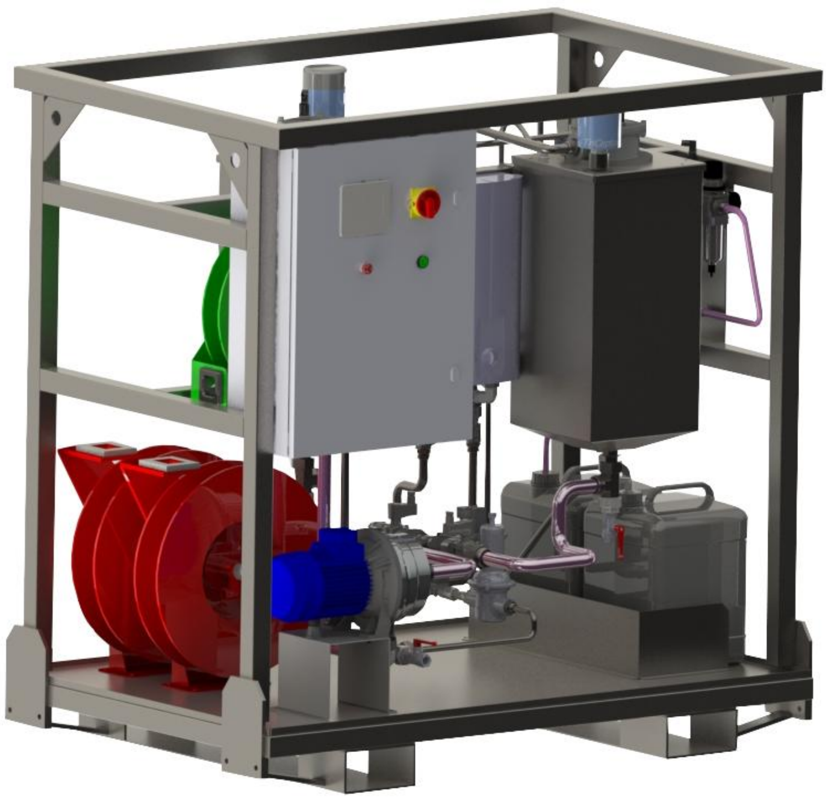
Project Report

Version 1

Version	Date	Changes	Status	Responsible
1	17.05.2015	This is the first version.	Document ready for final delivery.	Bjørnar Døviken

Name	Signatures
Bjørnar D. Døviken	
Henrik Lind	
Olav Parken	
Alexander Araya	



Project Description

The Portable Tube Washer Project is a Bachelor project given by FMC Technologies to group 14, M-Team HBV, at Buskerud and Vestfold University College during the time period 05.01.2015-03.06.2015.

The project group was assigned to develop and construct a fully automated, portable tube washer for the internal washing of small-bore hydraulic pipes; as well as plan, manage and document the project itself. Unfortunately, the physical construction of the product could not be realized due to insufficient budget funds that could not be raised.

Key focus points that have guided the development process are:

- *Availability* - Selection of well established suppliers
- *Serviceability* - Selection of simple, rather than complex, solutions
- *Transportabillity* - Designing solutions to avoid extraordinary transportation requirements
- *Drainability* - Installing taps and positioning components for practical draining
- *Health, Safety and Environment* - HSE focus in all we do!

It should be noted that some reports and documents are in Norwegian, although the most ciritical are in English. This has been the topic of some debate within the group and with external supervisors. Due to internal differences in laguage skills and abillities, the project group was given the permission to mix document languages, within reasonable bounds.

Meeting requests, follow-up documents, meeting minutes and draft versions of most documents are located in the file hierarchy and can easily be located if you have access to the digital ***Portable Tube Washer Project 2015*** *folder*.

Thanks to Opedal for their report that inspired this layout.

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Glossary and Acronyms

Name	Description
PTW	Portable Tube Washer
FMC	FMC Technologies
PLC	Programmable Logic Controller (industrial computer system)
P&I	Piping & Instrumentation
FEM	Finite Element Method

Project Documentation Overview

1 *Administrative*

The administrative section of this report features documents used to plan, keep track of and log the Portable Tube Washer Project process. Appended are a group overview, the project plan, activity list, risk analyses, Gantt-chart, time sheets for all group members and a report documenting the group's learning outcomes and experiences.

2 *Design*

This chapter includes documents and tools created to form the very foundation of the product design. Appended are the requirement specification, requirement matrix, stakeholders overview, use case flowcharts and a product breakdown structure.

3 *Manufacturing*

The manufacturing paragraph is a collection of documents describing the project outcome; more specifically, the selected final design's whats, whys and production bases. Appended are the technology document, PLC documentation, purchase list, test specification, analyses & calculations and 3D/2D drawings.

4 *Instructional*

This section includes the custom manual written for the PTW. It should be noted that this is the project group's most incomplete document, and is supposed to be; a proper manual requires not only years of education and experience to write, but also insight to the final product as testing goes on.

Appendices

Administrative

The administrative section of this report features documents used to plan, keep track of and log the Portable Tube Washer Project process. Appended are:

A1. Group Overview

Photos, main areas of responsibility and background information of all group members.

A2. Project Plan

A document made to plan and keep track on the project.

A3. Activity List

A list of all activities and tasks the group has been working on.

A4. Risk Analyses

Analyses made to ensure a structurized handling of mainly negative events and outcomes.

A5. Gantt-chart

This chart has been used to plan and keep track on the main project efforts.

A6. Time Sheets

Time sheets of all members, from project start to end.

A7. Learning Points & Experiences

A summary of the project group's main learning points, challenges and experiences gathered throughout the project.

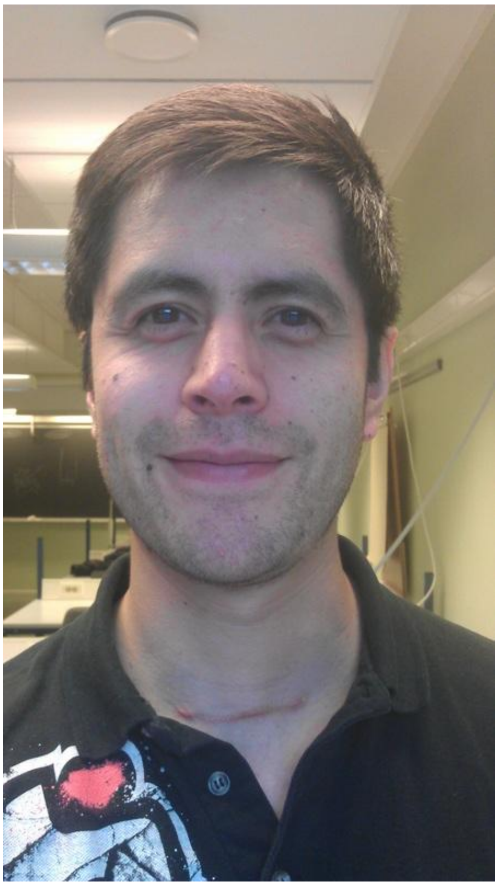
A1. Group Overview

Portable Tube Washer Project 2015\Appendices\1. Administrative\A1. Group Overview

Name: Bjørnar D. Døviken
Areas of responsibility: Group leader, project responsible, archiving and design.
About: Bjørnar has two years of education in Technical and industrial production with industrial technology from Aassiden High School. He got employed by HBV Kongsberg as project manager for Kongsberg Systems Engineering Event 2013 during his first year of mechanical engineering studies.

Name: Henrik Lind
Area of responsibility: Tests specification, programming/PLC and media.
About: Henrik has 3 years of education in media and communication and later one year of renewable energy from the University of Agder. He also has experience from warehouse assistance and several service industry jobs.

Name: Olav Parken
Areas of responsibility: Modeling, risk analyses and production documentation.
About: Olav has a certificate of apprenticeship as a car mechanic from 1986. He has been employed at the military workshop at Trandum since 1990, worked in the technical department and focused on development since 2003.



Name: Alexander Araya
Areas of responsibility: Requirement specification, test plan and manual.
About: Went to high school from 1995 to 1999 in La Serena, Chile. Has worked several years with mechanical/vehicle service jobs and sales.

A2. Project Plan

Portable Tube Washer Project 2015\Appendices\1. Administrative\A2. Project Plan

Project Plan

Version 3

Version	Date	Changes	Status	Responsible
1	01.02.2015	This is the first version, v1		Bjørnar Døviken
2	18.03.2015	Updated the document for the second presentation		Bjørnar Døviken
3	12.05.2015	Changes made after input from internal supervisor and final inspection.	Document ready for delivery.	Bjørnar Døviken

Name	Signatures
Bjørnar D. Døviken	
Henrik Lind	
Olav Parken	
Alexander Araya	

Introduction

This is a project plan written for the Portable Tube Washer Project; hereafter referred to as the PTW Project. We are developing this product for our client, FMC Technologies; hereafter referred to only as FMC.

The goal of the project is to make an automated system for the washing of hydraulic tubes, prior welding, used in subsea systems. FMC is using an automated washer, but they are not entirely satisfied with the product, as they have experienced difficulties with it (described in detail later). As an alternative to this, they have developed an almost all manual system that does not comply with regulations. Therefore FMC has given us the task to engineer a product with an edge compared to both existing systems.

This is a document created to help all parties understand our project's purpose, goals, scope, timeframe, and so on. The project group will get an understanding of which tasks need to be completed during the different phases of the project. It will also help the group to understand their roles and responsibilities in the project.

It can be used by the internal and external advisors to early discover issues before they become critical for the outcome of the project. The internal and external examiners will use this document as one of several documents to grade each person in the group. Last but not least, this document exists for the client as to establish a common understanding of what is to be done and when, and acts so as an extension of the FMC-provided vision document, appendix A. page 31.

Selected segments of text have been marked with red. These were relevant before the termination of the physical construction by FMC, but are now obsolete.

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Glossary and Acronyms

Name	Description
PTW	Portable Tube Washer
FMC	FMC Technologies
UP	Unified Process
HBV	Høgskolen i Buskerud og Vestfold

Table 1 - Glossary and Acronyms

1 Project Scope

1.1 *Project Boundaries*

- Both product and Product/project documentation shall be delivered to the client, FMC. HBV requires, and will only receive, the product/project documentation.
- The product will comprise one single unit, the PTW, with its required subsystems and components.
- The PTW will be an attempt to make the tube washing an easy, automatic, "no-brain" procedure.
- The project/system will not encompass, nor will we be responsible for:
  - Training and follow-up of personnel that will in the future use our product
  - Rigs for mounting and storage of pipes that will be, or have been washed
  - Maintenance and follow-up of any post-construction labours

1.2 *Project Objectives*

1.2.1 Learning Objectives

The learning objectives shall not encompass the product, but instead the objectives stated in the course description provided by HBV. After the end of this project, we as students should have gained skills in basic project work; this includes both how to organize and document a project through all the phases as such. It is also important that we show that we have knowledge of project tools, and how to use them correctly. Additionally, we will have to prove that we can work well as a group in a larger project, as well as individually, and communicate accordingly; this also applies to the collaboration with the client.

For further details, see appendix B. page 35.

1.2.2 Product Objectives

The two already existing solutions in use by FMC have several issues, being cost, transportability, safety, and lack of procedure guarantees.

From what was stated above FMC wants our project group to produce all necessary documentation for an automated tube washer that can compete with similar products on the market.

1.3 *Project Deliverables*

The project deliverables can be divided into three natural parts:

1.3.1 Documentation Deliverables

Both HBV and FMC expect us to deliver all relevant documentation associated with an engineering project, this document being one of many. The purposes of this documentation is for the evaluation of our project group, and for document records.

1.3.2 Presentation Deliverables

During the course of our project we will hold three presentations, all of which will be open for the general public's attendance. For each of the presentations we are required to deliver a folder containing all printed documentation relevant to the presentation itself, and a CD with all documentation produced throughout the project.

PRESENTATION 1:

For this presentation, HBV wants to know *what* we are going to build/create and estimates of *when* we are going to do what. More specifically, we will have first drafts and examples of the following documents ready:

Project plan: (this document) An overview of boundaries, objectives, deliverables, responsibilities, time schedules and more.

Requirements specification: A document defining all our system's requirements; both the derivative user requirements from FMC and our own.

Test plan: A short and concise overview, linked to the test specification, that provides insight to our general strategies of testing. It will include which resources we will need to have available, and definitions of which terms and strategies mean what. An example could be the written characterization of how and what a static component test would be.

Test specification: A document closely related to the requirements specification. It will allocate to each requirement a unique test that will make us able to verify and validate that said requirement is fulfilled.

PRESENTATION 2:

At this point, HBV wants a technical presentation of what we have done, what we plan to do onwards, and lastly a general update on projects progress. Baked into this, we will present our final product design and planned implementation. This implies that 3D-models, 2D-drawings for production, and a plan for how we will order and assemble should be ready.

Even though holding this presentation as late as possible may seem tempting, as to give ourselves enough time, it should be held early enough so that it's not too late to make correction after feedback.

PRESENTATION 3:

This presentation marks the end of the entire project, and the final product will be presented with all the work we have done.

1.3.3 Product Deliverables

FMC expects us to deliver necessary production documentation for an automated, portable tube washer for the internal washing of tubes. Following is an excerpt from FMC's vision document (appendix A. page 31):

"*The product is to comprise of one unit used for cleaning tubes prior to installation. The tube washer first and foremost is to be used for normal cleaning and preparation after bending and cutting. Serviceability and a modular design are two important key features. Also it should have an edge compared to already existing manufacturers systems. Plug cleaning capabilities after normal washing routine, and a safety system not allowing a new start until the cleaning plug routine have been run. Use of well-known manufacturers is a required request for easy support after closure of this student project.*"

Both the vision document and our own requirements specification provide a more in-depth look into what we are making.

2 Schedule and Time Frame

When we first began the planning-work in early January, we went with the V-model approach to guide our development work. However, two weeks later, we had a lecture where evolutionary project models were introduced and recommended to us; among others, the Unified Process model was one of the presented, and the one we chose to implement.

As pointed out during the lecture, an evolutionary approach would benefit us, due to our strict deadline for the project; there is no pushing the date a couple of days! Had we continued working with the V-model, it would be a huge risk if we would not get everything done before the deadline: If we only managed to complete design work while leaving the testing undone, it would not look good for our project. This is why UP is a safer method: It provides focus on all the aspects of project work throughout each phase, which means we will *at least* have a tiny bit of everything done to the deadline.

2.1 The Unified Process - How Does It Work?

The UP-model is normally divided into four phases, each with a set number of sub-phases called *iterations*. It should be noted that the following visualization is how we customized the UP-model to work for our project, e.g. the business modeling work that is usually present in such a model is not relevant here. Risk analyses relevant to each phase are also included below.

2.1.1 Before Construction Termination

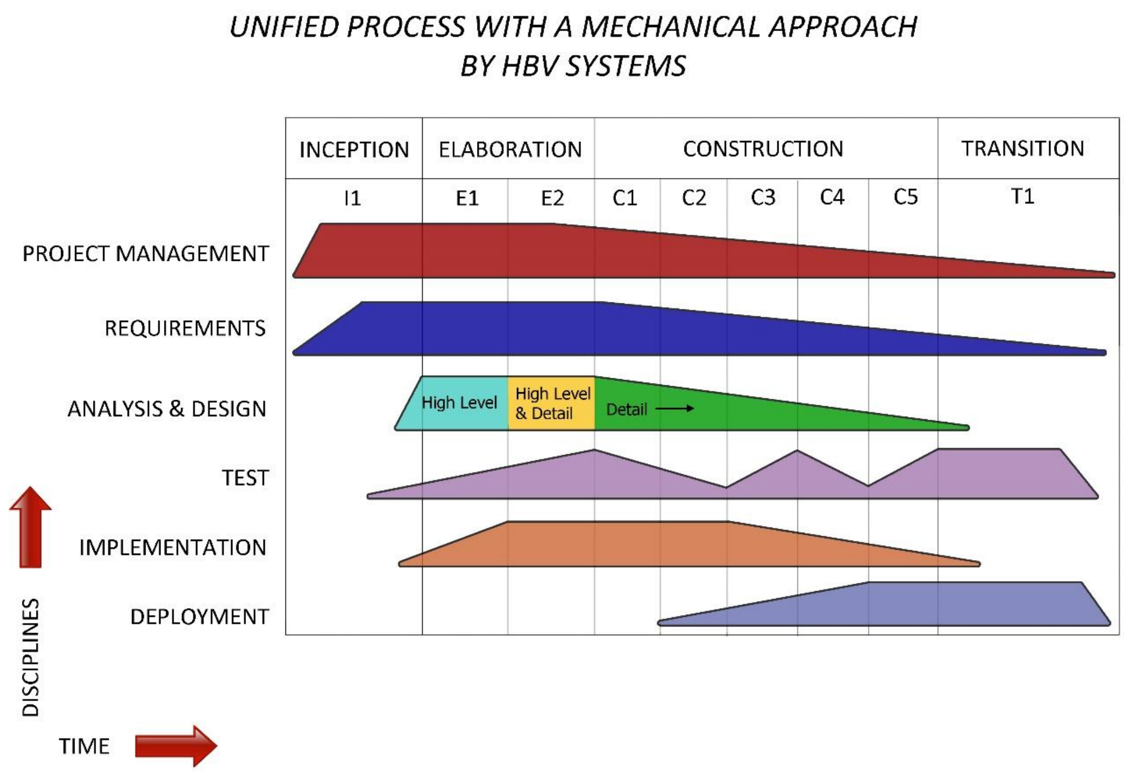

Figure 1 - Unified Process Before Construction Termination

2.1.2 After Construction Termination

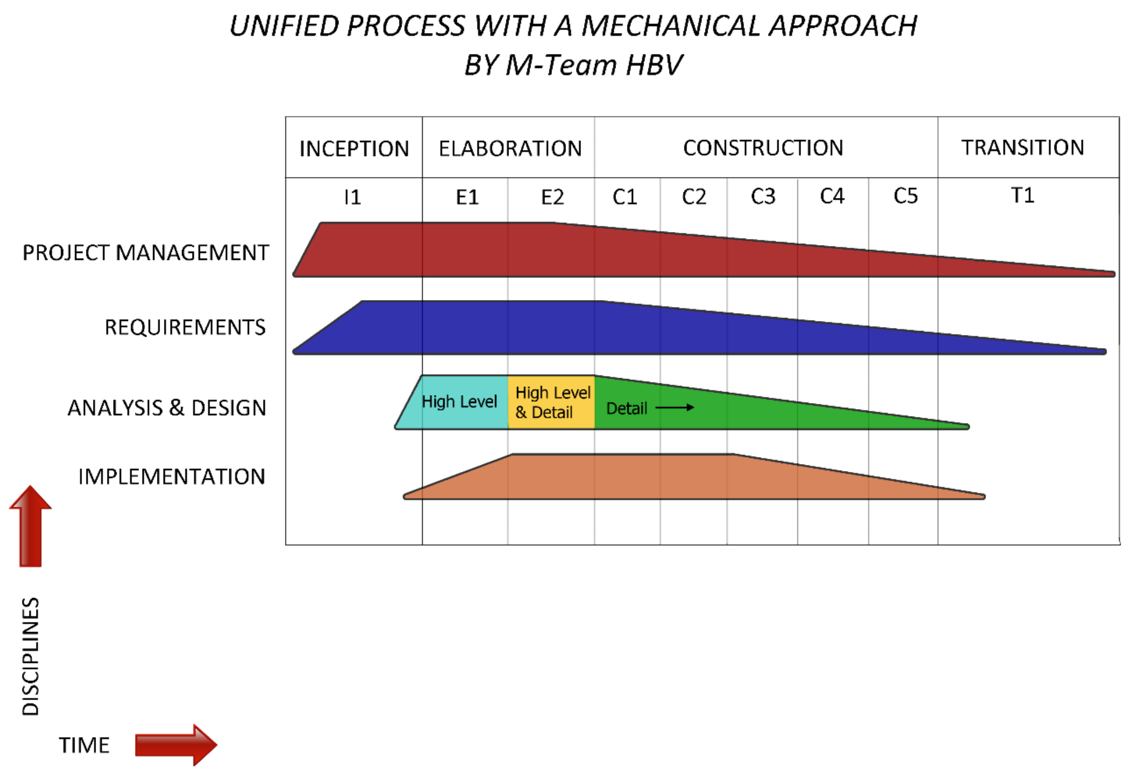

Figure 2 - Unified Process After Construction Termination

As shown, the model was modified after the client terminated the physical construction of the product.

1. **INCEPTION PHASE:** This marks the beginning of all project work, and is typically established with the identifications of stakeholders, the development of use case scenarios/flowcharts, the refinement of user requirements to system requirements, selection of which project tools to use and, in the end, some design. A supplement to these had to be added from HBV's requirements of a test plan and specification, which one normally would not focus this much on. There are no iterations in this phase.

For more information about how the risk analyses are set up, see the Risk Analyses document at file location ***Portable Tube Washer Project 2015\Appendices\1. Administrative\A4. Risk Analyses***.

Initiating The Project Poorly*

Probability

H			
M		A	
L		B	
	L	M	H

Consequence

Note	
Critical:	
Considerable:	X
Negligible:	

Consequence Without Measures(A):

If we do not initiate the project in the right way, progression will be hindered by unnecessary problems, e.g. if we choose an ineffective and problematic software to handle our Gantt-charts, too much time will be spent trying to make it work.

Proactive Measures(B):

Even before the inception phase, we began looking at different tools and, using the example above, quickly sorted out that the Google-software "Gantter" did not meet our demands and went for MS Projects instead.
We have also had some experience with project work from previous years.

Solutions:

If we discover that something has gone wrong in the project's inception, we will re-evaluate our choices and readjust accordingly.

Table 2 - Phase Risk Analysis 1 - Initiating The Project Poorly*

2. **ELABORATION PHASE:** There are two iterations in this phase, marked E#.

   - **E1:** Heavy requirement work, test work and high level design to define the system and its subsystems.

   - **E2:** More requirement work, yet at this point, time and effort spent on revising requirements is reduced. Design work, both high level and details, is in full focus, as is test work.

   By the end of this phase, most, if not all, the necessary system components should have been selected for the final design. Programming should also be well under way.

Not Having A Design Ready For Construction

Probability				
	H		A	
	M		B	
	L			
		L	M	H
			Consequence	

Note	
Critical:	X
Considerable:	
Negligible:	

Consequence Without Measures(A):
If the design is not complete before the construction phase, we cannot order all the necessary components and test them. Testing of how sensors communicate with the PLC is critical for the outcome of the project.
Proactive Measures(B):
By delegating the research efforts to all four group members and using objective Pugh-matrices to select subsystems and components, the time spent on design activities should be reduced.
Solutions:
If we discover that the design cannot be completed on schedule, we must prioritize selecting the most critical components for the system.

Table 3 - Phase Risk Analysis 2 - Not Having A Design Ready For Construction

3. **CONSTRUCTION PHASE:** This phase is divided into four iterations, marked C#.

   - **C1:** Heavy work with implementation, strong decline of requirements and slight decline of design work.
   - **C2:** More testing and implementation. Less and less requirements and design.
   - **C3 & C4:** Decline of implementation and continued decline of requirements and design. A final bulk of testing is done at the end of C4 (A final acceptance test could be done at this stage).

     This is the phase of ordering, constructing and testing of the final product.

     Due to the physical termination of the product, design efforts were extended into the construction phase.

Not having a partially tested prototype ready for delivery

Probability

H			
M			A
L			B
	L	M	H

Consequence

Note	
Critical:	X
Considerable:	
Negligible:	

Consequence Without Measures(A):

Given the time schedule of this project, the end product/prototype can never be fully tested, but tests guaranteeing correct functionality should be performed. If we do not have a partially tested prototype ready at the end of construction, essentially we will not have met our and FMC's goals.

Proactive Measures(B):

Since the PLC programming is expected to be the main source of time/labor consumption, we will actively be seeking aid for the selection of sensors and PLC/PLC equipment.

Solutions:

If we do not have a partially tested prototype ready at the end of construction, some of the time in Transition will be used.

Table 4 - Phase Risk Analysis 3 - Not having a partially tested prototype ready for delivery

4. **TRANSITION PHASE:** Between C4 and the transition phase, deployment of the product is in focus. We will receive some final feedback from FMC and make minor adjustments accordingly. This phase has been reduced to finalizing documentation, and making the test plan and specification perfect for future testing by FMC.

2.2 Schedule and Timeline

We have had to make some time-wise compromises due to having two clients, both HBV and FMC. The presentations the school demands need to be held within certain intervals, which limits us slightly; thankfully, they are set at quite natural milestones for our project.

A pizza party has been added once per iteration of each phase for team building purposes.

Activities found in work completed, but not in planned work, are things we had not considered when planning but discovered had to be made later. In this version of the document, work completed from P2 to P3 has been added.

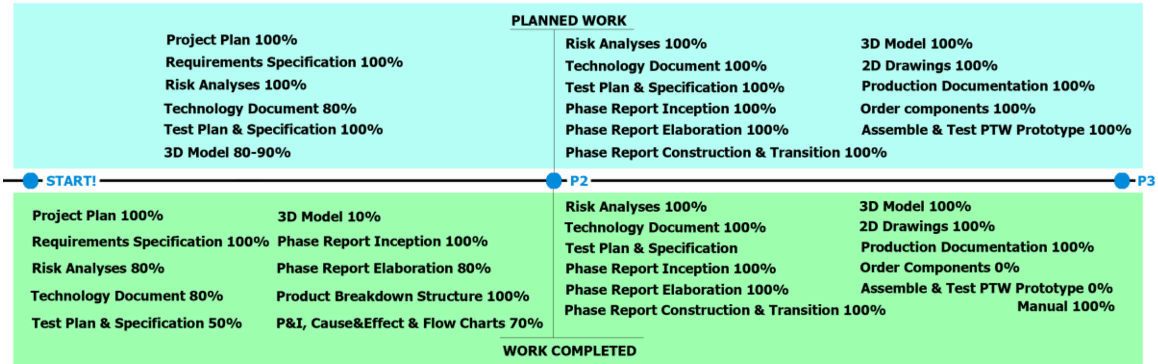

Figure 3 - Timeline

Appendices

A. FMC Vision Document

The FMC Vision Document is appended to the requirement specification, Appendix A, page 251.

B. Course Description Draft

HBV wants us to achieve to following learning outcomes, gathered from the course description plan:

KNOWLEDGE

The student

- Has knowledge on how project work and project management are used in an engineering work.
- Has knowledge within the field of project management
- Can analyze and deal with various sources of information and use them to carry out a project for a customer
- Knows about relevant methods for research and scholarly development

SKILLS

- Can use relevant methods for project work in both an independent manner and as part of a group
- The students are able to plan, conduct and document the work associated with a development project.
- Can work independently and within a group to work on a project solving practical and theoretical problems in cooperation with a client.
- The students shall be able to select and use relevant tools, plan and conduct necessary tests connected to the project.

GENERAL SKILLS

- The student are able to show how ethical and social be able to plan and organize a project, select and use relevant tools, plan and conduct necessary tests connected to the project.
- Can independently present the project work to both other subject specialist and general public.

C. Construction Termination Letter

Att: HBV Prosjektgruppe - Portable Tube Washer project

Deres ref: Bjørnar Døviken Vår ref: Olaf Ødegård Date: 08.04.2015

Kanselering av bygging av prototype.

Basert på innkommende priser og tilbud fra våre underleverandører må FMC desverre se seg nødt til å kanselere realiseringen av en fysisk prototype I prosjektet. Prisene må reforhandles med en målsetting om ca 40-50% reduksjon. Forhandlingene ikke er avsluttet men vi innser at det vil være vanskelig å nå målsettingen spesielt på kort sikt. Deler vil ikke bli satt I bestilling før ønsket prisnivå er oppnådd.

Det vil si at realiseringen av prototypen pr nu ikke er mulig å gjennomføre innenfor innen FMC sine kostnadsrammer og HBV prosjektets tidsramme. FMC beklager det inntruffne men håper på at design og dokumentasjonsunderlag utarbeides med en slik kvalitet at FMC kan gjennomføre byggingen selv på et senere tidspunkt.

Med vennlig hilsen

Olaf Ødegård

Manager, Kongsberg Workshop | Well Access Systems

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A3. Activity List

Portable Tube Washer Project 2015\Appendices\1. Administrative\A3. Activity List

Aktivitetsliste M-Team HBV, Hovedprosjekt

Fullført	
Aktiv	
Haster	
Endret	

AKTIVITET	OPPGAVE	ANSVARLIG	DELEGERT TIL	LAGT INN	BEGYNNER	FRIST	RESULTAT	KOMMENTAR
0	Eksempel: Rydde etter seg	Bjørnar		01.01.2015		10.01.2015	Såbraså, rent og pent	Tok 9 dager, men resultatet ble deretter
1	Lage/finne dokumentmaler for generell dokumentasjon, møteinkalling, oppfølgingsdokument og referat	Bjørnar, Olav		12.01.2015		14.01.2015	Referatmal klargjort, se "Referatmal". Mal for møteinnkalling og oppfølgingsdokument klartgjort, se "Meeting request and follow-up document MRFU".	Olav tar referat

							Førsteutkast av mal for generell dokumentasjon er klargjort, se "General Documentation Template v1"	
2	Undersøke om å bestemme hvilken Gantt-mal vi skal bruke	Henrik, Alex		12.01.2015		14.01.2015	Bruker Gantter på google disk. Endring: Gantter holder ikke mål, bruker Microsoft Projects istedet.	
3	Definere interessenter og behov, og deretter raffinere kravene fra FMC og legge til nye. Skal ikke gjøre det perfekt, men skal fungere som et førsteutkast, altså v0,1	Alex	Alex, Olav	12.01.2015		22.01.2015	Frist utsatt 1 dag fra 15.01.15 til 16.01.15 .Utsatt til 19.01.2015 etter ny plan . Requirement specification v0,1 ferdig	Bruk gjerne use case og con ops for finne fler behov og krav. Lag disse i eget dokument, og bruk til enhver tid utlagt mal og skriv på Engelsk. Lagre kladdversjoner i egen mappe. Olav og Alex utarbeider kravet, og sender til Bjørnar og Henrik for godkjenning.

								Bjørnar og Henrik gjør endringer og sender tilbake til arkivering. Samme prosedyre på testjobben.
3,10	Gå over Requirement specification v0,1 og gjøre endringer. Lage v0,2	Alex	Henrik, Bjørnar	21.01.2015	22.01.2015	26.01.2015	Ok, v0,2 til vurdering av Alex	
3,11	Gå over Requirement specification v0,2 og gjøre endringer. Lage v0,3	Alex	Henrik, Bjørnar, Alex	23.01.2015	26.01.2015	26.01.2015	Ok, v0,2 til vurdering av Alex	
4	Fylle ut gantt-diagrammet med den informasjonen vi har tilgjengelig og lage en overordnet prosjektplan v1	Bjørnar, Henrik		12.01.2015		15.01.2015	Ny aktivitet opprettet for denne, akt. 13 og akt. 14. Se akt. 20	Presentasjoner og innleveringer skal inn her, minst. Helst mer
5	Kalle inn til møte med intern veileder 15.01.2015 med nødvendig dokumentasjon. Finne tid og sted.	Bjørnar		12.01.2015		14.01.2015	Møte kalt inn 13,01.2015. Holdt 10:00, rom D354	Må inn 24 timer før selve møtet
6	Avtale når første fremføring skal være med intern sensor,	Bjørnar	Bjørnar	12.01.2015		ASAP		Må vite når det passer for ekstern sensor

	Karoline Moholt (Karoline.Moholth@hbv.no)							og veileder(e). Altså, vente på FMC
7	Inkalle alle parter til første fremføring og forklare fremgangen av fremføringene (intern/ekstern sensor og intern/ekstern Veileder)	Bjørnar	Bjørnar	12.01.2015	12.01.2015	TBA		
8	Purre opp møte med FMC ang kontrakt, verksted/ kontor plass, adgangskort osv.	Bjørnar	Bjørnar	12.01.2015		ASAP		Blir tatt på første møte
9	Fylle ut gruppeoversikt med all info vi har sålangt	Alex	Alex	13.01.2015		30.01.2015		Bjørnar sender mail til Karoline i forkant for å spørre om hun vil ha kladdversjonen
10	Skrive spørsmål til FMC til første møte	Bjørnar	Alle	13.01.2015		16.01.2015	Ok	Alle fyller inn fortløpende
11	Kontakte Erik fra Hannifin og høre om han vil komme på presantasjonene og om han har noe annet å bidra med.	Henrik	Henrik	14.01.2015		20.01.2015		
12	Skrive og ferdigstille referat fra 15.01.2015	Bjørnar	>	15.01.2015		11:00 16.01.2015	Referat godkjent og sendt inn 15.01.2015	

13	Muligvis lage en skriftlig rapport av hele oppgaven, med versjoner, som beskriver prosjektplanen i prosatekst.	TBA		15.01.2015		26.01.2015	Ny aktivitet opprettet for denne, akt. 4 og akt. 14. Se akt. 20	Høre med Karoline om dette
14	Fylle ut gantt-diagrammet med referanser fra V-modellen og legge en fullstendig prosjektplan. Samtidig skrive i prosatekst til rapport (akt. 13)	Henrik, Bjørnar		15.01.2015		26.01.2015	Ny aktivitet opprettet for denne, akt. 4 og akt. 13. Se akt. 20	Jamfør med punkt 13. Skal vi fortsatt gå for V-modellen, hva med den nye som kom frem på siste forelesning? Olav
15	Omorganisere arkivene våre på disk	Bjørnar	Bjørnar	15.01.2015		ASAP	Ok. Utført 17.01.2015	
16	Legge inn møtereferat 15.01.2015 i den norske malen. Flytte engelsk mal til søpledynga	Olav	Olav	15.01.2015		15.01.2015	Ok	
17	Oppdatere kontaktinfo med prosjektgruppe og Joakim	Henrik	Henrik	15.01.2015		16.01.2015	Ok	
18	Sette ansvarlig for utskrift og arkivering +	Bjørnar		15.01.2015		ASAP		

	permer/innleveringer							
19	Bestille rom for P1, både for presentasjon og før/ettermøter	Bjørnar	Bjørnar	18.01.2015		ASAP		
20	Utarbeide en overordnet prosjektplan v1, inkludert gantt-diagram og tidslinje, og prosatekstversjon	Bjørnar	Bjørnar, Henrik	18.01.2015	21.01.2015	30.01.2015		Jobber med dette samtidig med godkjenning av krav og test
20,10	Prosatekst v1	Bjørnar	Bjørnar, Henrik	21.01.2015	21.01.2015	30.01.2015		
20,11	Gantt v1	Bjørnar	Bjørnar, Henrik	21.01.2015	22.01.2015	30.01.2015		
21	Finne ut hvordan testspesifikasjon og plan skal settes opp	Bjørnar	Olav, Alex, Bjørnar	18.01.2015	22.01.2015	TBA		
21,10	Utarbeide testspesifikasjon v1.0	Henrik	Olav, Alex	18.01.2015	28.01.2015	30.01.2015		
21,11	Utarbeide testplan v1.0	Alex	Olav, Alex	18.01.2015	28.01.2015	30.01.2015		
22	Lage en prezi/PPT til 1. presentasjon	Henrik	Alle	26.01.2015	26.01.2015	30.01.2015	Ferdig 03.02.2015	
23	Sette opp Template i SolidWorks	Olav	Olav	29.01.2015	ASAP			
25	Prosjektplan m. Gantt v2	Bjørnar	Bjørnar, Olav, Alex	05.02.2015	09.02.2015	11.03.2015		
26	E1 rafinering og omorganisering av krav fra V1.0	Alex	Alle	06.02.2015	06.02.2015	10.02.2015		

27	Finne ut hvordan alt skal kryssrefereres på tverrs av dokumenter	Henrik	Henrik, Bjørnar	09.02.2015	09.02.2015	10.02.2015		
28	Sjekke med Drammen Automasjon om veiledning ang. PLS	Henrik	Henrik, Bjørnar	10.02.2015	11.02.2015	11.02.2015		
29	E1 Black Boxing	Bjørnar	Bjørnar, Olav	10.02.2015	11.02.2015	12.02.2015	Se 30,10	
30	E1 Utvikle systemarkitektur	Bjørnar	Bjørnar, Olav	10.02.2015	11.02.2015	12.02.2015	Se 30,10	
30,10	E1 Product breakdown structure v0.1	Bjørnar	Bjørnar, Olav	10.02.2015	11.02.2015	12.02.2015	Fant ut under arbeidet at vi trengte en større oversikt enn det en systemarkitektur kunne tilby. La til alt vi mente behøvdes og fant ut i ettertid at vi lagde en perfekt PBS	
31	Komponent-research	Bjørnar	Alle	10.02.2015	17.02.2015	05.05.2015		
32	Første risikoanalyse	Olav	Olav, Bjørnar	10.02.2015	13.02.2015	20.02.2015		
33	E1 utvikling av testspesifikasjon	Henrik	Henrik, Alex	10.02.2015	11.02.2015	23.02.2015		
34	Første concept screening/brainstorm	Bjørnar	Alle	16.02.2015	17.02.2015	20.02.2015		
35	Andre concept screeningbrainstorm	Bjørnar	Alle	22.02.2015	23.02.2015	09.03.2015		

36	Concept scoring	Bjørnar	Alle	22.02.2015	23.02.2015	05.05.2015		
37	Skaffe PLS-software og gjøre seg kjent med det	Henrik	Henrik, Alex	22.02.2015	16.02.2015			Finne ut av problemer vi kan få, begrensninger/ muligheter osv.
38	Gå over kravspec og gjøre den akseptabel til designarbeid og klar til P2	Alex	Alle	22.02.2015	23.02.2015	27.02.2015		
39	Gå over testspec og klargjøre den til P2. Skal bli ferdig til et punkt hvor store endringer ikke må gjøres før i construction	Henrik	Alle	22.02.2015	23.02.2015	27.02.2015		
40	Gå over risikoanalyse og klargjøre den til P2.	Olav	Alle	24.02.2015	24.02.2015	24.02.2015		
41	Skrive teknologidokument til P2	Bjørnar	Bjørnar,	03.03.2015	24.02.2015	18.03.2015		
42	Lage norsk versjon av dokumentmal	Henrik	Henrik	03.03.2015				
43	Skrive Faserapport 1: Inception	Olav	Olav,	03.03.2015	09.03.2015	18.03.2015		
44	Skrive Faserapport 2: Elaboration	Alex	Alex, Bjørnar	03.03.2015	09.03.2015	18.03.2015		
45	Lage spesifikk UP-modell til vårt prosjekt	Bjørnar	Bjørnar	04.03.2015	15.02.2015	15.02.2015		
46	Mekke tabell som	Alex	Alex	05.03.2015	05.03.2015	05.03.2015		

	beskriver hvilke av våre spesifikke krav som oppfyller hvilke av FMCs hovedkrav							
47	Lage mal til faserapporter		Olav, Alex	10.03.2015	10.03.2015			
48	Lage utkast og sende inn av spec-liste for komponenter, grunnlag for innhenting av priser og leverandør info (bestiller på FMC)	Olav	Bjørnar, Olav	11.03.2015	10.03.2015	Asap Zulu		
49	Lage PLS flowchart/sekvensdiagram	Henrik	Henrik	09.03.2015	09.03.2015	13.03.2015		
50	Utarbeide/ferdigstille presentasjon 2	Henrik	Alle	11.03.2015	11.03.2015	19.03.2015		
51	Lage oversikt over innhold til P2	Bjørnar	Alle					
52	Finne ut av hva som skal printes ut til P2	Bjørnar	Bjørnar	13.03.2015	13.03.2015	13.03.2015		
53	Legge filer på memory stick og printe ut + sette i permer	Bjørnar	Alle	13.03.2015	16.03.2015	18.03.2015	Lapp ble mottatt veldig positivt.	Skrive lapp og lime på innsiden av permene om hvilke dokumenter som bare er der for referanse, men som ikke trenger

								komplett gjennomlesning
54	Gjøre klar dokumenter for innlevering P2	Bjørnar	Alle	17.03.2015	16.03.2015	18.03.2015		
55	3D-modelering Ferdigstilling av basisramme	Olav	Olav	17.03.2015	17.03.2015	25.03.2015		
56	Skrive risikoanalyser til hovedkravene	Olav	Alex	23.03.2015	24.03.2015	27.03.2015		
57	Gå over v2 av testspec og kvalitetssikre, lage v2.1	Henrik	Olav, Bjørnar	23.03.2015	24.03.2015	27.03.2015		
58	Skaffe / lage 3D-materiell til vannvarmer og såpepumpe	Olav	Olav, Bjørnar	23.03.2015	24.03.2015	05.05.2015		
59	Ferdigstille flowcharts, P&I og cause&effect	Henrik	Henrik, Alex, (alle)	23.03.2015	24.03.2015	06.05.2015		
60	Møte med the Runar Kofstadmoen angående bøying	Bjørnar	Olav, Bjørnar	23.03.2015	25.03.2015	25.03.2015	Har fått oversikt over hvilke rørdimensjoner de har på lager og hvordan bøyetegninger skal settes opp.	
61	Lære og sett opp Pipe and routing i Solid Works	Olav	Olav, Alex	25.03.2015	25.05.2015	Snarest		
61,1	Sette opp et bøyediagram/2D-	Olav	Alex	07.04.2015	07.04.2015	Snarest	Utgår	

	tegning som kan sendes til Runar for test							
62	Oppdatere teknologidokument til P3	Bjørnar	Bjørnar	27.03.2015	27.03.2015	05.05.2015		Aktivitet vil jobbes med ettersom nye designvalg blir gjort og nye komponentet valgt ut
63	Lese over endringer v1.1 av risikoanalysene og opprette v1.2	Olav	Bjørnar	27.03.2015	27.03.2015	27.03.2015		
64	Utarbeide manufacturing document	Olav	Olav	27.03.2015	27.03.2015	08.05.2015		
65	Sette opp en midlertidig innkjøpsliste/tabell i excel med hva som skal kjøpes inn og hva som skal lages internt	Olav	Henrik	07.04.2015	07.04.2015	07.04.2015		
66	Midlertidig tankdesign: gjøre volumberegninger og sette opp en modell	Olav	Olav, Bjørnar	07.04.2015	07.04.2015	07.04.2015		
67	Sette opp prosjektstatus og veien videre til møtet på FMC 08.04.2015	Bjørnar	Bjørnar	07.04.2015	07.04.2015	07.04.2015		

68	Opprette notatdokument med ting skal med i manualen(e)	Bjørnar	Bjørnar	07.04.2015	07.04.2015	07.04.2015		
69	Lage user/service manual	Alex	Alex,	07.04.2015	24.04.2015	08.05.2015		
70	Felles gjennomgang av P&I	Henrik	Alle	08.04.2015	08.04.2015			
71	Møte med Pietro om P&I og Flowcharts	Henrik	Henrik, Bjørnar	08.04.2015	13.04.2015			
72	Utnevne ansvarlig for Construction Report samt skriving av denne	Bjørnar	Olav	11.04.2015				
73	Modellere ettersom flere komponenter blir valgt	Olav	Alle	11.04.2015	13.04.2015	08.05.2015		
74	Utarbiede 2D-tegninger for total assembly og komponenter som må lages	Olav	Olav, Bjørnar,	11.04.2015	13.04.2015	08.05.2015		
75	Utnevne ansvarlig for sluttrapport	Bjørnar	Bjørnar	11.04.2015	20.04.2015	20.04.2015		
76	Gå gjennom kvalitetssjekk (akt. 57) av v2.1 av testsplan&spec	Alex	Alex, Henrik	12.04.2015	13.04.2015	17.04.2015		
77	Sluttføre risikoanalysene til v3	Olav	Bjørnar, Olav	12.04.2015	13.04.2015	14.04.2015		
78	Fullføre instrumentation list	Henrik		13.04.2015	13.04.2015	28.04.2015		
79	Felles gjennomgang	Henrik	Alle	15.04.2015	15.04.2015	15.04.2015		

	av testplan&spec og kryssreferanser							
80	Fullføre Flowcharts (tidligere UseCase)+lage dem i Visio	Alex	Alex	16.04.2015	27.04.2015	08.05.2015		
81	Opprettet dokumenthirarki	Olav	Olav, Alex	16.04.2015	16.04.2015	16.04.2015		
82	Planlegging av sluttrapport	Bjørnar	Alle	16.04.2015	04.05.2015	05.05.2015		
83	Styrkeberegning av gammel ramme med rapport	Olav	Bjørnar	16.04.2015				
84	Modellering, styrkeberegning av stroppfester, inkl 2D-tegninger	Olav	Henrik	16.04.2015				
85	Skaffe tilveie 3D-modeller fra leverandører	Olav	Alle	16.04.2015				
86	Piping and routing, modelering av rør, inkl 2D-tegninger	Olav	Alex	17.04.2015				
87	Hente 3D-modeller til rør-koblinger	Alex	Alex					
88	Gjort endringer på basisrame etter møte med FMC 20/2	Olav	Olav				Endret materiale til aisi316, og tilpasset rørstørrelse	
89	Siste felles gjennomgang av testspec	Henrik	Alle	23.04.2015	23.04.2015	23.04.2015		
90	Ferdigstille testspec	Henrik	Henrik/Alex	24.04.2015	24.04.2015	06.05.2015		

91	Brainstorm på manual	Alex	Alle	26.04.2015					
92	Lage kraftregnskap for El-komponenter	Olav	Olav	28.04.2015	01.05.2015				
93	Ferdigstille key learning points and experiences	Henrik	Henrik, Bjørnar	24.04.2015	24.04.2015	06.05.2015			
94	Lage nettside	Henrik	Henrik	24.04.2015	24.04.2015	03.06.2015			
95	Gjennomgang av utkast til manual, key learning points&experiences, og construction report	Bjørnar	Bjørnar	24.04.2015	24.04.2015	24.04.2015			
96	Fullføre innkjøpsliste	Olav	Bjørnar / Olav	30.05.2015					
97	Lage Vektregnskap	Olav	Bjørnar	01.05.2015					
98	Lage sammenstilling av PTW med komponenter	Olav	Olav	04.05.2015					
99	Skrive sluttrapport	Bjørnar	Bjørnar	03.05.2015	04.05.2015	12.05.2015			
100	Avtale dag for printing hos FMC	Bjørnar	Bjørnar	03.04.2015	08.04.2015	08.04.2015			
101	Kvalitetssjekk og korrekturlesing av andreutkast til key learning points&experiences	Bjørnar	Bjørnar, Olav	05.05.2015	05.05.2015	05.05.2015			
102	Felles gjennomgang av all dokumentasjon	Henrik	Alle	05.05.2015					Henrik spesifiserer at PLS adresser må gåes nøye over

103	Føre inn grunnlag for valg av PLS i teknologidokument	Bjørnar	Henrik	05.05.2015	05.05.2015			
104	Rette opp modeller hentet fra internett/ leverandører	Olav	Olav	07.05.2015	04.05.2015	HSBF		
105	Oppdatere prosjektplan til sluttpresentasjon	Bjørnar	Bjørnar	08.05.2015	08.05.2015	08.05.2015		

A4. Risk Analyses

Portable Tube Washer Project 2015\Appendices\1. Administrative\A4. Risk Analyses

Risk Analyses

Version 2

Version	Date	Changes	Status	Responsible
1	18.03.2015	This is the first version created. Made ready for the second presentation.		Olav Parken
2	14.04.2015	Document reviewed for final inspection.	Document Ready for final delivery.	Olav Parken

Name	Signatures
Bjørnar D. Døviken	
Henrik Lind	
Olav Parken	
Alexander Araya	

Introduction

These risk analyses are written with the consequences for the project, as a student assignment, in mind; consequences for FMC are outside the document scope. The consequences are based on factors that may threaten our goal of getting good grades.

Probability	Definition
H (High)	The situation occurs in 70-100% of the cases
M (Medium)	The situation occurs in 30-70% of the cases
L (Low)	The situation occurs in 0-30% of the cases

Combination of Probability and Consequence	
(red)	This is a critical risk and demands action to prevent the situation.
(yellow)	This is a considerable risk. The group shall be aware of the situation and try to avoid it. It can be handled with minor adjustments.
(green)	The ideal situation. This risk can be neglected.

Assessment of:

Probability

H	(yellow)	(red)	(red)
M	(green)	(yellow)	(red)
L	(green)	(green)	(yellow)
	L	M	H

Consequence

Note	
Critical:	
Considerable:	
Negligible:	

Risk Description(A):

Proactive Measures(B):

Solutions:

Headings marked with * means that the analysis is written after proactive measures have been taken to reduce the risk.

A: Risk before proactive measures

B: Reduced risk after proactive measures

Solutions: If a worst case scenario should happen, these are the measures we have planned to take.

Risk titles marked with **red** have occurred and measures have been taken. These analyses have an additional row describing the outcome of the occurred risk, if applicable. Analyses made redundant by the occurrence of others have been moved to their own chapter.

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Glossary and Acronyms

Name	Description
PTW	Portable Tube Washer
FMC	FMC Technologies
PNR	Point-of-No-Return: Point at which no new significant input may be included in the project

3 Project

*3.1 Not Delivering A Complete Built Product**

Probability

H		A	
M		B	
L			
	L	M	H

Consequence

Note	
Critical:	
Considerable:	X
Negligible:	

Risk Description(A):

The probability of not delivering a completely built and fully tested PTW at the end of May is high. This will have a medium consequence for the project as the group will probably have finished all necessary documentation (ref 3.2).

Proactive Measures(B):

Choose a development model that allows for parallel, incremental work, and work disciplined to complete planned tasks according to project milestones.

Solutions:

If we cannot build and test the complete product in time, we must prioritize finishing all documentation.

Occurrence Report:

Meeting 08.04.2015 at FMC concluded with a no-go decision for the physical construction of the product. See appendix A, page 89 (letter from Manager, Kongsberg Workshop)

*3.2 Not Completing Project Documentation Before the Deadline**

Probability

H			A
M			
L			B
	L	M	H

Consequence

Note	
Critical:	X
Considerable:	
Negligible:	

Risk Description(A):

The probability of not delivering complete project documentation before the deadline is high, and will result in a high consequence for the project group.

Proactive Measures(B):

Choose a development model that allows for parallel, incremental work, and work disciplined to complete planned tasks at project milestones. We have decided to go for the Unified Process model. The project group will focus on completing documentation before the physical product.

Solutions:

Prioritize project documentation before production documentation.

3.3 *Inadequate Charting of Stakeholders*

Probability				
	H			
	M	A		
	L		B	
		L	M	H
		Consequence		

Note	
Critical:	X
Considerable:	
Negligible:	

Risk Description(A):

If a stakeholder is forgotten, important requirements may not be included in the project work.

Proactive Measures(B):

The project group's choice of development model and frequent meetings with already known primary stakeholders should capture unknown stakeholders. The consequence of finding a new stakeholder after the PNR increases.

The development of flow charts and iterative work on the requirements specification have increased the chance of unraveling new stakeholders.

Solutions:

If a new stakeholder is discovered before the PNR, the requirements will be updated in the next iteration.

3.4 *Not Understanding the Stakeholders' Needs*

Probability				
	H	A		
	M			
	L		B	
		L	M	H
		Consequence		

Note	
Critical:	X
Considerable:	
Negligible:	

Risk Description(A):

If stakeholders are misinterpreted, requirements not reflecting the stakeholder's true needs may affect the project work in a counter-productive way.

Proactive Measures(B):

Have frequent meetings with the client to discuss what the product shall do to ensure a common understanding. The consequence of misunderstood needs after the PNR increases.

Solutions:

If a flawed need is discovered before the PNR, the requirements will be updated in the next iteration. After the PNR, the limit for changing requirements is very high, and is subject to a major discussion with the stakeholder.

3.5 Inexperienced Project Management

Probability				
	H			A
	M			
	L			B
		L	M	H

Consequence

Note	
Critical:	X
Considerable:	
Negligible:	

Risk Description(A):

None of the group members have experience with project management, and are all students of mechanical engineering. There is also a chance that misunderstandings will appear, and that some decisions are made without the other members' consent, due to poor communication.

Proactive Measures(B):

The project is primarily lead by the project manager, but every major decision is made as a joint effort by all the members democratically.

Solutions:

a) The group members will have open discussions whenever there is a conflict and will not be afraid to be honest with each other.

b) If the group cannot secure its own progression, the group's internal supervisor will have to take necessary actions.

3.6 Internal Conflict

Probability			
H			A
M			
L		B	
	L	M	H
	Consequence		

Note	
Critical:	
Considerable:	X
Negligible:	

Risk Description(A):

Bad group chemistry can develop from heated discussions where two or more members disagree. If not addressed properly and immediately, the conflict may escalate and severely affect the project outcome.

Proactive Measures(B):

If we hadn't had a good chemistry to begin with, we would never have teamed up for this project. We also share a common understanding of the task, and a common goal.

Solutions:

It's the group's responsibility to resolve any internal conflict. If two members disagree strongly, the other members will intervene if necessary and try to establish a common understanding of the problem.

Occurrence Report:

Details not applicable due to their sensitive nature. Two of the members have disagreed strongly and resolved to argue on a personal level, which caused major disturbances within the group. Conflicts resolved successfully by the group, and were handled as described in solutions.

4 Resources

4.1 Global Data Loss*

Probability				
	H			A
	M			
	L			B
		L	M	H
		Consequence		

Note	
Critical:	
Considerable:	X
Negligible:	

Risk Description(A):

A global loss of data could be disastrous for the project, as our documentation is the most important deliverable we're creating.

Proactive Measures(B):

Use of cloud storage and local file duplications on multiple computers.

Solutions:

4.2 Insufficient Budget*

Probability				
	H		A	
	M		B	
	L			
		L	M	H
		Consequence		

Note	
Critical:	X
Considerable:	
Negligible:	

Risk Description(A):

If an automated tube washer cannot at all be funded with the given budget, the project work can continue and be finished, but the physical product may not be built.

Proactive Measures(B):

Try to find affordable components from reliable suppliers.

Solutions:

Have a meeting with the customer. If the budget proves insufficient and cannot be raised, the requirements have to be adjusted or the physical product canceled.

Occurrence Report:

Meeting 08.04.2015 at FMC concluded with a no-go decision for the physical construction of the product. See appendix A, page 89.

4.3 *Personnel Unavailability*

Probability				
	H			
	M	B		A
	L			
		L	M	H
		Consequence		

Note	
Critical:	
Considerable:	X
Negligible:	

Risk Description(A):

If one of the project group members is temporarily or permanently unavailable to partake in group activities, there is a chance that work done by that person will be inaccessible for the remaining members.

Proactive Measures(B):

Working in pairs on critical activities to ensure a global insight, as well as cloud-saving all documents for common availability.

Solutions:

In case of lasting or permanent unavailability of one member the group will re-allocate responsibilities and tasks.

5 Hardware

5.1 *Wrong Choice of PLC*

Probability				
	H			
	M			A
	L		B	
		L	M	H
		Consequence		

Note	
Critical:	X
Considerable:	
Negligible:	

Risk Description(A):

If the wrong PLC-supplier is selected, insufficient support and PLC functionality may be the outcome. The group has no experience within this particular field and is dependent on external competence and advice.

Proactive Measures(B):

Charting of all needed in/outputs, other software requirements and establish communication with supplier and other potential supervisors.

Solutions:

Upgrade or find new PLC.

6 Software

6.1 Unrealistic PLC/Software Requirements

Probability				
H		A		
M				
L		B		
	L	M	H	
	Consequence			

Note	
Critical:	X
Considerable:	
Negligible:	

Risk Description(A):

Too ambitious software requirements may result in problematic programming work, and there may not exist advanced enough products on the market.

Proactive Measures(B):

Doing research and acquiring knowledge/information from supplier, FMC and HBV.

Solutions:

Adjust requirements after feedback/research.

7 HSE

7.1 Capacity Overload of Project Group

Probability				
H			A
M			
L		B	
	L	M	H

Consequence

Note	
Critical:	X
Considerable:	
Negligible:	

Risk Description(A):

The group consists of four mechanical engineering students, while the project requires competence far exceeding what the members can deliver. Being over-worked can result in reduced effectiveness, efficiency and overall mood.

Proactive Measures(B):

Evenly delegate tasks and responsibilities, have the freedom not to work in the weekends (with the exception of especially critical periods) and reward ourselves for completing phases of the project/reaching milestones etc. The group has a collective responsibility for making sure that no member is at any time over-worked.

Solutions:

Re-delegate over-allocated tasks.

7.2 Personnel Workshop Injuries

Probability			
H			
M			
L	B		A
	L	M	H

Consequence

Note	
Critical:	X
Considerable:	
Negligible:	

Risk Description(A):

If one of the group members gets injured in the workshop he/she may not be able to participate in further work for a longer period.

Proactive Measures(B):

Follow the workshop/HSE behavior, and regulations for required protective wear and gear.

Solutions:

In the event of serious personnel injury, FMC has their own procedure to handle work accidents. In a worst case scenario, we have to phone FMC's internal emergency nr: 8111

8 General Requirements

*8.1 Unrealistic Requirements**

Probability

H	A		
M			
L	B		
	L	M	H

Consequence

Note	
Critical:	
Considerable:	X
Negligible:	

Risk Description(A):

Setting too ambitious requirements to one or more of the components/sub-systems, the overall system, or any other aspect of the project, will make the concept selection and testing processes nearly impossible to complete successfully.

Proactive Measures(B):

Have a meeting with the client as early as possible to discuss what the product will do, and a review of all the requirements to ensure a common understanding.

Solutions:

Discuss possible changes with the client and make changes accordingly.

8.2 Not Meeting All A-level Requirements

Probability

H	A		
M	B		
L			
	L	M	H

Consequence

Note	
Critical:	X
Considerable:	
Negligible:	

Risk Description(A):

Not meeting a major portion of all A-level requirements could result in a product that will have reduced functionality, and be of little use to the customer.

Proactive Measures(B):

Discuss requirements with client to ensure realistic goals.

Solutions:

Evaluate the criticality of the requirement and possibilities of reducing the requirement's scope, or possibly discarding it.

8.3 *Not Meeting All B-level Requirements*

Probability				
H				
M	A			
L	B			
	L	M	H	

Consequence

Note	
Critical:	
Considerable:	
Negligible:	X

Risk Description(A):

Not meeting B-level Requirements will not impact the project outcome severely.

Proactive Measures(B):

Discuss requirements with client to ensure realistic goals.

Solutions:

Evaluate the criticality of the requirement and possibilities of reducing the requirement's scope, or possibly discarding it.

9 Key Requirements

FMC has provided us with six key requirements that will be used to measure our performance towards them. Cross references between key requirements from FMC and specific requirements can be found in the file "Requirement Matrix". They are as follows:

1. *Software (PLC) should be from a reputed supplier with the possibility of service and support.*
2. *It should be easy to do maintenance on all critical components. It implies that all components requiring maintenance shall be with simple steps removed, replaced or serviced.*
3. *The finished product should be possible to move with ease between different locations. It is desirable that all connections are made in such a way that it does not require major changes to connect to the workshop infrastructure.*
4. *HSE-construction shall have all the necessary components and systems ensuring safe operation. By incorrect use or error the system shall go into Safe Mode, where pressure is bled off and there are no pressurized parts, as this may cause splashes of hazardous substances.*
5. *When emptying the system reservoirs (service interval), easy drainage of the fluids into containers should be possible for safe handling of hazardous waste.*
6. *The washing Routine shall comply according to PRD-000025424.*

9.1 *Key Requirement nr. 1*

Probability				
	H			A
	M			
	L	B		
		L	M	H
		Consequence		

Note	
Critical:	X
Considerable:	
Negligible:	

Risk Description(A):

If the project group does not do thorough work in finding the best suitable supplier, it may result in a “no-go” from the customer. It will be critical and will delay the project's completion and delivery of a finished physical product, since the consequence will be to use more and valuable time in finding a proper supplier.

Proactive Measures(B):

Early in the process of the project it was decided to meet up with potential suppliers, get direct contact and evaluate each supplier, based on the criteria set by the requirement from the customer.

Solutions:

In the event of a no-go from the client, we will re-evaluate the potential suppliers and choose one that the client approves.

9.2 *Key Requirement nr. 2*

Probability				
	H			
	M			A
	L			B
		L	M	H
		Consequence		

Note	
Critical:	
Considerable:	X
Negligible:	

Risk Description(A):

The customer has made clear, through documentation and in meetings, their desire for a modular design. If the final product is not designed for the ease of repair and maintenance, the consequence of not accomplishing this will be an unsatisfied customer.

Proactive Measures(B):

We have made one specific requirement that will make sure that all components that go into the construction are located for best the accessibility possible.

Solutions:

If the client does not comply with our suggested 3D arrangement and design, we will relocate the relevant components to meet the client’s demands.

9.3 *Key Requirement nr. 3*

Probability

H			
M			
L		B	A
	L	M	H

Consequence

Note	
Critical:	
Considerable:	X
Negligible:	

Risk Description(A):

The customer has defined mobility of the PTW as the ease by which one person can relocate the PTW without the use of heavy/advanced lifting equipment. The customer also requires that the connections of both the PTW and the workshop infrastructure shall be compatible. If relocating the PTW requires much planning and heavy duty machinery, the consequence can be of severe economic impact when having to move it, and the customer will not be satisfied with the end product.

Proactive Measures(B):

Several requirements will make sure that the washing machine has the mobility for one person alone to handle and that the supply connections to the workshop infrastructure are compatible.

Solutions:

If the requirements attempting to fulfill the client's demand fail, we will do our best to find suitable alternatives.

9.4 *Key Requirement nr. 4*

Probability

H			
M			A
L	B		
	L	M	H

Consequence

Note	
Critical:	X
Considerable:	
Negligible:	

Risk Description(A):

If measures are not implemented then any incorrect use or error will put the safety of the operator and workshop environment at high risk for potential accidents.

Proactive Measures(B):

High focus on the safety of the operator and the workshop environment. There exist several requirements that will ensure and preserve this demand.

Solutions:

Should our preventive measures prove insufficient to the client's standards, we will add supplemental solutions to further increase safety.

9.5 Key Requirement nr. 5

Probability				
H			A
M			
L			B
	L	M	H
	Consequence		

Note	
Critical:	X
Considerable:	
Negligible:	

Risk Description(A):

If this issue is not addressed it will force the operator to find his own solution to how to handle the waste. The consequence is that the operator and the workshop environment may be exposed to hazardous liquids and vapor.

Proactive Measures(B):

Making sure that the washing machine has the possibility to drain the reservoirs without major complication, and reduce spills.

Solutions:

If the client does not approve of our written procedure for handling of hazardous waste, we will re-evaluate our options and make stricter rules in a new procedure.

9.6 Key Requirement nr. 6

Probability			
H			
M			
L	B		A
	L	M	H
	Consequence		

Note	
Critical:	X
Considerable:	
Negligible:	

Risk Description(A):

If the PTW does not include all washing cycles required, the consequence will be washed pipes not passing the quality test that ensures that the pipes have been washed in a proper way.

Proactive Measures(B):

Several requirements are derived from the washing procedure document that state what is required for a complete cycle to be approved before welding. See appendix B, page 93 (washing procedure).

Solutions:

If the washing cycles are not approved by the client, we must make changes to better meet the washing procedure.

10 Redundant Analyses

10.1 Inadequate Workshop Space

Probability				
H				
M				
L	A			
	L	M	H	

Consequence

Note	
Critical:	
Considerable:	
Negligible:	X

Risk Description(A):
The project work can continue and be finished, but the physical product may not be built.
Proactive Measures(B):
Make arrangements as early as possible before the construction phase.
Solutions:

10.2 Unavailability of in-house Test Equipment

Probability			
H			
M	A		
L	B		
	L	M	H

Consequence

Note	
Critical:	
Considerable:	X
Negligible:	

Risk Description(A):

If certain tests cannot be performed, the group will not be able to verify that all the requirements are met.

Proactive Measures(B):

Check on beforehand which necessary test equipment is available and which are not, ref. test specification.

Solutions:

Acquire necessary equipment from elsewhere.

10.3 Wrong Choice of Components

Probability			
H			A
M			
L		B	
	L	M	H

Consequence

Note	
Critical:	X
Considerable:	
Negligible:	

Risk Description(A):

If the wrong component is selected, the budget may not allow the purchase of another part, ref. analysis 2.2.

Proactive Measures(B):

Follow a structured process of research, and selection via Pugh-matrices.

Solutions:

Evaluate budget, re-select a proper component.

10.4 Delivery (delayed shipping time or/and wrong component)

Probability			
H		A	
M			
L		B	
	L	M	H

Consequence

Note	
Critical:	
Considerable:	X
Negligible:	

Risk Description(A):

Consequence of delayed shipping or delivery of wrong components would result in the group's inability to assemble the PTW in time to be fully tested before the deadline of the project.

Proactive Measures(B):

When selecting components, just look at parts that are in stock from well-established suppliers; good contact with purchase office, order as soon as possible, check availability of components before ordering and check components immediately after arrival.

Solutions:

Notify supplier, reorder component.

10.5 Inadequate Programming Competence

Probability			
H			A
M		B	
L			
	L	M	H

Consequence

Note	
Critical:	X
Considerable:	
Negligible:	

Risk Description(A):

Not being able to program the PLC to the defined sequence will have high a consequence for the project. If we have to hire professional assistance, it would also have economic consequences.

Proactive Measures(B):

Get programming software early, make contact with supplier and people with good competence in this field

Solutions:

Acquire assistance.

Appendices

A. Cancelation of Physical Product

Att: HBV Prosjektgruppe - Portable Tube Washer project

Deres ref: Bjørnar Døviken   Vår ref: Olaf Ødegård   Date: 08.04.2015

Kanselering av bygging av prototype.

Basert på innkommende priser og tilbud fra våre underleverandører må FMC desverre se seg nødt til å kanselere realiseringen av en fysisk prototype I prosjektet. Prisene må reforhandles med en målsetting om ca 40-50% reduksjon. Forhandlingene ikke er avsluttet men vi innser at det vil være vanskelig å nå målsettingen spesielt på kort sikt. Deler vil ikke bli satt I bestilling før ønsket prisnivå er oppnådd.

Det vil si at realiseringen av prototypen pr nu ikke er mulig å gjennomføre innenfor innen FMC sine kostnadsrammer og HBV prosjektets tidsramme. FMC beklager det inntruffne men håper på at design og dokumentasjonsunderlag utarbeides med en slik kvalitet at FMC kan gjennomføre byggingen selv på et senere tidspunkt.

Med vennlig hilsen

Olaf Ødegård

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B. Washing Procedure

MISCELLANEOUS PROCEDURE, WASHING PROCDURE FOR INERNAL TUBE WASHER

Rev	ECN No.	Date	Reviewed By	Approved By	Status
A	6011884	26-JAN-2006	Henrichsen, Harald	Lilleland, Svein	RELEASED

Summary:

This document gives a description of the procedure and equipment that is in use by FMC Kongsberg Subsea for cleaning hydraulic tubes and pipes before assembly.

Flushing is not accepted as the only or primary means of cleaning hydraulic parts or components, including tubing systems.

The document is bilingual; English and Norwegian

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Abbreviations

The following abbreviations are used throughout this procedure.

Abbreviation	Description
HES	Health, Environment and Safety
MSDS	Material Safety Data Sheet
HMS	Norwegian; HES

Tube/pipe washing prior to assembly

1.0 Scope

This document gives a description of the procedure and equipment that is in use by FMC Kongsberg Subsea for cleaning hydraulic tubes and pipes before assembly.

Flushing is not accepted as the only or primary means of cleaning hydraulic parts or components, including tubing systems.

2.0 Required equipment

A suitable tube cleaning station is required, as an example: "FMC tube- pipe washer". See figure 1.

A soap which is fit for purpose is required. Being fit means that it will dissolve mineral based oils or greases and water-glycol based fluids and greases. The Kongsberg plant uses "Aluvask" soap.

3.0 HES

The operator shall know the contents of the MSDS of the soap before using the pipe-tube washer.

Verify that the pipe or tube is safely connected to the washer. Hot water leakage will cause harm and may be dangerous.

During the wash operation, personal protection is required; safety glasses, hard hat, noise suppression, gloves and long sleeved clothing.

Cleaned tubes or pipes shall be fitted with caps to prevent damage to eyes, or personnel in general. Ball type caps are recommended. See figure 5 as an example.

4.0 Procedure

1. Connect the tube to the washer using the appropriate wise grip, fitting or alternative interface as required.

2. The other end of the tube shall be located inside the soft plug container which is above a drain. See figure 2.

3. Flush with hot water for 15 seconds (Water temperature 60 °C).

4. Flush with soap for 3 seconds.
5. Flush with hot water for 30 seconds.
6. With the tube end inside the noise suppression box, blow the tube dry using oil free, filtered and dry air. See figure 3.
7. Shoot a clean soft plug (correct size) through the tube, using "Jet Cleaner" or similar. See figure 4. Ensure that the plug is retained inside the container, to verify that the complete plug has passed through the tube.
8. Plug the cleaned tube, to prevent ingression of contamination.
9. Take care to prevent external damage to the tube during the process

5.0 Attachment - illustrations

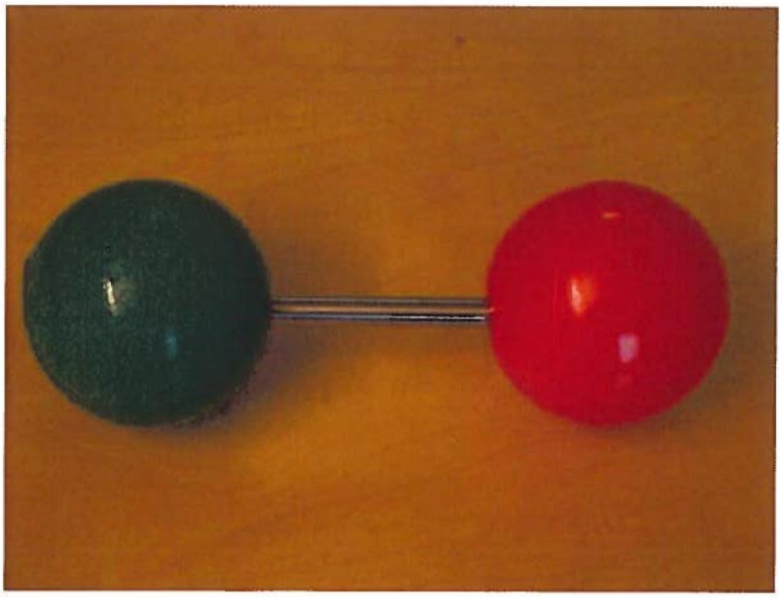
Figure 1: FMC tube- pipe washer

Figure 2: Container above drain, soft plug receiver

Figure 3: Noise suppression box with filter

Figure 4: Jet cleaner with soft plug

Figure 5: End protection. To prevent damage to personnel and to exclude contamination



6.0 Original document in Norwegian

6.1 Formålet

Beskriver en prosess for rengjøring av rør, slik at krav til renhet blir overholdt. Dvs skal man få et rent hydraulikk system må renhet, på komponent nivå, overholdes.

6.2 Krav til utstyr

Det kreves at det er en egnet vaskestasjon, for eksempel: type "FMC tube – pipe washer". Se fig. 1

Det kreves at det blir brukt en såpe som er egnet til formålet d.v.s. at den har evnen til og løse opp både mineral og glykolholdige oljer. Vi bruker Aluvask.

6.3 HMS

Operatør skal gjøre seg kjent med såpens HMS-datablad før vaskeprosessen kan igangsettes.

Påse at alle koblinger mot rør er festet på forsvarlig måte. Lekkasje av varmt vann, såpe og trykkluft kan medføre skade.

Det skal under vaskeprosessen brukes hjelm med visir (vernebriller), hørselsvern, engangshansker av Nitril, samt arbeidsklær med lange armer.

Etter endt vaskeprosess skal det påmonteres stor ende beskyttelse i hver ende av rørene. (Se Fig. 5 for forslag)

6.4 Utførelsen

1. Koble rør til vaskeutstyr med egnede klemmer, fittings eller det som er interfacen på røret.
2. Rør enden skal plasseres i beholder over sluk enten utvendig eller innvendig. Se fig.2
3. Spyl med varmt vann ca 15 sek. (vannet bør holde 60°)
4. Spyl med såpetilsatt vann i 3 sek.
5. Spyl med varmt vann i ca 30 sek.

6. Når dette gjøres plasseres rør enden i lyddempet kasse. Se fig.3. Blås med renset, oljefri og tørket luft. Dette gjøres til røret er fritt for vann.

7. Skyt en ren skumplugg (tilpasset dimensjonen på røret) gjennom, med "Jet cleaner" se fig.4. Sørg for at denne lander i en beholder slik at man kan se at hele pluggen er gått gjennom.

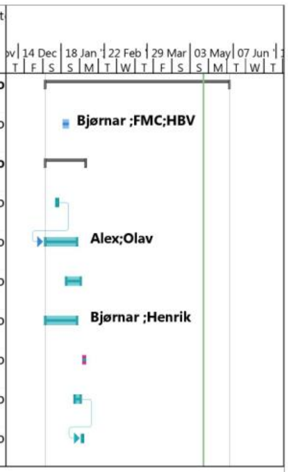
8. Det ferdig behandlede røret plugges, slik at forurensing ikke kan trenge inn i røret.

9. Sørg for at røret ikke påføres ytre skader under prosessen.

A5. Gantt - Chart

Portable Tube Washer Project 2015\Appendices\1. Administrative\A5. Gantt - Chart

ID	Task Mode	Task Name	Duration	Start	Finish	Pr	Resource Names	% Comp	Milest
1		**Project**	**108 days**	**Mon 05.01.15**	**Wed 03.06.15**			**83%**	**No**
2		Contract	5 days	Mon 19.01.15	Fri 23.01.15		Bjørnar ;FMC;HBV	10...	No
3		**Phase 1: Inception**	**25 days**	**Mon 05.01.15**	**Fri 06.02.15**			**10...**	**No**
4		Flow Charts [R1]	1,5 days	Wed 14.01.15	Thu 15.01.15			10...	No
5		Requirement spec [R2] v1.0	20 days	Mon 05.01.15	Fri 30.01.15	4	Alex;Olav	10...	No
6		Testplan&spec v1.0	8 days	Thu 22.01.15	Mon 02.02.15			10...	No
7		Project plan v1.0	20 days	Mon 05.01.15	Fri 30.01.15		Bjørnar ;Henrik	10...	No
8		Design initiation	3 days	Wed 04.02.15	Fri 06.02.15			10...	No
9		Hand in P1 (folder)	3 days	Thu 29.01.15	Mon 02.02.15			10...	No
10		Presentation 1	1 day	Wed 04.02.15	Wed 04.02.15	9		10...	No

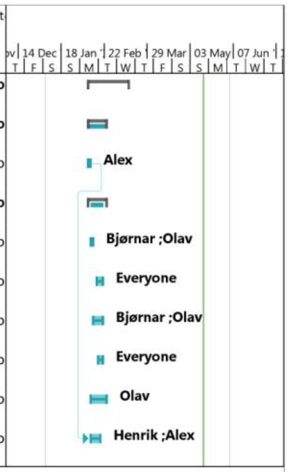


Project: Project plan
Date: Thu 14.05.15

Task, Split, Milestone, Summary, Project Summary, Inactive Task, Inactive Milestone, Inactive Summary, Manual Task, Duration-only, Manual Summary Rollup, Manual Summary, Start-only, Finish-only, External Tasks, External Milestone, Deadline, Path Successor Milestone Task, Path Successor Summary Task, Path Successor Normal Task, Path Predecessor Milestone Task, Path Predecessor Summary Task, Path Predecessor Normal Task, Progress, Manual Progress

Page 1

ID	Task Mode	Task Name	Duration	Start	Finish	Pr	Resource Names	% Comp	Milest
11		**Phase 2: Elaboration**	**25 days**	**Mon 09.02.15**	**Fri 13.03.15**			**90%**	**No**
12		**E1**	**11 days**	**Mon 09.02.15**	**Mon 23.02.15**			**10...**	**No**
13		Requirement spec v1.2	2 days	Mon 09.02.15	Tue 10.02.15		Alex	10...	No
14		**Design**	**11 days**	**Mon 09.02.15**	**Mon 23.02.15**			**10...**	**No**
15		Product breakdown structu	2 days	Wed 11.02.15	Thu 12.02.15		Bjørnar ;Olav	10...	No
16		Component Research	5 days	Mon 16.02.15	Fri 20.02.15		Everyone	10...	No
17		Risk Analysis v0.2	6 days	Fri 13.02.15	Fri 20.02.15		Bjørnar ;Olav	10...	No
18		Concept Screening vE1.1	4 days	Tue 17.02.15	Fri 20.02.15		Everyone	10...	No
19		Modeling & Production documentation v0.0	9 days	Wed 11.02.15	Mon 23.02.15		Olav	10...	No
20		Test spec v1.1	6 days	Wed 11.02.15	Wed 18.02.15	13	Henrik ;Alex	10...	No



Project: Project plan
Date: Thu 14.05.15

Task, Split, Milestone, Summary, Project Summary, Inactive Task, Inactive Milestone, Inactive Summary, Manual Task, Duration-only, Manual Summary Rollup, Manual Summary, Start-only, Finish-only, External Tasks, External Milestone, Deadline, Path Successor Milestone Task, Path Successor Summary Task, Path Successor Normal Task, Path Predecessor Milestone Task, Path Predecessor Summary Task, Path Predecessor Normal Task, Progress, Manual Progress

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ID	Task Mode	Task Name	Duration	Start	Finish	Pr	Resource Names	% Comp	Milestone
21		Project plan v1.1	11 days	Mon 09.02.15	Mon 23.02.15		Bjørnar	10...	No
22		Pizza!	1 day	Thu 19.02.15	Thu 19.02.15		Everyone	10...	Yes
23		**E2**	**15 days**	**Mon 23.02.15**	**Fri 13.03.15**			**78%**	**No**
24		Requirement spec v2	13 days	Mon 23.02.15	Wed 11.03.15			10...	No
25		**Design**	**15 days**	**Mon 23.02.15**	**Fri 13.03.15**			**85%**	**No**
26		Component Research	11 days	Mon 23.02.15	Mon 09.03.15			75%	No
27		Risk Analysis v1	11 days	Mon 23.02.15	Mon 09.03.15			10...	No
28		Concept Screening	11 days	Mon 23.02.15	Mon 09.03.15			75%	No
29		Concept Scoring	11 days	Mon 23.02.15	Mon 09.03.15			75%	No
30		First draft of system selection ready to FMC	6 days	Mon 02.03.15	Mon 09.03.15			10...	No
31		Second draft ready after FMC input	5 days	Mon 09.03.15	Fri 13.03.15			10...	No

Project: Project plan
Date: Thu 14.05.15

Task · Split · Milestone · Summary · Project Summary · Inactive Task · Inactive Milestone · Inactive Summary · Manual Task · Duration-only · Manual Summary Rollup · Manual Summary · Start-only · Finish-only · External Tasks · External Milestone · Deadline · Path Successor Milestone Task · Path Successor Summary Task · Path Successor Normal Task · Path Predecessor Milestone Task · Path Predecessor Summary Task · Path Predecessor Normal Task · Progress · Manual Progress

Page 3

ID	Task Mode	Task Name	Duration	Start	Finish	Pr	Resource Names	% Comp	Milestone
32		Modeling & Production documentation v1	13 days	Mon 23.02.15	Wed 11.03.15			25%	No
33		Project plan v2	13 days	Mon 23.02.15	Wed 11.03.15			10...	No
34		Test spec v2	13 days	Mon 23.02.15	Wed 11.03.15			10...	No
35		Code initiation	23 days	Mon 09.02.15	Wed 11.03.15			10...	No
36		Overview of content to P2	3 days	Mon 09.03.15	Wed 11.03.15			10...	No
37		Hand in P2 (folder)	7 days	Wed 11.03.15	Thu 19.03.15			10...	No
38		Make presentation	9 days	Wed 11.03.15	Mon 23.03.15			10...	No
39		Pizza!	1 day	Thu 12.03.15	Thu 12.03.15			10...	Yes
40		Presentation 2	1 day	Mon 23.03.15	Mon 23.03.15			10...	Yes
41		**Phase 3: Construction**	**30 days**	**Mon 23.03.15**	**Fri 01.05.15**			**70%**	**No**

Project: Project plan
Date: Thu 14.05.15

Task · Split · Milestone · Summary · Project Summary · Inactive Task · Inactive Milestone · Inactive Summary · Manual Task · Duration-only · Manual Summary Rollup · Manual Summary · Start-only · Finish-only · External Tasks · External Milestone · Deadline · Path Successor Milestone Task · Path Successor Summary Task · Path Successor Normal Task · Path Predecessor Milestone Task · Path Predecessor Summary Task · Path Predecessor Normal Task · Progress · Manual Progress

Page 4

ID	Task Mode	Task Name	Duration	Start	Finish	Pr	Resource Names	% Comp	Milest
42		**C1**	**5 days**	**Mon 23.03.15**	**Fri 27.03.15**			**73%**	**No**
43		Risk analyses completion	4 days	Tue 24.03.15	Fri 27.03.15		Alex;Bjørnar	90%	No
44		Test specification quality cont	4 days	Tue 24.03.15	Fri 27.03.15		Bjørnar ;Olav	10...	No
45		Soap pump & flow-thru 3D material	4 days	Tue 24.03.15	Fri 27.03.15		Bjørnar ;Olav	50%	No
46		PLS documentation completic	4 days	Tue 24.03.15	Fri 27.03.15		Alex;Henrik	75%	No
47		Concept selection	5 days	Mon 23.03.15	Fri 27.03.15		Everyone	50%	No
48		Pizza!	1 day	Thu 26.03.15	Thu 26.03.15			10...	Yes
49		Easter Holidays (Exam prep.)	6 days	Mon 30.03.15	Mon 06.04.15			10...	No
50		**C2**	**4 days**	**Tue 07.04.15**	**Fri 10.04.15**			**75%**	**No**
51		Risk analyses completion	3 days	Wed 08.04.15	Fri 10.04.15		Bjørnar	90%	No

Project: Project plan
Date: Thu 14.05.15

Task, Split, Milestone, Summary, Project Summary, Inactive Task, Inactive Milestone, Inactive Summary, Manual Task, Duration-only, Manual Summary Rollup, Manual Summary, Start-only, Finish-only, External Tasks, External Milestone, Deadline, Path Successor Milestone Task, Path Successor Summary Task, Path Successor Normal Task, Path Predecessor Milestone Task, Path Predecessor Summary Task, Path Predecessor Normal Task, Progress, Manual Progress

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ID	Task Mode	Task Name	Duration	Start	Finish	Pr	Resource Names	% Comp	Milest
52		PLS documentation completic	3 days	Wed 08.04.15	Fri 10.04.15		Alex;Henrik	85%	No
53		Concept selection	4 days	Tue 07.04.15	Fri 10.04.15		Everyone	50%	No
54		Pizza!	1 day	Wed 08.04.15	Wed 08.04.15			10...	Yes
55		**C3**	**5 days**	**Mon 13.04.15**	**Fri 17.04.15**			**64%**	**No**
56		Risk analyses completion	5 days	Mon 13.04.15	Fri 17.04.15		Bjørnar	10...	No
57		PLS documentation completic	5 days	Mon 13.04.15	Fri 17.04.15		Alex;Bjørnar ;Henr	95%	No
58		Concept selection	5 days	Mon 13.04.15	Fri 17.04.15		Everyone	60%	No
59		3D modelling/prod. Documentation	5 days	Mon 13.04.15	Fri 17.04.15		Bjørnar ;Olav ;Alex	15%	No
60		Pizza!	1 day	Thu 16.04.15	Thu 16.04.15			0%	Yes
61		**C4**	**5 days**	**Mon 20.04.15**	**Fri 24.04.15**			**55%**	**No**

Project: Project plan
Date: Thu 14.05.15

Task, Split, Milestone, Summary, Project Summary, Inactive Task, Inactive Milestone, Inactive Summary, Manual Task, Duration-only, Manual Summary Rollup, Manual Summary, Start-only, Finish-only, External Tasks, External Milestone, Deadline, Path Successor Milestone Task, Path Successor Summary Task, Path Successor Normal Task, Path Predecessor Milestone Task, Path Predecessor Summary Task, Path Predecessor Normal Task, Progress, Manual Progress

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ID	Task Mode	Task Name	Duration	Start	Finish	Pr	Resource Names	% Compl	Milest
62		PLS documentation completic	5 days	Mon 20.04.15	Fri 24.04.15		Bjørnar ;Henrik	98%	No
63		Concept selection	5 days	Mon 20.04.15	Fri 24.04.15		Everyone	75%	No
64		3D modelling/prod. Documentation	5 days	Mon 20.04.15	Fri 24.04.15		Everyone	50%	No
65		Manual	5 days	Mon 20.04.15	Fri 24.04.15		Alex	10%	No
66		Pizza!	1 day	Thu 23.04.15	Thu 23.04.15			0%	Yes
67		**C5**	**5 days**	**Mon 27.04.15**	**Fri 01.05.15**			**77%**	**No**
68		PLS documentation completic	5 days	Mon 27.04.15	Fri 01.05.15		Bjørnar ;Henrik	95%	No
69		Concept selection	5 days	Mon 27.04.15	Fri 01.05.15		Everyone	98%	No
70		3D modelling/prod. Documentation	5 days	Mon 27.04.15	Fri 01.05.15		Everyone	80%	No
71		Manual	5 days	Mon 27.04.15	Fri 01.05.15		Alex	30%	No

Project: Project plan
Date: Thu 14.05.15

Task		Duration-only		Path Successor Summary Task	
Split		Manual Summary Rollup		Path Successor Normal Task	
Milestone		Manual Summary		Path Predecessor Milestone Task	
Summary		Start-only		Path Predecessor Summary Task	
Project Summary		Finish-only		Path Predecessor Normal Task	
Inactive Task		External Tasks		Progress	
Inactive Milestone		External Milestone		Manual Progress	
Inactive Summary		Deadline			
Manual Task		Path Successor Milestone Task			

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ID	Task Mode	Task Name	Duration	Start	Finish	Pr	Resource Names	% Compl	Milest
72		Grillings!	1 day	Fri 01.05.15	Fri 01.05.15			10...	Yes
73		Requirement spec [R2] v3.0	37 days	Mon 23.03.15	Tue 12.05.15			10...	No
74		Testplan & Specification v3.0	37 days	Mon 23.03.15	Tue 12.05.15			10...	No
75		Project plan v3.0	37 days	Mon 23.03.15	Tue 12.05.15			10...	No
76		Technology Document v3.0	37 days	Mon 23.03.15	Tue 12.05.15			10...	No
77		Point of no return	1 day	Wed 01.04.15	Wed 01.04.15			10...	Yes
78		**Phase 4: Transition**	**23 days**	**Mon 04.05.15**	**Wed 03.06.15**			**47%**	**No**
79		Final post-work on testing&construction	5 days	Mon 04.05.15	Fri 08.05.15			90%	No
80		Finalize documentation and make final hand in (folder)	9 days	Mon 04.05.15	Thu 14.05.15			80%	No
81		Final hand in (date)	1 day	Tue 19.05.15	Tue 19.05.15			0%	Yes

Project: Project plan
Date: Thu 14.05.15

Task		Duration-only		Path Successor Summary Task	
Split		Manual Summary Rollup		Path Successor Normal Task	
Milestone		Manual Summary		Path Predecessor Milestone Task	
Summary		Start-only		Path Predecessor Summary Task	
Project Summary		Finish-only		Path Predecessor Normal Task	
Inactive Task		External Tasks		Progress	
Inactive Milestone		External Milestone		Manual Progress	
Inactive Summary		Deadline			
Manual Task		Path Successor Milestone Task			

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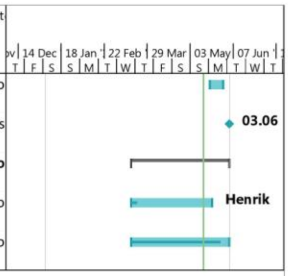
ID	Tasl Mo	Task Name	Duration	Start	Finish	Pr	Resource Names	% Comp	Milest
82		Make presentation 3	9 days	Tue 19.05.15	Fri 29.05.15			0%	No
83		Presentation 3	1 day	Wed 03.06.15	Wed 03.06.15			0%	Yes
84		**Media**	**58 days**	**Mon 16.03.15**	**Wed 03.06.15**			**54%**	**No**
85		Poster	48 days	Mon 16.03.15	Wed 20.05.15		Henrik	10%	No
86		Web site	58 days	Mon 16.03.15	Wed 03.06.15			90%	No



Project: Project plan
Date: Thu 14.05.15

Task		Duration-only		Path Successor Summary Task	
Split		Manual Summary Rollup		Path Successor Normal Task	
Milestone		Manual Summary		Path Predecessor Milestone Task	
Summary		Start-only		Path Predecessor Summary Task	
Project Summary		Finish-only		Path Predecessor Normal Task	
Inactive Task		External Tasks		Progress	
Inactive Milestone		External Milestone		Manual Progress	
Inactive Summary		Deadline			
Manual Task		Path Successor Milestone Task			

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A6. Time Sheets

Portable Tube Washer Project 2015\Appendices\1. Administrative\A6. Time Sheets

Each group member is expected to work an individual total of approximately 600 hours, in accordance with HBV's expected amount, to a group total of 2400 hours. Detailed time sheets can be found in their respective folder, but are not appended here.

Timeregnskap M-Team HBV per 18.05.2015

Navn	Uke nr.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Bjørnar Døviken		10,0	38,5	37,0	44,0	36,5	37,0	40,0	36,0	38,0	39,0	50,0	38,5	0,0	23,0	38,0	44,0	42,5	56,0	73,5	0,0
Alexander Araya		8,0	33,0	34,5	46,0	36,0	35,5	36,0	30,0	35,0	33,5	46,5	32,5	0,0	20,0	39,0	42,0	35,0	53,5	62,0	0,0
Henrik Lind		4,0	28,5	33,5	43,5	33,5	37,5	35,5	34,0	36,0	36,0	52,0	39,5	0,0	16,0	40,0	43,0	36,0	46,5	66,5	0,0
Olav Parken		9,0	31,0	33,5	33,0	36,0	33,5	39,5	32,0	37,5	26,0	42,5	39,5	0,0	16,0	44,5	48,0	43,5	66,5	64,0	0,0
Totalt timer pr. uke		31,0	131,0	138,5	166,5	142,0	143,5	151,0	132,0	146,5	134,5	191,0	150,0	0,0	75,0	161,5	177,0	157,0	222,5	266,0	0,0

Totalt pr. person	
Bjørnar Døviken	721,5
Alexander Araya	658,0
Henrik Lind	661,5
Olav Parken	675,5
Totalt timeforbruk	**2716,5**

A7. Learning Points and Experiences

Portable Tube Washer Project 2015\Appendices\1. Administrative\A7. Learing Points and Experiences

Learning Points and Experiences

Version 1

Version	Date	Changes	Status	Responsible
1	11.05.2015	Final formatting and added appendices.	Document ready for delivery.	Henrik Lind

Name	Signatures
Bjørnar D. Døviken	
Henrik Lind	
Olav Parken	
Alexander Araya	

Introduction

This document provides insight to what the project group has been struggling with the most, and generally, what we have learned from our rights and wrongs: which challenges we met, how we solved them and the experiences drawn from them, and whether they were good or bad relative to the project. The document is based on three “faserapporter” written, as a summary, for each phase of the project. The most crucial parts from each phase will conclude this document.

It is recommended to read the “faseraportene” if you want the full overview of what knowledge we will bring into a working environment.

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Glossary and Acronyms

Name	Description
PTW	Portable Tube Washer
FMC	FMC Technologies
PBS	Product Breakdown Structure
P&I	Piping and Instrumentation
PLC	Programmable Logic Controller

1. Inception

When the project began, the project group members already knew each other through previous work; we believed we knew each other's way of thinking, explaining and working. Additionally, this time we were going to deal and communicate with external clients from FMC. It was quickly discovered that this wasn't as easy as it first seemed.

We took several actions to prevent misunderstandings and poor planning: We tried to find a project model that would fit our project; and having a product development project, we decided to use a customized Unified Process model.

To establish a common understanding with the costumer (FMC) about the product, we focused on making a structured requirement specification. When the first version of the specification was done we had a meeting with FMC and reviewed it, requirement by requirement. This process was repeated several times until both parties were satisfied. The document is now finished and the way we made it stands out as one of the best methods used in the project.

In the early stages of the project, google drive was selected as the server for all documentation, mainly because everyone was familiar with it from before. Unfortunately, google docs lacks in formatting and automatic functions. If this was discovered earlier, we wold have considered using another platform (e.g. One-drive). Google drive was also causing us problems when creating documentation templates, as the google docs formatting doesn't correspond with MS-office products, which left us having to make the templates in MS-word. The whole process of selecting platforms and software took a long time, and by the time we discovered our mistake, it was too late changing our minds.

While writing the requirement and test specifications, we had much focus on cross-referencing and traceability, making it understandable to everyone. Creating a good layout, with that in mind, was a challenge. One of our greatest mistakes when creating these documents was, instead of writing requirements and later trying to place them in the right category, we made a lot of categories and tried placing the requirements in the right one, one at a time. This didn't work because many requirements fitted multiple categories.

We ended up doing a bottom-up approach where we grouped requirements and later decided a fitting category for each group, and putting each requirement in its own table. The process was repeated 3 times before we were happy with the result. If we were to make these documents again, we would have researched more thoroughly how others had done it as there's no need to re-invent the wheel.

2. Elaboration

With little to no experience in selecting, connecting and programming PLCs, this was expected to be one of the major challenges of the project. The first thing to find out was who was going to be our PLC supplier. Our lack of experience had us searching for an established supplier who would share their expertise and knowledge with us. Service and training was one of the most valued search criteria.

We arranged meetings with potential suppliers to select a proper PLC for our product. On these meetings we tried to extract as much information on the subject as possible: What does a PLC do? How do we program it? How to check component-PLC compatibility? These questions, together with personal research, made us able to detect interfacing issues with the PLC unit.

Seeing how much time the PLC work has occupied, we considered making a separate graph in the project model to illustrate its time consumption. We also learned that making contact with suppliers early in the project is smart to get an overview and is recommended for learning the subject. Scheduling meetings, so that both parts are aware of the subject up for discussions, may provide better answers.

The structure of the requirement specification was also up for discussion when noted that it would be hard to implement new requirements for easy reading in the structure at that time. After several joint discussions the current structure now allows for the addition of requirements without messing up the order. This is one of many experiences that have taught us that thorough work in the beginning of a project saves time later.

As in the inception phase, the test specification helped the group learn new things. Basically, the challenge was deciding how many levels of testing we should implement and the structure of the document itself. We decided that we would, in this phase, finalize the layout of the document and write as much as possible, and later fill in the rest when the specific components had been selected. The reason we wanted to do as much as possible was to detect faults in the requirement specification, because if a test description is hard to write, consider reviewing the requirement in question.

On several occasions have project tools ended up as something else than it began with. One example of this is the PBS: At one time we wanted to make a system architecture followed by some black boxing, while what we instead ended up with was a first draft of the PBS. What this experience taught us, was that even though you set out to make one thing you may end up making another, based on what you need.

As we knew, time estimation is really hard. We've had to change the project plan on multiple occasions due to poor estimation, examples being the consumption of time when researching, and concept screening and scoring. Initially, only three days were reserved for these two exercises, but it ended up taking a lot longer. We spent the three days researching and only selecting some of the main components instead. The assumptions were confirmed, and we are grateful for the insight it has given us.

New problems appeared while selecting components: Some sub-systems and components were easy to select because there were very few or no other alternatives. Others were harder: Should we decide the number of pumps first, and then which type of pump, or the other way around?

After joint discussions and blackboard sketching, we decided the sub-system had to be selected first and then which components would fit it.

There are many factors to consider when selecting a component, everything from how the component works to ensuring that it communicates well and if it's a fitting interface. The only way to be sure that you have selected correctly is by doing research and contacting people with knowledge in the field.

3. Construction

When the group first started designing the product, in the elaboration phase, we created several concept diagrams. These diagrams were further developed, and in the construction phase they turned into what is called a P&I diagram. A valve was discovered that had no effect on the system, and that had been there all the time due to a concept we worked on and was never taken out when the concept was discarded.

Something we are really happy with is the risk analyses. The thorough work we have done with this document have proven to be most useful. We have had internal conflicts, we got a no-go on building the product from the customer, the costumer presented new needs and requirements after the point of no return, etc. Every time a calculated risk has occurred the countermeasures have been effective. We all agree it's been time well spent making the analyses and that we absolutely have seen the benefit of it.

We hoped to be done with many of the documents early in this phase, but that has not happened. As mentioned earlier, about the cross-referencing, almost all the important documents have some kind of relation to each other, and if you make a change in one (e.g. requirement specification) another document (e.g. test specification) will have to be updated. One small change in one document can cause a lot more work than it seems.

In this phase, one of the main objectives is to find components to use in the system. First, we made a list of functions the components should be able to perform, and delivered this list of specifications to a purchasing manager at FMC. After some time we got a list back with suggestions of components and the cost of these components. Later we had a budget meeting with the costumer and were told to terminate the construction of the PTW as the budget was not sufficient.

This decision freed us from having to stick to FMC-approved suppliers, but also forced us to dig deeper into components specifications and use much of our time on component research. After a lot of e-mails, phone calls and general internet research we found that the sales quotes, when inquiring as students, were much lower than what FMC had received. It also made us come up with components that made the entire product a simpler system. It was confirmed, however, that most industrial components are not in stock in Norwegian warehouse and therefore have long delivery estimates.

As parts of the risk analysis state, we will be ready for changes. Changes of needs and requirements is to be expected, but in this project the budget has been a deciding factor to whether or not we would be building the product. We made FMC aware, in an early stage, that the budget could be in the lower range and that it may be impossible to construct the system.

We were right. Changes to needs and requirements have been presented continuously during the project. The construction of the product was cancelled due to the low budget boundaries. We have tried to implement as many changes as possible, but some, due to the extent of the change and some coming in too late, has been written down as future improvements in the documentation.

Again, we are grateful for the thorough work done with the risk analyses and the plans we laid for how to handle the changes. They prepared us for such things and removed any doubt about how we would handle them.

4. Transition

The keyword for this phase is “good preparatory work”. Finally, we can reap the benefits of the thorough work done early in the project. The way we have produced the documentation makes it all fit together rather nicely. It was a clever decision to make a “faserapport” for each of the phases; it made us aware of the experiences the project has given us.

Appendices

A. Faserapport Inception

Faserapport Inception

Versjon 2

Versjon	Dato	Endringer	Status	Ansvarlig
1	18.03.2015	Dette er den første endelige versjonen, klargjort til presentasjon 2	Vi ser muligens ikke full effekt av alle håndteringene vi har gjort før senere. Det er fullt mulig at flere versjoner utarbeides.	Olav Parken
2	09.05.2015	Siste gjennomgang av formatering	Dokumentet er ferdig	Henrik Lind

Navn	Signaturer
Bjørnar D. Døviken	
Henrik Lind	
Olav Parken	
Alexander Araya	

Innledning

Dette dokumentet er laget for å ivareta tanker og erfaringer i forbindelse med prosjektets fremdrift slik at vesentlige detaljer ikke blir glemt. Alle faserapportene vil danne grunnlag for vår oppsummering av hva vi har erfart, og vårt forbedringspotensial for et tilsvarende prosjekt. Dokumentet tar for seg utfordringene vi har møtt, hvordan vi løste de og hva vi har erfart både positivt og negativt i forhold til måten vi har arbeidet på.

Inception fasen er den første fasen i Unified Process modellen. Denne fasen danner grunnlag for hele prosjektet og inbefatter alt fra identifisering av interessenter til valg av arbeidsverktøyer og dokumentmaler. Fasen innbefatter også planlegging, kartlegging og raffinering av ønskede ytelser for produktet og fordeling av oppgaver og ansvarsområder for hele prosjektets varighet. Vi har i tillegg, etter skolens ønske, gjort en del på testspec og testplan. Dette ville normalt ikke bli gjort før i en senere fase av prosjektet.

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Forkortelser og Ordforklaringer

Forkortelse	Forklaringer
PTW	Portable Tube Washer
FMC	FMC Technologies

1 Utfordringer

1.1 *Valg av* Prosjektmodell

Her måtte vi finne en modell som passet vårt produkt og gruppas størrelse. Vi var avhengig av å kunne jobbe innen flere områder samtidig.

Gruppa satte seg ned og så på forskjellige prosjektmodeller som vi var blitt forelest i tidligere år. På en forelesning i forbindelse med hovedprosjektet kom Unified Process modellen opp. Denne virket riktig i forhold til vårt produkt og vi valgte denne, og har modifisert den til å passe med prosjektperioden som skolen har satt opp.

1.2 Felles Forståelse

Vi måtte skape en felles forståelse Internt i gruppen og opp mot kunde (FMC) om hva oppgaven gikk ut på, og hva kunden egentlig ønsket. Vi oppdaget snart at ikke alle hadde samme «bilde» i hodet når f.eks. navnet på en komponent ble uttalt. Dette var noe vi måtte få på plass hvis vi skulle kunne gå dypere inn på tekniske løsninger.

For å få en felles forståelse for hva oppgaven gikk ut på, gikk vi igjennom gjeldene vaskeprosedyrer i tillegg til visjonsdokumentet og begynte å utarbeide krav for å dekke opp mot det vi forsto som ytelser o.l. Samtidig diskuterte vi internt i gruppa hvordan vi kunne møte de enkelte kravene. Vi var nøye med ikke å tenke løsning for å møte kravet, men konsepter. I den forbindelse falt en del utrykk og teknisk forståelse på plass. Når vi hadde fått på plass første utkast av kravspec, ble denne gjennomgått i detalj med FMC. Resultatet av dette var at også de måtte revurdere enkelte ønsker og spesifisere andre bedre. Denne øvelsen gjorde vi 2 ganger i løpet av Inceptionfasen.

Dette viste seg å være en smart tilnærming til problemet, og det ga samtidig en godkjenning fra FMC i det at krav ble forstått og gitt aksept. Gruppen vokste mye på denne aktiviteten og felles forståelse både innad i gruppa og mot FMC ble hevet til ett høyere nivå. Vi erfarte også at ingenting av forståelse skal tas for gitt. Det er «avsender» som er ansvarlig for at «mottaker» har forstått det som er blitt meddelt. Det er også avsenders ansvar å forsikre seg om at dette er oppfylt. Flere ganger ga slike avklaringer oss som gruppe en aha-opplevelse.

1.3 Valg av Softwareplatform

Vi ønsket å velge en plattform for arbeidsverktøy slik at hele gruppen kunne bruke dette samtidig og alle kunne nå alle dokumenter uavhengig av hvor vi befant oss.

Vi testet ut dropbox noe som ga oss all tilgangen vi ønsket, men vi kunne ikke redigere i dokumentene samtidig. Så ble Google drive testet ut, det ga oss de ønskede funksjonene og ble valgt til arbeidsverktøy. Der var det alt vi så for oss av dokumentverktøyer. Vi brukte også i starten Gantter-prosjektplanlegging, noe som snart viste seg manglet mange funksjoner. Gruppen hadde da ikke kommet så langt i føringen av planverket, så MS-Project ble prøvd ut i og med dette var gratis for studenter. Her hadde vi alle de funksjonene vi ønsket og fortsatte videre med dette.

Etter en kort periode oppdaget vi mangler med Google Docs spesielt med hensyn på automatiske funksjoner og formatering. Dessverre hadde vi nå kommet så langt i fremdriften at å bytte system igjen ville ta for mye tid. Med litt bedre undersøkelse, i starten, ville vi ha oppdaget at Microsoft OneDrive ville ha gjort samme jobben som Google Drive. I tillegg ville vi ha kunnet brukt alle MS-Office produkter på samme måte som Google Docs, til å redigere samtidig i samme dokument. Dette er en ideell løsning for samarbeid med slike publikasjoner.

1.4 Felles Dokumentmaler

Gruppa fant fort ut at det skulle utarbeides felles maler for dokumenter slik at vi slapp en stor jobb med formatering og tilpassing mot slutten, noe som ville spare oss tid. Dette skulle hjelpe oss med å danne en helhetlig og presentabel oppgave gjennom hele prosessen.

Her viste det seg, igjen, at Google Docs kom til kort både når det gjaldt formatering og oppsett. I tillegg var mangel på funksjoner i de forskjellige programmene en utfordring i seg selv. Vi valgte derfor å gå tilbake til MS-Office å lage de offisielle dokumentene med det som verktøy. Mye tid ble kastet bort i denne prosessen med prøving og feiling.

Her viste det seg igjen at valget av felles medier ikke var grundig nok undersøkt på forhånd, og at vi neste gang vil prøve ut Microsoft OneDrive.

1.5 Utforming av Krav- og Testspesifikasjon

Utforming og oppsett med sporbarhet og kryssreferanser, samt et godt forståelig innhold for alle, også de utenfor prosjektet, var en utfordring.

Vi begynte med ren tekst og mange nivåer med overskrifter i en kravspec. Så satte vi inn kravene under passende overskrifter, det viste seg ganske raskt at et krav kunne passe under flere overskrifter. Det ble heller ikke lett å få dette inn i en oversiktsmatrise opp mot testspesifikasjonen. Vi ble nødt til å sjekke ut hvordan andre hadde løst dette før oss. Og ble enige om å sette alle krav opp i små tabeller og å samle krav vi mente hørte sammen, for til slutt å finne en passende overskrift. Utformingen av kravspesifikasjonen lagde grunnlag for testspesifikasjonen sin utforming. Vi gikk minst tre runder med utforming før denne var klar. Inn i mellom dette gjorde gruppa flere runder med hensyn på gruppering på tavla. Når vi hadde fått på plass dette, startet arbeidet med utforming av testspesifikasjonen. Det endte opp med å bli mange tester og mange nivåer på testene. I dette arbeidet dukket problemer med nummerering kryssreferanser og sporingsmetoder opp. Vi registrerte dette, men ble enig om å gjøre videre arbeid med dette i neste fase.

Vi erfarte at en bedre forundersøkelse, se på hva andre hadde gjort før oss og prøvd å kombinere dette på ett tidligere tidspunkt hadde spart oss for mye arbeid. Det å «finne opp hjulet» og prøve å gjøre ting lettvint er ikke alltid det raskeste og beste.

1.6 Gruppens Kapasitet

Sårbarhet i forhold til antall medlemmer i gruppa og omfang av oppgaven kan gi store konsekvenser for prosjektet.

Det at gruppa består av kun fire medlemmer gjør oss meget sårbare i forhold til fravær, spesielt av lengre karakter. Vi har valgt at minst to personer er involvert i alle komplekse oppgaver for lettere å kunne videreføre disse om en person skulle være borte. Vi oppdaget snart at det ville vært oppgaver nok, i dette prosjektet, til 1-2 personer utover dagens antall.

Neste gang vil en bedre kartlegging av omfanget kunne gi et bedre grunnlag for bemanning av gruppen. Etter hvert oppdaget vi at vi også sårt hadde bruk for en «elektro-mann» i forhold til styringsdelen og instrumenteringen i oppgaven.

B. Faserapport Elaboration

Faserapport Elaboration

Versjon 2

Versjon	Dato	Endringer	Status	Ansvarlig
1	17.03.2015	Oppretting av dokument	Enkelte ting ser vi ikke effekten av før senere, derfor blir ikke dokumentet oppdatert før den tid.	Alexander Araya
2	09.05.2015	Siste gjennomgang av formatering	Dokumentet er ferdig	Henrik Lind

Navn	Signaturer
Bjørnar D. Døviken	
Henrik Lind	
Olav Parken	
Alexander Araya	

Innledning

Dette dokumentet er laget for å ivareta tanker og erfaringer i forbindelse med prosjektets fremdrift slik at vesentlige detaljer ikke blir glemt. Alle faserapportene vil danne grunnlag for vår oppsummering av hva vi har erfart, og vårt forbedringspotensialet for et tilsvarende prosjekt. Dokumentet tar for seg utfordringene vi har møtt, hvordan vi løste de og hva vi har erfart både positivt og negativt i forhold til måten vi har arbeidet på.

Elaboration fasen er den andre fasen i Unified Process modellen. Det som skulle gjøres i denne fasen var å jobbe videre med kravspesifikasjoner, samt testspesifikasjoner og design. Her måtte det gjøres mye arbeid med å redefinere krav og gå gjennom krav strukturen. Etterhvert som dette falt på plass så ville tiden og ressursene brukt på dette reduseres betydelig, da var det nemlig tid for full fokus på å arbeide med design og testspesifikasjoner. På slutten av denne fasen så måtte det meste, vis ikke alt, av det nødvendige av system komponenter være valgt for det endelige designet. Programmeringen av PLS måtte også være godt på vei.

Denne fasen er delt opp i to iterasjoner. Vi har valgt å skrive i om det som har skjedd gjennom hele fasen i denne rapporten, siden det som ble satt i gang i første iterasjon ble jobbet med videre i iterasjon nummer to. Dette dokumentet inneholder mange av de utfordringene som vi har møtt på. Her er det skrevet først om utfordringen, så om hvordan vi håndterte utfordringen for å så avslutte med hva vi erfarte i den prosessen.

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Forkortelser og Ordforklaringer

Forkortelse	Forklaring
PTW	Portable Tube Washer
FMC	FMC Technologies

1 Utfordringer

1.1 Kravstruktur

Prosjekt gruppa møtte på mange utfordringer underveis i prosjektet, men en av de utfordringene som prosjekt gruppa møtte på i denne fasen var det det å lage et kravstruktur. Alexander og Henrik forstod at etterhvert som det ble jobbet videre i prosjektet, så ville det dukke opp nye krav og som da måtte legges under sine respektive grupper. Utfordringen her var at den strukturen vi brukte for oppbygging av krav, ville ende opp med at de nye kravene ville havne i en tilfeldig rekkefølge i bunnen av hver gruppe.

For å kunne finne den beste løsningen til hvordan å organisere en kravstruktur, gjorde de en brainstorming hvor ideer ble kastet fram og tilbake. Etter at ideene var diskutert, ble det satt opp en ny struktur som gjorde det lettere å legge nye krav under sine respektive grupper.

Prosjekt gruppen lærte, etterhvert som de jobbet med kravstrukturen, at selv om det ble brukt mye tid på å inkludere alle i prosjektgruppen så sparte dette oss mange problemer i senere tid. Her lærte vi også mer om viktigheten i hvordan man legger opp krav ID, slik at nye krav som ville komme etterhvert kunne legges fortløpende under sine respektive kategorier. En annen fordel var at alle i gruppen hadde enda bedre felles forståelse for hva produktet skulle gjøre.

1.2 Testspesifikasjon

Når Henrik og Alexander startet å jobbe med testspesifikasjonen, tidlig i design prosessen, var vanskelig å definere på hvilket nivåer vi skulle teste. Skulle det testes på komponent, sub-system eller system-nivå, eller teste på flere nivåer? Det var vanskelig å skrive test description når ikke noe av dette var definert. Spørsmålet om å lage en sjekkliste eller en test for hver enkelt komponent kom også opp.

Det ble satt i gang en brain storming som ga litt svar på hvor mye som egentlig kunne gjøres med testspesifikasjonen når alt ikke var på plass. Det ble enighet i gruppen at vi skulle jobbe med så mye vi rakk med selve oppsettet av dokumentet og at det som hadde med test å gjøre skulle begynne først når komponenter var valgt og et systemoversikten var ferdig.

Vi erfarte at ved å jobbe med testspesifikasjonen så er resultatet at man får en kvalitetssikring av kravene. Det hjalp for å se om defineringen av kravene var tydelige og entydige, og at de lar seg teste.

1.3 *Systemarkitektur og Black Box*

I denne fasen var det tid for å lage en system arkitektur for så å sette opp en Black Box. Dette var det Olav og Bjørnar som tok ansvaret med å få i gang.

Når det var tid for å lage et system arkitektur så brukte de tavlen til brainstorming og diskusjon om forslagene. Under arbeidet fant de ut av at de ville legge til ting som tradisjonelt ikke er med i en arkitektur, og resultatet ble altså en Product Breakdown Structure isteden.

Når man setter i gang med å lage en ting hender det at man ender opp med noe annet, slik som dette eksempelet viser. Dette kommer mest sannsynlig av at ingen i gruppen har erfaring med prosjektstyring. Det er derfor en erfaring verdt å ta med videre.

1.4 *Tidsestimering*

Det er i utgangspunktet en utfordring og en stor usikkerhet i prosjekter rundt dette med estimering av tidsforbruk. Siden prosjektgruppen ikke har noen erfaring med dette fra tidligere ble det gjort en dårlig estimering av tidsforbruket av Concept Screening & Scoring. Det viste seg at gruppen brukte mer tid enn forventet på research rundt enkelte komponenter, da det finnes veldig lite informasjon på nettet om mange av de spørsmålene vi hadde om produktet i forhold til hvordan vi hadde tenkt å bruke dem i vår system. Derfor ble prosjektplanen endret fra å skulle fullføre disse to aktivitetene på tre dager til å kun å velge ut de kritiske komponentene.

Vi fikk bekreftet at dette med tidsestimering faktisk er vanskelig, spesielt når vi ikke har noen erfaring med prosjektstyring. Det endte med at vi bomma helt, det tok lenger tiden enn forventet og vi ble liggende litt etter planen.

1.5 *Valg av PLS*

Det første vi måtte ta en stilling til, når det gjaldt PLS, var det det å velge ut hvilken leverandør vi skulle bruke. Dette viste seg å være komplisert og det ble en av de vanskeligste beslutningene vi måtte ta. Prosjektgruppen har veldig liten erfaring og absolutt ingen ekspertise innenfor automasjon, derfor har endt ut i å ha store spørsmål rundt hvordan en PLS fungerer, hvordan den kommuniserer med andre komponenter og hvordan man programmerer en PLS.

For å kunne velge den beste leverandøren, som ville stille med god service og oppfølging, ble Henrik sendt til å ha møter med Drammen Automasjon og Beijer Electronics angående PLS. Før disse møtene tok plass, satte gruppa av litt tid til å sette seg inn i hva en PLS var og hvordan de fungerte, slik at vi hadde konkrete spørsmål å stille PLS leverandørene. Disse møtene ga mange svar til spørsmålene vi hadde rundt PLS, men komponentvalg var fortsatt veldig usikkert grunnet utilstrekkelig kunnskap om hvordan de kom til å kommunisere med PLS-en. Etterhvert dukket det opp flere PLS leverandører, Goodtech som leverer Allen-Bradley ble anbefalt av FMC og Phoenix ble anbefalt av en privatperson. Når de forskjellige leverandørene ble vurdert opp mot hverandre, så var det et spesifikk krav fra FMC som ble lagt til grunn, som sa hvilket kriterier leverandøren måtte oppfylle for å være en god kandidat.

Erfaringen gruppen tar med seg videre er at de forskjellige leverandørene hadde forskjellige forutsetninger til hvordan de kunne bidra og hjelpe til i dette prosjektet, spesielt med tanke på at vi generelt i gruppa kan veldig lite om automasjon. Vi lærte at vis man bare tok direkte kontakt med leverandøren, avtalte et møte og presenterte problemstillingen, så får man i grunn veldig god hjelp av alle sammen. Det var en av leverandørene som vi ikke hadde avtalt møte med på forhånd som var litt mindre engasjert, sannsynligvis kommer det av den grunn at de ikke fikk tid til å forberede seg. I et fremtidig prosjekt kan det også være lurt å planlegge hvordan man skal takle noe man ser blir en utfordring helt fra starten av. Man kunne i dette prosjektet for eksempel laget en egen linje i Unified Process modellen for PLS.

1.6 *Valg av Komponenter*

Prosjekt gruppen har hatt noen problemer med fremgangsmåte for valg av komponenter. Noen komponenter og sub-systemer hadde vi allerede definert grunnet mangel på utvalg av andre løsninger. For eksempel er det bare en temperatursensor som kan måle temperatur. I tillegg er plassering av enkelte komponenter bestemt av kravene, og vi har ikke noe spillerom der; igjen, som eksempel er temperatursensoren som må være på enden av røret som skal vaskes. Alt dette gjorde det vrient å komme i gang med rekkefølgen av tradisjonell brainstorming, screening og scoring: Velger vi hvilken type pumpe vi skal ha først, eller om vi skal ha én eller to pumper med ulik plassering?

Etter litt flittig tavlebruk og diskusjon kom vi fram til at vi må gjøre om komponentproblemene til sub-systemproblemer, altså først tenke om vi skal ha én eller to pumper, og ta med i prosessen plassering, pris, effektivitet osv. Etter dette, når de tidligere sub-systemene er redusert til samme problemform som f.eks. temperatursensoren, kan vi velge f.eks. hvilken pumpe: Bladpumpe? Lammelpumpe? osv.

Erfaringer her var at det er mange faktorer som spiller inn når man skal velge en komponent. Alt fra hvordan selve komponenten fungerer til hvordan denne komponenten kommuniserer og fungerer opp mot andre komponenter. Man må bruke tid på research og prøve å få hjelp fra eksperter på disse områdene, slik at man forsikrer seg om å velge riktige komponenter til sitt bruk.

C. Faserapport Construction

Faserapport Construction

Versjon 1

Versjon	Dato	Endringer	Status	Ansvarlig
1	09.05.2015	Generell formatering	Dokument ferdigstilt	Henrik Lind

Navn	Signaturer
Bjørnar D. Døviken	
Henrik Lind	
Olav Parken	
Alexander Araya	

Innledning

Dette dokumentet er laget for å ivareta tanker og erfaringer i forbindelse med prosjektets fremdrift slik at vesentlige detaljer ikke blir glemt. Alle faserapportene vil danne grunnlag for vår oppsummering av hva vi har erfart, og vårt forbedringspotensial for et tilsvarende prosjekt. Dokumentet tar for seg utfordringene vi har møtt, hvordan vi løste de og hva vi har erfart både positivt og negativt i forhold til måten vi har arbeidet på.

Construction er den tredje fasen i Unified Process modellen. Denne fasen er delt i 5 iterasjoner. I disse fasene skjer en flytende overgang mellom detaljdesign og konstruksjon/montering. I starten er det mye design mens det mot slutten vil bli mye testing og produksjon av brukermanualer med tilstøtende dokumenter.

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Forkortelser og Ordforklaringer

Forkortelse	Forklaringer
PTW	Portable Tube Washer
FMC	FMC Technologies

1 Utfordringer

1.1 Endringer i dokumenter og krav

I ethvert prosjekt, og ved enhver gjennomgang av dokumenter, skjer det endringer: Ved gjennomgang av kravdokumentet endres krav litt, som gir ringvirkninger til testspesifikasjonen osv.

I Elaboration-fasen startet vi med flere konseptskjemaer for å kunne velge et konsept. I Construction-fasen ble skjemaene videreutviklet til P&I-diagram, og etter mange endringer og forbedringer så dette bra ut. Vi oppdaget at en ventil vi hadde satt inn i diagrammet så tidlig som i konseptutvelgelsen fortsatt var med i diagrammet. Dette lagde misforståelser i senere tid, og slike fallgruver har vi oppdaget flere av.

Vårt felles arbeid med dokumenter, og at alle er med i minst én gjennomgang av disse, har vist at vi fanger opp de fleste slike «ringvirkninger». Det er av stor nødvendighet å ha detaljkontroll på alle dokumenter og hvilke dokumenter som kobles til hverandre.

1.2 Risikoanalyser

Vi gjorde tidlig i prosjektet en omfattende jobb med å definere risikoområder og gjøre veloverveide analyser av disse. Dette grundige arbeidet har vi hatt stor nytte av i ettertid, da flere av våre antagelser har inntruffet. Vi har hatt indre konflikter i gruppen, midlene til innkjøp og bygging av maskinen ble stoppet, endringer i krav og nye ønsker fra oppdragsgiver kom inn så sent som i siste del av construction-fasen m.fl. Vi håndterte hendelsene slik som vi beskrev i mottiltak i risikoanalysene, og dette fungerte meget godt.

Vårt grundige arbeid var vel anvendt tid, og våre analyser med mottiltak var godt utarbeidet. Dette er absolutt noe å ta med seg videre i nye prosjekter.

1.3 Ferdigstilling av dokumenter

Vi så for oss å kunne ferdigstille mange av de dokumentene vi startet på tidlig i denne fasen.

Ferdigstilling av disse dokumentene viste seg å ta mye lengre tid enn først antatt, mye på grunn av at vi ønsker å få et helhetlig og godt resultat som vi som gruppe kunne stå inne for. Kryssreferanser og henvisninger mellom dokumentene kommer inn her: Det genererer mye arbeid og kontroll da en liten endring i ett dokument gir ringvirkninger inn i flere andre dokumenter.

1.4 Kartlegging av komponenter

I Construction-fasen er det fokus på å finne komponenter til bruk i produktet.

Vi kartla tidlig hvilke funksjoner som komponentene måtte inneha, og leverte en liste med disse spesifikasjonene til innkjøpsavdelingen hos FMC. Innkjøpsavdelingen der fant frem til noen av sine godkjente leverandører og kom med deres forslag og priser. Vi syntes prisene var forholdsvis høye i forhold til de enkle søkene vi selv hadde gjort. Etter dette hadde vi budsjettmøte med oppdragsgiver, og byggingen av produktet ble terminert grunnet økonomi. Vi ble da fristilt i forhold til valg av leverandør, og kunne gå tyngre ut i søken etter komponenter. Dette søkearbeidet har vært tidkrevende, men har gitt gode resultater. Det ble benyttet både tlf og mail i tillegg til internett i dette arbeidet. Kunnskapen som vi tilegnet oss i forhold til dette var veldig nyttig i videre arbeid.

Prisene som gruppen fikk ved direkte kontakt med de ulike leverandørene var vesentlig lavere enn de som FMC fikk. I tillegg fikk vi mye hjelp til å finne helt spesifikke komponenter som passet til vårt formål og gjorde det totale produktet mindre komplekst. Vi oppdaget også at en del komponenter ikke fantes på lager i Norge, og hadde forholdsvis lang leveringstid (som forventet).

1.5 Endrede forutsetninger

Vi forutså at det kunne komme endringer både i forhold til krav, ønsker og ikke minst i forhold til et budsjett som vi tidlig gjorde FMC oppmerksom på at var urealistisk lavt.

Vi fikk rett. Endringen kom i tur og orden, først i forhold til PLC, så i forhold til krav som vi utarbeidet med grunnlag i visjonsdokumentet. Videre kom det opp ønsker om flere/andre funksjoner før det til slutt endte med at den praktiske delen av byggingen stoppet på bakgrunn av økonomi. I det store og hele har det kommet mange større og mindre endringer i forutsetningene for prosjektet. Noen av de har vi hensyntatt, mens andre har vært av slikt omfang og kommet inn så sent at de blir notert som endringspotensiale/forbedringer ved en senere anledning. De som blir avvist er begrunnet med omfanget endringen har og tidskjemaet som gruppen har i forhold til oppgaven.

Vi kan her, igjen, vise til det gode arbeidet vi gjorde med risikoanalysene, og de handlingsmønstrene vi la opp til der. Disse forberedte oss for slike hendelser og vi hadde der laget klare føringer for håndteringen av disse hendelsene.

2 Sammendrag

Et av de gjennomgående punktene i denne delen av prosjektet er nytten av gode risikoanalyser og godt planlagte aksjoner hvis en av analysenes innvirkninger oppstår.

Det samme er beregning av tid: Planlegging og estimering av tidsforbruk er meget vanskelig og utrolig viktig. Vi har klart å holde oss innenfor våre planlagte milepeler hele veien, noe som skylles god innsats og målrettet jobbing i gruppa. Men vi ser at tidsaspektet fort kan skape problemer hvis ikke det er gjort en god jobb i planlegging og man ikke er lojal mot planverket. Man må også være åpen med resten av gruppa i forhold til sin egen kapasitet slik at alle kan bidra dersom etterslep oppstår.

Design

This chapter includes documents and tools created to form the very foundation of the product design. Appended are:

D1. Requirement Specification

A vital document concisely listing requirements derived from FMC's needs.

D2. Requirement Matrix

Closely linked to the requirement specification, this matrix shows which of the project group's derived requirements fulfill which of FMC's key requirements.

D3. Stakeholders

A short overview of the PTW project's active and passive stakeholders.

D4. Flowcharts (Use Cases)

Charts made by the project group to discover additional requirements and needed funtionality.

D5. Product Breakdown Structure

A tool used to visualize and structurize system components.

D1. Requirement Specification

Portable Tube Washer Project 2015\Appendices\2. Design\D1. Requirement Specification

Requirement Specification

Version 3

Version	Date	Changes	Status	Responsible
1	01.02.2015	This is the first version created.		Alexander Araya
2	18.03.2015	Updated document for the second presentation.	The document will be updated with minor adjustments to v3.	Alexander Araya
3	13.05.2015	Formatting and minor changes.	Ready for final delivery	Henrik Lind

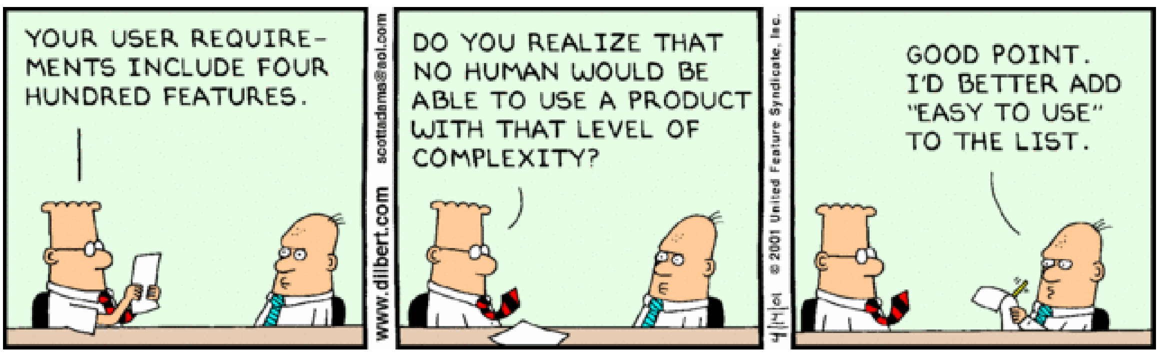
Name	Signatures
Bjørnar D. Døviken	
Henrik Lind	
Olav Parken	
Alexander Araya	

Introduction

This document exists to capture the needs of the customer and the requirements of the product. It defines the product and guarantees that the end product delivered to the customer is up to their expectations.

The document is designed to allow the project group to understand what the product should do and how it should work. It is formed in such a way that it is clearly and unambiguously defining the requirements. It defines the problems that the product must solve and it avoids defining the technical solution to those problems.

Every single requirement is generated from the FMC Vision Document (see appendix A, page 251) and/or meetings with FMC Technologies. Unambiguous requirements found in the vision document are signed with FMC as authors; however, requirements that had to be redefined by one of the group members have been signed with the name of the respective student.



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Glossary and Acronyms

Name	Description
C	Component
SS	Sub-System
S	System
TBL	To be Decided Later
PTW	Portable Tube Washer
JC	Jet Cleaner
WH	Water Heater
HMI	Human Machine Interface
PLC	Programmable Logic Controller
FMC	FMC Technologies

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1 Product Scope

The product will comprise one unit used for washing tubes prior to installation. The tube washer first and foremost is to be used for normal cleaning and preparation after bending and cutting. Serviceability and a modular design are two important key features. It should also have an edge compared to already existing manufactured systems. Plug cleaning capabilities after normal washing routine, and a safety system not allowing a new start until the cleaning plug routine has been run. Use of well-known manufacturers is a requirement for easy support after closure of this student project.

2 Applicable Documents

2.1 Order of Precedence

In the event of conflict between proposed requirements, the order of precedence is:

1. Industry Standards
2. Specification for tube washer project FMC Technologies, 2014
3. Referenced FMC documents

2.2 Documents

The documentation provided by FMC shall be used for references with regards to HSE and minimum required cleaning processes. Documents listed in the following sections are:

1. Applicable Industry Standard(s)

Document Number	Description
2006/42/EØS	Machinery directive

2. Applicable FMC Document(s)

Document Number	Description
FMC Vision Document	Specification for tube washer project FMC Technologies, 2014.

3. Applicable Referenced FMC Document(s)

Document Number	Description
Key Requirements from FMC	Requirements from FMC Technologies that will be used for assessment of the project.
PRD-0000025424	Miscellaneous procedure, washing procedure for internal tube washer.
SWI20021727	Standardized work instruction, subsea-completion & workover, global, tube washing.

Table 6 - Applicable Documents

3 Requirements

3.1 Key Requirements from FMC

Number	Requirement
1	Software (PLC) should be from a reputed supplier with the possibility of service and support.
2	It should be easy to do maintenance on all critical components. It implies that all components requiring maintenance shall be with simple steps removed, replaced or serviced.
3	The finished product should be possible to move with ease between different locations. It is desirable that all connections are made in such a way that it does not require major changes to connect to the workshop infrastructure.
4	HSE-construction shall have all the necessary components and systems ensuring safe operation. By incorrect use or error the system shall go into Safe Mode, where pressure is bled off and there are no pressurized parts, as this may cause splashes of hazardous substances.
5	When emptying the system reservoirs (service interval), easy drainage of the fluids into containers should be possible for safe handling of hazardous waste.
6	The washing Routine shall comply according to PRD-000025424.

Table 7 - Key Requirements

3.2 *How to Read the Requirements*

3.2.1 Identifying a Requirement

Each requirement has a unique ID#. That means if a requirement has expired, the ID# of that requirement will not be re-used; instead any new requirements will get a new ID#.

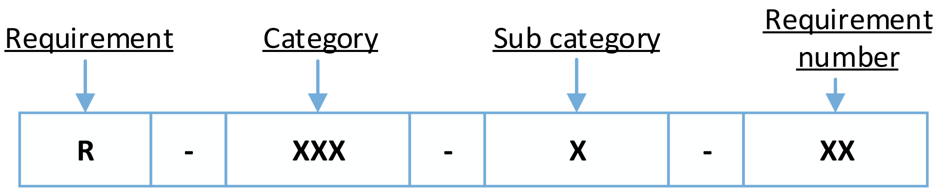

Figure 4 - Requirement ID#

NOTE:

- **Black color on requirement ID# means that this requirement is still <u>VALID.</u>**
- **Red color on requirement ID# means that this requirements has <u>EXPIRED.</u>**

Below is a description of each section of the requirement table.

Identification	
Requirement ID#	Unique requirement ID number
Requirement name	Name of requirement
Requirement description	The definition of the requirement
Category	The group the requirement underlies
Cross-reference	
UseCase Flowchart#	Reference to UseCase Flowchart ID number
Test ID#	Test ID number from test specification
Information	
Author	Name of person who defined the requirement
Date	When the requirement was defined
Type	If the requirement is: Functional or Non-Functional
Priority	**A** = Shall be implemented in the design **B** = May be implemented in the design **C** = Will be implemented in the design only if there is time to spare
Status	Status of the requirement after testing
Comments	Any extra information can be added here

Table 8 - Description of a requirement

3.2.2 Safe Mode and Fail Safe

Here is a representation of Safe Mode and which sensor values may be triggering it. It also points out the differences between Safe Mode and Fail Safe.

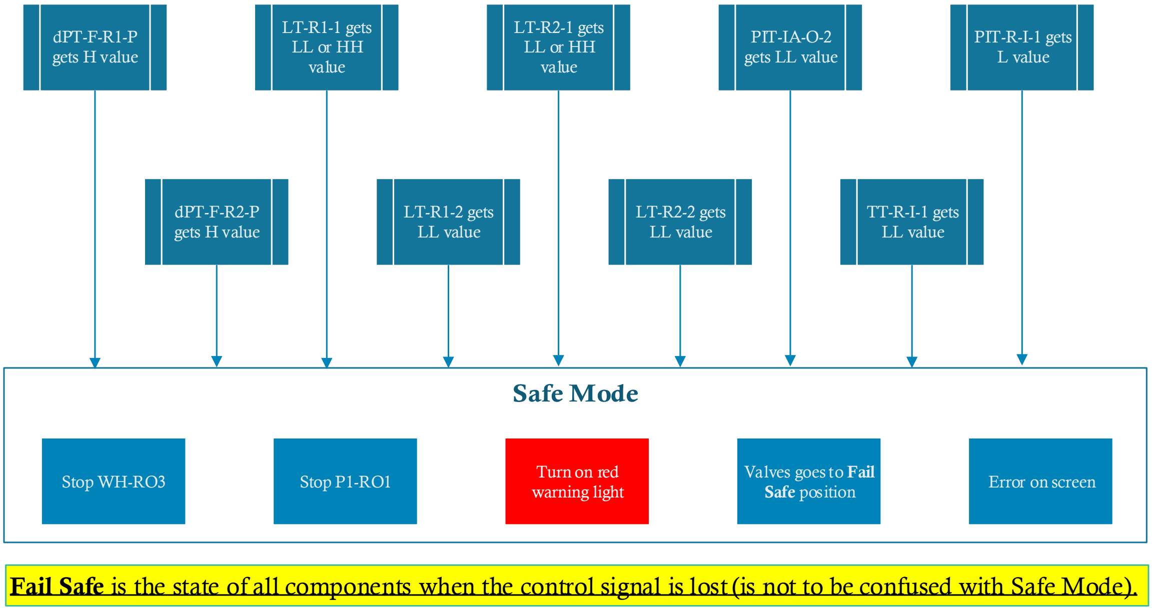

Figure 5 - Safe Mode & Fail Safe

3.3 Capabilities

Identification	
Requirement ID#	R-CAP-A-01
Requirement name	Automatic mixing soap in water
Requirement description	The process of filling the reservoir and mixing the soap with the water shall be automated.
Category	Automatic Capability
Cross-reference	
UseCase Flowchart#	
Test ID#	T-CAP-A-01
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 1 - Automatic mixing soap in water

Identification	
Requirement ID#	R-CAP-A-02
Requirement name	Adjustable soap mixing ratio
Requirement description	The mixing ratio of soap with water shall be adjustable. The mixing ratio must not differ more than +/- 10%.
Category	Automatic Capability
Cross-reference	
UseCase Flowchart#	
Test ID#	Component test list (T-CAP-A-02)
Information	
Author	Olav Parken
Date	12.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 2 - Adjustable soap mixing ratio

Identification	
Requirement ID#	R-CAP-A-03
Requirement name	Only automatic washing operation
Requirement description	The washing cycle shall be fully automated.
Category	Automatic Capability
Cross-reference	
UseCase Flowchart#	2.2
Test ID#	T-CAP-A-03
Information	
Author	Alexander Araya
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	Exception: Jet Clean

Requirement Table 3 - Only automatic washing operation

Identification	
Requirement ID#	R-CAP-A-04
Requirement name	Adjustable temperature
Requirement description	The washing temperature shall be adjustable.
Category	Automatic Capability
Cross-reference	
UseCase Flowchart#	
Test ID#	Component test list
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 4 - Adjustable temperature

Identification	
Requirement ID#	R-CAP-A-05
Requirement name	Jet Clean
Requirement description	After a successful washing cycle, the PTW shall get a confirmation from the plug shooting system, before allowing a new washing cycle to start.
Category	Automatic Capability
Cross-reference	
UseCase Flowchart#	2.2
Test ID#	T-CAP-A-05
Information	
Author	FMC
Date	06.02.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 5 - Jet Clean

Identification	
Requirement ID#	R-CAP-A-06
Requirement name	Washing cycle temperature
Requirement description	The PTW shall deliver water from +55°C and above.
Category	Automatic Capability
Cross-reference	
UseCase Flowchart#	
Test ID#	T-CAP-A-06
Information	
Author	FMC
Date	06.11.14
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 6 - Washing cycle temperature

Identification	
Requirement ID#	R-CAP-D-01
Requirement name	Hose length
Requirement description	The PTW washing hoses shall be able to handle tube length variations from 100 mm to 6000 mm.
Category	Design Capability
Cross-reference	
UseCase Flowchart#	2.1
Test ID#	T-CAP-D-01
Information	
Author	FMC
Date	06.11.14
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 7 - Hose length

Identification	
Requirement ID#	R-CAP-D-02
Requirement name	Tube fixture capacity
Requirement description	The tube fixture shall be able to handle minimum 2 tubes simultaneously.
Category	Design Capability
Cross-reference	
UseCase Flowchart#	2.1
Test ID#	T-CAP-D-02
Information	
Author	FMC
Date	06.11.14
Type	Functional
Priority	C
Status	
Comments	

Requirement Table 8 - Tube fixture capacity

Identification	
Requirement ID#	R-CAP-P-01
Requirement name	Maximum cycle time
Requirement description	The maximum time to run one complete washing cycle is 3,5 minutes.
Category	Performance Capability
Cross-reference	
UseCase Flowchart#	2.2
Test ID#	T-CAP-P-01
Information	
Author	Alexander Araya
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 9 - Maximum cycle time

Identification	
Requirement ID#	R-CAP-P-03
Requirement name	Dried air
Requirement description	All inlet air shall be dried before used in the tubes.
Category	Performance Capability
Cross-reference	
UseCase Flowchart#	
Test ID#	Component test list
Information	
Author	FMC
Date	06.11.14
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 10 - Dried air

Identification	
Requirement ID#	R-CAP-P-05
Requirement name	Air particles filtering
Requirement description	The working air shall be filtered for particles larger than 5µ before used in tubes.
Category	Performance Capability
Cross-reference	
UseCase Flowchart#	
Test ID#	Component test list
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 11 - Air particles filtering

Identification	
Requirement ID#	R-CAP-P-06
Requirement name	Fluid particles filtering
Requirement description	The working fluids shall be filtered for particles larger than 5µ before entering reservoirs.
Category	Performance Capability
Cross-reference	
UseCase Flowchart#	
Test ID#	Component test list
Information	
Author	Alexander Araya
Date	26.02.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 12 - Fluid particles filtering

3.4 Supply

Identification	
Requirement ID#	R-SUP-01
Requirement name	Power supply
Requirement description	The PTW shall use 400V, 50 Hz as primary electric power input.
Category	Supply
Cross-reference	
UseCase Flowchart#	1.2
Test ID#	T-SUP-01
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 13 - Power supply

Identification	
Requirement ID#	R-SUP-02
Requirement name	Electric connection
Requirement description	The electric connection for the PTW shall follow electrical standards.
Category	Supply
Cross-reference	
UseCase Flowchart#	1.2
Test ID#	T-SUP-02
Information	
Author	FMC
Date	06.11.14
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 14 - Electric connection

Identification	
Requirement ID#	R-SUP-03
Requirement name	Valves power supply
Requirement description	The PTW shall use 24V controlled valves.
Category	Supply
Cross-reference	
UseCase Flowchart#	
Test ID#	Component test list
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 15 - Valves power supply

3.5 Monitoring and Feedback

Identification	
Requirement ID#	R-MAF-01
Requirement name	Signal lights
Requirement description	There shall be a colored lights stack that will indicate the state of the PTW.
Category	Monitoring and Feedback
Cross-reference	
UseCase Flowchart#	4.1
Test ID#	Component test list & T-MAF-01
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 16 - Signal lights

Identification	
Requirement ID#	R-MAF-02
Requirement name	Pressure monitoring
Requirement description	The PLC shall monitor the system pressure.
Category	Monitoring and Feedback
Cross-reference	
UseCase Flowchart#	2.2
Test ID#	Component test list & T-MAF-02
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 17 - Pressure monitoring

Identification	
Requirement ID#	R-MAF-04
Requirement name	Washing cycle temperature monitoring
Requirement description	The system shall monitor the washing cycle temperature.
Category	Monitoring and Feedback
Cross-reference	
UseCase Flowchart#	
Test ID#	Component test list & T-MAF-04
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 18 - Washing cycle temperature monitoring

Identification	
Requirement ID#	R-MAF-05
Requirement name	Liquid level monitoring
Requirement description	The system shall monitor fluid levels (water, soap mix and soap canister).
Category	Monitoring and Feedback
Cross-reference	
UseCase Flowchart#	
Test ID#	Component test list & T-MAF-06
Information	
Author	Olav Parken
Date	25.03.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 19 - Liquid level monitoring

3.6 Interfaces

Identification	
Requirement ID#	R-INT-E-01
Requirement name	Inlet water connection
Requirement description	Inlet water hose shall be connected to the infrastructure without tools.
Category	External Interfaces
Cross-reference	
UseCase Flowchart#	
Test ID#	Component test list
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 20 - Inlet water connection

Identification	
Requirement ID#	R-INT-E-02
Requirement name	Air connection
Requirement description	Inlet air hose shall be connected to the infrastructure without tools.
Category	External Interfaces
Cross-reference	
UseCase Flowchart#	
Test ID#	Component test list
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 21 - Air connection

Identification	
Requirement ID#	R-INT-E-04
Requirement name	Tube fixture
Requirement description	The tube fixture clamp shall not compromise the quality (scratches) of the tube.
Category	External Interface
Cross-reference	
UseCase Flowchart#	2.1
Test ID#	T-INT-E-04
Information	
Author	Alexander Araya
Date	13.01.15
Type	Functional
Priority	C
Status	
Comments	

Requirement Table 22 - Tube fixture

Identification	
Requirement ID#	R-INT-I-01
Requirement name	Internal fittings in the PTW
Requirement description	The internal pipe fittings shall use A-lock from PARKER AS.
Category	Internal Interface
Cross-reference	
UseCase Flowchart#	
Test ID#	Component test list
Information	
Author	FMC
Date	26.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 23 - Internal fittings in the PTW

Identification	
Requirement ID#	R-INT-U-01
Requirement name	HMI
Requirement description	HMI shall be easy to read and user friendly.
Category	User Interface
Cross-reference	
UseCase Flowchart#	
Test ID#	Component test list
Information	
Author	FMC
Date	06.11.14
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 24 - HMI

Identification	
Requirement ID#	R-INT-U-02
Requirement name	Location of buttons and HMI
Requirement description	The operational buttons and HMI shall all be placed on the same side of the cabinet, except emergency stop button(s).
Category	User Interface
Cross-reference	
UseCase Flowchart#	
Test ID#	T-INT-02
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 25 - Location of buttons and HMI

Identification	
Requirement ID#	R-INT-U-03
Requirement name	Emergency stop button
Requirement description	The emergency stop button(s) shall be located within reach of the operator.
Category	User Interface
Cross-reference	
UseCase Flowchart#	
Test ID#	T-INT-U-03
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 26 - Emergency stop button

Identification	
Requirement ID#	R-INT-U-04
Requirement name	Washing hose to tube connection
Requirement description	The washing hose to tube connection shall be possible to connect with the tubes without using tools.
Category	User Interface
Cross-reference	
UseCase Flowchart#	
Test ID#	Component test list
Information	
Author	Alexander Araya
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 27 - Washing hose to tube connection

3.7 Safety

Identification	
Requirement ID#	R-SAF-S-02
Requirement name	Protection of the electrical system
Requirement description	The protection of the electrical system shall meet the standard of Industry Standards (2006/42/EØS) with no less then IP 44.
Category	System Safety
Cross-reference	
UseCase Flowchart#	
Test ID#	T-SAF-S-02
Information	
Author	FMC
Date	30.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 28 - Protection of the electrical system

Identification	
Requirement ID#	R-SAF-S-03
Requirement name	PLC after power loss
Requirement description	The PLC shall remember the last selected program after a power loss.
Category	System Safety
Cross-reference	
UseCase Flowchart#	
Test ID#	Component test list
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 29 - PLC after power loss

Identification	
Requirement ID#	R-SAF-S-04
Requirement name	Monitoring system failure
Requirement description	If a monitored component and/or any of the sensors fails/ is out of range the PTW shall stop any process. (ref. Safe Mode).
Category	System Safety
Cross-reference	
UseCase Flowchart#	4.1
Test ID#	T-SAF-S-04
Information	
Author	Alexander Araya
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 30 - Monitoring system failure

Identification	
Requirement ID#	R-SAF-S-05
Requirement name	Power failure/recovery
Requirement description	In case of loss and recovery of power supply the PTW shall go into Standby Mode.
Category	System Safety
Cross-reference	
UseCase Flowchart#	4.1
Test ID#	T-SAF-S-05
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 31 - Power failure/recovery

Identification	
Requirement ID#	R-SAF-S-06
Requirement name	Emergency stop
Requirement description	Pressing the emergency stop button shall bring the PTW to Safe Mode.
Category	System Safety
Cross-reference	
UseCase Flowchart#	4.1
Test ID#	T-SAF-S-06
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 32 - Emergency stop

Identification	
Requirement ID#	R-SAF-W-01
Requirement name	Vapor pollution
Requirement description	The vapor from the system shall not pollute the workshop environment.
Category	Workshop Environment Safety
Cross-reference	
UseCase Flowchart#	
Test ID#	Component test list
Information	
Author	Alexander Araya
Date	13.01.15
Type	Non-Functional
Priority	A
Status	
Comments	

Requirement Table 33 - Vapor pollution

Identification	
Requirement ID#	R-SAF-W-02
Requirement name	Noise levels
Requirement description	Noise levels shall follow Industrial Standards (2006/42/EØS).
Category	Workshop Environment Safety
Cross-reference	
UseCase Flowchart#	
Test ID#	T-SAF-W-02
Information	
Author	FMC
Date	06.11.14
Type	Non-Functional
Priority	A
Status	
Comments	

Requirement Table 34 - Noise levels

Identification	
Requirement ID#	R-SAF-U-01
Requirement name	Hot surfaces
Requirement description	All external reachable surfaces of the PTW, shall not exceed a temperature higher than 45°C while running. Tubes and pipes for cleaning are excluded from this requirement.
Category	User Safety
Cross-reference	
UseCase Flowchart#	
Test ID#	T-SAF-U-01
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 35 - Hot surfaces

Identification	
Requirement ID#	R-SAF-U-02
Requirement name	Antistatic hoses
Requirement description	All hoses of rubber material shall be of antistatic type.
Category	User Safety
Cross-reference	
UseCase Flowchart#	
Test ID#	Component test list
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 36 - Antistatic hoses

Identification	
Requirement ID#	R-SAF-U-03
Requirement name	Pressurized interfaces
Requirement description	The PTW shall have no leakage at 10 bar pressure of air between any pressurized interfaces.
Category	User Safety
Cross-reference	
UseCase Flowchart#	
Test ID#	T-SAF-U-03
Information	
Author	FMC
Date	06.11.14
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 37 - Pressurized interfaces

Identification	
Requirement ID#	R-SAF-U-05
Requirement name	Condition for start of cycle
Requirement description	The washing cycle shall not start if the pressure self-test fails.
Category	User Safety
Cross-reference	
UseCase Flowchart#	2.2
Test ID#	T-SAF-U-05
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 38 - Condition for start of cycle

Identification	
Requirement ID#	R-SAF-U-06
Requirement name	Personal protective equipment
Requirement description	The operator shall use personal protective equipment against chemicals and hot surfaces.
Category	User Safety
Cross-reference	
UseCase Flowchart#	
Test ID#	T-SAF-U-06 (test expired)
Information	
Author	Olav Parken
Date	13.01.15
Type	Non-Functional
Priority	A
Status	
Comments	

Requirement Table 39 - Personal protective equipment

3.8 Design

Identification	
Requirement ID#	R-DES-01
Requirement name	Interchangeability
Requirement description	All parts in the PTW shall be of normal supply standards.
Category	Modular Design
Cross-reference	
UseCase Flowchart#	
Test ID#	T-DES-01
Information	
Author	FMC
Date	06.11.14
Type	Non-Functional
Priority	A
Status	
Comments	Support and service is as important as price and quality.

Requirement Table 40 - Interchangeability

Identification	
Requirement ID#	R-DES-02
Requirement name	Modular construction
Requirement description	The design shall be made in such a way that everything is placed into the construction for accessibility, when need of repairs or maintenance.
Category	Modular Design
Cross-reference	
UseCase Flowchart#	
Test ID#	T-DES-02
Information	
Author	FMC
Date	06.11.14
Type	Non-Functional
Priority	A
Status	
Comments	Support and service is as important as price and quality.

Requirement Table 41 - Modular construction

Identification	
Requirement ID#	R-DES-04
Requirement name	PLC distributor
Requirement description	PLC-control system shall be provided by a supplier approved by FMC.
Category	Modular Design
Cross-reference	
UseCase Flowchart#	
Test ID#	T-DES-04
Information	
Author	FMC
Date	02.02.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 42 - PLC distributor

3.9 Transportation and Storage

Identification	
Requirement ID#	R-TAS-T-01
Requirement name	PTW mobility
Requirement description	The PTW shall be possible to move by one person.
Category	Transport
Cross-reference	
UseCase Flowchart#	
Test ID#	T-TAS-T-01
Information	
Author	FMC
Date	06.11.14
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 43 - PTW mobility

Identification	
Requirement ID#	R-TAS-T-02
Requirement name	Hookup points for secure transportation
Requirement description	The hookup points on the PTW shall withstand the load capacity described in rules and regulations for road transportation.
Category	Transport
Cross-reference	
UseCase Flowchart#	
Test ID#	T-TAS-T-02
Information	
Author	FMC
Date	06.11.14
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 44 - Hookup points for secure transportation

Identification	
Requirement ID#	R-TAS-T-03
Requirement name	Fork pockets
Requirement description	The fork pockets at the bottom of the PTW shall be possible to enter from all sides.
Category	Transport
Cross-reference	
UseCase Flowchart#	1.1
Test ID#	T-TAS-T-03
Information	
Author	FMC
Date	06.11.14
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 45 - Fork pockets

Identification	
Requirement ID#	R-TAS-S-01
Requirement name	Drainage of fluids
Requirement description	It shall be possible to drain all remaining fluids in the system.
Category	Storage
Cross-reference	
UseCase Flowchart#	1.1
Test ID#	T-TAS-S-01
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 46 - Drainage of fluids

Identification	
Requirement ID#	R-TAS-S-03
Requirement name	Blinding caps
Requirement description	The PTW shall have blinding caps that will fit the inlet couplings.
Category	Storage
Cross-reference	
UseCase Flowchart#	
Test ID#	Component test list
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 47 - Blinding caps

3.10 Instructional

Identification	
Requirement ID#	R-INS-02
Requirement name	Maintenance manual
Requirement description	The maintenance manual shall be complete with all content FMC requires and is approved by them.
Category	Instructional
Cross-reference	
UseCase Flowchart#	
Test ID#	T-INS-02
Information	
Author	Alexander Araya
Date	13.01.15
Type	Non-Functional
Priority	A
Status	
Comments	

Requirement Table 48 - Maintenance manual

Identification	
Requirement ID#	R-INS-03
Requirement name	Component marking
Requirement description	All components such as valves, pumps and filters shall be marked for later references.
Category	Instructional
Cross-reference	
UseCase Flowchart#	
Test ID#	Component test list
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	B
Status	
Comments	

Requirement Table 49 - Component marking

Identification	
Requirement ID#	R-INS-04
Requirement name	User manual
Requirement description	The user manual shall be complete with all content FMC requires and is approved by them.
Category	Instructional
Cross-reference	
UseCase Flowchart#	
Test ID#	T-INS-04
Information	
Author	Alexander Araya
Date	13.01.15
Type	Non-Functional
Priority	A
Status	
Comments	

Requirement Table 50 - User manual

Identification	
Requirement ID#	R-INS-05
Requirement name	Warning stickers
Requirement description	Stickers must be in accordance with regulations and standards.
Category	Instructional
Cross-reference	
UseCase Flowchart#	
Test ID#	T-INS-05
Information	
Author	Alexander Araya
Date	13.01.15
Type	Non-Functional
Priority	A
Status	
Comments	

Requirement Table 51 - Warning stickers

3.11 *Upgrades*

Identification	
Requirement ID#	R-UPG-01
Requirement name	Software upgrades
Requirement description	The PTW shall have possibility for software expansion and upgrade.
Category	Upgrades
Cross-reference	
UseCase Flowchart#	
Test ID#	Component test list
Information	
Author	Alexander Araya
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 52 - Software upgrades

Identification	
Requirement ID#	R-UPG-02
Requirement name	Hardware upgrade
Requirement description	The PTW shall have the possibility for hardware expansion and upgrades.
Category	
Cross-reference	
UseCase Flowchart#	
Test ID#	Component test list
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 53 - Hardware upgrade

3.12 *Physical Boundaries*

Identification	
Requirement ID#	R-PHY-01
Requirement name	Max size of system
Requirement description	The size of the PTW shall not lead to extraordinary transportation requirements (max $2{,}4 * 1{,}2 * 2{,}0$ meters).
Category	Physical Boundary
Cross-reference	
UseCase Flowchart#	1.1
Test ID#	T-PHY-01
Information	
Author	Olav Parken
Date	13.01.15
Type	Non-Functional
Priority	A
Status	
Comments	

Requirement Table 54 - Max size of system

Identification	
Requirement ID#	R-PHY-02
Requirement name	Fixed place for soap canister
Requirement description	The soap canister shall have a fixed place in the PTW.
Category	Physical Boundary
Cross-reference	
UseCase Flowchart#	3.1
Test ID#	T-PHY-02
Information	
Author	Olav Parken
Date	13.01.15
Type	Non-Functional
Priority	A
Status	
Comments	

Requirement Table 55 - Fixed place for soap canister

Identification	
Requirement ID#	R-PHY-05
Requirement name	Tube fixture incline
Requirement description	The tube fixture should provide an incline to aid water in stream direction.
Category	Physical Boundary
Cross-reference	
UseCase Flowchart#	2.1
Test ID#	T-PHY-05
Information	
Author	FMC
Date	06.11.15
Type	Functional
Priority	C
Status	
Comments	Earlier A-requirement

Requirement Table 56 - Tube fixture incline

3.13 Documentation

Identification	
Requirement ID#	R-DOC-01
Requirement name	Documentation language
Requirement description	The following documentation shall be in English: • Requirements Specification • Project Plan • Test plan & specification • Technology document • Manuals • Production documentation • Final report
Category	Documentation
Cross-reference	
UseCase Flowchart#	
Test ID#	T-DOC-01
Information	
Author	FMC
Date	06.11.14
Type	Non-Functional
Priority	A
Status	
Comments	

Requirement Table 57 - Documentation language

Identification	
Requirement ID#	R-DOC-02
Requirement name	3D-models file format
Requirement description	The 3D-models shall be delivered in step AP214 file format.
Category	Documentation
Cross-reference	
UseCase Flowchart#	
Test ID#	T-DOC-02
Information	
Author	FMC
Date	26.01.15
Type	Non-Functional
Priority	A
Status	
Comments	

Requirement Table 58 - 3D-models file format

Identification	
Requirement ID#	R-DOC-03
Requirement name	2D-drawings file format
Requirement description	All 2D-drawings shall be in DWG-format.
Category	Documentation
Cross-reference	
UseCase Flowchart#	
Test ID#	T-DOC-03
Information	
Author	Bjørnar Døviken
Date	25.02.15
Type	Non-functional
Priority	A
Status	
Comments	

Requirement Table 59 - 2D-drawings

3.14 Expired Requirements

Identification	
Requirement ID#	R-CAP-D-03
Requirement name	Efficiency
Requirement description	The washer shall have an efficiency rate of XXX%, measured by the actual number of items cleaned during a test day, divided by the number of items specified to be washed per day.
Category	Design Capability
Cross-reference	
UseCase Flowchart#	
Test ID#	
Information	
Author	Alexander Araya
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 60 - Efficiency

Identification	
Requirement ID#	R-CAP-P-02
Requirement name	Improved performance
Requirement description	Time saving on cycle should be in the range of 30-65% improvement, compared to existing cycle time.
Category	Performance Capability
Cross-reference	
UseCase Flowchart#	
Test ID#	
Information	
Author	FMC
Date	06.11.14
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 61 - Improved performance

Identification	
Requirement ID#	R-CAP-P-04
Requirement name	Air humidity
Requirement description	The working air shall have no higher humidity than in already existing machine.
Category	Performance Capability
Cross-reference	
UseCase Flowchart#	
Test ID#	
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	Covered by R-CAP-P-03

Requirement Table 62 - Air humidity

Identification	
Requirement ID#	R-MAF-03
Requirement name	Critical level in soap canister
Requirement description	When the level in the soap canister is critically low the user shall be alerted.
Category	Monitoring and Feedback
Cross-reference	
UseCase Flowchart#	
Test ID#	
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	Covered by R-MAF-02

Requirement Table 63 - Critical level in soap canister

Identification	
Requirement ID#	R-INT-E-03
Requirement name	Draining contaminated fluids
Requirement description	The PTW shall have the possibility to drain the contaminated fluids from the reservoirs.
Category	External Interfaces
Cross-reference	
UseCase Flowchart#	
Test ID#	
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	Covered by R-TAS-S-01

Requirement Table 64 - Draining contaminated fluids

Identification	
Requirement ID#	R-SAF-S-01
Requirement name	Allowing start of washing cycle
Requirement description	The washing cycle shall only start after the operator has loaded the tubes to be washed, selected the predetermined wash cycle for the load and pressed the Start button.
Category	System Safety
Cross-reference	
UseCase Flowchart#	
Test ID#	
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 65 - Allowing start of washing cycle

Identification	
Requirement ID#	R-SAF-S-07
Requirement name	Not start when lack of non-power supply
Requirement description	The PTW shall not start its washing cycle process if there is lack of a non-power supply in the system
Category	System Safety
Cross-reference	
UseCase Flowchart#	
Test ID#	
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	Covered by R-MAF-02

Requirement Table 66 - Not start when lack of non-power supply

Identification	
Requirement ID#	R-SAF-E-01
Requirement name	Contaminated fluids
Requirement description	Disposal of contaminated fluids from the reservoirs shall be handled after FMC regulations.
Category	Environment Safety
Cross-reference	
UseCase Flowchart#	
Test ID#	
Information	
Author	FMC
Date	27.01.15
Type	Non-funtional
Priority	A
Status	
Comments	

Requirement Table 67 - Contaminated fluids

Identification	
Requirement ID#	R-SAF-E-02
Requirement name	Contaminated fluids
Requirement description	Disposal of contaminated fluids are to be addressed by filtering.
Category	Environment Safety
Cross-reference	
UseCase Flowchart#	
Test ID#	
Information	
Author	FMC
Date	06.11.14
Type	Non-functional
Priority	A
Status	
Comments	Covered by R-SAF-E-01

Requirement Table 68 - Contaminated fluids

Identification	
Requirement ID#	R-SAF-W-03
Requirement name	Plug receiver and noise peak
Requirement description	The PTW shall have a plug receiver with noise protection. 1(one) plug shot shall not make louder noise then 130Db on peak.
Category	Workshop Environment Safety
Cross-reference	
UseCase Flowchart#	
Test ID#	
Information	
Author	Olav Parken
Date	13.01.15
Type	Non-Functional
Priority	A
Status	
Comments	Covered by R-SAF-W-02

Requirement Table 69 - Plug receiver and noise peak

Identification	
Requirement ID#	R-SAF-W-04
Requirement name	Noise level during washing cycle
Requirement description	The PTW shall not make louder noise then 80 Db when running a cycle.
Category	Workshop Environment Safety
Cross-reference	
UseCase Flowchart#	
Test ID#	
Information	
Author	Olav Parken
Date	13.01.15
Type	Non-Functional
Priority	A
Status	
Comments	Covered by R-SAF-W-02

Requirement Table 70 - Noise level during washing cycle

Identification	
Requirement ID#	R-SAF-U-04
Requirement name	Water pressure leakage
Requirement description	The connection washing hose to tube shall have no leakage on 12 bar pressure of water.
Category	User Safety
Cross-reference	
UseCase Flowchart#	
Test ID#	
Information	
Author	FMC
Date	06.11.14
Type	Functional
Priority	A
Status	
Comments	Covered by R-SAF-U-03

Requirement Table 71 - Water pressure leakage

Identification	
Requirement ID#	R-DES-03
Requirement name	PLC distributor
Requirement description	PLC-control system shall be provided by Siemens.
Category	Modular Design
Cross-reference	
UseCase Flowchart#	
Test ID#	
Information	
Author	FMC
Date	06.11.14
Type	Functional
Priority	A
Status	
Comments	

Requirement Table 72 - PLC distributor

Identification	
Requirement ID#	R-TAS-S-02
Requirement name	Manual drainage of air
Requirement description	The PTW shall have valves for manual drainage of compressed air.
Category	Storage
Cross-reference	
UseCase Flowchart#	
Test ID#	
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	Covered by R-TAS-S-01

Requirement Table 73 - Manual drainage of air

Identification	
Requirement ID#	R-INS-01
Requirement name	Scheduled maintenance
Requirement description	Scheduled maintenance shall be able to be performed in under 1 hour.
Category	Instructional
Cross-reference	
UseCase Flowchart#	
Test ID#	
Information	
Author	Henrik Lind
Date	13.01.15
Type	Non-Functional
Priority	A
Status	
Comments	

Requirement Table 74 - Scheduled maintenance

Identification	
Requirement ID#	R-PHY-03
Requirement name	Cleaning the soap canister area
Requirement description	The area for soap canister shall be possible to clean without disassembly.
Category	Physical Boundary
Cross-reference	
UseCase Flowchart#	
Test ID#	
Information	
Author	Olav Parken
Date	13.01.15
Type	Functional
Priority	A
Status	
Comments	Covered by R-PHY-02

Requirement Table 75 - Cleaning the soap canister area

Identification	
Requirement ID#	R-PHY-04
Requirement name	Max elevation height of soap canister
Requirement description	The soap canister shall be elevated maximum (50cm) over the workshop floor-level.
Category	Physical Boundary
Cross-reference	
UseCase Flowchart#	
Test ID#	
Information	
Author	Henrik Lind
Date	13.01.15
Type	Non-Funtional
Priority	A
Status	
Comments	Covered by R-PHY-02

Requirement Table 76 - Max elevation height of soap canister

Appendices

A. FMC Vision Document

Specification for tube washer project FMC Technoloies, 2014

Rev	ECN No.	Date	Reviewed By	Approved By	Status
01	NA	04.12.2014	Per Ole Gravningen	Kai Boldevin	preliminary

Summary:

This document is created to ensure we have a clear picture to what FMC expects to be delivered at end of student project "FMC Portable Tube washer 2015". FMC will provide support to the extent expected, and available.

Helge Hjallen

Kongsberg 06.11.2014

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Abbreviations

The following abbreviations are used throughout this procedure.
This table lists ALL ABBREVIATIONS USED in the document with a definition of each.
The list given below contains the abbreviations used in this template / basis document.
NOTE: Always check any new document to ensure a complete list.

Complete the list by sorting the abbreviations alphabetically. An example list of abbreviations is shown below.

Abbreviation	Description
DWG	Drawing
EQ	Equipment Number
HBV	Høyskolen i Buskerud og Vestfold
MWP	Max Working Pressure
N/A	Not Applicable
P/N	Part Number
TST	Test Procedure

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1.0 Scope

This document forms the basis for purchase, detail design and fabrication of the product comprising:

Table 1: *Insert Title*

FMC Part / Material No.	Name / Abbreviation	Location
XXXXXXXX	*Product*	*Shell Mars Platform*

**The table can be sorted automatically by highlighting all of the rows and selecting the 'Sort' function within the 'Paragraph' section of the 'Home' tab.*

1.1 Brief Description of Product

The product is to comprise of one unit used for cleaning tubes prior to installation. The tube washer first and foremost is to be used for normal cleaning and preparation after bending and cutting. Serviceability and a modular design are two important key features. Also it should have an edge compared to already existing manufacturers systems. Plug cleaning capabilities after normal washing routine, and a safety system not allowing a new start until the cleaning plug routine have been run. Use of well-known manufacturers is a required request for easy support after closure of this student project.

1.2 Responsibility

FMC Technologies AS shall provide expert assistance and advices during project. HBV to provide planning, documentation, product cost, actual work and a built product ready for testing.

1.3 Order of Precedence

In the event of conflict between proposed requirements, the order of precedence is:

- Industry standards
- This SPC document
- Referenced FMC documents

1.4 Referenced Documents

The provided documentation from FMC Technologies AS shall be used for references with regards to HSE and minimum required cleaning processes. Documents listed in the following sections are:

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1.4.1 Applicable Industry Standard(s)

Table 2: *Insert Title*

No.	Document Number	Description
/C1/	*2006/42/EØS*	Machinery directive
/C2/		

1.4.2 Applicable FMC Document(s)

Table 3: *Insert Title*

No:	Document Number	Description
/D1/	*SPC Cleaning process*	*FMC provided document*
/D2/	HSE references	FMC specific HSE golden rules minimum requirements

2.0 Requirement(s)

1. Applicable FMC project documentation including design basis documents and analysis, system documentation and sub-system documentation
2. External and internal interface requirements (e.g. Interface Register)

2.1 Functional and Performance Requirements

2.1.1 Capabilities

The equipment shall be designed to perform the requirements listed in this section.

- Easy access to all functions
- User interface to be simple and foul proof.
- Pressure classes for water and compressed air to be met (12 bar water and 12 bar air (Theoretical values))
- Easy to handle and be possible to be moved by one person.

2.1.2 Environmental Condition(s)

Environmental conditions to be evaluated, and disposal of contaminated fluids to be addressed.

2.1.3 Preservation, Storage, Transportability and Logistics

The product shall comply with a given plan for transportation, handling and storage.

2.1.4 Interchangeability

Ease of replacement of components.

2.1.5 Nameplate(s) and Product Marking(s)

FMC Technologies AS will provide nameplate for product, and branding name to be decided by HBV.

2.1.6 Safety

This section shall specify requirements to preclude or limit hazards to the physical environment and to personnel and equipment. To the extent practicable, it shall cite established and recognized standards.

It shall identify those safety characteristics unique to the product which constrain the design due to hazards in assembly, disassembly, test, transport, storage, operation, maintenance or disposal when they are not addressed by standard industrial or service practices.

It shall address "fail-safe" and emergency operating restrictions, when applicable. Where applicable, this paragraph shall also state health and safety criteria, including physical, mechanical, biological and explosive effects. These criteria shall include consideration of the toxicological effect and environmental impact of hazardous materials, waste and by-products; provisions in the software to prevent inadvertent actions or non-actions; gas detection and warning devices; grounding of electrical systems and explosion proofing.

Specify CE (Conformité Européenne) marking if applicable for the country.

Special attention must be taken when use of detergents and hazardous fluids.

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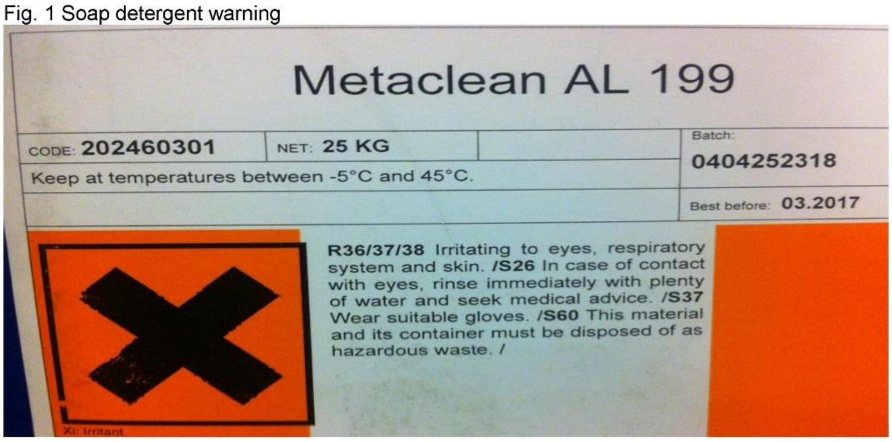
Fig. 1 Soap detergent warning



The machine have to be attached to venting Apparel or be equipped with such due to the fact the detergent used (METACLEAN AL 199) as soap is rated to be irritating to eyes, lungs and skin.(Datasheet)

1. Make Soap dispenser easy to clean/empty.
2. Simple hook up for water and other couplers.
3. If emergency stop, there should be an automatic drain to bleed off any pressure in system. Not present today.
4. Come up with a simple attachment method of tubes.
5. Machine to be equipped with easy filling access to avoid working at heights involving hazardous fluids.

2.1.7 Personnel and Training

Personnel shall be given appropriate training prior to start of use.

2.1.8 Human Factors Engineering

Avoid wrong operation. For example, the supplier shall position valves in a logical sequence to avoid faulty operation.

Design for easy operation.

2.2 Interface Requirement(s)

1. Package shall be modular built
2. Components to be from well-known suppliers(serviceability)
3. Simple / user friendly

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4. 3D models in a neutral format. All models from suppliers shall also be in documentation package when project is delivered / presented.
5. Make a fixture for attaching tubes that provides an incline to aid water i stream direction. This is a challenge today. WISEGRIP is a solution that can be used as a reference.
   Fig. 2 Typical type for stand.

Include both internal and external interface requirements.

2.2.1 Mechanical Interfaces

A requirement for washer is to be able to handle min 2 tubes separately!

2.2.2 Hydraulic Interfaces

2.2.3 Electric / Controls Interfaces

2.3 Design and Fabrication

Package shall be modular built
Components to be from well-known suppliers (serviceability)
Simple / user friendly
Shall not be a copy of already existing products. New thinking
PLS to be delivered from Siemens.
All documentation in english.

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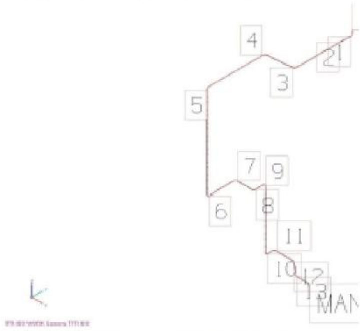
3D models in a neutral format. All models from suppliers shall also be in documentation package when project is delivered / presented.
Time saving on cycle should be in the range of 30-65% improvement.

Fig. 3 Examples of tube lengths. Variations from 100 mm to 6000 mm can occur.

Segment	Y	B	C	Radius
1.	127.018000	0.000000		

Total Developed Length = 127.018000



Segment	Y	B	C
1.	57.284888	0.000000	80.147833
2.	95.214686	-151.951368	41.797708
3.	550.040992	143.943932	90.007080
4.	331.746327	-180.000000	90.007080
5.	687.250002	-94.877664	89.999953
6.	1145.200000	0.000000	90.000047
7.	309.100942	90.000000	90.000000
8.	180.841846	180.000000	90.000000
9.	96.400000	-90.000000	90.000000
10.	718.314000	180.000000	90.000000
11.	60.000000	90.000000	90.000000
12.	212.425421	-6.709837	39.699267
13.	248.482916	180.000000	39.699267
14.	155.252973		

Total Developed Length = 5324.146334

2.4 Computer Resource Requirement(s)

PLS system decided previously. Siemens is favored supplier

2.5 Required Documentation

Typically include:

- General Assembly (GA) drawings
- Hydraulic and Electrical schematics
- Piping and Instrumentation Diagram (P&ID) / Schematics
- Design Review Minutes
- Design Calculations and Analysis

- Failure Mode, Effects and Criticality Analysis (FMECA)
- Part Report / Bill of Material (BOM) and applicable Drawings
- Recommended Spares List
- Preservation, Storage and Maintenance (PSM) Procedure
- Operations and Maintenance Manual (OMM)
- Assembly Procedures
- Applicable Test Procedures (e.g. Extended Factory Acceptance Test (EFAT) etc.)

3.0 Verification

Verification is inspection and control of the product during fabrication (not checking of the end product).

According to NS-EN ISO 9001:

'Verification of product: During the production process, product elements and engineering work shall be verified to ensure that the product will be according to the specification. The verification shall be documented.'

3.1 Method(s) of Verification

Include the methods of verification.

Methods utilized to accomplish verification include:

- Analysis: An element of verification that utilizes established technical or mathematical models or simulations, algorithms, charts, graphs, circuit diagrams or other scientific principles and procedures to provide evidence that stated requirements were met. Analytical methods selected for verification will include documented justification and explanation.
- Demonstration: An element of verification which generally denotes the actual operation, adjustment or re-configuration of items to provide evidence of the functional performance (i.e. serviceability, accessibility or transportability features.) The items may be instrumented and quantitative limits of performance monitored.
- Testing: An element of verification in which requirements are verified by measurement during or after the actual functional use of the equipment. Prior to testing, pass / fail criteria based on functional requirements shall be specified to ensure the actual performance meets or exceeds specifications.

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- Inspection: An element of verification in which the physical characteristics are examined or measured to determine compliance with the requirements and design specifications.

The following table specifies stakeholder and FMC requirements that must be verified during construction of the equipment.

Table 4: Verification of Requirement(s)

Method(s) of Verification						
☐ N/A – Not Applicable ☐ 1 – Analysis ☐ 2 - Demonstration ☐ 3 – Examination ☐ 4 – Test						
Unique Requirement Identifier	**Verification Method**					
	N/A	**1**	**2**	**3**	**4**	**Remarks**
3.1.2				X		
3.1.3.6				X		
3.1.3.15.1					X	

3.2 General Requirement(s)

All testing and inspection of procured parts shall be carried out in accordance with the manufacturer's quality plan, with approval from FMC prior to commencement of the work. Parts manufactured by FMC shall be inspected and tested according to applicable FMC Quality Plan(s) (QP). Any instrumentation used in the tests shall have valid calibration certificates.

The testing performed by the <*sub-system / product*> manufacturer shall include component tests such as flushing, pressure test, cable tests and functional tests.

The results of these tests shall be documented and available for inspection by both FMC and the Customer.

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NOTE

If the component has no relevant field record and is not considered as field proven, the component shall go through a qualifying test. Test procedures shall be written by the supplier and approved by both FMC and the Customer before the test is carried out.

4.0 Validation

Validation or inspection and control of the end product and shall be done according to ISO 9001 to ensure that the end product satisfies the specified user requirements. Validation of the end product shall be performed after an approved verification. Validation is normally performed under normal operational condition.

Validation methods of the <sub-system / product> shall be listed here in regard to EEP or Customer required deliverables. This may include test or qualification procedures.

4.1 Qualification Requirement(s)

FMC to provide simple rules of engagement.

4.2 Pressure Test

FMC to provide minimum requirements.

4.3 Factory Acceptance Test (FAT)

The detailed FAT procedure is to be agreed with the Customer prior to commencement of the FAT, and the test shall be performed by the manufacturer in the presence of the Customer if required.

The FAT shall at least cover the following sections:

- *Leakage test at Maximum Working Pressure (MWP)*
- *Functional Test*
- *Inspection*
- *Final Inspection*

4.3.1 Leakage Test at MWP

There shall be no external fluid leakage at MWP.

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4.3.2 Functional Test

This test shall verify all of the functions of the unit including such items as pump capacities and valve leakage rates. All outputs / inputs shall be verified using test boxes to simulate signals where necessary.

Fluid cleanliness is considered as a function and the results shall be available shortly after sampling, i.e. particle analyzing equipment shall be available on the test site.

4.3.3 Final Inspection

The main activities shall be to verify protective packing, marking, etc. and review of documentation.

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B. Washing Procedure

MISCELLANEOUS PROCEDURE, WASHING PROCDURE FOR INERNAL TUBE WASHER

Rev	ECN No.	Date	Reviewed By	Approved By	Status
A	6011884	26-JAN-2006	Henrichsen, Harald	Lilleland, Svein	RELEASED

Summary:

This document gives a description of the procedure and equipment that is in use by FMC Kongsberg Subsea for cleaning hydraulic tubes and pipes before assembly.

Flushing is not accepted as the only or primary means of cleaning hydraulic parts or components, including tubing systems.

The document is bilingual; English and Norwegian

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Figure 5: End protection. To prevent damage to personnel and to exclude contamination 8

Abbreviations

The following abbreviations are used throughout this procedure.

Abbreviation	Description
HES	Health, Environment and Safety
MSDS	Material Safety Data Sheet
HMS	Norwegian; HES

Tube/pipe washing prior to assembly

1.0 Scope

This document gives a description of the procedure and equipment that is in use by FMC Kongsberg Subsea for cleaning hydraulic tubes and pipes before assembly.

Flushing is not accepted as the only or primary means of cleaning hydraulic parts or components, including tubing systems.

2.0 Required equipment

A suitable tube cleaning station is required, as an example: "FMC tube- pipe washer". See figure 1.

A soap which is fit for purpose is required. Being fit means that it will dissolve mineral based oils or greases and water-glycol based fluids and greases. The Kongsberg plant uses "Aluvask" soap.

3.0 HES

The operator shall know the contents of the MSDS of the soap before using the pipe-tube washer.

Verify that the pipe or tube is safely connected to the washer. Hot water leakage will cause harm and may be dangerous.

During the wash operation, personal protection is required; safety glasses, hard hat, noise suppression, gloves and long sleeved clothing.

Cleaned tubes or pipes shall be fitted with caps to prevent damage to eyes, or personnel in general. Ball type caps are recommended. See figure 5 as an example.

4.0 Procedure

1. Connect the tube to the washer using the appropriate wise grip, fitting or alternative interface as required.
2. The other end of the tube shall be located inside the soft plug container which is above a drain. See figure 2.
3. Flush with hot water for 15 seconds (Water temperature 60 °C).

4. Flush with soap for 3 seconds.
5. Flush with hot water for 30 seconds.
6. With the tube end inside the noise suppression box, blow the tube dry using oil free, filtered and dry air. See figure 3.
7. Shoot a clean soft plug (correct size) through the tube, using "Jet Cleaner" or similar. See figure 4. Ensure that the plug is retained inside the container, to verify that the complete plug has passed through the tube.
8. Plug the cleaned tube, to prevent ingression of contamination.
9. Take care to prevent external damage to the tube during the process

5.0 Attachment - illustrations

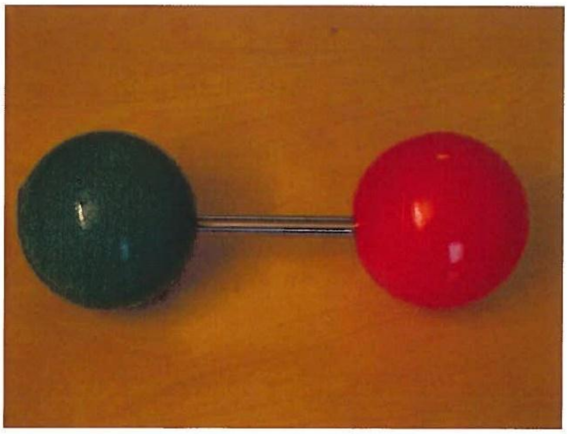
Figure 1: FMC tube- pipe washer

Figure 2: Container above drain, soft plug receiver

Figure 3: Noise suppression box with filter

Figure 4: Jet cleaner with soft plug

Figure 5: End protection. To prevent damage to personnel and to exclude contamination



6.0 Original document in Norwegian

6.1 Formålet

Beskriver en prosess for rengjøring av rør, slik at krav til renhet blir overholdt. Dvs skal man få et rent hydraulikk system må renhet, på komponent nivå, overholdes.

6.2 Krav til utstyr

Det kreves at det er en egnet vaskestasjon, for eksempel: type "FMC tube – pipe washer". Se fig. 1

Det kreves at det blir brukt en såpe som er egnet til formålet d.v.s. at den har evnen til og løse opp både mineral og glykolholdige oljer. Vi bruker Aluvask.

6.3 HMS

Operatør skal gjøre seg kjent med såpens HMS-datablad før vaskeprosessen kan igangsettes.

Påse at alle koblinger mot rør er festet på forsvarlig måte. Lekkasje av varmt vann, såpe og trykkluft kan medføre skade.

Det skal under vaskeprosessen brukes hjelm med visir (vernebriller), hørselsvern, engangshansker av Nitril, samt arbeidsklær med lange armer.

Etter endt vaskeprosess skal det påmonteres stor ende beskyttelse i hver ende av rørene. (Se Fig. 5 for forslag)

6.4 Utførelsen

1. Koble rør til vaskeutstyr med egnede klemmer, fittings eller det som er interfacen på røret.
2. Rør enden skal plasseres i beholder over sluk enten utvendig eller innvendig. Se fig.2
3. Spyl med varmt vann ca 15 sek. (vannet bør holde 60º)
4. Spyl med såpetilsatt vann i 3 sek.
5. Spyl med varmt vann i ca 30 sek.

6. Når dette gjøres plasseres rør enden i lyddempet kasse. Se fig.3. Blås med renset, oljefri og tørket luft. Dette gjøres til røret er fritt for vann.
7. Skyt en ren skumplugg (tilpasset dimensjonen på røret) gjennom, med "Jet cleaner" se fig.4. Sørg for at denne lander i en beholder slik at man kan se at hele pluggen er gått gjennom.
8. Det ferdig behandlede røret plugges, slik at forurensing ikke kan trenge inn i røret.
9. Sørg for at røret ikke påføres ytre skader under prosessen.

C. Standardized Work Instruction

STANDARDIZED WORK INSTRUCTION, SUBSEA - COMPLETION & WORKOVER, GLOBAL, TUBE WASHING

Rev	ECN No.	Date	Reviewed By	Approved By	Status
B	2261337	23-SEP-2013	Place, Frederic	Edgar, David	RELEASED

Summary:

This Standard Work Instruction has been created to give instructions on how to wash small bore control tubing.

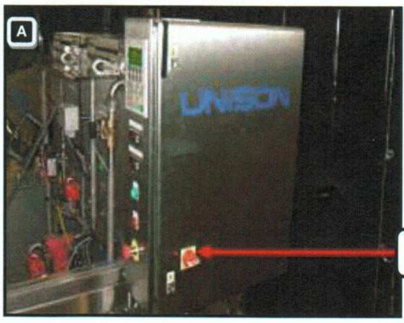
Time in this SWI is based on the entire process described for a single tube.

Local Washing of Small Diameter Tubing				*Refer to Routing* Std Time
Personal Protective Equipment	Safety	Quality	Caution	Tooling
SAFETY GLASSES STEEL TOE SHOES GLOVES				

Instruction:

If anything goes wrong during the tube washing machine operation, hit the emergency button to stop the machine immediately.

1. Power up the machine (A).



Power On Switch

The operation will only start once the cleaning fluid has reached a temperature of 60 degrees Celsius (indicated on the 'wash temperature' panel).

2. Select the required connector, from the tool panel that will match the size of the tube to be washed (B).

Connector Couplers

3. Connect the selected connector couplers to the hoses end (C).

4. Select the tubes with red foam from the rack to proceed with the wash (D).

5. Depress the coupler latch to engage tube connection to the coupler (E).

Verify that the tube is safely and properly secured to the coupler to avoid hot water leakage during washing.

Do not strike or tamper with the coupler connection during the washing operation.

6. When the temperature is set at operational level, you can start the machine by pressing F2 on the control panel (F).

When the cycle is running the red light will be on. The green light will come on when the cycle is finished.

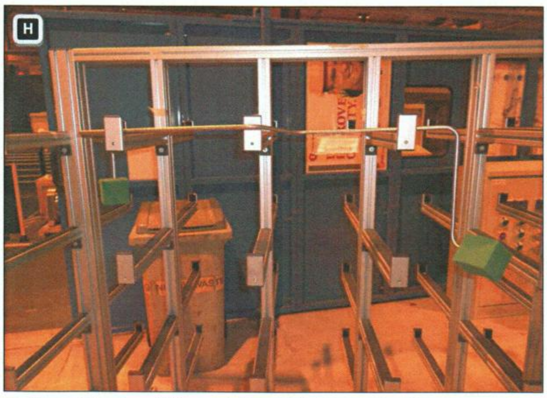
7. The washing cycle will take about a minute to run through hot water, soap, hot water and clean air. Once the cycle stops, disconnect the tube from the connector couplers.

Always put the connector couplers back into the designated place on the machine once all the tubes of the same size have been washed.

8. Verify that the tube has been cleaned internally by inserting a clean soft plug into the nozzle gun, and engaging the nozzle onto the tube outer diameter. Hold the tube tightly to engage with the nozzle and press the nozzle gun to shoot the clean soft plug (correct size) through the tube (G)

Ensure that the plug is retained inside a container to confirm that it has passed through the tube.

9. Cap the cleaned tube with color coded cap as per material specification. Fit a green foam cube to indicate that the tube has been washed and plugged (H).



10. Place all the cleaned tubes onto the portable tubes trolley (I).

D2. Requirement Matrix

Portable Tube Washer Project 2015\Appendices\2. Design\D2. Requirement Matrix

FMC checkpoints in the assessment of the project		Capabilities	Supply	Monitoring and Feedback	Interfaces	Safety	Design	Transportation and Storage	Instructional	Upgrades	Physical Boundaries	Documentation
1	Software(PLC) should be from a reputed supplier with the possibility of service and support.						R-DES-04			R-UPG-01		
2	It should be easy to do maintenance on all critical components. It implies that all components requiring maintenance shall be with simple steps removed, replaced or serviced.						R-DES-01 R-DES-02		R-INS-02 R-INS-03	R-UPG-02		
3	The finished product should be possible to move with ease between different locations. It is desirable that all connections are made in such a way that it does not require major changes to connect to the workshop infrastructure.				R-INT-E-01 R-INT-E-02			R-TAS-T-01 R-TAS-T-02			R-PHY-01	
4	HSE-construction shall have all the necessary components and systems ensuring safe operation. By incorrect use or error the system shall go into Safe Mode, where pressure is bled off and there are no pressurized parts, as this may cause splashes of hazardous substances.					R-SAF-S-02 R-SAF-S-04 R-SAF-S-06 R-SAF-W-01 R-SAF-W-02 R-SAF-U-01 R-SAF-U-02 R-SAF-U-03 R-SAF-U-05			R-INS-04 R-INS-05			
5	When emptying the system reservoirs (service interval), easy drainage of the fluids into containers should be possible for safe handling of hazardous waste.				R-TAS-S-01							
6	The washing Routine shall comply according to PRD-000025424.	R-CAP-A-05 R-CAP-A-06 R-CAP-P-01			R-INT-U-04	R-SAF-U-06						
7	Requirements originated from vision document	R-CAP-A-01 R-CAP-A-02 R-CAP-A-03 R-CAP-A-04 R-CAP-D-01 R-CAP-D-02 R-CAP-P-03 R-CAP-P-05 R-CAP-P-06	R-SUP-01 R-SUP-02 R-SUP-03	R-MAF-01 R-MAF-02 R-MAF-04 R-MAF-05	R-INT-E-04 R-INT-I-01 R-INT-U-01 R-INT-U-02 R-INT-U-03	R-SAF-S-03 R-SAF-S-05 R-SAF-E-01		R-TAS-T-03 R-TAS-S-03			R-PHY-02 R-PHY-05	R-DOC-01 R-DOC-02 R-DOC-03

D3. Stakeholders

Portable Tube Washer Project 2015\Appendices\2. Design\D3. Stakeholders

Active Stakeholders	Passive Stakeholders
• User(s): ○ Easy to use ○ Safety ○ Foul proof ○ Easy to move	• Owner FMC: ○ Regulations ○ HMS ○ Well established parts suppliers ○ Environmently chemicals ○ Modular design
• Maintainance: ○ Easy access	• Public Regulations: ○ Regulations ○ Laws
• Owner(FMC): ○ Time saving ○ Cost Effective ○ Procedure oriented FMC Doc.No:PRD-0000025424	• Fabrication Subcontractor: ○ Design
• Infrastructure: ○ Electricity Connection ○ Water Connection ○ Pressurized Air Connection ○ Drain	• Workshop Environment: ○ Must not pollute ○ Filtering contaminated fluids
• Transportation: ○ Size ○ weight	• Standards: ○ Follow ISO 9001 ○ Machinery Directive 2006/42/EØS
	• Developer ○ Keep simple

D4. Flowcharts (Use Cases)

Portable Tube Washer Project 2015\Appendices\2. Design\D4. Flow Charts (Use Cases)

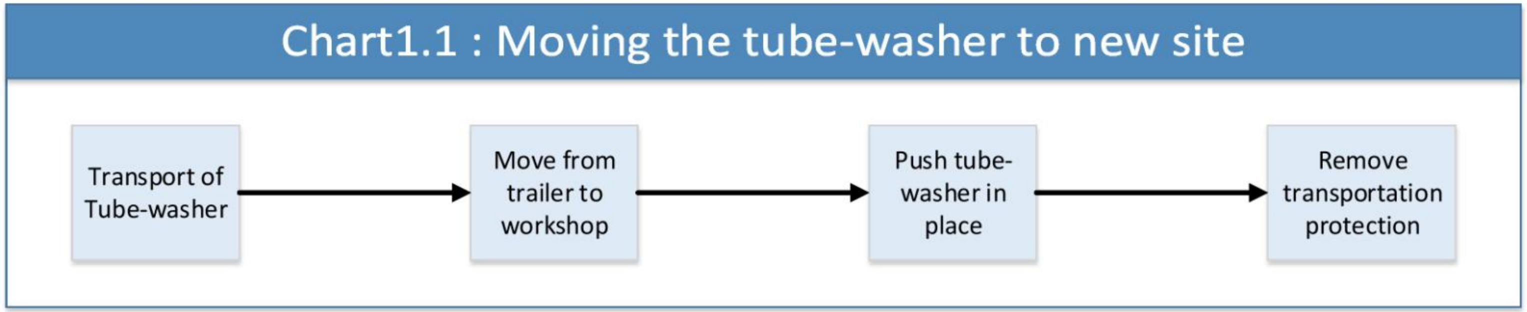


Chart1.1 : Moving the tube-washer to new site
Transport of Tube-washer
Move from trailer to workshop
Push tube-washer in place
Remove transportation protection

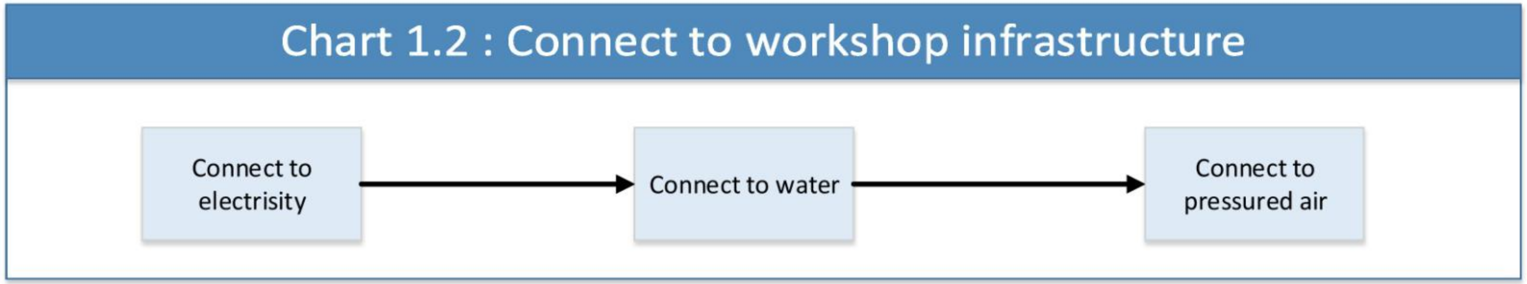


Chart 1.2 : Connect to workshop infrastructure
Connect to electrisity
Connect to water
Connect to pressured air

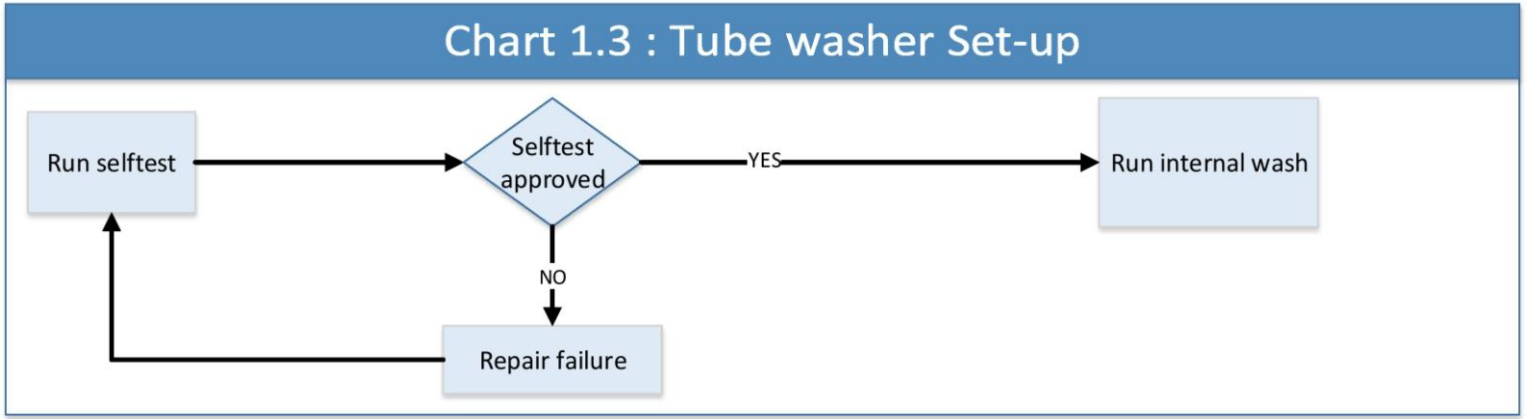


Chart 1.3 : Tube washer Set-up
Run selftest
Selftest approved
YES
Run internal wash
NO
Repair failure

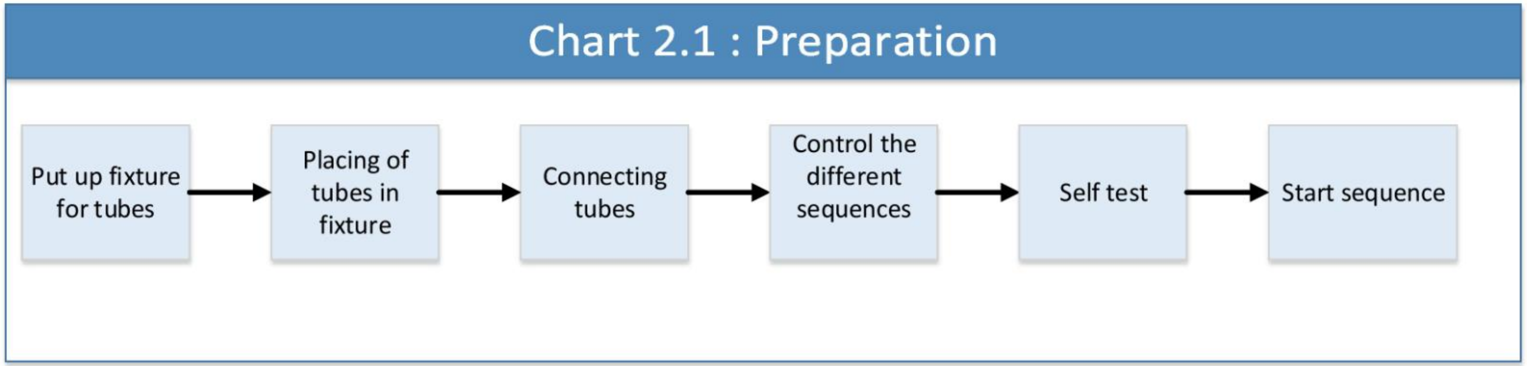


Chart 2.1 : Preparation
Put up fixture for tubes
Placing of tubes in fixture
Connecting tubes
Control the different sequences
Self test
Start sequence

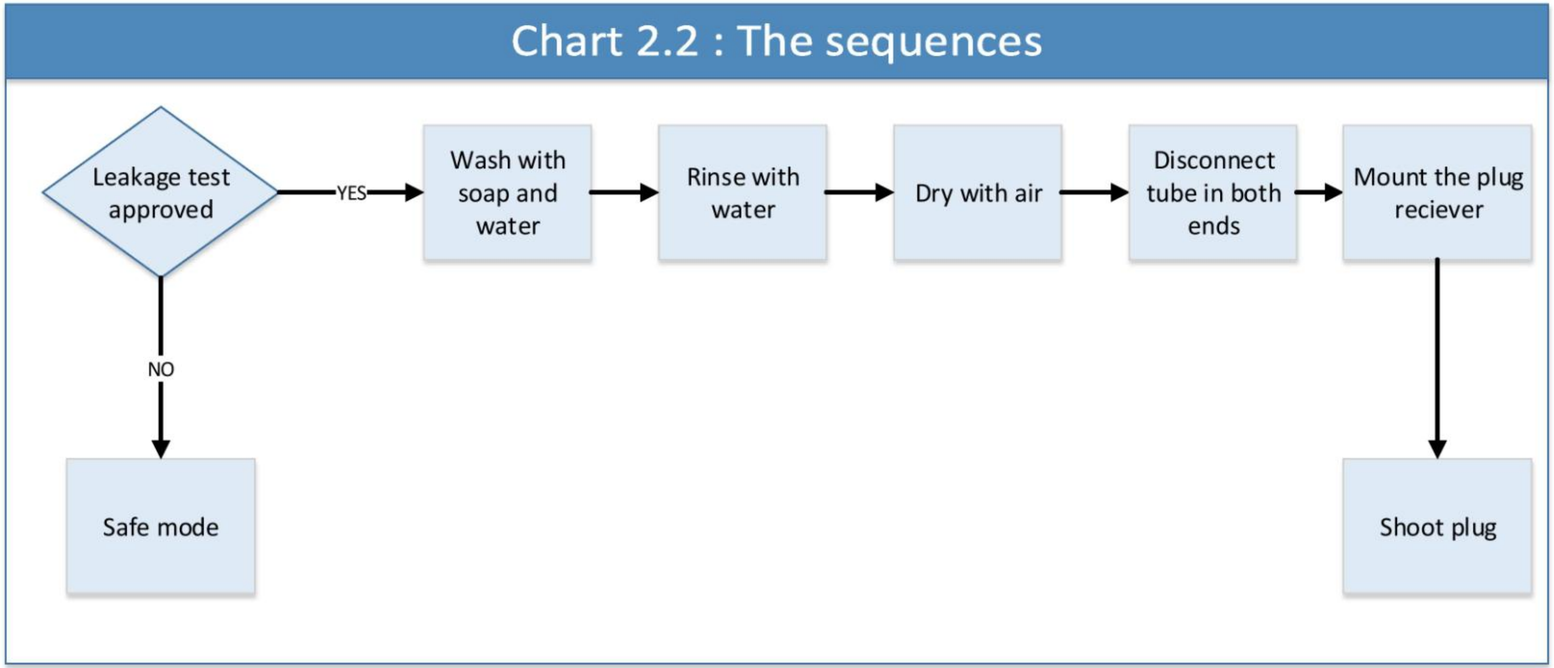


Chart 2.2 : The sequences
Leakage test approved
YES
NO
Wash with soap and water
Rinse with water
Dry with air
Disconnect tube in both ends
Mount the plug reciever
Safe mode
Shoot plug

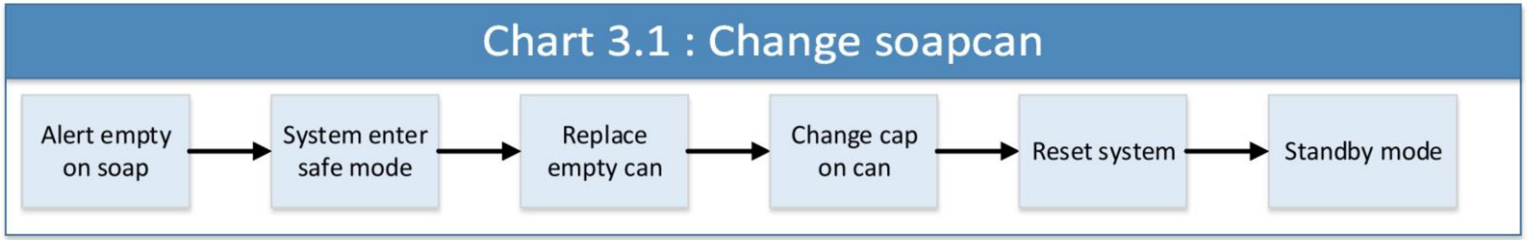


Chart 3.1 : Change soapcan
Alert empty on soap
System enter safe mode
Replace empty can
Change cap on can
Reset system
Standby mode

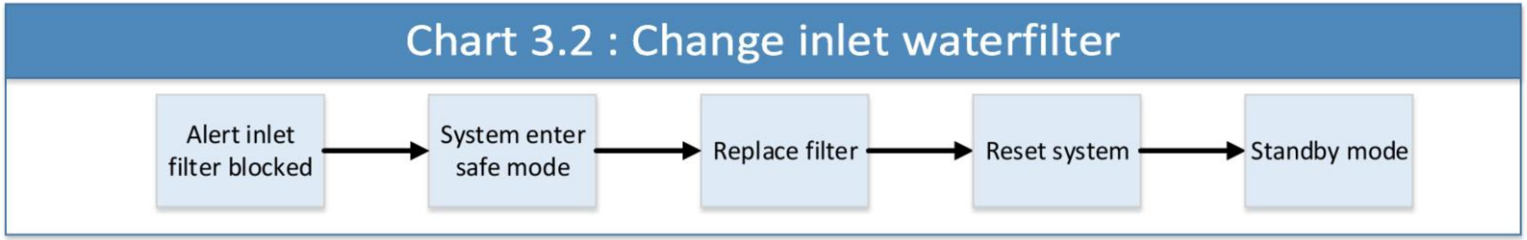


Chart 3.2 : Change inlet waterfilter
Alert inlet filter blocked
System enter safe mode
Replace filter
Reset system
Standby mode

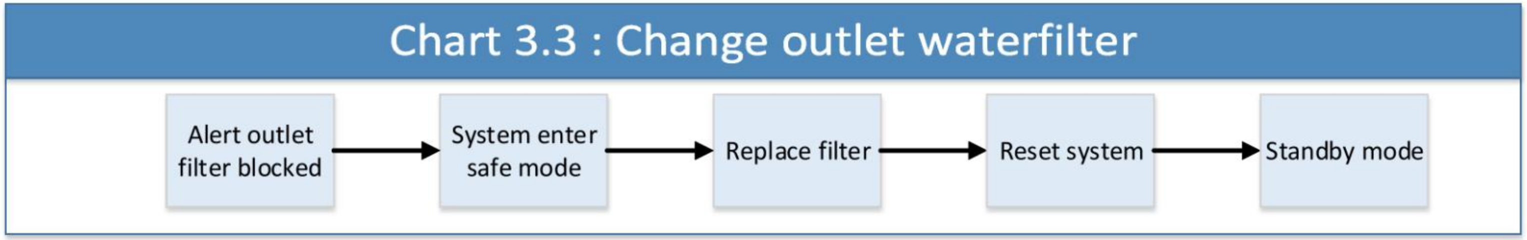


Chart 3.3 : Change outlet waterfilter
Alert outlet filter blocked
System enter safe mode
Replace filter
Reset system
Standby mode

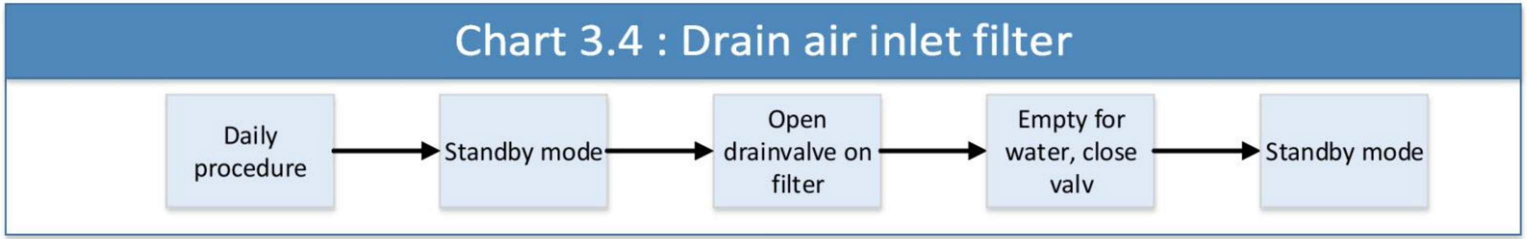


Chart 3.4 : Drain air inlet filter
Daily procedure
Standby mode
Open drainvalve on filter
Empty for water, close valv
Standby mode

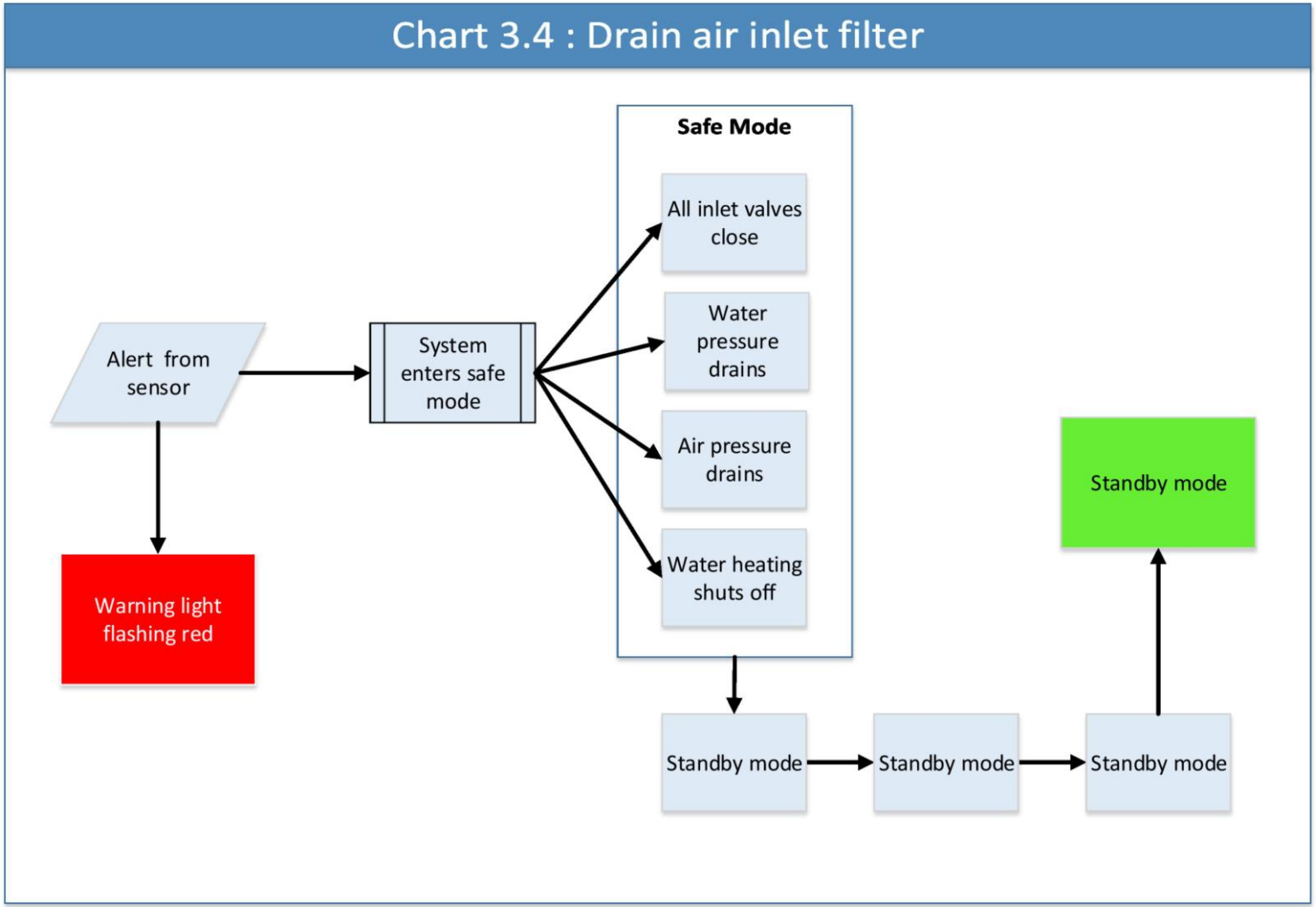
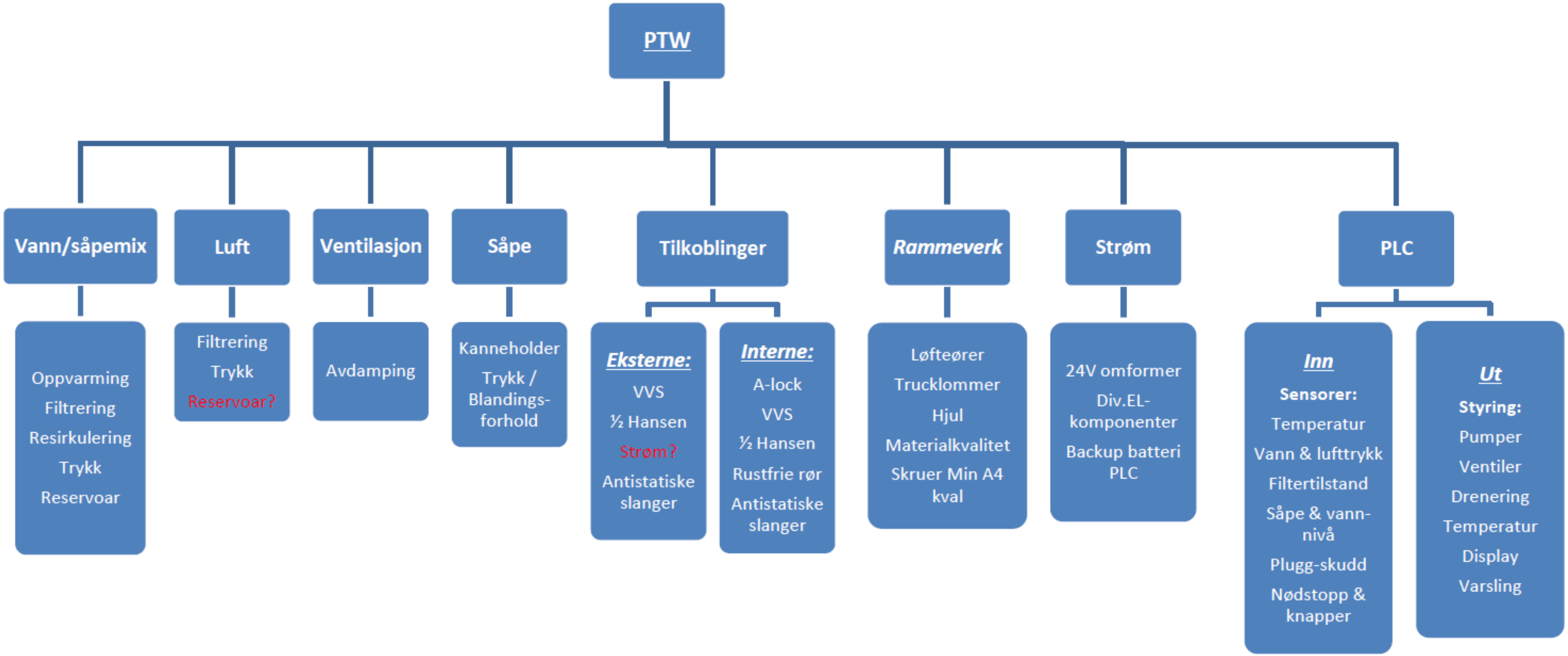


Chart 3.4 : Drain air inlet filter
Safe Mode
Alert from sensor
System enters safe mode
All inlet valves close
Water pressure drains
Air pressure drains
Water heating shuts off
Warning light flashing red
Standby mode
Standby mode
Standby mode
Standby mode

D5. Product Breakdown Structure

Portable Tube Washer Project 2015\Appendices\2. Design\D5. Product Breakdown Structure


PTW
Vann/såpemix
Oppvarming
Filtrering
Resirkulering
Trykk
Reservoar
Luft
Filtrering
Trykk
Reservoar?
Ventilasjon
Avdamping
Såpe
Kanneholder
Trykk / Blandings-forhold
Tilkoblinger
Eksterne:
VVS
½ Hansen
Strøm?
Antistatiske slanger
Interne:
A-lock
VVS
½ Hansen
Rustfrie rør
Antistatiske slanger
Rammeverk
Løfteører
Trucklommer
Hjul
Materialkvalitet
Skruer Min A4 kval
Strøm
24V omformer
Div.EL-komponenter
Backup batteri PLC
PLC
Inn
Sensorer:
Temperatur
Vann & lufttrykk
Filtertilstand
Såpe & vann-nivå
Plugg-skudd
Nødstopp & knapper
Ut
Styring:
Pumper
Ventiler
Drenering
Temperatur
Display
Varsling

Manufacturing

The manufacturing paragraph is a collection of documents describing the project outcome; more specifically, the selected final design's whats, whys and production bases. Appended are:

M1. Technology Document

This report serves as an overview of, and justification for, particularly critical design decisions made by the project group during the course of this project.

M2. PLC Documentation

A collection of documents made to communicate the intended purpose and tasks of the PLC to a programmer.

M3. Purchasing List

The purchase list is as natural supplement to the technology document, listing prices and suppliers of selected components.

M4. Test Plan & Specification

These two documents describe how the project group would have the requirements tested and specific test tables for each requirement.

M5. Analyses & Calculations

Analyses and calculation run/done to plan, and later verify, the design.

M6. 3D/2D Drawings

These files contain all needed information for manufacturing the PTW.

M1. Technology Document

Portable Tube Washer Project 2015\Appendices\3. Manufacturing\M1. Technology Document

Technology Document

Version 2

Version	Date	Changes	Status	Responsible
1	18.03.2015	This is the first version of the document.	Matrix for uncritical design choices to be added. Standard Criteria & Methods For Research to be translated. Document under construction.	Bjørnar Døviken
2	13.05.2015	Document updated for final delivery.	Document ready for final delivery.	Bjørnar Døviken

Name	Signatures
Bjørnar D. Døviken	
Henrik Lind	
Olav Parken	
Alexander Araya	

Introduction

This is a technology document written for the Portable Tube Washer project. It serves as an overview of, and justification for, particularly critical design decisions made by the project group during the course of this project.

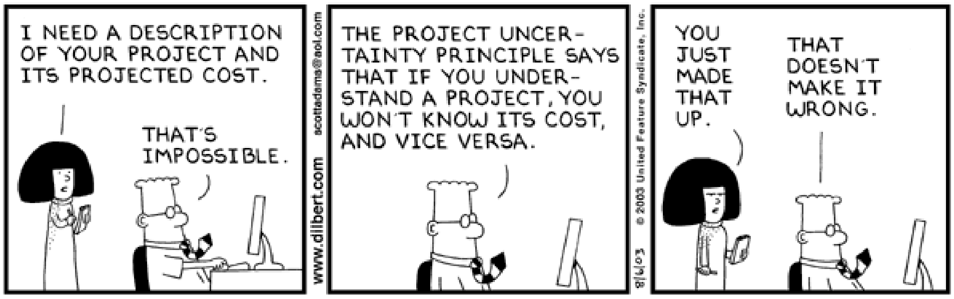
The document will consist of, for each analysis, the basis for the study (goals and purposes), the criteria that form the foundation of the study, the methods used for research, the results of the research and the conclusion.

The analyses will be done on a sub-system and specific component level. The sub-system selection (SS) will comprise problems like "will there be one or two pumps?" and "which specific type of pump will be used", while the component selection will decide which product will be selected.

Pugh matrices have been used when several options to solve a specific problem have resulted from research. If the result of the Pugh matrix is clear, in that one option far outscores the others, the others are excluded; however, if the result is dubious, a less structural weighing will decide which option fits the system best.

At the end of this document is a list concisely listing the design choices deemed less critical for the system as a whole.

Components prices are listed in the external Purchase List (***Portable Tube Washer Project 2015\Appendices\3. Manufacturing\M3. Purchase List***).



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B. Heating - DEL 27kW SLi 294
C. Jet Clean - Microswitch 698-9823 294
D. Main Pump - 2CDXU 1611200000B 294
E. PL Pressure Bleed-off - Overflow Valve 294
F. Particle Filtering - FIK-FIO 180/02, K051116 294
G. PLC and Accessories 294
H. Chemical Vapor Filtering - Triceptor 934330T 294
I. Flow Control - Strupev. 3/4" 210 bar DTFT1251234 294
J. 2-way NO/NC valves - E82560/90 294
K. Level and Pressure Monitoring - Vegabar 14 294
L. Level Monitoring (soap concentrate) - Nivåtransmitter 294
M. Temperature Monitoring - Temperaturføler 294
N. Warning Lights - LED lystårn, kompakt 37 294

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Glossary and Acronyms

Name	Description
PTW	Portable Tube Washer
FMC	FMC Technologies
C	Component level
SS	Sub-system level
FEN	Fornybar Energi Norge
PLC	Programmable Logic Controller
NO	Normally Open
NC	Normally Closed
PL	Power-Loss

Table 9 - Glossary and Acronyms

1 Standard Criteria & Methods for Research

Criteria

- *Cost:* Purchase price of component and other parts (non-control related) that the selection of said component results in, e.g. an additional valve as a result of venturi pump (aspirator) instead of a conventional soap pump.
- *Weight:* Weight of component/sub-system.
- *Service-friendliness:* How easy it is to replace components, e.g. clogged filter. Scheduled maintenance, e.g. changing reservoir liquids, is also considered by this criteria.
- *Control costs:* Extra costs beyond purchasing price, like extended need for electrical control.
- *Size:* Physical size of component/sub-system.

Research

Basic research on the internet to find websites, catalogues and data sheets.

2 Example Study

2.1 Study Name(C/SS)

Goals

Why are we doing this study and what is the purpose behind doing it?

Example: We need something to mix soap into the clean water.

Study-specific Criteria

Additions to the standard criteria specific to the study in focus.

Example: Suction height or power, if applicable.

Study-specific Research

How have we researched this? Called which companies, read which data sheets, sent which e-mails etc.

Example: Searched e-bay for venturi-pumps, found a product, went to its developers' website and read the data sheets.

Results

What did the research result in? Which components did we find and how good/bad are they compared to the study criteria.

Example: Discovered the Hydromaster venturi, Mini/SuperDos flow-based pumps etc. The Hydromaster costs this much, comes with these additions, takes up this much space etc.

Conclusion

What we have chosen, either in Pugh-matrix or prose form.

3 Critical Studies

3.1 Soap Pump(SS)

Goals

The system requires something to automatically inject and mix a defined amount of soap into the water.

Study-specific Criteria

- *Accuracy:* With what precision the injected soap can be guaranteed.
- *Adjustment:* How easily the amount of soap injected can be adjusted.

Study-specific Research

Contacted P.Lindberg, a Norwegian supplier, after having researched venturi and hybrid injector solutions on Hydro Systems' website.

Results

1. ***Venturi based (aspirator) pump:*** The Venturi principle exploits that as a fluid passes through a narrowed slit (nozzle), the static pressure at that point decreases, creating a negative pressure allowing another fluid to be "pushed/sucked" up from a reservoir connected to the main pipe.
   The "Hydromaster" from Hydro Systems is a good and versatile venturi-solution. Color coded nozzles for dosage adjustment are included with the purchase, but while this may seem practical, having to raise the soap tube to change the nozzle will require the use of safety gloves and eyewear.
2. ***Electric (e.g. piston) pump***: Any pump of this sort requires electricity to operate and electrical control by the PLC system.
3. ***Hybrid injector solution*:** This, much like a venturi, does not require any power to function and is inserted in, and driven by, the fluid (water) stream. Yet, where the venturi works by creating a negative pressure, this solution works by letting the water flow rotate an impeller to create suction.
   The "SuperDos" and "MiniDos", also from Hydro Systems, are two excellent alternatives for injecting precise amounts of soap. These solutions are also much easier to adjust than the venturi in that a screw can be turned to increase/decrease the dosage.

Conclusion

Soap Pump(SS)		Venturi	Pump
Criteria	Weighing	1	2
Cost	5,0	3	4
Weight	2,0	4	4
Service-friendliness	4,0	4	3
Control Costs	3,0	3	3
Size	4,0	4	4
Accuracy	3,0	5	4
Adjustment	5,0	4	5
Weighted Scores		99,0	102,0

Table 10 - Pugh Matrix Soap Pump(SS)

As the matrix above shows, both options score very close to the other. When the matrix was set up, the hybrid injector was included in the "pump" category, something that later was decided unwise; yet, this does not impact the conclusion as all three options are very equal. Due to this uncertainty, a second round of research was conducted to distinguish the options.

The hybrid injector has been selected due to its continuous, safe and accurate adjustment control, its ease of installation and usage, and non-power required operation.

3.2 *Heating(SS)*

Goals

The system requires something to heat both clean water and soap mix to a predefined temperature.

Study-specific Criteria

- *Heating time:* How long it takes to heat cold water to the set washing temperature.
- *Draining:* How easy/practical it is to completely drain the heating option of fluids.

Study-specific Research

Results

1. ***Flow-thru Heaters*:** The major advantage of flow-thru heaters is their capability to heat water instantly as it passes through, hence "flow-thru". Limited, however, by the amount of water it can heat within a certain temperature range, it proved difficult to find industrial solutions that would also satisfy our budget.
2. ***Immersion Heaters***: Heaters like these typically heat a tank holding liquids. Though amazingly simple to use and allowing for easy draining of the liquid reservoirs, they require an unnecessary long time interval for heating the fluids to a set temperature.
3. ***Storage Heaters:*** Being similar to the immersion heater options in every way but practicality, these heaters prove cumbersome to drain

Conclusion

Heating(SS)		**Flow-thru**	**Immersion**	**Storage**
Criteria	**Weighing**	**1**	**2**	**3**
Cost	5,0	4	4	3
Weight	2,0	5	5	3
Service-friendliness	4,0	4	3	3
Control Costs	3,0	4	3	4
Size	4,0	4	5	2
Heating time	5,0	5	2	2
Draining	4,0	4	5	2
Weighted Scores		**115,0**	101,0	71,0

Table 11 - Pugh Matrix Heating(SS)

Though the flow-thru option is the clear winner of this matrix, problems with the alkaline soap arose later when thoroughly reading data sheets. See Heating(C) for how this issue was resolved.

3.3 Heating(C)Heating(C)

Goals

It must be determined which specific flow-thru heater will satisfy the system in the best possible way.

Study-specific Criteria

Study-specific Research

Contacted Norske Backer and Fornybar Energi Norge about their flow-thru heaters.

Asked Otto Waaraas (HBV) and Mehdi Gebreil Mousavi (HBV) questions regarding the corrosive effects of the alkaline soap, Metaclean AL 199, on copper. Bjørnar Døviken had a meeting with metallurgist Stein Ivar Ramberg (FMC), 13.03.2015, regarding the same questions.

Results

1. ***Fornybar Energi Norge, DEL 18-27kW SLi, DHB-E 11-27kW SLi, DHE 18-24kW SLi:*** These domestic models can provide sufficient flow rates at adequate pressure levels. Both the ***DHB-E 11-27kW SLi*** and ***DHE 18-24kW SLi*** models cannot heat pre-heated water, and the latter is very costly due to remote options, while ***DEL 18-27kW*** is affordable and can heat pre-heated water. Sadly, their internal copper piping is susceptible to the corrosive effects of the alkaline soap the system requires, and hence no guarantees can be made for the life-span of these heaters.
2. ***Coax:*** These models share many common traits with the FEN-heaters, yet the limited availability of documentation has stayed us from choosing Coax.
3. ***Norske Backer Gjennomstrømningsvarmer:*** The industrial heaters from Norske Backer can be tailored to satisfy any need, but they are much too costly. One such unit would exceed over half the budget.

Conclusion

The meeting with Stein Ivar Ramberg at FMC provided us with the guarantees we needed to pursue the domestic flow-thru heater options: Though there will always be risks, flushing the heater with clean water after each passing of soap should greatly reduce the corrosive effects of the alkaline chemicals. FMC agreed (see *Møtereferat 13.03.2015 - Stein Ramberg* for details) that these risks are acceptable, and hence, the flow-thru heater DEL 27kW SLi from FEN will be the heating solution.

3.4 *Jet Clean(SS)*

Goals

Requirement *R-CAP-A-05* demands that a plug shall be discharged through the tube post washing. The system shall also monitor in an applicable fashion that the plug has been discharged before allowing another cycle to start.

Hence, the system requires something to detect that the Jet Cleaner has been used.

Study-specific Criteria

Study-specific Research

Olav had a meeting with Ronny Gjerden (FMC) regarding sensors and general PLC-related inquires.

Results

1. ***Flow Detection:*** A flow meter can detect fluids flowing through it.
2. ***Accumulator Reservoir:*** An accumulator stores pressurized fluids. A manometer, or any similar product, can detect pressure drops in the accumulator. This option includes several additional valves, which is costly.
3. ***Micro-switch:*** Probably the simplest option. The Jet Cleaner would push this switch down for as long as it rests in its holster, meaning the switch would detect the removal of the Jet Cleaner and send a signal to the PLC unit. This option was suggested by Ronny Gjerden as an alternative to the two pre-existing ones.

Conclusion

Jet Clean(SS)		Flow Detection	Reservoir (acc)	Micro-switch
Criteria	Weighing	1	2	3
Cost	5,0	4	3	5
Weight	2,0	4	2	5
Service-friendliness	4,0	4	2	5
Control Costs	3,0	4	2	5
Size	4,0	4	2	5
Weighted Scores		72,0	41,0	90,0

Table 12 - Pugh Matrix Jet Clean(SS)

Its unfailing simplicity of use and control, as well as its cost and size, make the micro-switch a suitable solution for the system. An additional alternative is to use two micro-switches to work with signals opposite of each other; if one fails, the signals will be equal. With this configuration, it makes it possible to know when one of the micro-switches is malfunctioning.

3.5 Number of Main Pumps(SS)

Goals

The configuration and sub-system of the pressure providing units in the system must be decided.

Study-specific Criteria

Study-specific Research

Henrik Lind had a meeting with Jonas Carlstedt (FMC).

Results

1. ***One Pump:*** Perhaps the most intuitive option. Going for this solution, both soap mix and clean water will pass through the pump, meaning the reservoirs will gradually become more alike in content.
2. ***Two Pumps:*** This option guarantees control over which fluid passes through which pump, yet it is costly and more complex construction-wise.
3. ***Zero Pumps (Reservoirs pressurized by air):*** Pressurized air from the facility compressor would drive the fluids through the system. At first glance it may look great: no pumps should imply less complexity. As it turns out, it doesn't: since the fluids need to move in a loop back towards the reservoirs, two intermediary reservoirs plus several valves must be added to make this work.

Conclusion

Number of Pumps(SS)		1 Pump	2 Pumps	0 Pumps
Criteria	Weighing	1	2	3
Cost	5,0	4	2	2
Weight	2,0	2	1	5
Service-friendliness	4,0	4	3	4
Control Costs	3,0	4	2	1
Size	4,0	3	2	1
Weighted Scores		64,0	38,0	43,0

Table 13 - Pugh Matrix Number of Pumps(SS)

One pump is the best alternative for the system.

3.6 *Main Pump(SS)*

Goals

The system requires something to pressurize the working fluids and secure a steady flow.

Study-specific Criteria

- *Flow rate to size ratio:* How big the pump is compared to its specified maximum flow-rate.
- *Particle resistivity:* How susceptible the pump is for particle damage.
- *Safety:* How much pressure will build up, should the pump control system fail and the pump continue pumping.
- *Low circuit complexity:* How complex the entire system will become as a result of the selected configuration.
- *Lubrication:* How well the pump runs with non-lubricating liquids, such as water.

Study-specific Research

Results

1. ***Centrifugal:*** Centrifugal pumps are generally applicable when high pressure levels are not required, but high flow-rates are of interest. In addition, these types of pumps will be unaffected by particles flowing through them, and, in the event of piping blockage, will not build up pressure until something goes wrong, as e.g. piston pumps would.
2. ***Piston:*** These pumps can generate enormous amounts of pressure, yet this isn't of any particular interest for our system, as in fact, we don't want high pressure levels whatsoever. Piston pumps are also extremely susceptible for particle damages.
3. ***Gear:*** Similar to piston pumps, particles will have severe effects on the performance of these pumps.

Conclusion

Main Pump(SS)		Centrifugal	Piston	Gear pump
Criteria	**Weighing**	**1**	**2**	**3**
Flow Rate to size ratio	5,0	4	1	2
Particle resistivity	4,0	5	1	3
Safety	5,0	5	1	2
Low circuit complexity	4,0	5	2	2
Lubrication	4,0	5	1	2
Weighted Scores		**105,0**	26,0	48,0

Table 14 - Pugh Matrix Main Pump(SS)

The selection of which type of pump to use as the main pressure unit concluded with a centrifugal pump.

3.7 PL Pressure Bleed-off(SS)

Goals

In the eventuality of power-loss, the system shall bleed off any remaining fluid pressure.

Study-specific Criteria

- *Reservoir Ratio Control:* To which level control of the reservoir soap/water ratio remains maintained after a bleed-off.

Study-specific Research

By technical reasoning and discussion, the following statement has been made: *Naturally, valves controlling this must have a completely mechanical fail-safe system; if they lose power, they must open/close mechanically, hence "fail-safe-open/close" or "normally open/close".*

Results

1. ***Back to Reservoir:*** Letting the pressurized fluid escape to the soap reservoir will result in a thinner soap/water ratio if the system is currently running clean water cycles. Similarly, if the system is in a soap cycle, letting it escape to the clean water tank is not ideal. It would result in having to change the "bleed-off-to" reservoir after a power-loss and refill it.
2. ***External Container:*** Though it requires one additional valve and a container, the simplicity of this option reduces the amount of manual labor, and number of service intervals by retaining reservoir ratio control.

Conclusion

PL Pressure Bleed-off(SS)		Back to Reservoir	External Container
Criteria	**Weighing**	**1**	**2**
Cost	5,0	5	3
Service-friendliness	4,0	2	4
Control Costs	3,0	4	3
Size	4,0	5	4
Reservoir Ratio Control	5,0	1	5
Weighted Scores		70,0	**81,0**

Table 15 - Pugh Matrix PL Pressure Bleed-off(SS)

For these reasons, it's been decided to let the system bleed off to a third, separate container through a normally open valve, letting the two main reservoir valves remain normally closed.

3.8 *Particle Filtering(SS)*

Goals

The positioning and mounting of the filter housing needs to be ideal for the optimization of reservoir capacities and replacement of filter cartridges.

Study-specific Criteria

- *Liquid Processing Amount:* How much liquid the filter housing will store as it fills up.

Study-specific Research

Olav called Anne Engebritsen from Egil Eng AS regarding submersible filters.

Results

1. **In-line Free-standing:** Mounted on a separate flange, the inlet is on the top and the outlet on the bottom, allowing for practical drainage. Due to its mounting, hoses, instead of pipes, can be attached. They are easily replaceable, but the housing will store a large amount of liquid, which will increase the reservoir capacity requirement.
2. **Submersible Synthetic In-line:** Mounted in the top of the tank with the piping leading into it, these filters are easily replaceable and do not store more water than the amount already stored in the reservoir.
3. **In-line Pipe-mounted:** Mounted directly in the piping structure and supported by it, this housing requires attachments to load-bearing pipes, and e.g. hoses cannot be used. These filters are also easily replaceable, however, the housing will store a large amount of liquid, which will increase the reservoir capacity requirement.

Conclusion

Particle Filtering(SS)		In-line Free-standing	In-line Submersible	In-line Pipe-mounted
Criteria	**Weighing**	**1**	**2**	**3**
Cost	5,0	1	4	2
Weight	2,0	4	5	4
Service-friendliness	4,0	4	4	2
Control Costs	3,0	3	4	3
Size	4,0	2	4	2
Liquid Processing Amount	3,0	1	5	1
Weighted Scores		49,0	**89,0**	46,0

Table 16 - Pugh Matrix Particle Filtering(SS)

The in-line, submersible filter housing is the preferred alternative due to its practical functionality and positioning options. It will take up no additional space, nor store extra liquid amounts.

3.9 PLC Supplier(SS)

Goals

Something to control the system's automated processes and make it possible for the user to enter inputs is required.

Study-specific Criteria

- The PLC shall be from an established supplier.
- Software shall be accessible and without restrictions for future upgrades.

Study-specific Research

In addition to the research mentioned below, Henrik Lind and Alexander Araya have downloaded a training program for programming PLCs.

- Henrik had a meeting with Drammen Automasjon regarding using them as the supplier of Siemens PLC.
- Henrik had two meetings with Erling Aas at Beijer Electronics. Olav Parken participated in the second meeting to ensure common understanding of the Mitsubishi PLC system in general within the group.
- Henrik mailed and made phone calls with Goodtech regarding the Allen-Bradley PLC capabilities, sensors and specific questions about interfacing between parts and the PLC.
- Henrik mailed and made phone calls with Phoenix Contact about getting a sales quote on the PLC system they deliver.

Results

All of the following PLC suppliers are well established companies with many years of experience and are approved by FMC.

1. **Drammen Automasjon (Siemens):** A well-established supplier that FMC is familiar with from before. As they deliver Siemens PLC, they are the most expensive supplier and not widely known for good support on smaller projects. Drammen Automasjon also gave an indication that they were not going to be available for training the project group.
2. **Beijer Electronics (Mitsubishi):** A supplier that FMC has ordered PLC systems from many times before. As Siemens, Mitsubishi is also a renowned manufacturer of PLCs, only more affordable. They also accommodate smaller systems better. Service wise, Beijer Electronics seems to be a good option as FMC have automaticians trained in the Mitsubishi software, therefore future upgrades could easily be applied.
3. **Goodtech (Allen-Bradley):** The most affordable alternative so far. In addition to low priced hardware they also offer a free software which is very accessible. There are people stationed at FMC, while being employed by Goodtech. This makes it much easier to get in contact with the supplier for future upgrades, service and follow-up. Since this is a student project, Goodtech offered to give 1-2 days of coursing if we choose them as the supplier.
4. **Phoenix Contact (Phoenix Contact):** Offers free software and is very service oriented. The PLC they supply is designed for small systems and the software is easy to use. Unfortunately Phoenix is the least established supplier of the four.

Conclusion

For FMC, the most important criteria when selecting parts is the supplier and not the manufacturer. Goodtech was the supplier which could offer the best product at the lowest price. They are also very accessible as they have a consultant placed at FMC, full time. The manufacturer is not the most established of the four, but will perform satisfactory in a system as simple as the PTW is.

4 Uncritical Studies

The following list concisely lists the design choices deemed less critical for the system as a whole, and that it's not time-wise worth analyzing with pinpoint accuracy.

It should be noted that analyses of electrical components, such as sensors, are only the project group's suggestions to possible solutions. The students cannot guarantee, due to lack of necessary electrical competence, that the proposed alternatives will work as expected in the system. All electrical selections should be reviewed by certified personnel.

The project group sent a list of component specifications to Tor Furuvald, responsible for purchasing at FMC's WAS department. This resulted in numerous component alternatives, some of which have been selected for the system.

4.1 Bolts and Nuts etc.

Analysis
Bolts and nuts must comply with applicable standards in corrosive/alkaline environments.

Conclusion
All mechanical fasteners shall be of stainless steel 316 A4 according to ISO 3506.

4.2 Chemical Vapor Filtering

Analysis
The system requires something to filter hazardous chemical soap vapors to the workshop environment. A regular breather type can be used to condense vapor and filter particles, while an active coal filter will neutralize some or all of the vapors. Active coal filters are generally expensive and require accurate particle filtering before fluids can enter it.

Conclusion
A breather type filter is determined to be sufficient for the system. The filter "Triceptor Desiccant Type Breather", supplied by Parker[1] has been selected.

If even finer filtration is deemed necessary after tests, an active coal filter, like "OIL-X EVOLUTION", could possibly be implemented. This filter is also supplied by Parker.

4.3 PL Pressure Bleed-off(C)

Analysis
A pressure relief/overflow valve is required, and is selected for the system. Another option considered is a combination consisting of a shut-off valve (e.g. a ball valve) and pressure transmitters connected to the PLC could work, but would be both expensive and complex.

Conclusion
The overflow valve "UV 5.1", supplied by VP Service/Mavix/Valnor and manufactured by Pressure Tech[2], has been selected for the system.

[1] http://ph.parker.com/us/en/filters-separators-purifiers
[2] http://pressure-tech.com/UV_51.html

4.4 Flow Control

Analysis

The system requires a component to adjust the pipeline backpressure to secure sufficient fluid velocity. Hundreds of options exist to perform this task: simple choke valves (e.g. needle), flow-rate valves, pressure regulators (that will implicitly regulate flow) and so on.

Choke valves are affordable and easy to use due to their simple design. Flow-rate valves can include one-way return circuits and other regulating components, raising the component cost significantly. What's included in the valve body varies greatly with the manufacturer.

Conclusion

A simple choke valve is sufficient for the system. The valve "Strupev. 3/4" 210 bar", supplied by Egil Eng[3] has been selected.

4.5 2-way NO Valve

Analysis

We need a 24V solenoid valve that will stay NO. There are two viable options that are both electrically controlled: actuated by electromagnetism or by pneumatics. Electromagnetically actuated valves do not require a pressurized air supply and an additional pilot valve, while pneumatic ones do. For this reason, electromagnetically actuated valves are generally expensive on their own, but require less additional equipment to work.

Conclusion

An electromagnetically actuated valve is suitable for the system. The "8259250.9151.02400 NO, 1/2"" valve, supplied by Norgren[4] and manufactured by Buschjost[5], has been selected.

4.6 2-way NC Valves

Analysis

These valves are identical to the NO valve, with the exception of their normal function, which will close the valve.

Conclusion

Electromagnetically actuated valves are suitable for the system. The "8259514.9401.02400, 8259514.9401.02400, 8256200.8001.02400, 8259314.9151.02400, 8259314.9151.02400, 8256200.8001.02400 and 8256200.8001.02400" valves, supplied by Norgren[6] and manufactured by Buschjost[7], have been selected.

[3] http://egileng.no/produkter/DTFT1251234
[4] http://store.norgren.com/uk/en/list/valves/solenoid-valve-without-differential-pressure
[5] http://www.buschjost.com/
[6] http://store.norgren.com/uk/en/list/valves/solenoid-valve-without-differential-pressure
[7] http://www.buschjost.com/

4.7 Level Monitoring (soap mix and clean water)

Analysis

Monitoring of the liquid levels in both main reservoirs is required. This sensor can either be a float type, ultrasound, submersible or non-submersible. There are many options here, but these are most common for level monitoring. Float-types are affordable and easily adjustable, but rely on moving parts; so the floater may get stuck, which increases the amount of service intervals. Ultrasound is reliable but expensive, which goes for submersible types as well. Non-submersible types are generally affordable, service friendly (no moving parts) and accurate.

Conclusion

A non-submersible level transmitter can be suitable for the system. The "Vegabar 14" sensor, produced by Vega[8] and supplied by HypTeck[9], has been selected.

The second suggestion is the submersible level transmitter "*Nivåtransmitter, keramisk membran, 4..20mA"* supplied by Stork Elektro & Automasjon.
These suggestions apply for both the main circuit and safety circuit.

4.8 Level Monitoring (soap concentrate)

Analysis

Monitoring of the liquid level in the soap can is required. Load cells, micro switch & spring arrangements, float-types, ultrasound and submersible pressure transmitters are among the options considered. Load cells are typically complex, signal/programming-wise, while being practical due to their external placement. Micro switch & spring is very affordable but provides limited and complex adjustment options. Float-types may not work well here since they take up too much space (they have to fit through the canister opening). Ultrasound is, as before, too expensive. Submersible transmitters are tough and reliable, can be expensive; and will raise the same issues as float-types, yet not to such a degree.

Conclusion

A submersible pressure transmitter is suitable for the system. The "*Nivåtransmitter, keramisk membran, 4..20mA*" sensor, supplied by Stork Elektro & Automasjon[10], has been selected.

4.9 Temperature Monitoring

Analysis

The system requires something to monitor the temperature at the tube outlet. This sensor can either be inserted into the fluid stream in the pipes (in-line), or strapped on externally to measure the surface temperature. In-line sensors will more quickly read the correct temperature, while costing about the same as strap-on versions.

Conclusion

The in-line temperature transmitter "Temperaturføler m/transmitter 4..20mA", supplied by Stork has been selected.
The other alternative is type MH resistance sensor with or without type MH clamp, supplied by HypTeck.

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[8] http://www.vega.com/en/index.htm
[9] http://www.hypteck.no/startside
[10] http://stork.ipb.no/default.aspx?gid=1

4.10 Pressure Monitoring

Analysis

The system requires something to monitor the active air and water pressures. The only viable option for pipe pressure monitoring is in-line pressure transmitters.

Conclusion

The "Vegabar 14" sensor, produced by Vega and supplied by HypTeck, has been selected.

4.11 Particle Filtering(C)

Analysis

The system requires something to filter particles larger than 5µm from the working fluids. The phone call Olav had with Egil Eng AS provided sufficient information about their submersible filters. No additional options have been explored as the price offered from Egil Eng AS is more than satisfactory.

Conclusions

The submersible return line filter "FIK-FIO", supplied by Egil Eng AS[11], manufactured by Donaldson[12] has been selected.

4.12 Filter Guard /Indicator

Analysis

The selected particle filter has an integrated filter guard that will monitor fill-ups.

Conclusions

No additional guard is deemed necessary for the system. The integrated guard will suffice.

4.13 Jet Clean(C)

Analysis

A variety of micro-switches exist on the market with many different trigger mechanisms: rollers, flat arms, buttons etc. Only a few switches are insulated to the required IP-grade of the system. Both rollers and flat arms provide the leeway needed for the Jet-clean process.

Conclusions

The micro-switch "SPDT Short Hinge Lever Microswitch, 2 A@ 250 V ac, 2 A@ 30 V dc" supplied by RS[13] has been selected.

[11] http://egileng.no/kategori/returfilter
[12] http://www.emea.donaldson.com/en/index.html
[13] http://no.rs-online.com/web/p/microswitches/6989823/

4.14 Soap Pump(C)

Analysis

Both the MiniDos and SuperDos solutions from Hydro Systems[14] can fulfill the system requirements. The Minidos model has a higher pressure rating while costing almost the same as SuperDos.

Conclusion

The MiniDos model has been selected for the system.

4.15 Main Pump(C)

Analysis

Most pumps of this type of stainless steel 316 and with reasonable capacities cost and weigh about the same. Centrifugal pumps from both Intec Pumper AS and LFG have been considered. The Intec pump is also the current pump in use in the Unison washer, making it the more available alternative.

Conclusion

The centrifugal pump "Stainless steel two-stage end suction centrifugal 2CDXU", supplied by Intec Pumper AS[15] and manufactured by Ebara[16], has been selected.

4.16 Warning Lights

Analysis

The system requires warning lights to signal its current state to the workshop environment and operator. A range of colors are available, but a four-colored stack consisting of green, yellow, red and blue is sufficient for the system.

Conclusion

The light stack "LED lystårn, kompakt 37", supplied by Elfa[17] and manufactured by Werma, has been selected.

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[14] http://hydrosystemsco.com/product/minidos/ - http://hydrosystemsco.com/product/superdos/
[15] http://www.pumper.no/produkter/vannforsyning/torroppstilte/ebara-2cdx.html
[16] http://www.pumpsebara.com/products/2cdxu-2cdu/
[17] https://www.elfaelektronikk.no/elfa3~no_no/elfa/init.do?item=10-795-25&toc=20093

4.17 PLC(C)

Analysis

The selected PLC and its accessories have been selected based on GoodTech's recommendation of required I/O ports and electrical specifications.

Conclusion

The following products are supplied by Goodtech[18] and manufactured by Rockwell/Allen-Bradley[19].

- PLC: 2080-LC50-48QWB (28DI , 20DO)
- Expansion module: 2085-OW8
- HMI: 2711C-T4T
- Power supply: 1606-XLS240E
- Communication switch: Opal5 (a more affordable option from Kyland[20])

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[18] http://www.goodtech.no/
[19] http://www.rockwellautomation.com/
[20] http://www.kyland.com/

Appended Datasheets

All datasheets are located at ***Portable Tube Washer Project 2015\Appendices\3. Manufacturing\M1. Technology Document\Appendices***, if you have access to this folder.

A. Soap Pump - MiniDos

B. Heating - DEL 27kW SLi

C. Jet Clean - Microswitch 698-9823

D. Main Pump - 2CDXU 1611200000B

E. PL Pressure Bleed-off - Overflow Valve

F. Particle Filtering - FIK-FIO 180/02, K051116

G. PLC and Accessories

PLC: 2080-LC50-48QWB (28DI , 20DO)
Expansion module: 2085-IF
HMI: 2711C-T4T
Power supply: 1606-XLS240E
Communication switch: Opal 5

H. Chemical Vapor Filtering - Triceptor 934330T

I. Flow Control - Strupev. 3/4" 210 bar DTFT1251234

J. 2-way NO/NC valves - E82560/90

8259250.9151.02400, 8259514.9401.02400, 8259514.9401.02400, 8256200.8001.02400, 8259314.9151.02400, 8259314.9151.02400, 8256200.8001.02400, 8256200.8001.02400.

K. Level and Pressure Monitoring - Vegabar 14

L. Level Monitoring (soap concentrate) - Nivåtransmitter

*K*eramisk membran, 4..20mA

M. Temperature Monitoring - Temperaturføler

m/transmitter 4..20mA

N. Warning Lights - LED lystårn, kompakt 37

M2. PLC Documentation

Portable Tube Washer Project 2015\Appendices\3. Manufacturing\M2. PLC Documentation

Automatic operation has been a crucial factor to this project, hence the need for a Programmable Logic Contorller (PLC). As no code has been produced, due to the no-go decision to construct the product, the project group has invested a lot of time in making the PLC documentation as thoroughly as possible. With the produced documentation, a skilled PLC programmer should be able to write code, fulfilling the intended purpose of all processes and components.

Henrik Lind, with help from the other group members, has worked closely with FMC to make sure the information provided is sufficient to program the PLC to FMC's requirements. Information about the selection of PLC supplier can be found in the technology document.

P&I 297

Cause & Effects Matrix 298

Process Flowcharts 299

Instrumentation & Valve List 300

P&I

The P&I is a diagram describing which components are included in the system, their addressed locations and piping. All other PLC documents have references to the P&I.

The P&I diagram is located in the *Portable Tube Washer Project 2015\Appendices\3. Manufacturing\M2. PLC Documentation\P&I Diagram* folder.

Cause & Effects Matrix

This matrix links causes, given by a sensor input, to one or more effects e.g. a valve closing.

The Cause & Effects Matrix is located in the *Portable Tube Washer Project 2015\Appendices\3. Manufacturing\M2. PLC Documentation\Cause & Effects Matrix* folder.

Process Flowcharts

The flowcharts are made to visualize the cycle of the PTW and its underlaying processes. Combining this document with the P&I will make a programmer able to program the different processes.

The Process Flowcharts are located in the *Portable Tube Washer Project 2015\Appendices\3. Manufacturing\M2. PLC Documentation\Process Flowcharts* folder.

Instrumentation & Valve List

This document is used to preset the different levels of the sensors for programming. It also states the components' specific material information, how they function, the medium it is subjected to, etc.

The Instrumentation & Vales List is located in the *Portable Tube Washer Project 2015\Appendices\3. Manufacturing\M2. PLC Documentation\Instrumentation & Valves List* folder.

M3. Purchase List

Portable Tube Washer Project 2015\Appendices\3. Manufacturing\M3. Purchase List

The purchase list is as natural supplement to the technology document, listing prices and suppliers of selected components. It is located in the *Portable Tube Washer Project 2015\Appendices\3. Manufacturing\M3. Purchase List* folder.

M4. Test Plan & Specification

Portable Tube Washer Project 2015\Appendices\3. Manufacturing\M4. Test Plan & Specification

Test Plan & Specification

Version 3

Version	Date	Changes	Status	Responsible
1	01.02.2015	Created document		Alexander A. (plan) and Henrik L.(spec)
2	17.03.2015	Updated document for the second presentation.	Under construction. Unable to finalize the document before order for components are done.	Henrik Lind
3	13.05.2015	Formatting and small corrections.	Ready for final delivery.	Henrik Lind Alexander Araya

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Bjørnar D. Døviken	
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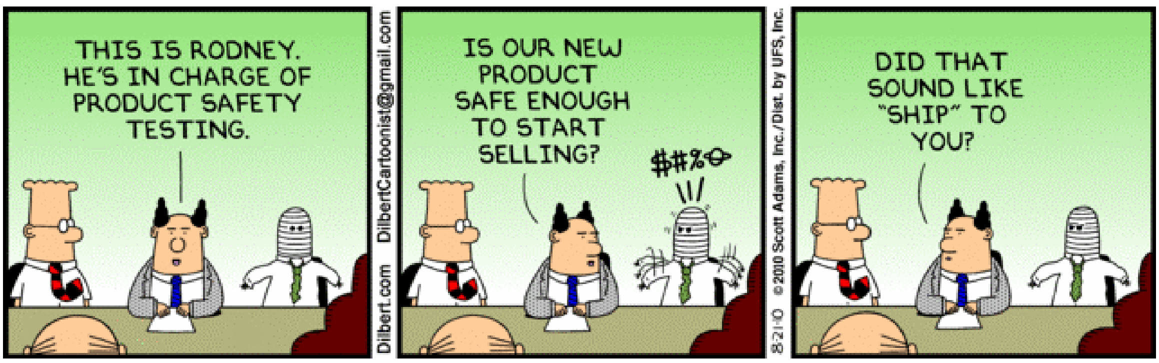
Introduction

This document contains a test plan and a test specification.

The *test plan* exists to make sure the project group gets a common understanding of how the components, sub-systems and the system will be tested. This includes the level of testing and what methods will be used to make sure that the system has been verified and validated, basically to make sure the right system is built. It is also included a section about the importance of testing for the same reason as above, to have a common understanding of why testing is necessary.

The *test specification* will address how each requirement will be tested on a specific level. As there is going to be many different tests, the project group decided to put each test into different tables which will make the document easier to navigate. Each table will include an identification of the test, some cross-references for knowing the test's origins and general information about the test.

Under Certified Tests are all the tests and approvals that must be performed by authorized technicians. This will normally include things such as review and approval of electrical wiring diagrams, check that the design is in accordance with declaration of conformity, etc.



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Glossary and Acronyms

Name	Description
C	Component
SS	Sub-System
S	System
TBL	To be Decided Later
PTW	Portable Tube Washer
JC	Jet Cleaner
WH	Water Heater
HMI	Human Machine Interface

Table 17 - Glossary and Acronyms

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1 Importance of Testing

When working in a large project, individual parts and software units are often developed separately before merged together into one complex integrated system. A system is commonly defined to be “a collection of hardware, software, people, facilities, and procedures organized to accomplish some common objectives”. This makes testing a system up against requirements a very important part in the process of developing a product. Testing can make the developers detect issues at an early stage and therefore minimize risking a lot of money as well as the time limit of the project. It is essential to make sure that the finished product meets the customer needs and key requirements, or else the system produced will be a failure. There are many levels of testing, which this document will explain.

The purpose of testing can be summed up in two words: Verification and Validation (V&V). Verifying something means that the component, sub-system or the system complies with one or several requirement(s) from the requirement specification. Validation however usually involves the customer and confirm that the customer agrees that the final product is doing what it was expected to do.

If verification fails, it is a result of a design error and mean that the system is incomplete or otherwise unusable. If validation fails it would mean that the requirements were not correctly defined to begin with.

2 Test Methods

The testing strategy in this section explains how the project group makes sure, in the long run, that the right system is build. It is crucial to make sure that the product meets the customer needs, requirements and key performances. The project group's approach to achieve this long term goal is by using several test methods. The methods will be briefly described and explained why they are included.

A strategy can evolve as time passes, conditions change and the understanding of things learned may increase. The project group has decided for a strategy that involves the bottom-up approach. That implies that all component will be tested first, then sub-systems and last as a system. But due to the less complex way the PTW is constructed and built, there will not be necessary with many tests in a sub-system level, unless they are evaluated as necessary of practical reasons.

Using this strategy has its pros and cons. Some of the advantages are easier detection of flaws on component level, easier creation of test conditions and that observation of the test results simplifies. A disadvantage of this approach is that it will be impossible to start verification of the product before the whole system is assembled.

2.1 Levels of Testing

Component testing (C) – This is testing at the lowest level and involves testing a component in isolation from the system. It is decided that even though purchased parts can be a system by themselves, they will be treated as a single component. Component testing involves only those characteristics that are vital to the performance of the component.

Each component will be tested and validated when proper documentation is gathered, such as technical specification and data sheet. Therefore it will be used a checklist of purchased parts and the documentation from the manufacturer to verify that this is correct. Exceptions will be made for some components that will be physically tested.

Components tested while connected to the PLC will still be considered a component test. An example of this is that sensors will be connected to the PLC to check the conversion factor.

Sub-system testing (SS) – It is decided that there is no need for major testing at this level, as stated earlier, due to the low complexity of the system and the way the PTW is constructed. It is not necessary to test the interaction between components until they are assembled as a complete system, since testing on component level will confirm that the component have the right specifications. Testing on sub-system level will only be considered if necessary. When tested on a sub-system level there will be no need to test to the same extent in the system.

System testing (S) – This is the highest level of testing in the development stage, where the entire system will be tested for all its current functionalities. This level is also a verification that the system works according to the key requirements. Tests at this level will mostly be functional and performance oriented by running user scenarios.

It is also envisaged that components will be tested at system level to ensure that they work as intended. An example of this is the sensors, they will have to be calibrated by testing once they are assembled in the completed system.

2.2 Static and Dynamic Testing

Static testing is a visual inspection of the components and the system without needing to set anything in motion. It consists of visual analysis of workmanship, drawings and a component's specifications up against production documentation. Static testing method will typically be used on component testing level.

Dynamic testing is a method of assessing the functionality of a component or system by giving input and examining output (I/O). It is to describe the testing of the dynamic behavior of a component, sub-system or system. Dynamic analysis refers to the examination of the physical response from the system to variables that change with time. The dynamic testing method will typically be used when testing on sub-systems and system level.

2.3 How to Read the Tests

2.3.1 Identifying a Test

Test		Category		Sub category		Test number
T	**-**	**XXX**	**-**	**X**	**-**	**XX**

Figure 6 - Reading the test ID#

NOTE!

- **Black** colour on test ID# means that the test is **VALID**
- **Red** colour on test ID# means that the test has **EXPIRED**

Identification	
Test ID#	Unique test ID number
Test name	Name of test
Test description	How the test is to be performed **Preparations:** What we will have to do before starting the test **During test:** What we will have to do during the test
Test level	What level the test is to be performed in
Cross-reference	
Requirement ID#	Requirement ID number from requirement specification
Requirement description	Description of requirement
UseCase Flowchart#	Reference to UseCase Flowchart ID number
Information	
Test equipment	Equipment required for performing the test
Success criteria	Required/expected performance
Test site	Where the test are to be executed
Author	Name of test author
Tested by	Who have performed the test
Date of first test	Date
Number of test runs	Number of test runs
Results w/ comments	
Date of last test	Date
Final result	Passed/failed

Table 18 - Description of a test

2.3.2 Safe Mode and Fail Safe

Here is a representation of Safe Mode and what sensor values may be triggering it. It also points out the differences between Safe Mode and Fail Safe.

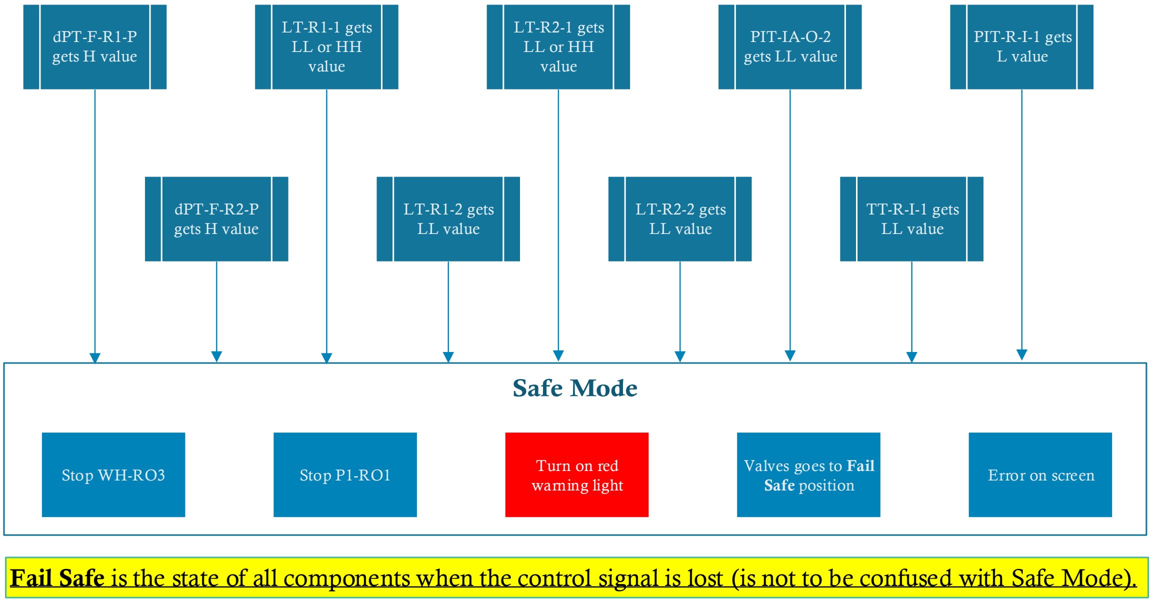


Figure 7 - Safe Mode & Fail Safe

3 Test Specification

3.1 Cross References

Test ID#	Requirement ID#	Test name	UseCase Flowchart#	Test level
T-CAP-A-01	R-CAP-A-01	Automatic mixing soap with water		S
T-CAP-A-02	R-CAP-A-02	Adjustable soap mixing ratio		C (has own table)
T-CAP-A-03	R-CAP-A-03	Automatic washing operation	2.2	S
T-CAP-A-05	R-CAP-A-05	Jet Clean	2.2	S
T-CAP-A-06	R-CAP-A-06	Washing cycle temperature		S
T-CAP-D-01	R-CAP-D-01	Hose length	2.1	S
T-CAP-D-02	R-CAP-D-02	Tube fixture capacity	2.1	S
T-CAP-P-01	R-CAP-P-01	Maximum cycle time	2.2	S
T-MAF-01	R-MAF-01	Signal lights	4.1	S
T-MAF-02	R-MAF-02	Pressure monitoring	2.2	S
T-MAF-04	R-MAF-04	Temperature monitoring		S
T-MAF-05	R-MAF-05	Liquid level monitoring		S
T-INT-E-04	R-INT-E-04	Tube fixture	2.1	S
T-SAF-S-04	R-SAF-S-04	Monitoring system failure	4.1	S
T-SAF-S-05	R-SAF-S-05	Power failure/recovery	4.1	S
T-SAF-S-06	R-SAF-S-06	Emergency stop	4.1	S
T-SAF-U-01	R-SAF-U-01	Hot surfaces		S
T-SAF-U-03	R-SAF-U-03	Pressurized interfaces		S
T-SAF-U-05	R-SAF-U-05	Condition for start of cycle	2.2	S
T-TAS-T-01	R-TAS-T-01	PTW mobility		S
T-TAS-T-03	R-TAS-T-03	Fork pockets	1.1	S
T-TAS-S-01	R-TAS-S-01	Draining of fluids	1.1	S
T-PHY-01	R-PHY-01	Max size of system	1.1	S
T-PHY-02	R-PHY-02	Fixed place for soap canister	3.1	S
T-PHY-05	R-PHY-05	Tube fixture incline	2.1	SS
T-DOC-01	R-DOC-01	Documentation language		C
T-DOC-02	R-DOC-02	3D-Models file format		C
T-DOC-03	R-DOC-03	2D-drawings		C

Certified Tests				
T-SUP-01	R-SUP-01	Power supply	1.2	S
T-SUP-02	R-SUP-02	Electric connection	1.2	S
T-INT-U-02	R-INT-U-02	Location of buttons and HMI		S
T-INT-U-03	R-INT-U-03	Emergency stop button		S
T-SAF-S-02	R-SAF-S-02	Protection of the electrical system		
T-SAF-E-01	R-SAF-E-01	Contaminated fluid		SS/S
T-SAF-W-02	R-SAF-W-02	Noise levels		S
T-SAF-U-06	R-SAF-U-06	Personal Protective Equipment		C
T-DES-01	R-DES-01	Interchangeability		C
T-DES-04	R-DES-04	PLC Distributor		
T-TAS-T-02	R-TAS-T-02	Hookup point for secure transportation		C
T-INS-02	R-INS-02	Maintenance manual		C
T-INS-04	R-INS-04	User manual		C
T-INS-05	R-INS-05	Warning stickers		S
T-DES-02	R-DES-02	Modular construction		S

Table 19 - Requirements cross-references

3.2 Component Tests

Component	Requirement	Right part received & data sheet obtained	Damage check	Physical test (optional) Description	Check
Pump					
Water Heater	R-CAP-A-04				
Temperature transmitter	R-MAF-04			Connect to PLC, manipulate and check signals	
Level transmitter (water)	R-MAF-05			Connect to PLC, manipulate and check signals	
Level transmitter (mix)	R-MAF-05			Connect to PLC, manipulate and check signals	
Level transmitter (soap)	R-MAF-05			Connect to PLC, manipulate and check signals	
Pressure transmitter (end of tubing)	R-MAF-02			Connect to PLC, manipulate and check signals	
Micro switch (plug)					
Soap pump	R-CAP-A-02			See T-CAP-A-02 for description	
Air drying filter	R-CAP-P-03				
Air particle filter	R-CAP-P-05				
Water particle filter	R-CAP-P-06				
24V Powered Valves	R-SUP-03				
Colored light stack	R-MAF-01				
Water quick connection	R-INT-E-01				
Air quick connection (1/2" Hansen)	R-INT-E-02				
Manual reservoir drainage valve	R-INT-E-03				
A-lock Parker A/S all internal tube	R-INT-I-01				

fittings					
HMI	R-INT-U-01			Connect to PLC and check	
Quick connection hose to tube	R-INT-U-04				
Vapor filter (reservoirs)	R-SAF-W-01				
Antistatic hoses	R-SAF-U-02				
Blinding caps	R-TAS-S-03				
Component markings	R-INS-03				
PLC after power loss	R-SAF-S-03			Shall remember last selected program	
Emergency button	R-SAF-S-06			Test while connected to PLC	
Software upgrade	R-UPG-01			Verify the requirement	
Hardware upgrade	R-UPG-02			Verify the requirement	

Test Table 1 – Component test list

3.3 Tests

Identification	
Test ID#	T-CAP-A-01
Test name	Automatic mixing soap with water
Test description	**Preparations:** **During test:** When the level sensor for the water/soap mix reservoir reaches low(L), the PTW shall open the valve for inlet water, and the soap shall be injected into the water stream and stop when it reaches high(H). By visual inspection we will verify that the soap mixes automatically with the water.
Test level	S
Cross-reference	
Requirement ID#	R-CAP-A-01
Requirement description	The process of filling the reservoir and mixing the soap with the water shall be automated.
UseCase Flowchart#	
Information	
Test equipment	Measuring cup
Success criteria	Fill automatic to upper level height of reservoir +/- 5% and confirm that the soap level has been reduced.
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 2 - Automatic mixing soap with water

Identification	
Test ID#	T-CAP-A-02
Test name	Adjustable soap mixing ratio
Test description	**Preparations:** Connect the Hydromaster minidos to a hose in each end. Connect one end to a water tap. **During test:** Soap pump connects to water in main stream, the soap inlet I connected to a hose put in a measuring cup filled with water. When approximately 10 liter has gone through the pump the measuring cup shall be checked to see how much water was mixed into the stream. That the soap pump I adjustable shall be confirmed with the data sheet.
Test level	C (see own table)
Cross-reference	
Requirement ID#	R-CAP-A-02
Requirement description	The mixing ratio of soap with water shall be adjustable. The mixing ratio must not differ more than +/- 10%.
UseCase Flowchart#	
Information	
Test equipment	Measuring cup, canisters, data sheet
Success criteria	Mix ratio must not differ more than +/- 10%
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 3 - Adjustable soap mixing ratio

Identification	
Test ID#	T-CAP-A-03
Test name	Automatic washing operation
Test description	**Preparations:** Mount dummy pipe. Start a washing cycle from the PLC. **During test:** We will monitor the PLC/computer during the whole cycle, and confirm the correct cycle
Test level	S
Cross-reference	
Requirement ID#	R-CAP-A-03
Requirement description	The washing cycle shall be fully automated. (exception: Jet Clean)
UseCase Flowchart#	2.2
Information	
Test equipment	Dummy tube
Success criteria	The washing cycle shall run from start to end without any user interactions. All processes shall run as intended.
Test site	FMC workshop
Author	Alexander Araya
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 4 - Automatic washing operation

Identification	
Test ID#	T-CAP-A-05
Test name	Jet Clean
Test description	**Preparations:** Define SS. JC is placed in its holster. **During test:** Step 1: Finish one washing cycle. Don't trigger the MS-JC sensor. Try starting a new washing cycle. Step 2: Finish one washing cycle. Trigger the MS-JC sensor by lifting JC. Trigger MS-JC again by placing JC back.
Test level	S
Cross-reference	
Requirement ID#	R-CAP-A-05
Requirement description	After a successful washing cycle, the PTW shall get a confirmation from the plug shooting system, before allowing a new washing cycle to start.
UseCase Flowchart#	2.2
Information	
Test equipment	Jet Cleaner
Success criteria	Step 1: A new washing cycle can't be started. Step 2: *Outcome 1:* Triggering the MS-JC by placing JC back before 10 sec shall make the timer reset and not allow a new cycle to be started. *Outcome 2:* Triggering the MS-JC by placing JC back after 10 sec shall make the PTW allow a new cycle to be started.
Test site	FMC workshop
Author	Alexander Araya
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 5 - Jet Clean

Identification	
Test ID#	T-CAP-A-06
Test name	Washing cycle temperature
Test description	**Preparations:** Connect washing hoses to the dummy tube, start washing cycle. **During test:** Monitor the temperature from the sensor TT-R-I-1 on PLC. Measure temperature with reference gauge at end of dummy pipe and compare the two.
Test level	S
Cross-reference	
Requirement ID#	R-CAP-A-06
Requirement description	The PTW shall deliver water from +55°C and above.
UseCase Flowchart#	
Information	
Test equipment	Calibrated temperature reference gauge, 6000 mm dummy pipe
Success criteria	The temperature at the end of the dummy pipe shall reach +55°C and stay constant over time.
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 6 - Washing cycle temperature

Identification	
Test ID#	T-CAP-D-01
Test name	Hose length
Test description	**Preparations:** Mount the dummy tube on the tube fixture. Connect the washing hoses to each end of the tube. **During test:** Visual inspection of the SS. Measure total gap between ends of hoses, ends oriented to each other.
Test level	S
Cross-reference	
Requirement ID#	R-CAP-D-01
Requirement description	The PTW washing hoses shall be able to handle tube length variations from 100 mm to 6000 mm.
UseCase Flowchart#	2.1
Information	
Test equipment	6000 mm dummy tube (without bends), tube fixture
Success criteria	The hoses shall be of a length sufficient to connect to each end of the dummy pipe without applying tension.
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 7 - Hose length

Identification	
Test ID#	T-CAP-D-02
Test name	Tube fixture capacity
Test description	**Preparations:** 2 tubes mounted in fixture and run washing cycle. **During test:** Visual observation of tubes during cycle.
Test level	S
Cross-reference	
Requirement ID#	R-CAP-D-02
Requirement description	The tube fixture shall be able to handle minimum 2 tubes simultaneously.
UseCase Flowchart#	2.1
Information	
Test equipment	2 x 6000 mm dummy pipes ¾" size
Success criteria	The tube fixture shall remain stable at full weight of the pipes with max water pressure applied from PTW.
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 8 - Tube fixture capacity

Identification	
Test ID#	T-CAP-P-01
Test name	Maximum cycle time
Test description	**Preparations:** Connect tube to tube fixture. Start a washing cycle. **During test:** Start the timer when the washing cycle starts (excluding heating loops). Stop timer when the cycle is finished and next required step in shooting plug.
Test level	S
Cross-reference	
Requirement ID#	R-CAP-P-01
Requirement description	The maximum time to run one complete washing cycle is 3,5 minutes.
UseCase Flowchart#	2.2
Information	
Test equipment	Timer
Success criteria	One cycle is finished in under 3,5 minutes.
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 9 - Maximum cycle time

Identification	
Test ID#	T-MAF-01
Test name	Signal lights
Test description	**Preparations:** A computer connected to the PLC. Print the cause and effect matrix. **During test:** Trigger different states in the program and confirm which color lights up. Use the cause and effect matrix to confirm that the right colored light is lit. All states shall be checked.
Test level	S
Cross-reference	
Requirement ID#	R-MAF-01
Requirement description	There shall be a colored lights stack that will indicate the state of the PTW.
UseCase Flowchart#	4.1
Information	
Test equipment	Computer with PLC software installed. Cause and effects matrix.
Success criteria	The right color shall be lit according to the state the PTW is in.
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 10 - Signal lights

Identification	
Test ID#	T-MAF-02
Test name	Pressure monitoring
Test description	**Preparations:** Mount analog reference gauge to hose. **During test:** Pressurize the system in steps by 0,5 bars. Manually read pressure on the gauge and compare this with PLC signals.
Test level	S
Cross-reference	
Requirement ID#	R-MAF-02
Requirement description	The PLC shall monitor the system pressure.
UseCase Flowchart#	2.2
Information	
Test equipment	Calibrated pressure reference gauge, equipment to raise pressure in steps.
Success criteria	The pressure on the reference gauge and the registered pressure on the PLC is the same in all steps.
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 11 - Pressure monitoring

Identification	
Test ID#	T-MAF-04
Test name	Temperature monitoring
Test description	**Preparations:** Mount analog reference gauge on hose for checking temperature. **During test:** Manually read temperature on reference gauge and compare this with PLC registered temperature.
Test level	S
Cross-reference	
Requirement ID#	R-MAF-04
Requirement description	The system shall monitor the washing cycle temperature.
UseCase Flowchart#	
Information	
Test equipment	6000 mm dummy tube, calibrated temperature reference gauge
Success criteria	When the temperature reaches low(L) the timer for the process shall start. The reference gauge temperature equals the PLC registered temperature.
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 12 - Temperature monitoring

Identification	
Test ID#	T-MAF-05
Test name	Liquid level monitoring
Test description	**Preparations:** Measure and mark critical levels in reservoirs. A computer connected to the PLC, print the cause and effect matrix. **During test:** Trigger different states for the level transmitters in the program and use the cause and effect matrix to confirm the effect. All states shall be checked.
Test level	S
Cross-reference	
Requirement ID#	R-MAF-05
Requirement description	The system shall monitor fluid levels (water, soap mix and soap canister).
UseCase Flowchart#	
Information	
Test equipment	Measuring tool, marker.
Success criteria	The right component shall be activated/deactivated according to the cause and effect matrix and at marked level.
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 13 - Liquid level monitoring

Identification	
Test ID#	T-INT-E-04
Test name	Tube fixture
Test description	**Preparations:** Mount dummy tube in fixture **During test:** Run washing cycle and visually inspect the pipe afterwards
Test level	S
Cross-reference	
Requirement ID#	R-INT-E-04
Requirement description	The tube fixture clamp shall not compromise the quality (scratches) of the tube.
UseCase Flowchart#	2.1
Information	
Test equipment	6000 mm dummy tubes of smallest and largest diameter.
Success criteria	There shall be no indication of scratches (by visual inspection)
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 14 - Tube fixture

Identification	
Test ID#	T-SAF-S-04
Test name	Monitoring system failure
Test description	**Preparations:** Power up PLC, run cycle **During test:** Part 1 (sensors): Disconnect sensors one at a time, both in standby and during washing cycle. Part 2 (components): Disconnect the pump and water heater signal circuit one at a time, both in standby and during washing cycle.
Test level	S
Cross-reference	
Requirement ID#	R-SAF-S-04
Requirement description	If a monitored component and/or any of the sensors fails/ is out of range the PTW shall stop any process (ref. Safe Mode).
UseCase Flowchart#	4.1
Information	
Test equipment	PC and hand tools
Success criteria	Part 1 (sensors): When a sensor fails/is out of range the PTW shall enter Safe Mode, even in standby mode. Part 2 (components): When either the pump or water heater fails the PTW shall enter Safe Mode, even in standby mode.
Test site	FMC workshop
Author	Alexander Araya
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 15 - Monitoring system failure

Identification	
Test ID#	T-SAF-S-05
Test name	Power failure/recovery
Test description	**Preparations:** Power up PLC, start cycle. **During test:** Cut power supply and power up again. Run test also in standby mode.
Test level	S
Cross-reference	
Requirement ID#	R-SAF-S-05
Requirement description	In case of loss and recovery of power supply the PTW shall go into Standby Mode.
UseCase Flowchart#	4.1
Information	
Test equipment	PLC
Success criteria	*When power is lost:* The system goes to Fail Safe. *When power is recovered:* The PTW shall enter standby mode.
Test site	FMC workshop
Author	Alexander Araya
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 16 - Power failure/recovery

Identification	
Test ID#	T-SAF-S-06
Test name	Emergency stop
Test description	**Preparations:** Emergency button wired **During test:** Push emergency button in every state of the washing cycle, standby and Safe Mode.
Test level	S
Cross-reference	
Requirement ID#	R-SAF-S-06
Requirement description	Pressing the emergency stop button shall bring the PTW to Safe Mode.
UseCase Flowchart#	4.1
Information	
Test equipment	
Success criteria	Every time the emergency button is pressed the PTW shall go into Safe Mode and stay there until the system is reset on the HMI, even if emergency button is released.
Test site	FMC workshop
Author	Alexander Araya
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 17 - Emergency stop

Identification	
Test ID#	T-SAF-U-01
Test name	Hot surfaces
Test description	**Preparations:** Run at least 3 full cycles **During test:** During last cycle, measure temperature at all relevant surfaces.
Test level	S
Cross-reference	
Requirement ID#	R-SAF-U-01
Requirement description	All external reachable surfaces of the PTW, shall not exceed a temperature higher than 45°C while running. Tubes and pipes for cleaning are excluded from this requirement.
UseCase Flowchart#	
Information	
Test equipment	Hand-held infrared temperature measurement instrument
Success criteria	The exposed surfaces does not exceed the temperature of 45°C.
Test site	FMC workshop
Author	Alexander Araya
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 18 - Hot surfaces

Identification	
Test ID#	T-SAF-U-03
Test name	Pressurized interfaces
Test description	**Preparations:** Pressurize the system, close pressure medium (nitrogen). **During test:** Spray on leakage seeker on every pressurized interface. Observe eventual bubbles over time. Observe pressure gauge on gas tank.
Test level	S
Cross-reference	
Requirement ID#	R-SAF-U-03
Requirement description	The PTW shall have no leakage at 10 bar pressure of air between any pressurized interfaces.
UseCase Flowchart#	
Information	
Test equipment	Dummy pipe, leakage seeker spray, gas tank (nitrogen)
Success criteria	There shall be no indication of bubbles from the leakage seeker sprayed area at 10 bar pressure after at least 10 minutes.
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 19 - Pressurized interfaces

Identification	
Test ID#	T-SAF-U-05
Test name	Condition for start of cycle
Test description	**Preparations:** Connect pressure transmitters, power up PLC. **During test:** Pressurize the transmitters according to process flowchart (step 1.0). Provoke failed self-test with a pressure drop >0,5bar. Provoke self-test with a pressure drop = <0,4bar.
Test level	S
Cross-reference	
Requirement ID#	R-SAF-U-05
Requirement description	The washing cycle shall not start if the pressure self-test fails.
UseCase Flowchart#	2.2
Information	
Test equipment	Analog pressure gauge.
Success criteria	The PTW does not start its cycle when the pressure self-test fails (drop > 0,5 bar in 10 sek). The PTW shall instead go to standby mode.
Test site	FMC workshop
Author	Alexander Araya
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 20 - Condition for start of cycle

Identification	
Test ID#	T-TAS-T-01
Test name	PTW mobility
Test description	**Preparations:** **During test:** Read total weight on complete 3D-model
Test level	S
Cross-reference	
Requirement ID#	R-TAS-T-01
Requirement description	The PTW shall be possible to be moved by one person.
UseCase Flowchart#	
Information	
Test equipment	
Success criteria	The total weight is under the 700 kg without fluids.
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 21 - PTW mobility

Identification	
Test ID#	T-TAS-T-03
Test name	Fork pockets
Test description	**Preparations:** Open complete 3D-model **During test:** Confirm placement of fork pockets according to requirement.
Test level	S
Cross-reference	
Requirement ID#	R-TAS-T-03
Requirement description	The fork pockets at the bottom of the PTW shall be possible to enter from all sides.
UseCase Flowchart#	1.1
Information	
Test equipment	3D-model
Success criteria	Entering the PTW from all sides with trolley and forklift is possible.
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 22 - Fork pockets

Identification	
Test ID#	T-TAS-S-01
Test name	Draining of fluids
Test description	**Preparations:** Run one cycle. Turn off the PTW **During test:** Drain pump and water heater.
Test level	S
Cross-reference	
Requirement ID#	R-TAS-S-01
Requirement description	It shall be possible to drain all remaining fluids in the system.
UseCase Flowchart#	1.1
Information	
Test equipment	
Success criteria	The pump and water heater can be drained.
Test site	FMC workshop
Author	Alexander Araya
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 23 - Draining of fluids

Identification	
Test ID#	T-PHY-01
Test name	Max size of system
Test description	**Preparations:** **During test:** Measure PTW 3D-model frame, including components outside the frame boundaries.
Test level	S
Cross-reference	
Requirement ID#	R-PHY-01
Requirement description	The size of the PTW shall not lead to extraordinary transportation requirements. (max $2{,}4 * 1{,}2 * 2{,}0$ meters).
UseCase Flowchart#	1.1
Information	
Test equipment	Measuring device, 3D-model
Success criteria	The system is no more than $2{,}4 * 1{,}2 * 2{,}0$ meters.
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 24 - Max size of system

Identification	
Test ID#	T-PHY-02
Test name	Fixed place for soap canister
Test description	**Preparations:** **During test:** Inspect 3D-model
Test level	S
Cross-reference	
Requirement ID#	R-PHY-02
Requirement description	The soap canister shall have a fixed place in the PTW.
UseCase Flowchart#	3.1
Information	
Test equipment	3D-model
Success criteria	The 3D-model shows that the sop canister has a fixed place in the system
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 25 - Fixed place for soap canister

Identification	
Test ID#	T-PHY-05
Test name	Tube fixture incline
Test description	**Preparations:** **During test:**
Test level	SS
Cross-reference	
Requirement ID#	R-PHY05
Requirement description	The tube fixture shall provide an incline to aid water in stream direction.
UseCase Flowchart#	2.1
Information	
Test equipment	Dummy tubes with different lengths and bending
Success criteria	The tube fixture provides an incline, aiding the water in stream direction.
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 26 - Tube fixture incline

Identification	
Test ID#	T-DOC-01
Test name	Documentation language
Test description	**Preparations:** **During test:** Inspect all relevant documentation
Test level	C
Cross-reference	
Requirement ID#	R-DOC-01
Requirement description	The following documentation shall be in English: • Requirements Specification • Project Plan • Test plan & specification • Technology document • Manuals • Production documentation • Final report
UseCase Flowchart#	
Information	
Test equipment	
Success criteria	All required documentation is made in English
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 27 - Documentation language

Identification	
Test ID#	T-DOC-02
Test name	3D-Models file format
Test description	**Preparations:** **During test:** Inspect all relevant files
Test level	C
Cross-reference	
Requirement ID#	R-DOC-02
Requirement description	The 3D-models shall be delivered in step AP214 file format.
UseCase Flowchart#	
Information	
Test equipment	3D-model files
Success criteria	All 3D-models are documented in a step AP214 file format
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 28 -3D-Models file format

Identification	
Test ID#	T-DOC-03
Test name	2D-drawings file format
Test description	**Preparations:** **During test:** Inspect all relevant documentation
Test level	C
Cross-reference	
Requirement ID#	R-DOC-03
Requirement description	All 2D-drawings shall be in DWG-format.
UseCase Flowchart#	
Information	
Test equipment	
Success criteria	All relevant 2D-drawings shall be in DWG-format
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 29 -2D-drawings

3.4 Certified Tests

Identification	
Test ID#	T-SUP-01
Test name	Power Supply
Test description	**Preparations:** Contact authorized personnel. **During test:** Authorized personnel controls wiring cabinet and wiring diagram.
Test level	S
Cross-reference	
Requirement ID#	R-SUP-01
Requirement description	The PTW shall use 400V, 50 Hz as primary electric power input.
UseCase Flowchart#	1.2
Information	
Test equipment	Wiring diagram
Success criteria	Wiring cabinet and wiring diagram shall be in accordance with declaration of conformity.
Test site	FMC workshop
Author	Alexander Araya
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 30 - Power Supply

Identification	
Test ID#	T-SUP-02
Test name	Electric Connection
Test description	**Preparations:** Contact authorized personnel. **During test:** Authorized personnel controls wiring cabinet and wiring diagram.
Test level	S
Cross-reference	
Requirement ID#	R-SUP-02
Requirement description	The electric connection for the PTW shall follow electrical standards.
UseCase Flowchart#	1.2
Information	
Test equipment	Workshop documentation on electrical standards, wiring diagram
Success criteria	Wiring cabinet and wiring diagram shall be in accordance with declaration of conformity.
Test site	FMC workshop
Author	Alexander Araya
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 31 - Electric Connection

Identification	
Test ID#	T-INT-U-02
Test name	Location of buttons and HMI
Test description	**Preparations:** **During test:** Control placement of buttons and HMI on the 3D-model
Test level	S
Cross-reference	
Requirement ID#	R-INT-U-02
Requirement description	The operational buttons and HMI shall all be placed on the same side of the cabinet, except emergency stop button(s).
UseCase Flowchart#	
Information	
Test equipment	3D-model and 2D-drawings
Success criteria	The location of the buttons and HMI on the 3D-model and 2D-drawings shall be placed correctly according to the requirement
Test site	FMC workshop
Author	Alexander Araya
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 32 - Location of Buttons and HMI

Identification	
Test ID#	T-INT-U-03
Test name	Emergency stop button
Test description	**Preparations:** **During test:** Inspect the 3D-model
Test level	S
Cross-reference	
Requirement ID#	R-INT-U-03
Requirement description	The emergency stop button(s) shall be located within reach of the operator.
UseCase Flowchart#	
Information	
Test equipment	3D-model
Success criteria	The emergency stop button is at the front panel.
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 33 - Emergency Stop Button

Identification	
Test ID#	T-SAF-S-02
Test name	Protection of the Electrical System
Test description	**Preparations:** Contact authorized technician **During test:** Check documentation
Test level	S
Cross-reference	
Requirement ID#	R-SAF-S-02
Requirement description	The protection of the electrical system shall meet the standard of Industry Standards (2006/42/EØS) with no less than IP 44.
UseCase Flowchart#	
Information	
Test equipment	Industry Standards (2006/42/EØS), technical data sheets
Success criteria	Wiring cabinet and wiring diagram shall be in accordance with declaration of conformity. The components and protection of the electrical system meets IP 44.
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 34 - Protection of the Electrical System

Identification	
Test ID#	T-SAF-E-01
Test name	Contaminated Fluid
Test description	**Preparations:** **During test:**
Test level	SS/S
Cross-reference	
Requirement ID#	R-SAF-E-01
Requirement description	Disposal of contaminated fluids from the reservoirs shall be handled after FMC regulations.
UseCase Flowchart#	
Information	
Test equipment	
Success criteria	The chosen filters pass the test criteria set by the Industry Standards (2006/42/EØS).
Test site	FMC workshop
Author	Alexander Araya
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 35 - Contaminated Fluid

Identification	
Test ID#	T-SAF-W-02
Test name	Noise Levels
Test description	**Preparations:** Start a washing cycle **During test:** Measure noise level during a full washing cycle (with plug shot)
Test level	S
Cross-reference	
Requirement ID#	R-SAF-W-02
Requirement description	Noise levels shall follow Industry Standards (2006/42/EØS).
UseCase Flowchart#	
Information	
Test equipment	Decibel meter
Success criteria	The noise level does not exceed accepted levels in accordance with Industry Standards (ref.2006/42/EØS).
Test site	FMC workshop
Author	Alexander Araya
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 36 - Noise Levels

Identification	
Test ID#	T-SAF-U-06
Test name	Personal protective equipment
Test description	**Preparations:** **During test:**
Test level	C
Cross-reference	
Requirement ID#	R-SAF-U-06
Requirement description	The operator shall use personal protective equipment against chemicals and hot surfaces.
UseCase Flowchart#	
Information	
Test equipment	Checklist
Success criteria	It is stated in the User Manual. + stickers on the PTW
Test site	FMC workshop
Author	Alexander Araya
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 37 - Personal protective equipment

Identification	
Test ID#	T-DES-01
Test name	Interchangeability
Test description	**Preparations:** **During test:**
Test level	C
Cross-reference	
Requirement ID#	R-DES-01
Requirement description	All parts in the PTW shall be of normal supply standards.
UseCase Flowchart#	
Information	
Test equipment	
Success criteria	All parts/components are from well-established companies.
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 38 - Interchangeability

Identification	
Test ID#	T-DES-04
Test name	PLC Distributor
Test description	**Preparations:** **During test:**
Test level	C
Cross-reference	
Requirement ID#	R-DES-04
Requirement description	PLC-control system shall be provided by a supplier approved by FMC.
UseCase Flowchart#	
Information	
Test equipment	Technical data sheet
Success criteria	PLC-control system is provided by a supplier approved by FMC.
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 39 - PLC Distributor

Identification	
Test ID#	T-TAS-T-02
Test name	Hookup point for secure transportation
Test description	**Preparations:** Run FEM-analysis with defined g-forces stated in rules and regulations for road transportation. **During test:**
Test level	S
Cross-reference	
Requirement ID#	R-TAS-T-02
Requirement description	The hookup points on the PTW shall withstand the load capacity described in rules and regulations for road transportation.
UseCase Flowchart#	
Information	
Test equipment	FEM-analysis
Success criteria	The hookup points shall resist the required stress load stated in the rules and regulation of transportation (x2).
Test site	FMC workshop
Author	Henrik Lind
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 40 - Hookup point for secure transportation

Identification	
Test ID#	T-INS-02
Test name	Maintenance manual
Test description	**Preparations:** Deliver first draft of the manual to FMC **During test:**
Test level	C
Cross-reference	
Requirement ID#	R-INS-02
Requirement description	The maintenance manual shall be complete with all content FMC requires and is approved by them.
UseCase Flowchart#	
Information	
Test equipment	
Success criteria	The maintenance manual is complete with all content information FMC requires and is approved by them.
Test site	FMC workshop
Author	Alexander Araya
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 41 - Maintenance manual

Identification	
Test ID#	T-INS-04
Test name	User manual
Test description	**Preparations:** Deliver first draft of the manual to FMC **During test:**
Test level	C
Cross-reference	
Requirement ID#	R-INS-04
Requirement description	The user manual shall be complete with all content FMC requires and is approved by them.
UseCase Flowchart#	
Information	
Test equipment	User manual
Success criteria	The user manual is complete with all requirements to content information FMC requires and is approved by them.
Test site	FMC workshop
Author	Alexander Araya
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 42 - User manual

Identification	
Test ID#	T-INS-05
Test name	Warning stickers
Test description	**Preparations:** **During test:** Locate stickers
Test level	S
Cross-reference	
Requirement ID#	R-INS-05
Requirement description	Stickers must be in accordance with regulations and standards.
UseCase Flowchart#	
Information	
Test equipment	
Success criteria	The PTW is marked as required due to Industry Standards (2006/42/EØS)
Test site	FMC workshop
Author	Alexander Araya
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 43 - Warning stickers

Identification	
Test ID#	T-DES-02
Test name	Modular construction
Test description	**Preparations:** **During test:**
Test level	S
Cross-reference	
Requirement ID#	R-DES-02
Requirement description	The design shall be made in such a way that everything is placed into the construction for accessibility, when need of repairs or maintenance.
UseCase Flowchart#	
Information	
Test equipment	3D-model
Success criteria	Approved in a DR4 review
Test site	FMC workshop
Author	Olav Parken
Tested by	
Date of first test	
Number of test runs	
Results w/ comments	
Date of last test	
Final result	

Test Table 44 - Modular construction

M5. Analyses

Portable Tube Washer Project 2015\Appendices\3. Manufacturing\M5. Analyses

Several analyses have been run, and calculations made, to guarantee the quality of the end product. Power consumption has been calculated to select a sufficient power supply and relays, component weights to run FEM-analyses and model the frame, fluid flow to set a goal of turbulent fluctuations and fluid volume to determine reservoir caoacity.

Power Consumption 364

Component Weights 365

Fluid Flow 366

Fluid Volume 366

FEM-analyses 367

Power Consumption

Address	Component	Voltages	Power consumption in Watt		In use cocurrently		
					24V	230V	400V
Sensors							
TT-R-I-1	Temperature transmitter	24V	0,48		0,48		
PT-R-I-1	Pressure transmitter	24V	0,48		0,48		
PT-IA-O-2	Pressure transmitter	24V	0,48		0,48		
LT-R1	Level transmitter	24V	0,48		0,48		
LT-R2	Level transmitter	24V	0,48		0,48		
LT-R3	Level transmitter	24V	0,48		0,48		
LS-R1	Level transmitter	24V	0,48		0,48		
LS-R2	Level transmitter	24V	0,48		0,48		
Valves							
V-R1O1	On/off valve	24V	38		38		
V-R2O1	On/off valve	24V	38				
V-IAO2	On/off valve	24V	12		12		
V-B3	On/off valve	24V	12		12		
V-R1I1	On/off valve	24V	18		18		
V-R2I1	On/off valve	24V	18				
V-TWO1	On/off valve	24V	12				
V-TWO2	On/off valve	24V	12				
Other							
P1-RO1	Pump	400V	1500				1500
WH-RO3	Flow through heater	400V	27000				27000
	Contactor Pump 9A	230V	30			30	
	Contactor Heater 72A	230V	70			70	
	Powersupply 230V-24V	230V	276			276	276
	Relais for contactor 2 stk of 9mA	24V	0,42				
	Warningligths	24V	4,8		4,8		
	PLC	24V	33		33		
	HMI	24V	3,5		3,5		
	Comunication Switch	24V	2,7		2,7		
			Total in Watts		127,84	376	28776

Component Weights

Address	Component	Weight in kilograms	Comment
Valves			
V-R1O1	On/off valve	4,30	
V-R2O1	On/off valve	4,30	
V-IAO2	On/off valve	0,60	
V-B3	On/off valve	0,80	
V-R1I1	On/off valve	0,90	
V-R2I1	On/off valve	0,90	
V-TWO1	On/off valve	0,60	
V-TWO2	On/off valve	0,60	
FCMV-RI1	Flow control valve	0,90	
SMV-B1	Safety manual valve	2,50	
MV-R1O3	Manual valve	0,30	
MV-R2O3	Manual valve	0,30	
Filters			
F-R1-B	Triceptor breather filter	0,60	
Other			
P1-RO1	Pump	20,00	
WH-RO3	Flow through heater	4,50	
P2-R3O1	Minidos (soap mix pump)	1,60	
HR-RI1+HR-RO4	Hose reel for washing x2	40	20 kg each
HR-IAO4	Hose reel for air	10,00	
R1+R2	Reservoir x2	30,00	15 kg each
	Frame	200,00	aprox
	Contactor Pump 9A		
	Contactor Heater 72A		
	Powersupply 230V-24V	0,90	
	PLC	0,70	
	HMI	0,35	
	Comunication Switch	0,25	
	Relais for contactor 2 stk of 9mA		
	Warningligths	0,20	
	Total	**326,10**	

Fluid Flow

U=(Re*v)/d												
		Vi må over 5000 i Reynold`s tall for å ha turbulent strømning. Noe vi antar har en større skyllende effekt i rørene										
U= middel flow hastighet												
v= Kinematisk viskositet for vann v/60°C = 0,475 kvm/Sek*10^-6												
Re=> 5000												
d=diameter i M												
A= π*R^2												
V= volumflow = A*U												
A=		0,0002834	kvm									
Rør d i mm=	19	0,019		1000								
Re=		5000										
v=	0,475	4,75E-07		0,000001								
U=		0,125	M/S	7,5	M/min							
V=		0,0021254	kbm/min									
		2,1253875	L/min									
Vi må over 2,12 L/min for å få turbulent strømning i et rør som er 19 mm inv. (3/4" rør)												

Fluid Volume

Anntatte volummengder i L				
Vannvarmer				1
3/4" rør m/1,65mm vegg, L= 6000mm				1,2
1-1/4" rør 2mm vegg L=6000, (antatt max mengde rør i maskinens oppbyggning)				3,6
Anatt behov for å fylle systemet				5,8
Beregner volum i reservoaer etter dette.				

FEM-analyses

Two FEM-analyses have been run on the system.

1. On the frame: Applying excessive forces on both top and bottom parts of the frame resulted in a deformation well below the yield strength of the selected AISI 316L steel.
2. Hookup Points: Stresses will occur, as expected, around the forklift pockets. The maximum stresses found pose no threat to the system.

Both analyses are located in the *Portable Tube Washer Project 2015\Appendices\3. Manufacturing\M5. Analyses* folder.

M6. 3D and 2D Material

Portable Tube Washer Project 2015\Appendices\3. Manufacturing\M6. 3D and 2D Material

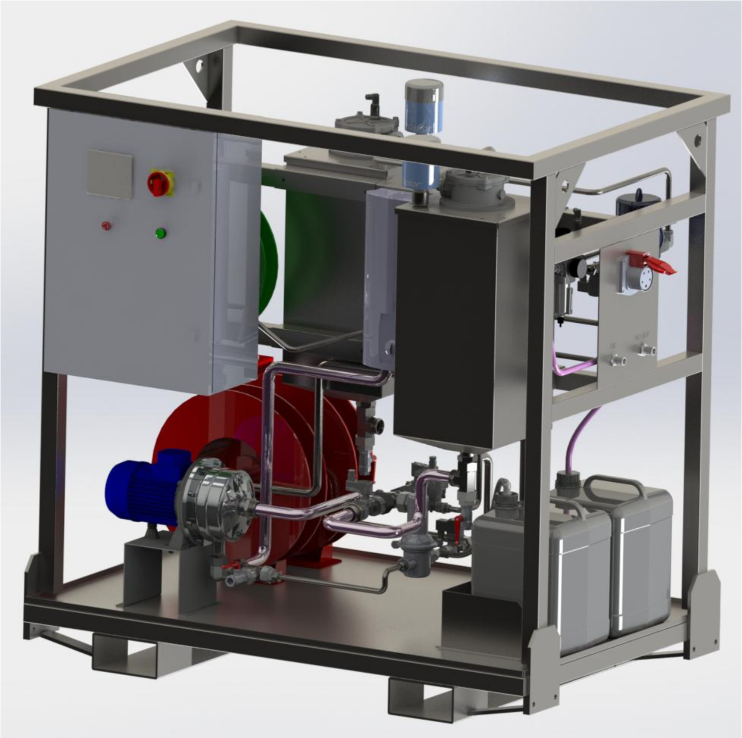
Due to the nature of this project, little innovative 3D-modelling has been done, as the focus has been on selecting existing components, not making new ones. As a result of this, the modelling work began quite late in the process, after all the system components had been selected.

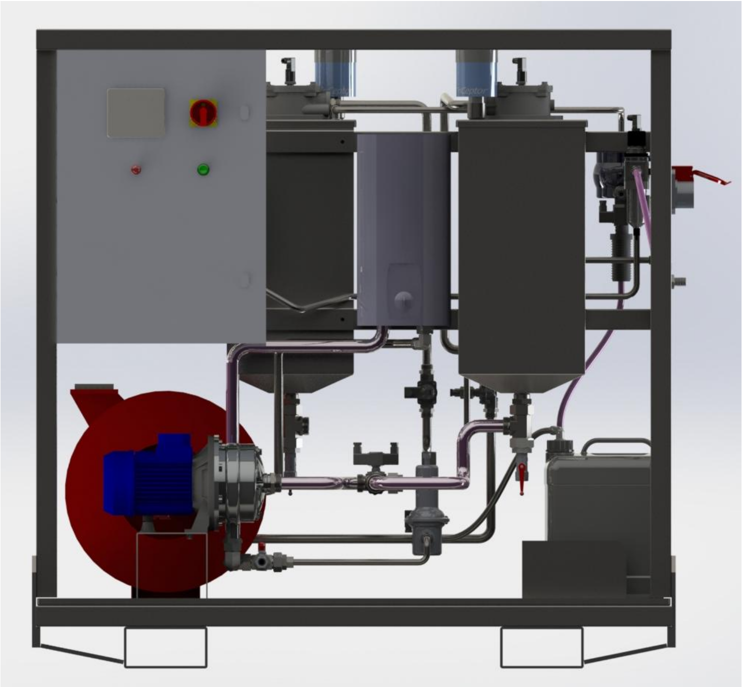
All 3D models are either made in SolidWorks or are downloaded from manufacturers' sites and converted for use within SolidWorks. The models will exist in SolidWorks file format and exchange format STEP 214.

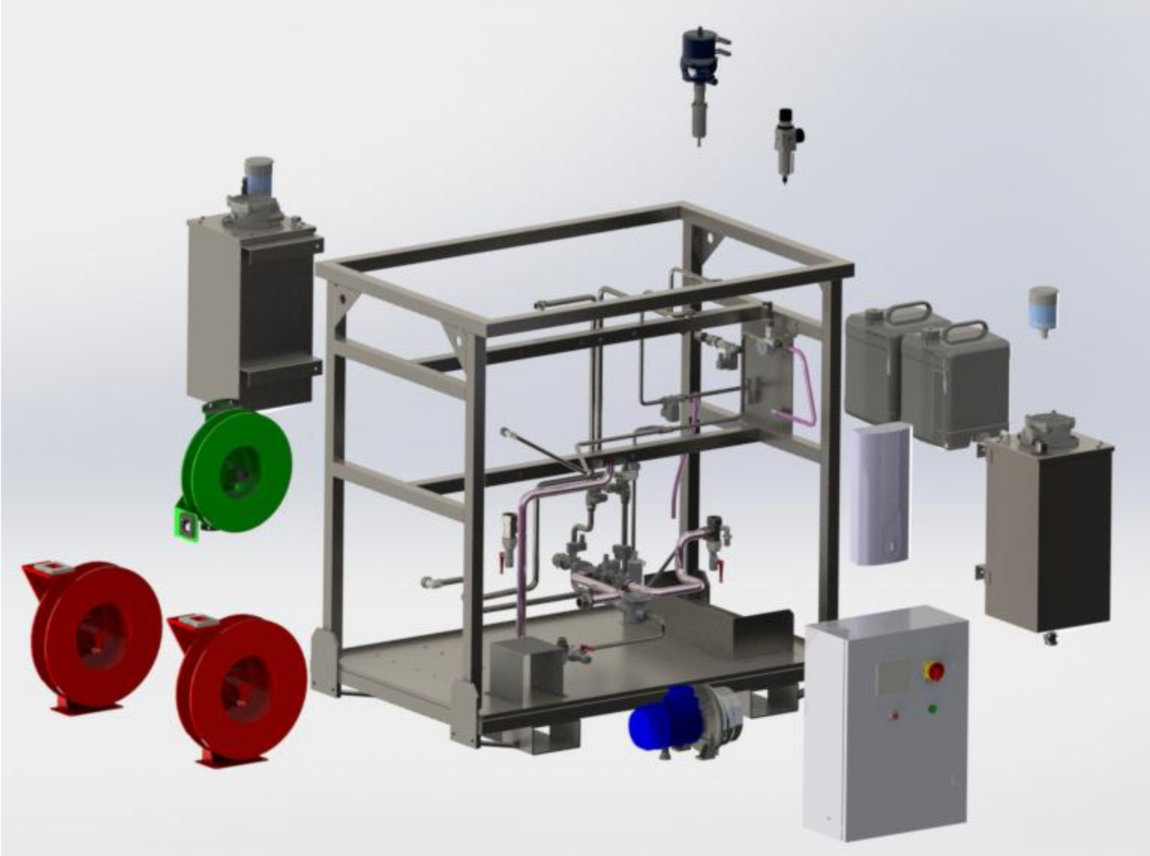
3D Model Snippets 370

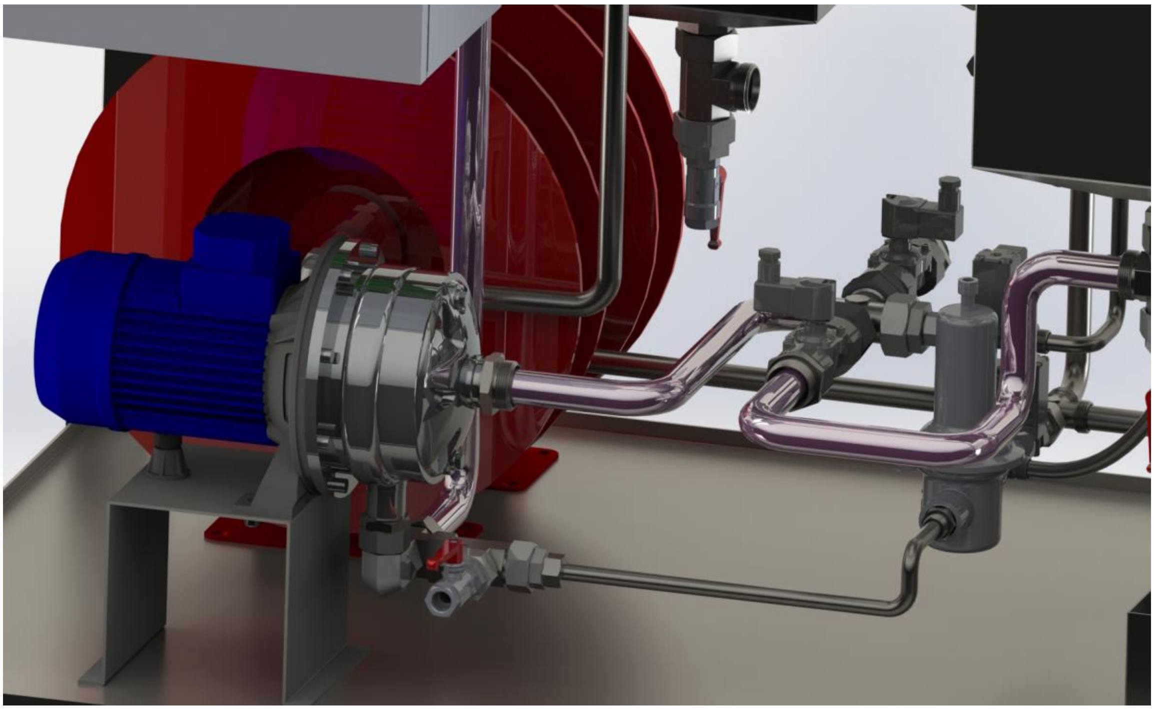
Numbering Hierarchy and 2D Snippet 375

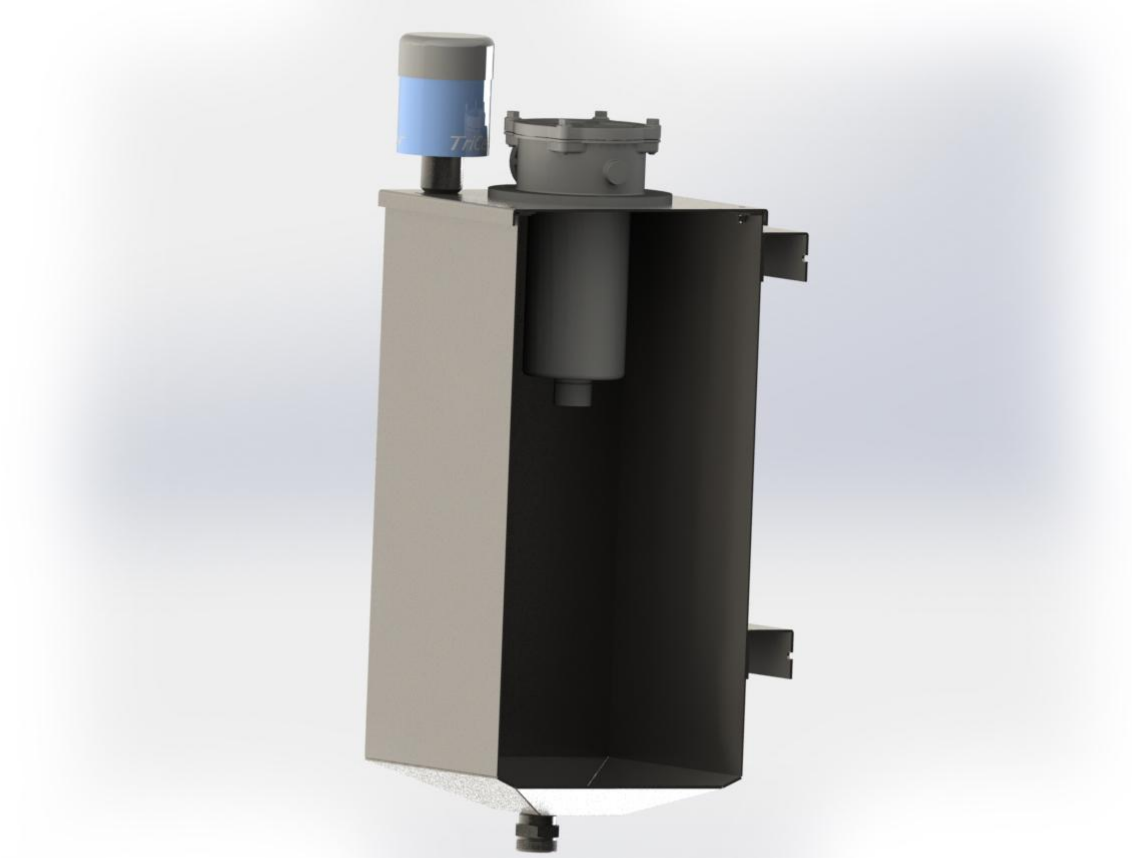
3D Model Snippets







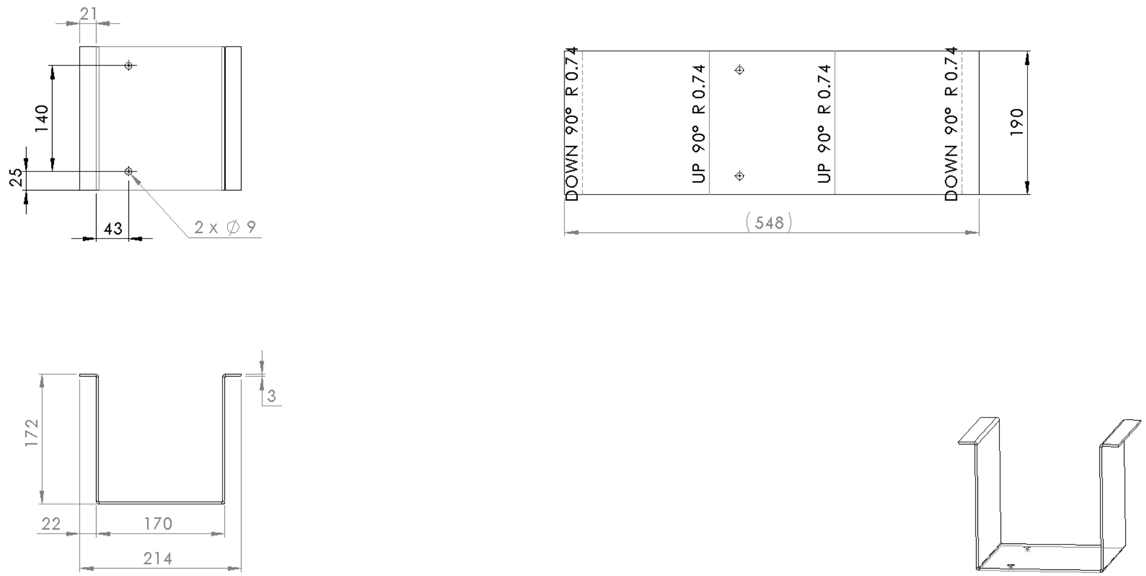




Numbering Hierarchy and 2D Snippet

The PTW is built with the number series DU600160364 as the top level assembly. The following table describes the buildup of the number series.

Drawing Level	Typical numbering	Comment
Top level	DU600160364	
Subassemblies	DU600160364-0#	
Sub Subassemblies	DU600160364-00#	
Parts	DU600160364-#	
Piping	DU600160364-#P	
Wiring Top Level	DU600160364EL.	
Subsystem Wiring	DU600160364-0#EL	E.g. inside cabinet



UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS **Tolerances: NS-ISO 2768-1 Midium** **Welding** in accordance with: **WPS60059501**	DEBUR AND BREAK SHARP EDGES 0,5X45°	DO NOT SCALE DRAWING	REVISION
	NAME	DATE	
Drawn by	Alex	15.05.2015 02:17:35	
Last saved	Olav Parken	18.05.2015 10:38:18	

FMC Technologies

TITLE: Bracket for pump

Included in DWGNO: DU600160364-3

DWG NO.

A3

WEIGHT: 312.07

SCALE:1:5

SHEET 1 OF 1

Instructional

This section includes the custom manual written for the PTW. It should be noted that this is the project group's most incomplete document, and is supposed to be; a proper manual requires not only years of education and experience to write, but also insight to the final product as testing goes on.

I1. PTW Manual

Portable Tube Washer Project 2015\Appendices\4. Instructional\I1. PTW Manual

PTW Manual

Version 1

Version	Date	Changes	Status	Responsible
1.0	14.05.2015	Formatting and minor changes.	Ready for final delivery.	Alexander Araya

Name	Signatures
Bjørnar D. Døviken	
Henrik Lind	
Olav Parken	
Alexander Araya	

Introduction

This is a user and service manual made for the Portable Tube Washer project. It includes diagrams, explains how to install and prepare the PTW, and how to do maintenance and repairs.

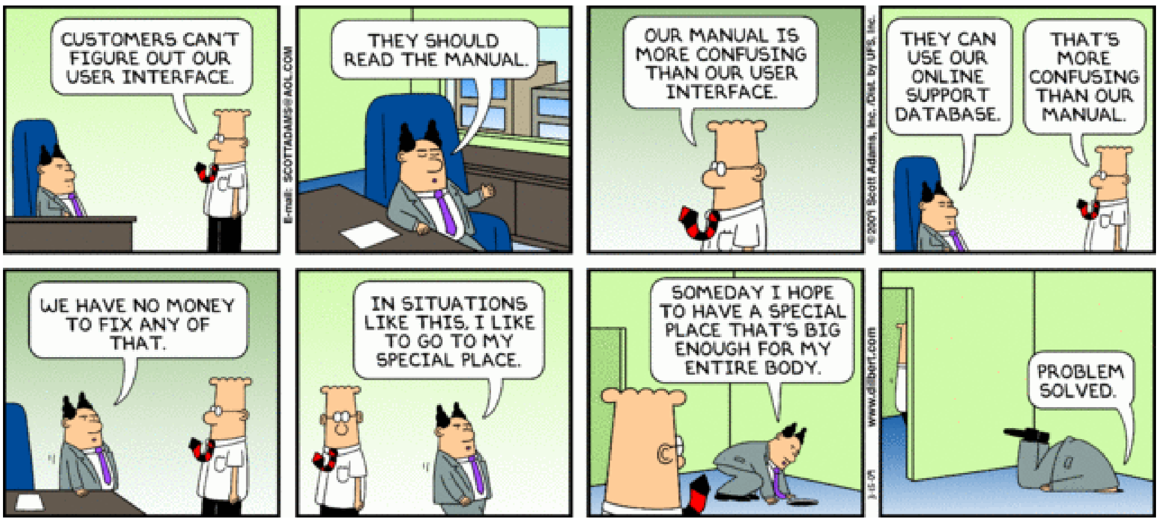
The user manual includes information the operator will need to use the PTW correctly. The information helps the operator familiarize with the PTW, e.g. where the different operating functions are located. It gives a basic guideline for how to go forward when issues occur and also how to handle the PTW in case of transportation or storage.

The service manual includes more detailed information, needed when servicing the PTW. It explains more specifically locations of the different parts and gives a more advanced guideline when disassembling or overhauling the PTW. This part is mainly intended for authorized technicians.

This manual is at this stage not finished and can only be completed once the PTW is built. When reading this document and the symbol below appears, it means that the section is incomplete.

This section is incomplete.

Figure 8 - Symbol signifying incomplete sections



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Glossary and Acronyms

Name	Description
PTW	Portable Tube Washer
FMC	FMC Technologies
HSE	Health, Environment and Safety
MSDS	Material Safety Data Sheet
P&I	Piping & Instrumentation
IA	Instrument Air
TW	Town Water
JC	Jet Clean

Table 20 - Glossary and Acronyms

Symbol Definition

The following symbols are used to indicate different levels of danger:

 DANGER	Indicates an imminently hazardous situation, which, if not avoided may result in death or serious injury. The information described in the DANGER frame must be strictly observed.
 WARNING	Indicates a potentially hazardous situation, which, if not avoided may result in serious injury.
 CAUTION	Indicates an imminently hazardous situation which, if not avoided may result in minor or moderate damage to the machine

Figure 9 - Danger/Warning/Caution Definitions

Parts Reference List

Parts referenced to P&I instrument number (See Chapter 2.6.2).

Instrument No.	Transmitter
TT-R-I-1	Temperature
MS-JC	Micro-switch
LT-R1-1	Level
LT-R2-1	Level
LT-R3	Level
LT-R1-2	Level
LT-R2-2	Level
PIT-R-I-1	Pressure
PIT-IA-O-2	Pressure
dPT-F-R1-P	Pressure
dPT-F-R2-P	Pressure

Instrument No.	Valve
V-R1O1	Liquid
V-R2O1	Liquid
V-IAO2	Air
SMV-B1	Liquid
V-B3	Liquid
FCMV-RI1	Liquid
V-R1I1	Liquid
V-R2I1	Liquid
MV-R1O3	Liquid
MV-R2O3	Liquid
MV-TWO1	Liquid
MV-TWO2	Liquid

Instrument No.	Filter
F-R1-B	Tank breather
F-R2-B	Tank breather
F-IAO1	Air
F-R1-P	Particles (liquid)
F-R2-P	Particles (liquid)

Instrument No.	Component
R1	Water Reservoir
R2	Soap mix Reservoir
R3	Soap Canister
R4	Disposal Canister
P1-RO1	Main Pump
P2-R3O1	Soap Pump
WH-RO3	Water Heater

Instrument No.	Component
HR-RI1	Hose Reel
HR-RO4	Hose Reel
HR-IAO4	JC Reel

Table 21 - P&I referenced parts

1 User Manual

1.1 HSE

The operator must have proper training prior to use of the PTW. Reading this manual before using the PTW is mandatory.

DANGER	Wrong usage of the PTW may lead to severe injuries to the operator and workshop environment.
	Turn off the main power on the PTW before any repair of components or the electrical system.
	Use the transportation hooks for secure and safe transportation.

WARNING	The operator shall use Personal Protective Equipment at all times when operating the PTW.
	The operator shall know the contents of the MSDS of the soap before using the PTW.
	The reservoirs must be drained before relocating the PTW inside the workshop. Guideline for transportation and storage see Chapter 1.6.
	Beware of hot surfaces when the PTW is running a washing cycle.
	Beware of hot surfaces and fluids when performing maintenance or repairs.
	All contaminated fluids and soap must be handled after regulations (FMC).
	Verify that the tube has been safely connected to the washer hose.
	Do not disconnect the washer hoses from the tube when the PTW is running washing cycle.

CAUTION	Wrong usage may lead to damages on the PTW.
	The PTW shall only be used with Industrial alkaline-based soap. Any use of soap that does not categorize as alkaline based soap may cause harm to the machine.
	Do not close the inlet pressurized air and inlet water supply when the PTW is running a washing cycle.

Figure 10 - User Manual HSE

1.2 Unit Description

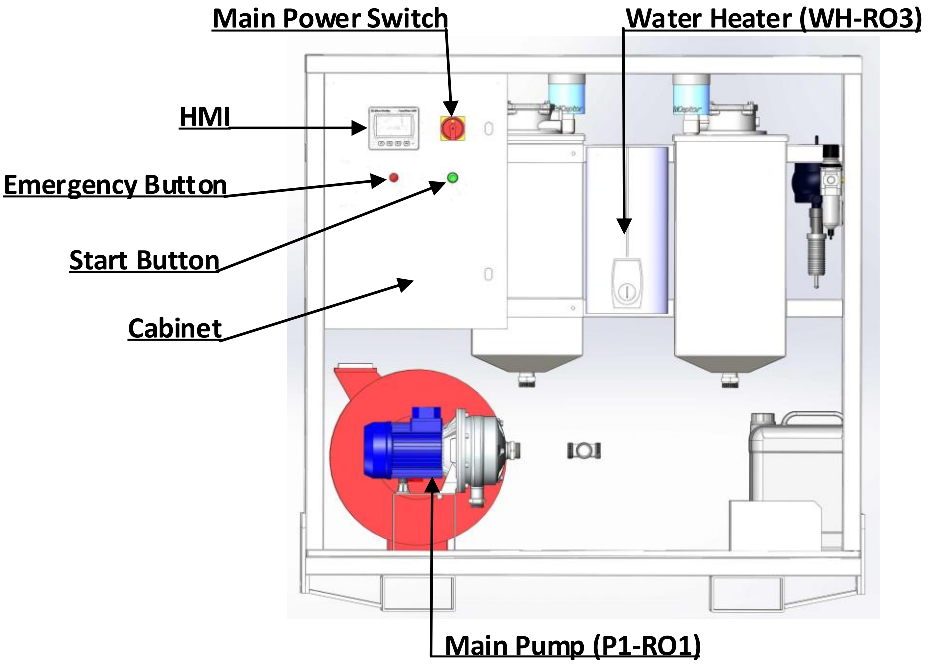


Figure 11 - Front side of the PTW

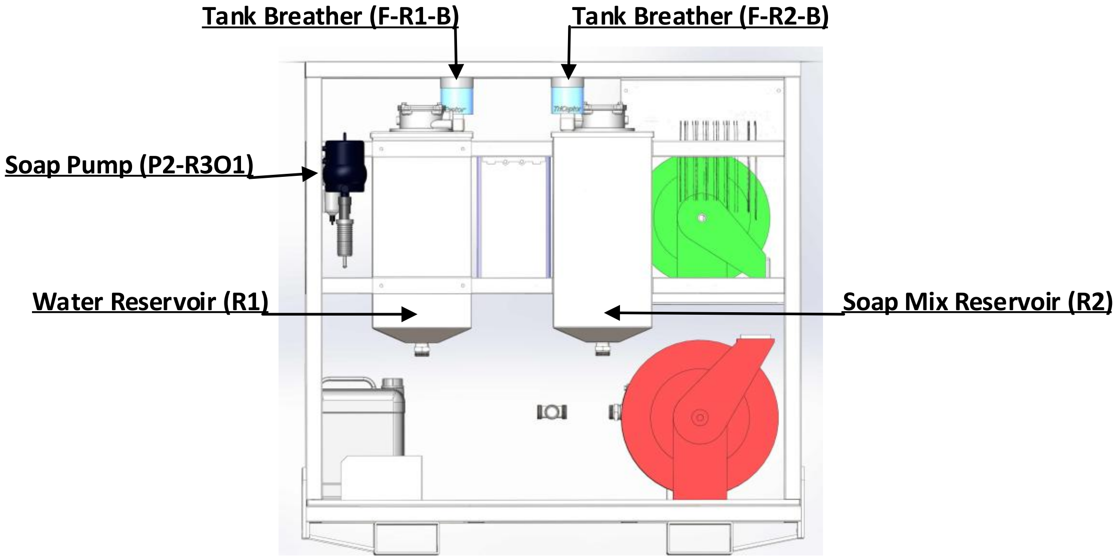


Figure 12 - Back side of the PTW

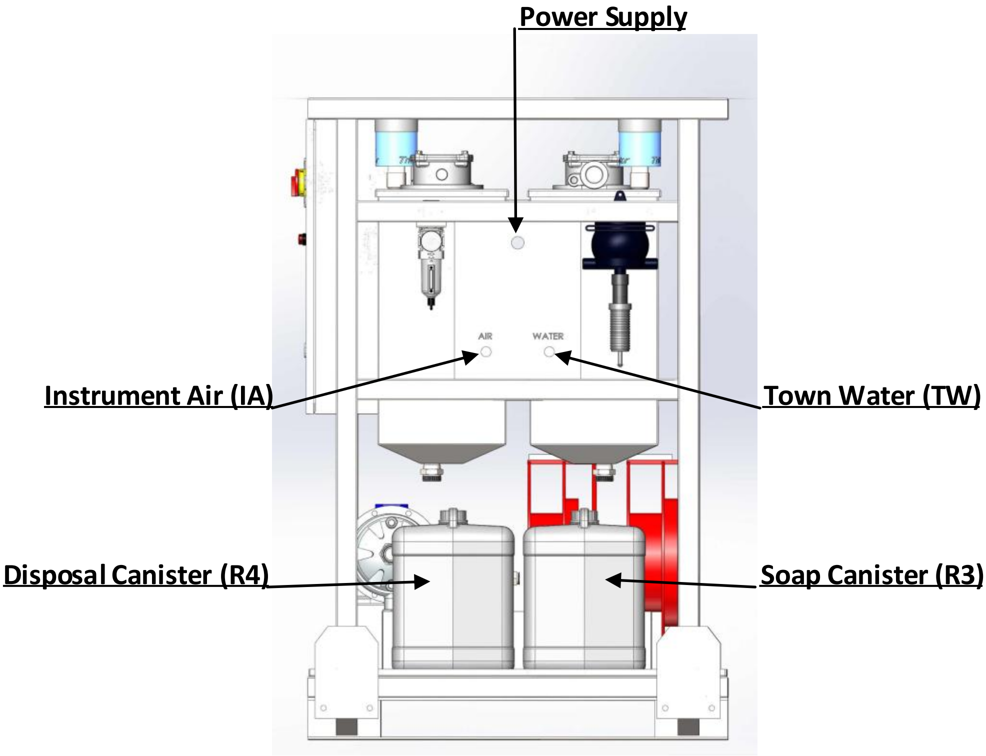


Figure 13 - Right side of the PTW

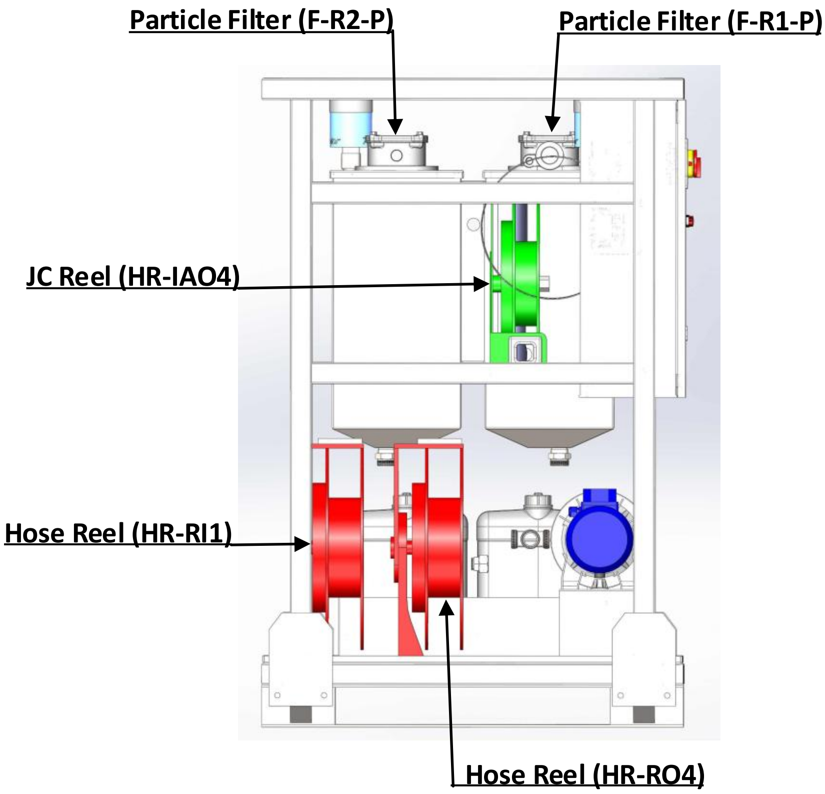


Figure 14 - Left side of the PTW

1.3 Installation (Before use)

CONNECTING TO WORKSHOP INFRASTRUCTURE & PREPARATIONS

Make sure the PTW is placed on a level floor before the PTW is connected to the workshop infrastructure. When connecting IA and TW, make sure there is no leakage.

1. Remove blinding caps.
2. Place a soap canister (R3) in the marked area.
3. Place a disposal canister (R4) in the marked area.
4. Connect IA.
5. Connect TW.
6. Check that all drainage valves are closed.
7. Connect to power supply.
8. Check that the tank breather filters are not obstructed (F-R1-B and F-R2-B).

Pictures

⚠CAUTION: The PTW shall **ONLY** be used with Industrial alkaline-based soap.

Figure 15 - Metaclean AL 199

NOTE: Only use soaps that will dissolve mineral-based oils or greases and water-glycol based fluids and greases. The Kongsberg workshop uses “Metaclean AL 199”.

This section is incomplete:

- Illustration pictures missing.

1.4 *Operating Instructions*

1.4.1 HMI Screen Navigation

- See Basic Troubleshooting Table for error messages.

This section is incomplete.

- Add pictures of the screen
- Add a sentence explaining, that this is to be completed once the programming is done by FMC (How to choose different washing cycle, how to adjust temperature or washing cycle time, etc).

1.4.2 Washing Procedure

⚠WARNING: The operator shall use Personal Protective Equipment at all times when operating the PTW.

INSTRUCTIONS:

1. Power up the PTW (Illustration fig.#).

2. Select desired tube from the rack (Illustration fig.#)

3. Place the tube on the tube-fixture and make sure it is proper secured.

4. Select the required connector, from the tool panel that will match the size of the tube to be washed (Illustration fig.#).

5. Connect the selected connector coupler to the hoses end (Illustration fig.#)

6. Depress the coupler latch tube connection to the coupler (Illustration fig.#)

⚠WARNING: Verify that the tube is safely and properly secured to the coupler to avoid hot water leakage during washing.

⚠WARNING: Do not strike or tamper with the coupler connection during the washing cycle.

7. Select a predetermined washing cycle and press start. The timer for the washing cycle will start once the cleaning fluid has reached a predefined temperature (Illustration fig.#).

NOTE: When the cycle is running the xxx light will be on. The xxx light will come on when the cycle is finished.

8. The washing cycle will take about xxx minutes to run through hot water, soap, hot water and clean air. Once the cycle stops, disconnect the connector couplers.

NOTE: Always put the connector couplers back into the designated place on the machine when not in use.

9. Insert a soft plug in the Jet Cleaner pistol. Place one end of the tube into the plug receiver box, then insert the nozzle onto the tube outer diameter in the other end (Illustration fig.#). **Ensure that the soft plug is retained inside a container to confirm that it has passed through the tube.**

NOTE: A new washing cycle will not be able to start if STEP 9 is not performed. If STEP 9 is performed, but a new washing cycle will still not start try to lift the JC and place it back, if this does not solve the problem see Advanced Troubleshooting Table.

10. Put caps on the washed tube to prevent ingression of contamination.

1.4.3 Daily Maintenance Table

Visual Check	Ins. No.	Level	Connection	Leakage	Color	Action
Soap Canister	R3	x	x	x		
Disposal Canister	R4	x	x	x		
Instrument Air	IA		x	x		
Town Water	TW		x	x		
Power Supply			x			
Tank Breather	F-R1-B				x	Blue = Ok Pink = Replace
Tank Breather	F-R2-B				x	Blue = Ok Pink = Replace

Table 22 - Daily Maintenance Table

This section is incomplete.

- Add illustration pictures where the operator can find the different parts that need maintenance.

1.4.4 Basic Troubleshooting Table

This matrix shows **Error messages** on the HMI and other **Problem(s)** encountered when operating the PTW. It explains **Possible cause** and **Solutions**. If this doesn´t resolve the problem, see **Reference** for further information.

Error message/ Problem	Possible cause	Solution	Reference
"Temperature too low, press reset for standby"	1. The WH and PLC are not synchronized to the same temperature. 2. WH has not had time to reach predefined temperature.	1. Adjust the WH and PLC to the same predefined temperature. 2. Press "reset" for standby and run a new cycle.	Advanced Troubleshooting Table.
"Critically low water level, see manual"	The reservoir is not filled with water.	Check that the water tap (TW) is open.	Advanced Troubleshooting Table.
"Critically high water level, see manual"	The valve V-TW02 is in open position.	Turn off the water tap (TW).	Advanced Troubleshooting Table.
"Critically low mix level, see manual"	The reservoir is not filled with water.	Check that the water tap (TW) is open.	Advanced Troubleshooting Table.
"Critically high mix level, see manual"	The valve V-TW01 is in open position.	Turn off the water tap (TW).	Advanced Troubleshooting Table.
"Replace soap canister"	The soap canister has reached minimum level.	Replace empty canister with new canister (R3).	Advanced Troubleshooting Table.
"Pressure too low to continue"	The air supply is not sufficient.	- Check that the air supply tap (IA) is fully open. - Check the pressure regulator on filter F-IA01.	Advanced Troubleshooting Table. See default specifications.
"No air pressure!"	No air pressure is registered.	- Check the air supply from the workshop. - Check that the air supply tap (IA) is open.	Advanced Troubleshooting Table.
"Replace clean water filter"	Clogged water filter.	Replace with new filter.	Maintenance
"Replace mix filter"	Clogged mix filter.	Replace with new filter.	Maintenance
Not possible to run a new washing cycle after plug shooting.	The JC is not placed correctly back in holder.	Lift the JC from the holder and place it back.	Advanced Troubleshooting Table.

Table 23 - Basic Troubleshooting Table

1.5 *Transportation and Storage*

⚠CAUTION: The PTW shall not be used or stored in places where the temperature is below +5°C.

Transportation:
If the PTW is to be transported to another location these steps must be followed.

1. Disconnect Instrument Air (IA), Town Water (TW) and Power Supply (Illustration fig.#+explaining text).
2. Drain the reservoirs R1 & R2 (Illustration fig.#+explaining text).
3. Remove the soap canister R3 and secure the suction hoses (Illustration fig.#+explaining text).
4. Remove the disposal canister R4 and secure the hoses (Illustration fig.#+explaining text).
5. Cover all inlet supply with protection caps and secure the couplings.
6. Use a trolley or truck.

⚠WARNING: Use the transportation hooks for secure and safe transportation.

Storage:
If the PTW is to be stored over a significant period of time this steps must be followed.

1. Disconnect Instrument Air (IA), Town Water (TW) and Power Supply (Illustration fig.#+explaining text).
2. Drain and clean the reservoirs R1 & R2 (Illustration fig.#+explaining text). The water and mix filter-housing will be drained when draining the reservoirs.
3. Remove the soap canister R3 and secure the suction hose (Illustration fig.#+explaining text).
4. Remove the disposal canister R4 and secure the hoses (Illustration fig.#+explaining text).
5. Drain the air filter-housing F-IA01 (Illustration fig.#+explaining text).
6. Cover all inlet supply with protection caps and secure the couplings (Illustration fig.#+expl.text).

⚠CAUTION: Neglecting any of the steps may lead to corrosions of components and PTW malfunction.

2 Service Manual

2.1 HSE

 DANGER	Remember to disconnect Instrument Air (IA), Town Water (TW) and Power Supply before performing maintenance or repairs on the PTW.

 WARNING	Beware of hot surfaces and fluids when performing maintenance or repairs.
	The operator shall use Personal Protective Equipment at all times when operating the PTW.

Figure 16 - Service Manual HSE

2.2 *Component Locations (Exploded view)*

2.2.1 Mechanical

This section is incomplete:

- Add exploded view of the PTW and point out all working components (such as pump, WH, valves, filters, etc).

2.2.2 Electrical

This section is incomplete:

- Add exploded view of the electrical system (such as inside the cabinet).

2.3 Maintenance

2.3.1 Notified Maintenance

This section is incomplete:

- Add here pictures and how to go forward when the user gets messages on HMI about maintenance of filters (F-R1-P & F-R2-P).

2.3.2 Scheduled Maintenance Table

Parts	Inst.No.	Frequency	Washing cycles	What to do
Air filter	F-IAO1	Every week		Drain the filter for accumulated water.
Jet Clean	MS-JC	Every week		Clean the JC holder.
Soap canister Area	R3	Every month		Make sure that the connection and the area are clean.
Disposal canister Area	R4	Every month		Make sure that the connection and the area are clean.
Main Pump	P1-RO1	Every 6 months		Remove and clean the inside.
Soap Pump	P2-R3O1	Every 3 months		Remove and clean the inside.
Water Reservoir	R1		xxxx	Replace the water.
Soap Mix Reservoir	R2		xxxx	Replace the soap mix.

Table 24 - Scheduled Maintenance Table

This section is incomplete.

- Replace the washing water and soap water after xxx cycles. This is to be determined and set when the PTW is constructed and testing over time is possible.

2.4 Advanced Troubleshooting Table

Error message/ Problem	Possible cause	Solution	Reference
"Temperature too low, press reset for standby"	1. The WH has no power. 2. The WH is broken.	1. Check for blown fuse, damaged wirings, loose or corroded connections. 2. The WH must be replaced.	Chapter… Chapter…
"Critically low water level, see manual"	The valve V-TW02 is not opening.	- Check Led-indicator on valve. - Check damaged wirings, loose or corroded connections.	Chapter… Chapter…
"Critically high water level, see manual"	1. The valve V-TW02 is in open position. 2. Soap mix has wrongly been filled into the water reservoir.	1. Press "reset" for standby and check if the Led-indicator light is still on. 2. Press "reset" for standby and check valve V-R2I1 and V-R1I1 if the Led-indicator light is on.	Chapter… Chapter…
"Critically low mix level, see manual"	The valve V-TW01 is not opening.	- Check Led-indicator on valve. - Check damaged wirings, loose or corroded connections	Chapter…
"Critically high mix level, see manual"	1. The valve V-TW01 is in open position. 2. Clean water has wrongly been filled into the soap mix reservoir.	1. Press "reset" for standby and check if the Led-indicator light is still on. 2. Press "reset" for standby and check valve V-R2I1 and V-R1I1 if the Led-indicator light is on.	Chapter… Chapter…
"Replace soap canister"	The soap canister has not reached minimum level.	- Check the submersible level transmitter. - Check for damaged wirings, loose or corroded connections.	Chapter… Chapter…
"Pressure too low to continue"	Clogged air filter.	Replace the air filter F-IA01.	Chapter…
"No air pressure!"	Faulty pressure sensor PIT-IA-O-2.	- Check for damaged wirings, loose or corroded connections. - Replace pressure sensor PIT-IA-O-2.	Chapter… Chapter…
"Replace clean water filter"	1. Clogged outlet. 2. Faulty filter guard.	1. Remove filter and clean outlet. 2. - Check for damaged wirings, loose or corroded connections. - Replace the filter guard.	Chapter… Chapter…

"Replace mix filter"	1. Clogged outlet. 2. Faulty filter guard.	1. Remove filter and clean outlet. 2. - Check for damaged wirings, loose or corroded connections. - Replace the filter guard.	Chapter... Chapter...
Not possible to run a new washing cycle after plug shooting.	The micro-switch MS-JC is not working.	This will require testing of component. Replace micro-switch	Chapter...

Table 25 - Advanced Troubleshooting Table

This section is incomplete.

- Update references with their respective chapters that explains procedures for overhauls.

2.5 Repair and Overhaul

2.5.1 Components

This section is incomplete:

- Add chapters with pictures and description on how to perform replacement of different components (such as: pump, WH, valves, micro-switch, etc.).

2.5.2 Electrical System

2.5.2.1 PLC & HMI

This section is incomplete:

- The service personnel must see the PLC user manual, when need of maintenance or repair.
- The service personnel must see the HMI user manual, when need of maintenance or repair.

2.5.2.2 Cabinet

This section is incomplete:

- Instructions of maintenance and repair of the cabinet must be completed when the PTW is built, included the electrical components inside.

2.5.2.3 Lights

This section is incomplete:

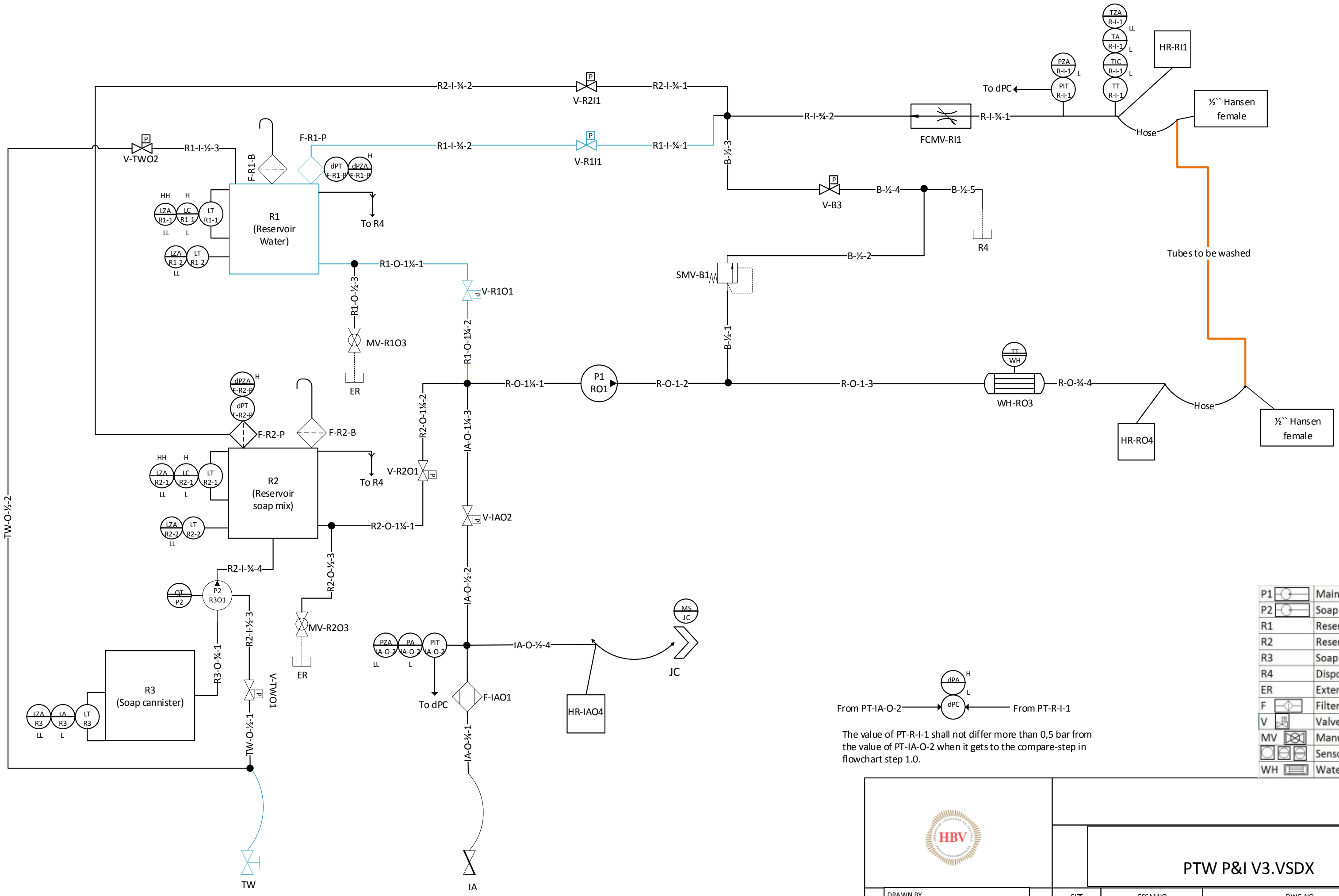
- The service personnel must see data sheet when need of maintenance or repair.

2.6 Diagrams

2.6.1 Wiring

This section is incomplete.

2.6.2 P&I



P1		Main pump
P2		Soap pump
R1		Reservoir (water)
R2		Reservoir (water-soap mix)
R3		Soap cannister
R4		Disposal reservoir
ER		External Reservoir
F		Filters
V		Valves
MV		Manual Valves
		Sensors
WH		Water Heater

PTW P&I V3.VSDX

DRAWN BY	Henrik Lind	SIZE	FSCM NO
DATE	11.05.2015	DWG NO	REV
SCALE	1:1	SHEET	1 OF 1

2.6.3 Cause & Effect

Portable Tube Washer Project 2015\Appendices\3. Manufacturing\M2. PLC Documentation

2.6.4 Process Flowchart

Portable Tube Washer Project 2015\Appendices\3. Manufacturing\M2. PLC Documentation