain management engagement and support by identifying project value add.	Problem summary. Results to date. Sustain gains. Best practice. JMS alterations. Risk assessment review/alterations.	1 Page Summary with visual aids.	Green Belt	Monthly
3	Operators	To gain support and acceptance. Encourage suggestions and reassurance.	Problem summary. Results to date. JMS alterations. New systems/equipment training.	Notice board. Face to face coms.	Green Belt	Ad Hoc
4	Maintenance Craft	To gain support, encourage suggestions/ideas.	Problem summary. Results to date. Maintenance/calibration alterations. New systems/equipment training.	Notice board. Face to face coms. Email.	Green Belt	Ad Hoc
5	Section Engineers	Maintain Engineer engagement and support by identifying project value add. To gain support, encourage suggestions/ideas.	Problem summary. Results to date. Sustain gains. Best practice. Maintenance/calibration alterations. New systems/equipment details.	Detailed summary of project to date.	Green Belt	Ad Hoc
6	Team Members	Maintain Team commitment, engagement and support by identifying project value add. Encourage suggestions/ideas.	Problem summary. Results to date. Sustain gains. Best practice. Maintenance/calibration alterations. New systems/equipment details.	Detailed summary of project to date.	Green Belt	Ad Hoc
7	HSE Manager	Maintain Support and communicate any safety concerns.	Problem summary. Results to date. JMS alterations. Risk assessment review and alterations. New systems/equipment training.	1 Page Summary with visual aids.	Green Belt	Monthly

Table 10: Project Stakeholder Analysis (Sigmapro, 2020).

		IMPORTANCE OF STAKEHOLDER			
		Unknown	Little/no importance	Some importance	Significant importance
INFLUENCE OF STAKEHOLDER	Significant Influence	C		6	7 1 5
	Somewhat Influential				
	Little/No Influence	D		B	
	Unknown				

3.5 PROJECT RISK ANALYSIS

Project risk analysis and risk management is an essential part of project management, and was undertaken to ensure that any surprises throughout the project were kept to a minimum (Table 11). Although not all risks can be identified with certainty, by applying a risk management process at the start of the project, many of the uncertainties can be minimised to improve on the chance of success. Risk identification will continue throughout the project life-cycle and any issues that develop into problems will require careful management, and expectations with regard to project delivery will be communicated through to Stakeholders.

Apm.org.uk, 2020 defines Risk analysis and risk management ‘as a process that allows individual risk events and overall risk to be understood and managed proactively, optimising success by minimising threats and maximising opportunities and outcomes’.

The Project Risk Matrix in Table 12 distinguishes the risks identified based on the severity of the impact to the project and likelihood of occurrence. Those risks judged as high impact and high likelihood will need careful monitoring, although control measures have been implemented to reduce the likelihood, the impact to the project if such an event should happen remains the same.

Table 11: Project Risk Analysis (Sigmapro, 2020).

PROJECT OWNER: ANDREW CURTIS		PROJECT RISK MATRIX				DATE: 15/03/19
PROJECT RISK		CAUSE	LIKELIHOOD	IMPACT	RISK PRIORITY	RISK MITIGATION
1	Availability of CAPEX	Other projects may take priority for this years budget.	6	9	54	Justify the business risks and build a compelling capital case.
2	Project overrunning	Unplanned delays / poor planning.	3	6	18	Construct a realistic and accurate project timing plan, factoring in a contingency for any problems which may be encountered. Communicate to all stakeholders the project timing plan and emphasize the importance to its adherence.
3	Scope creep	Not clearly defining the projects goals.	3	3	9	Clearly outline the projects objectives within a project charter, highlight all deliverables in and out of scope to the project.
4	Project delays because of hazardous environment for new machinery installation or modification.	Titanium grinding fines are highly flammable.	6	6	36	Follow Time's safe systems of work and HSE Guidelines.
5	New design concept suitability	Unproved technology	9	9	81	On site testing from portable unit Confirmation from other businesses within the PCC group of Oberlin's technology.
6	Engineering Manning	Engineering resource is dependent on plant priorities	1	3	3	Timet resource cannot be guaranteed, outsource and secure requirements from timets approved contactor list.
7	Process availability for improvements	Machine availability is dependent on plant priorities	3	6	18	Communicate timing plan to stakeholders within production to secure necessary release of equipment.
8	Lack of subject matter expertise	Limited knowledge of current coolant filtration systems.	3	6	18	Research current technology and markets.
KEY					IMPACT	1 = Insignificant 3 = Low 6 = Medium 9 = High
					LIKELIHOOD	1 = Not Likely 3 = Likely 6 = Certain 9 = Almost Certain

Table 12: Project Risk Matrix (Sigmapro, 2020).

RISK MATRIX					
LIKELIHOOD	Almost Certain				5
	Certain			4	1
	Likely		3	2, 7, 8	
	Not Likely			6	
		Insignificant	Low	Medium	High
		IMPACT			

3.6 PROJECT CHARTER

A project charter was developed as a semi-formal contract between management and the project team to establish what is in scope and out of scope for the project (Tables 13 and 14). The charter protects the team members against scope creep, which are any unanticipated demands that might be added later on during the consecutive phases of the project. The charter is a statement of the project's objectives, deliverables, timeline and team members. However, a project charter is often referred to as a living document, meaning the charter will be revised as more knowledge is gained throughout the development of the project (Srinivasan et al., 2016).

Table 13: Project Charter (Sigmoidpro, 2020).

PROJECT CHARTER		LATEST UPDATE: 20/03/20	
PROJECT TITLE:	FIRST STAGE GRINDING DOWNTIME REDUCTION	PROJECT NUMBER:	8
BUSINESS/DIVISION:	TIMET UK	BLACK/GREEN BELT:	ANDREW CURTIS
PROJECT TYPE (BB/GB)	GREEN BELT	PROCESS OWNER:	MATHEW DAVIES
BUSINESS FUNCTION:	MANUFACTURING	CHAMPION:	IAN DAVIES
SITE/FACILITY/LOCATION:	SWANSEA PLANT	FINANCE:	ROBERT LANG
		MENTOR:	ANDREW THORN
PROBLEM STATEMENT:	Between Q1 & Q2 2019, Timet's Quarterly Membrane Products Revenue Plan, sustained a loss totalling \$273k as a result of constraints within the process route at First Stage Grinding. Further analysis identified that 57% of the downtime which caused the constraint was a result of repeated failure of the coolant filtration system at this process. These quarterly misses affected OTD, missed opportunities and customer relationships became strained.		
PROJECT OBJECTIVE:	Reduce constraints within the Membrane Products process route, caused by repeated failures within the coolant filtration system at First Stage Grinding. Capitalise on opportunities within Quarterly Revenue Plans, improve on OTD.		
PROJECT DELIVERABLES:	Chart or graph to illustrate improvement		
PROJECT MEASURES (Y'S)	Y1 - First Stage Grinding Downtime MTBF		

Table 14: Project Chart Continued (Sigmapro, 2020).

IN SCOPE FOR PROJECT:	Products - Membrane Product Processes - First Stage Grinding Coolant Filtration People - Production operators & Maintenance Craft Waste - Filtration Media & Grinding Fines
	Products - Any other product Processes - Upstream and downstream processes People - Personnel not directly impacting on the process Quality - Dimensional accuracy & Surface Finish
	Availability of CAPEX, Machine availability for improvement, New design concept suitability, Area Hot Work Risks, Team member time commitments and Lack of subject matter expertise must all be carefully managed through to completion.

TEAM MEMBERS:		
Name	Phone	E-mail
Andrew Curtis		Timet email
Steve Clark		Timet email
Simon Protheroe		Timet email
Kevin Alderman		Timet email
Mathew Davies		Timet email

PROJECT MEASURES (Y'S):			
Metric	Units	Current	Target
Y1 - First Stage Grinding Downtime Metric	MTBF (Hrs)	175	80% Improvement

PROJECT SCHEDULE:		
DEFINE	Week 35 (2019)	Complete
MEASURE	Week 38 (2019)	Complete
ANALYSE	Week 41 (2019)	Complete
IMPROVE	Week 11 (2020)	Ongoing
CONTROL	Week 11 (2020)	Ongoing
CLOSE	Week 11 (2020)	Ongoing

ESTIMATED PROJECT SAVINGS/BENEFITS:	
CUSTOMER	Improve OTD
FINANCIAL	\$320K (Potential annual saving)
ASSOCIATES	Reduced Filtration Media Costs
PROCESS	Improve Reliability

3.7 TOLLGATE REVIEW:

After completion of each phase within the DMAIC roadmap, a tollgate, or checkpoint was reviewed amongst the project team to ensure all goals during that stage had been achieved. Progression onto the next phase cannot start until all objectives within the current phase have been met. The approach provides updates for champions and stakeholders, and ensures the project is running to plan.

- Does the Problem Statement reflect the pain the organisation is feeling? ✓
- Is the project objective smart? ✓
- Are all required team members involved? ✓
- Have the team roles been clearly established? ✓
- Have the customer requirements been captured and translated into project objectives? ✓
- Has a risk assessment been done and action plan created? ✓
- Have stakeholders been identified and support/influence mapped? ✓
- Is there a communication plan reflecting stakeholder support? ✓
- Is there a communication plan reflecting stakeholder support? ✓

(Sigmapro, 2020).

CHAPTER 4 - MEASURE

Within this phase the process's current baseline performance is measured, assessed and key metrics are established. Any form of measurement is validated, however, as there are not any applicable measurements to validate within the filtration process, this section will be excluded.

4.1 PROCESS FLOW CHART

A process flowchart was generated to graphically represent the process through a flowchart. This activity is often used as a means of getting a top-down understanding of how a process works, what steps it consists of, what events change outcomes, and so forth. Process flow charts provide structure to the Analyse phase by identifying sources of possible variation and through visualisation, make the process significantly easier to fully comprehend. A process flow-chart will also help during the Control phase when decisions on process controls and mistake proofing measures for long term control need to be implemented as far upstream as possible (Microsoft.com, 2020; Theodore, 2019).

A typical membrane panel process route was mapped to define process boundaries, process ownership and process responsibilities.

Figure 16: Process Flow Chart Key (Microsoft.com, 2020)

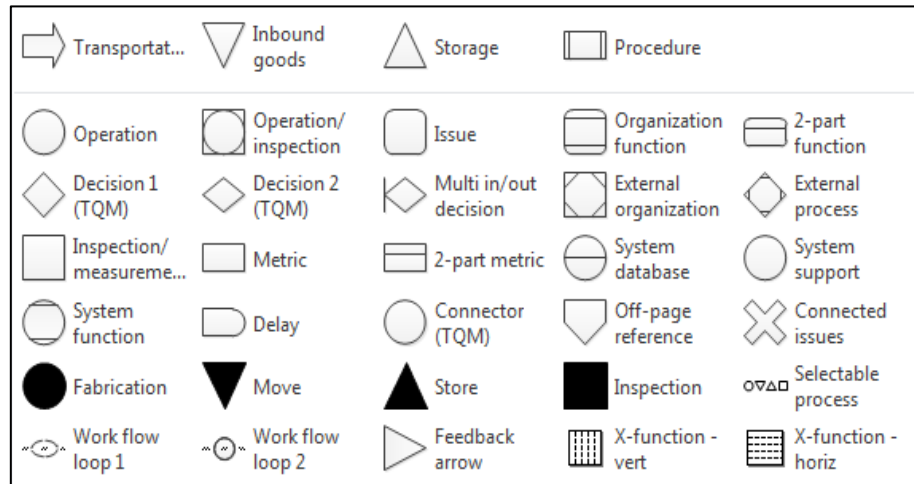
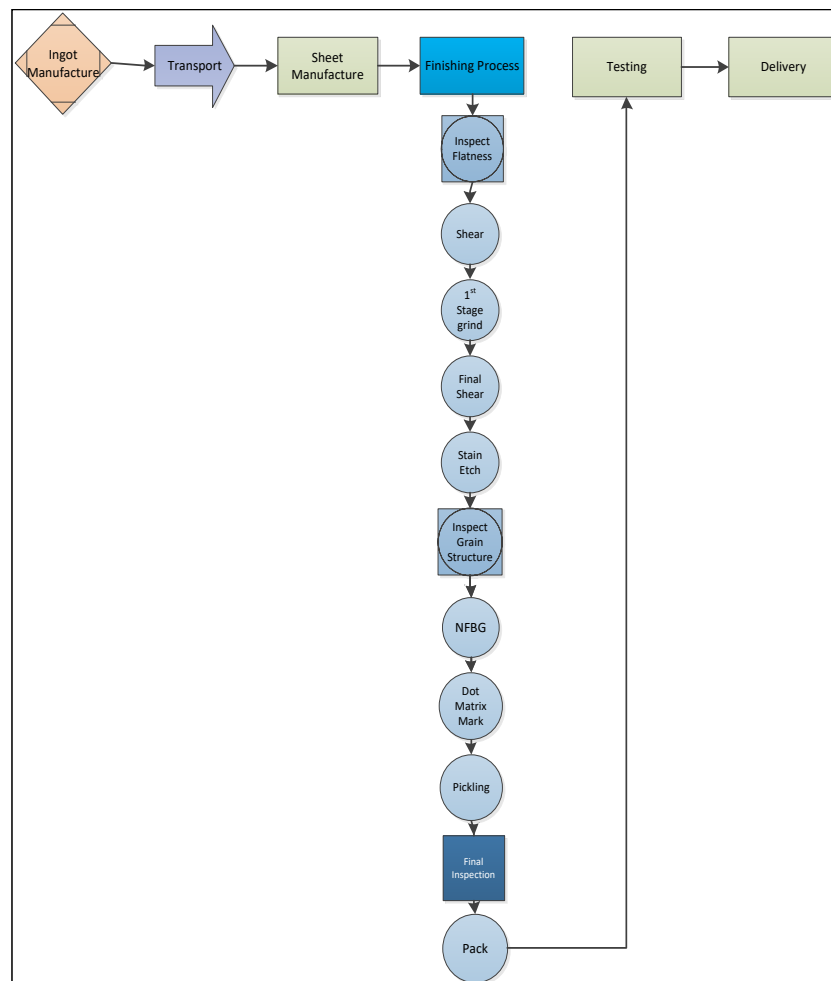


Figure 17: First Stage Grinding Process Flow Chart (Microsoft.com, 2020)



4.2 DETERMINE BASELINE PERFORMANCE AND KEY METRICS

4.2.1 DATA SOURCE

TIMET's Maintenance History Report was used as the source of historical data for determining the key metrics to establish a performance baseline within this analysis. A sample of the report is illustrated in Table 15. The report is completed each shift by the Engineering Shift Manager detailing all plant breakdowns, attributed resource and times (Curtis, 2020). The Maintenance History Report has in excess of 15,000 entries for 2019 and is part of the engineering computerised maintenance management system (CMMS).

Table 15: TIMET's Maintenance History Report Sample (Curtis, 2020).

Date	Shift	Day	Week	Month	Main Area	Sub Area	Work Cell	Machine	Craft	Job Start Time	Job Finish Time	Time to repair	Total Man Hrs	Prod Down Time	Description of Work	Comp/Pass on/Temp	Elec/Mech/Prod/Cont	Cause	Sub System	Time to repair (hrs)
02/01/2019	DAYS	Wed	1	1	Sheet Finishing	SF Lifting Equip	SF Vacuum Lifts	UNKNOWN	-	00:00:00	00:00:00	0:00	0:00:00	-	Fitted new actuator to S39. Needs connecting up electrically and testing when B3 gantry is	Comp	Elec	Failure	Cylinder	0
02/01/2019	DAYS	Wed	1	1	Sheet Finishing	SF Lifting Equip	SF Gantries	B3 SF Barnsley	MW KP	00:45:00	08:00:00	1:25	29:00:00	12:00	Gantry stopped mid way down bay. Inspected pendant cabling and ok. 24V present at p	Comp	Elec	Failure	-	7.25
02/01/2019	DAYS	Wed	1	1	Sheet Finishing	SF Grinding	SF EFCD	EFCD 2	MH	00:45:00	01:45:00	1:00	2:00:00	-	Hoffman overflowing, adjusted level sensor now o.k.	Comp	Mech	Failure	Sensors	1
02/01/2019	DAYS	Wed	1	1	Sheet Finishing	SF Machine Centre	SF Milling	Noble & Lund	MH	00:00:00	05:00:00	5:00	6:00:00	-	Chuck vacuum pressure alarm for vacuum o.k. visual light u/s. resoldered cables in switch	Comp	Elec	Failure	Vacuum	5
02/01/2019	DAYS	Wed	1	1	Sheet Finishing	SF Shear Stretch	SF Shears	Scottish	MH	02:00:00	02:30:00	0:50	0:30:00	-	Unable to raise blade, charged accumulator now o.k.	Comp	Mech	Failure	Cylinder	0.5
02/01/2019	DAYS	Wed	1	1	Sheet Finishing	SF FBC	SF NFBG	NFBG 4	MH	00:45:00	04:00:00	1:25	3:45:00	-	Hoffman vacuum pump heating up and smoking. Disconnected electrically for production	Comp	Mech	Damage	Fan	1.25
02/01/2019	DAYS	Wed	1	1	Sheet Finishing	SF Grinding	SF EFCD	EFCD 2	MH GE	06:00:00	06:15:00	0:25	0:45:00	-	dirty coolant pump blocked with sponge, cleared o.k. also welded hoffman steps.	Comp	Mech	Coolant Blockage	Hoffman	0.25
02/01/2019	NIGHTS	Wed	1	1	Sheet Finishing	SF FBC	SF NFBG	NFBG 6	SP	08:30:00	09:00:00	0:50	0:30:00	-	PC on station had no power, traced feed and found mch tripped. Reset.	Comp	Elec	Reset - power supply	Fuse/MCB	0.5
02/01/2019	NIGHTS	Wed	1	1	Sheet Finishing	SF FBC	SF UST	USL 4	SP	00:00:00	02:00:00	2:00	2:00:00	12:00	Joystick not operating. Changed with unit from USL 2 and tested still not operating. Open	Pass	Elec	Failure	-	2
02/01/2019	NIGHTS	Wed	1	1	Sheet Finishing	SF Grinding	SF EFCD	EFCD 2	ST GL	08:00:00	08:30:00	0:50	1:00:00	0:50	Low coolant flow, levelled tanks and running ok.	Comp	Mech	Coolant Level	Hoffman	0.5
02/01/2019	NIGHTS	Wed	1	1	Sheet Finishing	SF Machine Centre	SF Milling	Elgamill 1	ST GL	08:30:00	09:30:00	1:00	2:00:00	12:00	Machine stopping mid cut, checked lube oil all good, topped up hydraulic oil level and te	Pass	Elec	Failure	-	1
03/01/2019	DAYS	Thu	1	1	Sheet Finishing	SF FBC	SF UST	USL 4	MW AS	00:25:00	00:00:00	00:25	2:00:00	-	Joystick not operating. Changed with unit from USL 2 and tested still not operating. Open	Pass	Elec	Failure	-	10.25
03/01/2019	DAYS	Thu	1	1	Sheet Finishing	SF Machine Centre	SF Milling	Elgamill 1	-	00:00:00	00:00:00	0:00	0:00:00	12:00	Machine stopping mid cut, checked lube oil all good, topped up hydraulic oil level and te	Pass	Elec	Failure	-	0
03/01/2019	DAYS	Thu	1	1	Sheet Finishing	SF Grinding	SF EFCD	EFCD 1	MW	06:25:00	00:30:00	4:25	4:15:00	-	sheet calibration tool not charging. Fault traced to loose mains lead, correctly connected	Comp	Elec	Failure	Cabling	4.25
03/01/2019	DAYS	Thu	1	1	Sheet Finishing	SF WUC	SF Pumps	Pump 3	JB	07:00:00	08:30:00	1:50	2:30:00	-	Fitted new RP seals	Comp	Mech	Failure	Seal	1.5
03/01/2019	DAYS	Thu	1	1	Sheet Finishing	SF Machine Centre	SF Milling	Elgamill 1	KP	00:00:00	01:00:00	1:00	1:00:00	-	Operator reported leak above DB 860 near elgamill, leak is from exhaust on hoffman, put	Comp	Prod	Failure	Pipe Work	1
03/01/2019	DAYS	Thu	1	1	Sheet Finishing	SF WUC	SF WUCs	WUC 2	MH EJ	09:45:00	01:00:00	1:25	2:30:00	-	AS45 pump drive tripped, fault traced to DCH1 overvolt fault. Reset and run for a while up	Pass	Elec	Failure	Drives	1.25
03/01/2019	DAYS	Thu	1	1	Sheet Finishing	SF FBC	SF UST	USL 4	MW AS	00:30:00	07:15:00	6:75	13:30:00	-	Joystick fault. Remove cards from computer as instructed by V. Alderman and found short	Comp	Elec	Failure	Cabling	6.75
03/01/2019	DAYS	Thu	1	1	Sheet Finishing	SF WUC	SF WUCs	WUC 1	JB	01:00:00	02:45:00	1:75	2:45:00	1:00	AS45 unblocked agitation pipework unbooked and drains cleared	Comp	Mech	Failure	Pipe Work	1.75
03/01/2019	DAYS	Thu	1	1	Sheet Finishing	SF WUC	SF Pumps	Pump 6	JB	03:00:00	04:45:00	1:75	2:45:00	1:00	Changed RP seals completed	Comp	Mech	Failure	Seal	1.75
03/01/2019	DAYS	Thu	1	1	Sheet Finishing	SF Other	SF Other	SF Other	NMH	04:30:00	05:45:00	1:25	2:15:00	-	Dot matrix on inspection stripped and cleaned as required and tested ok	Comp	Mech	Failure	-	1.25
03/01/2019	NIGHTS	Thu	1	1	Sheet Finishing	SF FBC	SF UST	USL 4	-	00:00:00	00:00:00	0:00	0:00:00	-	Joystick not operating. Changed with unit from USL 2 and tested still not operating. Open	Pass	Elec	Failure	-	0
03/01/2019	NIGHTS	Thu	1	1	Sheet Finishing	SF Machine Centre	SF Milling	Elgamill 1	-	00:00:00	00:00:00	0:00	0:00:00	-	Machine stopping mid cut, checked lube oil all good, topped up hydraulic oil level and te	Pass	Elec	Failure	-	0
03/01/2019	NIGHTS	Thu	1	1	Sheet Finishing	SF WUC	SF WUCs	WUC 2	-	00:00:00	00:00:00	0:00	0:00:00	-	AS45 pump drive tripped, fault traced to DCH1 overvolt fault. Reset and run for a while up	Pass	Elec	Failure	Drives	0
03/01/2019	NIGHTS	Thu	1	1	Sheet Finishing	SF Grinding	SF GAC	GAC 1	MR	08:00:00	09:30:00	1:50	2:30:00	2:00	Stop bolt missing on tracking belows. Replaced bolt with new. Adjusted air eye pressures	Comp	Mech	Failure	-	1.5
03/01/2019	NIGHTS	Thu	1	1	Sheet Finishing	SF Grinding	SF GAC	GAC 2	MR	09:30:00	09:30:00	1:00	2:00:00	1:00	Replaced air eye and adjusted tracking pressures.	Comp	Mech	Machine setup	-	1
03/01/2019	NIGHTS	Thu	1	1	Sheet Finishing	SF Grinding	SF GAC	GAC 2	MR	09:30:00	02:00:00	1:50	2:30:00	0:50	Air eye adjusted for wider belt, also had tracking problems, adjusted air eye and tested ok	Comp	Mech	Machine setup	-	1.5
03/01/2019	NIGHTS	Thu	1	1	Sheet Finishing	SF FBC	SF NFBG	NFBG 1/US Hoffman	SP MH	04:00:00	04:45:00	0:75	2:30:00	-	Clean tanks overflowing. Overspill from NFBG 4 causing tank level to be too high. Pumped	Comp	Prod	Operational	Coolant	0.75

4.2.1 GRAPHICAL ANALYSIS

The Maintenance History Report can be further analysed through an Excel PivotChart to graphically display downtime trends.

‘An Excel PivotChart is a tool built into Excel that enables you to summarise, analyse, explore and present large quantities of data quickly and easily. The visualisations allow you to easily see comparisons, patterns and trends, helping the user to make informed decisions based on the data source’ (Support.office.com, 2020).

The chart chosen to display the statistical graphic was a pie chart. Figure 18 and Figure 19 illustrate the downtime sustained to the First Stage Grinding Cell caused by Hoffman filtration failures. Each graph section represents a portion of the total, or whole downtime. The analysis identified that 57% of the downtime which caused the constraint was a result of repeated failure of the coolant filtration system at this process.

Figure 18: EFCO One Downtime Analysis

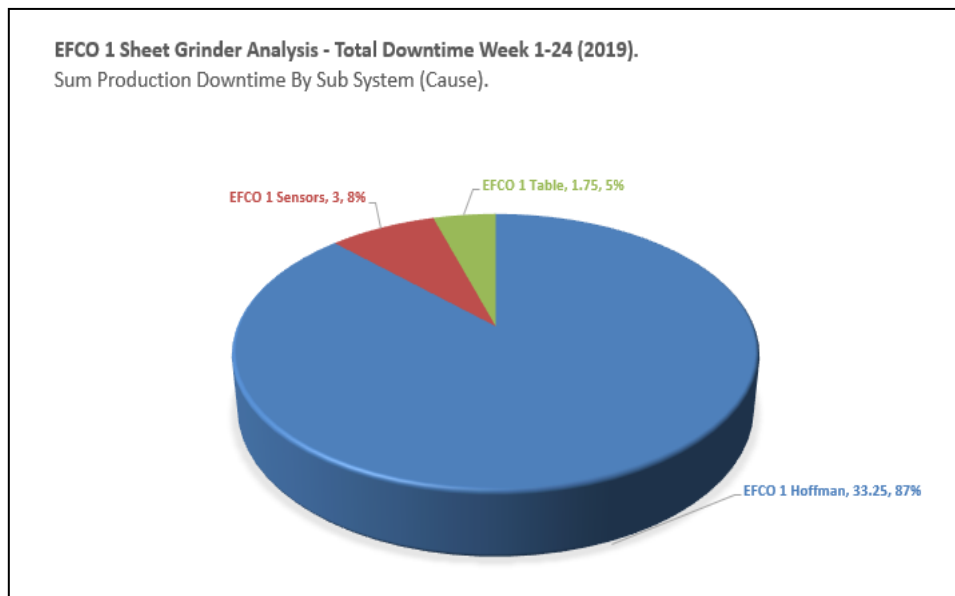
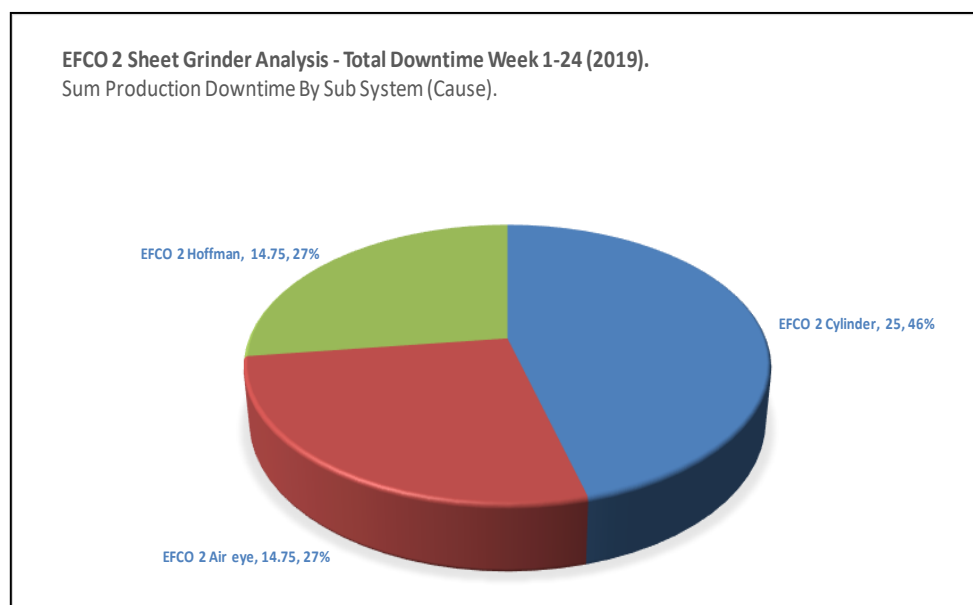
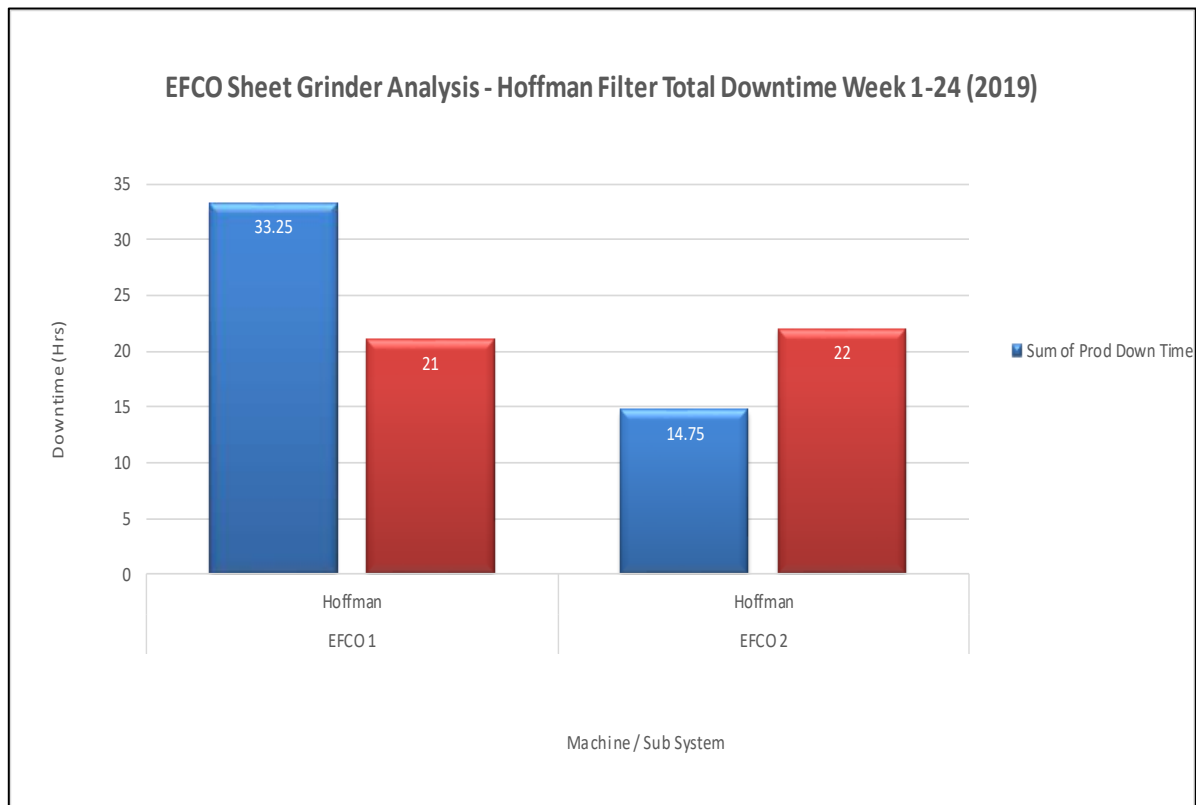


Figure 19: EFCO Two Downtime Analysis



Through further manipulation of the pivot table, the Sum of Production Downtime and the Count of Production Downtime (each event) by hour, can be displayed for each Hoffman filter within a histogram (Figure 20). This analysis shows that the combine downtime from the Hoffman filters have caused 48 hours of downtime throughout Weeks 1-24 of 2019, and this has been attributed to by 43 events. From this historical data the key metrics can be calculated to establish a baseline process performance.

Figure 20: First Stage Grinding Combined Downtime Analysis



4.2.3 ESTABLISHING KEY METRICS

Any process improvement needs to support the business aims and operating strategy. An ideal way to show this is to establish Key Performance Indicators (KPIs), that define a clear link between business goals and the process performance needed to achieve them. By establishing clear KPIs, a base line, can be measured and any changes to a process can be evaluated for improvements against this measure (Curtis, 2020; Lifetime-reliability.com, 2020b). The maintenance KPIs utilised at TIMET are:

- **Mean Time between Failure (MTBF):** Which is the average amount of time that a system functions before failing. Only the operational time between failure is measured and any repair time is excluded. MTBF figures are often used to project how likely a single unit is to fail within a certain period of time. See formula below:

$$MTBF = \frac{TotalUptime}{NumberofFailures}$$

- **Mean Time to Repair (MTTR):** Which is a measure of the maintainability of repairable equipment or parts, the metric details the average time required to repair a specific item or component and return it to working status. It includes notification time, diagnosis and the time spent on actual repair before the equipment can be used again. The formula for MTTR is:

$$MTTR = \frac{TotalDowntime}{NumberofFailures}$$

- **Failure Rate:** Which is derived from taking the inverse of the MTBF and is a common tool used within planning and designing systems. The metric allows prediction of a component or a system performance and is often measured in number of failures per hour. The formula used to calculate the failure rate is:

$$\lambda = \frac{1}{MTBF}$$

- **Reliability:** Which is essentially the probability of component or systems chance of failure and is calculated in one of two ways:

Where time is relatively small; $R = 1 - \lambda t$

Where time is relatively large; $R = e^{-\lambda t}$

(Curtis, 2020; Epsilonengineer.com, 2020; Lifetimereliability.com, 2020b).

Table 16: First Stage Grinding Process Baseline Key Metrics (Curtis, 2020; Epsilonengineer.com, 2020).

	OPERATING HOURS	TOTAL OPERATIONAL TIME (hrs)	MEAN TIME BETWEEN FAILURE (hrs)	MEAN TIME TO REPAIR (hrs)	FAILURE RATE	RELIABILITY (11.25hrs)	RELIABILITY (100hrs)
	Operating hrs = 24 (No. of wks) X 7 (No. of dys) X 22.5 (No. of hrs) x 2 (No. of M/Cs)	Σ (Start of Downtime after last Failure – Start of Uptime after last Failure)	$MTBF = \Sigma (TOT) / F$	$MTTR = (\Sigma PDT / F)$	$\lambda = 1 / MTBF$	$R(t) = e^{-\lambda t}$	$R(t) = e^{-\lambda t}$
HOFFMAN FILTERS COMBINED	7560	7512	174.70	1.12	0.0057	93.76%	56.42%

4.3 TOLLGATE REVIEW

- Has the process been clearly mapped? ✓
- Has a source of data been established? ✓
- Has the process performance baseline and key metric been established? ✓

(Sigmapro, 2020).

CHAPTER 5 – ANALISE PHASE

The Analyse phase isolates the top causes behind the Critical-To-Quality Characteristic (CTQ), or metric that is being analysed. This phase identifies gaps between current performance and goal performance, sources of variation and prioritises improvement opportunities. Tools used within this phase include fishbone diagrams and Pareto charts.

5.1 FIX THE OBVIOUS

A planned maintenance activity was implemented to fully clean, inspect and repair any obvious faults encountered during the initiative. However, no noticeable faults with any of the mechanical elements or electrical control were encountered. The only common concern with both machines was the volume of fines which had escaped the filter media and accumulated within the clean side of the filters. This is a common occurrence on these assets and a planned maintenance task is in place to manage this problem. Therefore, after the initiative the system was refilled with new MWF and the filters were returned to service. Unfortunately, problems were still occurring and there was no improvement in performance.

The team then focused on MWF containment in the event of an overflow. Bespoke drip trays were manufactured and strategically placed around the filters in an attempt to contain any leaks. The justification for this was that the majority of the downtime was consumed by the clean-up activity after an event. Figure 21 illustrates the placement of one of those drip trays.

Figure 21: Strategical Placement of Individual Drip Trays



Unfortunately, these drip trays also provided very little improvement. The design of the Hoffman filters made containment from individual drip trays very difficult. Also, these drip trays needed to be managed and emptied each shift by the operator, which proved to be a time-consuming task that was detrimental to production.

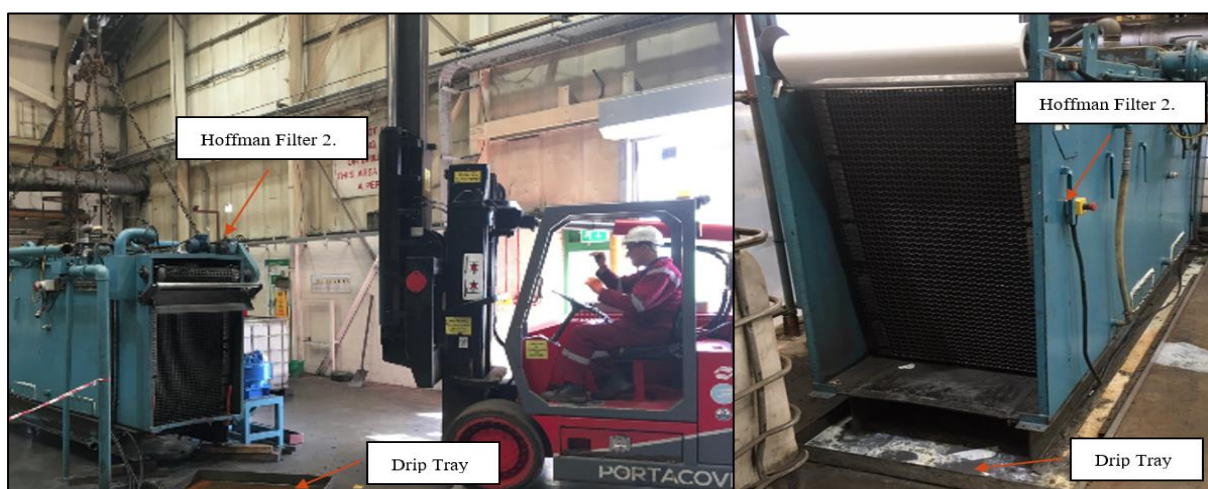
The final solution to mitigate the safety risk presented by the overflow events was through the manufacture of a large drip tray which would contain the whole filter and waste container. Figure 22 illustrates the Hoffman filters prior to installation.

Figure 22: Hoffman Filters Prior to Drip Tray Installation



As is evident, both Hoffman Filters needed to be lifted to install the drip trays underneath. Figure 23 illustrated the activity, when Portacover Machinery Movement Specialists were commissioned to provide the necessary lifts required for installation.

Figure 23: Hoffman Filter Drip Tray Installation

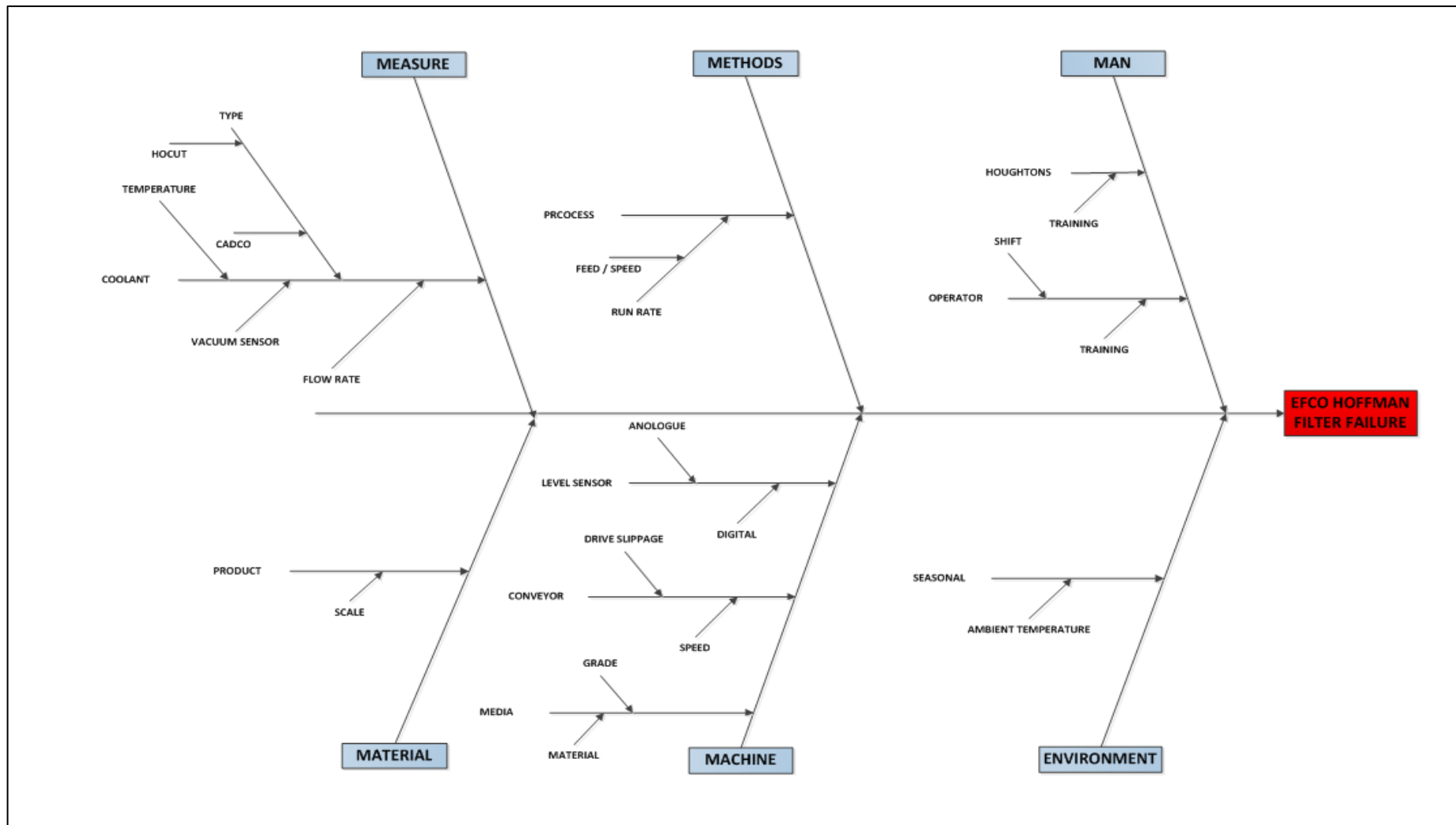


The new drip tray installation proved successful in containing the MWF after an overflow event and mitigated the problem by reducing the recovery time after breakdowns. However, the failures were still evident, and a full root cause analysis activity was undertaken to establish the requirements needed to correct the problem.

5.2 CAUSE AND EFFECT ANALYSIS

To establish possible causes for the Hoffman filtration failures, a cross functional team was gathered comprising of operators, section managers, engineering craft, quality technicians and professional engineers. The group undertook a brainstorming activity which was structured through a cause and effect diagram. A cause and effect diagram is a visual tool used to logically display possible causes associated with specific problems or effects by graphically displaying them in detail. The tool helps to identify root causes and is often utilised in a team approach to problem solving. From identifying possible causes, actions can be taken to control or modify them to meet the desired goals and objectives. The tool is often referred to as a fishbone or an Ishikawa diagram (Doggett, 2005; Brook, 2014).

Figure 24: First Stage Grinding Failure Cause and Effect Diagram (Doggett, 2005; Brook, 2014).



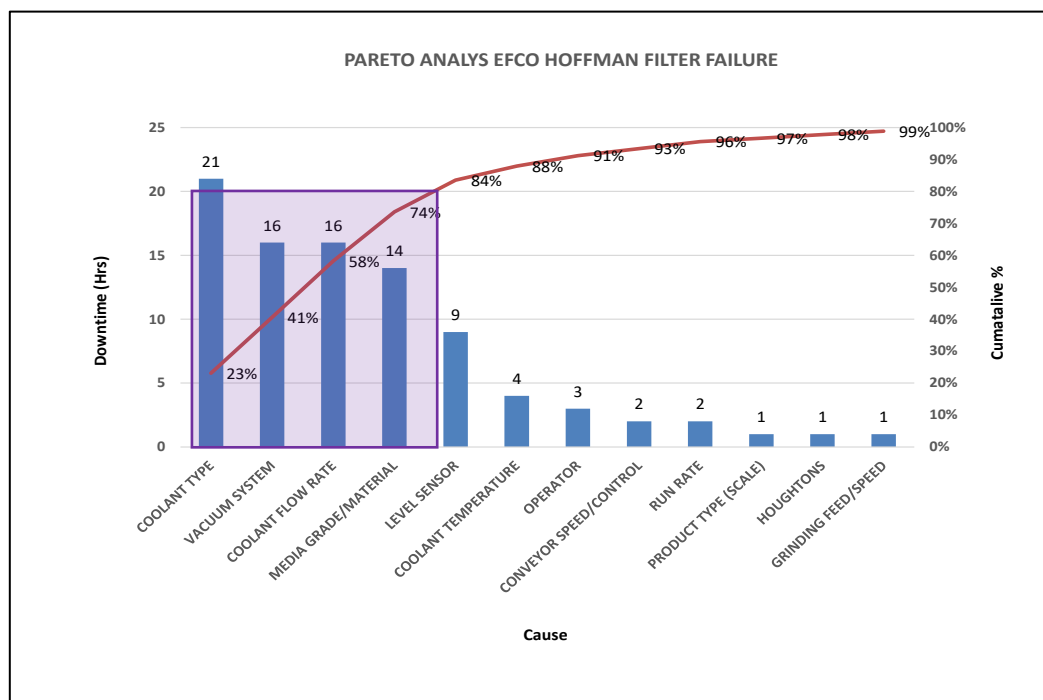
5.3 MULTI-VOTING (N/3) TECHNIQUE

After the development of the cause and effect diagram, a multi-voting technique was used to prioritise the ideas generated. Multi-voting, or sometimes referred to as N/3, is a voting technique which can be used to prioritise ideas. With the objective to reduce the amount of options to prevent any resource constraints. It is often used within group or team settings when a democratic or mutually agreeable choice is required based on a range of solutions. Each team member is given N/3 votes and instructed to vote on the most important ideas; the team member can only assign a maximum of three votes per idea. Therefore, if there are 30 ideas, each team member gets 30/3 or 10 votes each. Since there are less votes than there are ideas, the less important ideas will naturally be removed, which will reduce the number of ideas the team must contend with (ReVelle, 2004; George et al., 2004).

5.4 PARETO ANALYSIS

Additional prioritisation of the identified causes was provided through Pareto analysis, which ascertains the problem areas or tasks that will make the biggest gains. A Pareto analysis uses the Pareto principle which was identified by the Italian economist Vilfredo Pareto in his book published in 1896. The principle states that 80 percent of a project's benefit comes from 20 percent of the work. Or, as in this case; 80 percent of the problems can be allied to 20 percent of the causes (Brook, 2014; George et al., 2004).

Figure 25: First Stage Grinding – Hoffman Filter Pareto Analysis (Brook, 2014).



5.5 FIVE WHY ANALYSIS

Five Why analysis is a technique often used during the Analyse phase of Six Sigma DMAIC projects. The tool can be used as an approach to problem solving that does not involve data segmentation, hypothesis testing, regression or other advanced statistical tools. The approach is believed to have been created by Sakichi Toyoda (1867-1930), the founder of Toyota, as a simple way to begin any investigation with the aim of determining the ‘root cause’ (Card, 2017).

Brook (2014) describes how the principal of Five Why analysis is based on the understanding that for every effect there is a cause. However, it is also known that there is a chain of reactions called symptoms before the cause reaches its effect. These symptoms are often mistakenly perceived as the cause of the problem and as a result, the solutions generated will walk in a wrong direction and will not help to solve the issue at hand. The Five Why technique ensures that the problem (effect) is pinpointed and solved from its root cause and no time is wasted on correcting symptoms. The technique focuses on asking the question ‘Why’ repetitively (five is a rule of thumb), to peel away the layers of symptoms which can lead to the root cause. The analysis can be used individually or as part of the Cause and Effect diagram. The Cause and Effect diagram helps a project team explore all potential or real causes that result in a failure. Once all these inputs have been established, the Five Why technique helps to drill down further into the root causes. Tables 17, 18, 19 and 20 contain the Five Why analysis for each of the four prioritised causes.

Table 17: Five Why Analysis - Coolant Type Cause (Brook, 2014; Card, 2017).

SWANSEA PLANT - DELAY ANALYSIS FORM (DELAYS EXCEEDING 8Hrs)							
BREAKDOWN TYPE (E/M/O).		MECHANICAL					
AREA / MACHINE		FIRST STAGE GRINDING HOFFMAN FILTRATION					
DATE		05/02/2020					
TIME		N/A					
REPORTED BY		A CURTIS					
DOWNTIME DURATION		REPEATED FAILURES					
DESCRIPTION OF FAULT AND PROBLEM DEFINITION							
FIRST STAGE GRINDING FAILURE AND REPEATED COOLANT OVERFLOWS - COOLANT TYPE CAUSE							
WHY'S		REASON	ACTIONS	ASSIGNED	WHEN	STATUS	OUTCOME
WHY 1	Why would the coolant effect the filtration system	The coolant was changed from CADCO to HOCUT, a different type of coolant in September 2018.	Review D Jones coolant trial data and ascertain any correlation or evidence of filtration difficulty during the trial	AC	03-Feb	Complete	No permissible information in regard to adverse affects to the coolant system during the trial. Unable to acquire CADCO sample to analyse and make a comparison to the characteristics of the new MWF.
WHY 2	Why would a different type of coolant effect the filtration system	Different MWF could potentially have different characteristics or properties.					
WHY 3	Why would different MWF characteristics or properties affect the filtration system	MWF viscosity would slow the transition through the filter media and negate to lower achievable flow rates.					
WHY 4	Why would a reduced coolant flow through the filter media result in an overflow event	The coolant flow rate must be maintained because of a customer fixed process approval agreement and to reduce the risk of fire. If the filtration system can no longer process MWF at this flow rate, the coolant will still be delivered to the filter, however, it will overflow out into the surrounding area.					
Concluding Remarks: The consensus from the project team's RCA and discussion was that it was highly likely that the MWF change had been the catalyst to the problems encountered. Unfortunately, the team was unable to procure any samples of CADCO coolant to undertake any formal testing or analysis to continue investigations into this area. Also, there was the added factor that any further changes to the MWF would require an FPA. Therefore, the team accepted and assumed that the new MWF properties were adversely affecting the system and focused efforts into what could be done to enable efficient processing of the new MWF through the Hoffman Filters.							

Table 18: Five Why Analysis - Vacuum System Cause (Brook, 2014; Card, 2017).

SWANSEA PLANT - DELAY ANALYSIS FORM (DELAYS EXCEEDING 8Hrs)							
BREAKDOWN TYPE (E/M/O).		MECHANICAL					
AREA / MACHINE		FIRST STAGE GRINDING HOFFMAN FILTRATION					
DATE		05/02/2020					
TIME		N/A					
REPORTED BY		A CURTIS					
DOWNTIME DURATION		REPEATED FAILURES					
DESCRIPTION OF FAULT AND PROBLEM DEFINITION							
FIRST STAGE GRINDING FAILURE AND REPEATED COOLANT OVERFLOWS - VACUUM SYSTEM CAUSE							
WHY'S		REASON	ACTIONS	ASSIGNED	WHEN	STATUS	OUTCOME
WHY 1	Why would vacuum cause this failure	The Hoffman filters are in excess of 30 years old and were originally designed for vacuum to drive the transfer of coolant through the filter media. The vacuum pumps on these machines which generated this negative pressure had failed long ago, had been removed and never replaced. This vacuum pump removal from the system had not presented any historical problems.	Procure and install new vacuum system and return filters to original design. Trial and monitor to ascertain improvement.	AC	12-Feb	Complete	No significant change in failures.
WHY 2	Why would this present a problem now	In September 2018, the coolant on this machine was changed from CADCO to HOCUT.					
WHY 3	Why would this coolant change effect the filtration process	The coolant properties are likely to be different between the two types and the new coolant is causing the filter media to 'blind' and reduce coolant flow rate capability.					
WHY 4	Why would a reduced coolant flow through the filter result in an overflow event	The coolant flow rate must be maintained because of a customer fixed process approval agreement and to reduce the risk of fire. If the filtration system can no longer process MWF at this flow rate, the coolant will still be delivered to the filter, however, it will overflow out into the surrounding area.					
Concluding Remarks:							
The consensus from the project team's RCA and discussion was that by retuning the Hoffman filter to the original design through the reintroduction of a vacuum system; this change could potentially maximise the achievable coolant flow rate through the filters and potentially prevent MWF overflow events..							

Table 19: Five Why Analysis - Coolant Flow Rate Cause (Brook, 2014; Card, 2017).

SWANSEA PLANT - DELAY ANALYSIS FORM (DELAYS EXCEEDING 8Hrs)							
BREAKDOWN TYPE (E/M/O).		MECHANICAL					
AREA / MACHINE		FIRST STAGE GRINDING HOFFMAN FILTRATION					
DATE		05/02/2020					
TIME		N/A					
REPORTED BY		A CURTIS					
DOWNTIME DURATION		REPEATED FAILURES					
DESCRIPTION OF FAULT AND PROBLEM DEFINITION							
FIRST STAGE GRINDING FAILURE AND REPEATED COOLANT OVERFLOWS - COOLANT FLOW RATE CAUSE							
WHY'S	REASON	ACTIONS	ASSIGNED	WHEN	STATUS	OUTCOME	
WHY 1	Why would the coolant flow rate effect the filtration system	The coolant rate is determined by the customer FPA, to reduce fire risk and is constrained by the system's capability to process and maintain this coolant flow. In the event of the MWF being delivered to the filtration system above manageable transition rates through the media, the MWF would pool and gather on top of the media until the filter housing can no longer contain this abundance of MWF. This would eventually result in an overflow event.	Review historical operator pre-use checks and ensure the flow rate is correct being recorded. Calibrate flow meter	AC	22-Jan	Complete	Pre-use checks audited and all found to be correct. Flow meter calibrated with very minor adjustment needed. No significant change to the problem.
WHY 2	Why would the flow be increased	Potentially; if MWF spray bars become blocked and flow is restricted, then the machine will not start. It is feasible in such an event that the flow can be increased to overcome this issue without the necessity of cleaning the spray bars. However, if this continues with further spray bar jets becoming blocked and further increases to the pressure, then eventually the spray bars will have to be removed and cleaned. Unless the coolant flow is throttled back after unblocking these restrictions, then this can lead to high flow rates. Flow meter requires calibration.					
WHY 3	Why is the coolant flow rate not controlled	The coolant flow rate can be adjusted through manually operated valves. The minimum flow rate is maintained through an interlocked flow meter. Where, the machine will not start unless adequate flow to the machine is delivered. However, there is no such function to restrict the maximum flow. The machine flow rate is recorded at the start of each shift and contained within an operator pre-use check sheet.					
Concluding Remarks: The machine flow rate was measured, operator pre-use checks audited and the flow meter was calibrated. No evidence of errors were found and problems were still evident.							

Table 20: Five Why Analysis – Media Grade / Material Cause (Brook, 2014; Card, 2017).

SWANSEA PLANT - DELAY ANALYSIS FORM (DELAYS EXCEEDING 8Hrs)							
BREAKDOWN TYPE (E/M/O).		MECHANICAL					
AREA / MACHINE		FIRST STAGE GRINDING HOFFMAN FILTRATION					
DATE		05/02/2020					
TIME		N/A					
REPORTED BY		A CURTIS					
DOWNTIME DURATION		REPEATED FAILURES					
DESCRIPTION OF FAULT AND PROBLEM DEFINITION							
FIRST STAGE GRINDING FAILURE AND REPEATED COOLANT OVERFLOWS - MEDIA GRADE/MATERIAL							
WHY'S		REASON	ACTIONS	ASSIGNED	WHEN	STATUS	OUTCOME
WHY 1	Why would the filter media roll cause an overflow event	The grade of filter media will determine the transition time through the filter. A finer grade media would increase the transition time, where a coarser media would speed the process up. Therefore, if the type media should change for some reason, then this could potentially cause and overflow event.	Check filter media supplier has not changed. Trial alternative medias on recommendation from supplier and other specialists.	AC	20-Feb	Complete	No change to filter media supplier, or with supplier specification. High flow coarser polyester media trailed. This presented further problems as the grinding fines were escaping into the clean side of the system and causing blockages.
WHY 2	Why would the filter media change	Supplier / manufacturing change					
WHY 3	Could the filter media be changed to correct the problem	Potentially, a coarser or high flow media would prevent the overflow events.					
Concluding Remarks: Alternative high flow media was trialled unsuccessfully, as this cause other problems with grinding fines escaping into the clean side of the filter causing coolant jet blockages. The original filter media was checked and had not changed in any way.							

5.5 TOLLGATE REVIEW

- Have possible causes of waste and variation been identified? ✓
- Have suitable graphical techniques been used to evaluate the data? ✓
- Have obvious actions been taken? ✓
- Have statistical techniques been used to confirm causes of variation? ✓

(Sigmapro, 2020).

CHAPTER 6 - IMPROVE PHASE

The intent of the fourth phase is to ensure a full understanding of the causes identified during the Analyse phase, with the aim to eliminate or control these causes. An implementation plan is created for the solutions that will both fix and prevent the identified problems.

6.1 GENERATE POTENTIAL SOLUTIONS

The root-cause analysis (RCA) identified twelve possible causes of Hoffman Filtration failure, and through the Pareto analysis the project team's efforts and resources were focused onto four causes which were voted as the most probable. The reasoning and relevance behind each cause can be summarised as follows:

Coolant (MWF) type; TIMET is a supplier to customers working within the aerospace industry, that often require a fixed process approval (FPA) agreement to document and outline the complete manufacturing process for a given product. Any change to this process must be justified, agreed and trialled before implementation. This is a costly exercise for both TIMET and the customer. However, in September 2018 the MWF supplier at the First Stage Grinding process was replaced because of an acquisition issue. The MWF use and supply had been prohibited within Europe because of safety concerns surrounding the ingredients, and as a result an alternative MWF had to be sourced. The prohibition had happened quite suddenly and there was no contingency in place to quickly source and trial an alternative. Therefore, a different type of MWF, which had FPA and that was in use on another product within the plant was quickly introduced into the process. This replacement of the MWF within the process was a significant change and must be considered during the root cause analysis.

Vacuum system; The Hoffman filters have been in use for approximately thirty years and are now obsolete. Spare parts are no longer available from the original equipment manufacturer (OEM), and

many components have been removed or modified over time. One perceptible change which affects the fundamental operation of the machine is the removal of the vacuum pump. As previously described in the literature review, the vacuum pump generates the negative pressure which drives the MWF through the filter media. A vacuum driven system is capable of higher flow rates than those systems of comparable size which are reliant solely on gravity. Therefore, the two Hoffman filters were no longer vacuum driven systems and could be correctly described as gravity filters. However, these vacuum systems had been removed many years ago without ill effect.

Coolant flow rate; The process of grinding titanium creates an elevated risk of a fire because of the combustible nature of the element. The small fines generated during this process must be carefully managed throughout, and part of this management is to ensure the tool-workpiece interface is saturated with MWF to cool the operation. The FPA documents that a sustained 200 l/min flow must be delivered to the grinding machine, and is interlocked to the machine control to prevent levels dropping below this flow rate. However, the delivery pump has the capability of delivering 300 l/min to the machine. This could potentially affect the MWF systems balance and result in an overflow event.

Media grade/material; Despite best efforts, the project team's root cause analysis activities were highly bias towards the MWF change. This had led to discussions regarding solution generating ideas before the cause had been established. To summarise, the filter media roll used at this process had not been changed or altered in any way for several years, therefore was unlikely to be the cause of the problems encountered. However, a possible solution to the sustained overflow events would be to source and trial coarser filter media, or higher flow materials.

6.1.1 SOLUTION SELECTION MATRIX

The project team evaluated each of the four causes described and established potential solutions:

- **Coolant type:** Source alternative MWF and pilot study
- **Vacuum system:** Source, install and pilot study a new vacuum system
- **Coolant flow rate:** Pilot study different flow rates
- **Media grade/material:** Pilot study different types of media

In addition to these targeted solutions, the project team discussed the feasibility of a complete overhaul to both filtration systems. The reasoning for this was that the targeted solutions would not address the many other problems associated with the Hoffman failure modes such as: difficulty in procurement of spare parts, worn mechanical components, suspected breach of filter integrity from corrosion due to age and so forth. An overhaul solution could potentially provide upgrade

opportunities, or modifications to enable OEM spare part compatibility, tank and structure integrity could be addressed, and each filter could be returned to the original design standard. However, the costs involved to upgrade and fully repair the filters could potentially amount to more than that of a new filtration system, which could be designed for the application and built in line with current technological advancements.

To enable analysis and a structured evaluation of the most effective solution to implement, a solution selection matrix was generated. The criterion which would best satisfy the business goals was discussed and determined through the project team, weighted for importance and scored accordingly throughout the matrix. Table 21 illustrates the solution selection matrix analysis.

Table 21: Solution Selection Matrix

PROJECT OWNER: ANDREW CURTIS		DATE: 15/07/19		SELECTION CRITERIA																			
PROJECT SOLUTION SELECTION MATRIX				SPEED OF DELIVERY	WILL SOLVE THE PROBLEM FULLY	COST	CUSTOMER IMPACT OTD	NO REGULATORY REQUIREMENT	FLEXIBILITY POTENTIAL	QUALITY IMPROVEMENT POTENTIAL	RELIABILITY IMPROVEMENT POTENTIAL	OEM SUPPORT (MAINTENANCE / FAULTS / SPARES)											
													WEIGHTING										
SOLUTIONS				20	20	20	15	20	10	20	20	10	WEIGHTED TOTAL	RANKING TOTAL	IMPLIMENT YES / NO								
Source Alternative MWF		Value		1	3	3	3	1	1	1	3	1	305	6	NO								
	Weighted Cal.			20	60	60	45	20	10	20	60	10											
Source and Install New Vacuum System		Value		9	3	1	3	9	1	1	3	1	585	3	YES								
	Weighted Cal.			180	60	20	45	180	10	20	60	10											
Pilot Study Different Flow Rates		Value		9	1	9	9	1	1	1	1	1	595	2	YES								
	Weighted Cal.			180	20	180	135	20	10	20	20	10											
Pilot Study Different Media Grades / Types		Value		3	3	9	9	1	1	1	1	1	515	4	NO								
	Weighted Cal.			60	60	180	135	20	10	20	20	10											
Complete Hoffman System Overhaul and Upgrade		Value		1	9	1	3	1	3	3	3	1	445	5	NO								
	Weighted Cal.			20	180	20	45	20	30	60	60	10											
Purchase New Filtration System		Value		1	9	1	3	1	9	9	9	9	825	1	YES								
	Weighted Cal.			20	180	20	45	20	90	180	180	90											
					KEY		1 = Low (Less Good)		3 = Medium		9 = High (Good)												

Figure 26: Histogram to Display Solution Selection Matrix Ranking Score

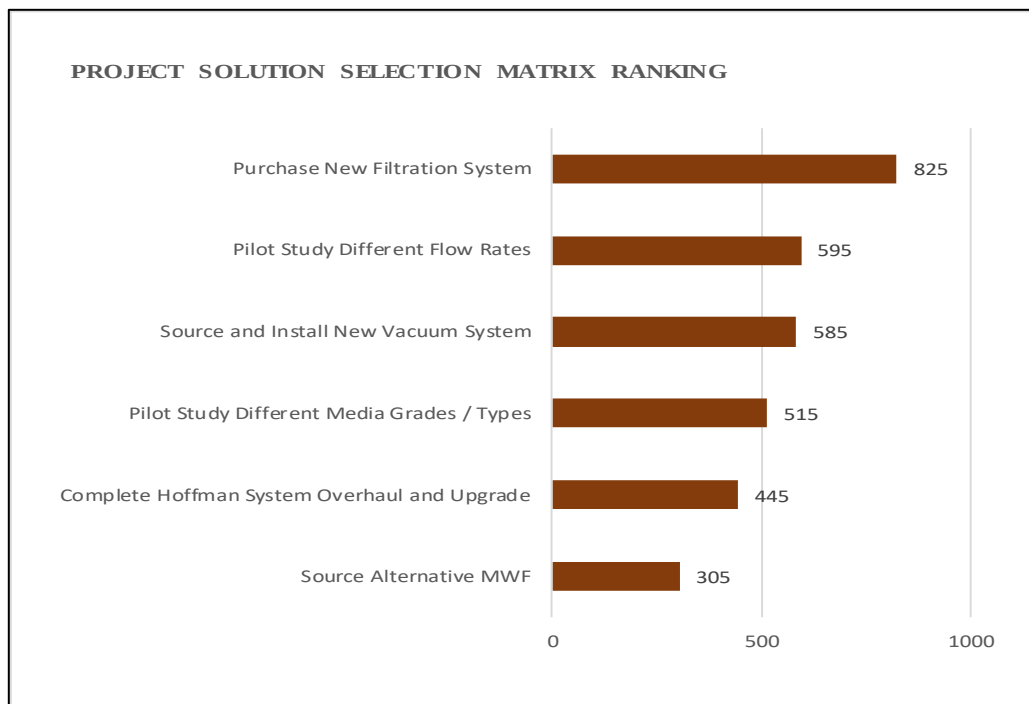
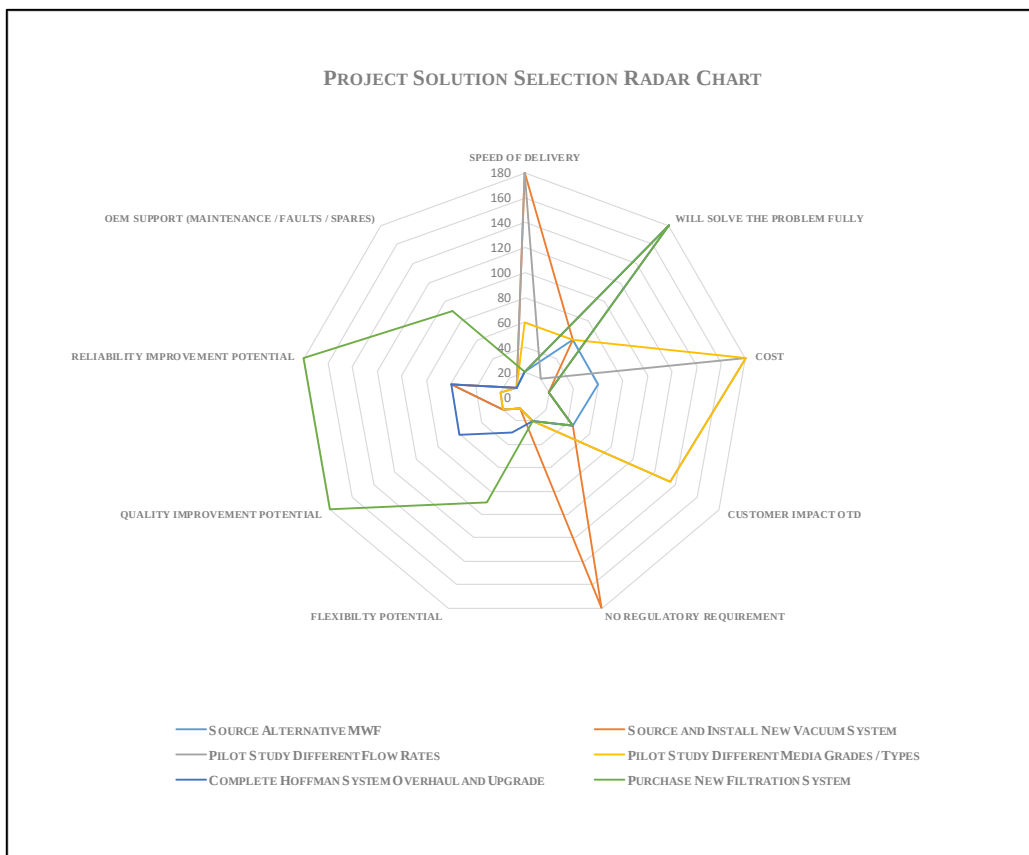


Figure 27: Radar Chart to Display Solution Selection Matrix Criterion Ranking



As is evident from the solution analysis contained in Table 21 and Figure 27, the benefits to the long term business needs which could potentially be realised from the purchase of a new filtration system such as: reliability, quality, flexibility for future product development and OEM support, has ranked this solution as the best course of action. However, because this solution presented the longest delivery time, the project team decided to implement further mitigating control measures which had been identified through the solution generation process. The two mitigating solutions selected were to source, install and pilot study a replacement vacuum system for the existing filters, and to measure current MWF flow rates to ensure flow rate instrumentation and control were correctly calibrated. The minimum MWF flow rate could not be reduced to values determined within the FPA, however, this flow rate required confirmation. These two mitigating solutions could potentially be easily implemented based on the low cost and speed of delivery, and had a high potential to impact the problem positively. The two further mitigating solutions intent was to improve the problem until the long term solution could be implemented.

6.2 SOLUTION IMPLEMENTATION

6.2.1 SOURCE, INSTALL AND PILOT STUDY AN ALTERNATIVE VACUUM SYSTEM

Unfortunately, very little information regarding the original system requirements for vacuum pressure was available because of the age of the two EFCO Hoffman filters. However, newer versions of the Hoffman Vacumatic systems were in use at similar processes within the plant. These newer designs were slightly different, however, a manual for these newer systems was available and dictated vacuum pressure requirements of between 12 to 15 in. of mercury (41 to 51 kPa). Also available from these newer versions was a complete spare centrifugal vacuum pump, held as stock within the stores. This opportunity presented a potential simple and quick solution to determine if vacuum pressure would positively impact the problem. Unfortunately, after installation of the new vacuum pump, problems were still persistent and no noticeable or significant improvement was evident.

Figure 28: Compatible Centrifugal Pump Installation and Trial



A further attempt to implement the vacuum system solution was undertaken with consultation and recommendations from an external resource who specialised in vacuum systems (Controlgear). Evaluation of the unsuccessful first attempt determined that insufficient vacuum pressures was being maintained, possibly because of the larger vacuum chamber on the EFCO Hoffman filters, which necessitated larger vacuum volume requirements. Based on recommendations and an agreed trial before purchase with the vendor, a new system was installed using two claw vacuum pumps in tandem with a liquid separator.

Figure 29: Controlgear Vacuum System Installation and Trial



The second vacuum system pilot study was run for two weeks, downtime associated to Hoffman filtration failures had not significantly changed and overflow events were still persistent. Therefore, no investment through the purchase of this system from Controlgear was justifiable and the vacuum system was removed and returned.

6.2.2 CONFIRMATION OF METALWORKING FLUID FLOW RATES

As previously discussed, the FPA for this process documents that a sustained 200 l/min flow must be delivered to the grinding machine, and is interlocked to the machine control to prevent levels dropping below this flow rate. However, the delivery pump has the capability of delivering 300 l/min to the machine and is controlled by operator pre-use checks. The pre-use check involves a visual inspection of a flow meter (Figure 30), to record the flow rate at the start of each shift. Appendix 2 contains a copy of the EFCO pre-use check sheet.

Figure 30: EFCO MWF Flow Meter

An audit of the operator pre-use check documentation was undertaken to ensure procedures were being adhered to, and each flow meter was calibrated to confirm the measured value was accurate. These investigations provided no further insight into the causes of the overflow events, as the flow values recorded in the check sheets were within normal limits, and the flow meter calibration required very little adjustment.

6.3.3 CAPITAL ACQUISITION OF NEW FILTRATION SYSTEMS

Research through internet searches provided a comprehensive list of suppliers who specialised in MWF processing equipment. In attempts to reduce the selection from this available resource, the PCC Corporate Group were reached out to, for recommendations on manufacturers for this type of equipment. This process involves an email to the Vice President of PCC, who will circulate a request for information amongst the PCC group (Appendix 3). This is common practice when sourcing new equipment at TIMET, and often helps to promote a CapEx project and eases the approval process.

The outcome for this request for information came from the Toronto Plant, who had recently purchased and installed MWF processing equipment through the Oberlin Filter Company (OFC). Apparently, Toronto had found OFC through an external contractor who regularly process sheet product for them. The external contractor exclusively used OFC within their facility, and allowed engineers from the Toronto plant to view the filters in operation prior to pursuing the purchase of the equipment. The new Oberlin filters had been received well within Toronto and were highly recommended (Appendix 4).

OBERLIN FILTER LTD

Oberlin Filter Company is an American organisation who design, manufacture and supply bespoke automated filtration equipment for MWF applications and operate within the Aerospace, Medical, Rotor and Gear Grinding and Automotive industries. OFC formed Oberlin Filter Ltd in Newton Aycliffe, County Durham, England in 1999 to develop its market in the United Kingdom, Ireland and throughout Europe including the Netherlands, Belgium and France (Oberlinfilter.com, 2020).

Oberlin Filter Ltd were contacted and a site visit was arranged to determine TIMET's process requirements. During this visit, the engineer performed field test trials from a portable version of the pressure filter which Oberlin manufacture. The field test determines the filtration system's capability for an application. The process involved plumbing Oberlin's portable unit into the MWF system, where different media types and grades were trialled and samples of the filtered MWF were collected and analysed. The field test will also determine the size of the filter required (surface area), which is governed by the processes MWF solids content and flow rate.

Figure 31 illustrate the successful field test at TIMET Swansea by the Oberlin engineer. This was followed by a request for a design solution, project proposal and quotation (Appendix 5).

Figure 31: Oberlin Filter Ltd Field Test Trial



CAPITAL EXPENDITURE PROJECTS

The estimated cost for a new filtration system exceeded the maximum spend allowable on TIMET's Operating Expenditure. Therefore, a Capital Expenditure project business case was required to justify the level of investment for the new filtration system. Capital Expenditure, which is commonly referred to as CapEx, is funding used by an organisation to acquire, upgrade or maintain physical assets such as industrial plant equipment, buildings, technologies and so forth. This type of financial outlay is also made by companies to maintain or increase the scope of their operations. CapEx is any type of expense that a company capitalises, or shows on its balance sheet as an investment, rather than on its income statement as an expenditure. It also illustrates how much an organisation is investing in existing and new fixed assets to maintain or grow the business (Kenton, 2019).

TIMET utilises an electronic platform to manage CapEx projects, which documents and contains the CapEx approval process. The project manager responsible for a project's execution will initiate the process in the form of an electronic contract (ECON), which is integrated with supporting documentation and budgets along with the request for CapEx. The project manager must define technical requirements for the project, scope of work, project timelines, schedules, contract requirements and so forth. The originator of the request gets a notification email at each step. If tasks are not completed in specified days, reminder emails are sent out. Managers can approve, reject, or ask for additional information about the authorisation request at each stage of the approval and each stakeholder is notified about the progress of the request (Clark et al., 1989; Jaafari, 2001). Appendix 5 contains the capital appropriation request and ECON documentation for the Oberlin filters. The following are a few key considerations that are contained within the ECON document:

- Key assumptions used in the justification of the project.
- Safety implications related to occupational health issues.
- Details of expenditure that replaces existing assets.
- Basic financial analysis (e.g., discounted cash flow analysis, payback, ROI, etc.)
- Financial justification for specific project types, such as modernisation/technology upgradation, energy conservation or cost reduction, capacity expansion, etc.
- The financial payback to the company related to the purchase of the particular capital item/project (applicable to the cost reduction/income producing justification category only).

(Jaafari, 2001),

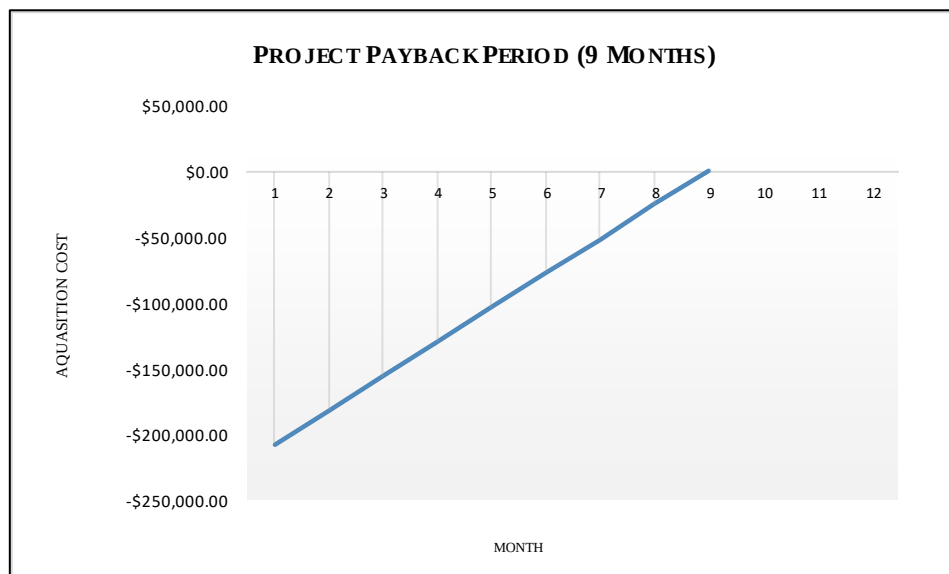
RETURN ON INVESTMENT (PAYBACK)

The payback period is the time period required to recover the cost of a project; therefore, it is the length of time taken when a project's cumulated cash flow will be able to pay back for its initial investment. Efinancialmodels.com (2020) states that the payback period tool is often used to determine the profitability of a project by calculating the break-even period, which provides information regarding the liquidity of the project under analysis. Table 22 illustrates the costs associated to the Hoffman Failures in comparison to the total cost of the procurement of the new filters. Figure 32 determines that the payback period for the Oberlin filter project would be nine months.

Table 22: Project Return on Investment Metric

RETURN ON INVESTMENT (ROI) METRIC	
COSTS	VALUE
FORCASTED TOTAL ANNUAL COST OF EFCO HOFFMAN FILTER FAILURE	\$313,634.52
TOTAL PROJECT COST OF OBERLIN FILTER PROCUREMENT	\$233,995.92

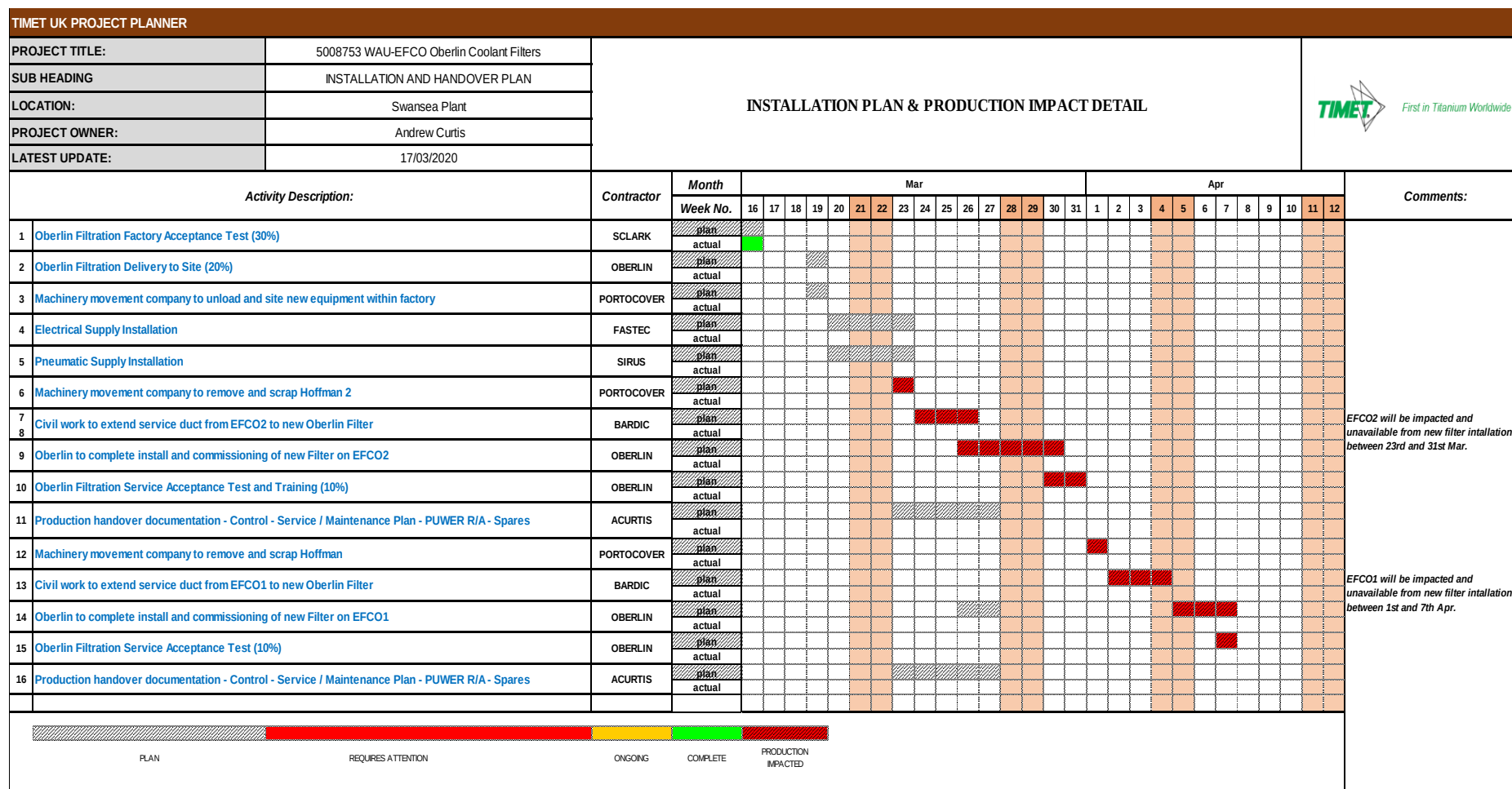
Figure 32: Project Payback Period Chart (Efinancialmodels.com, 2020).



PROJECT PLANNING

A project plan is a management document that allows team members and stakeholders to have a complete understanding of what is happening to prepare for upcoming challenges and disruptions. A high-level plan (Figure 33) is often generated at the start of a project to highlight key milestones and deliverables so there is a common understanding of expectations. Production managers may need to prepare for issues such as labour, costs and throughput targets. Team members may need to organise resources, contractors and facilitate actions at the required time. The project plan is a live document and any changes or delays must be communicated through to stakeholders immediately. Further focused or detailed planning can be implemented when necessary on subsequent documents for individual tasks, as demonstrated in Figure 34, which illustrates the plan for the Oberlin filter installation. The plan has been developed to minimise production impact by focusing on one EFCO at a time, and working through weekends when this process is often running at half capacity. Only on the successful completion of the first installation will the second installation start. This will ensure production can continue at reduced throughput and not stop altogether (Prince2.com, 2020).

Figure 34: Oberlin Filter Installation Plan and Detailed Production Impact

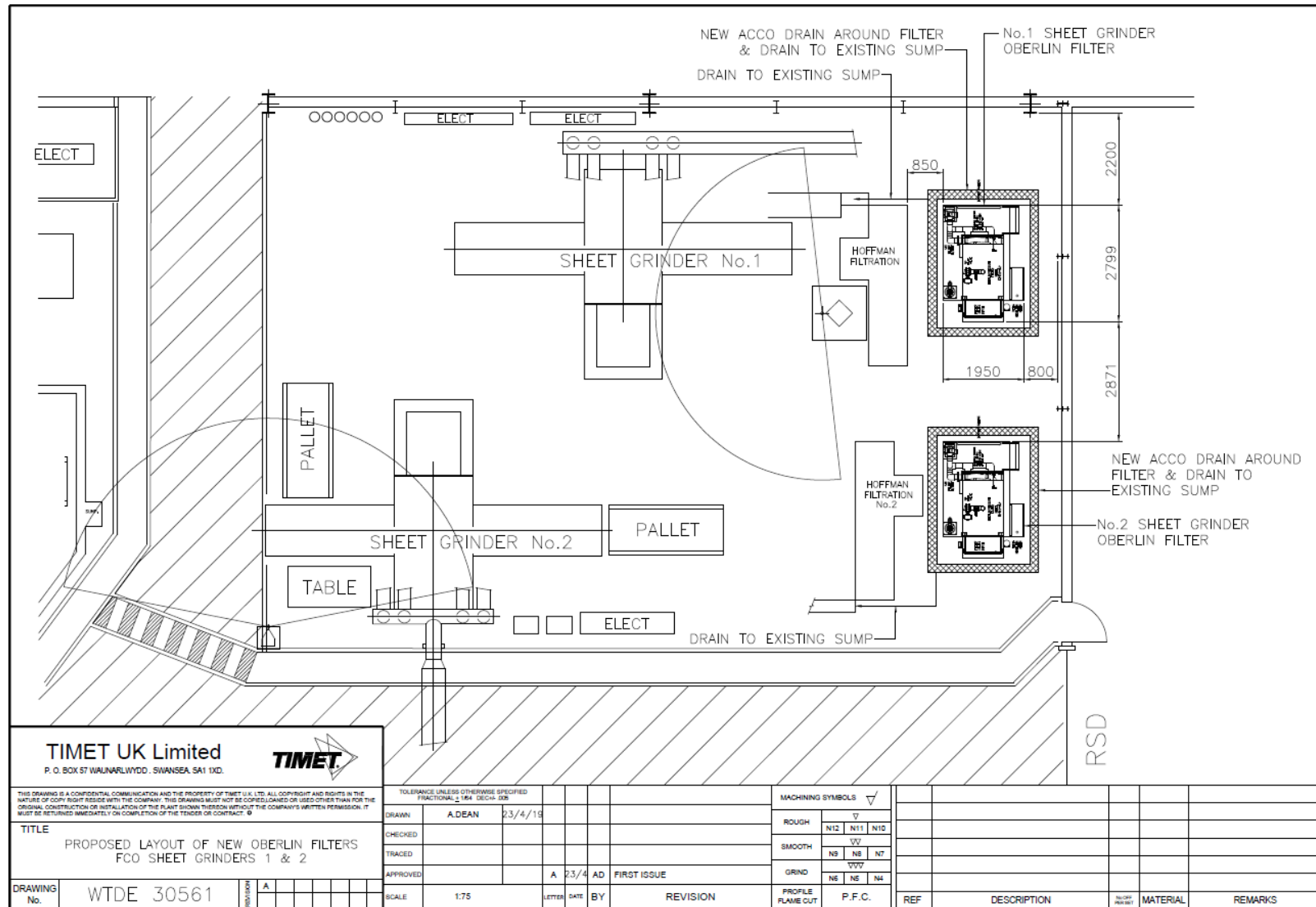


CAPITALISE ON FURTHER OPPORTUNITIES

The new filter installation as illustrated in Figure 35 presented many opportunities to improve the work cell:

- The First Stage Grinding Cell often becomes congested from ‘work in progress’ (WIP) storage. By situating the new filters further along ‘C Bay’ and closer to the wall, the processes floor space, or work area was substantially increased, potentially allowing for safer storage and a safer working environment for operators.
- Contained within the CapEx budget was provision for installation of linear drainage. The linear drainage surrounds the new filters and would prevent any coolant egress in the event of a system failure. The linear drainage returns any leaks, spillages or over-fill events to the MWF sump for recovery back into the system.
- By placing the Oberlin filters behind the existing Hoffman filters, the Hoffman filters were not compromised in any way and could remain operational. Therefore, 80% of the Oberlin filter installation could be completed without impacting production throughput. The final 20% of the installation could then be scheduled and aligned to production needs

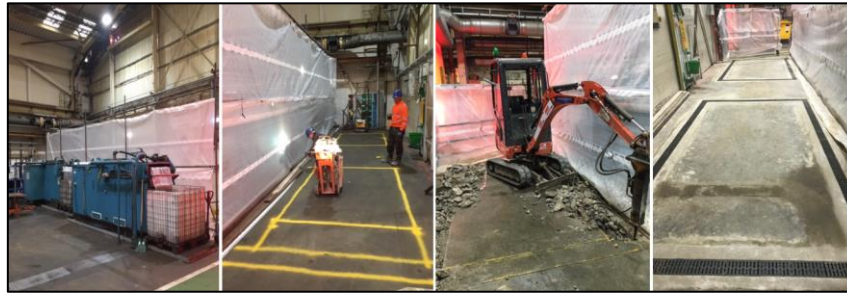
Figure 35: Proposed Layout of Oberlin Filters



OBERLIN FILTER LINEAR DRAINAGE INSTALLATION

To ensure all work was undertaken safely, the Oberlin Filter installation area was cordoned off and a scaffolding barrier was erected with a flame-retardant screen. The primary purpose of the barrier was to mitigate the risk of a fire from any sparks generated during the civil work. Figure 36 illustrates the linear drainage installation.

Figure 36: Oberlin Filter Linear Drainage Installation



OBERLIN FILTER DELIVERY

The Oberlin Filters were delivered to TIMET Swansea Plant on March 19th. Figures 37 and 38 illustrate the offloading and siting process for the filters by a local contractor (Portacover Machinery Movement).

Figure 37: Oberlin Filter Delivery and offloading



Figure 38: Oberlin Filter Placement



4.3 TOLLGATE REVIEW

- | | |
|--|---|
| • Have potential alternative solutions been identified? | ✓ |
| • Has the suitability of each potential solution been evaluated? | ✓ |
| • Has any planned investment been financially justified and agreed? | ✓ |
| • Have appropriate pilots and trials been carried out? | ✓ |
| • Have any required experiments been done to optimise the process? | ✓ |
| • Have the best solutions been selected? | ✓ |
| • Have the solutions been verified as effective? | x |
| • Has statistical analysis confirmed the solutions have made a significant difference? | x |

(Sigmapro, 2020).

CHAPTER 7 - COVID-19 PROJECT IMPACT

In January 2020 the World Health Organization (WHO) declared the outbreak of a new coronavirus disease in Hubei Province, China to be a Public Health Emergency of International Concern. WHO stated there was a high risk of the 2019 coronavirus disease (COVID-19) spreading to other countries around the world. On March 23rd the UK enforced restrictions to prevent the spread of the pandemic and entered a 'Lockdown' period where many organisations were forced to close. Organisations supplying essential goods or services were permitted to continue trading, and those employees working at these organisations have been termed as 'Key Workers'. TIMET Swansea plant has remained operational throughout the pandemic because of its supply links to the medical industry and ministry of defence, and have been operating under the UK governments safety guidelines (World Health Organisation, 2020).

The UK government guidelines and control measures enforced at TIMET has prevented any further work on the Oberlin filter project. The timeline of events are as follows

- March 23rd - TIMET prohibited site access to contractors.
- March 23rd - Deliveries are carefully managed through a quarantine process off site.
- March 23rd - Employee social distancing control measures implemented.
- March 23rd - Office staff working from home.
- April 6th - 100 employees placed on the government furlough scheme.
- May 4th - Mandatory personal protective equipment (face mask and hand sanitiser).
- May 4th - Employee temperature checks at security before permitted access to site.
- May 11th - 140 redundancies, currently in forty-day consultation period.

- May 15th - Plant closure on May 25th announced (one week).

The Covid-19 pandemic has significantly impacted the project and any further work is currently on hold. The planned next steps for the project were for Oberlin Filter Ltd to attend site and complete the installation, commissioning and TIMET operator training. However, the prohibition of contractors has prevented this for the foreseeable future. Progress on the DMAIC Control Phase and any additional project work has been effected by a significant reduction in TIMET engineering staff through furlough and sickness. The focus for the remaining engineering staff has now been realigned to statutory, legislation and essential plant requirements. The Oberlin filter project was deemed non-essential to TIMET's business needs at this current time.

CHAPTER 8 - CONTROL PHASE

The final stage on the DMAIC Roadmap has not been completed because of the impact from Covid-19 to TIMET Swansea plant. However, this work is still required and the Control phase must be completed to ensure all improvements are controlled and sustained. The objectives of the Control phase are to complete all outstanding work and hand over the process improvement to the process owner. This phase focuses on establishing control measures to ensure all project gains are sustained. A process control plan is often used to outline the necessary procedures that need to be adhered to, to prevent the process from returning to the 'old ways'. The process owner should be provided with the before and after data on the key project metrics, operational and training documents, and updated process maps. The financial benefits to the improvement should be quantified and a process control plan to monitor the key metrics for periodic auditing needs to be implemented. Montgomery and Woodall (2008) emphasise the importance of auditing the process periodically, to ensure that the original results are still in place and stable so that the any financial benefits will be sustained. For project completion, all actions within the Control phase Tollgate Review must be completed.

8.1 TOLLGATE REVIEW

- | | |
|---|---|
| • Have ongoing control risks been considered and appropriate actions taken? | x |
| • Has a control plan been completed? | x |
| • Has the performance been proven over time? | x |
| • Has the necessary documentation been incorporated into the management system? | x |
| • Has a formal audit been planned? | x |

- Has a hand over meeting been held? x
- Have lessons learnt been recorded? x
- Has the project been signed off by the company? x

(Sigmapro, 2020).

CHAPTER 9 - CONCLUSION

Many of the project's key deliverables have been successfully met through the movement of this project, and upon completion of the Oberlin filter installation, the project team are confident all objectives will be accomplished. The following lists all of the key deliverables identified at the project launch and details the solutions implemented:

- *Implement an immediate short-term solution to mitigate the safety concerns or hazards, as a result of Hoffman filter failure and the associated MWF spillages.*

The short-term solution to mitigate the safety implications associated to an overflow event upon Hoffman filter failure was achieved through the installation of a drip tray, which fully contained any MWF leaks or spills. The final design was developed from trials involving multiple drip trays. The drip trays were strategically placed in troublesome zones around the Hoffman. This proved unsuccessful as the trays required managing and emptying by the operators, which was detrimental to production.

- *Implement immediate short-term solution to prevent or reduce the potential further loss to the organisation.*

The drip tray solution correspondingly reduced the Hoffman filter failure cost, by reducing the repair time (MTTR). The reasoning for this was that the majority of the downtime was consumed by the clean-up activity after an MWF overflow event. Also, through this MWF containment, the contractor costs associated with the clean-up activity were eliminated.

- *Analyse and establish the root cause of the Hoffman Filtration repeated failures.*

The project team's RCA identified many potential causes for the Hoffman filter failures. However, through consensus the team's conclusion was that the catalyst or root cause of the problem was the MWF change. This change had altered the process requirements for the filtration system, possibly expanding these requirements outside that of the Hoffman filter's capability. The

Hoffman filter could not reliably process the new MWF at the required flow rate after contamination from the process. Potential reasoning for this was substantiated by Astakhov and Joksch (2012) in Chapter 2 - Literature Review. Where detail is given on how the viscosity of a liquid will affect a mechanical filtration system, and that liquids with high viscosity will have a reduced sedimentation speed and flow rate compared to a liquid with low viscosity. Unfortunately, limitations to the RCA process is evident from the inability to conclusively determine the different properties between the MWFs. The availability and procurement issues surrounding the old type of MWF made obtaining a sample for analysis extremely difficult. Therefore, the project team moved forward with the assumption that the new MWF had different properties that were having detrimental effects to the system, and the project team progressed onto solution generating ideas to improve the system based on this assumption.

- *Implement long-term solution to improve the reliability of the process.*

The project highlighted many problems and potential causes of failure for the Hoffman filters, such as: difficulty in procurement of spare parts because of obsolescence, worn mechanical components, suspected breach of filter integrity from corrosion due to age, and component removal or system modification over time. The project team's discussion during the solution generating process provided solutions to target many of these possible causes of failure. However, these targeted solutions would not correct all the problems identified, and would still leave the system vulnerable to breakdown. For this reason, a full overhaul of the filtration system was discussed, with the aim to repair and modify the existing filters to allow fitment of current OEM parts. On further evaluation, and when the costs to this venture were realised, the idea was found to be not cost effective against the procurement of a new filtration system, which could be designed for the application and built in line with current technologies.

Research undertaken for the new MWF processing equipment provided a multitude of suppliers specialising in this field. However, information and recommendations from TIMET Toronto plant guided the project team to Oberlin Filter Ltd. Through field test trials at TIMET Swansea plant, Oberlin Filter Ltd provided a design solution and quotation. Normal conditions or requirements for the Capital Appropriation process at TIMET often require three separate quotations, from three different suppliers to obtain approval for the spend. However, the recommendation of Oberlin Filter Ltd from another organisation within the PCC group enabled this necessity to be bypassed. The Capital Appropriation Request was approved and the new filters were purchased to provide a long-term solution to the Membrane Products process route bottleneck.

The financial benefits of this project cannot be realised until the equipment has been fully installed and commissioned. Once the new filters are online, a payback period on the investment

in the new filters of nine months has been calculated. Thereafter, the estimated potential project return of \$235,000 per annum can be achieved, which is based on a conservative 75% improvement to the First Stage Grinding Filtration processes reliability.

- *Capitalise on further opportunities presented throughout the development of the project, provided that the opportunities are within the project scope.*

Through the Capital Appropriation process, additional spend was approved for installation of linear drainage. The linear drainage would surround the new filters and prevent any coolant egress in the event of a system failure. The linear drainage would return any leaks, spillages or over-fill events to the MWF sump for recovery back into the system. The linear drainage in effect mimics the drip tray solution implemented for the Hoffman filters, however, as the linear drainage is floor level, these do not present any potential trip hazards.

The new filter installation process facilitated a new production cell layout. The Oberlin filters have been sited to create more floor space and a larger work cell. The First Stage Grinding Cell often becomes congested from WIP storage. This area will be substantially increase on completion of the project allowing for safer storage and a safer working environment for operators.

CHAPTER 10 - RECOMMENDED FOR FURTHER WORK

Once the installation process has been completed and the filters are online, the full benefits of the project must be calculated and realised. This can be achieved through monitoring the new performance metrics for the filters, and comparing these to the original base line established for the Hoffman filters. Additional studies can be undertaken to establish the new filter consumable usage and operational costs, as the Oberlin filters were promoted to be far more efficient. Expected savings through reduced filter media, reduced MWF and waste disposal costs can be calculated.

Once the financial benefits to the MWF filter improvement is fully quantified, this information can be used to justify the investment for a further six filters, to replace those on similar processes at TIMET Swansea plant. By using Oberlin Filter Ltd as the primary supplier, equipment spares can be standardised within the stores. Further financial benefits will be made by reducing stores inventory by eliminating the many different critical spares held for the current filters.

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APPENDIX 1: TIMET ENGINEERING STRUCTURE



APPENDIX 2: EFCO GRINDER PRE-USE INSPECTION

		EFCO: PRE-USE CHECK SHEET	
Item	OK/NO	Comment	
Check emergency stops are operational			
Complete Argon and Coolant Fire Extinguishant Safety Checks			
Check Gate Interlocks are operational			
Check rolling table limit switches are operational			
Check peloby/vacuum unit			
Check floor/steps are clear of debris/clutter			
Visually check machine/piping for damage or leaks and stored correctly			
Check scrap belt tray is at acceptable level			
Check and record coolant flow meter, values must be maintained at 48-50 GPM.			
Hoffman Pre use Checks			
Check Emergency Stop for functionality			
Clean and ensure area is free from escaped sponge deposits			
Check Hoffman waste bins are filled to correct levels of water			
Check Hoffman paper has been loaded into the machine correctly			
Machine number:		Name:	Date/time:
Note: If any safety issues are identified inform the Shift Supervisor prior to start up.			
IMPORTANT: IF OPERATOR LEAVES THE MACHINE UNATTENDED FOR MORE THAN 15 MINUTES NO STANDING SPONGE IS TO BE LEFT TO DRY ON HOFFMAN FILTER PAPER		- When the m/c is left unattended for a short period of time (0 minutes to 1hr) - Ensure that the hoffman is not switched off, so that the paper/swarf continually runs off into the IBC - When the m/c is left unattended for a longer period of time (1hr +) i.e. serious break down, planned maint OR no manning/WIP - Ensure that the swarf is run off into the IBC, that hoffman paper is cut, the m/c is thoroughly cleaned down, before leaving the area	

APPENDIX 3: OBERLIN FILTER EMAIL CORRESPONDENCE (MARTIN WILKINSON)

From: "Wilkinson, Martin" <Martin.Wilkinson@Timet.com>

Date: 8 April 2019 at 14:01:01 BST

Subject: FW: Oberlin Filtration Information

Jeremiah, Brandon and Chris – any and all comments to our brothers in Swansea would be appreciated. Swansea are looking to upgrade their filtering systems on their sheet grinders. Please provide pluses and minuses on Oberlin (copy me). Thanks, Martin

From: Curtis, Andrew

Sent: Friday, April 05, 2019 6:03 AM

To: Trinone, Jeremiah <Jeremiah.Trinone@Timet.com>

Cc: Clark, Steve <Steve.Clark@Timet.com>; Whiles, Andrew <Andrew.Whiles@Timet.com>; Jakuta, Mark <Mark.Jakuta@timet.com>; Wright, Steve <Steve.Wright@Timet.com>; Wilkinson, Martin <Martin.Wilkinson@Timet.com>

Subject: Oberlin Filtration Information

Good Morning

My name is Andrew Curtis and I am the mechanical Engineer within the Finishing Department at Timet Swansea. This week we had a visit from Steve Wright and Martin Wilkinson, who have suggested reaching out to you for feedback on the Oberlin Filtration System you installed in 2017.

Coincidentally, I have reached the same conclusion as you did two years ago and have been in contact with Oberlin for design solutions to our current filtration problems (old obsolete Hoffman vacuum filters).

Any information on performance, reliability and after sales would be greatly appreciated.

Kind Regards,

Andrew Curtis

Mechanical Engineer

TIMET UK Ltd, PO Box 57, Waunarlwydd, Swansea, SA1 1XD.

Mobile: 07391865947

Office: 01792 870383

Driving to Waunarlwydd? SAT NAV Post Code: SA5 4SF

TIMET UK Limited is registered in England and Wales. Company Registration Number: 530589

Registered address: PO Box 704, Witton, Birmingham, B6 7UR, UK.

Additional information about TIMET UK Limited and its ultimate parent company, Titanium Metals Corporation can be found on www.timet.com



Think before printing this mail - help preserve the environment

APPENDIX 4: OBERLIN FILTER EMAIL CORRESPONDENCE (JEREMIAH TRINONE)

From: "Trinone, Jeremiah" <Jeremiah.Trinone@Timet.com>

Date: 26 April 2019 at 15:32:39 BST

Subject: RE: Oberlin Filtration Information

Hi Andrew-

I forgot to respond to this and just caught it while cleaning up my Inbox.

Apologies for the delay.

Real quick to the Oberlin, we found them via an outside processor we use to grind sheet product. That convertor uses them exclusively in their facility and allowed us to view them in operation prior to pursuing the purchase of the equipment. Our main push for them was that we could eliminate the filter media that is required for the existing vacuum filters and gravity filters we have in operation. We have not had them in operation long enough to encounter any major maintenance issues, but the design is very simple and other than the pumps needing rebuilt and some issues with pressure sensors they have worked well for us since the installation. The only real con that I have, falls back to me when I installed them which is the lockout /tagout of them for Maintenance/cleaning requirements. There are two (2) twin filters that utilize the same drive cabinet with no dedicated disconnect for each filter. Something you need to discuss with them if you pursue them as an option. Attached is a layout of the system we have. Let me know if you have any technical questions about them.

We recently (June 2018) installed a new Pacific shear that we use on the packs. Photo attached, manual attached, and the Sales contact info is below. Another Engineer that is no longer with the company purchased it and I installed it after he left so I am not sure of any Equipment Specification that was created as I have not come across one in the project files. We did have issues with the hydraulic hold-downs that were originally installed, but Pacific has since provided new cylinders of a different design which has fixed the issues. Let me know what information you are looking for and I can dig something out.

<image001.png>

Thanks!

Jeremiah Trinone
Project Engineer

TIMET

Toronto, OH

Office: (740) 537-5680

Mobile: (740) 275-8424

Jeremiah.trinone@timet.com

APPENDIX 5: OBERLIN FILTER CAPITAL APPROPRIATION REQUEST



CAPITAL APPROPRIATION REQUEST**TITANIUM METALS CORPORATION
WAUNARLWYDD PLANT UK****Project Title: WAU-EFCO Oberlin Coolant Filters**

Waunarlyydd Project 2019- [REDACTED]

Cost Center: [REDACTED]

Work Area: Sheet Finishing

Date: 16/05/2019

EXPENSE COST ESTIMATE: \$1,628.38

CAPITAL COST ESTIMATE: \$232,367.55

TOTAL PROJECT ESTIMATE: \$233,995.92

PROJECT OWNER: Andrew Curtis



Executive Summary

To purchase and install two new Oberlin Filtration Systems, which will remove titanium-grinding fines from water-based metalworking fluid, one for each EFCO Sheet Grinder.

Project Justification

a. Description of present situation:

The ACME EFCO Sheet Grinder One and Two at Swansea Plant process sheet and plate up to 12mm thick. The swarf produced during this process is in the form of fines, or often referred to as sponge. The swarf fines are currently filter from the coolant by two Hoffman Vacuum Filter conveyors. The estimated age of these filters is 30 years old and they are now obsolete, this equipment has come to an end of its useful life and is no longer cost effective to maintain. Failure to replace these aged units will lead to unplanned downtime and loss of revenue.



The Hoffman Filters are causing many production delays and safety concerns to include:

- Paper blinding and causing floods in surrounding area.
- Paper feed issues causing swarf fine to enter into the clean side of the filter, resulting in spray bar, flow gauge and pipe blockages.
- The conveyor is prone to excessive downtime through filter media and conveying jams.
- Obsolescence – spares are no longer available for this model.
- Excess filter paper usage.
- External contractor manually separates swarf fines from the filter paper for disposal.



b. Description and specifications of proposed project:

i. Statement of what is proposed:



- To purchase and install two new Oberlin Filtration Systems, which will remove titanium-grinding fines from water-based metalworking fluid, one for each EFCO Sheet Grinder.
- The system designed for Timet Swansea by Oberlin, is a scaled down version of the system currently in operation within Timet Toronto.
- The new Filter Systems will provide efficient filtration to the current process and separate swarf fines from the media.
- Additionally supplied with each filter are two appropriate waste containers, which are transportable via a FLT.
- Linear drainage will be installed around the filter systems to prevent any egress of coolant into the surrounding area.
- The installation will require an upgrade to the existing Electrical and Pneumatic supply to meet appropriate standards.

ii. Plans and dates:

The project will commence immediately once approval has been granted
The work would be carried out alongside normal plant operations.

iii. Present status:

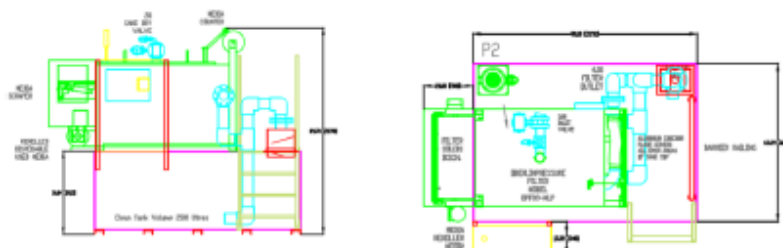
a. Project planning

Timeline	2019											
	Q1 2019			Q2 2019			Q3 2019			Q4 2019		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Purchase Order												
Manufacture												
Deliver												
Commission Approvals												



b. Design and engineering

Oberlin have conducted onsite trials on the current process to determine system size and media requirements. Additionally to the filter system, Oberlin have designed a new Filter Feed Pumping System to improve on our current solids pumping capacity.



c. Cost analysis

Project Title: EFCO Coolant Filter		Wau-EFCO Oberlin Coolant Filters			FX	1.9027	
No.	Parts / Labour	Supplier/Manufacturer	No. Req	Unit Cost(£)	Total Cost (£)	Total Cost (\$)	Quote
1	Filtration System	Oberlin	2	£64,525.00	£129,050.00	\$168,113.44	
2	FLT-waste solids container	Oberlin	4	£1,500.00	£6,000.00	\$7,816.20	
3	Additional Filter Media	Oberlin	40	£60.00	£2,400.00	\$3,126.48	
4	Electrical Service Costs	Fastec Electrical Services	1	£11,198.00	£11,198.00	\$14,587.63	
5	Mechanical Service Costs	Sinus Fluid Power	1	£1,768.00	£1,768.00	\$2,303.17	
6	Civil Service Costs	Bardic Construction	1	£10,492.00	£10,492.00	\$13,667.93	
7	Machinery Movement / Installation Costs	Portacover	1	£1,250.00	£1,250.00	\$1,628.38	
19							
20	Contingency				£163,158.00	\$ 211,243.23	
19							
25	Quotes only held for 30 days			10%	£16,215.80	\$ 21,134.32	
Total Capital Cost					£178,373.80	\$ 232,367.55	

Project Title:		Wau-EFCO Oberflin Coolant Filters			FX	1.9027
No.	Parts / Labour	Supplier Manufacturer	No. Req	Unit Cost(£)	Total Cost (£)	Total Cost (\$)
1	Machinery Removal Costs (estimate)	Portacover	1	£1,250.00	£1,250.00	\$1,628.38
2						
3						
4						
5						
	Total Expense Cost				£1,250.00	\$1,628.38

d. Negotiations

Further cost reductions will be negotiated by raising the PO



- iv. **All assumptions used in financial estimates**
 Required isolations will be completed by Timet prior to work commencing.
 Scaffold will be provided by Timet.
 All work will be completed during normal working hours.
 All contractors will need to complete a site induction prior to working on site.
 Contractors will have access to toilet, washing & canteen facilities.
 Contractor shall be responsible for the safe storage of all tools and materials.

c. **Analysis of the Situation**

- i. **Discussion of the financial benefit:**
 No direct financial benefits associated with the installation of these filter systems.
- ii. **Discussion of indirect (non-financial) benefits:**
 This case has been justified on Business Continuity
- iii. **Discussion on other costs resulting from project:**
- iv. **Discussion on working capital accounts:**
 Full spend will be completed in line with the project plan.
- v. **Discussion on fixed assets to be replaced:**
 No Assets to replace
- vi. **Discussion on alternative course(s) of action:**
 N/A
- vii. **Discussion on critical assumptions and risks:**
 N/A

Projects >\$2.5M will include PCC Dashboard attachment



ECAR Description:
ECAR#:

Wau-EFCO Oberlin Coolant Filters
2019-18271

1.3027 \$/£

Yr	Spend by Quarter:	(USD)		
19 Q1	\$	-	£	-
19 Q2	\$	-	£	-
19 Q3	\$	69,710.26	£	53,512.14
19 Q4	£	-	£	-
20 Q1	£	162,657.28	£	124,861.66
Other				
	£	232,367.55	Total Spend for CAR	<-----should tie to total Amount of CAR

Completed by:

Andrew Curtis

Date:

16-May-19

232,367.55

Instructions

1. This schedule should be completed for all CARs that will have spend go beyond the current quarter
2. Enter ECAR & ECAR #
3. Show the estimated spending by quarter. Please use USD
4. Sign and date


ALL ITEMS ARE REQUIRED FOR CAPITAL APPROPRIATION REQUEST SUBMISSIONS

	Completed Status
1. New Acq: UL > 1yr and > \$5k	YES
2. Modifications: > \$200k or where > \$5k and over 25% cost of original asset if meets one or more of: <i>Extends UL of entire asset by 1 or more yrs, enhances productivity, capacity increases.</i>	NO
3. Is expenditure for engagement of outside consultants > 12 months or > \$25k ?	N/A
4. Where outside consultant cost is > \$500k, has CEO approval been obtained?	N/A
5. Capitalised Interest (only if project cost is > \$2million)	N/A
6. Expense costs related to removing old equipment, and not directly attributable to installation of a new asset <i>Clearly state in Executive Summary and Complete Section in ECAR</i>	YES
7. Any Critical Spares? <i>If yes, ensure the cost is in the Expense and NOT the CAPITAL section of the ECAR.</i>	NO
8. Leases	
i. Where by the end of the lease term, ownership of the leased property is transferred to the lessee	N/A
ii. The lease contains a bargain purchase option.	N/A
iii. The lease term is substantially (75% or more) equal to the estimated useful life of the lease property.	N/A
iv. At the start of the lease, the present value of the minimum lease payment, with certain adjustments	N/A
9. CapEx Budget Valuation <i>If not included in the approved Budget, clearly outline reconciliation and attach to ECAR</i>	YES
9. Executive Summary <i>Use PCC Metals Capital Template</i>	YES
10. Quotations <i>Consolidate all quotes and bid wavier on one attached PDF file. Requests with less than 3 quotes must be accompanied by a Timet's Bid Wavier</i>	YES
11. PCC Marketplace <i>PCC Marketplace has been reviewed for current available equipment from other PCC locations before proposing to buy any new equipment.</i>	YES
12. AR200 Form <i>Must be completed where Production will be increased or Costs will be reduced.</i>	NO
13. Life of Project <i>Populate the box on the E CAR with the useful life of the asset.</i>	YES
14. EMERGENCY PROJECT <i>Was the project originally approved as an EMERGENCY ? If yes, attach approval Email</i>	NO
15. Quarterly Spend Analysis <i>Attach Quarterly Spend Spreadsheet (in USD)</i>	YES
16. Did you check for grammatical errors & typos? Did you run spell-check?	YES
17. For large pdf's (> 10 pages), did you include a table of contents?	N/A



BID WAIVER REQUEST

Form Purpose:

Per TIMET corporate policy, three bids are required for any purchase with a total value of \$10,000 or over. Repetitive Stores Items, Material or Services covered by a Blanket Purchase Order, Consultants and purchases from a Qualified or Approved Supplier are exempt from this requirement, but are encouraged when prudence may warrant or dictate a bid waiver. Purchasing is required to maintain, with the Purchase Order, a written statement from the Requisitioner that is approved by the Department Manager or Plant Manager/Director if three (3) competitive bids **were not** obtained or if competitive bids were obtained and a supplier other than the low bidder was chosen.

Form Instructions:

The Requisitioner shall complete Section A, B & C of this Form, and submit to their respective Department Manager [$< \$50,000$] or Plant Manager/Director [$\geq \$50,000$] for approval. The Department Manager or Plant Manager/Director shall approve the Bid Waiver Request by signing in Section D and returning to the Buyer, or forwarding to the Buyer an e-mail approving the waiver. The Buyer shall print/sign Section D of the Bid Waiver Request and file with approval correspondence in the Purchase Order File.

SECTION A – WAIVER INFORMATION

REQUISITION NUMBER		DATE OF REQUEST	30/05/19
REQUESTER NAME	Andrew Curtis	VENDOR NUMBER	
REQUESTING DEPARTMENT	Sheet Finishing	VENDOR NAME	See Below

SECTION B – REASON FOR WAIVER

- | | |
|---|---|
| ☐ Supplier Other Than Low Bidder | ☐ OEM or Sole Source Supplier |
| ☐ Emergency | ☒ Less Than Three (3) Quotes Received |

SECTION C – JUSTIFICATION FOR WAIVING COMPETITIVE BIDS

Bardic Construction

Bardic Construction are specialists for this type of work and have the necessary qualified and experience personnel based at this site. Bardic are familiar with Timet processes and EHS systems. Recent market comparisons have proven Bardic to be extremely competitive for comparable site work.

Fastec

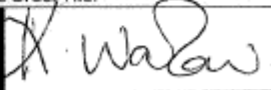
Fastec also have the necessary qualified and experienced personnel, who generally undertake all of the electrical installation and distribution projects at Timet Swansea. Fastec are familiar with Timet processes and EHS systems and have recently proved to be competitive in recent market comparisons.

Both Contractor are fully aware, understand and except Timet's payment Terms

SECTION D – APPROVAL AUTHORITIES

MANAGER APPROVAL (Print)	Andrew Whiles	BUYER (Print)	Kelly Warlow
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Rev: May 12

Form Purpose:	
Per TIMET corporate policy, three bids are required for any purchase with a total value of \$10,000 or over. Repetitive Stores Items, Material or Services covered by a Blanket Purchase Order, Consultants and purchases from a Qualified or Approved Supplier are <u>exempt</u> from this requirement, but are encouraged when prudence may warrant or dictate a bid waiver. Purchasing is required to maintain, with the Purchase Order, a written statement from the Requisitioner that is approved by the Department Manager or Plant Manager/Director if three (3) competitive bids were not obtained or if competitive bids were obtained and a supplier other than the low bidder was chosen.	
Form Instructions:	
The Requisitioner shall complete Section A, B & C of this Form, and submit to their respective Department Manager [<\$50,000] or Plant Manager/Director [=>\$50,000] for approval. The Department Manager or Plant Manager/Director shall approve the Bid Waiver Request by signing in Section D and returning to the Buyer, or forwarding to the Buyer an e-mail approving the waiver. The Buyer shall print/sign Section D of the Bid Waiver Request and file with approval correspondence in the Purchase Order File.	
MANAGER APPROVAL (Sign)	BUYER (Sign)
	



BID WAIVER REQUEST

Form Purpose:

Per TIMET corporate policy, three bids are required for any purchase with a total value of \$10,000 or over. Repetitive Stores Items, Material or Services covered by a Blanket Purchase Order, Consultants and purchases from a Qualified or Approved Supplier are exempt from this requirement, but are encouraged when prudence may warrant or dictate a bid waiver. Purchasing is required to maintain, with the Purchase Order, a written statement from the Requisitioner that is approved by the Department Manager or Plant Manager/Director if three (3) competitive bids **were not** obtained or if competitive bids were obtained and a supplier other than the low bidder was chosen.

Form Instructions:

The Requisitioner shall complete Section A, B & C of this Form, and submit to their respective Department Manager [<\$50,000] or Plant Manager/Director [=>\$50,000] for approval. The Department Manager or Plant Manager/Director shall approve the Bid Waiver Request by signing in Section D and returning to the Buyer, or forwarding to the Buyer an e-mail approving the waiver. The Buyer shall print/sign Section D of the Bid Waiver Request and file with approval correspondence in the Purchase Order File.

SECTION A – WAIVER INFORMATION

REQUISITION NUMBER		DATE OF REQUEST	16/05/19
REQUESTER NAME	Andrew Curtis	VENDOR NUMBER	
REQUESTING DEPARTMENT	Sheet Finishing	VENDOR NAME	

SECTION B – REASON FOR WAIVER

- | | |
|---|---|
| ☐ Supplier Other Than Low Bidder | ☐ OEM or Sole Source Supplier |
| ☐ Emergency | ☒ Less Than Three (3) Quotes Received |

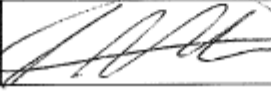
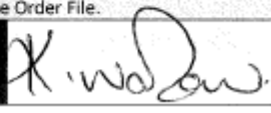
SECTION C – JUSTIFICATION FOR WAIVING COMPETITIVE BIDS

The system designed for Timet Swansea by Oberlin, is a scaled down version of the system currently in operation within Timet Toronto. The system has been verified and recommended as a reliable solution to titanium grinding fines filtration from coolant.

SECTION D – APPROVAL AUTHORITIES

MANAGER APPROVAL (Print)		BUYER (Print)	K. WARLOW
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Rev: May 12

Form Purpose:	
Per TIMET corporate policy, three bids are required for any purchase with a total value of \$10,000 or over. Repetitive Stores items, Material or Services covered by a Blanket Purchase Order, Consultants and purchases from a Qualified or Approved Supplier are <u>exempt</u> from this requirement, but are encouraged when prudence may warrant or dictate a bid waiver. Purchasing is required to maintain, with the Purchase Order, a written statement from the Requisitioner that is approved by the Department Manager or Plant Manager/Director if three (3) competitive bids <u>were not obtained</u> or if competitive bids were obtained and a supplier other than the low bidder was chosen.	
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MANAGER APPROVAL (Sign)	BUYER (Sign)
	

APPENDIX 6: OBERLIN FILTER CAPITAL APPROPRIATION REQUEST - QUOTES

**OBERLIN FILTER LIMITED**

2 Hurworth Road
Aycliffe Business Park
Newton Aycliffe
Co. Durham, DL5 6UD
Tel. No: 01325 317900
Fax No: 01325 317945
mwj@oberlinfilter.co.uk

Andrew Curtis
TIMET UK Ltd,
Waunarlwydd,
Swansea,
Wales, SA5 4SF

14th May 2019

Your ref.: Coolant **Filtration System for One (1) Belt Grinder**
Oberlin ref.: Proposal Number: **UK19.6110.2** (revised since 16th April)

Dear Andrew,
Further to application testing at end of March and site visit end of April please find this proposal based on findings.

The application, as I understand it, is as follows.

Application: Remove titanium grinding fines from water-based metalworking fluid.

Fluid: Water-based metalworking fluid (HOCUT 3880)

Desired Flow/Pressure: 266 l/min (estimated pressure 3 bar)

System Functionality Description:

Used/contaminated coolant, from belt grinder, flows to underground pit of approx. volume: 1500litres. From pit a Self-priming Horizontal pump will direct contaminated coolant into Oberlin filter. Solids will be removed from coolant using disposable media. Majority of solids will fall from media at discharge area. Filtered coolant will over flow back to pit. One coolant pump will be located on clean tank thus providing clean coolant back to process/machine/grinder.

Benefits of the Oberlin Pressure Filter are as follows:

Fully Automatic: The Oberlin filter system is completely automatic. The only operator intervention is to change media every 2 to 4 weeks.

Reliable: The Oberlin filter has only two (2) moving parts and one (1) wear item (seal).

Custom Design: The system is designed to fit customer floor space requirements.

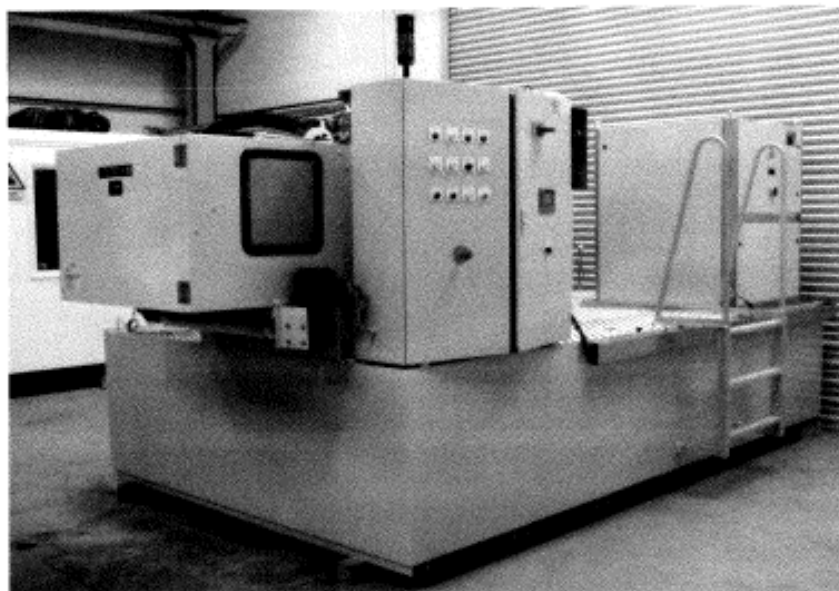
Dry solids discharge up to 3" thick! The solids will be 85%+ dry by weight when discharged from the filter. The dry solids are separated from the filter paper and the paper rerolled for easy disposal (or reclamation) of both. A full 3" thick cake of solids can be easily discharged from the filter – this is not true with competing designs.

Extremely clean fluid. Solids are removed by previously collected solids thereby providing the cleanest fluid possible. There will be no need to dispose of the fluid under normal conditions.

Economical: Dry solids discharge (less fluid carry out) and extremely clean fluid ensure that fluid and disposal costs are minimized

TIMET UK Ltd
Proposal # UK19.6110.2

Registered in England No. 369134
VAT No. 721 831259



OPFLD9-008MLP (a similar example to what is being proposed in this document)

Item:	Description:	Benefit:
1	Filter Model OPF09MLP : One (1) Constructed from carbon steel, finish coated per Oberlin specifications (light grey: RAL 5023) with a filtering area of 9ft² (0.83 m²) operating at up to 2.7bar differential pressure. The filter uses disposable, non-woven media to trap and remove solids. Majority of dry solids fall from media at discharge. Remaining solids separated from media at discharge end and spent media is re-rolled onto collapsible double bar mechanism for ease of spent media removal and disposal. Full CE certification.	Filter utilises disposable media to trap and remove solids. Other RAL available (may incur small cost increase)
2	Clean Tank: One (1) Carbon steel rectangular construction approximate dimensions 2.3m x 1.6m x 0.94m deep (light grey: RAL 5023). Structures are included to mount filter, drip tray and MC pump on top. Tank Covers will be provided and access steps. Overflow (back to pit) via 2inch flange to flexible hose. The tank coolant working volume is approximately 2,500 liters. Total retention time equates to 9 minutes + thereby reducing air entrainment in the fluid.	Overflow to pit to enhance flush and coolant circulation. Other RAL available (may incur small cost increase)
3	Filter Feed Pump + Box section frame and Skid: One (1) Victor self-priming horizontal centrifugal S83 G31T or similar rated 750 l/min @ 2.8bar. Motor control (7.5kW) is included. Solid pipe inlet 3inch of approx. length 1.5m (from pit). Outlet solid pipe 3inch to filter AND 3 inch butterfly valve	Heavy-duty open impeller and wear plate designed form abrasion and passage of solids up



	Flushing solid pipe 3 inch back to pit. Manual by-pass will be installed and a pressure gauge fitted. Box section c/s frame and skid of approx. 0.7m length, 0.6m width and 0.5m depth to mount pump ~~across~~ under grid and locate on concrete plinth with pump inlet plumbing overhanging into existing underground pit. Painted to RAL: 5023.	to 27mm diameter.
5	Main Coolant Pump: One (1) Brinkmann (or similar) vertically mounted centrifugal SAL 902/640 (or similar) rated 300l/min @ 3.5bar. Motor control (6kW), by-pass/anti-syphon tube and pressure gauge included and fitted.	
6	Filter System Control: All necessary electrical and pneumatic controls are provided to operate the system automatically. PLC Siemens. Appropriate HMI	HMI with language: English
7	Level Monitoring: The clean tank coolant level will be fully monitored to safeguard pump. Minor and Major alarm notification when level abnormal to pre-designated parameter.	Continuous monitoring ensures low fluid level is safeguarded.
8	Mechanical and Electrical Interface: One (1) 3m length 3inch flexible hose to supply overflow from clean tank back to pit. Three (3) 2.25m Stanchions to support filter inlet plumbing and MCP outlet flexible hose. Two (2) 3m length tray. Mechanical fittings to secure hoses to tray and tray to stanchions.	
9	Filter Media: One (1) Roll 0.5oz REEMAY (32" x 250 yds.) Part # 716-1032	For commissioning and immediate use.
10	Start Up, Commissioning & Training: One (1) site visit to TIMET, Waunarlwydd not exceeding Three (3) days. Operator & Maintenance training.	Ensuring correct operation
11	Electrical Interface: All communications between Oberlin Filter and host machine/grinder comprising Clean Pump control and major/minor fault signaling.	
12	Manuals, Documentation and Labelling: One (1) hard copy and one (1) electronic copy of the Operating and Maintenance manual in English. Copies of purchased component parts will be included. A set of system engineering drawings will be included in the manual as well as the control panel of the filter. Labels featured on filter: English.	
13	High Level Monitoring of existing Dirty Pit: The existing dirty pit coolant level will be monitored to safeguard pump/flooding of concrete plinth area. Minor and Major alarm notification when level is high.	



Total Filter System Price: **£64,525.00** (Ex. VAT)

Options:

Item:	Description:	Price Modifications
1	Additional Filter Media: One (1) Roll 0.5oz REEMAY (32" x 250 yds.) Part # 716-1032	ADD: £60.00
2	Compressed Air Receiver: One (1) 340 litre air receiver installed adjacent to filter system tank and integrated into filter system pneumatics.	ADD: £930.00
3	Forklift-able waste solids container: One (1) fully maneuverable solids container suitably sized for filter discharge area. C/w self – tipping mechanism and four heavy duty castors. RAL 5023 (other colours may incur slight cost increase)	ADD: £1,500.00

Main Service requirements:

Electrical – 400V, 3ph, 50Hz

Power Supply (amps) – ~ 32.5A (TBC)

Compressed Air – 1" BSP at Minimum 5.5bar, Maximum 8bar

Exclusions:

Off-loading filter system, electrical and pneumatic Main Service connections to be provided by others

Terms:

Freight: Ex-works; Newton Aycliffe

Payment Terms: net thirty (30) days of month following invoice date
 30% with order confirmation
 60% on delivery
 10% on acceptance (within 3 months from Delivery Date)

Warranty: Twelve (12) months

TIMET UK Ltd
 Proposal # UK19.6110.2

Registered in England No. 369134
 VAT No. 721 831259



Please note: Pumps come with manufacturer's warranty; however by nature of use they are considered a "wear and tear" item.

Please note: For the warranty period the use of Oberlin filter media is mandatory.

Delivery: At time of writing 24-26 weeks and subject to change. *Please note: Oberlin are currently experiencing large demand. As a result lead time is at an unprecedented high. Normal lead times are typically 14-16 weeks.*

Validity: This proposal is valid until August 19th 2019.

Observations: For Item #7 and 13 (major alarm), Oberlin, if desired, can send a zero volt signal to host machine, if presented with relevant interface information, to halt process in a major alarm scenario.

Should you require further information please don't hesitate to contact me.
I thank you for your continued interest in Oberlin Filter products.

Yours sincerely,

Mike Johnson
Sales and Administration Director
Oberlin Filter Ltd.

FASTEC ELECTRICAL SERVICES LIMITED (ELECTRICAL CONTRACTORS)

297, Swansea Road, Waunarlwydd, Swansea, SA5 4SL.-Tel: 01792 874618-Fax 01792 872267
E-mail: tim@fastec.uk.com V.A.T. Registration No.:655 688 288 ECA Membership No.:106286

Quotation

Customer Address: TIMETUK Ltd, Waunarlwydd Works, SWANSEA. SA1 1XD	Quotation: 1807-27q	Date:02 th May 2019
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FAO Andrew Curtis

Re: EFCO Oberlin Filters

I have pleasure in submitting my quotation for following works as per your request:

1. For the supply and installation of 6 way Schneider MCCB panel board, fitted with a 400A incomer on the East wall of Z Bay
2. For the supply and installation of 400A TP sub main, from the Pink Sub MCC, to the above Board
3. For the supply and installation of a 8 way Schneider Isobar DB, next to the above Panel Board.
4. For the supply and installation of 2 x Eaton 100A Isolators, to be fitted in Z bay on the east wall, for the new Garnet recovery units
5. For the supply and installation of 1 x 100A TP , and 2 x 63A TP outgoing Schneider MCCB, to feed the above outgoing circuits
6. For the supply and installation of all the cabling and containment required to carry out the above works.
7. For the supply to site 2 x Articulating Boom MEWP's to assist in the above works
8. For the testing upon completion.

Total Cost for the above

£11198.00 plus vat

With Thanks

Tim Lillicrap

Company Registration No. 5998624-Registered Office: 297, Swansea Road, Waunarlwydd, Swansea, SA5 4SL.
Registered in England and Wales

Portacover

Machinery Movements Ltd

E.M. Edwards Works,
Llandarcy,
Neath,
SA10 6JY
Tel: 01792 321600 Fax: 01792 816458
www.portacover.co.uk

07831 634714



Andrew Curtis
Timet UK Ltd
Waunarlwydd
Swansea.

DATE: 15.05.2019
QUOTATION: PCMM/43080.03

Dear Sir,

We thank you for your enquiry for the work set out below: -

To provide lift assistance to offload and position 2 number Oberlin Filters allowing for one day on site

Total £1250.00+vat

TERMS OF PAYMENT, 30 days EOM.
All prices plus VAT

We thank you for this opportunity of quoting and look forward to receiving your instructions. In the meantime if we can be of further assistance please do not hesitate to contact the writer.

Yours faithfully
Portacover Machinery Movements Limited
Kevin Watson.

Our General conditions apply to this quotation (Available on Request).

Registered in England No. 1436641

Directors J Goodlad, C. F. Hutt S. Watson

Sirus Fluid Power Ltd
 Unit 3A , Europa way
 Felinfach, Swansea West Business Park
 Fforestfach
 Swansea
 SA5 4AJ
 VAT Reg No: 869233982



Page 1

Quotation

Timet
 Accounts Payable
 Timet UK Ltd
 PO Box 704
 Birmingham
 B6 7UR

Quotation No: 22377

Date: 01/05/2019

Customer Order No:

Qty Ordered	Product Code	Product Description	Unit Price	Net Price
1.00	S1	supply labour and materials to install 1" air supply lines for no 1 + 2 sheet grinder Oberlin filter to incude indivdual isolation valves	1,768.00	1,768.00

Total Net Amount	1,768.00
Carriage	0.00
Total VAT Amount	353.60
Order Total	2,121.60

BARDIC CONSTRUCTION

12 CILONNEN ROAD
THREE CROSSES
SWANSEA
SA4 3PH

Tel: 01792 874559
Fax: 0871 6615361
Mobile: 07501202325
E-Mail: r.oliver@bardicconstruction.com
OUR VAT Reg No: 709 6722 16

DATE: 01/05/2019

TIMET UK
WAUNARLWYDD WORKS
SWANSEA
SA1 1XD

FOR THE ATTENTION OF: Mr Andrew Curtis

QUOTATION No 461

- 1. New Acco Drain around 2 No Oberlin Filters**
- 2. New concrete drainage duct with angle receivers and durbar plates**

To include:

- Floor Cutting and excavation
- Supply and installation of approximately 32m of channels
- Formwork for concrete duct – approximately 9m in total
- Cast in floor and walls of duct
- Cast in angles to wall
- Supply and installation of durbar plates

Plant required – Excavator, hammer attachment, floor saw, dumper and fuel
Materials – timber for formwork, channels, angles, plates, dowels and concrete.

Cost 1 – Acco Channels	£6957-00
Cost 2 – Concrete Duct	£3535-00

LUMP SUM £10,492-00