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PRH612-1-20V Bachelor thesis

Design and Implementation of Automatic Sequencing for the Kettle and Fermenting Tank in the Beer Lab using Emerson DeltaV

IA6-4-20

Faculty of Technology, Natural Sciences and Maritime Sciences
Campus Porsgrunn

University of South-Eastern Norway

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Course: PRH612-1 20V Bachelor thesis

Title: Design and Implementation of Automatic Sequencing for the Kettle and Fermenting Tank in the Beer Lab, using Emerson DeltaV

This report forms part of the basis for assessing the student's performance in the course.

Project group: IA6-4-20 **Availability:** Open

Group participants: Adrian Anderson Bergfłødt
Are Strand Rinden
Torbjørn Slåttekjær
Audun Bjørkøy Theie

Supervisor: Carlos Pfeiffer
Bjørn Vegard Tveraaen

Project partner: Emerson Process Management AS

Approved for archiving: ______________________________

Summary:

The University of South Eastern Norway, Campus Porsgrunn has invested in a pilot beer production plant. The purpose of the plant is to provide hands-on experience with process engineering tasks for the students.

The objective of the project was to create automatic- or semiautomatic control of the boiling and fermenting stages of beer production, using the Emerson DeltaV DCS system. The methods applied was data acquisition through analysis of papers, reports and handbooks, basic training was provided by Emerson, and trial and error when programming/testing the controllers.

During the project, the world was affected by the Corona virus pandemic, resulting in the university closing off for student access. The team adapted to the difficult situation and managed to complete and deliver the project in time, without restricting the objectives or scope of the project. This resulted in valuable experience of working remotely and having online meetings for the team members.

Universitetet i Sørøst-Norge

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Emne: PRH612-1 20V Bacheloroppgave

Tittel: Design and Implementation of Automatic Sequencing for the Kettle and Fermenting Tank in the Beer Lab, using Emerson DeltaV

Denne rapporten utgjør en del av vurderingsgrunnlaget i emnet.

Prosjektgruppe: IA6-4-20 **Tilgjengelighet:** Open

Gruppedeltakere:

Adrian Anderson Bergflødt
Are Strand Rinden
Torbjørn Slåttekjær
Audun Bjørkøy Theie

Veiledere:

Carlos Pfeiffer
Bjørn Vegard Tveraaen

Prosjektpartner:

Emerson Process Management AS

Godkjent for arkivering: ______________________________

Sammendrag:

Universitetet har bygget en pilotmodell av en industriell ølproduksjonsrigg. Formålet bak riggen er å gi studentene praktisk erfaring med prosessautomasjon.

Oppgaven til prosjektet var å produsere automatisk- eller semiautomatisk kontroll av koke- og fermenteringsstegene i produksjonsfasen, ved bruk av DCS systemet Emerson DeltaV. Metoder brukt for å gjennomføre oppgaven var datainnsamling, gjennom analyse av ulike tidsskrift, rapporter og håndbøker, praktisk opplæring i DeltaV ble gitt av Emerson, prøv og feil-metoden ble anvendt under programmering og testing av kontrollerne.

Under prosjektet, ble verden rammet av koronapandemien. Dette resulterte med at universitetet ble stengt for studenter. Teamet tilpasset seg fort til situasjonen og ved bruk av fjernstyring av arbeidsstasjonen, klarte de å levere prosjektet som definert i oppgavebeskrivelsen og oppgavebegrensningen, uten å komprimere eller endre dette underveis. Fjernstyring og nettbaserte møter ga gruppemedlemmene verdifull og nyttig erfaring.

Preface

This project was completed by four Automation and Computer science students in their sixth semester. This Report is written for students and instructors working on the beer production plant. We would like to thank Carlos Pfeifer and Bjørn Vegard Tveraaen for their guidance and contributions to this project, Md Safayet Ahmed Shaon for providing us with introductory training in DeltaV, and lastly Rune Andersen and Per Kristian Fylkesnes from Emerson for granting us project specific training in DeltaV and providing tips on how to move forward with our control strategy.

This report was written using Microsoft Word 2017, communication and filesharing throughout this project was done with the use of Microsoft Teams. Drawings were drawn using Microsoft Visio Professional 2017, P&ID was created using Autodesk AutoCAD Plant 3D 2019. Microsoft Project Professional 2017 was used to draw the Gant diagram and to monitor project progression.
Administrating the DeltaV Database was done through DeltaV Database Administrator. Creation of the HMI was done in DeltaV Operator (Configure), DeltaV Explorer was used for the creation of our control strategy. DeltaV Control Studio was used to program our PLM and sequences and to modify modules. For remote control of the DeltaV workstation, TeamViewer was used.

This report requires that the reader has basic knowledge of process automation and DCS systems. Knowledge of the Emerson DeltaV system is not required but may improve the reading experience.

Cover Photo: Taken by Audun Bjørkøy Theie, 15.05.2020

Porsgrunn, 15. May 2020

Nomenclature

DCS	–	Distributed Control System
ESD	–	Equipment State Diagram
GUI	–	Graphical User Interface
HMI	–	Human Machine Interface
HSE	–	Health Safety and Environment
IMC	–	Internal Model Control
P&ID	–	Piping and Instrumentation Diagram
PC	–	Personal Computer
PID	–	Proportional Integral Derivative
PLM	–	Phase Logic Module
PV	–	Process Value
PWM	–	Pulse Width Modulation
SFC	–	Sequential Function Chart
SP	–	Setpoint
SSR	–	Solid-State Relay

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1 Introduction

1.1 Background

The beer lab at the University of Southeastern Norway Campus Porsgrunn is a dynamic process plant, that is constantly changing and evolving. At the time of completion of this project, the rig stands completely assembled with tanks, actuators, sensors, and the Emerson DeltaV Distributed Control System. The purpose of the plant is to provide hands-on experience with process engineering tasks for the students. The plant is equipped with pneumatic valves, heating elements, a two-phase heat exchanger, pumps, a cooling system, and various temperature and level sensors.

1.2 Objectives

The objective of this project is to provide automatic or semiautomatic control of the beer production plant, located at the University of South Eastern Norway Campus Porsgrunn using the Emerson DeltaV control system. As a result of this project, the team will gain greater knowledge of process automation and DCS systems. Another result is that the project supervisors will receive valuable feedback, with possible improvements of the plant.

1.3 Methods

The methods used in this project are data acquisition through analysis of scientific papers, reports, and hand manuals. Knowledge of the DeltaV system is provided through training from an Emerson employee and a masters student and different papers written by Emerson. Trial and error was used when programming the controllers and the HMI.

1.4 Scope

The project is limited to development, implementation and testing of the semi-automatic control of the Fermenter and Kettle parts of the plant and updating the existing P&ID. The project focuses on the operation and control of the plant.

1.5 Report Structure

Chapter 2 contains information about the plant itself, beer production in general and HSE. Chapter 3 introduces the planning process and execution of the project. Chapter 4 capsulate the DeltaV system and its programs. Chapter 5 discusses the design process and the implementation of the sequential control of the kettle and fermenter parts of the plant. Chapter 6 and Chapter 7 describes the Kettle and Fermenter tank respectively, including its function the science behind them and the control and operation of these processes. Chapter 8 describes the HMI, including its design philosophy and functionality. Chapter 9 describes the testing of the plant, including the testing of the process equipment, diagrams created during the project and the control system created by the project group. Chapter 10 presents the results of this project and Chapter 11 is a discussion chapter that encapsulates problems that arose during this project and alternatives to the solution provided. Chapter 12 is a final summary of the solutions created during this project.

2 Plant Description

This chapter provides an introduction of the Beer Process Plant shown in Figure 2.1, including a description of the process plant instrumentation. The process flow will be presented in stages from the first step to the finished product, the chapter also describes how the production of beer is performed in general. The chapter ends with what safety precautions were to be followed at the laboratory.

Figure 2.1 Beer Process Plant

2.1 Process Description

The beer process plant in Figure 2.1, consists of seven vessels in stainless steel, from right to left; hot water, mash, separator (lauter), kettle, fermenter, bright beer, and coolant (ice water) tank. The plant also consists of a heat exchanger, pneumatic valves, manual valves, sensors, gauges, and an advanced DCS control system, DeltaV delivered by Emerson, which allows for the application of advanced control principles on the plant.

The P&ID in Figure 2.2 gives an overview of the beer process plant, showing tanks, piping, valves, pumps, and other relevant instrumentation. The P&ID is a document that provides the reader with information about the equipment in the process plant. Information like where equipment is located, its function and its affiliation with other equipment in the plant. The complete P&ID is available in Appendix D.

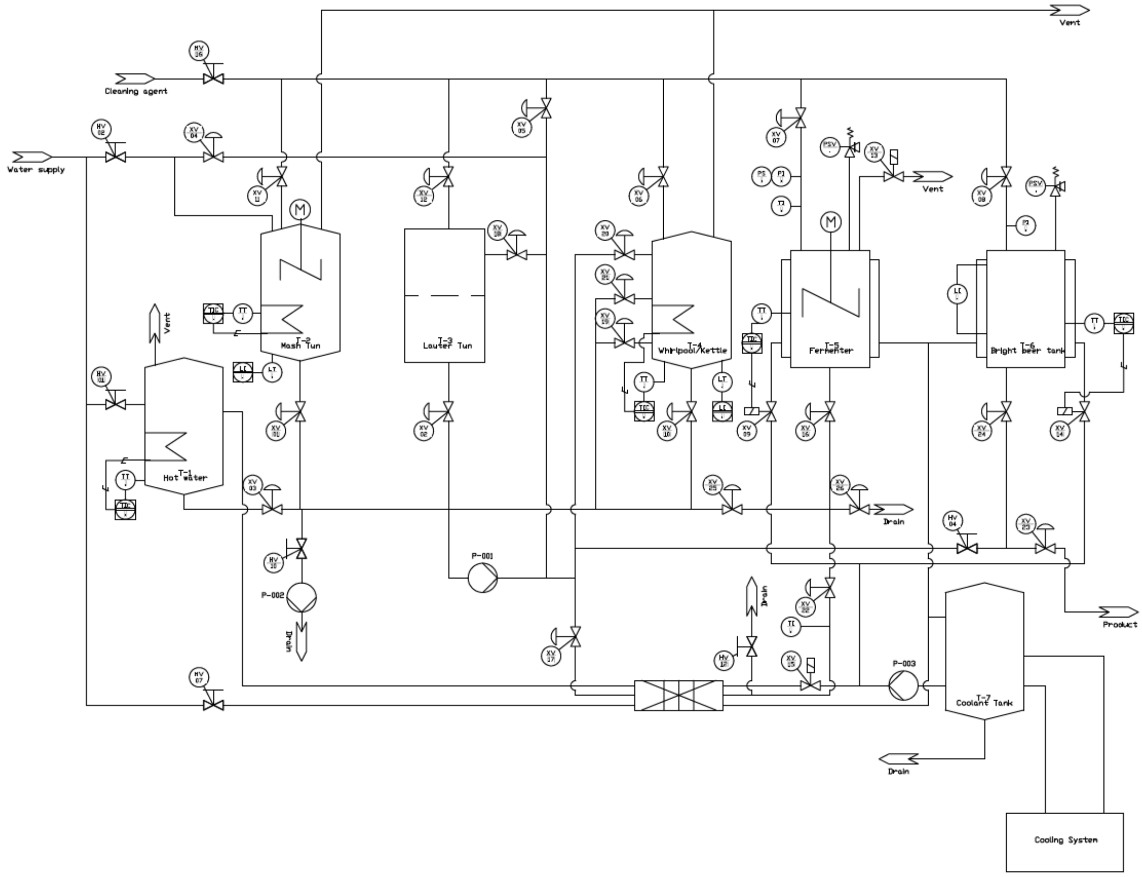

Figure 2.2 P&ID of the beer process plant

Figure 2.3 shows the entire process brewing beer from boiling water to the finished product.

The first step starts when the hot water tank is filled with the right amount of water. In the hot water tank, the water is sterilized by being heated to about 80˚C with the 3 kW heater element installed in the tank.

The hot water is then transferred to the Mesh tank, the stirrer is started, and the grist is added manually through a funnel. A heater inside the Mesh tank, regulated by a PWM controller regulates the temperature during the mash stage. The mash is then transferred to the separator tank, where solids are separated from the liquid before the wort is transferred to the kettle.

Meanwhile, the water in the boiler is reheated before it is used for sparging the grist in the separator tank. When the sparging is done, the remaining wort is transferred to the kettle tank. In the kettle, the whirlpool effect is started, and the heater element is activated to bring the temperature up to about 100℃ and keep at that temperature for one hour. Hops are added sometime before the step is finished.

The wort is then transferred to the fermenter tank through the heat exchanger where it is rapidly cooled down to about 24℃. The cooling of the fermenter tank is now activated to keep the desired temperature in the fermenter tank at 24℃ for approximately two weeks. Yeast is manually added through a funnel while the transfer of wort is ongoing, and then the stirrer is started. The stirrer will be activated for one hour every other hour, to stir up the yeast during the first seven days of the r. After 14 days, when the fermentation is done, the finished product can be transferred to the bright beer tank where it can be stored and tapped on bottles.

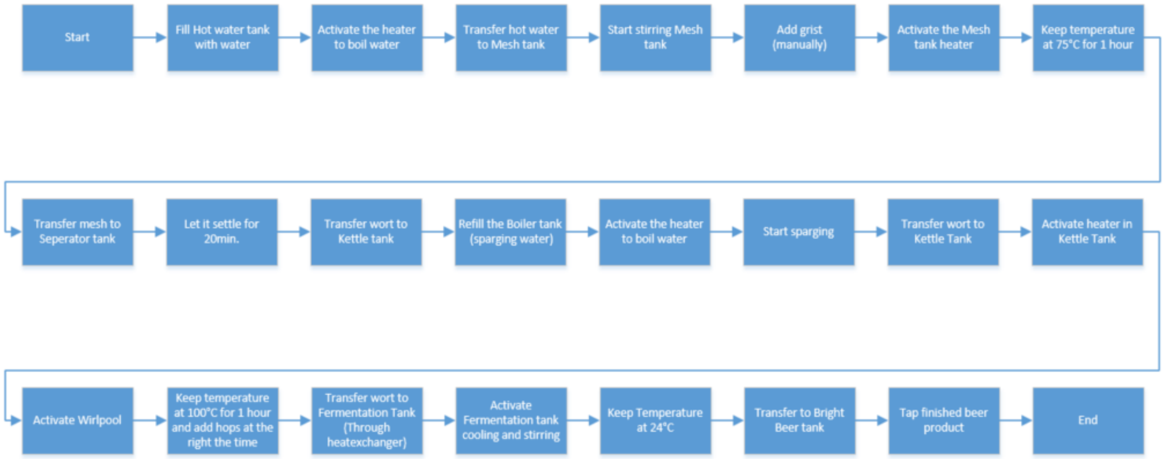

Figure 2.3 Process Flow Diagram

2.2 Process Equipment and Instrumentation

The beer process plant consists of a DeltaV Controller, a Control cabinet, I/P-converter, a total of seven vessels and several valves, pumps, and different sensors. This chapter provides a description of these components.

2.2.1 DeltaV Controller

The DeltaV controller shown in Figure 2.4 is installed in the control cabinet and handles all the I/O-signals. The control cabinet in Figure 2.5 contains all the internal wiring between the plant and the control system.

Figure 2.4 DeltaV Controller

Figure 2.5 Control cabinet

2.2.2 Converter

There are two I/P-converter blocks like the one shown in Figure 2.6, containing several solenoid activated block valves that are necessary for operating the valves in the plant. A 24V digital signal from the DeltaV output card triggers the correct block valve and allows air supply to the chosen valve.

Figure 2.6 I/P converter block

2.2.3 Tanks

The plant consists of seven vessels: hot water tank, mash tank, separator tank, kettle tank, fermenter tank, bright beer tank and the coolant tank. Specification of the tanks can be found in Table 2.1.

Table 2.1 Beer plant tank specifications

Beer Plant Tank specifications			
Tank	**Total capacity**	**Weight**	**Dimensions**
T-1 Hot water tank	60 liters	70 kg	500x1350 mm
T-2 Mash tank	60 liters	80 kg	450x1300 mm
T-3 Separator/Whirlpool tank	60 liters	72 kg	500x1000 mm
T-4 Kettle tank	60 liters	70 kg	550x1000 mm
T-5 Fermenter Tank	60 liters	95 kg	500x1460 mm
T-6 Bright beer tank	60 liters	70 kg	450x1700 mm
T-7 Ice Water/coolant Tank	150 liters	108 kg	660x1380 mm

2.2.3.1 Hot Water Tank

The hot water tank in figure 2.7, is the first tank in the beer plant, and is used for heating up, and sterilize the water used in the beer production. Figure 2.8 shows the production specifications of the tank.

Figure 2.7 Hot water tank

Figure 2.8 Hot water tank production specifications

2.2.3.2 Mash Tank

The mash tank in Figure 2.9, is the second tank in the beer plant and is used for mash conversion. See Chapter 2.3.1 for more info on the process. Figure 2.10 shows the production specifications of the mash tank.

Figure 2.9 Mash tank

Figure 2.10 Mash tank production specifications

2.2.3.3 Separator Tank

The separator (lauter) tank in Figure 2.11, is the third tank in the beer plant. It is used for separating the grain from the mash. See Chapter 2.3.2 for more info on the process. Figure 2.12 shows the production specifications of the separator tank.

Figure 2.11 Lauter tank

Figure 2.12 Lauter tank production specifications

2.2.3.4 Kettle/Whirlpool Tank

The kettle tank in Figure 2.13, also called the whirlpool tank is the fourth tank in the beer plant and is used for sterilizing the worth and separation. See Chapter 2.3.3 for more info on the process. Figure 2.14 shows the production specifications of the kettle tank.

Figure 2.13 Kettle tank

Figure 2.14 kettle tank production specifications

2.2.3.5 Fermenter Tank

The fermenter tank in Figure 2.15, is the fifth tank in the beer plant and is used in the fermentation process. See Chapter 2.3.4 for more info on the process. Figure 2.16 shows the production specifications of the fermenter tank.

Figure 2.15 Fermenter tank

Figure 2.16 Fermenter tank production specifications

2.2.3.6 Bright Beer Tank

The bright beer tank in Figure 2.17, is the sixth tank in the beer plant and it is mostly used for storing finished beer before bottling. It can also be used for making lager beer that has a longer fermentation time, which means that the fermenter tank can be cleaned and made ready for a new batch of beer while the lager is still fermenting. Figure 2.18 shows the production specifications of the bright beer tank.

Figure 2.17 Bright beer tank

Figure 2.18 Bright beer tank production specifications

2.2.3.7 Ice Water Tank

The ice water tank in Figure 2.19, also referred to as the coolant tank is the seventh tank in the beer plant and contains coolant for cooling of the fermenter tank, bright beer tank, and the heat exchanger. Figure 2.20 shows the production specifications of the coolant tank.

Figure 2.19 Coolant tank

Figure 2.20 Ice water tank production specifications

2.2.4 Valves

The plant consists of 22 pneumatic butterfly valves like the one in Figure 2.21, four magnetic valves like the one in Figure 2.22, seven manual valves like the one in Figure 2.23 and two pressure relief valves like the one in Figure 2.24. The Pneumatic valves are marked XV in the P&ID and is operated through the DeltaV control system. Manual valves marked HV in the P&ID is operated manually when needed between different stages of the brewing process.

Figure 2.21 Pneumatic valve

Figure 2.22 Solenoid valve

Figure 2.23 Manual valve

Figure 2.24 Pressure Relief valve

2.2.5 Pumps

Three pumps are installed in the plant. The Main process pump P-001 shown in Figure 2.25, handles the transfer of liquid through the pipelines. The waste pump P-002, seen in Figure 2.26 is meant for draining out waste liquids. The coolant circulation pump P-003, shown in Figure 2.27, is used for circulating coolant through the fermenter tank, the heat exchanger, and the bright beer tank.

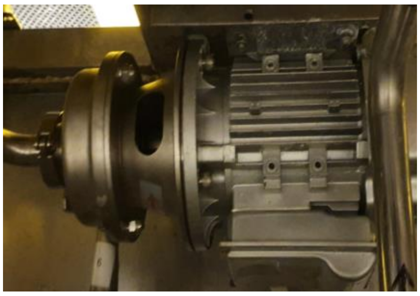

Figure 2.25 Main process pump

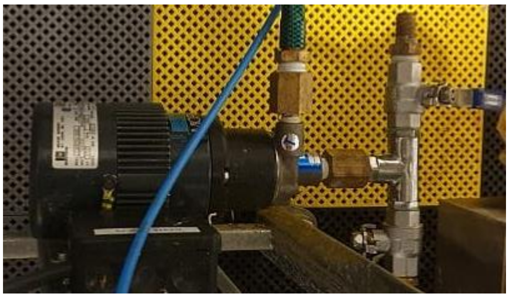

Figure 2.26 Waste pump

Figure 2.27 Coolant circulation pump

2.2.6 Sensors and Indicators

PT-100 elements shown in Figure 2.28, are used for temperature readings and for temperature control. There is one installed in every tank except for the separator tank.

Temperature gauge shown in Figure 2.29, installed on top of the fermenter tank, gives an indication of the temperature on site. The temperature gauge shown in Figure 2.30, gives an indication of the temperature on the outlet of the heat exchanger.

Pressure gauge with pressure switch shown in Figure 2.31, is installed on top of the fermenter tank for pressure indication and is a part of the pressure control in the fermenter. There is also a pressure gauge installed on top of the bright beer tank, shown in Figure 2.32.

Pressure sensors shown in Figure 2.33, is used for level readings. There is one mounted in the lower part of the hot water tank, mesh tank, and the kettle tank. The bright beer tank has a plastic tube shown in Figure 2.34, to indicate the level of the tank.

Figure 2.28 Pt-100 temperature element

Figure 2.29 Temperature gauge fermenter tank

Figure 2.30 Temperature gauge heat exchanger

Figure 2.31 Pressure gauge with switch on fermenter tank

Figure 2.32 Pressure gauge on bright beer tank

Figure 2.33 Pressure sensor for level readings

Figure 2.34 Level indicator tube on bright beer tank

2.2.7 Motors for Stirrers

The Motor shown in Figure 2.35, is mounted on top of the mesh tank and the fermenter for running the stirrers to stir the liquid.

Figure 2.35 Stirrer motor

2.2.8 Heaters

Two coil heater elements shown in Figure 2.36, are installed in the hot water tank, mesh tank, and the kettle tank, to heat up the liquids. The heaters have an output rate of 1500 watts per coil.

Figure 2.36 Heating elements

2.2.9 Heat Exchanger

A counter flow plate heat exchanger sown in Figure 2.37 is installed in the plant. The heat exchanger is used for cooling down the wort to fermentation temperature and to preheat the tap water running back to the hot water tank. A mix of methylated spirit and water is circulated through the heat exchanger to ensuring efficient cooling. For a more detailed explanation of how the heat exchanger is being used in the control sequence, see Chapter 7.1 and Figure 7.2.

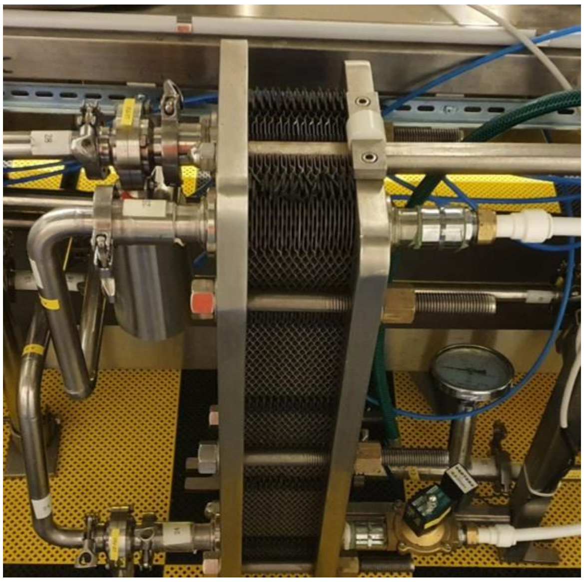

Figure 2.37 Heat exchanger

2.2.10 Additional equipment

Refrigeration compressor shown in Figure 2.38 is used for cooling down the coolant, submersible pump shown in Figure 2.39, is used for transferring waste liquid when draining the system and, an air compressor for instrument air shown in Figure 2.40, provides air supply for the valves trough the I/P-converter block shown in Figure 2.6.

Figure 2.38 Refrigeration compressor

Figure 2.39 Submersible pump [1]

Figure 2.40 Air compressor

2.3 Beer Production Shortly Explained

Beer brewing in the plant is a process that involves several steps; mash conversion, separation, kettle whirlpool and, fermenting.

2.3.1 Mash Conversion

Hot water from the boiler is transferred to the mash tank, the grist is added and mixed with the stirrer. The conversion process uses the natural enzymes in the malt to break the malt's starch into fermentable sugars, ultimately providing the necessary "food" for the yeast. This process will also create the base for color, body and, the overall flavor of the beer, depending on the brewing recipe.

2.3.2 Separation

The mash produced in the previous step is pumped into the separator to be separated from the grain husks. This process is done in two stages, in the first stage the mash settles for about 20 minutes before the wort is pumped to the kettle. In the second stage, heated water from the hot water tank is used for sparging water. The reason for that is to extract as much of the remaining sugars as possible, which means more food for the yeast that results in a more successful fermentation. This worth is then transferred to the kettle.

2.3.3 Kettle Whirlpool

The wort is brought up to a controlled boil to destroy unwanted remaining enzymes, removing harmful oxygen and stabilizing the worth by lowering the pH. The hops are also added to provide balance the beer by adding bitterness to counteract the sweetness of the grain. During this stage any malt and hop particles are also removed from the wort due to a whirlpool effect. A More detailed description of how this part of the process is done at the beer pilot plant is described in Chapter 6.

2.3.4 Fermenting

During the transfer of the process liquid from the kettle to the fermenter tank, the worth is quickly cooled down to fermenting temperature through a heat exchanger. To initiate the fermenting process, yeast is added during the filling of the fermenter tank. The yeast converts the sugary wort into beer by producing alcohol, flavors, and carbon dioxide. A more detailed description of how this part of the process is done at the beer pilot plant is described in Chapter 7.

2.4 Health Safety and Environment

A safety course was needed before the group could access the beer lab. This course gave important information about safety rules and safety equipment inside the beer lab. Figure 2.41 is showing important safety information if an accident were to occur. There were also additional precautions taken, due to the covid-19 epidemic.

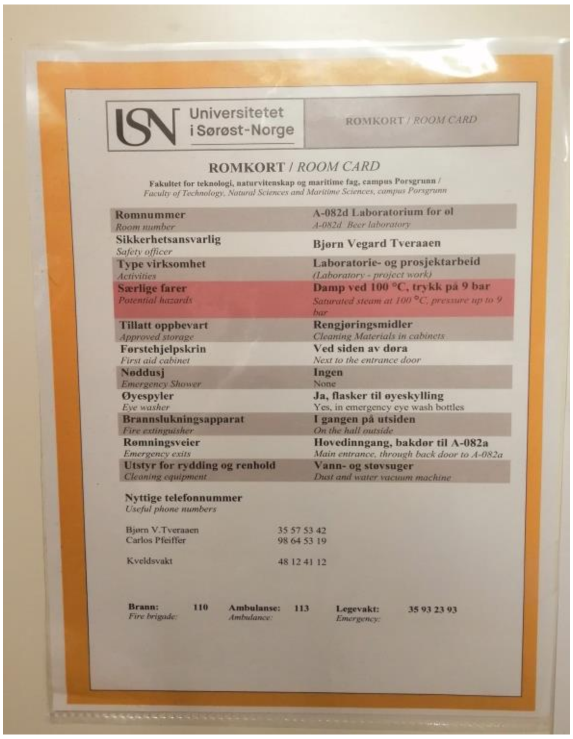

Figure 2.41 Lab safety information

2.4.1 Safety in the Beer Lab

The working space around the plant is tight, therefore be careful and observant when moving around.

A lot of liquid is involved in the brewing process and can cause slippery floors. Therefore, perforated floorboards that have been laid surrounding the plant, makes it much safer.

Under manually cleaning of tanks there can be a risk of getting exposed to caustic soda. Therefore, have eyewash available, and use the lab coat, visors, and gloves provided by the supervisors to reduce that risk.

If its required to open the tanks, it is important to ensure that the power safety switch and the main fuse are turned off. This to prevent the mixer motors or heating elements from accidentally hurting any operators.

In production of beer, be aware of hot pipes, or tanks that can produce steam under high pressure. Using the protection gear provided and staying outside the black and yellow perforated floorboards during production, will reduce the risk of injuries.

Working with electric connections and mechanical equipment will be done by or together with the supervisors. That way unwanted incidents like short-circuit, electrical shock, or damage to equipment is not a problem.

In case of fire, a fire extinguisher is available outside the lab, and a first aid kit is available next to the door inside the lab.

3 Organizing and Planning the Project

An instrumental part of delivering a successful project, is good organization and planning. Distributing workload enables the use of all available resources. Several documents related to planning were created throughout the project.

3.1 Guidelines for the Project

According to the USN guidelines [2] for the bachelor thesis the students must:

- Work in groups and manage the project using tools such as goal formulation, schedule and meetings.
- Define and limit the projects scope.
- Gather and sort relevant information
- Develop ideas
- Analyze the problem using a theoretical and/or practical approach
- Write a technical report
- Have a project presentation with an external sensor
- Attend USN EXPO

After the completion of the project the students are expected to:

- Have used a scientific approach to define and solve a problem
- Have gathered information relevant to solve the problem through literature or contact people with expertise regarding the problem and present it. Incorporate previous and new knowledge to solve a technical problem.
- Reference literature correctly.
- Have worked independently and as a group in planning and execution of experiments.

These are some of the requirements for a successful bachelor project and this report aim to prove that the students successfully accomplished the project. Which can be read in Chapter 10.

3.2 Project Schedule & Planning

The project was set to start during the 3rd week of 2020 and had a deadline 19.05.2020, during week 21. During these 19 weeks each of the students are expected to have a workload of 540 hours which correlates to 28.5 hours weekly working on the project. The first few weeks were spent planning and developing initializing documents:

- Multiple versions of P&ID
- A group agreement
- WBS
- Gantt diagram for scheduling of the project
- A process flow diagram
- Equipment State Diagram
- Document presenting the project for USN EXPO

These documents improved the groups understanding of the plant and project as well as creating an initial schedule and rough draft of what needs to be done to complete the project.

During this time the group also had lectures on scientific methods for solving a technical problem and writing a project report. The first visits to the beer lab with the project supervisor were arranged and the group were introduced to the plant, how to brew beer and the hazards present in the beer plant. The group agreed that every participant of the group, following recommendation by the supervisor, must read the parts of last year's master thesis regarding the beer process. The thesis includes an explanation of the beer lab and overview on how to brew beer [3]. In week 6 equipment in the plant were tested which is covered in Chapter 9.By the end of week 7 the scope of the project scope (Chapter 1.4) had to be defined and the focus shifted as to how the group would solve the problem for the project.

The next weeks were spent gathering information on the beer process and becoming familiar with the plant, in addition to reading manuals and experimenting with the DeltaV system. During this time, the group received more in-depth training in DeltaV and were able to consult our external mentor. Every participant of the group was required to read the E-book DeltaV Getting Started [4]. All the relevant literature regarding this project can be found in the reference list at the end of the report.

In week 10 the group started with the control strategy for automated control of the kettle and fermentation tanks (Chapter 5.2). Then programming a PLM (Chapter 4.3), developing controllers (Chapter 6 and Chapter 7), and configuring the HMI (Chapter 8). Tests regarding transportation of process medium were completed in week 10 and testing of the HMI and control system in week 18. More information about these tests can be found in Chapter 9. The remaining weeks were spent on the project report.

As a result of the initial weeks spent on planning, gathering information and becoming familiar with the plant and the DeltaV system the group acquired a good base of knowledge for the project, plant and DeltaV system. When USN was shut-down due to the Coronavirus this proved to be a great benefit as the group worked remotely on the project.

3.3 Explanation of Planning Documents

3.3.1 P&ID

P&ID is explained in Chapter 2.1. The P&ID in Appendix D contains suggested updates of labeling of equipment in the plant.

3.3.2 Group Agreement

The group agreement is a list of rules for the members of the project and creates a base for how the group will work together to solve the project. Its function is to limit unnecessary arguments between the project members and hold the members accountable for further progression of the project. Appendix F shows the group agreement.

3.3.3 WBS

A WBS was created to separate the project into smaller more manageable tasks. The WBS document was used to get an overview of the group intended to solve the project and can be found in Appendix G.

3.3.4 Gantt Diagram

A Gantt chart was used to organize tasks, set deadlines, manage resources and plan progression for the project. The Gantt chart was continuously updated during the project. The Gantt chart can be viewed in Appendix C.

3.3.5 Process Flow Diagram

A PFD was developed to increase understanding of the beer process and how to brew at the USN Beer lab. The PFD can be viewed in Figure 2.3.

3.3.6 Equipment State Diagram

The equipment state diagram shows a graphical representation of the state of equipment relevant to process operations. The document was created to easily identify configuration that needed to be done when programming sequences for controlling the plant and proved valuable during testing (Chapter 9.2). Appendix H contains the Equipment State Diagram.

3.3.7 EXPO Presentation

According to the requirements for the bachelor project, further explained in Chapter 3.1, the students had to prepare a document explaining the purpose of the project for EXPO. Because of the Coronavirus EXPO was cancelled. The document for EXPO can be viewed in Appendix I.

3.4 Organizing the Group

The group was assigned a room at USN where they would meet at 08.15 everyday if there were no lectures or other group work scheduled for that day. Every member of the group signed a group agreement (Appendix F) and were responsible to follow those rules. For communication within the group outside of the assigned room we used the Facebook group chat and Microsoft Teams for voice and video communication and file sharing. Microsoft Teams were also used for formal meetings with our supervisor Carlos during the Coronavirus. Communication with our supervisor and external mentors from Emerson were through email when not in person.

3.5 Organizing the Project Tasks

The project was divided into six parts initiation, planning, programming, testing, project management and documentation. Each of these parts was subsequently divided into smaller tasks and can be viewed in the WBS (Appendix G). Project management tools such as Gantt chart allowed for allocating of resources and management of time.

Configuration of DeltaV was further divided into three subtasks PLM programming, configuration of controllers and HMI. One group member was assigned to be responsible for each of these configurations and testing the implementations (Appendix E).

3.6 Meetings

One of the obligatory requirements for a bachelor project is that the group had to organize, send meeting notices, and document four formal meetings with the project supervisor. The purpose of these meetings was to update our supervisor on the state of the project, receive feedback and document it. The meeting minutes from these formal meetings can be found in Appendix H.

3.7 Training

In order to complete the project, the group received training at several stages of the project.

- Introductory course in beer brewing, the beer plant and HSE by the project supervisor
- Introductory course in DeltaV and the cleaning project by a previous master student were the group also were introduced to DeltaV Internal documentation which was a great source of information to understand the DeltaV system.
- More in-depth DeltaV training by an Emerson external mentor. During this training a lot of questions about the structure of DeltaV were answered and the group was introduced to DeltaV Control Studio. After consulting the projects external mentor the group changed its control strategy for the sequences to implement a PLM, instead of having separate sequences activated by buttons in the HMI. Implementing a PLM was a better solution for our project and can be used for future projects in the beer lab, Chapter 11 elaborates on this topic

The external mentors and supervisors for the project were able to answer follow-up questions via email.

3.8 Challenges During Execution of the Project

A challenge that impacted this project was the Coronavirus that forced USN to shut down, which lead to the group no longer having access to the group room and beer lab. To overcome this challenge the group relied heavily on communication through Microsoft Teams. At the time when the Coronavirus happened the group worked on programming so remote access to the lab was implemented using TeamViewer. A schedule had to be implemented since TeamViewer only allows access for one remote operator at a time and there were multiple parts of programming remaining. To test our configuration of the plant we were given access to the beer plant in the weeks 18 and 19. The group handled the Coronavirus very well and were able to maintain communication and finish the project on schedule.

4 DeltaV System

The Emerson DeltaV system is the worlds most applied DCS system. DeltaV is designed according to the ISA 88 standard, which is a standard for batch production control, the system is however also applicable for process automation. DeltaV is the “brain” of the Beer process plant, it controls everything in the plant except for the hand valves. [5]

4.1 DeltaV Programs

There are several programs in the DeltaV package, during this project the following programs where used:

- DeltaV Operator (Configure)
- DeltaV Operator (Run)
- DeltaV Explorer
- DeltaV Control Studio
- DeltaV Database Administrator

4.1.1 DeltaV Operator (Configure)

This program is used to design and add functionality of the HMI to the DeltaV system, it provides basic buttons, indicators, and figures for designing the HMI. For more user defined design and functionality, it is possible to write code in Visual Basic. For this plant Visual Basic was not applied as the functionality already provided in DeltaV Operator (Configure) was sufficient. [4]

4.1.2 DeltaV Operator (Run)

DeltaV Operator (Run) is used to run the HMI created in DeltaV Operator (Configure). Control system operators use this HMI in the daily monitoring and maintenance of the process. [4]

4.1.3 DeltaV Explorer

This program is used to program the users control strategy, here the user can create new modules for control of instrumentation and equipment as well as define the DeltaV hierarchy of the system. It allows the user define components and view the overall structure and layout of the system. [4]

4.1.4 DeltaV Control Studio

DeltaV explorer provides templates for control modules that are used for control of instrumentation and equipment. DeltaV Control Studio is used to design and modify individual modules that make up the control strategy. In DeltaV Control Studio it is possible to change alarm limits, add functionality to control blocks and create a new module from scratch. Control Studio uses graphical languages based on IEC 61131-3. [4]

4.1.5 DeltaV Database Administrator

DeltaV configuration data is stored in a database in one of the workstations in the system. A system can have several databases, but only one database can be active within a system at a time. The database includes everything that is viewable from the DeltaV Explorer. This includes:

- The library of control modules and function blocks included with the system
- The modules the user create
- The workstations and controllers in the system.
- System-wide data, such as named sets and alarm preferences

In short, the database contains the entire functionality of the system [6]

This program allows the user to preform database maintenance tasks such as creating, deleting, copying, and backing up databases. [4]

4.2 Network Topology

The DeltaV system is very scalable being able to consist of up to 120 Nodes, 100 Controllers and 60 workstations. The network topology of the plant however is quite simple, only consisting of three main components, a workstation, the DeltaV controller and a remote pc that has access to the workstation through TeamViewer, as seen in Figure 4.1. Manual operation of valves and equipment and initiation of sequences is done through the HMI on the workstation or through the remote PC. [7]

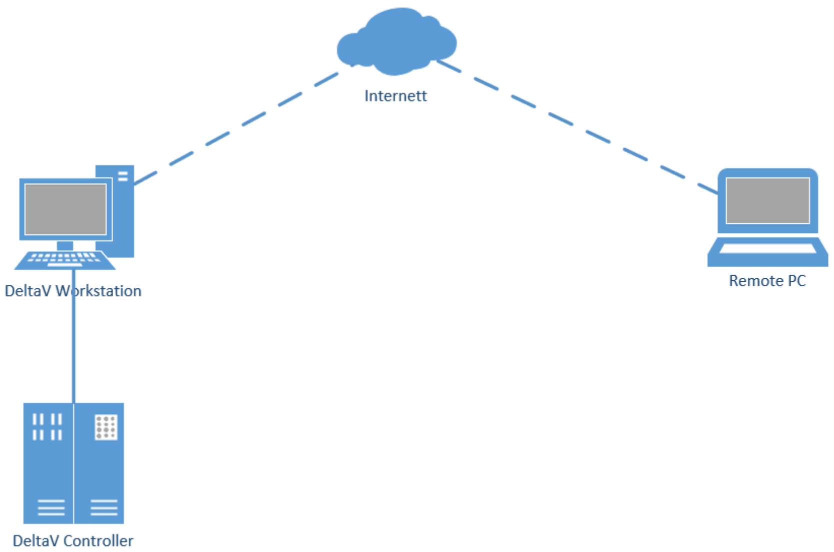

Figure 4.1 Network topology

4.3 Phase Logic Module

A PLM is a state machine that executes an SFC based on what state the PLM is in, a schematic of the state machine is shown in Figure 4.1. The PLM starts off in the Idle state, when the operator tells the PLM to start it goes into the Running state, the running state contains an SFC. Should the sequence complete without failure it will go to the complete state, if the operator intends to send the PLM into the idle state again in order to start the sequence anew, the PLM must be reset. Should the Running SFC not complete without failure it will go into the Holding state, and the Holding SFC will be run. Once the holding SFC is complete the PLM will go to the Held state, from here the operator needs to decide whether the PLM should be aborted, restarted or stopped, and the PLM will act accordingly. To request a change in state, the XCOMMAND parameter must be changed, the values of this parameter is defined by a named set, a list of the named set is shown in Table 4.1. this is done through the activation of a button on the HMI. [6]

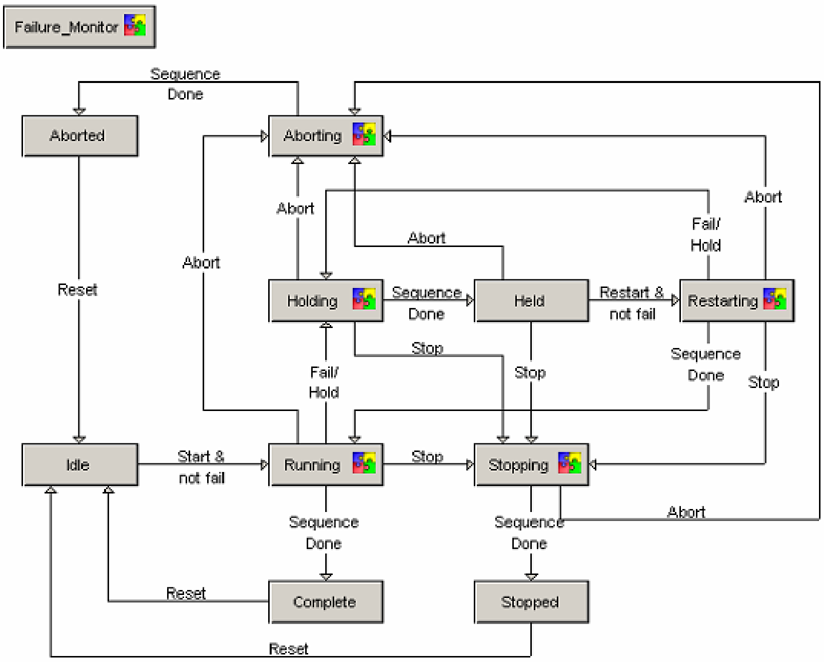

Figure 4.2 PLM state chart

Table 4.1 Named set list [6]

String	Ordinal Value
Abort	10
Hold	20
Stop	30
Reset	40
Pause	50
SingleStep	60
Download	70
Resume	80
Restart	90
Start	100
Automatic	110
Manual	120
Clear Failures	130
Not Loaded	254

5 Sequence Design and Implementation

5.1 Equipment State Diagram

To have a foundation when designing the sequential controls and to provide for easy manual operation of the plant, an *Equipment State Diagram* was made. The diagram represents the state of every equipment module in the plant, *for all phases of the system*.
The Equipment State Diagram was based on the P&ID and was created by manually drawing the desired paths for the process medium and marking the state of each related valve and equipment module to achieve the correct pathing. Figure 5.1 represents how each column of the ESD was created, with the use of the P&ID. The figure displays the transition phase from the kettle to the fermenter tank, through the two-staged heat exchanger. The blue lines represent spring water, orange represents beer and the green is coolant. Every equipment marked with a green check is open/on. Those marked with a red cross are closed/off.
The complete Equipment State Diagram is attached in Appendix F

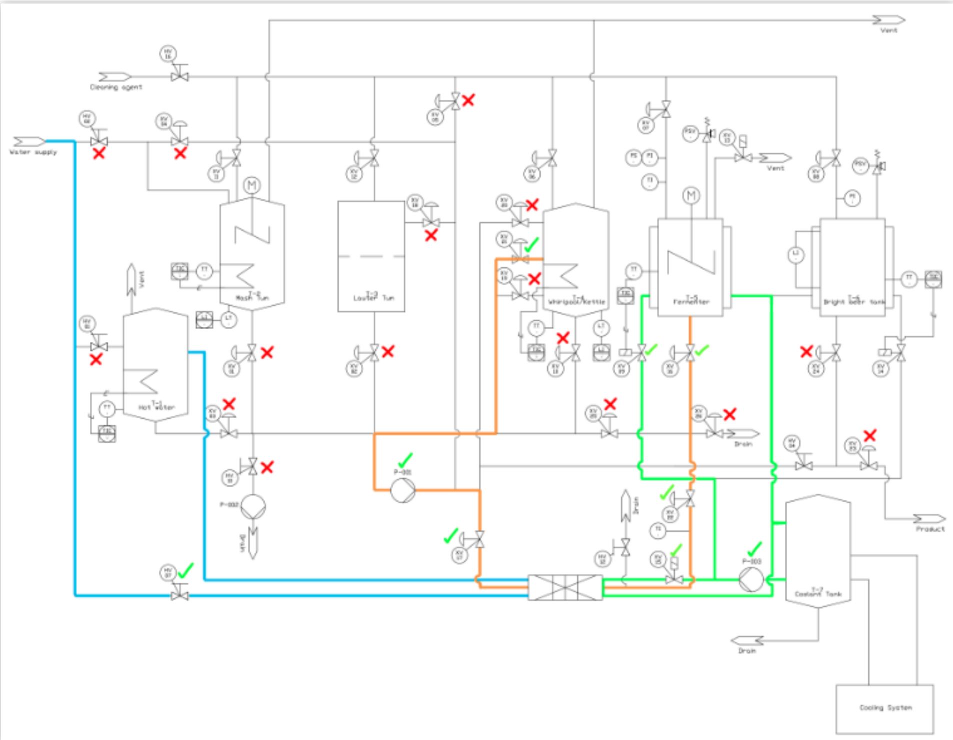

Figure 5.1 - Kettle to Fermenter Transition Sequence

5.2 Kettle and Fermenter Sequence Design

Using the Equipment State Diagram, the kettle and fermenter sequences were designed and drawn in Microsoft Visio. This was done to enable manual testing of the sequences and make revisions before they were implemented in as an SFC in the PLM. The kettle sequence incorporates the Whirlpool part of the equipment state diagram, while the fermenter sequence uses the Kettle-Fermenter and Cooling Fermenter parts. Chapter 6.1 and Chapter 7.1 takes an in depth look at the kettle and fermenter sequences respectively.

5.3 Implementation

The scope of this project was strictly the sequential control of the Kettle and fermenter tanks in the process. These sequences were implemented in the Running SFC in the BEER_PROCESS_PLM. The PLM is currently on the Control module level in the DeltaV system and handles all sequential control defined by the task scope. Documentation on the BEER_PROCESS_PLM, including step actions for each step, is available in Appendix I.

5.3.1 Running SFC

The Running SFC or RUN_LOGIC shown in Figure 5.2, contains the normal sequential control for this project, including the fermenter and kettle sequences. Steps one through seven contains the kettle sequence, and steps eight through 15 contains the Fermenter sequence. The sequence contains one input parameter and two output parameters. The input parameter FERM_DONE takes a Boolean value which the operator changes to true through the HMI in order to let the SFC know that the beer is done fermenting. The output parameters SEQUENCE_RUNNING and SEQUENCE_STATUS contains strings, SEQUENCE_RUNNING updates the HMI with information of which sequence is currently running. The SEQUNCE_STATUS provides the operator with information of what the Running SFC is doing.

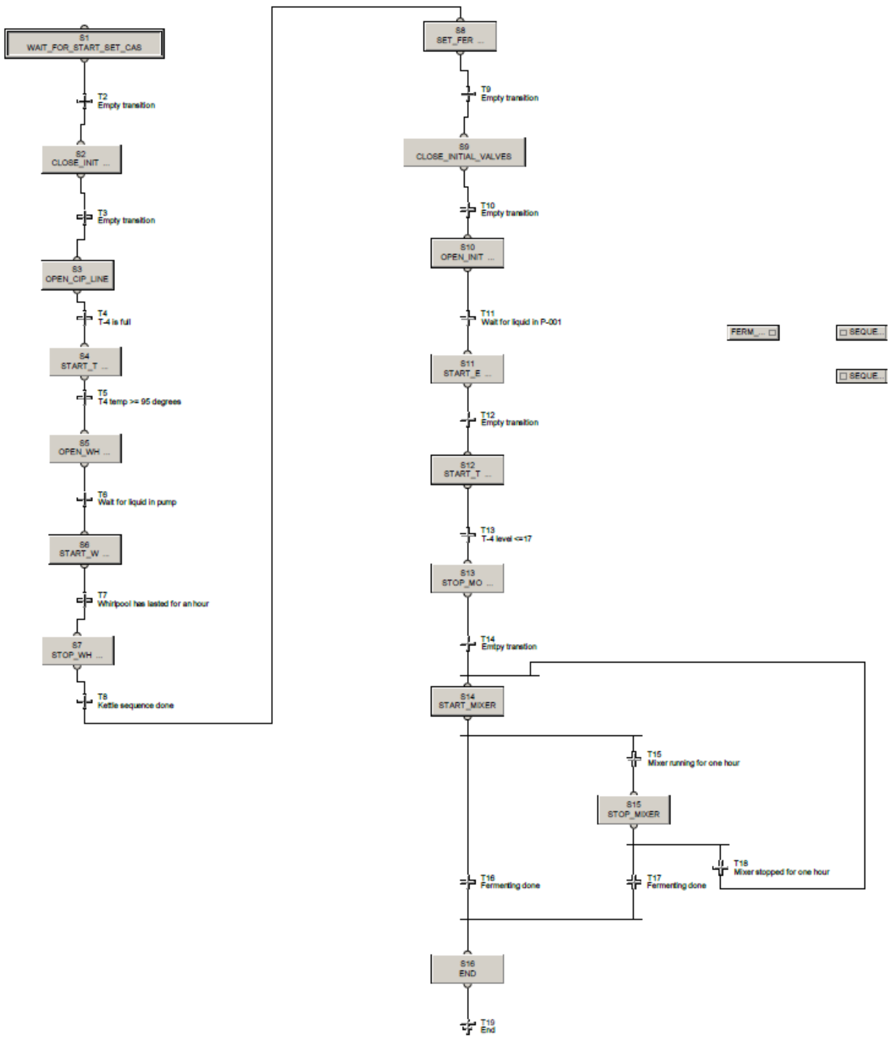

Figure 5.2 Running SFC

5.3.2 Holding SFC

Should the execution of the Running SFC fail, or the operator request that the system should be held, the PLM will stop the Running SFC and run the Holding SFC or HOLD_LOGIC. The holding SFC closes all inlets and outlets except for ventilation to the kettle and fermenter. All pumps and mixers are stopped, however temperature control is not. This is to ensure that the product quality isn't affected whilst in the held state. The Holding SFC is shown in Figure 5.3.

Figure 5.3 Holding SFC

5.3.3 Stopping SFC

The Stopping SFC or STOP_LOGIC will be activated if an operator prompts the PLM to stop through the HMI. This SFC closes all inlet and outlet valves to the kettle and fermenter tanks, stops temperature control, pumps and mixers. The purpose of the stopping SFC is to allow the operator to stop the PLM completely without discarding the product. The Stopping SFC is depicted in Figure 5.4.

Figure 5.4 Stopping SFC

5.3.4 Aborting SFC

The Aborting SFC or ABORT_LOGIC will be activated if an operator prompts the PLM to abort the process through the HMI. This SFC opens all inlet and outlet valves to the kettle and fermenter tanks, stops temperature control, pumps and mixers. It also opens the drain valves located beneath the fermenter tank. The purpose of the Aborting SFC is to allow the operator to stop the process and dispose of the product. The Aborting SFC is shown in Figure 5.5.

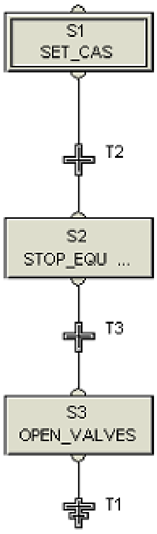

Figure 5.5 Aborting SFC

6 Operation and Control of the Kettle/Whirlpool Tank

Inside the kettle tank is where the wort is boiled. The boiling phase usually lasts an hour [8] [9]. Boiling sterilizes the wort and makes the final product safe for consumption. It is sufficient to heat the wort over 80°C for 5-10 minutes, in order to eliminate contamination by killing all live bacteria, yeast and fungi [10]. Another key accomplishment provided by the boiling, is the removal of volatile compounds. These are removed with the steam. The compounds containing sulfur are especially unwanted, for instance *dimethyl sulfide* $(CO_3)_2S$. Dimethyl sulphide can give a cooked vegetable flavour to the beer and is not desirable in the finished product [8].

Hops are added to the boiling wort to add bitterness to the beer. While the heat dissolves the hop resins, *alpha acids* in the hop are not initially soluble. The alpha acids must be *isomerized* to become soluble. This process requires a lot of heat and energy; thus, the boiling time usually lasts an hour. [11]

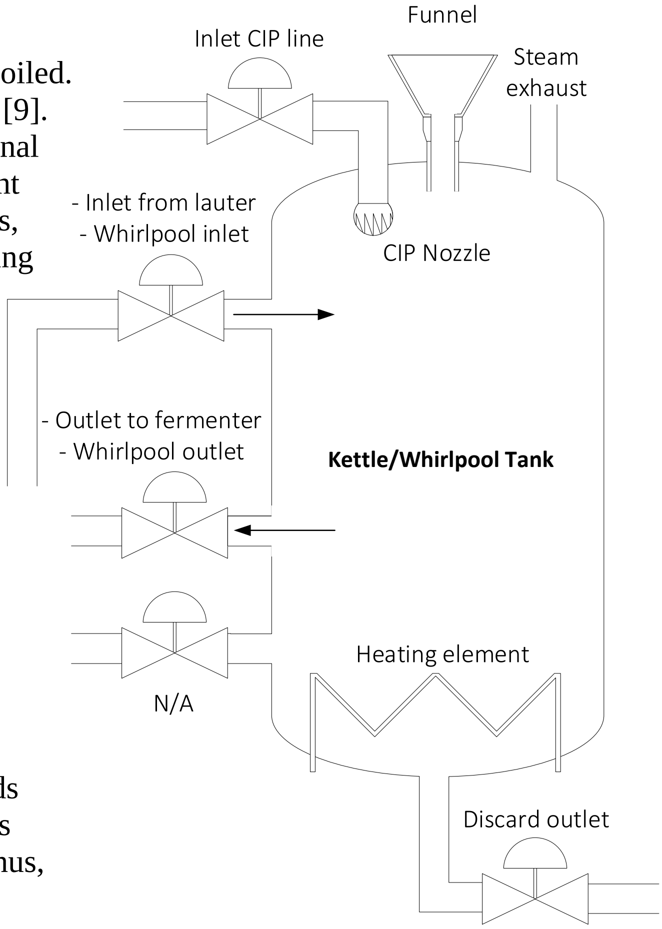

Figure 6.1 Kettle/Whirlpool Tank

Tannins are a class of polyphenolic molecules, made up from *phenols*. A phenol is an organic chemical comprised of six carbon molecules bonded in a ring. There are three classes of tannins, two of them are relevant for the brewing process. These classes are condensed- and hydrolysable tannins, who are water soluble. Tannins are extracted from the malt during the mashing process and from the hops in the boiling process. They react with proteins in the wort, causing chains of proteins from the grain to *coagulate*. The coagulated proteins and tannins formed during the boiling is called *hot break*. The hot break formed during the boiling process is unwanted in the final product and is therefore removed. The separation process of the hot break and the wort is done using a whirlpooling effect. [8] [12] [9]

The tank, as illustrated in Figure 6.1, has a dual-purpose inlet and a dual-purpose outlet pipe. The inlet pipe is where the wort from the Separator Tank enters the Kettle Tank. This is also the inlet for the whirlpool effect that is being used in the tank. The outlet pipe is where the wort is drained to the fermenter, but also serves as the outlet for the whirlpool effect. By pumping the boiling wort from the outlet pipe and up to the inlet, a whirlpool is created inside the tank. The centripetal forces causes the coagulated proteins and other solid particles to migrate to the bottom of the tank, in a cone-shaped mass. [13]

6.1 The Control Sequence for the Kettle Tank

The control sequence was designed using the Equipment State Diagram, as seen in Appendix F. This diagram shows the states of all process equipment, for this given phase. For more detail on how this diagram was developed, see Chapter 5.1.

The initial control step ensures that all the related process equipment is set to Cascade mode. The following steps closes and opens various valves, related to the process. This to ensure correct pathing of the beer.

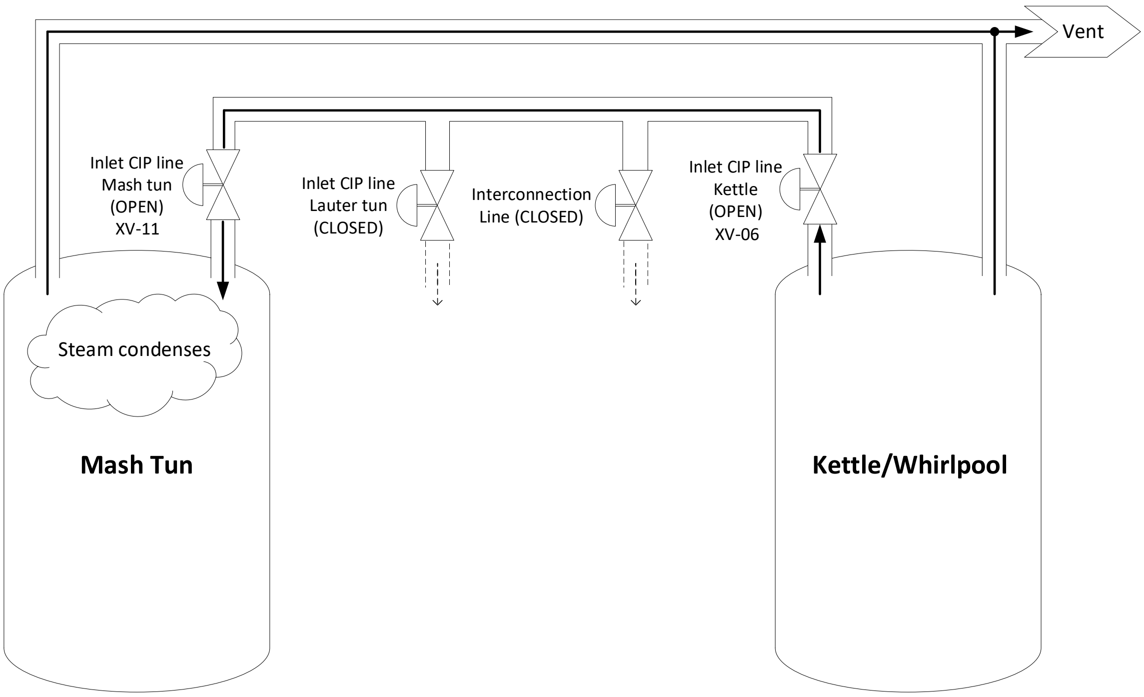

Figure 6.2 Steam path in the kettle sequence

The following step opens the pneumatic valves XV-06 and XV-11, see Figure 6.2. XV-06 is the inlet valve for the CIP line in the kettle tank. XV-11 serves the same purpose on the mash tun. The connection between the mash tun and the kettle is open because steam will be sent to the mash tun to condense. The steam from the kettle travels through the CIP line, where it condenses in the mash tun, before exiting the exhaust pipe in the mash tun and finally merges with the additional steam coming from the kettle exhaust pipe.

Afterwards, a transition requires that a level sensor must indicate that the kettle tank has reached the final setpoint in volume. The next step turns on the heating element in the kettle and starts the temperature control. Afterwards, a transition waits till the temperature reaches 100°C.

The following step, (step five) opens XV-20 and XV-21, these are the inlet and outlet pipes for the whirlpool effect, see Figure 6.1. After these valves have been opened, the control sequence waits 5 seconds, to ensure that the process pump is submerged before starting. The next step starts the main process pump, P-001, and runs the pump for as long as the step is active. The transition waits for a confirmation that previous step has been active for an hour.

Step seven closes the same valves as were opened in step five and turns off the heating element and temperature control, before the sequence ends. The full control sequence is available in Appendix J.

6.2 Temperature Controller in the Kettle Tank

The Kettle tank is equipped with two heating coils, where each coil has a power consumption of 1.5 kW. The heating elements are turned on/off with the use of a Solid-State Relay (SSR), with zero detection. The SSR can switch up to 100 times per second, as the current is 50 Hz [14]. The purpose of the heating element is highlighted in Chapter 4. The Control Module in DeltaV Explorer is named TIC_KETTLE.

6.2.1 Designing the TIC_KETTLE Control Module.

The design-phase of the controller is divided in three sections:
Requirements for the Temperature Controller, Control Strategy and Design and Implementation.

6.2.1.1 Requirements for Temperature Controller

To control the temperature of the beer inside the kettle tank, a controller that drives the heating elements, must be implemented. There are three fundamental requirements for the controller:

1) The controller must have a Start/Stop function that is set ON.
2) The regulator output must be "high"
3) The heating coils must be submerged.

Figure 6.3 illustrates the logic with an AND gate.

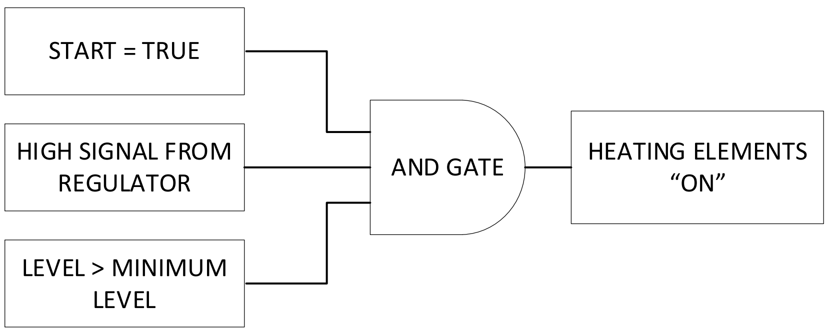

Figure 6.3 Requirements for the heating elements to be turned on

If these three requirements are met, the heating element should be turned on. Otherwise, it will be turned off.

Another key requirement of the controller, is the ability to change setpoint throughout the process.

6.2.1.2 Selecting the Control Strategy for the Temperature Controller

Initially, an ON/OFF-controller with hysteresis was thought to be sufficient for controlling the temperature in the kettle tank. When *steam buildup* was taken into consideration, the controller poses a potential risk of being too aggressive. The ON/OFF controller oscillates between upper and lower bands, providing either 100 or 0 percent power at any given time. This means the system never achieves a steady state and the heating element is providing full power when transitioning from lower to upper bound. This may cause the liquid to boil vigorously, which is problematic due to multiple reasons;
Firstly, achieving a "rolling" boil, where formation of foam and risk of boilover is kept at a minimum, is optimal [11]. Secondly, losing more product to boiloff than necessary is unwanted. Lastly, a vicious boil increases steam buildup and high-pressured steam poses a potential danger for operators and equipment. Therefore, this strategy was abandoned. Instead, a PID block, using *Proportional-Integral control action*, cascaded to a PWM function was selected as the control strategy. This would pulse the electric heater on, proportional to the output of the controller. Figure 6.4 shows a simple illustration of how a PI-controller regulates the output, compared to an ON/OFF-controller (this figure is just an illustration and does not represent any real data). This results in a less aggressive controller and minimizes steam buildup.

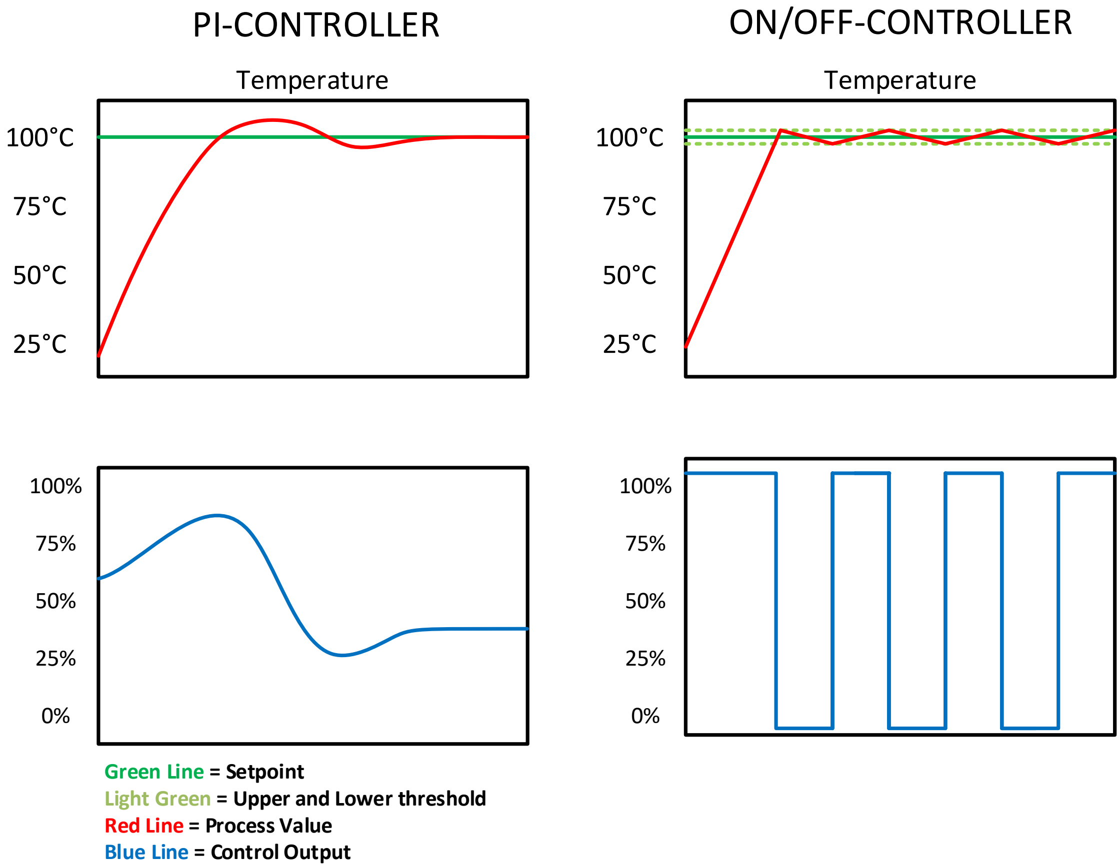

Figure 6.4 Illustration of how a PI-controller varies from an ON/OFF controller

6.2.1.3 Designing and Implementing TIC_KETTLE in DeltaV Control Studio

6.2.1.3.1 The First Version of TIC_KETTLE

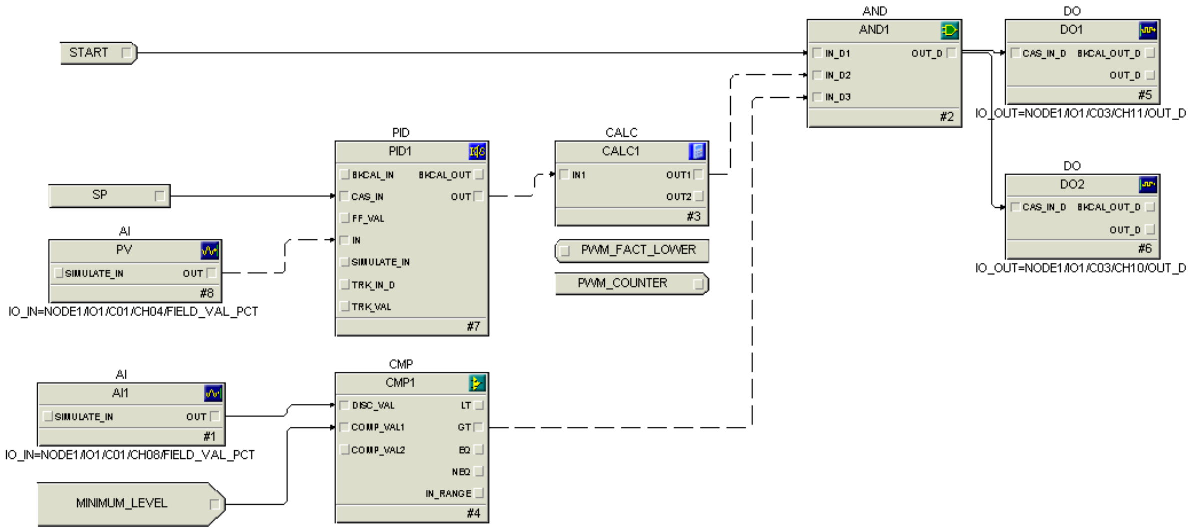

Figure 6.5 The first version of TIC_KETTLE

The first version of the regulator (Figure 6.5) was made using DeltaV Control Studio, with the controller requirements in mind.
The first requirement was that there must be a “Start” function for the controller. An Internal Read Parameter function block, named “**START**” was implemented. The block outputs Boolean data values “True” or “False” and is connected to the first input port on the AND gate. The “Start” parameter is set to “True” by the Phase Logic Module (PLM), when the control sequence for the kettle tank is in ‘Running’ state (See Chapter 5.3.1).

The second requirement was that a temperature regulator had to output a “High” signal to the AND gates’ second input port.
The “**SP**” block is a numeric Input Parameter function block, where the target setpoint for the process is set. The “**PV**” block is an Analog Input function block, that provides the current temperature from the kettle tank’s PT100 element.

A PID function block was implemented in the control unit, where IN is the connection for the process variable (PV) and CAS_IN is the connection for the setpoint value (SP). [6]
The thought behind the PID block was to have the output be set between 0-100%, where this value would control a PWM, but no inbuilt PWM was found in the version of DeltaV that was installed on the lab. Instead, a “Logic/Calc” function block was implemented to serve the purpose of a PWM. The “**CALC”** block’s internal expressions can be read in Appendix K.
The block counts from 0-100 continuously and resets every time it reaches 100. If the input value (0-100) is greater or equal to the value of the counter the output of the CALC block is high. If the counter is greater than the input, the output is low, as illustrated in Figure 6.6.
This in effect realizes a programmable duty cycle which serves the purpose of a PWM.

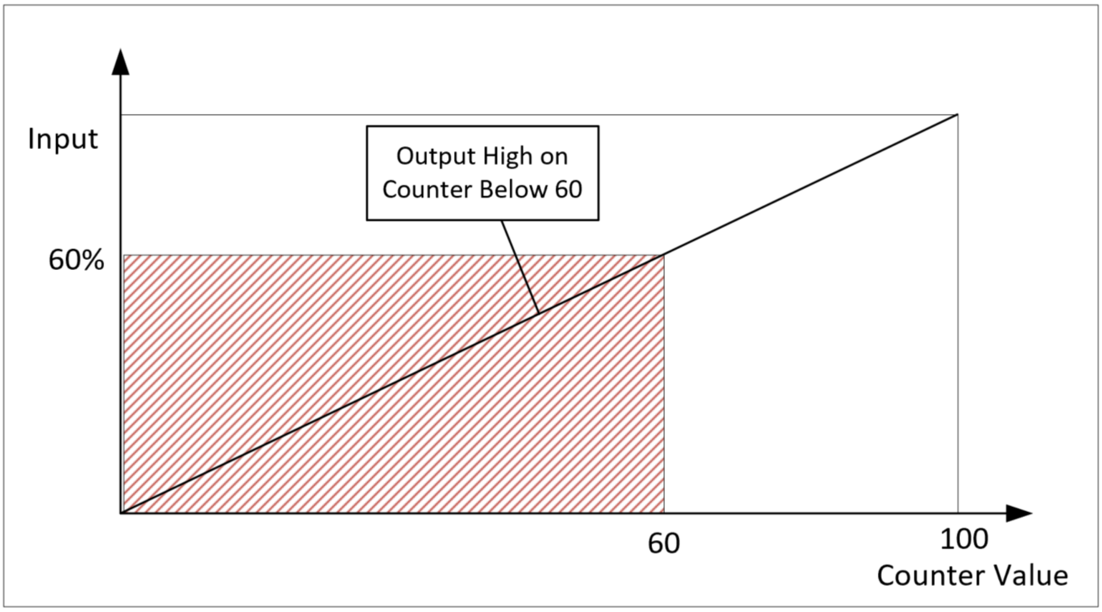

Figure 6.6 Illustration of the counter logic

The PID function block has various internal parameters that must be configured, one of which was the "STRUCTURE" parameter.
The parameter was configured to "PI Action on Error, D Action on PV", that is defined by "Proportional and integral action are applied to error; derivative action is applied to PV. A setpoint change will exhibit a proportional kick." [6]

Another initial parameter that was configured was the FORM parameter, as there are two supported PID expression forms:

Standard PID: $OUT(s) = GAIN_a * \left(1 + \frac{1}{T_r s} + \frac{T_d s}{(\alpha T_d s+1)}\right) * E(s) + F(s)$

Equation 6.1 - Standard PID Form [6]

Series PID: $OUT(s) = GAIN_a * \left(1 + \frac{T_d s}{(\alpha T_d s+1)}\right)\left(\frac{T_r s+1}{T_r s}\right) * E(s) + F(s)$

Equation 6.2 - Series PID Form [6]

Where $E(s)$ is error $(SP - PV)$, T_r is reset time in seconds, T_D is derivate time in seconds, $GAIN_a$ is normalized gain after scaling the parameter GAIN from PV to OUT, $F(s)$ is the feedforward contribution and s is the Laplace notation for the derivative with respect to time. [6]

The Series form (Equation 6.2) essentially consists of a PD (Proportional-Derivative) and a PI (Proportional-Integral) controller in series. As derivative action is not wanted, the Standard form (Equation 6.1) was used.

The GAIN parameter corresponds with the normalized Proportional gain value and was set between 1 and 500 for testing.
The RESET parameter corresponds with the Integral action time constant and was set between 1 and 20000 seconds for testing.

The RATE parameter corresponds with the derivative time constant and was set to *null* as derivate action is rarely used and not wanted in the controller.

The CONTROL_OPTS parameter defines what type of control action that is present in the system. The two types are *Direct Acting* and *Reverse Acting* controllers. Where the direct acting increases the output as the process variable increases, and reverse acting decreases the output as the process variable increases. As the system requires less energy from the heating element as it approaches setpoint, the system requires a *Reverse Acting Controller*. Therefore, it was important to leave the parameter “Direct acting” unchecked.

The third requirement was to ensure that the heating elements were submerged in water. A *Comparitor* function block was used to compare the level in the tank to a fixed minimum level, where the GT (Greather Than) output port is high when DISC_VAL input is greater than COMP_VAL input.
An Internal Read function block, “MINIMUM_LEVEL” was connected to the COMP_VAL input, and an Analog Input function block “AI”, later renamed “LEVEL” was connected to the DISC_VAL input. The analog input block was configured to provide the sensor data from the level transmitter in the kettle tank.

Upon testing the strategy with DeltaV Control Studio OnLine, the AND gate did output a HIGH signal to the Discrete Output function blocks corresponding to the two heating elements in the Kettle tank, as seen in Figure 6.7. A full view of the controller during the test is seen in Figure 6.8.

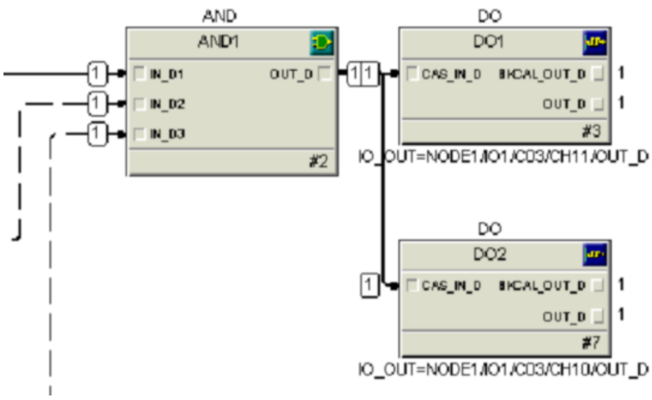

Figure 6.7 Testing the output of the first version controller

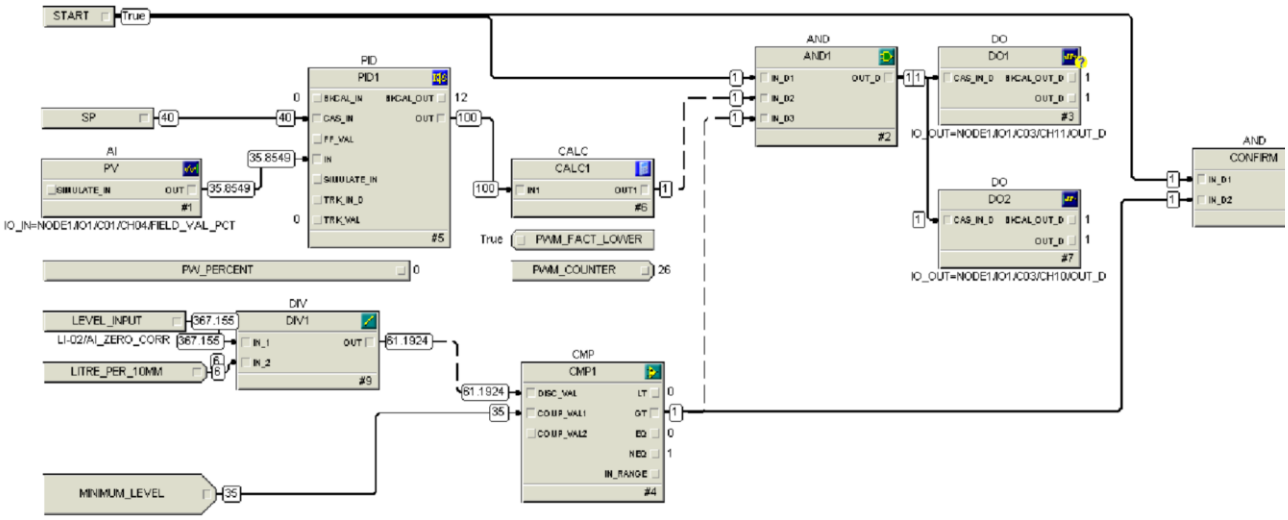

Figure 6.8 Full view of the controller during testing

6.2.1.3.2 The Final Version of TIC_Kettle

After encountering various configuration issues (see Chapter 11.1), the PID block was replaced with custom logic. The new controller has all necessary features of the PID block, at minimal complexity and overhead.

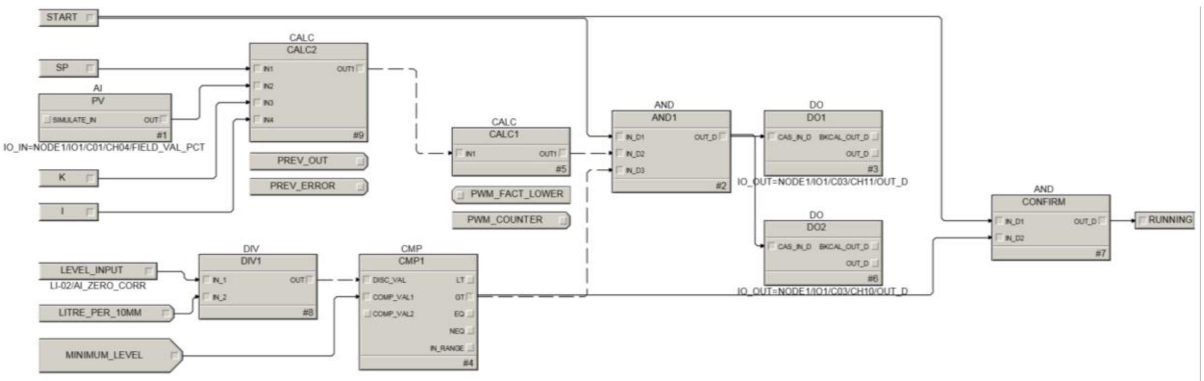

Figure 6.9 The Final Controller

Figure 6.9 shows the final TIC_KETTLE controller, documentation for this controller is available in Appendix K. Some minor changes were done to the level check in the comparator, as the input signal from the Analog input block was scaled in millimetres. A divider block was implemented to convert the level signal from millimetre to litre, by dividing the sensor value by 6, as seen in Figure 6.10.

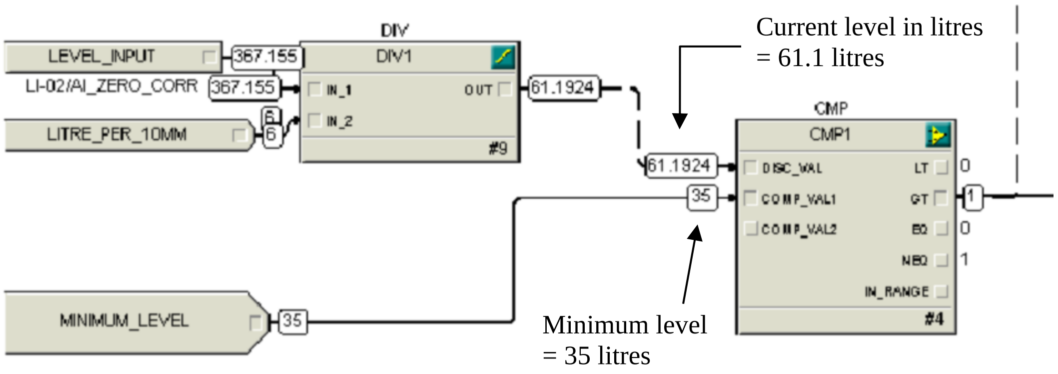

Figure 6.10 Converting sensor data for level requirement

The PID function block was replaced with a CALC/Logic function block, two Internal Write Parameter blocks “PREV_OUT” and “PREV_ERROR” and two Input Parameters blocks “K” and “I”. See Figure 6.11.

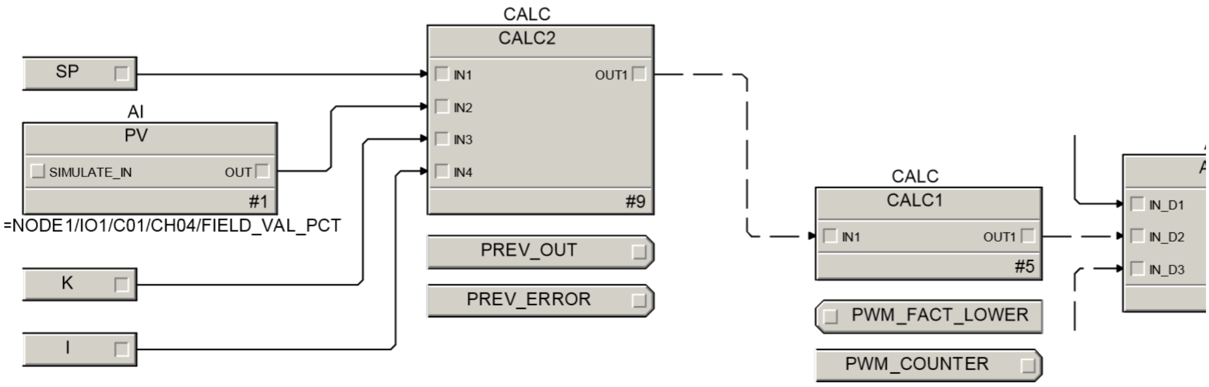

Figure 6.11 Replacing the PID function block

The logic block replaces the functionality of the PID block, where the internal expression is shown in Figure 6.12.

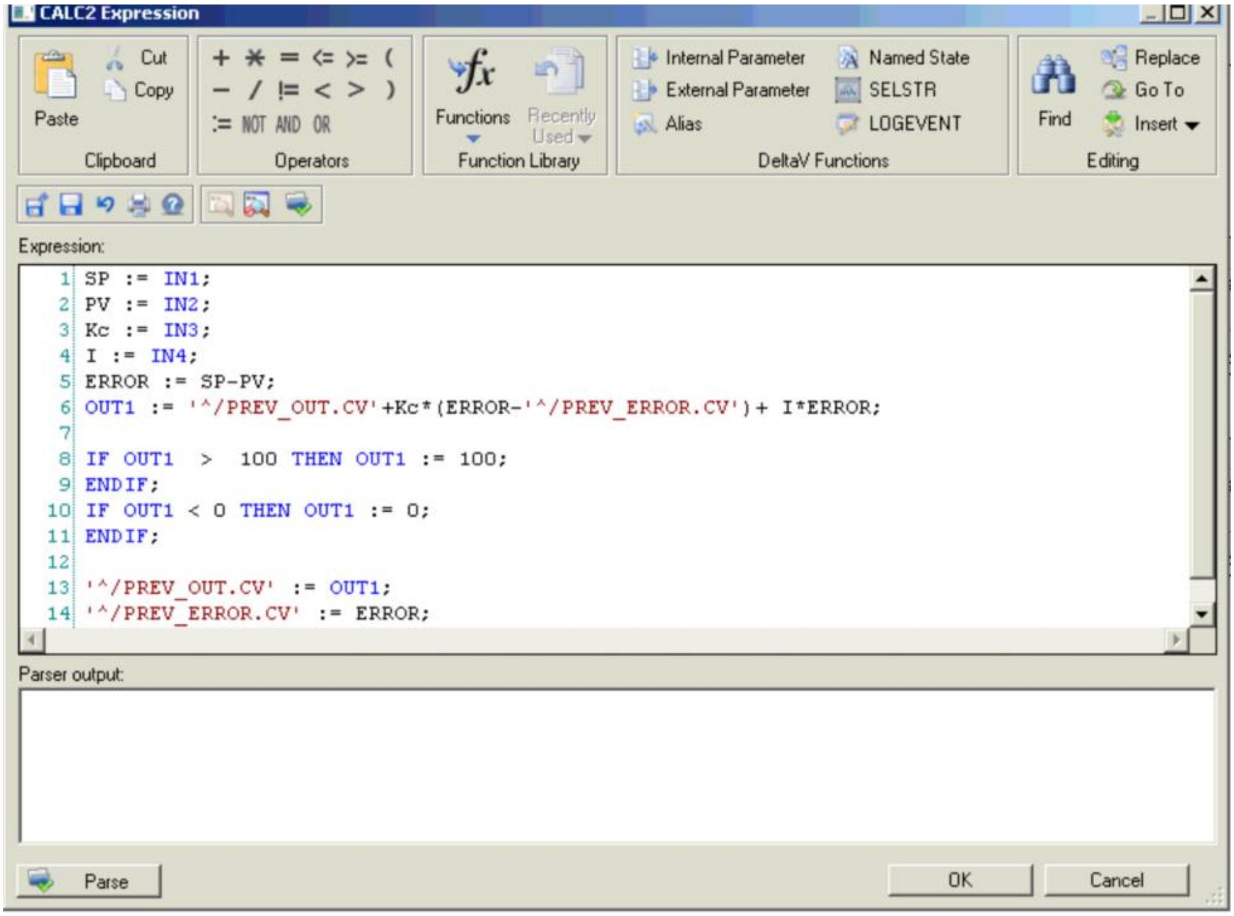

Figure 6.12 PI action by the Calc/Logic block

The output of the PI controller (CALC2 block) was then connected to the same “PWM” controller as used in the first version.

7 Operation and Control of the Fermenter Tank

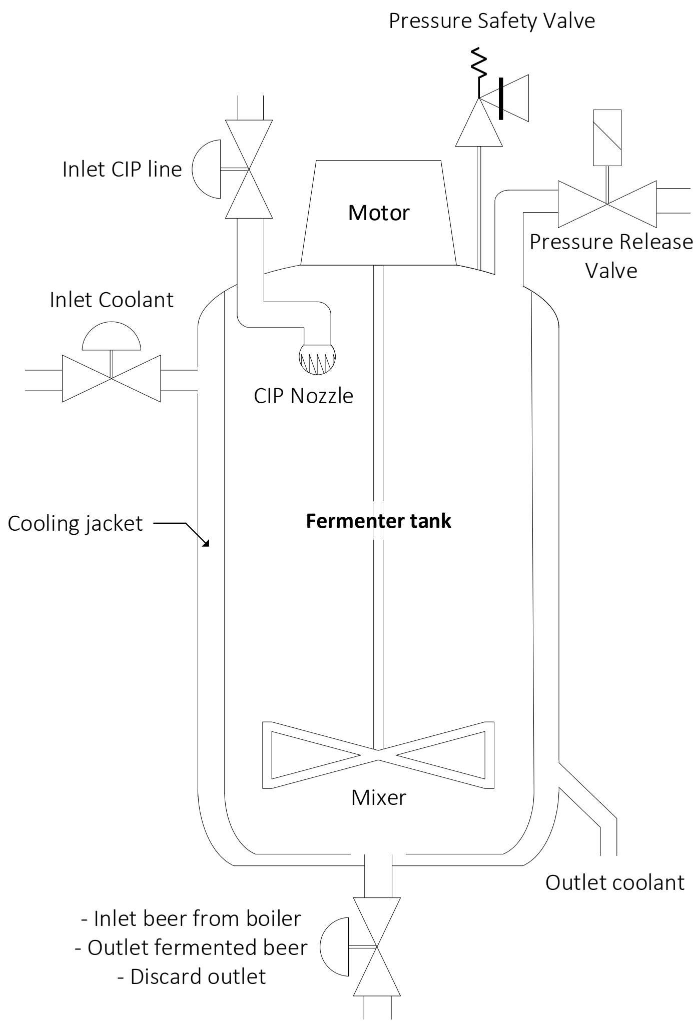

Figure 7.1 Fermenter tank

When the wort has completed the boiling process, the hot wort must be rapidly cool down before its ready for fermentation. There are several reasons why this change in temperature must happen quickly; Firstly, the temperature in the wort must be cool enough to not kill any of the *yeast* added in the fermentation stage.
Secondly, once the wort drops below 71°C, there are multiple bacteria, called *wort spoilers*, that can quickly grow and produce off flavors in the finished product. By swiftly bringing the temperature down to the fermentation temperature, the impact and formation of the wort spoilers are minimized. [15]
Lastly, when the wort is cooling down, there is a similar effect to the hot break (See Chapter 6), called the *cold break*. The cold break is similar, as there are coagulated proteins being formed as the wort is cooling down. The faster the wort is chilled; the less cold break is formed.

In the process plant, a two-staged plate heat exchanger is used to cool the wort to fermentation temperature. The first stage chills the wort using cold spring water, the second stage brings the temperature further down, using a coolant that is pumped from a separate coolant tank. Afterwards, the wort is transferred to the *fermenter tank* (see Figure 7.1 and Figure 7.2).

Fermentation turns the wort from sugary water to beer. During fermentation, yeast is added to the wort. The yeast feeds on sugars in the beer wort and the chemical reaction taking place in the process can be seen in $C_6H_{12}O_6\ (Glucose) \rightarrow\ 2C_2H_5OH(Ethanol) + 2CO_2 + Energy$ Equation 7.1 below. The starting sugar is not necessarily glucose, but the overall reactions are similar. [8] The fermentation process may last for multiple days or weeks, depending on the recipe.

$$C_6H_{12}O_6\ (Glucose) \rightarrow\ 2C_2H_5OH(Ethanol) + 2CO_2 + Energy$$

Equation 7.1 - Conversion of glucose to ethanol by yeast [16]

7.1 Fermenter Sequence

The Fermenter Sequence is a continuation to the Kettle Sequence and was designed using the Equipment State Diagram, Appendix F. The Fermenter Sequence can be viewed in Appendix L.

This is a two-staged phase of the process; The first stage is the transportation and cooling of the hot beer from the Kettle Tank to the Fermenter Tank, through a two-staged plate heat exchanger. Figure 7.2 shows a visual representation of the transition phase, Figure 7.3 displays a detailed view of the installed heat exchanger.
The second stage consists of controlling the temperature of the fermenting beer and the release of overpressure being built up by the yeast, with a pressure controller.

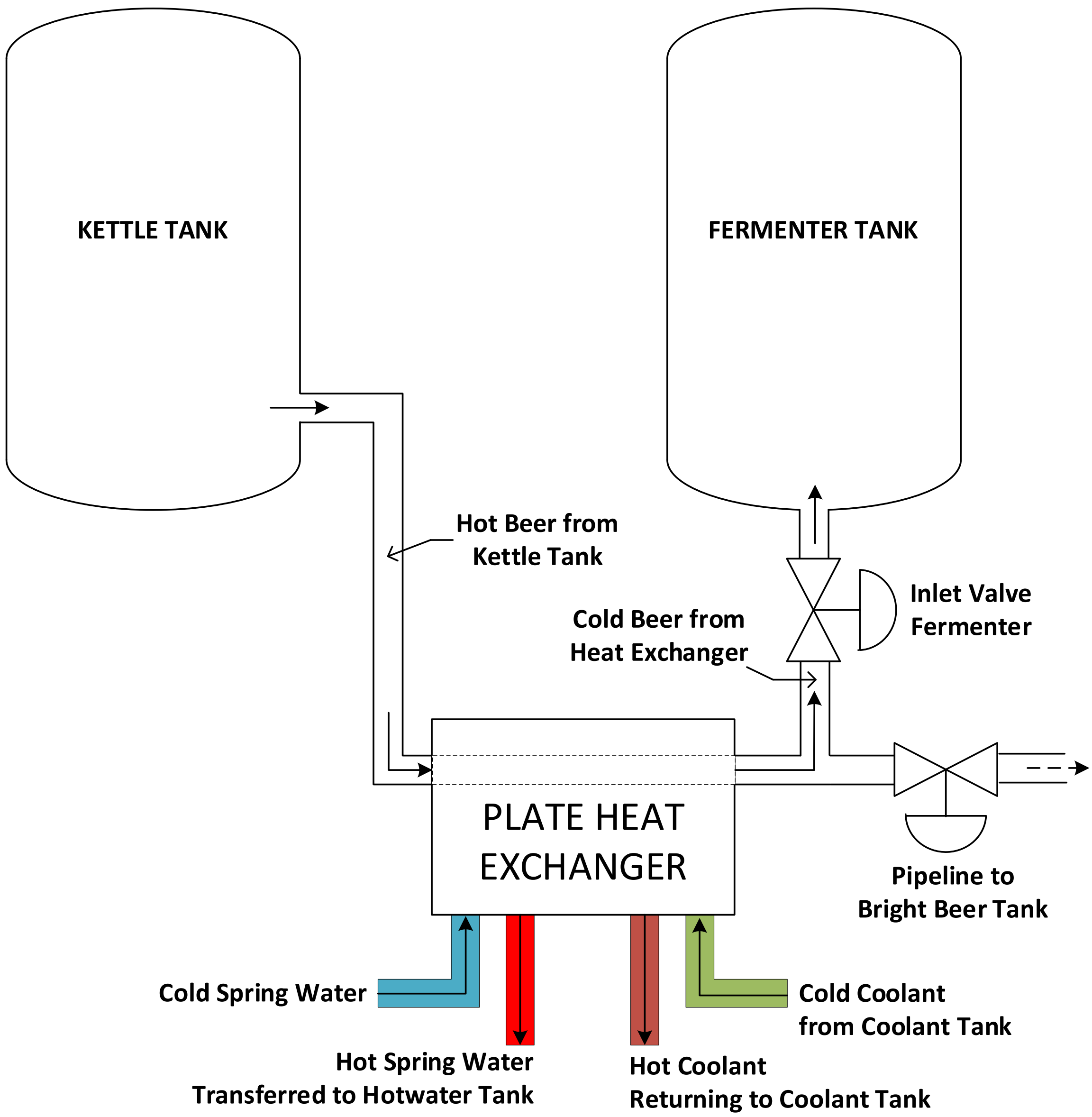

Figure 7.2 Transportation of Beer to the Fermenter Tank

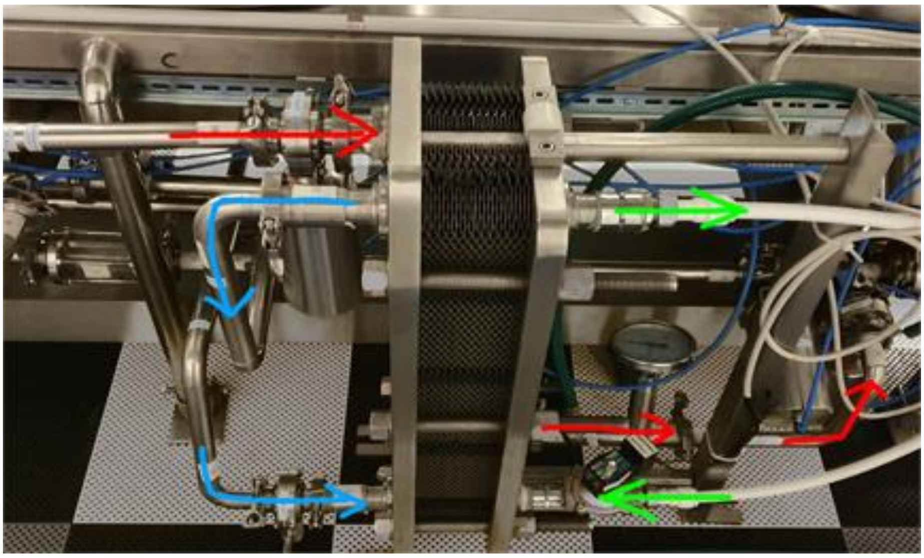

Figure 7.3 Heat Exchanger inlet/outlet piping

Figure 7.3 shows the real heat exchanger being used at the process plant. The arrows represent the flow of each element in the process. The red arrows represent the beer coming from the Kettle tank at the top and out to the Fermenter or Bright Beer tank at the bottom. The blue arrows indicate tap water, the returning hot water is sent to the hot water tank, where it can be used in a new batch. The green arrows represent coolant from the coolant tank.

The control sequence begins by setting the related equipment to Cascade mode.
Thereafter, a set of pneumatic valves are opened/closed to ensure correct pathing for the beer, when transitioning from the Kettle to the Fermenter tank, through the heat exchanger.
The process pump (P-001) should preferably not be running dry, as this may cause various damages over time. Therefore, the sequence waits 5 seconds after opening the related valves, to ensure that the pump is submerged in liquid.
The following step starts the process pump (P-001), coolant pump (P-003) and the fermenter mixer motor (FT-Mixer) and initiates temperature control of the coolant, with a 4°C setpoint.
Afterwards, temperature control in the Fermenter Tank is started and the sequence waits until the remaining level in the Kettle Tank is 17 litres before transitioning to the next step. The remaining 17 litres are mostly discard/waste and is not wanted in the final product.

When the Fermenter Tank is filled, all transportation and exhaust related valves are closed, to ensure no product loss and trap all remaining oxygen in the system. This step also starts the mixer and the pressure release controller.
The mixer runs with intervals of 1 hour on/off respectively, until the fermentation process is done. This may take several days or weeks.
When the fermentation process is done, the mixer is stopped before the sequence terminates.

7.2 Temperature Controller for the Coolant Tank

The whole documentation of controller, TIC_COOLANT, can be seen in Appendix M.
The coolant from the Coolant Tank is used to both chill the beer that is pumped through the heat exchanger (see Figure 7.2) and to regulate the fermentation temperature in the Fermenter and Bright Beer Tank. The hot room temperature and internal exothermic reactions heats the fermenting beer, therefore the coolant must be below target temperature setpoint, to have any effect when used as a regulation medium [17].
To have an immediate cooling effect and keep the liquid above freezing point, the coolant temperature is kept at 4 ± 0.3°C, unless a new setpoint is requested.

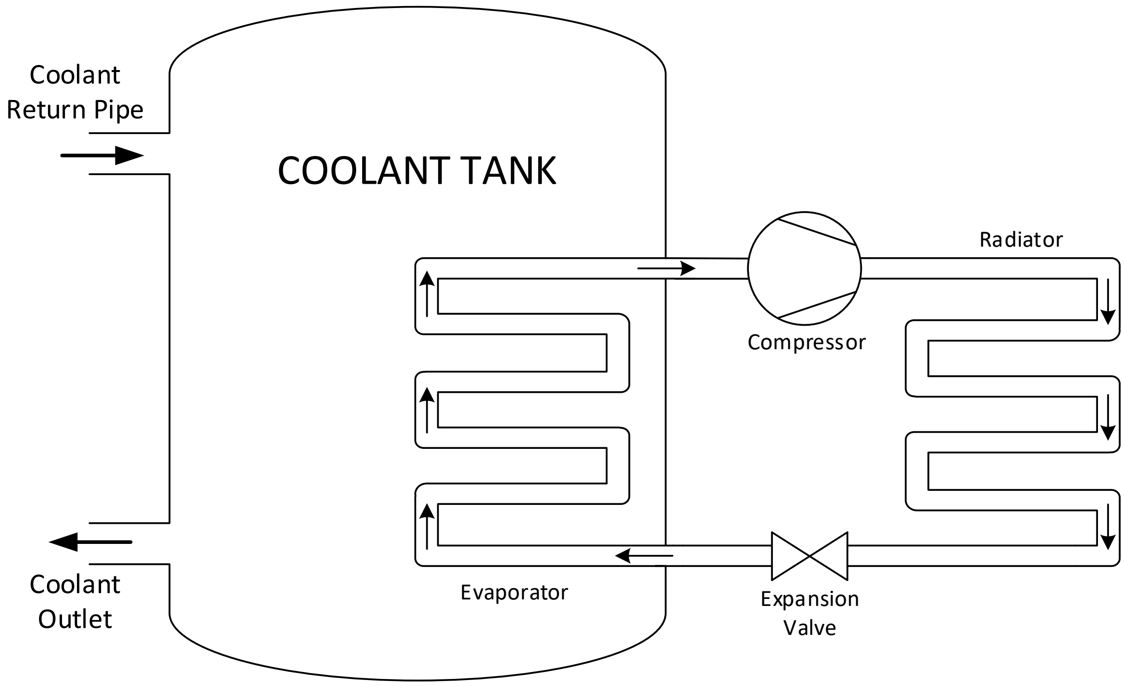

Figure 7.4 Regulating the coolant temperature with a refrigeration unit

The coolant tank has a refrigerating system installed, consisting of a compressor, an expansion valve, an evaporator coil, and a radiator, all connected by a copper tube, as seen in Figure 7.4.

The compressor reduces the volume of the refrigerant, the increase in pressure causes the temperature of the gas to rise. The hot gas is then pumped through a radiator, where it cools down by the surrounding air and transitions into a hot liquid.
The hot liquid is forced through the expansion valve, where it loses pressure and is misted into the evaporator. The cold gas is then pumped through the evaporator, where it chills the surrounding coolant. The cooling effect is explained by the Ideal Gas Law, as seen in Equation 7.2, where p = Pressure, V = Volume, n = Number of moles, R = gas constant and T = temperature [18] [19].

$$pV = nRT$$

Equation 7.2 - Ideal Gas Law

7.2.1 Designing and Implementing the TIC_COOLANT Control Module

The design-phase of the controller is divided in three sections:
Requirements for the Temperature Controller, Control Strategy and Design and Implementation.

7.2.1.1 Requirements for Temperature Controller

To control the temperature of the coolant, a controller that drives the refrigerant compressor must be implemented.

The controller that powers the compressor must meet two requirements:

4) The controller must have a Start/Stop function that is set ON.
5) The regulator output must be “high”

Figure 7.5 illustrates the logic with an AND gate.

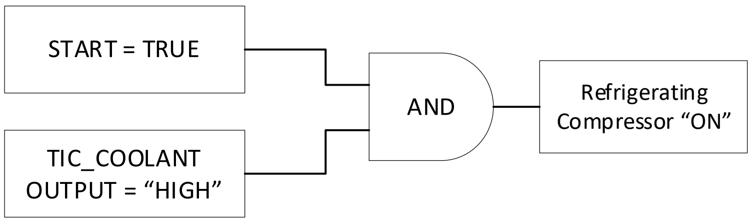

Figure 7.5 TIC_COOLANT Control Logic

If these requirements are met, the refrigerating compressor is turned on. Otherwise, it will be turned off.

7.2.1.2 Selecting the Control Strategy for the Coolant Temperature Controller

An ON/OFF-controller with hysteresis provides all necessary functionality, while also requiring minimal implementation effort. As previously mentioned in Chapter 6.2.1.2, the ON/OFF controller oscillates between upper and lower bands. Figure 7.6 illustrates how the temperature in the coolant tank could behave with an ON-OFF controller, with a 4°C setpoint (orange line), and $\pm$ 0.3°C threshold. The red line represents the upper band limit and the green represents the lower band limit. The figure is not a real representation of acquired data and is only used for illustration purposes.

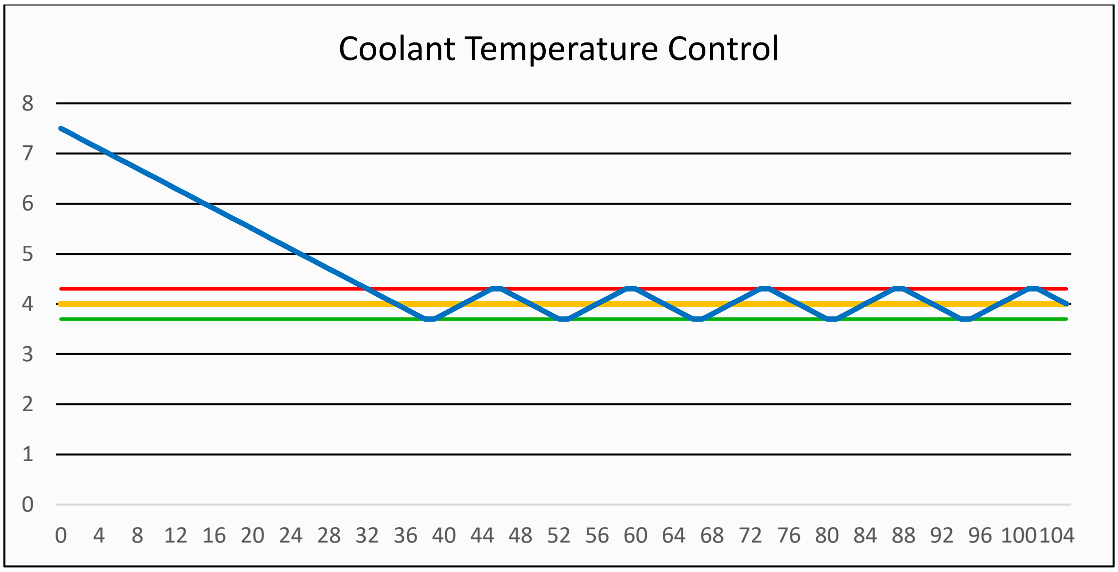

Figure 7.6 ON-OFF Controlling the Coolant Temperature

As the process variable (blue line) is above setpoint, the refrigeration compressor will be turned on, until it reaches the lower band. When the system reaches the lower band, the compressor is turned off. The room temperature will slowly heat the coolant, until the temperature reaches the upper band, where the compressor is turned on again. This makes the temperature oscillate around setpoint. The ON-OFF controller was selected as the control strategy, as it fulfills all requirements and takes minimal effort to implement.

7.2.1.3 Designing and Implementing TIC_COOLANT in DeltaV Control Studio

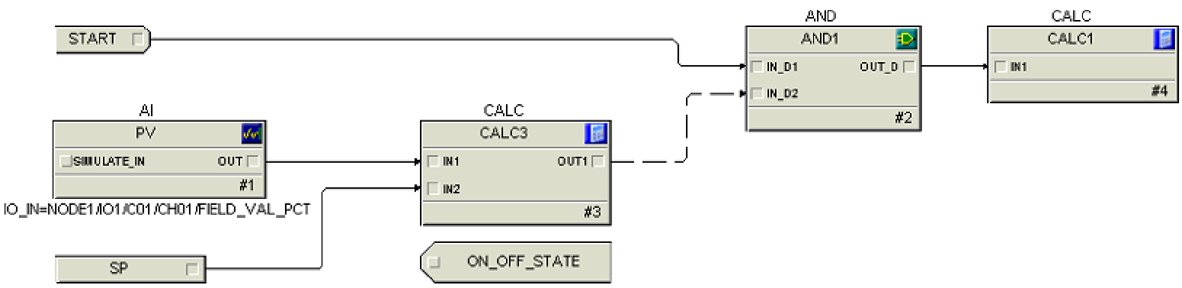

Figure 7.7 TIC_COOLANT in DeltaV Control Studio

Similar to the TIC_KETTLE controller, the first version of TIC_COOLANT (Figure 7.7) was made using DeltaV Control Studio, with the controller requirements in mind.

The first requirement was that there must be a “Start” function for the controller. An Internal Read Parameter function block, named “**START**” was implemented. The block outputs Boolean data values “True” or “False” and is connected to the first input port of the AND gate. The “Start” parameter is set to “True” by the Phase Logic Module (PLM), when the control sequence for the Fermenter Tank is in ‘Running’ state (See Chapter 5.3.1).

The second requirement was that a temperature regulator had to output a “High” signal to the second input of the AND gate.
The “SP” block is a numeric Input Parameter function block, where the target setpoint for the process is set. The “PV” block is an Analog Input function block, that provides the current temperature from the PT-100 element located in the Coolant Tank.

The first CALC/LOGIC function block is where the logic of the controller is programmed. The internal expression is seen in Figure 7.8.
If the current temperature is greater than setpoint + 0.3°C, the refrigerating compressor is turned on.
If the current temperature is less or equal to setpoint - 0.3°C, the compressor is turned off.
In order to keep a constant output after each iteration, the state of the controller is written to an Internal Write Function Block, “ON_OFF_STATE”.
The last CALC/FUNCTION block works as a Discrete Output block, switching the refrigerating compressor on/off proportional to the state of the “ON_OFF_STATE” block.

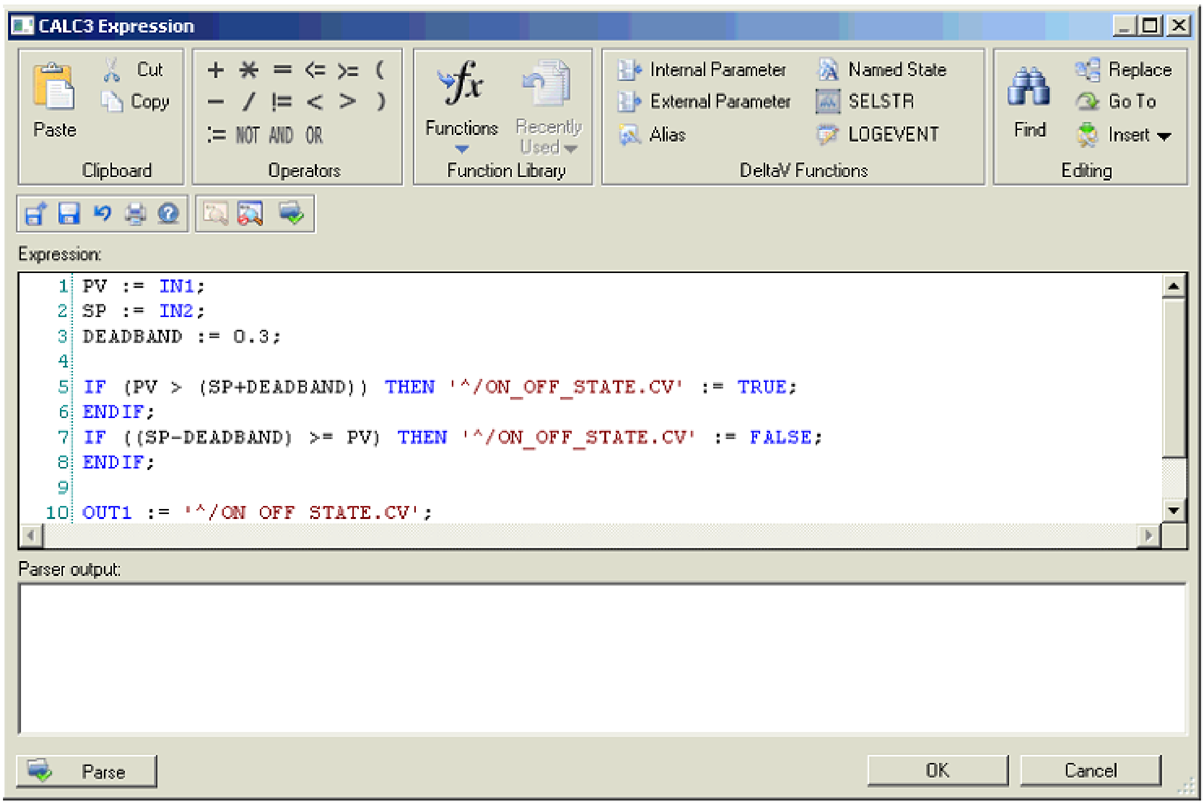

Figure 7.8 TIC_COOLANT ON/OFF-Controller Internal Expression

7.3 Temperature Controller for the Fermenter Tank

The whole documentation of the TIC_FERMENTER controller, is available in Appendix N. The Fermenter Tank is where the beer is added yeast and the beer is left to ferment. The fermentation temperature, as mentioned in 7.2, is affected by the external room temperature and internal exothermic reactions. The yeast is sensitive to temperature and exceeding 37°C may kill the yeast. Optimal fermentation temperature is varying with each recipe. Most lager beers are kept between 4-12°C and ales between 13-21°C [20]. Controlling the temperature is the most important aspect of the fermentation process. The other being release of overpressure that has built up from the live yeast feeding on the sugars in the beer, in such manner that no new oxygen is added in the process [21]. Figure 7.9 shows the cooling system of the Fermenter (and Bright Beer) tank.

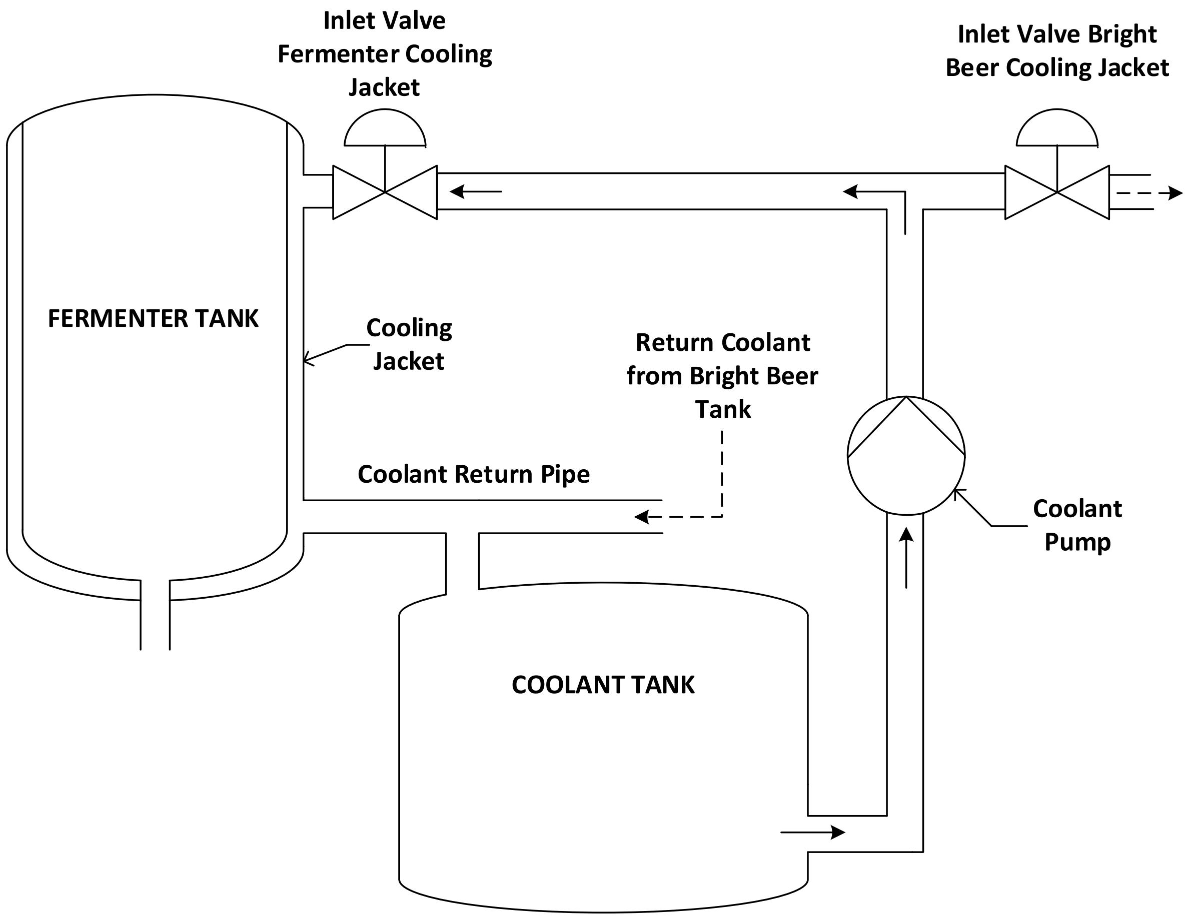

Figure 7.9 Cooling System of the Fermenter and Bright Beer tank

7.3.1 Designing the Temperature Controller for the Fermenter Tank

The requirements and implementation of the temperature controller (TIC_FERMENTER) in the fermenter tank is identical to the ON/OFF-controller (TIC_COOLANT) used to regulate the coolant temperature.

7.3.2 Design and Implementation of TIC_FERMENTER in DeltaV Control Studio

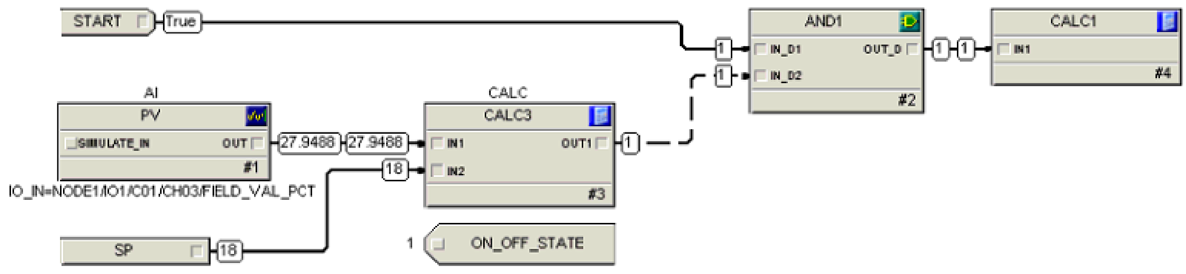

Figure 7.10 Initial testing of the TIC_FERMENTER control module

The TIC_FERMENTER controller was implemented, by cloning the TIC_COOLANT control module and renaming it. Afterwards, three changes were made: Default setpoint, changing the analog input to the respective temperature transmitter (TT-03) and replacing the controller output with the coolant pump (P-003).

7.4 Pressure Control in the Fermenter Tank

The yeast in fermentation process produces CO_2 while feeding on the sugar strain the beer. This results in pressure buildup. To relieve this pressure and remove excessive CO_2, a water lock on top of the tank is commonly used. In this process plant however, a solenoid valve and a pressure switch are used instead of a water lock. The pressure switch registers when the pressure inside the fermenter tank is too high, which in turn opens the solenoid valve.

7.4.1 Designing the PRESS_CTRL_FERM Control Module

The control module has one function, to open and close the solenoid valve (XV-13) once the pressure switch activates or deactivates. To do this task the control module requires the following information: should it start pressure control or not, is the pressure switch activated or not and if the valve is being manipulated manually. The valve should open during two different scenarios, either the valve is opened manually, or the pressure switch sends a high signal and the control module is told to run pressure control. This logic is shown in Figure 7.11.

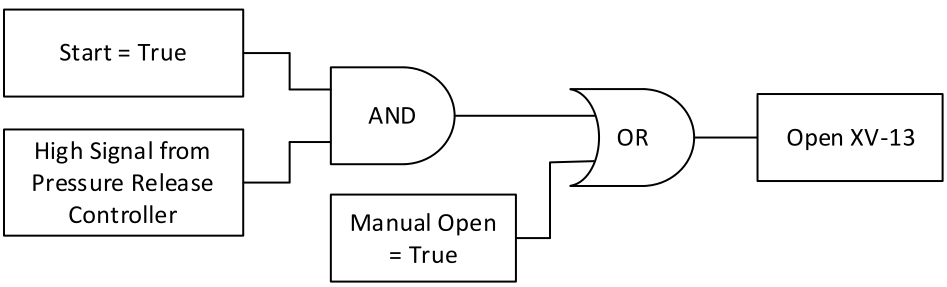

Figure 7.11 Logic for opening XV-13

7.4.2 Implementing the PRESS_CTRL_FERM Control Module

The logic designed in Chapter 7.4.1 was implemented in control studio by creating a new control module from scratch. The block has one discrete input, one discrete output, one input parameter, and one external read parameter. The discrete input is the signal from the pressure switch, the discrete output is the actuator for XV-13, the input parameter is the start condition for the pressure control, and the external read parameter points to the manual setpoint for the XV-13 control module. To activate pressure control of XV-13 the START parameter must be set to true, either through the HMI or another module, which in this case is the PLM. Documentation for this control module is available in Appendix O

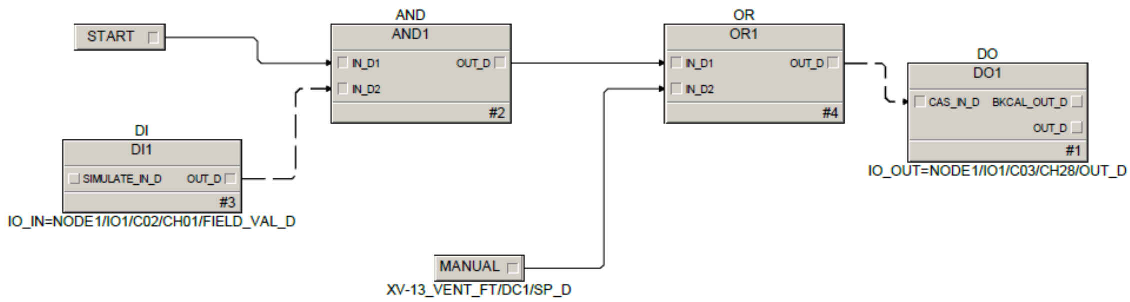

Figure 7.12 PRESS_CTRL_FERM Function Bloc Diagram

8 Operator Control Using Human Machine Interface

The HMI is an important part of the plant because the operator needs an HMI/GUI to monitor and control the equipment, process variables and alarms. An HMI allows for interaction between the operator and the plant and should be designed to make this interaction easy to understand and monitor.

A DeltaV user interface has several built-in templates which include alarm banner, alarm acknowledgment window with list of active alarms, toolbars, buttons for easy navigation and opening of new pictures in addition to the main operator picture. This chapter will focus on the main operator picture. At the USN Beer lab, a pre-existing HMI was in use. There have been several changes made to the lab since the original HMI was designed and our project requires operator control of a PLM so updating the HMI was necessary. Modifications to the HMI was done using DeltaV Operate Configure which had pre-installed libraries and toolboxes, in addition to these, more advanced users can configure and create their own dynamos with scripting using Visual Basic. These libraries contain module dynamos, faceplates and detail displays which makes configuring an HMI easier, less time consuming and provides a consistent theme, which makes it easier for the operator to understand the HMI. DeltaV also has recommended guidelines regarding design and configuration of the HMI [6].

8.1 Explanation of terms regarding the HMI

Dynamo: A dynamo is a preprogrammed base for programming modules in the DeltaV HMI that provides consistent properties such as color or animations and can be reused to simplify programming. For example, instead of programming 10 different valves with the same properties independently, a dynamo can be used for those valves with pre-implemented properties thus saving time for the programmer. Examples of dynamos can be found in Figure 8.1 and Figure 8.2.

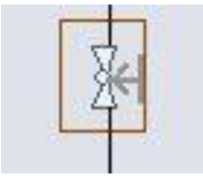

Figure 8.1 Closed valve dynamo

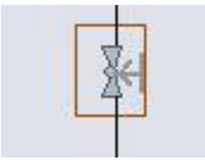

Figure 8.2 Open valve dynamo

Faceplate: A faceplate is a pop-up picture that provides some limited information, for example state and active alarms for a pump, and operator control of equipment. When a module is created in DeltaV Explorer a default faceplate and detail picture become attached with that module. When an object of that module is created in the HMI, for example a dynamo of a valve, the assigned faceplate picture will pop up when clicked on in DeltaV Configure Run. An example of a faceplate picture is provided in Figure 8.3.

Figure 8.3 Faceplate picture for controlling a valve

The beer lab has one main operator picture which provides the operator with an overview of the process. This picture is designed like a P&ID drawing showing the tanks, valves and pipelines for the process. The picture uses several dynamos for graphical representation of equipment, and faceplate pictures for a more detailed view and operator control of equipment.

8.2 Designing the New HMI

The beer lab is a dynamic process plant, where several changes have been implemented throughout the years. As a result, the HMI must be updated proportional to these changes. Some of the older versions of the HMI has missing valves and pipelines from the existing process plant. At first, the idea was to create a High-Performance HMI, following the guidelines by Bill Hollifield and Hector Perez [22]. Following these guidelines requires implementation of a new hierarchy system, with several new operator pictures. The operator pictures would be layered in this order:

- An overview picture of the important parts of the plant. This would be layer 1 of the plant and the most important operator picture. The idea behind this picture is for the operator to easily recognize the state of the plant and important equipment such as, in the case of the beer plant, process pumps as well as important process parameters like temperature. Control of the plant are reserved for layer 2 pictures and therefore easy navigation between pictures would need to be implemented.
- Control pictures. Layer 2 of the plant are for control pictures and the idea was to design one control picture for each of the tanks and the cooling system where each picture only includes controls for equipment relevant to that tank or cooling system.
- Layer 3 detail pictures. These detail pictures would include information about equipment parameters such as alarm limits and gain values for controllers.

In addition to a new hierarchal system with several operator pictures, there are also specific guidelines for usage of colors, alarm pictures and trends.

The idea of creating a High-Performance HMI was discarded for several reasons:

- DeltaV already has built in functions like easy navigation between operator pictures, faceplate pictures for control of equipment, detail pictures and specific placement of alarms with the alarm acknowledgement window and alarm banner.
- The dynamos available in our DeltaV system do not match the High-Performance HMI guidelines thus requiring the group to create and script new dynamos using Visual Basic which is an unfamiliar scripting language to us.
- To be able to operate the beer plant we would have to configure HMI pictures for all the tanks even though our project’s scope is the kettle and fermentation parts.

It was therefore decided that the new HMI design should use the DeltaV recommended guidelines and use the preexisting HMI as a base. It would then be updated to match the plant to take advantage of prebuilt functions of DeltaV and use the preinstalled libraries. The new design is centered around the updated P&ID [Appendix A] showing the correct labeling and pipelines for the plant. The valves missing in the old HMI was added (XV-15 and HV-16) using dynamos with faceplate pictures for control. To avoid cluttering of the main overview picture, all information regarding the previous cleaning sequence project, a button was implemented that opens a new picture. All the information regarding the cleaning sequence project was then stored inside this new picture and could therefore be removed from the main operator picture. The color of live variables such as values from a temperature sensor was changed from black to dark blue to highlight these values within the HMI. All static texts are colored black. The new main overview picture can be seen in Figure 8.4.

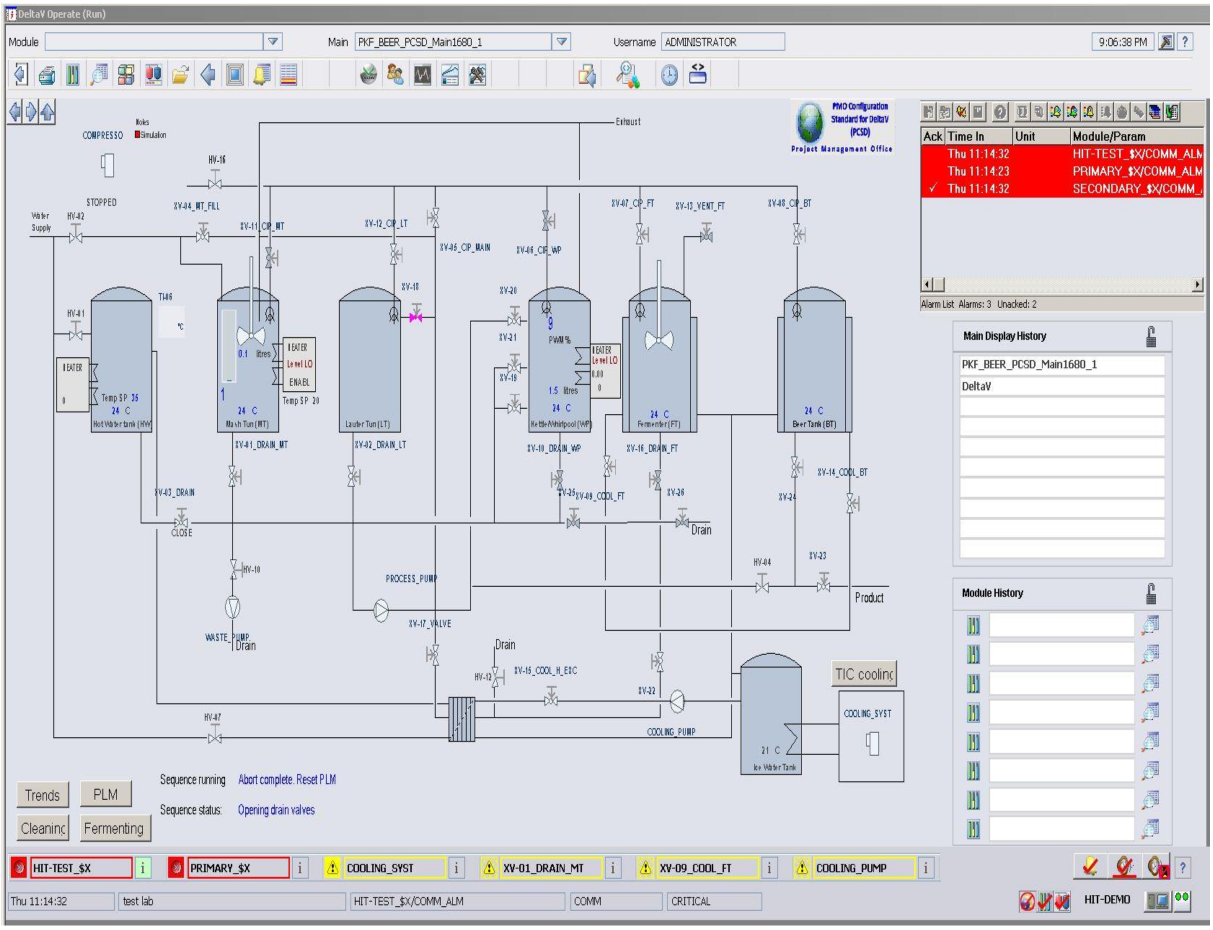

Figure 8.4 The new overview picture for the beer lab

8.3 Controlling the PLM

A button for opening the PLM faceplate was created to provide the operator with control of the PLM. The PLM faceplate is a DeltaV standard faceplate, located in one of the preinstalled libraries, and was set as default faceplate picture for the PLM in DeltaV Explorer. Due to varying requirements for the fermentation time for beers, a manual button for indicating the completion of fermentation was added in the HMI. The button signals to the PLM sequence that fermentation is complete and must be activated for the PLM to finish its sequence. The PLM sequence has multiple parts and therefore text indicators inform the operator as to what sequence (kettle, fermenting, holding, aborting etc.) is running and what specifically is happening in the sequence (transferring medium, opening valves, starting whirlpool etc.). These text indicators are live variables that get their values from string outputs in different steps of the PLM sequence. The buttons and text indicators can be seen in Figure 8.5 and the PLM faceplate in Figure 8.6.

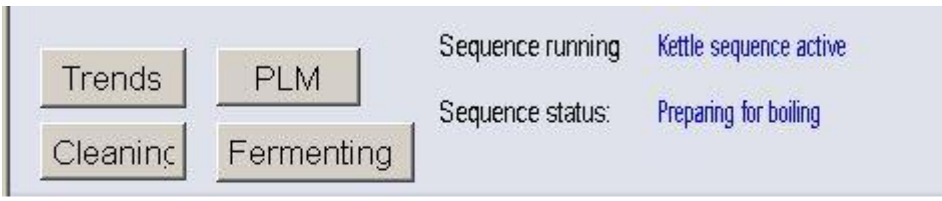

Figure 8.5 Added buttons and text indicators. Blue text are live variables.

Figure 8.6 DeltaV standard faceplate for controlling the PLM

8.4 Monitoring Key Process Variables

In the beer process the main process variable to keep track of for the operator is temperature. Every tank has its process value temperature highlighted in blue inside the respective tanks. To provide the operator with a graphical representation of the temperatures six trends was implemented in a new picture. These trends show the setpoint and current process values for the tanks and the cooling system in the most recent two hours. Trends are used because they provide the operator with information as to *how* the system is responding. It is easier to understand the state of the system when the operator can observe for example a declining graph in a trend rather than raw values represented in the HMI. Raw values provide no information as to whether they are increasing or decreasing before a change in the actual value is present. In order to open this trend picture from the main operator picture a button was added. The temperature trend overview can be seen in Figure 8.7. Figure 8.7 does not show a change in process value due to controllers not being active when the picture was taken.

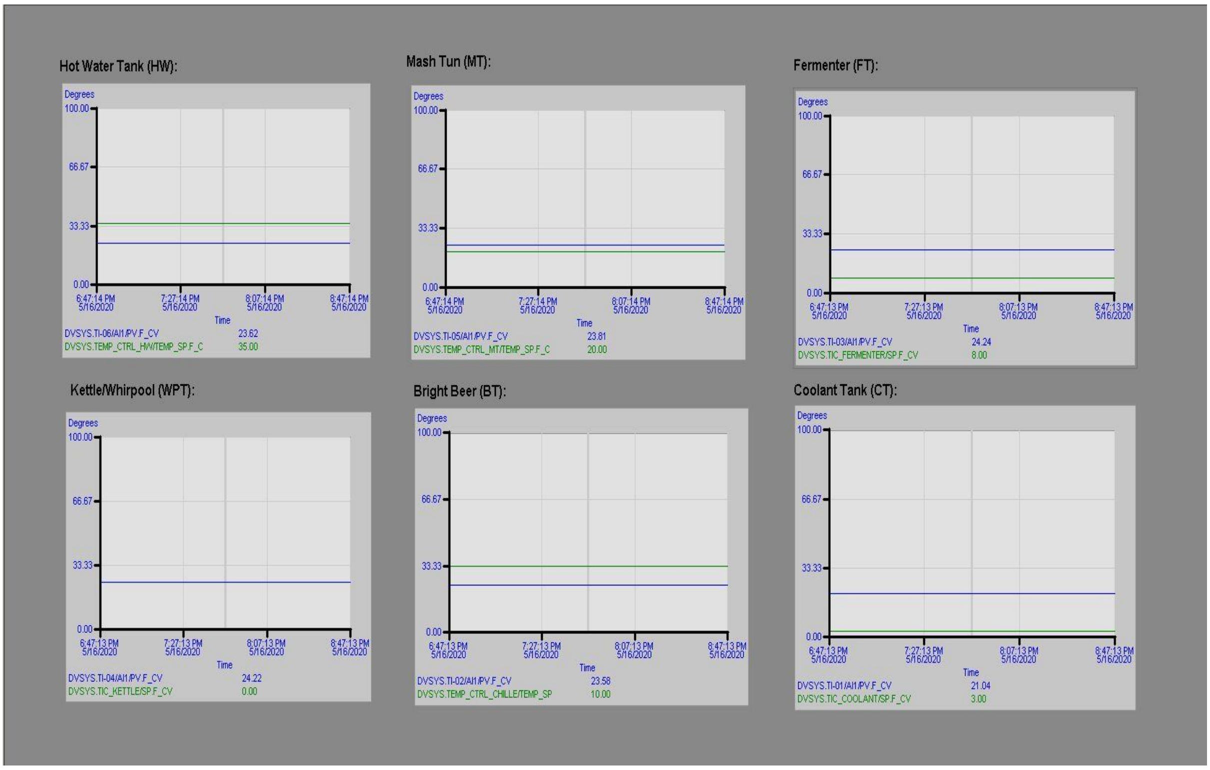

Figure 8.7 Trend picture showing setpoint values in green and process values in blue for temperatures in the plant

During this project a controller for temperature in the cooling system was created and in order to access this controller a button was created that opens a new picture for the controller. This picture for the temperature controller is simple and was created because the standard DeltaV faceplate for such a controller did not work as intended, and due to time-constraints a simple solution was implemented instead of debugging the standard DeltaV faceplate.

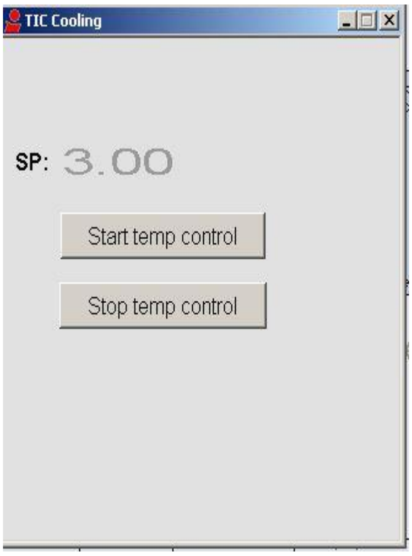

Figure 8.8 Faceplate for cooling systems controller. Allows for changing setpoint in addition to starting and stopping temperature control

9 Testing

Testing of the system was done in three phases, equipment testing, transportation testing and control system testing. Equipment and transportation testing where preliminary tests that was done before implementation of sequencing. The test document is available in Appendix P.

9.1 Test Case 1 Equipment

The first test that was completed on the beer process plant was testing of the plants process equipment. This test was done to check what equipment was in working condition before any changes was made to the plant, and what equipment needed troubleshooting or replacing. This test resulted in XV-08, XV-13, XV-15 and XV-24 not working as intended. Troubleshooting revealed that the controller was not connected to XV-08, XV-13 was faulty and needed to be replaced. XV-15 was not implemented in the HMI and XV-24 had a faulty pneumatic valve block.

9.2 Test Case 2 Transportation

During the planning of the project, the group created an equipment state diagram. The equipment state diagram shows the status of every equipment in the plant during the plant's different states. To test that this diagram was accurate, the transportation test was completed. This test involved filling the hot water tank with water and simulating the brewing process manually through the HMI.

This test was successful, indicating that the equipment state diagram was correct, and design of the kettle and fermenter sequences was done according to this diagram.

9.3 Test Case 3 Control system and operator control

The final test on the beer process plant was the testing of the control system created by the project group. During this test, starting, holding, stopping, and aborting of the PLM from the HMI was tested, activation of the kettle and fermenter PWM controllers were tested. Change of setpoint values for the controllers were tested and viewed in trend picture in HMI.

The results of this tests showed that the pressure control in the fermenter was faulty. Troubleshooting revealed that the pressure switch in the fermenter was wrongly wired.

Faceplate for controlling TIC cooling did not function as intended and the operator was not able to interact with the controller, resulting in a new simple operator picture for configuring the controller.

10 Results

After designing the Equipment State Diagram (Chapter 5.1), the various stages of the process were tested. The test proved that our design strategy worked as intended, where we used the P&ID to draw the pathing of the liquid and mark the states of all process equipment.

The PLM developed in Chapter 5.3 and tested in Chapter 9.3 was successful in handling the sequential control of the kettle and fermenter parts of the system. The finished controller fulfilled all requirements stated by the task scope.

The temperature controller in the kettle tank, TIC_KETTLE, is documented in Chapter 6.2. The proportional and integral parameters were tuned by test and error; started with a small gain and small increase in temperature setpoint. After some trial and error, the proportional gain parameter was set to 1.2 and integral parameter 0.1 and the system was brought to setpoint as seen in Figure 10.1 and Figure 10.2. The deviation between the setpoint and process value is highlighted in Figure 10.2 (The integral action was changed to 0 at the time of capturing these figures).

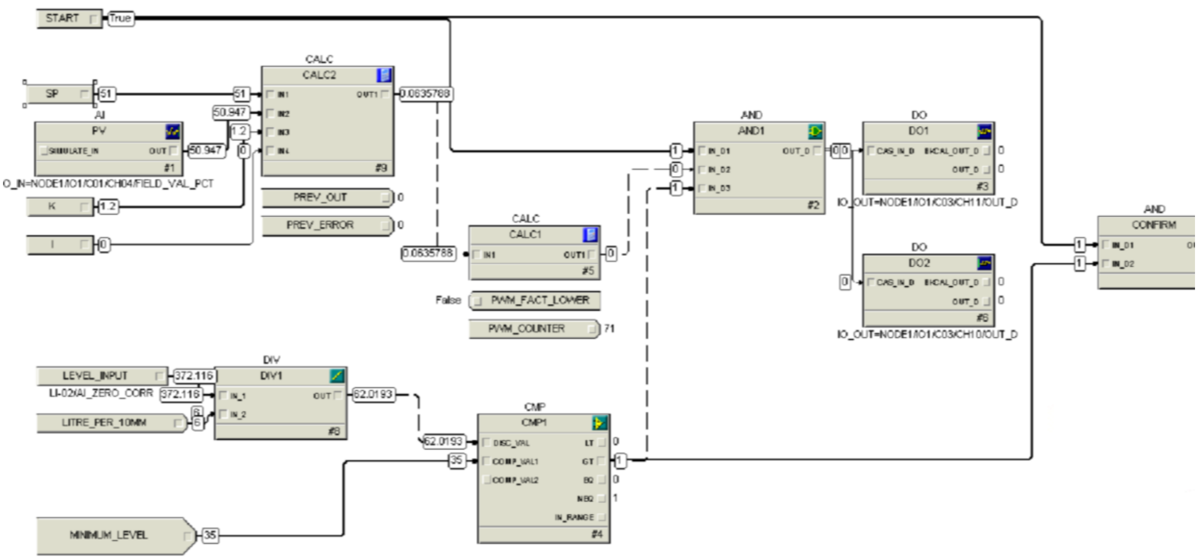

Figure 10.1 Testing the final version of TIC_Kettle

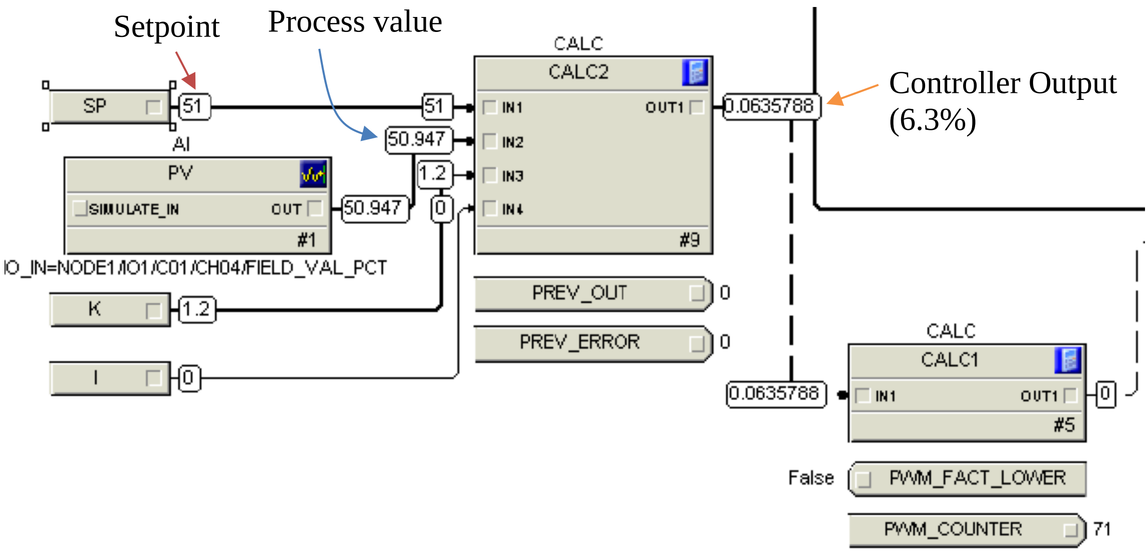

Figure 10.2 Detailed view of the controller in action

The final controller fulfilled all design requirements and brought the process variable to a steady state at the target setpoints.

The temperature controller for the coolant tank, TIC_COOLANT, is documented in Chapter 7.2. The controller principles work by oscillating the process value between setpoint plus/minus a given threshold. After initialization of the controller, the controller was left on for three days, with target setpoint left at 4°C. When the team revisited the laboratory the following days, the coolant temperature was kept within the upper and lower threshold (4 ± 0.3°C constant). Figure 10.3 shows the final state of the controller before it was shut off. The picture was taken when the system was transitioning from the lower to the upper bound. This concludes that the controller worked as intended.

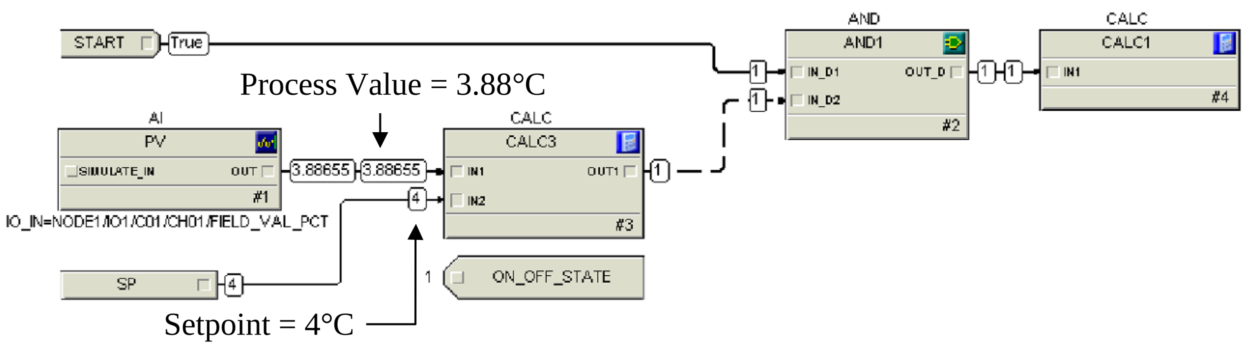

Figure 10.3 Testing TIC_COOLANT with DeltaV Control Studio On-Line

The temperature controller of the fermenter tank, TIC_FERMENTER, is documented in Chapter 7.3. The controller is a reconfigured clone of TIC_COOLANT.

Figure 10.4 shows the initial start-up of the controller, using DeltaV Control Studio On-Line, where water was used as a test medium. Deadband was changed from 0.3 to 1°C during testing. The controller acted correctly, by immediately turning on the coolant pump.

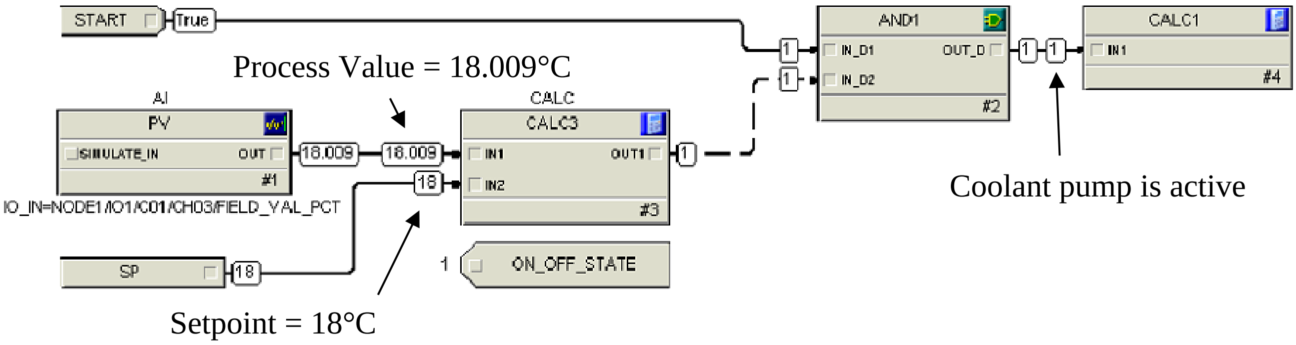

Figure 10.4 TIC_FERMENTER Approaching Setpoint

Figure 10.5 shows the process value after crossing the setpoint and approaching the lower bound. The pump was still running as designed when the system is transitioning from the upper to lower bound.

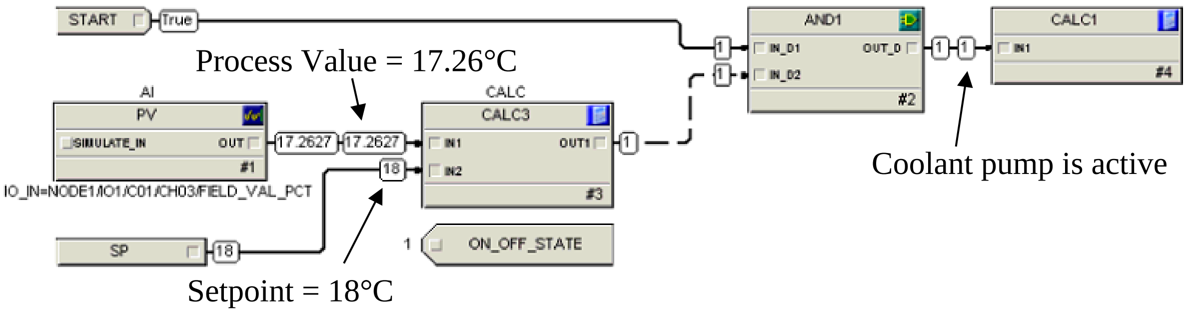

Figure 10.5 TIC_FERMENTER Approaching Lower Band

Figure 10.6 shows that the coolant pump was immediately shut down, as the system crossed the lower band.

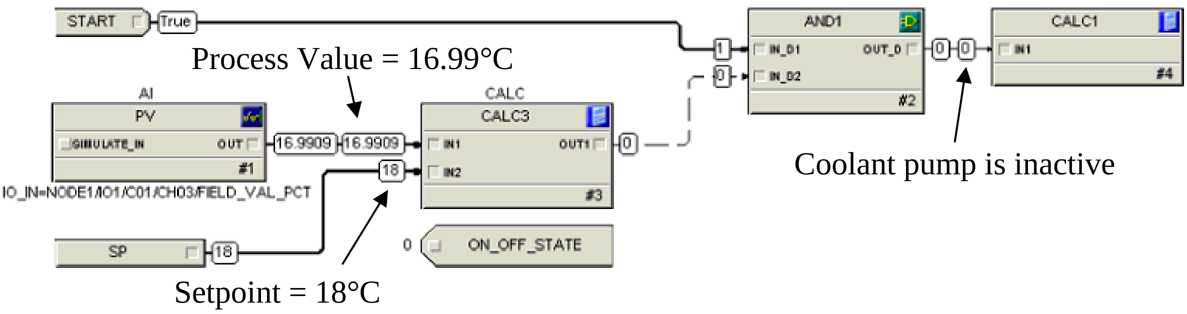

Figure 10.6 TIC_FERMENTER Crossed Lower Band

The pressure controller, PRESS_CTRL_FERM, should work in theory, but a wiring issue caused a signal loss between the controller and the pressure release valve. As a consequence manual pressure release is required, or the funnel could be disconnected and replaced with a water lock temporarily, until this wiring has been fixed. More information about the controller can be read in Chapter 7.4.

Operator control of the plant were improved through updating the HMI following the DeltaV guidelines for operator pictures. Implementation of trends and text indicators result in improved understanding of the plant state for the operator. Activation of PLM and controllers through HMI was successful and was required to accomplish the project scope.

11 Discussion

During the completion of this project the world was affected by the Coronavirus and the beer lab was closed. The participants adapted to the difficult situation and managed to complete the project on time, without restricting the objectives or scope of the project. This resulted in valuable experience of working remotely and having online meetings for the group members.

11.1 Further Tuning of Kettle Controller

In the first version of the TIC_KETTLE controller the inbuilt PID function block was used, this is a general block for multiple configurations and has multiple configuration options and parameters. Due to time constrains and the time required to configure the PID function block properly; a decision was made to make a simple standalone version of the PID block.

As an effect from the insulation in the tank, this is an integrating process and the controller must be tuned accordingly. Due to this integration effect, a proportional controller, or a proportional-integral controller, with very little integral action, is sufficient.

Further tuning the PI-controller in the TIC_KETTLE control module is possible, but not necessary, as the final parameters provides sufficient control of the system. If optimization of the controller would be required, this would be done using the *Lambda Tuning* method.

Lambda tuning works well both in open- and closed loops and it requires only a modest adjustment to the controller output during dynamic testing [23]. It is a form of internal model control (IMC) and provides the PI-controller the ability to generate smooth, non-oscillatory control effects, when step-responding to a new setpoint [24]. Thus, it is the primary choice for tuning strategy.

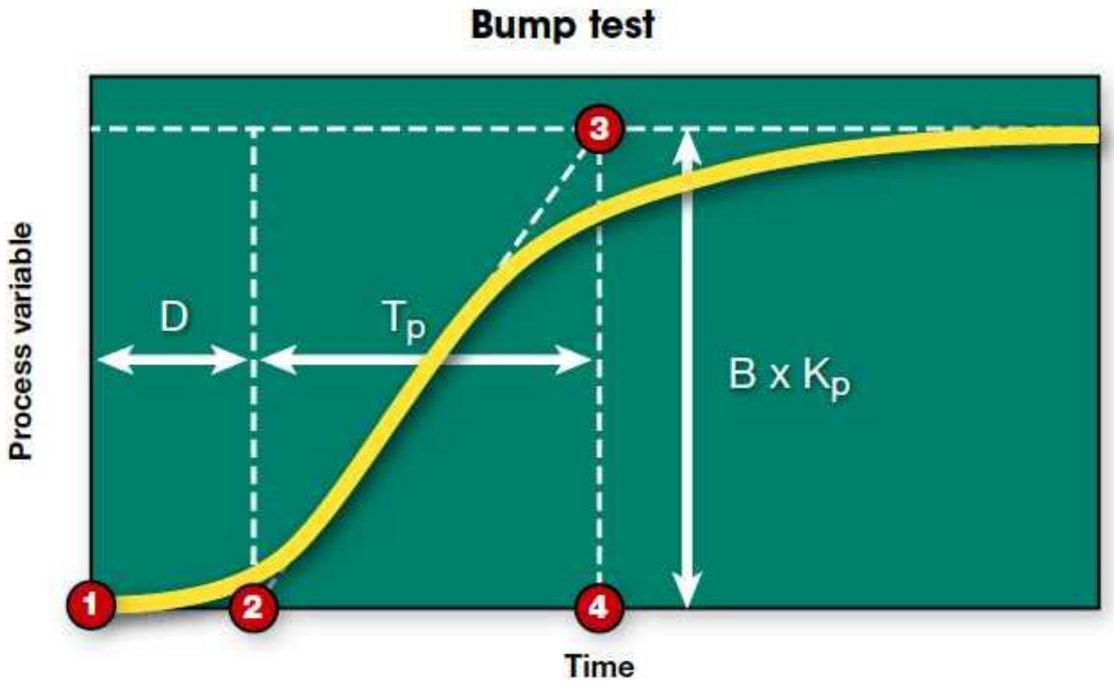

Figure 11.1 - Using bump test to find elements of various functions used to determine the control parameters. [24]

The first step of the tuning method is to determine how fast and how much the process responds to the controller output, with a bump test, see Figure 11.1.

The bump test is divided into nine steps, known as *open-loop reaction curve test* or *step test*. This provides all necessary information about the integrating process.

Performing the bump test: [24]

1. The controller must be set to manual mode, or control output must be emulated.
2. Wait until the process variable achieves a steady state.
3. Manually increase the control output by B%, defined by how much increase it takes to make the process variable move appreciably but not excessively.
4. Record the process with a trend, including time of step change, initial process value and when it achieves a new steady state.
5. Draw an ascending line tangent to the steepest part of the process variable's trend line.
6. Draw horizontal lines through the process variable's initial and final values.
7. Mark where the two horizontal lines intersect the ascending line at points 2 and 3.
8. Record the deadtime D from point 1 to point 2 and the process time constant T_p from point 2 to 4
9. Record the PV change from point 3 to 4 and divide this value by B to get the process gain K_P.

When the behavior of the system has recorded and the process variables have been characterized (process gain K_p, time constant T_p and deadtime D), tuning the controller requires minimal effort. [24]

Firstly, a λ value is defined by approximately $\frac{1}{4}$ of the time it takes to achieve steady state after a change in setpoint. This value is then used, together with the process gain, time constant and deadtime to get the Proportional-Integral parameters, K_C and T_i.

Equation 11.2 represents the mathematical function of the PI-control output, where e is the error (or deviation) between the setpoint(t) and process variable(t), defined by Equation 11.1. K_c is defined by Equation 11.3 and T_I by Equation 11.4 - Defining integral time

. [24]

$$e(t) = SP(t) - PV(t)$$

Equation 11.1 - error between setpoint and process variable

$$Output(t) = K_C[e(t) + \frac{1}{T_i}\int e(t)dt]$$

Equation 11.2 $-$ Control Output of PI $-$ controller

$$K_C = \frac{T_P}{K_p(\lambda + D)}$$

Equation 11.3 - Calculating Kc using the process parameters

$$T_i = T_p$$

Equation 11.4 - Defining integral time

11.2 Further Automation of the Plant

Due to time constraints, restart logic for the PLM was neither implemented nor designed, meaning that there is no logic for restarting the run logic after it enters the holding state. To enable safe restarting of the run logic, this SFC must be designed.

The DeltaV system allows for batch production using recipes, a recipe orchestrates the execution of PLMs including passing recipe parameters. To enable this, further improvements of the control system are required. There must be developed PLMs for the parts of the lab that are not yet automated, and the PLM created in this project should be separated into two separate PLMs. These changes would further automate the system and make it easier to create different types of beer. [25]

11.3 Enhancing Operator Interaction

DeltaV allows for scripting and creation of custom dynamos and can be used to enhance the operator’s management of the plant. Creating custom dynamos for level indication of the tanks with alarm limits graphicly presented in the HMI would help the operator manage heating elements. Adding a timer to keep track of time during the different process stages, such as fermenting, can be implemented to increase operator awareness.

12 Summary

The goal of this project was to produce automatic or semiautomatic control for the kettle and fermenter stages of the beer production plant using the Emerson DeltaV DCS system.
The project was delivered on time and fulfilled the project objective and task scope.

The semiautomatic control of these phases were developed, implemented, and tested. The participants gained a greater knowledge of process automation and the DeltaV system, possible improvements of the lab and its control systems was documented. Managing and planning the resources and contributions from the team, was an important part of this project.

The group developed and implemented a PLM that handles the sequential control of the Kettle and Fermenter processes of the plant. It also handles stopping, aborting and exceptions of said sequential control.

The group created an updated P&ID and a suggestion to new labels for process equipment in the form of a revised P&ID. From the updated P&ID an equipment state diagram was created. This diagram shows the state of every process equipment for each phase of production. The kettle and fermenter sequences were designed using the equipment state diagram and drawn in Visio. The sequences for the kettle and fermenter tank from the equipment state diagram, were tested manually before they were implemented in the PLM.

The activation of this PLM is done through an HMI that was revised and improved on by the project group. Three different temperature controllers were implemented. To regulate the temperature in the kettle tank, a PI-controller cascaded to a PWM, was implemented. The coolant and fermenter tank had its temperature regulated by two identical on/off controllers, with minor variations. The controllers were all activated and configured by the PLM, throughout the sequences.

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Appendices

Appendix A Task description

Appendix B Goal setting

Appendix C Gantt Diagram

Appendix D P&ID Original Plant

Appendix E P&ID Tag Suggestion

Appendix F Group Agreement

Appendix G WBS

Appendix H Equipment State Diagram

Appendix I EXPO Presentation of project

Appendix J Meeting minutes

Appendix K PLM Documentation

Appendix L Kettle Sequence

Appendix M TIC_KETTLE Documentation

Appendix N Fermenter Sequence

Appendix O TIC_COOLANT Documentation

Appendix P TIC_FERMENTER Documentation

Appendix Q PRESS_CTRL_FERM Documentation

Appendix R Test document

Universitetet i Sørøst-Norge

Fakultet for Teknologi, Naturvitenskap og Maritime fag

PRH612 Bacheloroppgave

Studieretning: Informatikk og Automatisering

Prosjektgruppe: IA6-4-20

Tittel: Design and Implementation of Automatic Sequencing for the Kettle and Fermenting Tank in the Beer Lab, using Emerson DeltaV

Veileder: Carlos F. Pfeiffer and Bjørn Vegard Tveraasen

Samarbeidspartner: Emerson, Porsgrunn

<u>Prosjektets bakgrunn:</u>
Universitetet i Sørøst-Norge har en pilot prosess for produksjon av øl, for å gi studenter praktisk erfaring med prosess ingeniør arbeid, instrumentering og prosess styring. Prosessen er utstyrt med pneumatiske ventiler, varmeelementer, pumper, kompressor og diverse temperatur og nivå sensorer. Prosessen er tilkoblet et Emerson DeltaV styresystem, verdens mest anvendte industrielle DCS system. Derfor er kunnskap og ekspertise i DeltaV høyt ettertraktet i mange bedrifter knyttet til automasjon.

<u>Målbeskrivelse for prosjektet:</u>
Gjennomgå de forskjelige stadiene av ølproduskjon, med fokus på koking-, avkjøling- og gjæringsfasene i prosessen. Designe detaljerte prosedyrer for automatisk eller semiautomatisk operering av kettle-whirpool tanken, varmeveksleren og gjæringstanken, inkludert:

- Tidsbestemt temperatur kontroll
- Whirpool timing kontroll.
- Koketid
- Kjøle sekvensering (ved å benytte varmeveksler)
- Temperatur regulering i gjæringstanken

Implementere og teste disse prosedyrene gjennom DeltaV systemet.
Oppdatere P&ID, skrive en detaljert rapport som inkluderer en prosjektbeskrivelse, instrumenterinsdiagrammer, graphset diagrammer, beregninger, kode osv.

Signatur

Carlos F. Pfeiffer	
Carlos Pfeiffer, Veileder	Bjørn Vegard Tveraasen, Veileder
Audun Theie	Are Rinden
Audun Bjørkøy Theie, Student	Are Strand Rinden, Student
Adrian A. Bergflødt	Torbjørn Slåttekjær
Adrian Bergføldt, Student	Torbjørn Slåttekjær, Student

Goal setting

Main objective:

The main objective of this project is to incorperate semi-automatic control of kettle and fermetation processes at the beer process plant located at USN Porsgrunn using the Emerson DeltaV system, by 01.05.2020.

Sub goals:

- Develop temprature controllers for kettle, fermenter and cooling system by 01.04.2020.
- Design and implement sequential control for the kettle and fermentation process by 15.04.2020.
- Implement monitoring and control of updated beer plant through the HMI by 30.04.2020.

ID	Indicators	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names	% Complete
1			**1. Bachelor Project**	**104 days?**	**Mon 1/13/2(**	**Thu 6/4/20**			**99%**
2	✓		**1.6 Documentatio**	**92 days**	**Mon 1/13/2(**	**Tue 5/19/20**			**100%**
4	✓		1.1.1 Group agreement	9 days	Mon 1/13/20	Thu 1/23/20		AB	100%
10	✓		1.5.1 Meeting reports	92 days	Mon 1/13/20	Tue 5/19/20		All	100%
11	✓		1.2.3 Limit scope of task	26 days	Mon 1/13/20	Sat 2/15/20		AT	100%
12	✓		EXPO catalog	24 days	Mon 1/20/20	Thu 2/20/20	11	AT	100%
3	✓		1.2.2 WBS	1 day	Thu 1/23/20	Mon 2/17/20	11,21	ASR	100%
9	✓		1.2.1 Gant diagram	84 days	Thu 1/23/20	Tue 5/19/20		ASR	100%
8	✓		1.6.1 P&ID diagr	6 days	Fri 1/24/20	Fri 1/31/20		AB	100%
13	✓		Process flow diagram	15 days	Mon 1/27/20	Fri 2/14/20	21	TS	100%
15	✓		Suggested improvements list	13 days	Fri 5/1/20	Tue 5/19/20		TS	100%
5	✓		Valve Diagram	2 days	Mon 2/3/20	Tue 2/4/20	8	AB	100%
6	✓		SFC Diagram	2 days	Mon 2/3/20	Tue 2/4/20	5,30	AB	100%
14	✓		Revised P&ID	3 days	Fri 2/14/20	Tue 2/18/20	8	AB	100%
16	✓		HMI Design	9 days	Mon 3/2/20	Thu 3/12/20		ASR	100%
7	✓		1.6.3 Test documents	58 days	Fri 2/7/20	Tue 4/28/20	22	All	100%
17	✓		Finish appendix	0 days	Tue 5/19/20	Tue 5/19/20			100%
18	✓		**Information gathering**	**36 days**	**Mon 1/13/20**	**Mon 3/2/20**			**100%**
21	✓		1.1.2 Beer process	20 days	Mon 1/13/20	Fri 2/7/20		All	100%
20	✓		1.1.3 DeltaV training	1 day	Thu 2/27/20	Thu 2/27/20		All	100%
19	✓		DeltaV manuals	11 days	Mon 2/17/20	Mon 3/2/20		All	100%
35			**Report**	**17 days**	**Mon 4/27/2(**	**Wed 5/20/2(**	**17,28,34**		**99%**
36	✓		Write report	17 days	Mon 4/27/20	Tue 5/19/20		All	100%
37	✓		Edit report	12 days	Mon 4/27/20	Tue 5/12/20			100%
38			Submit report	0 days	Wed 5/20/20	Wed 5/20/20	36,37		0%
22	✓		**1.3 Programming**	**44 days?**	**Mon 3/2/20**	**Thu 4/30/20**	**18,11,8,19**		**100%**
23	✓		1.3.2 Kettle tank	31 days	Mon 3/2/20	Mon 4/13/20		AB	100%
24	✓		1.3.3 Fermentaion tank	31 days	Mon 3/2/20	Mon 4/13/20		AB	100%
26	✓		Controllers	31 days	Mon 3/2/20	Mon 4/13/20		AT,TS	100%
27	✓		PLM Programming	11 days	Mon 3/16/20	Mon 3/30/20		AB	100%
25	✓		1.3.1 HMI	31 days	Tue 4/14/20	Tue 5/26/20	23,24	ASR	100%
28	✓		Programming completed	0 days	Wed 5/27/20	Wed 5/27/20	23,24,25,26,27	All	100%
29			**Testing**	**63 days**	**Fri 2/7/20**	**Tue 5/5/20**	**22,7**		**50%**
30			1.4.1 Test Valves and equipment	1 day	Fri 2/7/20	Fri 2/7/20	5	AT	0%
31			1.4.2 Test sequences	1 day	Wed 3/4/20	Wed 3/4/20	6	AB	0%
32	✓		1.4.3 Test controllers	1 day	Tue 4/28/20	Tue 4/28/20	26	AT	100%
33	✓		1.4.4 Test HMI	1 day	Tue 4/28/20	Tue 4/28/20		ASR	100%
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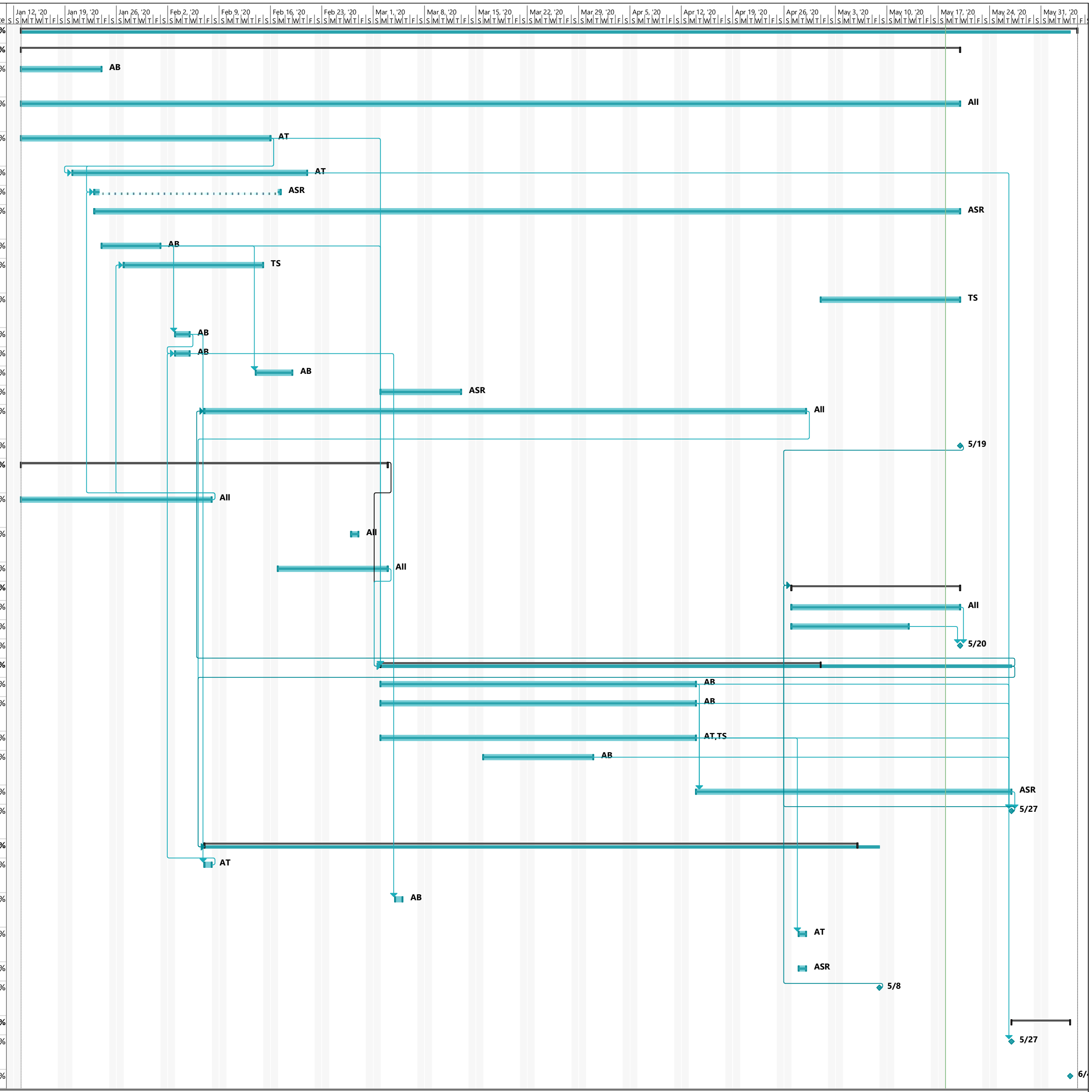
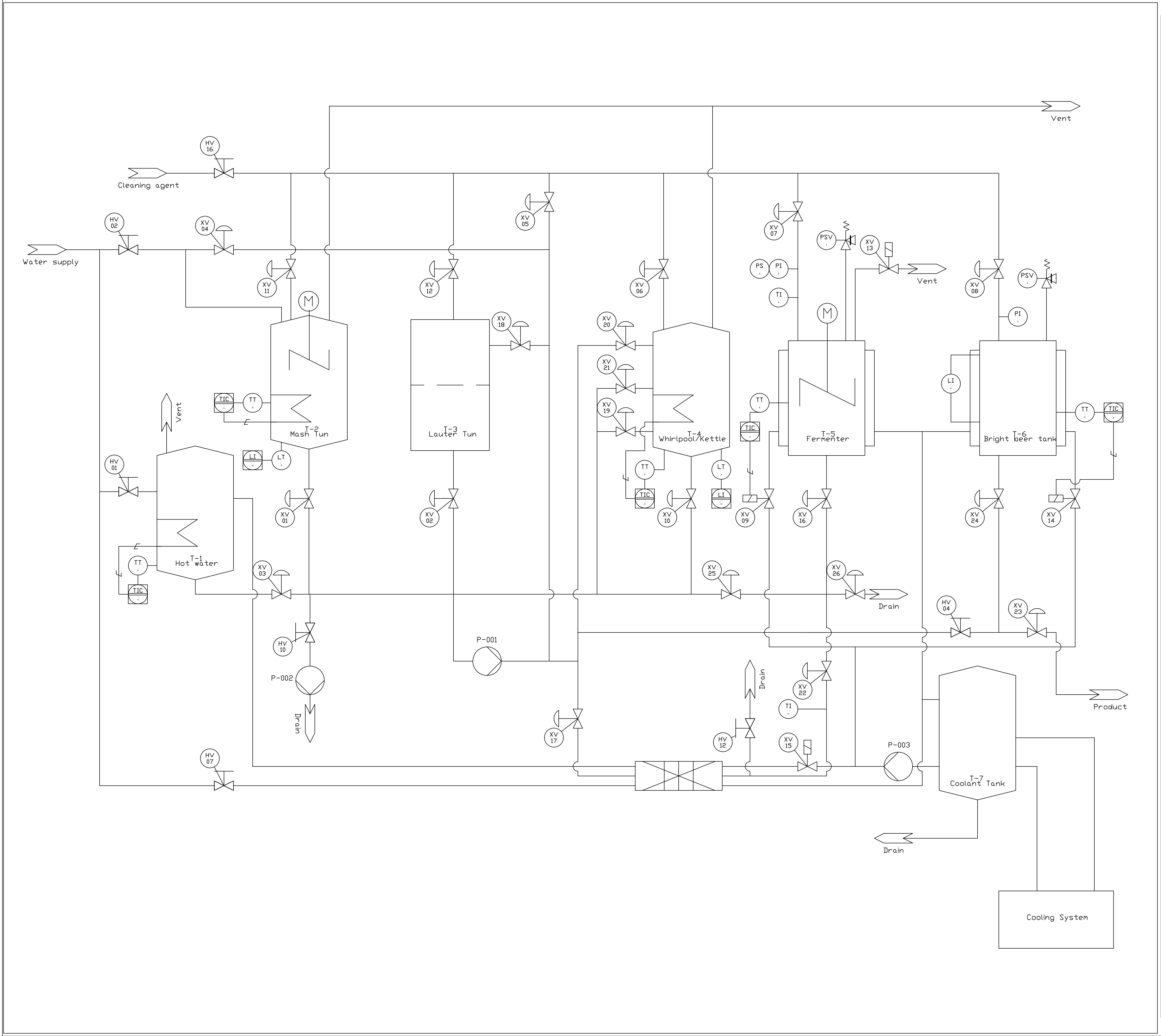


Project: GantBachelor
Date: Mon 5/18/20

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



General Notes

No.	Revision/Issue	Date
0	P&ID updated	08.05.20

Drawing Name

Original Plant

Original plant without sugested changes to labeling

Project Name and Address

IA6-4-20
Industrial beer production
Kjølnes ring 56
Porsgrunn

Area	Stamp
Beer Plant	
Drawing Number	
1	
Author	
Adrian Bergfløдt	

C:\Users\adria\Documents\Bachlor 3.år\6. Semester\Bachlor\P&ID\Bachlorprosjekt\PID DWG\EntirePlant2.dwg

PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION
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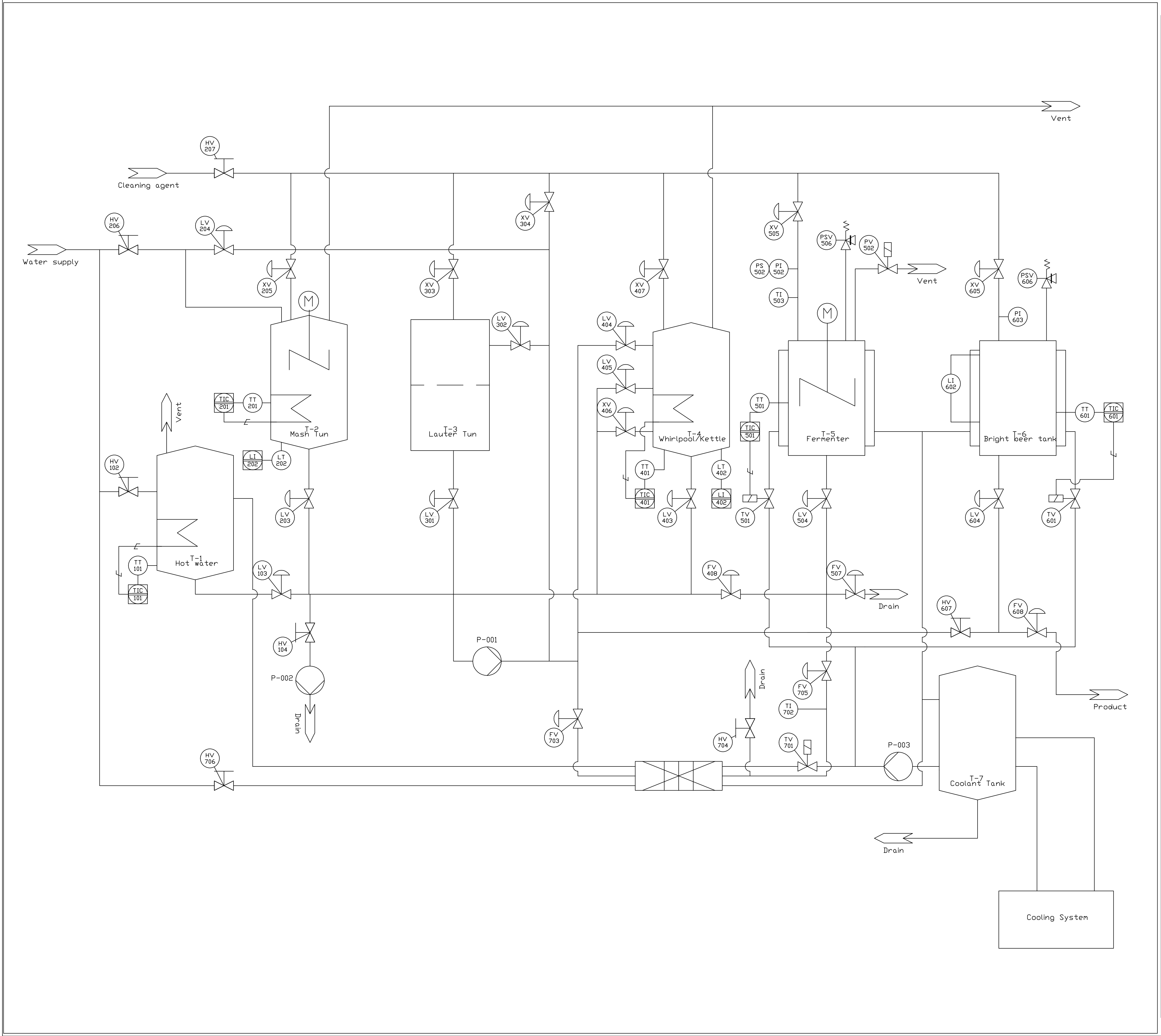

General Notes

No.	Revision/Issue	Date
0	Tags redefined	08.05.20

Drawing Name

EntirePlantRevised

Revised P&ID with sugested equipment labeling

Project Name and Address

IA6-4-20
Industrial beer production
Kjølnes ring 56
Porsgrunn

Area: Beer plant

Drawing Number: 2

Author: Adrian Bergfløדt

Stamp

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Group agreement

This group agreement is valid for project group IA6-4-20

Project duration

This agreement is valid from 13.01.2020 to 19.06.2020

Requirements for all project participants

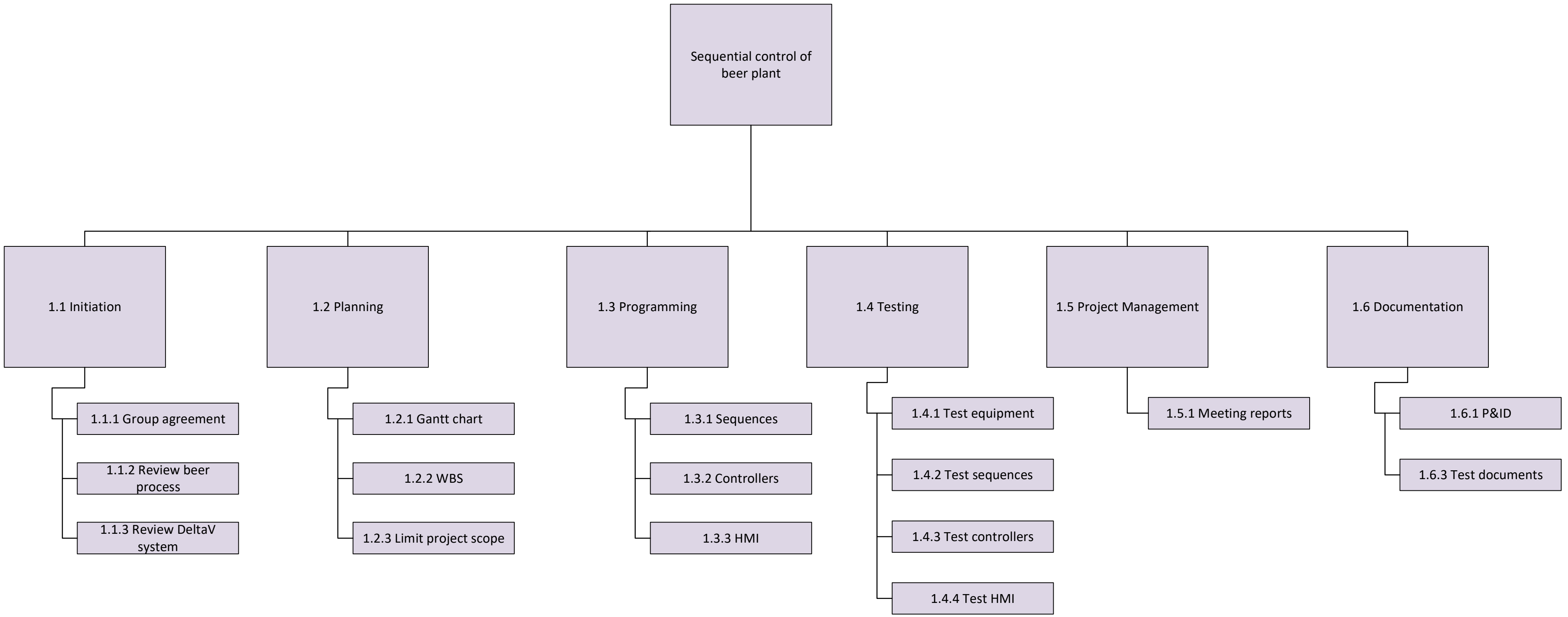
1. All meet at the agreed time and place.
2. Agreed work tasks must be completed within the given timeframe.
3. All absence must be notified in good time.
4. Problems with the progress of the project must be reported as soon as possible.
5. Respect each other’s views and time.
6. Mobile phones and other distractions should not be used unless relevant during meetings and groupwork.
7. The member responsible for a task is accountable for task completion.
8. Any violations without reasonable cause may result in the member in question to present cake or pizza for the next weekly informal meeting.
9. Undocumented absence and complete lack of communication for 72 hours will result in eviction.
10. All work done by the group members is to be considered as group property.

Adrian A. Bergflødt
Adrian Anderson Bergflødt

Audun Theie
Audun Bjørkøy Theie

Are Strand Rinden
Are Strand Rinden

Torbjørn Slåttekjær
Torbjørn Slåttekjær


Sequential control of beer plant
1.1 Initiation
1.1.1 Group agreement
1.1.2 Review beer process
1.1.3 Review DeltaV system
1.2 Planning
1.2.1 Gantt chart
1.2.2 WBS
1.2.3 Limit project scope
1.3 Programming
1.3.1 Sequences
1.3.2 Controllers
1.3.3 HMI
1.4 Testing
1.4.1 Test equipment
1.4.2 Test sequences
1.4.3 Test controllers
1.4.4 Test HMI
1.5 Project Management
1.5.1 Meeting reports
1.6 Documentation
1.6.1 P&ID
1.6.3 Test documents

State	Colour
Open/Running	
Closed/Stopped	
Regulated	
Not relevant	

	Tapwater-hotwater	Boiling in Hotwater	Hotwater-Mash	Mashsequence	Mash-Lauter	Lauter-Kettle	Whirlpool seq	Kettle-Fermenter	Cooling Fermenter	Fermenter-Bright	Cooling Bright
XV-01	Not relevant	Not relevant	Closed/Stopped	Closed/Stopped	Open/Running	Closed/Stopped	Closed/Stopped	Closed/Stopped	Not relevant	Closed/Stopped	Not relevant
XV-02	Not relevant	Not relevant	Closed/Stopped	Not relevant	Closed/Stopped	Open/Running	Closed/Stopped	Closed/Stopped	Not relevant	Closed/Stopped	Not relevant
XV-03	Closed/Stopped	Closed/Stopped	Open/Running	Not relevant	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Not relevant	Closed/Stopped	Not relevant
XV-04	Not relevant	Not relevant	Open/Running	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Not relevant	Closed/Stopped	Not relevant
XV-05	Not relevant	Not relevant	Closed/Stopped	Not relevant	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Not relevant	Closed/Stopped	Not relevant
XV-06	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Open/Running	Open/Running	Not relevant	Not relevant	Open/Running	Not relevant
XV-07	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Closed/Stopped	Not relevant	Closed/Stopped	Closed/Stopped	Closed/Stopped	Not relevant
XV-08	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Closed/Stopped	Not relevant	Not relevant	Not relevant	Open/Running	Closed/Stopped
XV-09	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Regulated	Regulated	Closed/Stopped	Closed/Stopped
XV-10	Not relevant	Not relevant	Closed/Stopped	Not relevant	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Not relevant	Closed/Stopped	Not relevant
XV-11	Not relevant	Not relevant	Not relevant	Closed/Stopped	Open/Running	Closed/Stopped	Open/Running	Not relevant	Not relevant	Not relevant	Not relevant
XV-12	Not relevant	Not relevant	Not relevant	Not relevant	Open/Running	Open/Running	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant
XV-13	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Open/Running	Regulated	Open/Running	Not relevant
XV-14	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Closed/Stopped	Closed/Stopped	Regulated	Regulated
XV-15	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Open/Running	Closed/Stopped	Closed/Stopped	Closed/Stopped
XV-16	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Open/Running	Closed/Stopped	Open/Running	Not relevant
XV-17	Not relevant	Not relevant	Closed/Stopped	Not relevant	Closed/Stopped	Closed/Stopped	Closed/Stopped	Open/Running	Not relevant	Closed/Stopped	Not relevant
XV-18	Not relevant	Not relevant	Closed/Stopped	Not relevant	Open/Running	Closed/Stopped	Closed/Stopped	Closed/Stopped	Not relevant	Closed/Stopped	Not relevant
XV-19	Not relevant	Not relevant	Closed/Stopped	Not relevant	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Not relevant	Closed/Stopped	Not relevant
XV-20	Not relevant	Not relevant	Closed/Stopped	Not relevant	Closed/Stopped	Open/Running	Open/Running	Closed/Stopped	Not relevant	Closed/Stopped	Not relevant
XV-21	Not relevant	Not relevant	Closed/Stopped	Not relevant	Closed/Stopped	Closed/Stopped	Open/Running	Open/Running	Not relevant	Closed/Stopped	Not relevant
XV-22	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Open/Running	Not relevant	Closed/Stopped	Not relevant
XV-23	Not relevant	Not relevant	Closed/Stopped	Not relevant	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Not relevant	Closed/Stopped	Not relevant
XV-24	Not relevant	Not relevant	Closed/Stopped	Not relevant	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Not relevant	Open/Running	Closed/Stopped
XV-25	Not relevant	Not relevant	Closed/Stopped	Not relevant	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Not relevant	Open/Running	Not relevant
XV-26	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Closed/Stopped	Not relevant	Closed/Stopped	Not relevant
HV-01	Open/Running	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Open/Running	Closed/Stopped	Not relevant	Not relevant	Not relevant
HV-02	Closed/Stopped	Not relevant	Closed/Stopped	Closed/Stopped	Not relevant	Not relevant	Open/Running	Closed/Stopped	Not relevant	Not relevant	Not relevant
HV-04	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Open/Running	Not relevant
HV-07	Closed/Stopped	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Open/Running	Not relevant	Not relevant	Not relevant
HV-10	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped
HV-12	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Closed/Stopped	Not relevant	Not relevant	Not relevant
HV-16	Not relevant	Not relevant	Closed/Stopped	Not relevant	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped
P-001	Closed/Stopped	Closed/Stopped	Open/Running	Closed/Stopped	Open/Running	Open/Running	Open/Running	Open/Running	Closed/Stopped	Open/Running	Closed/Stopped
P-002	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped
P-003	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Open/Running	Open/Running	Open/Running	Open/Running
H-001	Closed/Stopped	Regulated	Closed/Stopped	Regulated	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped
H-002	Closed/Stopped	Closed/Stopped	Closed/Stopped	Regulated	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped
H-003	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Regulated	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped
M-001	Closed/Stopped	Closed/Stopped	Closed/Stopped	Open/Running	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped
M-002	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Closed/Stopped	Open/Running	Regulated	Closed/Stopped	Closed/Stopped

Design and Implementation of Automatic Sequencing for the Kettle and Fermenting Tank in the Beer Lab, using Emerson DeltaV

Øllabben hos USN Porsgrunn er en levende prosessrig som stadig er i utvikling. Riggen står i dag komplett, med både tanker, sensorer, aktuatorer og styresystem. Vår oppgave er å ferdigstille den automatiserte prosess sekvensen, med fokus på koketank, fermenteringstank og varmeveksler.

Prosjektnummer:

IA6-4-20

Problemstilling:

Hvordan kan man oppnå automatisk eller semi-automatisk styring av Kettle og Fermenteringstanken?

Hvordan kan sekvenseringen optimaliseres, da det kun er én hovedpumpe og felles rørsystem for alle tankene?

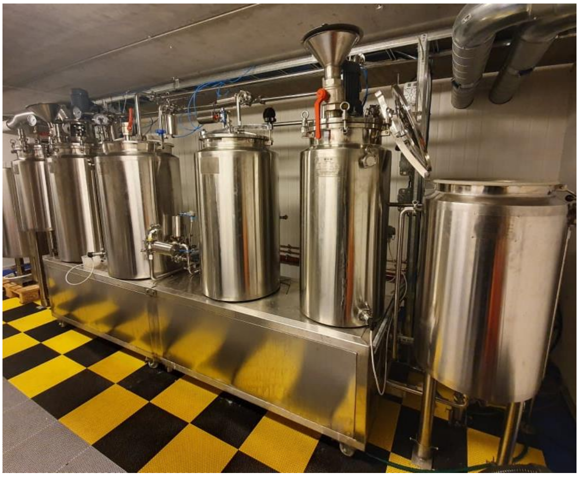
Hvordan skal brukergrensesnittet utformes og hvordan skal informasjon vises?

Sammendrag:

Prosessriggen står i dag komplett, med både tanker, sensorer, aktuatorer og styresystem. Vår oppgave er å ferdigstille den automatiserte prosess sekvensen, med fokus på koketank, fermenteringstank og varmeveksler, samt lage et brukergrensesnitt (HMI) for operatører.

Om prosjektgruppen:

Vi er en gruppe bestående av ingeniørstudenter innen Automasjon og Informatikk hos USN. Tre av oss jobbet med øllabben allerede i første semester, med valg av sensorer og måleprinsipp i F1 prosjektet. Et av medlemmene har akademisk bakgrunn, tre av gruppemedlemmene går yrkes-vei, der en har bakgrunn i prosess-automasjon.



Adrian Bergflødt
T: 908 17 039
E: adrian.bergflodt@live.no

Are Strand Rinden
T: 926 10 111
E: are_terk@Hotmail.com

Torbjørn Slåttekjær
T: 971 18 460
E: sl.klimatek@gmail.com

Audun Bjørkøy Theie
T: 464 30 667
E: audun.theie@gmail.com

University of South-Eastern Norway
Faculty of Technology, Natural Sciences and Maritime Sciences
Group IA6-4-20, Design and Implementation of Automatic Sequencing for the Kettle and Fermenting Tank in the Beer Lab, Using Emerson DeltaV

Location: USN, C-229a, 20.02.20

To: Carlos Pfeiffer, Adrian Bergflødt, Are Strand Rinden,Torbjørn Slåttekjær, Audun Theie.

PROJECT MEETING MINUTES NO. 1

Present: Carlos Pfeiffer, Adrian Bergflødt, Are Strand Rinden, Torbjørn Slåttekjær, Audun Theie.
Absent:

Duration of meeting: 12:00 -13:00 (Originally from 13:00 – 14:00)

Item 01/20 Preliminary items

1. HSE
   i. Nothing to report. Everything is in order.
2. Approval of the notice of meeting (call-in)
   i. Approved
3. Approval of agenda – Agenda is approved
   i. Approved
4. Approval of Group Agreement
   i. Approved
5. Any other business

Item 02/20 Status/information items

1. Status Report
   i. Group Agreement is 100%, Gantt at 65% WBS at 65%, P&ID at 80%, Report structure 50%, Process Flow Diagram 100%, Sequence sketch at 60%, Valve diagram spreadsheet at 95%.
2. Emerson DeltaV Training
   i. Send mail to Rune at Emerson to arrange meeting for DeltaV Training. Must be done this week.
3. P&ID Approval
   i. Approved but some changes must be done.
      1. Tag the drain for wastewater
      2. Tag the heat-exchanger inn an out flow.
   ii. Send mail to Carlos with the latest version of the P&ID for him to make a poster of the P&ID.
   iii. When implementing changes, we need to keep the old versions.
4. Valve replacement and relocation
   i. Carlos agrees on, that valve HV-04 change place with XV-23.
5. WBS
   i. So far approved.
6. Gantt
   i. So far approved.
7. Sequence sketch
   i. Approved with some Changes.

1. Carlos like us to use DeltaV standards for Sequence sketch.
2. Like us to add the conditions for the transitions. Carlos would like states of the plant to be known at all time through the process.

8. Report Structure
   i. Not gone through, due to lack of time.

Item 03/20 <u>Election of Chair and Secretary for next meeting</u>

i. Adrian as Chair and Are as secretary

Item 04/20 <u>Any other business</u>

1. Discussing about the heater-elements in the tanks.
   a. Concerns about the dissolving around the connection in the tank.
   b. We stop using Caustic Soda, because it makes the cooper oxidize.
   c. Carlos will talk to Fredrik and ask if he can help with this problem.
   d. Send mail to Carlos of the findings and status on the heater oxidize problem.
2. Send mail to Carlos with pdf documents that can of interest for the DeltaV system, like DeltaV Getting Started and other documents of relevance.
3. Include Carlos and Emerson contact in EXPO Catalog. Send mail to Emerson for approval.
4. Pump can be run some minutes without water, but too long can destroy the impeller.

Secretary: Torbjørn Slåttekjær

University of South-Eastern Norway
Faculty of Technology, Natural Sciences and Maritime Sciences
Group IA6-4-20, Design and Implementation of Automatic Sequencing for the Kettle and Fermenting Tank in the Beer Lab, Using Emerson DeltaV

Location: Online meeting over Microsoft Teams, 16.03.2020

To: Carlos Pfeiffer, Adrian Bergflødt, Are Strand Rinden, Torbjørn Slåttekjær, Audun Theie.

PROJECT MEETING MINUTES NO. 2

Present: Carlos Pfeiffer, Adrian Bergflødt, Are Strand Rinden, Torbjørn Slåttekjær, Audun Theie.
Absent:

Duration of meeting: 12:00 -13:00 (Originally from 11.15 – 13:00)

Item 05/20 Preliminary items

1. HSE
    i. Covid-19 and quarantines slows progression.
2. Approval of the notice of meeting (call-in)
    i. Approved
3. Approval of agenda – Agenda is approved
    i. Approved
4. Approval of minutes for previous meeting
    i. Approved
5. Any other business

Item 06/20 Status/information items

1. Status Report
    i. Design of sequences 100% complete, Manual testing of sequences completed, Implementation of sequences 10%, Revised P&ID at 100%, Valve diagram 100%, HMI design 30%, Report at 20%.
2. Emerson DeltaV Training
    i. Group has met with Rune Andersen from Emerson and received basic training; it was also decided to use a PLM in the implementation of the sequences with regards to future USN projects concerning the beer lab.
3. Faults in the plant
    i. During testing in the beer lab several faults were present
        1. XV-13 doesn't open/close.
        2. XV-18 isn't connected to controller due to missing wire.
        3. XV-24 block needs to be replaced. Bjørn Vegard Tveraaen has ordered new block.
        4. XV-15 is not present in HMI.
        5. Bright beer tank level meter needs to be replaced.
        6. Heating element in the mash tun doesn't have PWM regulation. Group has implemented regulation for the heating element, but not yet tested.
    ii. Bjørn Vegard has been made aware of the faults in the plant.
    iii. Procedures for exposing these faults needs to be included in the project report.

4. WBS
    i. Testing of system integrity needs to be added in the WBS
5. Gantt
    i. Gantt chart needs to be updated with changes due to Covid-19.
6. HMI Design
    i. Changes in the HMI design to become more of a High Performance HMI were discussed
        1. A change to an High Performance HMI will require designing an HMI for processes outside of the scope for this project.
        2. Carlos like us to add options and discuss in the report how the HMI should be designed and implemented.
        3. The group should consult Per Kristian Fylkesnes regarding changes to the HMI.

Item 07/20 <u>Sensor sample rate</u>

i. No changes in the sample rate for sensors will be made.

Item 08/20 <u>Election of Chair and Secretary for next meeting</u>

i. Torbjørn as Chair and Audun as secretary

Item 09/20 <u>Any other business</u>

1. Due to Covid-19 a change to the projects scope may be needed as the group do not have access to the beer plant for implementation of the sequences.
2. Several ideas were listed as a way of dealing with the current Covid-19 situation.
    a. Remote operation of plant
        i. Carlos would like that remote operation to be discussed in the project report.
        ii. Carlos will speak with IT department to see if remote operation is a viable option.
    b. Possible co-operation with Emerson for use of another lab to implement sequences.
    c. Groups of max 2 students at a time to be allowed access to the plant.
    d. Changing the scope of the project to become a strictly design based project without implementation.
        i. Documentation as to how the group planned on implementing the sequences must be included in report using Emerson standards so that implementation can be done by external people.
3. A new meeting will take place next week with Carlos (Week 13) with an update to the covid-19 status and how the group should proceed with the task.

Secretary: Are Strand Rinden

University of South-Eastern Norway
Faculty of Technology, Natural Sciences and Maritime Sciences
Group IA6-4-20, Design and Implementation of Automatic Sequencing for the Kettle and Fermenting Tank in the Beer Lab, Using Emerson DeltaV

Location: Online meeting over Microsoft Teams, 31.03.2020

To: Carlos Pfeiffer, Adrian Bergflødt, Are Strand Rinden, Torbjørn Slåttekjær, Audun Theie.

PROJECT MEETING MINUTES NO. 3

Present: Carlos Pfeiffer, Adrian Bergflødt, Are Strand Rinden, Torbjørn Slåttekjær, Audun Theie.
Absent:

Duration of meeting: 11:15 -12:15

Item 10/20 Preliminary items

1. HSE
    i. Covid-19 and quarantines continue to slow progression and productivity.
2. Approval of the notice of meeting (call-in)
    i. Approved
3. Approval of agenda – Agenda is approved
    i. Approved
4. Approval of minutes for previous meeting
    i. Approved
5. Any other business

Item 11/20 Status/information items

1. Status Report
    i. The report structure is in place, but there are still parts that needs to be added and some chapters are yet to be filled.
    ii. PLM has been implemented, but remains to be tested
        1. Bjørn Vegard will be contacted and asked to supervise the plant as we will test the SFCs remotely.
        2. Per Kristian Fylkesnes will be contacted regarding how to engage and initiate the PLMs.
    iii. HMI development has hit a roadblock due to software constraints, disallowing further implementation and design of new objects.
        1. Minor updates to pre-existing HMI will be developed. Per Kristian Fylkesnes will be consulted as to what HMI design principles Emerson uses, and a draft will be created using these principles.

Item 12/20 Election of Chair and Secretary for next meeting

    i. Are Rinden as Chair and Adrian Bergflødt as secretary

Item 13/20 Any other business

1. Everyone must know DeltaV configuration, we probably must educate each other.

2. When the report has been completed, graded and accepted, we will invite the external sensor for the presentation.
3. The external sensor will only grade the report, therefore it extremely important that all work is well documented. Everything could be of value and use in future projects.

Secretary: Audun Bjørkøy Theie

University of South-Eastern Norway
Faculty of Technology, Natural Sciences and Maritime Sciences
Group IA6-4-20, Design and Implementation of Automatic Sequencing for the Kettle and Fermenting Tank in the Beer Lab, Using Emerson DeltaV

Location: Online meeting over Zoom, 14.05.2020

To: Carlos Pfeiffer, Adrian Bergflødt, Are Strand Rinden, Torbjørn Slåttekjær, Audun Theie.

PROJECT MEETING MINUTES NO. 4

Present: Carlos Pfeiffer, Adrian Bergflødt, Are Strand Rinden, Torbjørn Slåttekjær, Audun Theie.
Absent:

Duration of meeting: 10:30 -11:30

Item 14/20 Preliminary items

1. HSE
2. Approval of the notice of meeting
    i. Approved
3. Approval of agenda
    i. Approved
4. Approval of minutes for previous meeting
    i. Approved
5. Any other business
    i. Presentation information
    ii. Zoom testing

Item 15/20 Status/information items

1. Project report review
    i. Increase line width
    ii. Fix report structure
    iii. Results:
        1. Note what we programmed and tested
        2. Refer to previous chapters
    iv. Introduction:
        1. Define where results are,
        2. Note what we focus on the operation of the plant mention chapter 3
    v. Process description:
        1. Add a basic diagram and picture of the plant.
        2. Specify what the plant consists of, how many valves, the capacity of the tanks, be more specific.
        3. Make a great process description, it sets the tone of the entire report.
        4. Reduce the HSE part of the report, be more concise.
    vi. Planning:
        1. Add information about how we organized, how many meetings, issues that occurred, what actions where taken… what we had to adapt to, meeting minutes as appendix.

2. Describe the training on the DeltaV and contacting people at Emerson.
3. Rewrite the chapter.
4. Rename it to Planning and execution.
5. Refer to the Gant.
6. Mention the Ebok

vii. Kettle:
1. Add reference to the equations
2. Rename the chapter to something more descriptive.
3. Emphasise that important actions happens in the kettle and what's critical. Why do we need PWM not just on/off controller. Why did we make a simpler controller?
4. Talk about improvements

viii. Fermenter:
1. Rename chapter to something more descriptive.
2. Reference to the P&ID
3. Fig 5.2 make small changes.

ix. HMI:
1. Emphasize that dynamo sets are DeltaV specific, sell the chapter better.
2. Refer to standards, emphasize why the HMI is important.
3. Fig 6.7 specify that the picture was taken when the system was not running

x. DeltaV system:
1. Restructure

xi. Discussion;
1. Show possible solutions not problems.
2. Show how we worked during unexpected situations.
3. Say what was good, not what was bad, what we learned.
4. Use this chapter to show our expertise

2. Appendices review
   i. Appendices Ok

Item 16/20 <u>Any other business</u>

1. Presentation information
   i. 10 minute presentation each. Can better or lower each students grade.
   ii. After the presentation there is a discussion regarding grades with each individual student in separate rooms.
2. Zoom testing
   i. Zoom was tested successfully

Secretary: Adrian Anderson Bergflødt

Report:	Phase Logic Module
Name:	BEER_PROCESS_PLM
Contents:	ABORT_LOGIC FAIL_MONITOR HOLD_LOGIC RESTART_LOGIC RUN_LOGIC STOP_LOGIC

Report:	Phase Logic Module
Name:	BEER_PROCESS_PLM
Description:	Phase Logic Module
Path:	PKF_MAIN/BEER_PROCESS_PLM
Node Assignment:	NODE1
Execution Period:	1 sec
Algorithm Type:	Phase Algorithm
Primary Graphic Name:	
Detail Graphic Name:	PLM_DT
Faceplate Graphic Name:	PLM_FP
Work In Progress?	No
Restore parameters	No
Phase Class:	
Assigned to Units:	
Simulated	No
Equipment ID:	2
Max Owners:	1
Needed Equipment:	

Hierarchy for PKF_MAIN/BEER_PROCESS_PLM

BEER_PROCESS_PLM			
+	ABORT_LOGIC	Embedded Composite	
+	+	S1	Start Step
+	+	S2	Step
+	+	S3	Step
+	+	T1	Transition
+	+	T2	Transition
+	+	T3	Transition
+	FAIL_MONITOR		Embedded Composite
+	+	BLOCK1	Function
Block			
+	HOLD_LOGIC	Embedded Composite	
+	+	S1	Start Step
+	+	S2	Step
+	+	S3	Step
+	+	T2	Transition
+	+	T3	Transition
+	+	T4	Transition
+	RESTART_LOGIC		Embedded Composite
+	+	S1	Start Step
+	+	T1	Transition
+	RUN_LOGIC	Embedded Composite	
+	+	S1	Start Step
+	+	S10	Step
+	+	S11	Step
+	+	S12	Step
+	+	S13	Step
+	+	S14	Step
+	+	S15	Step
+	+	S16	Step
+	+	S2	Step
+	+	S3	Step
+	+	S4	Step
+	+	S5	Step
+	+	S6	Step
+	+	S7	Step
+	+	S8	Step
+	+	S9	Step
+	+	T10	Transition
+	+	T11	Transition
+	+	T12	Transition
+	+	T13	Transition
+	+	T14	Transition
+	+	T15	Transition
+	+	T16	Transition
+	+	T17	Transition
+	+	T18	Transition
+	+	T19	Transition
+	+	T2	Transition
+	+	T3	Transition
+	+	T4	Transition
+	+	T5	Transition
+	+	T6	Transition
+	+	T7	Transition
+	+	T8	Transition
+	+	T9	Transition
+	STOP_LOGIC	Embedded Composite	
+	+	S1	Start Step
+	+	S2	Step
+	+	S3	Step
+	+	T2	Transition
+	+	T3	Transition
+	+	T4	Transition

Actions for Step BEER_PROCESS_PLM/ABORT_LOGIC/S1

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A3	Assignment	6	0	0	Action Expression: '^/RUN_LOGIC/SEQUENCE_RUNNING' := "Abort enabled"; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
A1	Assignment	6	0	0	Action Expression: '//XV-10_DRAIN_WP/DC1/MODE.CST' := CAS; '//XV-13_VENT_FT/DC1/MODE.CST' := CAS; '//XV-16_DRAIN_FT/DC1/MODE.CST' := CAS; '//XV-25/DC1/MODE.CST' := CAS; '//XV-26/DC1/MODE.CST' := CAS; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Valves to CAS					
A2	Assignment	6	0	0	Action Expression: '//PROCESS_PUMP/DC1/MODE.CST' := CAS; '//COOLING_PUMP/DC1/MODE.CST' := CAS; '//FT-MIXER/DC1/MODE.CST' := CAS; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Misc to CAS					

Actions for Step BEER_PROCESS_PLM/ABORT_LOGIC/S2

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A7	Assignment	6	0	0	Action Expression: '^/RUN_LOGIC/SEQUENCE_STATUS' := "Stopping equipment"; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Equipment stopped string					
A1	Assignment	6	0	0	Action Expression: '//PROCESS_PUMP/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//PROCESS_PUMP/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Stop P-001					
A2	Assignment	6	0	0	Action Expression: '//TIC_COOLANT/START.CV' := False Delay Expression: 0.000000 Confirm Expression: '//COOLING_SYST/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Stop Cooling system					
A3	Assignment	6	0	0	Action Expression: '//FT-MIXER/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//FT-MIXER/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Stop mixer					
A4	Assignment	6	0	0	Action Expression: '//TIC_KETTLE/START.CV' := False; Delay Expression: 0.000000 Confirm Expression: '//TIC_KETTLE/RUNNING' = False Confirm Timeout Expression: 0.000000
Description: Stop temp ctrl kettle					
A5	Assignment	6	0	0	Action Expression: '//TIC_FERMENTER/START.CV' := False; Delay Expression: 0.000000 Confirm Expression: '//COOLING_PUMP/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Stop temp ctrl Fermenter					
A6	Assignment	6	0	0	Action Expression: '//TIC_COOLANT/START' := False; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Stop Colling system temp controll					

Actions for Step BEER_PROCESS_PLM/ABORT_LOGIC/S3

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A1	Assignment	6	0	0	Action Expression: '^/RUN_LOGIC/SEQUENCE_STATUS' := "Opening drain valves"; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Drain string					
A3	Assignment	6	0	0	Action Expression: '//XV-10_DRAIN_WP/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//XV-10_DRAIN_WP/PV_D' = 1 Confirm Timeout Expression: 0.000000
Description: Open XV-10					
A4	Assignment	6	0	0	Action Expression: '//XV-13_VENT_FT/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//XV-13_VENT_FT/PV_D' = 1 Confirm Timeout Expression: 0.000000
Description: Open XV-13					
A5	Assignment	6	0	0	Action Expression: '//XV-16_DRAIN_FT/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//XV-16_DRAIN_FT/PV_D' = 1 Confirm Timeout Expression: 0.000000
Description: Open XV-16					
A6	Assignment	6	0	0	Action Expression: '//XV-25/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//XV-25/PV_D' = 1 Confirm Timeout Expression: 0.000000
Description: Open XV-25					
A7	Assignment	6	0	0	Action Expression: '//XV-26/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//XV-26/PV_D' = 1 Confirm Timeout Expression: 0.000000
Description: Open XV-26					
A2	Assignment	6		0	Action Expression: '^/RUN_LOGIC/SEQUENCE_RUNNING' := "Abort complete. Reset PLM";

Actions for Step BEER_PROCESS_PLM/HOLD_LOGIC/S1

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A3	Assignment	6	0	0	Action Expression: '^/RUN_LOGIC/SEQUENCE_RUNNING.CV' := "Holding enabled"; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
A1	Assignment	6	0	0	Action Expression: '//XV-10_DRAIN_WP/DC1/MODE.CST' := CAS; '//XV-16_DRAIN_FT/DC1/MODE.CST' := CAS; '//XV-19/DC1/MODE.CST' := CAS; '//XV-20/DC1/MODE.CST' := CAS; '//XV-21/DC1/MODE.CST' := CAS; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Valves to CAS					
A2	Assignment	6	0	0	Action Expression: '//PROCESS_PUMP/DC1/MODE.CST' := CAS; '//FT-MIXER/DC1/MODE.CST' := CAS; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Misc to CAS					

Actions for Step BEER_PROCESS_PLM/HOLD_LOGIC/S2

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:

Actions for Step BEER_PROCESS_PLM/HOLD_LOGIC/S2

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A3	Assignment	6	0	0	Action Expression: '^/RUN_LOGIC/SEQUENCE_STATUS' := "Stopping pump and mixer"; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Stop pumpMixer string					
A1	Assignment	6	0	0	Action Expression: '//PROCESS_PUMP/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//PROCESS_PUMP/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Stop P-001					
A2	Assignment	6	0	0	Action Expression: '//FT-MIXER/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//FT-MIXER/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Stop mixer					

Actions for Step BEER_PROCESS_PLM/HOLD_LOGIC/S3

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A6	Assignment	6	0	0	Action Expression: '^/RUN_LOGIC/SEQUENCE_STATUS' := "Close drain valves and whirpool"; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Close drain valveswhirpool					
A1	Assignment	6	0	0	Action Expression: '//XV-10_DRAIN_WP/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-10_DRAIN_WP/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-10					
A2	Assignment	6	0	0	Action Expression: '//XV-16_DRAIN_FT/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-16_DRAIN_FT/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-16					
A3	Assignment	6	0	0	Action Expression: '//XV-19/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-19/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-19					
A4	Assignment	6	0	0	Action Expression: '//XV-20/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-20/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-20					
A5	Assignment	6	0	0	Action Expression: '//XV-21/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-21/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-21					
A7	Assignment	6		0	Action Expression: '^/RUN_LOGIC/SEQUENCE_RUNNING' := "Holding complete. Reset PLM";

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S1

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S1

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A1	Assignment	6	0	0	Action Expression: '//XV-01_DRAIN_MT/DC1/MODE.CST' := CAS; '//XV-02_DRAIN_LT/DC1/MODE.CST' := CAS; '//XV-03_DRAIN/DC1/MODE.CST' := CAS; '//XV-04_MT_FILL/DC1/MODE.CST' := CAS; '//XV-05_CIP_MAIN/DC1/MODE.CST' := CAS; '//XV-06_CIP_WP/DC1/MODE.CST' := CAS; '//XV-10_DRAIN_WP/DC1/MODE.CST' := CAS; '//XV-11_CIP_MT/DC1/MODE.CST' := CAS; '//XV-17_VALVE/DC1/MODE.CST' := CAS; '//XV-18/DC1/MODE.CST' := CAS; '//XV-19/DC1/MODE.CST' := CAS; '//XV-20/DC1/MODE.CST' := CAS; '//XV-21/DC1/MODE.CST' := CAS; '//XV-23/DC1/MODE.CST' := CAS; '//XV-24/DC1/MODE.CST' := CAS; '//XV-25/DC1/MODE.CST' := CAS; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Valves to CAS					
A2	Assignment	6	0	0	Action Expression: '//PROCESS_PUMP/DC1/MODE.CST' := CAS; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Misc to CAS					
A3	Assignment	6	0	0	Action Expression: 'SEQUENCE_RUNNING' := "Kettle sequence active"; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Kettle sequence is running					

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S10

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A1	Assignment	6	0	0	Action Expression: '//XV-09_COOL_FT/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//XV-09_COOL_FT/PV_D' = 1 Confirm Timeout Expression: 0.000000
Description: Open XV-09					
A2	Assignment	6	0	0	Action Expression: '//XV-13_VENT_FT/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//XV-13_VENT_FT/PV_D' = 1 Confirm Timeout Expression: 0.000000
Description: Open XV-13					
A3	Assignment	6	0	0	Action Expression: '//XV-15_COOL_H_EXC/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//XV-15_COOL_H_EXC/PV_D' = 1 Confirm Timeout Expression: 0.000000
Description: Open XV-15					
A4	Assignment	6	0	0	Action Expression: '//XV-16_DRAIN_FT/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//XV-16_DRAIN_FT/PV_D' = 1 Confirm Timeout Expression: 0.000000
Description: Open XV-16					
A5	Assignment	6	0	0	Action Expression: '//XV-17_VALVE/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//XV-17_VALVE/PV_D' = 1 Confirm Timeout Expression: 0.000000
Description: Open XV-17					
A6	Assignment	6	0	0	Action Expression: '//XV-21/DC1/SP_D.CV' := 1;

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S10

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A6	Assignment	6	0	0	Action Expression: '//XV-21/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//XV-21/PV_D' = 1 Confirm Timeout Expression: 0.000000
Description: Open XV-21					
A7	Assignment	6	0	0	Action Expression: '//XV-22/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//XV-22/PV_D' = 1 Confirm Timeout Expression: 0.000000
Description: Open XV-22					

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S11

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A1	Assignment	6	0	0	Action Expression: '//PROCESS_PUMP/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//PROCESS_PUMP/PV_D' = 1 Confirm Timeout Expression: 0.000000
Description: Start P-001					
A2	Assignment	6	0	0	Action Expression: '//FT-MIXER/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//FT-MIXER/PV_D' = 1 Confirm Timeout Expression: 0.000000
Description: Start Mixer					
A3	Assignment	6	0	0	Action Expression: '//TIC_COOLANT/START.CV' := True Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Start Cooling system					
A4	Assignment	6	0	0	Action Expression: '//TIC_COOLANT/SP.CV' := 4 Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Set Point = 4 degrees celcius					
A5	Assignment	6	0	0	Action Expression: '//COOLING_PUMP/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//COOLING_PUMP/PV_D' = 1 Confirm Timeout Expression: 0.000000
Description: Start P-003					
A6	Assignment	6	0	0	Action Expression: 'SEQUENCE_STATUS' := "Transfering"; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Update state param					

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S12

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A2	Assignment	6	0	0	Action Expression: '//TIC_FERMENTER/START.CV' := True; Delay Expression: 0.000000 Confirm Expression: '//COOLING_PUMP/PV_D' = 1 Confirm Timeout Expression: 0.000000
Description: Start temp ctrl in T-5					
A3	Assignment	6	0	0	Action Expression: '//TIC_FERMENTER/SP' := 8; Delay Expression: 0.000000

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S12

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A3	Assignment	6	0	0	Action Expression: '//TIC_FERMENTER/SP' := 8; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Set point = 8					

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S13

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A1	Assignment	6	0	0	Action Expression: '//PROCESS_PUMP/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//PROCESS_PUMP/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Stop P-001					
A2	Assignment	6	0	0	Action Expression: '//XV-05_CIP_MAIN/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-05_CIP_MAIN/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-05					
A3	Assignment	6	0	0	Action Expression: '//XV-15_COOL_H_EXC/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-15_COOL_H_EXC/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-15					
A4	Assignment	6	0	0	Action Expression: '//XV-16_DRAIN_FT/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-16_DRAIN_FT/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-16					
A5	Assignment	6	0	0	Action Expression: '//XV-17_VALVE/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-17_VALVE/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-17					
A6	Assignment	6	0	0	Action Expression: '//XV-21/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-21/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-21					
A7	Assignment	6	0	0	Action Expression: '//XV-22/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-22/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-22					
A8	Assignment	6	0	0	Action Expression: 'SEQUENCE_STATUS' := "Transfer complete"; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Update state param					
A9	Assignment	6		0	Action Expression: '//PRESS_CTRL_FERM/START.CV' := True;
Description: Start pessure regulation					

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S14

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A1	Assignment	6	0	0	Action Expression: '//FT-MIXER/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//FT-MIXER/PV_D' = 1 Confirm Timeout Expression: 0.000000
Description: Start Mixer					
A2	Assignment	6	0	0	Action Expression: 'SEQUENCE_STATUS' := "Fermenting"; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Update state param					

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S15

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A1	Assignment	6	0	0	Action Expression: '//FT-MIXER/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//FT-MIXER/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Stop mixer					

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S16

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A1	Assignment	6	0	0	Action Expression: 'SEQUENCE_RUNNING' := "Running SFC completed"; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Sequences done					
A2	Assignment	6		0	Action Expression: 'SEQUENCE_STATUS' := "Click fermenting done when finished";
Description: Update state param					
A3	Assignment	6	0	0	Action Expression: '//FT-MIXER/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//FT-MIXER/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Stop mixer					

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S2

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A1	Assignment	6	0	0	Action Expression: '//XV-01_DRAIN_MT/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-01_DRAIN_MT/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-01					
A2	Assignment	6	0	0	Action Expression: '//XV-02_DRAIN_LT/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-02_DRAIN_LT/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-02					
A3	Assignment	6	0	0	Action Expression: '//XV-03_DRAIN/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-03_DRAIN/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-03					

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S2

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A3	Assignment	6	0	0	Action Expression: '//XV-03_DRAIN/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-03_DRAIN/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-03					
A4	Assignment	6	0	0	Action Expression: '//XV-04_MT_FILL/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-04_MT_FILL/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-04					
A5	Assignment	6	0	0	Action Expression: '//XV-05_CIP_MAIN/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-05_CIP_MAIN/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-05					
A6	Assignment	6	0	0	Action Expression: '//XV-10_DRAIN_WP/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-10_DRAIN_WP/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-10					
A7	Assignment	6	0	0	Action Expression: '//XV-17_VALVE/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-17_VALVE/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-17					
A8	Assignment	6	0	0	Action Expression: '//XV-18/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-18/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-18					
A9	Assignment	6	0	0	Action Expression: '//XV-19/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-19/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-19					
A10	Assignment	6	0	0	Action Expression: '//XV-20/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-20/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-20					
A11	Assignment	6	0	0	Action Expression: '//XV-23/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-23/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-23					
A12	Assignment	6	0	0	Action Expression: '//XV-24/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-24/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-24					
A13	Assignment	6	0	0	Action Expression:

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S2

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A13	Assignment	6	0	0	Action Expression: '//XV-25/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-25/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-25					
A14	Assignment	6	0	0	Action Expression: 'SEQUENCE_STATUS' := "Preparing for boiling"; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Update state param					

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S3

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A1	Assignment	6	0	0	Action Expression: '//XV-06_CIP_WP/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//XV-06_CIP_WP/PV_D' = 1 Confirm Timeout Expression: 0.000000
Description: Open XV-06					
A2	Assignment	6	0	0	Action Expression: '//XV-11_CIP_MT/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//XV-11_CIP_MT/PV_D' = 1 Confirm Timeout Expression: 0.000000
Description: Open XV-11					

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S4

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A1	Assignment	6	0	0	Action Expression: '//TIC_KETTLE/START.CV' := True; Delay Expression: 0.000000 Confirm Expression: '//TIC_KETTLE/RUNNING' = True Confirm Timeout Expression: 0.000000
Description: Start temp ctrl in T-4					
A2	Assignment	6		0	Action Expression: '//TIC_KETTLE/SP' := 100;
Description: Set point = 100					
A3	Assignment	6	0	0	Action Expression: 'SEQUENCE_STATUS' := "Heating process fluid"; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Update state param					

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S5

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A1	Assignment	6	0	0	Action Expression: '//XV-20/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//XV-20/PV_D' = 1 Confirm Timeout Expression: 0.000000
Description: Open XV-20					
A2	Assignment	6	0	0	Action Expression: '//XV-21/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//XV-21/PV_D' = 1 Confirm Timeout Expression: 0.000000

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S5

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A2	Assignment	6	0	0	Action Expression: '//XV-21/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//XV-21/PV_D' = 1 Confirm Timeout Expression: 0.000000

Description: Open XV-21

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S6

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A1	Assignment	6	0	0	Action Expression: '//PROCESS_PUMP/DC1/SP_D.CV' := 1; Delay Expression: 0.000000 Confirm Expression: '//PROCESS_PUMP/PV_D' = 1 Confirm Timeout Expression: 0.000000

Description: Start P-001

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A2	Assignment	6	0	0	Action Expression: 'SEQUENCE_STATUS' := "Whirlpool is active"; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000

Description: Update state param

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S7

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A1	Assignment	6	0	0	Action Expression: '//PROCESS_PUMP/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//PROCESS_PUMP/PV_D' = 0 Confirm Timeout Expression: 0.000000

Description: Stop P-001

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A2	Assignment	6	0	0	Action Expression: '//XV-20/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-20/PV_D' = 0 Confirm Timeout Expression: 0.000000

Description: Close XV-20

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A3	Assignment	6	0	0	Action Expression: '//XV-21/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-21/PV_D' = 0 Confirm Timeout Expression: 0.000000

Description: Close XV-21

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A4	Assignment	6	0	0	Action Expression: '//TIC_KETTLE/START.CV' := False; Delay Expression: 0.000000 Confirm Expression: '//TIC_KETTLE/RUNNING' = False Confirm Timeout Expression: 0.000000

Description: Stop temp ctrl in T-4

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A5	Assignment	6	0	0	Action Expression: '//TIC_KETTLE/SP' := 0; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000

Description: Set point = 0

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S8

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A1	Assignment	6	0	0	Action Expression: '//XV-01_DRAIN_MT/DC1/MODE.CST' := CAS; '//XV-02_DRAIN_LT/DC1/MODE.CST' := CAS;

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S8

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A1	Assignment	6	0	0	Action Expression: '//XV-01_DRAIN_MT/DC1/MODE.CST' := CAS; '//XV-02_DRAIN_LT/DC1/MODE.CST' := CAS; '//XV-03_DRAIN/DC1/MODE.CST' := CAS; '//XV-04_MT_FILL/DC1/MODE.CST' := CAS; '//XV-05_CIP_MAIN/DC1/MODE.CST' := CAS; '//XV-07_CIP_FT/DC1/MODE.CST' := CAS; '//XV-09_COOL_FT/DC1/MODE.CST' := CAS; '//XV-10_DRAIN_WP/DC1/MODE.CST' := CAS; '//XV-13_VENT_FT/DC1/MODE.CST' := CAS; '//XV-14_COOL_BT/DC1/MODE.CST' := CAS; '//XV-15_COOL_H_EXC/DC1/MODE.CST' := CAS; '//XV-16_DRAIN_FT/DC1/MODE.CST' := CAS; '//XV-17_VALVE/DC1/MODE.CST' := CAS; '//XV-18/DC1/MODE.CST' := CAS; '//XV-19/DC1/MODE.CST' := CAS; '//XV-20/DC1/MODE.CST' := CAS; '//XV-21/DC1/MODE.CST' := CAS; '//XV-22/DC1/MODE.CST' := CAS; '//XV-23/DC1/MODE.CST' := CAS; '//XV-24/DC1/MODE.CST' := CAS; '//XV-25/DC1/MODE.CST' := CAS; '//XV-26/DC1/MODE.CST' := CAS; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Valves to CAS					
A2	Assignment	6	0	0	Action Expression: '//PROCESS_PUMP/DC1/MODE.CST' := CAS; '//COOLING_PUMP/DC1/MODE.CST' := CAS; '//FT-MIXER/DC1/MODE.CST' := CAS; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Misc to CAS					
A3	Assignment	6	0	0	Action Expression: 'SEQUENCE_RUNNING' := "Fermenter sequence active"; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Fermenter sequence running					

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S9

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A1	Assignment	6	0	0	Action Expression: '//XV-01_DRAIN_MT/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-01_DRAIN_MT/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-01					
A2	Assignment	6	0	0	Action Expression: '//XV-02_DRAIN_LT/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-02_DRAIN_LT/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-02					
A3	Assignment	6	0	0	Action Expression: '//XV-03_DRAIN/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-03_DRAIN/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-03					
A4	Assignment	6	0	0	Action Expression: '//XV-04_MT_FILL/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-04_MT_FILL/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-04					
A5	Assignment	6	0	0	Action Expression: '//XV-05_CIP_MAIN/DC1/SP_D.CV' := 0;

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S9

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A5	Assignment	6	0	0	Action Expression: '//XV-05_CIP_MAIN/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-05_CIP_MAIN/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-05					
A6	Assignment	6	0	0	Action Expression: '//XV-07_CIP_FT/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-07_CIP_FT/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-07					
A7	Assignment	6	0	0	Action Expression: '//XV-10_DRAIN_WP/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-10_DRAIN_WP/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-10					
A8	Assignment	6	0	0	Action Expression: '//XV-14_COOL_BT/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-14_COOL_BT/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-14					
A9	Assignment	6	0	0	Action Expression: '//XV-18/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-18/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-18					
A10	Assignment	6	0	0	Action Expression: '//XV-19/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-19/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-19					
A11	Assignment	6	0	0	Action Expression: '//XV-20/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-20/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-20					
A12	Assignment	6	0	0	Action Expression: '//XV-23/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-23/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-23					
A13	Assignment	6	0	0	Action Expression: '//XV-24/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-24/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-24					
A14	Assignment	6	0	0	Action Expression: '//XV-25/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-25/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-25					
A15	Assignment	6	0	0	Action Expression:

Actions for Step BEER_PROCESS_PLM/RUN_LOGIC/S9

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A15	Assignment	6	0	0	Action Expression: '//XV-26/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-26/PV_D' = 0 Confirm Timeout Expression: 0.000000

Description: Close XV-26

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A16	Assignment	6	0	0	Action Expression: 'SEQUENCE_STATUS' := "Preparing for tranfer"; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000

Description: Update state param

Actions for Step BEER_PROCESS_PLM/STOP_LOGIC/S1

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A3	Assignment	6		0	Action Expression: '^/RUN_LOGIC/SEQUENCE_RUNNING.CV' := "Stopping sequence active";
A1	Assignment	6	0	0	Action Expression: '//XV-06_CIP_WP/DC1/MODE.CST' := CAS; '//XV-07_CIP_FT/DC1/MODE.CST' := CAS; '//XV-10_DRAIN_WP/DC1/MODE.CST' := CAS; '//XV-13_VENT_FT/DC1/MODE.CST' := CAS; '//XV-16_DRAIN_FT/DC1/MODE.CST' := CAS; '//XV-19/DC1/MODE.CST' := CAS; '//XV-20/DC1/MODE.CST' := CAS; '//XV-21/DC1/MODE.CST' := CAS; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000

Description: Valves to CAS

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A2	Assignment	6	0	0	Action Expression: '//PROCESS_PUMP/DC1/MODE.CST' := CAS; '//COOLING_PUMP/DC1/MODE.CST' := CAS; '//FT-MIXER/DC1/MODE.CST' := CAS; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000

Description: Misc to CAS

Actions for Step BEER_PROCESS_PLM/STOP_LOGIC/S2

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A7	Assignment	6		0	Action Expression: '^/RUN_LOGIC/SEQUENCE_STATUS.CV' := "Stopping equipment";
A1	Assignment	6	0	0	Action Expression: '//PROCESS_PUMP/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//PROCESS_PUMP/PV_D' = 0 Confirm Timeout Expression: 0.000000

Description: Stop P-001

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A2	Assignment	6	0	0	Action Expression: '//COOLING_SYST/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//COOLING_SYST/PV_D' = 0 Confirm Timeout Expression: 0.000000

Description: Stop P-003

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A3	Assignment	6	0	0	Action Expression: '//FT-MIXER/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//FT-MIXER/PV_D' = 0 Confirm Timeout Expression: 0.000000

Description: Stop mixer

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A4	Assignment	6	0	0	Action Expression: '//TIC_KETTLE/START.CV' := False; Delay Expression: 0.000000 Confirm Expression: '//TIC_KETTLE/RUNNING' = False Confirm Timeout Expression: 0.000000

Actions for Step BEER_PROCESS_PLM/STOP_LOGIC/S2

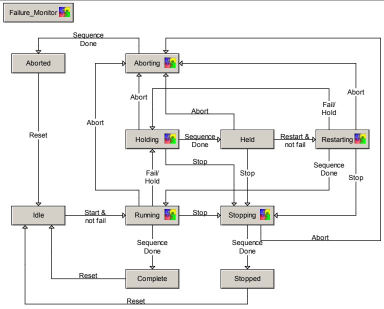
Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A4	Assignment	6	0	0	Action Expression: '//TIC_KETTLE/START.CV' := False; Delay Expression: 0.000000 Confirm Expression: '//TIC_KETTLE/RUNNING' = False Confirm Timeout Expression: 0.000000
Description: Stop temp ctrl kettle					
A5	Assignment	6	0	0	Action Expression: '//TIC_FERMENTER/START.CV' := False; Delay Expression: 0.000000 Confirm Expression: '//COOLING_PUMP/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Stop temp ctrl Fermenter					
A6	Assignment	6	0	0	Action Expression: '//TIC_COOLANT/START' := False; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
Description: Stop Colling system temp controll					

Actions for Step BEER_PROCESS_PLM/STOP_LOGIC/S3

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A9	Assignment	6	0	0	Action Expression: '^/RUN_LOGIC/SEQUENCE_STATUS.CV' := "Closing valves"; Delay Expression: 0.000000 Confirm Timeout Expression: 0.000000
A1	Assignment	6	0	0	Action Expression: '//XV-06_CIP_WP/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-06_CIP_WP/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-06					
A2	Assignment	6	0	0	Action Expression: '//XV-07_CIP_FT/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-07_CIP_FT/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-07					
A3	Assignment	6	0	0	Action Expression: '//XV-10_DRAIN_WP/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-10_DRAIN_WP/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-10					
A4	Assignment	6	0	0	Action Expression: '//XV-13_VENT_FT/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-13_VENT_FT/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-13					
A5	Assignment	6	0	0	Action Expression: '//XV-16_DRAIN_FT/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-16_DRAIN_FT/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-16					
A6	Assignment	6	0	0	Action Expression: '//XV-19/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-19/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-19					
A7	Assignment	6	0	0	Action Expression:

Actions for Step BEER_PROCESS_PLM/STOP_LOGIC/S3

Step Actions:	Action Type:	Qlf	Dly	Dis	Expression:
A7	Assignment	6	0	0	Action Expression: '//XV-20/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-20/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-20					
A8	Assignment	6	0	0	Action Expression: '//XV-21/DC1/SP_D.CV' := 0; Delay Expression: 0.000000 Confirm Expression: '//XV-21/PV_D' = 0 Confirm Timeout Expression: 0.000000
Description: Close XV-20					
A10	Assignment	6		0	Action Expression: '^/RUN_LOGIC/SEQUENCE_RUNNING' := "Stopping complete, reset PLM";



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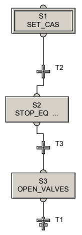
	Module Name:PKF_MAIN/BEER_PROCESS_PLM	



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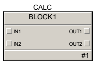

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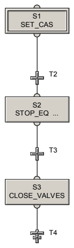
	Module Name:PKF_MAIN/BEER_PROCESS_PLM/FAIL_MONITOR	



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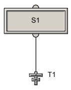
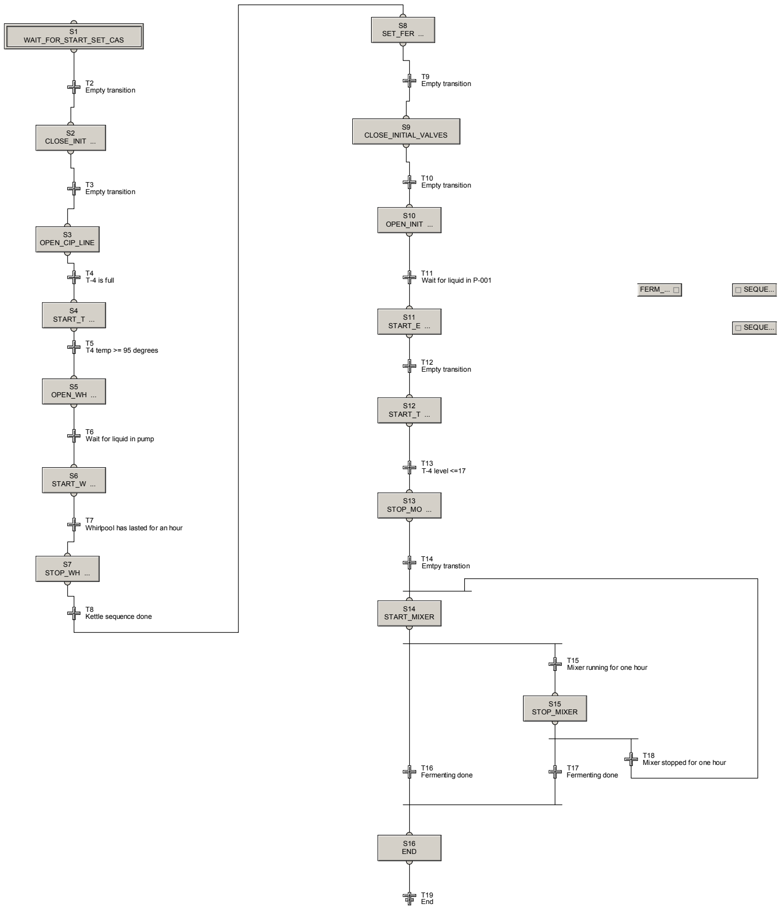
	Module Name:PKF_MAIN/BEER_PROCESS_PLM/HOLD_LOGIC	


S1
T1



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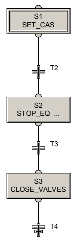
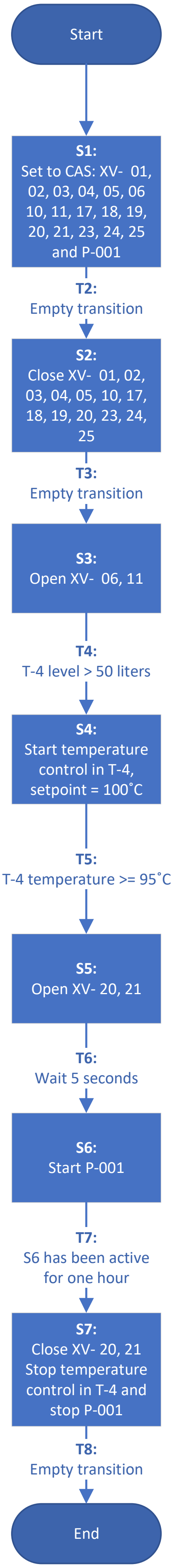
	Module Name:PKF_MAIN/BEER_PROCESS_PLM/RUN_LOGIC	



S1
SET_CAS
T2
S2
STOP_EQ ...
T3
S3
CLOSE_VALVES
T4



Start
S1:
Set to CAS: XV- 01, 02, 03, 04, 05, 06 10, 11, 17, 18, 19, 20, 21, 23, 24, 25 and P-001
T2:
Empty transition
S2:
Close XV- 01, 02, 03, 04, 05, 10, 17, 18, 19, 20, 23, 24, 25
T3:
Empty transition
S3:
Open XV- 06, 11
T4:
T-4 level > 50 liters
S4:
Start temperature control in T-4, setpoint = 100˚C
T5:
T-4 temperature >= 95˚C
S5:
Open XV- 20, 21
T6:
Wait 5 seconds
S6:
Start P-001
T7:
S6 has been active for one hour
S7:
Close XV- 20, 21 Stop temperature control in T-4 and stop P-001
T8:
Empty transition
End

Report:	Control Module
Name:	TIC_KETTLE
Contents:	AND1 CALC1 CALC2 CMP1 CONFIRM DIV1 DO1 DO2 PV ALARM1 DV_HI_ALM DV_LO_ALM HI_ALM HI_HI_ALM LO_ALM LO_LO_ALM PVBAD_ALM

Report:	Control Module
Name:	TIC_KETTLE
Description:	FLC control loop
Path:	PKF_MAIN/TIC_KETTLE
Node Assignment:	NODE1
Execution Period:	100 ms
Algorithm Type:	FBD
Parameter Download Behavior	Preserve critical block values
Primary Graphic Name:	
Detail Graphic Name:	FLC_DT
Faceplate Graphic Name:	FLC_FP
Work In Progress?	No
Restore parameters	Yes
Auto-assign blocks to H1 Port	No
Device Tag:	HE-03_WP
Device Tag:	HE-04_WP
Device Tag:	TT-04

Hierarchy for PKF_MAIN/TIC_KETTLE

TIC_KETTLE

+	AND1	Function Block
+	CALC1	Function Block
+	CALC2	Function Block
+	CMP1	Function Block
+	CONFIRM	Function Block
+	DIV1	Function Block
+	DO1	Function Block
+	DO2	Function Block
+	PV	Function Block

Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	
Parameters for TIC_KETTLE/AND1						
IN_D1	0		I/O	Input	Discrete with status	False
IN_D2	0		I/O	Input	Discrete with status	False
IN_D3	0		I/O	Input	Discrete with status	False
OUT_D	0		Operating	Output	Discrete with status	True
Parameters for TIC_KETTLE/CALC1						
ABNORM_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
ALGO_OPTS			Tuning	Internal	Option bitstring	False
Abort On Read Errors	False					
BAD_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BAD_MASK			Alarm	Internal	Option bitstring	False
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BLOCK_ERR			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
IN1	0		I/O	Input	Floating point with status	False
OUT1	0		Operating	Output	Floating point with status	False
Parameters for TIC_KETTLE/CALC2						
ABNORM_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
ALGO_OPTS			Tuning	Internal	Option bitstring	False

Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	
Parameters for TIC_KETTLE/CALC2						
ALGO_OPTS			Tuning	Internal	Option bitstring	False
Abort On Read Errors	False					
BAD_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BAD_MASK			Alarm	Internal	Option bitstring	False
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BLOCK_ERR			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
IN1	0		I/O	Input	Floating point with status	False
IN2	0		I/O	Input	Floating point with status	False
IN3	0		I/O	Input	Floating point with status	False
IN4	0		I/O	Input	Floating point with status	False
OUT1	0		Operating	Output	Floating point with status	False
Parameters for TIC_KETTLE/CMP1						
COMP_VAL1	0		Operating	Input	Floating point with status	False
COMP_VAL2	0		Misc	Input	Floating point with status	False
DISC_VAL	0		Operating	Input	Floating point with status	False
EQ	0		Operating	Output	Discrete with status	True
GT	0		Operating	Output	Discrete with status	True
IN_RANGE	0		Operating	Output	Discrete with status	True
LT	0		Operating	Output	Discrete with status	True
NEQ	0		Operating	Output	Discrete with status	True
Parameters for TIC_KETTLE/CONFIRM						
IN_D1	0		I/O	Input	Discrete with status	False
IN_D2	0		I/O	Input	Discrete with status	False
OUT_D	0		Operating	Output	Discrete with status	True
Parameters for TIC_KETTLE/DIV1						
IN_1	0		I/O	Input	Floating point with status	False

Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	
Parameters for TIC_KETTLE/DIV1						
IN_2	0		I/O	Input	Floating point with status	False
OUT	0		Operating	Output	Floating point with status	False
Parameters for TIC_KETTLE/DO1						
ABNORM_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BAD_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BAD_MASK			Alarm	Internal	Option bitstring	False
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BKCAL_OUT_D	0		I/O	Output	Discrete with status	True
BLOCK_ERR			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
CAS_IN_D	0		I/O	Input	Discrete with status	False
INSPECT_ACT	0		Alarm	Internal	Alarm	True
IO_OPTS			I/O	Internal	Option bitstring	False
Use PV for BKCAL_OUT	False					
SP-PV Track in LO or IMan	False					
SP-PV Track in Man	True					
Invert	False					
IO_OUT	HE-04_WP/OUT_D		I/O	Internal write only	I/O Reference	False
IO_READBACK			I/O	Internal read only	I/O Reference	False
MODE			Operating	Internal	Mode	False
Normal mode	Cascade					
Target	Cascade					
Actual						
Out Of Service	True					
Manual	True					
Auto	True					
Cascade	True					
Remote Cascade	True					
Remote Output	False					
OUT_D	0		Operating	Output	Discrete with status	False
PV_D	0		Operating	Internal	Discrete with status	True

Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	
Parameters for TIC_KETTLE/DO1						
RCAS_IN_D	0		I/O	Internal	Discrete with status	False
RCAS_OUT_D	0		I/O	Internal	Discrete with status	True
READBACK_D	0		I/O	Internal	Discrete with status	True
SI Field Value	0		Tuning	Internal	Simulate discrete	False
Simulate Value	0					
SP_D	0		Operating	Internal	Discrete with status	False
STDEV	0		Operating	Internal	Floating point	True
STDEV_CAP	0		Misc	Internal	Floating point	True
STDEV_LIMIT	5		Operating	Internal	Floating point	False
STDEV_TIME	0		Operating	Internal	Floating point	False
Parameters for TIC_KETTLE/DO2						
ABNORM_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BAD_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BAD_MASK			Alarm	Internal	Option bitstring	False
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BKCAL_OUT_D	0		I/O	Output	Discrete with status	True
BLOCK_ERR			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
CAS_IN_D	0		I/O	Input	Discrete with status	False
INSPECT_ACT	0		Alarm	Internal	Alarm	True
IO_OPTS			I/O	Internal	Option bitstring	False
Use PV for BKCAL_OUT	False					
SP-PV Track in LO or IMan	False					
SP-PV Track in Man	True					
Invert	False					
IO_OUT	HE-03_WP/OUT_D		I/O	Internal write only	I/O Reference	False
IO_READBACK			I/O	Internal read only	I/O Reference	False
MODE			Operating	Internal	Mode	False
Normal mode	Cascade					
Target	Cascade					
Actual						

Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	
Parameters for TIC_KETTLE/DO2						
MODE			Operating	Internal	Mode	False
Normal mode	Cascade					
Target	Cascade					
Actual						
Out Of Service	True					
Manual	True					
Auto	True					
Cascade	True					
Remote Cascade	True					
Remote Output	False					
OUT_D	0		Operating	Output	Discrete with status	False
PV_D	0		Operating	Internal	Discrete with status	True
RCAS_IN_D	0		I/O	Internal	Discrete with status	False
RCAS_OUT_D	0		I/O	Internal	Discrete with status	True
READBACK_D	0		I/O	Internal	Discrete with status	True
SIField Value	0		Tuning	Internal	Simulate discrete	False
Simulate Value	0					
SP_D	0		Operating	Internal	Discrete with status	False
STDEV	0		Operating	Internal	Floating point	True
STDEV_CAP	0		Misc	Internal	Floating point	True
STDEV_LIMIT	5		Operating	Internal	Floating point	False
STDEV_TIME	0		Operating	Internal	Floating point	False
Parameters for TIC_KETTLE/PV						
ABNORM_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
ALARM_HYS	0.5		Alarm	Internal	Floating point	False
BAD_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BAD_MASK			Alarm	Internal	Option bitstring	False
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BLOCK_ERR			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
FIELD_VAL	0		Operating	Internal	Floating point with status	

Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	
Parameters for TIC_KETTLE/PV						
FIELD_VAL	0		Operating	Internal	Floating point with status	True
HI_ACT	0		Alarm	Internal	Alarm	True
HI_HI_ACT	0		Alarm	Internal	Alarm	True
HI_HI_LIM	100		Alarm	Internal	Floating point	False
HI_LIM	95		Alarm	Internal	Floating point	False
INSPECT_ACT	0		Alarm	Internal	Alarm	True
IO_IN	TT-04/FIELD_VAL_PCT		I/O	Internal read only	I/O Reference	False
IO_OPTS			I/O	Internal	Option bitstring	False
Low cutoff	False					
L_TYPE			Tuning	Internal	Named Set	False
Named Set	$l_typ2					
Named Value	Indirect					
LO_ACT	0		Alarm	Internal	Alarm	True
LO_LIM	0		Alarm	Internal	Floating point	False
LO_LO_ACT	0		Alarm	Internal	Alarm	True
LO_LO_LIM	0		Alarm	Internal	Floating point	False
LOW_CUT	0		Tuning	Internal	Floating point	False
MODE			Operating	Internal	Mode	False
Normal mode	Auto					
Target	Auto					
Actual						
Out Of Service	True					
Manual	True					
Auto	True					
Cascade	False					
Remote Cascade	False					
Remote Output	False					
OUT	0		Operating	Output	Floating point with status	False
OUT_SCALE			I/O	Internal	Scaling	False
High Scale Value	100					
Low Scale Value	0					
Scale Eng. Units	no units					
PV	0		Operating	Internal	Floating point with status	True
PV_FTIME	0		Tuning	Internal	Floating point	False
SIMULATE			Tuning	Internal	Simulate floating point	False
Field Value	0					
Simulate Value	0					
SIMULATE_IN	0		I/O	Input	Floating point with status	False
STATUS_OPTS			Tuning	Internal	Option bitstring	False
Uncertain if Man mode	False					
Bad if Limited	False					
Uncertain if Limited	False					
STDEV	0		Operating	Internal	Floating point	True
STDEV_CAP	0		Misc	Internal	Floating point	True
STDEV_LIMIT	5		Operating	Internal	Floating point	False
STDEV_TIME	0		Operating	Internal	Floating point	False
XD_SCALE			I/O	Internal	Scaling	False
High Scale Value	100					
Low Scale Value	0					
Scale Eng. Units	%					
Parameters for TIC_KETTLE						
ABNORM_ACTIVE	False		Alarm	Internal	Boolean	True
BAD_ACTIVE	False		Alarm	Internal	Boolean	True
BLOCK_ERR			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Device Needs Maintenance Now	False					
Readback Failed	False					
Lost Non-Volatile Data	False					
Lost Static Data	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Needs Maintenance Soon	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Link Configuration Error	False					
Configuration Error	False					
Other Error	False					
EXEC_TIME	0		Misc	Internal	32 bit signed integer	True
I	0.1			Input	Floating point	False
K	1			Input	Floating point	False

Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	
Parameters for TIC_KETTLE						
LEVEL_INPUT	LI-02/AI_ZERO_CORR			Input	External Reference	False
LITRE_PER_10MM	6			Internal read only	Floating point	False
MCOMMAND			Tuning	Internal	Named Set	False
Named Set	$module_states					
Named Value	In Service					
MERROR			Operating	Internal	Option bitstring	True
Algorithm Error	False					
IO Input Error	False					
IO Output Error	False					
Input Transfer Error	False					
Output Transfer Error	False					
Alarm Processing Error	False					
FB Bad Active	False					
MERROR_MASK			Tuning	Internal	Option bitstring	False
Algorithm Error	False					
IO Input Error	False					
IO Output Error	False					
Input Transfer Error	False					
Output Transfer Error	False					
Alarm Processing Error	False					
FB Bad Active	False					
MINIMUM_LEVEL	35			Internal read only	Floating point	False
MSTATE			Operating	Internal	Named Set	True
Named Set	$module_states					
Named Value	In Service					
MSTATUS			Operating	Internal	Option bitstring	True
Component Disabled	False					
Component Error	False					
Out Of Service	False					
Breakpoint Set	False					
Debug View Active	False					
Value Forced	False					
Unresolved Reference	False					
Not Running	False					
FB Abnormal Active	False					
MSTATUS_MASK			Tuning	Internal	Option bitstring	False
Component Disabled	False					
Component Error	False					
Out Of Service	False					
Breakpoint Set	False					
Debug View Active	False					
Value Forced	False					
Unresolved Reference	False					
Not Running	False					
FB Abnormal Active	False					
PREV_ERROR	0			Internal read only	8 bit unsigned integer	False
PREV_OUT	0			Internal read only	8 bit unsigned integer	False
PWM_COUNTER	0			Internal read only	8 bit unsigned integer	False
PWM_FACT_LOWER	False			Internal write only	Boolean	False
RUNNING	0			Output	Floating point	False
SP	50		Control	Input	Floating point	False
START	False			Input	Boolean	False
VERSION	1		Operating	Internal	32 bit unsigned integer	False

Alarms for PKF_MAIN/TIC_KETTLE

Report:	Parameter
Name:	ALARM1
Linked	True
Limit:	0
Priority:	ADVISORY
Enabled:	Yes
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	Any Alarm
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified

Report:	Parameter
Name:	DV_HI_ALM
Linked	True
Limit:	0
Priority:	ADVISORY
Enabled:	No
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	Deviation Alarm
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified

Report:	Parameter
Name:	DV_LO_ALM
Linked	True
Limit:	0
Priority:	ADVISORY
Enabled:	No
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	Deviation Alarm
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified

Report:	Parameter
Name:	HI_ALM
Linked	True
Limit:	0
Priority:	WARNING
Enabled:	No
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	High Alarm
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified

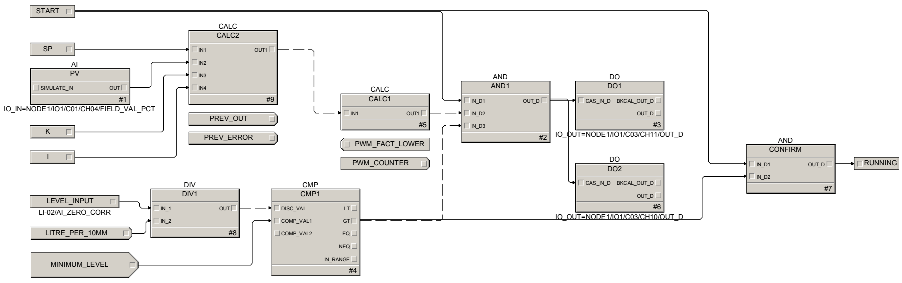
Report:	Parameter
Name:	HI_HI_ALM
Linked	True
Limit:	0
Priority:	CRITICAL
Enabled:	No
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	High High Alarm
P1 Parameter Path:	
P2 Parameter Path:	

Report:	Parameter
Name:	HI_HI_ALM
Linked	True
Limit:	0
Priority:	CRITICAL
Enabled:	No
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	High High Alarm
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified

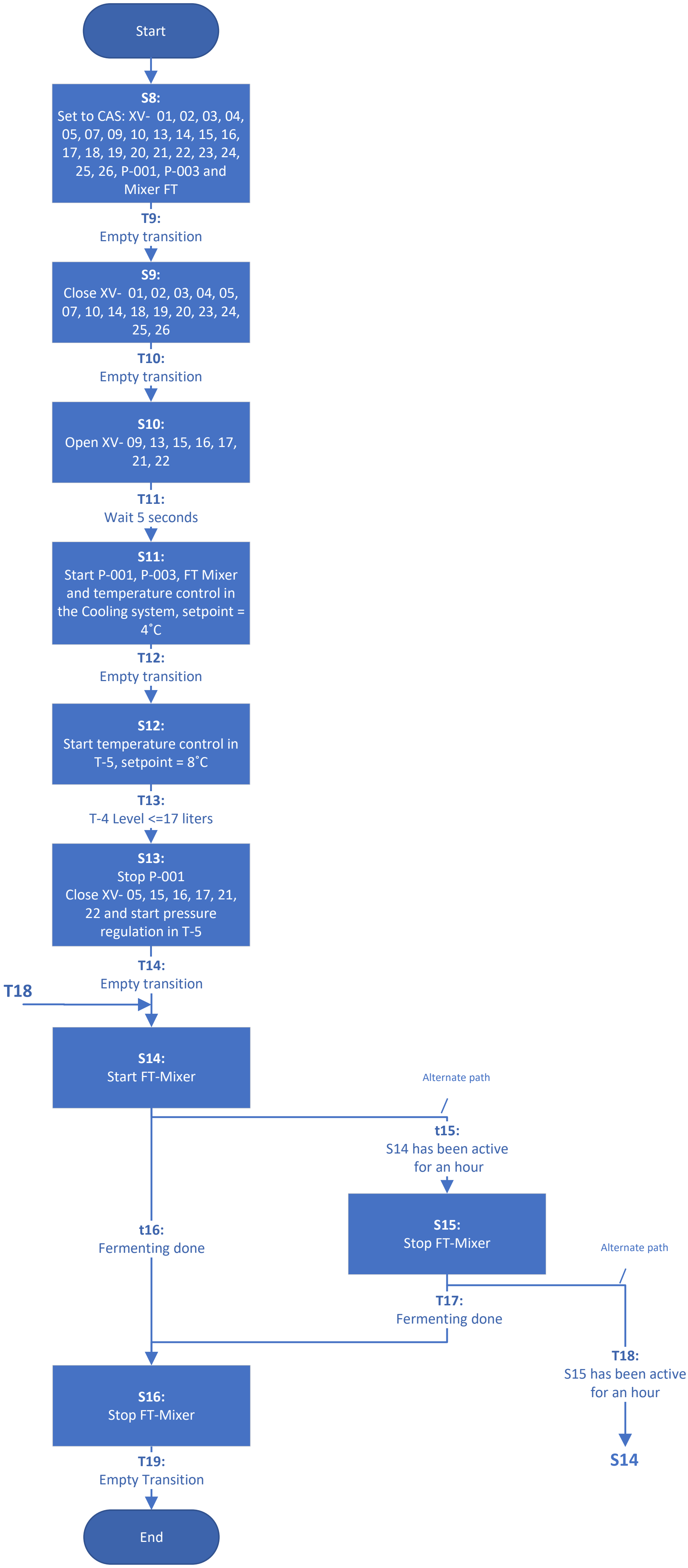
Report:	Parameter
Name:	LO_ALM
Linked	True
Limit:	0
Priority:	WARNING
Enabled:	No
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	Low Alarm
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified

Report:	Parameter
Name:	LO_LO_ALM
Linked	True
Limit:	0
Priority:	CRITICAL
Enabled:	No
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	Low Low Alarm
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified

Report:	Parameter
Name:	PVBAD_ALM
Linked	True
Limit:	0
Priority:	CRITICAL
Enabled:	Yes
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	General I/O Failure
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified



Title:	User Name: ADMINISTRATOR	Date Printed: 5/11/2020 6:17:18 PM
		Page: 1
	Module Name:PKF_MAIN/TIC_KETTLE	


Start
S8:
Set to CAS: XV- 01, 02, 03, 04, 05, 07, 09, 10, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, P-001, P-003 and Mixer FT
T9:
Empty transition
S9:
Close XV- 01, 02, 03, 04, 05, 07, 10, 14, 18, 19, 20, 23, 24, 25, 26
T10:
Empty transition
S10:
Open XV- 09, 13, 15, 16, 17, 21, 22
T11:
Wait 5 seconds
S11:
Start P-001, P-003, FT Mixer and temperature control in the Cooling system, setpoint = 4˚C
T12:
Empty transition
S12:
Start temperature control in T-5, setpoint = 8˚C
T13:
T-4 Level <=17 liters
S13:
Stop P-001
Close XV- 05, 15, 16, 17, 21, 22 and start pressure regulation in T-5
T14:
Empty transition
T18
S14:
Start FT-Mixer
Alternate path
t15:
S14 has been active for an hour
S15:
Stop FT-Mixer
Alternate path
t16:
Fermenting done
T17:
Fermenting done
T18:
S15 has been active for an hour
S14
S16:
Stop FT-Mixer
T19:
Empty Transition
End

Report:	Control Module
Name:	TIC_COOLANT
Contents:	AND1 CALC1 CALC3 PV ALARM1 DV_HI_ALM DV_LO_ALM HI_ALM HI_HI_ALM LO_ALM LO_LO_ALM PVBAD_ALM

Report:	Control Module
Name:	TIC_COOLANT
Description:	FLC control loop
Path:	PKF_MAIN/TIC_COOLANT
Node Assignment:	NODE1
Execution Period:	1 sec
Algorithm Type:	FBD
Parameter Download Behavior	Preserve critical block values
Primary Graphic Name:	
Detail Graphic Name:	FLC_DT
Faceplate Graphic Name:	TIC_CoolantFP
Work In Progress?	No
Restore parameters	No
Auto-assign blocks to H1 Port	No
Device Tag:	TT-01

Hierarchy for PKF_MAIN/TIC_COOLANT

TIC_COOLANT

+	AND1	Function Block
+	CALC1	Function Block
+	CALC3	Function Block
+	PV	Function Block

Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	
Parameters for TIC_COOLANT/AND1						
IN_D1	0		I/O	Input	Discrete with status	False
IN_D2	0		I/O	Input	Discrete with status	False
OUT_D	0		Operating	Output	Discrete with status	True
Parameters for TIC_COOLANT/CALC1						
ABNORM_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
ALGO_OPTS			Tuning	Internal	Option bitstring	False
Abort On Read Errors	False					
BAD_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BAD_MASK			Alarm	Internal	Option bitstring	False
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BLOCK_ERR			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
IN1	0		I/O	Input	Floating point with status	False
Parameters for TIC_COOLANT/CALC3						
ABNORM_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
ALGO_OPTS			Tuning	Internal	Option bitstring	False
Abort On Read Errors	False					
BAD_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					

Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	
Parameters for TIC_COOLANT/CALC3						
BAD_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BAD_MASK			Alarm	Internal	Option bitstring	False
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BLOCK_ERR			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
IN1	0		I/O	Input	Floating point with status	False
IN2	0		I/O	Input	Floating point with status	False
OUT1	0		Operating	Output	Floating point with status	False
Parameters for TIC_COOLANT/PV						
ABNORM_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
ALARM_HYS	0.5		Alarm	Internal	Floating point	False
BAD_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BAD_MASK			Alarm	Internal	Option bitstring	False
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					

Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	
Parameters for TIC_COOLANT/PV						
BAD_MASK			Alarm	Internal	Option bitstring	False
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BLOCK_ERR			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
FIELD_VAL	0		Operating	Internal	Floating point with status	True
HI_ACT	0		Alarm	Internal	Alarm	True
HI_HI_ACT	0		Alarm	Internal	Alarm	True
HI_HI_LIM	100		Alarm	Internal	Floating point	False
HI_LIM	95		Alarm	Internal	Floating point	False
INSPECT_ACT	0		Alarm	Internal	Alarm	True
IO_IN	TT-01/FIELD_VAL_PCT		I/O	Internal read only	I/O Reference	False
IO_OPTS			I/O	Internal	Option bitstring	False
Low cutoff	False					
L_TYPE			Tuning	Internal	Named Set	False
Named Set	$l_typ2					
Named Value	Indirect					
LO_ACT	0		Alarm	Internal	Alarm	True
LO_LIM	0		Alarm	Internal	Floating point	False
LO_LO_ACT	0		Alarm	Internal	Alarm	True
LO_LO_LIM	0		Alarm	Internal	Floating point	False
LOW_CUT	0		Tuning	Internal	Floating point	False
MODE			Operating	Internal	Mode	False
Normal mode	Auto					
Target	Auto					
Actual						
Out Of Service	True					
Manual	True					
Auto	True					
Cascade	False					
Remote Cascade	False					
Remote Output	False					
OUT	0		Operating	Output	Floating point with status	False
OUT_SCALE			I/O	Internal	Scaling	False
High Scale Value	100					
Low Scale Value	0					
Scale Eng. Units	no units					
PV	0		Operating	Internal	Floating point with status	True
PV_FTIME	0		Tuning	Internal	Floating point	False
SIMULATE			Tuning	Internal	Simulate floating point	False
Field Value	0					
Simulate Value	0					
SIMULATE_IN	0		I/O	Input	Floating point with status	False
STATUS_OPTS			Tuning	Internal	Option bitstring	False
Uncertain if Man mode	False					
Bad if Limited	False					
Uncertain if Limited	False					
STDEV	0		Operating	Internal	Floating point	True
STDEV_CAP	0		Misc	Internal	Floating point	True
STDEV_LIMIT	5		Operating	Internal	Floating point	False
STDEV_TIME	0		Operating	Internal	Floating point	False
XD_SCALE			I/O	Internal	Scaling	False
High Scale Value	100					
Low Scale Value	0					
Scale Eng. Units	%					
ABNORM_ACTIVE	False		Alarm	Internal	Boolean	True
BAD_ACTIVE	False		Alarm	Internal	Boolean	True

Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	
Parameters for TIC_COOLANT						
BLOCK_ERR			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Device Needs Maintenance Now	False					
Readback Failed	False					
Lost Non-Volatile Data	False					
Lost Static Data	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Needs Maintenance Soon	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Link Configuration Error	False					
Configuration Error	False					
Other Error	False					
EXEC_TIME	0		Misc	Internal	32 bit signed integer	True
MCOMMAND			Tuning	Internal	Named Set	False
Named Set	$module_states					
Named Value	In Service					
MERROR			Operating	Internal	Option bitstring	True
Algorithm Error	False					
IO Input Error	False					
IO Output Error	False					
Input Transfer Error	False					
Output Transfer Error	False					
Alarm Processing Error	False					
FB Bad Active	False					
MERROR_MASK			Tuning	Internal	Option bitstring	False
Algorithm Error	False					
IO Input Error	False					
IO Output Error	False					
Input Transfer Error	False					
Output Transfer Error	False					
Alarm Processing Error	False					
FB Bad Active	False					
MSTATE			Operating	Internal	Named Set	True
Named Set	$module_states					
Named Value	In Service					
MSTATUS			Operating	Internal	Option bitstring	True
Component Disabled	False					
Component Error	False					
Out Of Service	False					
Breakpoint Set	False					
Debug View Active	False					
Value Forced	False					
Unresolved Reference	False					
Not Running	False					
FB Abnormal Active	False					
MSTATUS_MASK			Tuning	Internal	Option bitstring	False
Component Disabled	False					
Component Error	False					
Out Of Service	False					
Breakpoint Set	False					
Debug View Active	False					
Value Forced	False					
Unresolved Reference	False					
Not Running	False					
FB Abnormal Active	False					
ON_OFF_STATE	0			Internal write only	Floating point	False
SP	0		Control	Input	Floating point	False
START	True			Internal read only	Boolean	False
VERSION	1		Operating	Internal	32 bit unsigned integer	False

Alarms for PKF_MAIN/TIC_COOLANT

Report:	Parameter
Name:	ALARM1
Linked	True
Limit:	0
Priority:	ADVISORY
Enabled:	Yes
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	Any Alarm
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified

Report:	Parameter
Name:	DV_HI_ALM
Linked	True
Limit:	0
Priority:	ADVISORY
Enabled:	No
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	Deviation Alarm
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified

Report:	Parameter
Name:	DV_LO_ALM
Linked	True
Limit:	0
Priority:	ADVISORY
Enabled:	No
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	Deviation Alarm
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified

Report:	Parameter
Name:	HI_ALM
Linked	True
Limit:	0
Priority:	WARNING
Enabled:	No
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	High Alarm
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified

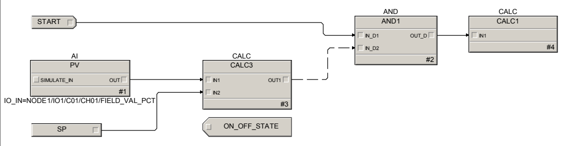
Report:	Parameter
Name:	HI_HI_ALM
Linked	True
Limit:	0
Priority:	CRITICAL
Enabled:	No
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	High High Alarm
P1 Parameter Path:	
P2 Parameter Path:	

Report:	Parameter
Name:	HI_HI_ALM
Linked	True
Limit:	0
Priority:	CRITICAL
Enabled:	No
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	High High Alarm
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified

Report:	Parameter
Name:	LO_ALM
Linked	True
Limit:	0
Priority:	WARNING
Enabled:	No
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	Low Alarm
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified

Report:	Parameter
Name:	LO_LO_ALM
Linked	True
Limit:	0
Priority:	CRITICAL
Enabled:	No
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	Low Low Alarm
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified

Report:	Parameter
Name:	PVBAD_ALM
Linked	True
Limit:	0
Priority:	CRITICAL
Enabled:	Yes
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	General I/O Failure
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified



Title:

User Name: ADMINISTRATOR

Date Printed: 5/11/2020 6:11:01 PM

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Module Name:PKF_MAIN/TIC_COOLANT

Report:	Control Module
Name:	TIC_FERMENTER
Contents:	AND1
	CALC1
	CALC3
	PV
	ALARM1
	DV_HI_ALM
	DV_LO_ALM
	HI_ALM
	HI_HI_ALM
	LO_ALM
	LO_LO_ALM
	PVBAD_ALM

Report:	Control Module
Name:	TIC_FERMENTER
Description:	FLC control loop
Path:	PKF_MAIN/TIC_FERMENTER
Node Assignment:	NODE1
Execution Period:	1 sec
Algorithm Type:	FBD
Parameter Download Behavior	Preserve critical block values
Primary Graphic Name:	
Detail Graphic Name:	FLC_DT
Faceplate Graphic Name:	FLC_FP
Work In Progress?	No
Restore parameters	No
Auto-assign blocks to H1 Port	No
Device Tag:	TT-03

Hierarchy for PKF_MAIN/TIC_FERMENTER

TIC_FERMENTER

+ Block	AND1	Function
+ Block	CALC1	Function
+ Block	CALC3	Function
+ Block	PV	Function

Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	
Parameters for TIC_FERMENTER/AND1						
IN_D1	0		I/O	Input	Discrete with status	False
IN_D2	0		I/O	Input	Discrete with status	False
OUT_D	0		Operating	Output	Discrete with status	True
Parameters for TIC_FERMENTER/CALC1						
ABNORM_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
ALGO_OPTS			Tuning	Internal	Option bitstring	False
Abort On Read Errors	False					
BAD_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BAD_MASK			Alarm	Internal	Option bitstring	False
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BLOCK_ERR			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
IN1	0		I/O	Input	Floating point with status	False
Parameters for TIC_FERMENTER/CALC3						
ABNORM_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
ALGO_OPTS			Tuning	Internal	Option bitstring	False
Abort On Read Errors	False					
BAD_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					

Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	
<u>Parameters for TIC_FERMENTER/CALC3</u>						
BAD_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BAD_MASK			Alarm	Internal	Option bitstring	False
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BLOCK_ERR			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
IN1	0		I/O	Input	Floating point with status	False
IN2	0		I/O	Input	Floating point with status	False
OUT1	0		Operating	Output	Floating point with status	False
<u>Parameters for TIC_FERMENTER/PV</u>						
ABNORM_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
ALARM_HYS	0.5		Alarm	Internal	Floating point	False
BAD_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BAD_MASK			Alarm	Internal	Option bitstring	False
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					

Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	
Parameters for TIC_FERMENTER/PV						
BAD_MASK			Alarm	Internal	Option bitstring	False
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BLOCK_ERR			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
FIELD_VAL	0		Operating	Internal	Floating point with status	True
HI_ACT	0		Alarm	Internal	Alarm	True
HI_HI_ACT	0		Alarm	Internal	Alarm	True
HI_HI_LIM	100		Alarm	Internal	Floating point	False
HI_LIM	95		Alarm	Internal	Floating point	False
INSPECT_ACT	0		Alarm	Internal	Alarm	True
IO_IN	TT-03/FIELD_VAL_PCT		I/O	Internal read only	I/O Reference	False
IO_OPTS			I/O	Internal	Option bitstring	False
Low cutoff	False					
L_TYPE			Tuning	Internal	Named Set	False
Named Set	$l_typ2					
Named Value	Indirect					
LO_ACT	0		Alarm	Internal	Alarm	True
LO_LIM	0		Alarm	Internal	Floating point	False
LO_LO_ACT	0		Alarm	Internal	Alarm	True
LO_LO_LIM	0		Alarm	Internal	Floating point	False
LOW_CUT	0		Tuning	Internal	Floating point	False
MODE			Operating	Internal	Mode	False
Normal mode	Auto					
Target	Auto					
Actual						
Out Of Service	True					
Manual	True					
Auto	True					
Cascade	False					
Remote Cascade	False					
Remote Output	False					
OUT	0		Operating	Output	Floating point with status	False
OUT_SCALE			I/O	Internal	Scaling	False
High Scale Value	100					
Low Scale Value	0					
Scale Eng. Units	no units					
PV	0		Operating	Internal	Floating point with status	True
PV_FTIME	0		Tuning	Internal	Floating point	False
SIMULATE			Tuning	Internal	Simulate floating point	False
Field Value	0					
Simulate Value	0					
SIMULATE_IN	0		I/O	Input	Floating point with status	False
STATUS_OPTS			Tuning	Internal	Option bitstring	False
Uncertain if Man mode	False					
Bad if Limited	False					
Uncertain if Limited	False					
STDEV	0		Operating	Internal	Floating point	True
STDEV_CAP	0		Misc	Internal	Floating point	True
STDEV_LIMIT	5		Operating	Internal	Floating point	False
STDEV_TIME	0		Operating	Internal	Floating point	False
XD_SCALE			I/O	Internal	Scaling	False
High Scale Value	100					
Low Scale Value	0					
Scale Eng. Units	%					
ABNORM_ACTIVE	False		Alarm	Internal	Boolean	True
BAD_ACTIVE	False		Alarm	Internal	Boolean	True

Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	
<u>Parameters for TIC_FERMENTER</u>						
BLOCK_ERR			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Device Needs Maintenance Now	False					
Readback Failed	False					
Lost Non-Volatile Data	False					
Lost Static Data	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Needs Maintenance Soon	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Link Configuration Error	False					
Configuration Error	False					
Other Error	False					
EXEC_TIME	0		Misc	Internal	32 bit signed integer	True
MCOMMAND			Tuning	Internal	Named Set	False
Named Set	$module_states					
Named Value	In Service					
MERROR			Operating	Internal	Option bitstring	True
Algorithm Error	False					
IO Input Error	False					
IO Output Error	False					
Input Transfer Error	False					
Output Transfer Error	False					
Alarm Processing Error	False					
FB Bad Active	False					
MERROR_MASK			Tuning	Internal	Option bitstring	False
Algorithm Error	False					
IO Input Error	False					
IO Output Error	False					
Input Transfer Error	False					
Output Transfer Error	False					
Alarm Processing Error	False					
FB Bad Active	False					
MSTATE			Operating	Internal	Named Set	True
Named Set	$module_states					
Named Value	In Service					
MSTATUS			Operating	Internal	Option bitstring	True
Component Disabled	False					
Component Error	False					
Out Of Service	False					
Breakpoint Set	False					
Debug View Active	False					
Value Forced	False					
Unresolved Reference	False					
Not Running	False					
FB Abnormal Active	False					
MSTATUS_MASK			Tuning	Internal	Option bitstring	False
Component Disabled	False					
Component Error	False					
Out Of Service	False					
Breakpoint Set	False					
Debug View Active	False					
Value Forced	False					
Unresolved Reference	False					
Not Running	False					
FB Abnormal Active	False					
ON_OFF_STATE	0			Internal write only	Floating point	False
SP	18		Control	Input	Floating point	False
START	False			Internal read only	Boolean	False
VERSION	1		Operating	Internal	32 bit unsigned integer	False

Alarms for PKF_MAIN/TIC_FERMENTER

Report:	Parameter
Name:	ALARM1
Linked	True
Limit:	0
Priority:	ADVISORY
Enabled:	Yes
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	Any Alarm
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified

Report:	Parameter
Name:	DV_HI_ALM
Linked	True
Limit:	0
Priority:	ADVISORY
Enabled:	No
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	Deviation Alarm
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified

Report:	Parameter
Name:	DV_LO_ALM
Linked	True
Limit:	0
Priority:	ADVISORY
Enabled:	No
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	Deviation Alarm
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified

Report:	Parameter
Name:	HI_ALM
Linked	True
Limit:	0
Priority:	WARNING
Enabled:	No
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	High Alarm
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified

Report:	Parameter
Name:	HI_HI_ALM
Linked	True
Limit:	0
Priority:	CRITICAL
Enabled:	No
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	High High Alarm
P1 Parameter Path:	
P2 Parameter Path:	

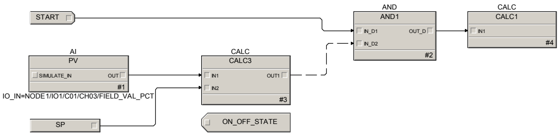
Alarms for PKF_MAIN/TIC_FERMENTER

Report:	Parameter
Name:	HI_HI_ALM
Linked	True
Limit:	0
Priority:	CRITICAL
Enabled:	No
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	High High Alarm
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified

Report:	Parameter
Name:	LO_ALM
Linked	True
Limit:	0
Priority:	WARNING
Enabled:	No
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	Low Alarm
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified

Report:	Parameter
Name:	LO_LO_ALM
Linked	True
Limit:	0
Priority:	CRITICAL
Enabled:	No
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	Low Low Alarm
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified

Report:	Parameter
Name:	PVBAD_ALM
Linked	True
Limit:	0
Priority:	CRITICAL
Enabled:	Yes
Inverted:	No
Parameter Path:	
Limit Path:	
Alarm Type:	General I/O Failure
P1 Parameter Path:	
P2 Parameter Path:	
Alarm Suppression Timeout	999 Days 0 Hours 0 Minutes
Functional Classification	Not classified



Title:	User Name: ADMINISTRATOR	Date Printed: 5/11/2020 6:15:47 PM
		Page: 1
	Module Name:PKF_MAIN/TIC_FERMENTER	

Report:	Control Module
Name:	PRESS_CTRL_FERM
Contents:	AND1 DI1 DO1 OR1
Report:	Control Module
Name:	PRESS_CTRL_FERM
Description:	Control Module
Path:	PKF_MAIN/PRESS_CTRL_FERM
Node Assignment:	NODE1
Execution Period:	1 sec
Algorithm Type:	FBD
Parameter Download Behavior	Preserve critical block values
Primary Graphic Name:	
Detail Graphic Name:	
Faceplate Graphic Name:	MOD_FP
Work In Progress?	No
Restore parameters	No
Auto-assign blocks to H1 Port	No
Device Tag:	PI-01
Device Tag:	XV-13

Hierarchy for PKF_MAIN/PRESS_CTRL_FERM

PRESS_CTRL_FERM		
+	AND1	Function Block
+	DI1	Function Block
+	DO1	Function Block
+	OR1	Function Block

Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	

Parameters for PRESS_CTRL_FERM/AND1

Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	
IN_D1	0		I/O	Input	Discrete with status	False
IN_D2	0		I/O	Input	Discrete with status	False
OUT_D	0		Operating	Output	Discrete with status	True

Parameters for PRESS_CTRL_FERM/DI1

Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	
ABNORM_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BAD_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BAD_MASK			Alarm	Internal	Option bitstring	False
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BLOCK_ERR			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
DISC_ACT	0		Alarm	Internal	Alarm	True
DISC_LIM	255		Alarm	Internal	8 bit unsigned integer	False
FIELD_VAL_D	0		Operating	Internal	Discrete with status	True
INSPECT_ACT	0		Alarm	Internal	Alarm	True
IO_IN	PI-01/FIELD_VAL_D		I/O	Internal read only	I/O Reference	False
IO_OPTS			I/O	Internal	Option bitstring	False
Invert	False					
MODE			Operating	Internal	Mode	False
Normal mode	Auto					
Target	Auto					
Actual						
Out Of Service	True					
Manual	True					
Auto	True					
Cascade	False					
Remote Cascade	False					
Remote Output	False					
OUT_D	0		Operating	Output	Discrete with status	False
PV_D	0		Operating	Internal	Discrete with status	True
PV_FTIME	0		Tuning	Internal	Floating point	False

Parameters for PRESS_CTRL_FERM/DI1

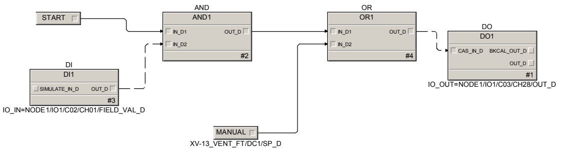
Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	
SIField Value	0		Tuning	Internal	Simulate discrete	False
Simulate Value	0					
SIMULATE_IN_D	0		I/O	Input	Discrete with status	False
STATUS_OPTS			Tuning	Internal	Option bitstring	False
Uncertain if Man mode	False					
STDEV	0		Operating	Internal	Floating point	True
STDEV_CAP	0		Misc	Internal	Floating point	True
STDEV_LIMIT	5		Operating	Internal	Floating point	False
STDEV_TIME	0		Operating	Internal	Floating point	False

Parameters for PRESS_CTRL_FERM/DO1

Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	
ABNORM_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BAD_ACTIVE			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BAD_MASK			Alarm	Internal	Option bitstring	False
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
BKCAL_OUT_D	0		I/O	Output	Discrete with status	True
BLOCK_ERR			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Readback Failed	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Configuration Error	False					
Other Error	False					
CAS_IN_D	0		I/O	Input	Discrete with status	False
INSPECT_ACT	0		Alarm	Internal	Alarm	True
IO_OPTS			I/O	Internal	Option bitstring	False
Use PV for BKCAL_OUT	False					
SP-PV Track in LO or IMan	False					
SP-PV Track in Man	True					
Invert	False					
IO_OUT	XV-13/OUT_D		I/O	Internal write only	I/O Reference	False
IO_READBACK			I/O	Internal read only	I/O Reference	False
MODE			Operating	Internal	Mode	False
Normal mode	Cascade					
Target	Cascade					
Actual						
Out Of Service	True					
Manual	True					
Auto	True					
Cascade	True					

Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	
Parameters for PRESS_CTRL_FERM/DO1						
MODE			Operating	Internal	Mode	False
Normal mode	Cascade					
Target	Cascade					
Actual						
Out Of Service	True					
Manual	True					
Auto	True					
Cascade	True					
Remote Cascade	True					
Remote Output	False					
OUT_D	0		Operating	Output	Discrete with status	False
PV_D	0		Operating	Internal	Discrete with status	True
RCAS_IN_D	0		I/O	Internal	Discrete with status	False
RCAS_OUT_D	0		I/O	Internal	Discrete with status	True
READBACK_D	0		I/O	Internal	Discrete with status	True
SIField Value	0		Tuning	Internal	Simulate discrete	False
Simulate Value	0					
SP_D	0		Operating	Internal	Discrete with status	False
STDEV	0		Operating	Internal	Floating point	True
STDEV_CAP	0		Misc	Internal	Floating point	True
STDEV_LIMIT	5		Operating	Internal	Floating point	False
STDEV_TIME	0		Operating	Internal	Floating point	False
Parameters for PRESS_CTRL_FERM/OR1						
IN_D1	0		I/O	Input	Discrete with status	False
IN_D2	0		I/O	Input	Discrete with status	False
OUT_D	0		Operating	Output	Discrete with status	True
Parameters for PRESS_CTRL_FERM						
ABNORM_ACTIVE	False		Alarm	Internal	Boolean	True
BAD_ACTIVE	False		Alarm	Internal	Boolean	True
BLOCK_ERR			Alarm	Internal	Option bitstring	True
Out Of Service	False					
Power Up	False					
Device Needs Maintenance Now	False					
Readback Failed	False					
Lost Non-Volatile Data	False					
Lost Static Data	False					
Memory Failure	False					
Output Failure	False					
Input Failure/Bad PV	False					
Device Needs Maintenance Soon	False					
Device Fault State Set	False					
Local Override	False					
Simulate Active	False					
Link Configuration Error	False					
Configuration Error	False					
Other Error	False					
EXEC_TIME	0		Misc	Internal	32 bit signed integer	True
MANUAL	XV-13_VENT_FT/DC1/SP_D		Control	Input	External Reference	False
MCOMMAND			Tuning	Internal	Named Set	False
Named Set	$module_states					
Named Value	In Service					
MERROR			Operating	Internal	Option bitstring	True
Algorithm Error	False					
IO Input Error	False					
IO Output Error	False					
Input Transfer Error	False					
Output Transfer Error	False					
Alarm Processing Error	False					
FB Bad Active	False					
MERROR_MASK			Tuning	Internal	Option bitstring	False
Algorithm Error	False					
IO Input Error	False					
IO Output Error	False					
Input Transfer Error	False					
Output Transfer Error	False					
Alarm Processing Error	False					

Parameter Name:	Parameter Value:	Linked:	Parameter Category:	Connection Type:	Parameter Type:	
Parameters for PRESS_CTRL_FERM						
MERROR_MASK			Tuning	Internal	Option bitstring	False
Algorithm Error	False					
IO Input Error	False					
IO Output Error	False					
Input Transfer Error	False					
Output Transfer Error	False					
Alarm Processing Error	False					
FB Bad Active	False					
MSTATE			Operating	Internal	Named Set	True
Named Set	$module_states					
Named Value	In Service					
MSTATUS			Operating	Internal	Option bitstring	True
Component Disabled	False					
Component Error	False					
Out Of Service	False					
Breakpoint Set	False					
Debug View Active	False					
Value Forced	False					
Unresolved Reference	False					
Not Running	False					
FB Abnormal Active	False					
MSTATUS_MASK			Tuning	Internal	Option bitstring	False
Component Disabled	False					
Component Error	False					
Out Of Service	False					
Breakpoint Set	False					
Debug View Active	False					
Value Forced	False					
Unresolved Reference	False					
Not Running	False					
FB Abnormal Active	False					
START	False		Control	Input	Boolean	False
VERSION	1		Operating	Internal	32 bit unsigned integer	False



Title:	User Name: ADMINISTRATOR	Date Printed: 5/11/2020 6:19:09 PM	
			Page: 1
	Module Name:PKF_MAIN/PRESS_CTRL_FERM		

Test case: Equipment		**Test case 1**	**Date:** 07.02.20	**Tested by:** Audun Theie
Test nr:	**Test:**	**Status:**	**Description**	**Additional information**
1	Valves working as intended?	Not ok	Testing opening and closing of valves	XV-08, XV-13, XV-15 and XV-24 Faulty
2	Pumps working as intended?	Ok	Testing the activation of pumps	Worked as intended
3	Mixers working as intended?	Ok	Testing the activation of stirrers	Worked as intended
4	Sensors working as intended?	Ok	Tested the accuracy of the sensors	Worked as intended
5	Pipelines ok?	Ok	Check for leaks	No leaks
6	Heatingelements working as intended?	Ok	Tested the activation of heating elements	Worked as intended
7	Coolingsystem working as intended?	Ok	Tested the activation of the cooling system	Worked as intended
8	Compressor working as intended?	Ok	Tested the activation of the compressor	Worked as intended

Test case: Transport of process medium **Test case 2** **Date:** 04.03.20 **Tested by:** Adrian A. Bergflødt

Test nr:	Test:	Status:	Description	Additional information
1	Tapwater to Hotwater tank ok?	Ok	Testing transfer of liquid from tap to hot water	Worked as intended
2	Hotwater tank to Mash tun ok?	Ok	Testing transfer of liquid from hot water mash	Worked as intended
3	Mash tun to Lauter tank ok?	Ok	Testing transfer of liquid from mash to lauter	Worked as intended
4	Lauter tank to Kettle ok?	Ok	Testing transfer of liquid from lauter to kettle	Worked as intended
5	Whirlpool in Kettle working as intended?	Ok	Testing the whirlpool on the kettle tank	Worked as intended
6	Kettle to Fermenter tank ok?	Ok	Testing transfer of liquid from kettle to fermenter	Worked as intended
7	Fermenter tank to Bright beer tank ok?	Ok	Testing transfer of liquid from fermenter bright beer	Worked as intended

Test case: Control System and operator control **Test case 3** **Date:** 28.04.20 **Tested by:** Audun Theie

Test nr:	Test:	Status:	Description	Additional information
1	PLM ok?	Ok	Triggering the PLM through HMI/GUI	Worked as intended
1	Activation of Running SFC	Ok	Testing the activation of Running SFC through the HMI	Worked as intended
2	Activation of Holding SFC	Ok	Testing the activation of Holding SFC through the HMI	Worked as intended
3	Activation of Stopping SFC	Ok	Testing the activation of Stopping SFC through the HMI	Worked as intended
4	Activation of Aborting SFC	Ok	Testing the activation of Aborting SFC through the HMI	Worked as intended
5	Status texts recieved from PLM sequence	Ok	Testing text indicators for monitoring process	Worked as intended
6	Temperature control Hotwater Tank ok?	Ok	Testing PWM temperature Controller	Worked as intended
7	Temperature control Mash Tun ok?	Ok	Testing PWM temperature Controller	Worked as intended
8	Temperature control Kettle ok?	Ok	Testing PWM temperature Controlle	Worked as intended
9	Temperature control Fermenting tank ok?	Ok	Testing PWM temperature Controller	Worked as intended
10	Temperature control Bright beer tank ok?	Not tested		
11	Temperature control Coolant tank?	Ok	Testing the on/off temperature Controller	Worked as intended
12	Trends working	Ok	Test trend pictures with varying setpoint values	Worked as intended
13	Pressure control Fermenting tank ok?	Not Ok	Testing the pressure switch control	Incorrect wiring
14	Level indicator Mash tun ok?	Ok	Checking level in tank T2	Worked as intended
15	Level indicator Kettle ok?	Ok	Checking level in tank T4	Worked as intended
16	Test equipment faceplates for control	Not Ok	Test if equipment is controllable in HMI	TIC cooling faceplate didnt work. Replaced picture.