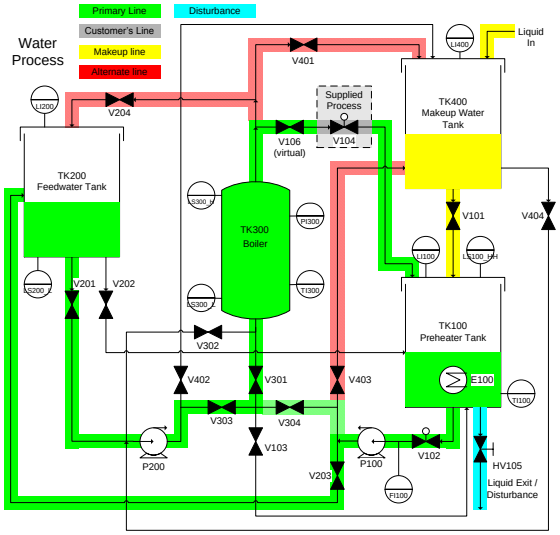

ASlab T14

Automation Description

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Modification history

Date	Description	Author
4.8.2009	Updated P&ID to match Demo2 designations	JUP
24.8.2009	Details checked and document formatted better.	JUP

Abstract

Document describes the required automation functionality for the heat production process described in ASlab_T14-ProcessDescription document. The reference process is influenced by a fictional industrial heat production plant, which is loosely adapted to TKK's water process equipment.

Contents

1 Introduction

This document describes the functionality required from automation implementation of the heat production process defined in ASlab_T14-ProcessDescription. The specification aims to be independent from implementation details and the application should be implementable using alternative target platforms (various DCS and PLC products). Functional descriptions in this document provide the necessary information for detailed application design and implementation using some DCS or PLC tool (e.g. function block coding).

Chapter 2 Instrumentation presents the instrumentation and IO points that the automation system uses to control the process. This is source information for specifying the required functionality in more detail in Chapter 3 Requirements for Control Software.

2 Instrumentation

This chapter lists the instrumentation and IO used to control the process. This includes the measurement and actuation devices, their IO points and related automation devices. Names (reference designations) link instruments and IO points to P&ID symbols. This information is produced based on process design materials (See ASlab_T14-ProcessDescription) and it specifies the interface that the to-be-implemented automation application has to control the process system. Instrumentation design belongs to a more general design area of field design. Field design is again considered a sub activity of automation design.

2.1 Instrument-list

These are the actuator and sensor devices that are required to run the process. They form the technical interface between the process system and the automation system. The list is extracted from the process design materials and their symbols can be seen in the P&ID.

#	TagName	Category	Device Type	Function	IO-type
1	E100	Actuator	Heater	off/on	DO
2	Y101	Actuator	Magnetic valve	closed/open	DO
3	Y103	Actuator	Magnetic valve	closed/open	DO
4	Y201	Actuator	Magnetic valve	closed/open	DO
5	Y202	Actuator	Magnetic valve	closed/open	DO
6	Y203	Actuator	Magnetic valve	closed/open	DO
7	Y204	Actuator	Magnetic valve	closed/open	DO
8	Y301	Actuator	Magnetic valve	closed/open	DO
9	Y302	Actuator	Magnetic valve	closed/open	DO
10	Y303	Actuator	Magnetic valve	closed/open	DO
11	Y304	Actuator	Magnetic valve	closed/open	DO
12	Y401	Actuator	Magnetic valve	closed/open	DO
13	Y402	Actuator	Magnetic valve	closed/open	DO
14	Y403	Actuator	Magnetic valve	closed/open	DO
15	Y404	Actuator	Magnetic valve	closed/open	DO
16	L101	Sensor	Floater switch	wet/dry	DI
17	L201	Sensor	Floater switch	dry/wet	DI
18	L301	Sensor	Capacitive limit switch	dry/wet	DI
19	L300	Sensor	Capacitive limit switch	dry/wet	DI
20	Y501	Actuator	Proportional valve	closed..open	AO
21	M200	Actuator	Pump	stopped..max	AO
22	M100	Actuator	Pump	stopped..max	AO
23	Y102	Actuator	Proportional valve	closed..open	AO
24	F100	Sensor	Flow meter	low..high	AI
25	L200	Sensor	Level sensor	low..high	AI
26	T100	Sensor	Temperature sensor	cold-warm	AI
27	P300	Sensor	Pressure sensor	low..high	AI
28	L400	Sensor	Level sensor	low..high	AI
29	T300	Sensor	Temperature sensor	cold-warm	AI
30	L100	Sensor	Level sensor	low..high	AI

2.2 IO-list

Selection of the required instrument devices during instrumentation design enables to list the exact IOs needed. Depending on the type of the device, a single actuator may require several IO signals; for example, a valve may have one binary output control signal (close/open) and additional signals for its position (1xAI) and limit sensors (2xDI) for indicating closed or open state. This information is also used by electrical and cabling designers.

Following table of process input and output points covers all IO of the devices in the process system. Some of them are not used in the heat production process application and thus they are not wired to any fieldbus module (ModuleSlot column). Most instrument devices have only one related signal.

#	TagName	Device Type	HW Signal	Signal Meaning	Panel Connector	Wire#	FieldbusSlave	IO-Module	ModuleSlot	PDO	VIPA-IO#	IEC type
1	E100	Heater	0/24V	off/on	XMA1-Y	D1-02	VIPA IM253-1CA10	VIPA 222-1BH10, DO 16x24V 1A	0.0	RxPDO1..4	DO_00	bool 0/1
2	Y101	Valve	0/24V	closed/open	XMA1-Y	D1-06	VIPA IM253-1CA10	VIPA 222-1BH10, DO 16x24V 1A	0.1	RxPDO1..4	DO_01	bool 0/1
3	Y103	Valve	0/24V	closed/open	XMA1-Y	D1-07	VIPA IM253-1CA10	VIPA 222-1BH10, DO 16x24V 1A	0.2	RxPDO1..4	DO_02	bool 0/1
4	Y201	Valve	0/24V	closed/open	XMA2-Y	D2-03	VIPA IM253-1CA10	VIPA 222-1BH10, DO 16x24V 1A	0.3	RxPDO1..4	DO_03	bool 0/1
5	Y202	Valve	0/24V	closed/open	XMA2-Y	D2-04	VIPA IM253-1CA10	VIPA 222-1BH10, DO 16x24V 1A	0.4	RxPDO1..4	DO_04	bool 0/1
6	Y203	Valve	0/24V	closed/open	XMA2-Y	D2-05	VIPA IM253-1CA10	VIPA 222-1BH10, DO 16x24V 1A	0.5	RxPDO1..4	DO_05	bool 0/1
7	Y204	Valve	0/24V	closed/open	XMA2-Y	D2-06	VIPA IM253-1CA10	VIPA 222-1BH10, DO 16x24V 1A	0.6	RxPDO1..4	DO_06	bool 0/1
8	Y301	Valve	0/24V	closed/open	XMA2-Y	D2-07	VIPA IM253-1CA10	VIPA 222-1BH10, DO 16x24V 1A	0.7	RxPDO1..4	DO_07	bool 0/1
9	Y302	Valve	0/24V	closed/open	XMA2-Y	D2-08	VIPA IM253-1CA10	VIPA 222-1BH10, DO 16x24V 1A	1.0	RxPDO1..4	DO_08	bool 0/1
10	Y303	Valve	0/24V	closed/open	XMA2-Y	D2-13	VIPA IM253-1CA10	VIPA 222-1BH10, DO 16x24V 1A	1.1	RxPDO1..4	DO_09	bool 0/1
11	Y304	Valve	0/24V	closed/open	XMA2-Y	D2-14	VIPA IM253-1CA10	VIPA 222-1BH10, DO 16x24V 1A	1.2	RxPDO1..4	DO_10	bool 0/1
12	Y401	Valve	0/24V	closed/open	XMA1-Y	D1-08	VIPA IM253-1CA10	VIPA 222-1BH10, DO 16x24V 1A	1.3	RxPDO1..4	DO_11	bool 0/1
13	Y402	Valve	0/24V	closed/open	XMA1-Y	D1-13	VIPA IM253-1CA10	VIPA 222-1BH10, DO 16x24V 1A	1.4	RxPDO1..4	DO_12	bool 0/1
14	Y403	Valve	0/24V	closed/open	XMA1-Y	D1-14	VIPA IM253-1CA10	VIPA 222-1BH10, DO 16x24V 1A	1.5	RxPDO1..4	DO_13	bool 0/1
15	Y404	Valve	0/24V	closed/open	XMA1-Y	D1-15	VIPA IM253-1CA10	VIPA 222-1BH10, DO 16x24V 1A	1.6	RxPDO1..4	DO_14	bool 0/1
16	L101	Overflow switch	0/24V	wet/dry	XMA1-14	D1-16	VIPA IM253-1CA10	VIPA 221-1BF00, DI 8x24V	2	TxPDO1	DI_00	bool 0/1
17	L201	Floater	0/24V	dry/wet	XMA2-12	D2-15	VIPA IM253-1CA10	VIPA 221-1BF00, DI 8x24V	3	TxPDO1	DI_01	bool 0/1
18	L301	Capacitive limit switch	0/24V	dry/wet	XMA2-13	D2-17	VIPA IM253-1CA10	VIPA 221-1BF00, DI 8x24V	4	TxPDO1	DI_02	bool 0/1
19	L300	Capacitive limit switch	0/24V	dry/wet	XMA2-14	D2-16	VIPA IM253-1CA10	VIPA 221-1BF00, DI 8x24V	5	TxPDO1	DI_03	bool 0/1
20	-	-	-	-	-	-	VIPA IM253-1CA10	VIPA 221-1BF00, DI 8x24V	6		DI_04	-
21	-	-	-	-	-	-	VIPA IM253-1CA10	VIPA 221-1BF00, DI 8x24V	7		DI_05	-
22	-	-	-	-	-	-	VIPA IM253-1CA10	VIPA 221-1BF00, DI 8x24V	8		DI_06	-
23	-	-	-	-	-	-	VIPA IM253-1CA10	VIPA 221-1BF00, DI 8x24V	9		DI_07	-
24	F100pulse	Flow meter	0/24V	pulse (rot)	XMA1-Y	D1-17	-	-	-		-	-
25	Y501	Proportional valve	0-10Vdc	closed..open	X1-13	A1-13	VIPA IM253-1CA10	VIPA 232-1BD51	2	RxPDO1..4	AO_00	UINT
26	Y501 activ.	Propo Valve	0/24V	off/on	XMA1-Y	D1-01	-	-	-		-	-
27	M200	Pump	0-10Vdc	stopped..max	X2-2	A2-02	VIPA IM253-1CA10	VIPA 232-1BD51	4	RxPDO1..4	AO_01	UINT
28	M200 activ.	Pump	0/24V	off/on	XMA2-Y	D2-01	VIPA IM253-1CA10	VIPA 222-1BH10, DO 16x24V 1A	1.7	RxPDO1..4	DO_15	bool 0/1
29	M200 bin	Pump	0/24V	off/on	XMA2-Y	D2-02	-	-	-		-	-
30	M100	Pump	0-10Vdc	stopped..max	X1-2	A1-02	VIPA IM253-1CA10	VIPA 232-1BD51	6	RxPDO1..4	AO_02	UINT
31	M100 activ.	Pump	0/24V	off/on	XMA1-Y	D1-03	VIPA IM253-1CA10	VIPA 222-1BH10, DO 16x24V 1A	1.7	RxPDO1..4	DO_15	bool 0/1
32	M100 bin	Pump	0/24V	off/on	XMA1-Y	D1-04	-	-	-		-	-
33	Y102	Proportional valve	0-10Vdc	closed..open	X1-1	A1-01	VIPA IM253-1CA10	VIPA 232-1BD51	8	RxPDO1..4	AO_03	UINT
34	Y102 activ.	Propo Valve	0/24V	off/on	XMA1-Y	D1-05	-	-	-		-	-
35	F100	Flow meter	0-10Vdc	low..high	X1-7	A1-07	VIPA IM253-1CA10	VIPA 231-1BD70, AI 4x12bit +/-10V,	0.M0	TxPDO1..4	AI_00	UINT
36	L200	Level sensor	0-10Vdc	low..high	X2-8	A2-08	VIPA IM253-1CA10	VIPA 231-1BD70, AI 4x12bit +/-10V,	0.M1	TxPDO1..4	AI_01	UINT
37	T100	Temperature sensor	0-10Vdc	cold-warm	X1-14	A1-14	VIPA IM253-1CA10	VIPA 231-1BD70, AI 4x12bit +/-10V,	0.M2	TxPDO1..4	AI_02	UINT
38	P300	Pressure sensor	0-10Vdc	low..high	X2-13	A2-13	VIPA IM253-1CA10	VIPA 231-1BD70, AI 4x12bit +/-10V,	0.M3	TxPDO1..4	AI_03	UINT
39	L400	Level sensor	0-10Vdc	low..high	X1-18	A1-18	VIPA IM253-1CA10	VIPA 231-1BD70, AI 4x12bit +/-10V,	1.M0	TxPDO1..4	AI_04	UINT
40	T300	Temperature sensor	0-10Vdc	cold-warm	X2-14	A2-14	VIPA IM253-1CA10	VIPA 231-1BD70, AI 4x12bit +/-10V,	1.M1	TxPDO1..4	AI_05	UINT
41	L100	Level sensor	0-10Vdc	low..high	X2-7	A2-07	VIPA IM253-1CA10	VIPA 231-1BD70, AI 4x12bit +/-10V,	1.M2	TxPDO1..4	AI_06	UINT
42	-	-	-	-	not connected	-	VIPA IM253-1CA10	VIPA 231-1BD70, AI 4x12bit +/-10V,	1.M3	TxPDO1..4	AI_07	-

The above IO list contains some columns that are related to documenting cabling and fieldbus designs. They are filled in during the course of the field design. Functional specification of the application does not need this information. For the purpose of this document (functional specification) it is sufficient to know the TagNames, meanings and IO types of the signals.

3 Requirements for Control Software

This chapter specifies the required functionality for the software circuits implementing the process functionality. This includes a functional description of basically everything that needs to be implemented by the control system: control loops, interlocks, sequential functions and operator displays. The chapter corresponds to *basic design phase* of a process automation project from the software application's point of view (not fields design etc.) and provides a functional specification for implementing the process control application in the later *application design phase* (actual function block coding and parameterization).

Most of the functional descriptions are structured to automation functions called "control loops", which typically encapsulate a process measurement, control algorithm and actuation functions. Together they specify a control function for some process variable. Interlocks are presented using similar structure, as interlock loops. Sequential functions and operator displays are also specified.

3.1 Automation Functions

Automation functions specify the required control software functionality. Based on the requirements stated in the ASlab_T14-ProcessDescription document, following automation functions have been specified. There are five control loops that keep the process in a desired continuous state and stable. Overview of the loops on a detailed P&ID is in the end of this document. Other specified categories are interlocks, sequences and operator displays.

3.1.1 LIC100, Preheater Tank (B100) Surface Level Control

Measurement

L100 is used as level measurement.

Control

Surface level of the Tank is controlled using a limit controller. Desired level should be maintained within +/-5 mm or less around setpoint.

Actuation

An on/off valve *Makeup Water Valve* (Y101) is used as the controlling device.

User Interface

A display in operating station is needed.

Alarms

Warnings and alarms of surface level (LL, L, H, HH) should be produced.

Interlocks

Overflow of the tank should be prevented by using the level measurement's (L100) HH alarm and, as a backup, a separate overflow switch (L101). Either of the two should close all inlet streams, including the customer line Y305.

Signals from other functions

-

Information to other loops

LL-alarm is used in Preheater Pump's (M100) interlock.

LL-alarm is used in Heater's (E100) interlock.

3.1.2 TIC100, Preheater Tank (B100) Temperature Control

Measurement

T100 is used as temperature measurement.

Control

Temperature of the water in the Preheater Tank (B100) is controlled using a limit controller. Desired level should be maintained within +/-0.5°C around setpoint.

Actuation

A Heater element (E100) is used as the controlling device.

User Interface

A display in operating station is needed.

Alarms

Warnings and alarms of water temperature (LL, L, H, HH) should be produced.

Interlocks

Overheating of the equipment should be prevented by using the temperature's (T100) HH alarm. The HH alarm should turn off the heater.

Dry operation of the Heater should be prevented. The LL alarm of L100 should turn off the Heater.

Information to other loops

-

3.1.3 FIC100, Preheater Pump (M100) Flow Control

Measurement

F100 is used as flow measurement.

Control

Flow is controlled using a PID controller. This is a cascaded slave controller, which is used to control surface level of B200 by LIC200.

Actuation

The PreheaterControlValve (Y102) is used as the controlling device. Flow is generated by switching the PreheaterPump on when needed.

User Interface

A display in operating station is needed.

Alarms

Warnings and alarms of measured flow (LL, L, H, HH) should be produced.

Interlocks

If PreheaterToFeedwater Valve (Y203) is forced to off then the pump should also be forced to off.

Signals from other functions

Setpoint signal from cascade controller LIC200.

Cascaded interlock from B200 overflow interlock.

Information to other loops

-

3.1.4 LIC200, Feedwater Tank (B200) Surface Level Control

Measurement

L200 is used as level measurement.

Control

Surface level of the Tank is controlled using a PID controller.

Actuation

The Preheater Pump (M100) Flow Control (FIC100) is used as the controlling “device” (cascade control loop) .

User Interface

A display in operating station is needed.

Alarms

Warnings and alarms of surface level (LL, L, H, HH) should be produced.

Interlocks

Overflow is protected by closing inlet valves PreheaterToFeedwater Valve (Y203) and BoilerToFeedwater Valve (Y204) when HH alarm of L200 is active.

Signals from other functions

-

Information to other loops

-

3.1.5 PIC300, Boiler (B300) Pressure Control

Measurement

P300 is used as pressure measurement.

Control

Pressure is controlled using a PID controller.

Actuation

The Boiler Pump (M200) is used as the controlling device.

User Interface

A display in operating station is needed.

Alarms

Warnings and alarms of pressure (LL, L, H, HH) should be produced.

Interlocks

Overpressure of the Boiler should be prevented by using the pressure measurement (P300) HH alarm. The HH alarm should open BoilerToFeedwater Valve (Y204) used in this situation as emergency valve.

Signals from other functions

-

Information to other loops

-

3.1.6 Preheater Tank (B100) Overflow Protection

Overflow of the tank (B100) should be prevented by using the level's (L100) HH alarm. The HH alarm should close all inlet streams; customer line Supply Valve (Y305), MakeupToPreheater Valve (Y101) and FeedwaterToPreheater Valve (Y202).

3.1.7 Preheater's Heater (E100) Protection

Dry operation of the Heater should be prevented. The LL alarm of L100 should turn off the Heater.

3.1.8 Preheater Tank (B100) Overheating Protection

Overheating of the equipment should be prevented by using the temperature's (T100) HH alarm. The HH alarm should turn off the heater (E100).

3.1.9 Makeup Water Tank (B400) Overflow Protection

Overflow of the tank (B400) should be prevented by using the level's (L400) HH alarm. The HH alarm should close all inlet streams; Y401, Y402, Y403.

3.1.10 Preheater Pump (M100) Drain Protection

Draining the pump should be prevented. The LL alarm of L100 should turn off the pump.

3.1.11 Feedwater Tank (B200) Overflow Protection

Overflow of the tank should be prevented by using the level's HH alarm. The HH alarm should close all inlet streams, PreheaterToFeedwater Valve (Y203) and BoilerToFeedwater Valve (Y204).

3.1.12 Feedwater Pump Drain Protection

Draining the pump should be prevented. The LL alarm of L200 should turn off the pump.

3.1.13 B300 Overpressure Protection

Overpressure of the Boiler should be prevented by using the pressure measurement (P300) HH alarm. The HH alarm should open BoilerToFeedwater Valve (Y204) used in this situation as emergency valve.

3.1.14 Makeup Tank Overflow Protection

Overflow of the tank should be prevented by using the level's HH alarm. The HH alarm should close all inlet streams: FeedwaterPumpToMakeup Valve (Y402), BoilerToMakeup Valve (Y401) and PreheaterPumpToMakeup Valve (Y403).

3.1.15 Filling Sequence

Detailed specification TBD.

3.1.16 Startup Sequence

Detailed specification TBD.

- At startup, there should be a certain amount of water in all tanks and pipelines.

- The sequence should measure the current amount and proceed accordingly. If necessary the sequence should wait and ask the operator to fill the *Makeup Water Tank* manually.
- The final state in the *Startup Sequence* should be such that the *Primary Stream* is active, but the *Customer's Line* is bypassed. At this point the operator may start the *Supply Sequence*, which closes the bypass stream and opens the customer's *Supply Valve*.

3.1.17 Supply Sequence

Detailed specification TBD.

The beginning of the *Supply Sequence* should check that process is in suitable state. If everything is fine, *Supply Stream* is activated by opening and closing relevant valves.

3.1.18 Shutdown Sequence

Detailed specification TBD.

3.1.19 Emptying Sequence

Detailed specification TBD.

3.2 Operator Displays

3.2.1 Main System Display

Main display must show overall process system structure and important state variables as intuitively as possible. In this project it means that P&ID is used as background picture.

3.2.2 Main Operating Display

Main operating display must have a user friendly operating interface to the basic sequential functions of the system.

3.2.3 Preheater Tank (B100) Display

The tank and all connected instruments and their state variables must be shown. Also, the control loops that affect the sub system (LIC100 and TIC100) must be displayed here. Faceplates of all devices and control loops must be available. Interlocks must be visually highlighted.

3.2.4 Preheater Pump (M100) Display

The flow generation sub system with all devices and their state variables must be displayed here. Also, the control loop FIC100 must be visible. All device and control loop faceplates must be available. Interlocks must be visually highlighted.

3.2.5 Feedwater Tank Display

The tank and all connected instruments and their state variables must be shown. Also, the control loops that affect the sub system must be displayed here. Faceplates of all devices and control loops must be available. Interlocks must be visually highlighted.

3.2.6 Boiler Display

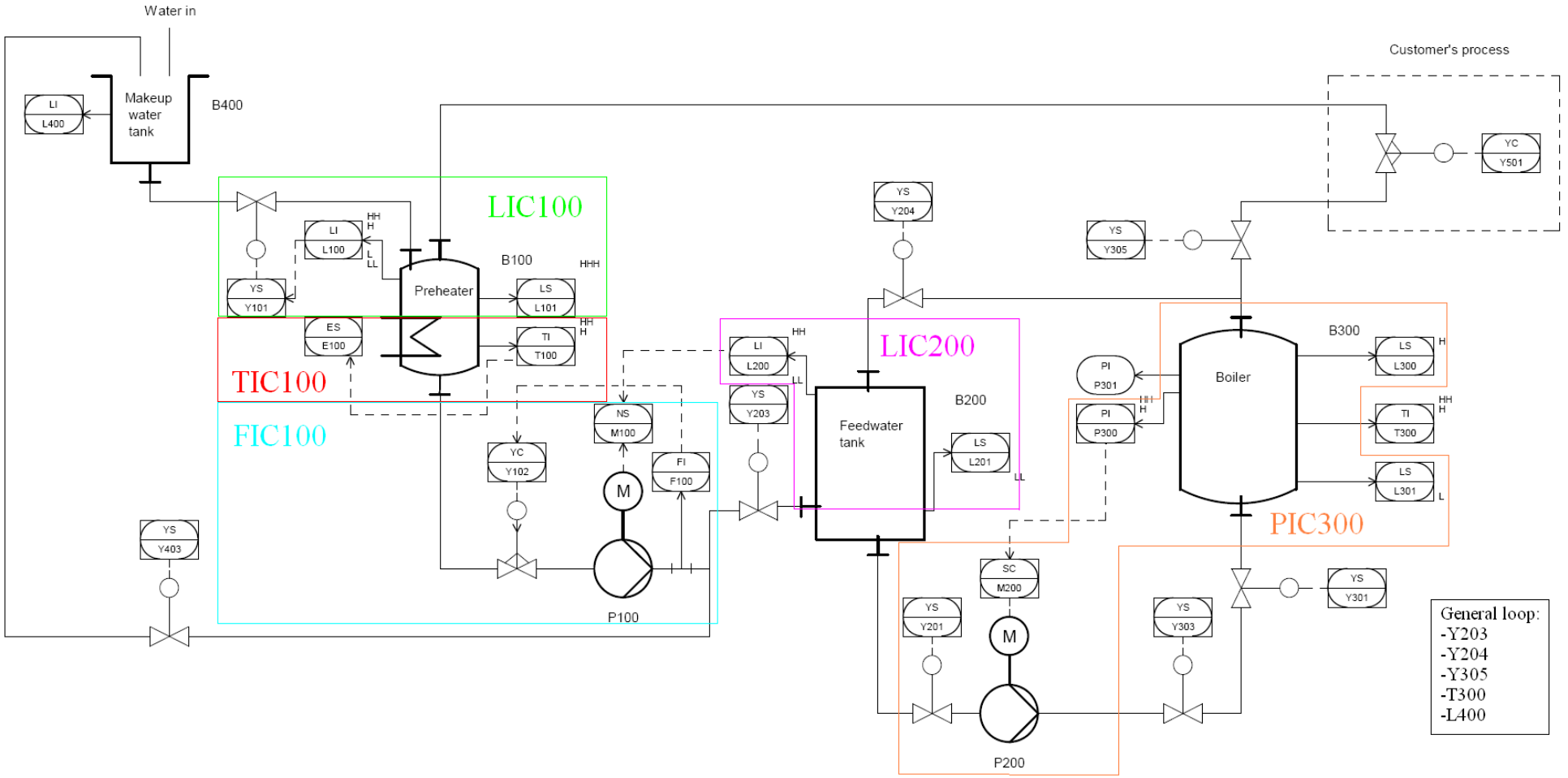
The tank and all connected instruments and their state variables must be shown. Also, the control loop that affects the sub system (LIC200) must be displayed here. Faceplates of all devices and control loops must be available. Interlocks must be visually highlighted.

3.2.7 Alarms Display

List of alarms. TBD.

3.2.8 Interlocks Display

Interlock statuses. TBD.


Water in
Makeup water tank
B400
LI L400
Customer's process
YC Y501
LIC100
TIC100
FIC100
LIC200
PIC300
Preheater
B100
HHH
LI L100
HH H
L LL
YS Y101
LS L101
ES E100
TI T100
HH H
YS Y204
YS Y305
LI L200
HH
LL
YS Y203
Feedwater tank
B200
LS L201
LL
PI P301
PI P300
HH H
Boiler
B300
LS L300
H
TI T300
HH H
LS L301
L
PIC300
YS Y301
NS M100
FI F100
M
YC Y102
P100
YS Y403
SC M200
YS Y201
YS Y303
M
P200
General loop:
-Y203
-Y204
-Y305
-T300
-L400