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Project Acronym: I-UPS

D4.1 – Detailed engineering of I-UPS lab rig and risk assessment

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Executive summary

This document presents the detailed engineering and design framework for the integration of a high-temperature heat pump system operating between a water loop and a molten salts loop. The objective is to establish a robust system capable of validating heat pump driven waste heat recovery and thermal storage under different operational conditions.

The different stages of process design are reflected throughout the document, starting with project description, a comprehensive process flow diagram and an overview of the system's architecture. The basis of design section defines the operational principles of the heat pump and its interaction with the water and molten salt loops.

For the different operating conditions, heat and mass balances and hydraulic calculations are included for both loops based on the PFD. In a next stage, engineering drawings are developed, which encompass piping and instrumentation diagrams (P&ID) and system layouts.

A detailed technical specifications and datasheets section outlines key equipment and is followed by all the necessary documentation on the piping classification, instrumentation, and control system. This includes descriptions of control loops, safety interlocks, and automation architecture to optimize operational efficiency and safety.

The testing plan defines the procedures for evaluating system performance under various operating conditions. It includes warm-up and stabilization, baseline testing, variable load scenarios, transient behaviour analysis, and long-duration testing.

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1. Introduction

1.1 Scope

This deliverable will provide a comprehensive engineering and integration plan for the I-UPS experimental rig. The engineering report includes a full Process and Instrumentation Diagram (P&ID), main energy balances, technical specifications for all components, and key operational and testing plans.

1.2 Structure

First, the scope of the experimental rig is explained in the process description and the Process Flow Diagram (PFD), establishing a clear understanding of the system's working principles. Following this, the Basis of Design details the operation of the heat pump, water loop, and molten salt loop, defining key operational parameters.

The Basic Engineering section includes heat and mass balance calculations and hydraulic calculations for both the water and molten salts loops. This leads into Engineering Drawings, which present essential diagrams such as the Piping and Instrumentation Diagram (P&ID) and Layout.

The Technical Specifications and Datasheets section provides an equipment list, electrical consumption data, and specifications for major components in the water and molten salts loops, including tanks, pumps, heaters, and coolers.

The Detailed Engineering section further refines this by presenting line lists, instrumentation details, control system descriptions, operating modes, vendor lists, heat tracing, and insulation requirements.

1.3 Relation to other deliverables

The detailed experimental rig design is built upon the system definition and boundary conditions identified in Task 5.1 and the preliminary designs from Deliverables D2.1 and D3.1.

The experimental testing plan will serve as the foundation for the testing campaign in Task 4.3.

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2. Project Description

In this part of the deliverable, the main functionality of the process is explained using the Process Flow Diagram.

2.1 Process Flow Diagram

The process flow diagram (Figure 1) gives an overview of the main process flows and equipment (see Table 1 for equipment names).

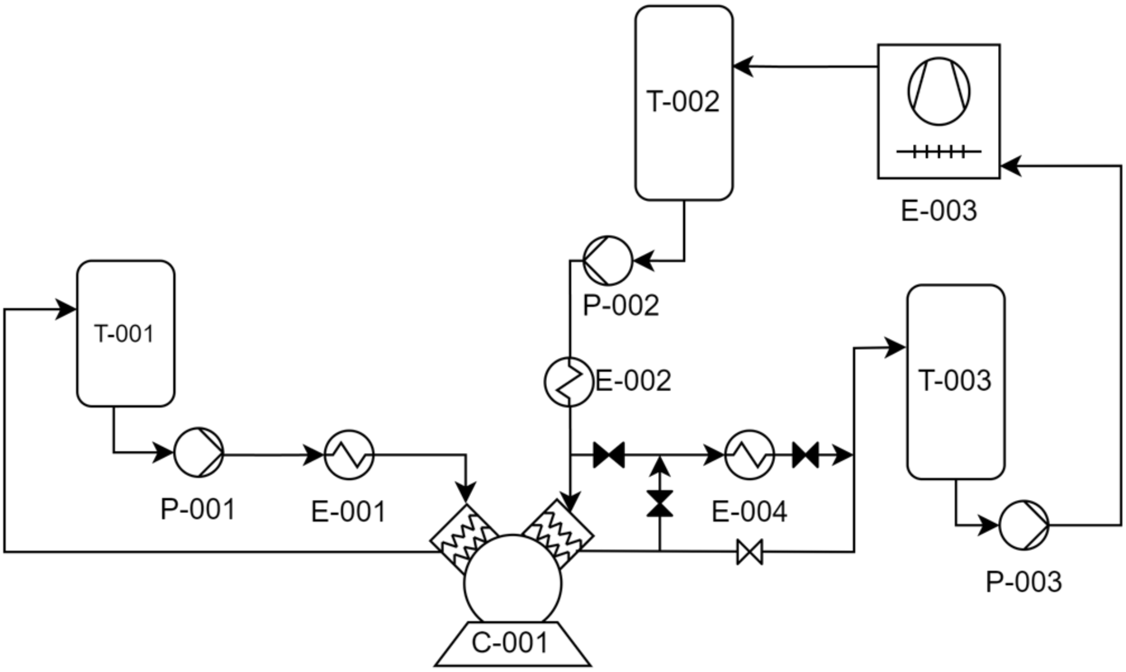

Figure 1: Process Flow Diagram for the I-UPS pilot plant. The equiment numbers are explained in Table 1.

Table 1: Equipment names for the different elements of the PFD (see Figure 1)

Equipment Number	Equipment Name
C-001	HTHP
E-001	Water Heater
E-002	HTHP Inlet heater
E-003	MS Air Cooler
E-004	MS Booster Heater
P-001	Water Circulation Pump
P-002	Cold MS Pump
P-003	Hot MS Pump
T-001	Water Buffer Tank
T-002	Cold MS Tank
T-003	Hot MS Tank

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2.2 Process Description

The I-UPS pilot installation consists of two distinct loops that operate as the hot and the cold sink for the high temperature heat pump. The two loops are:

- Water Loop
- Molten Salt Loop (MS Loop)

Each loop has specific equipment designed to ensure optimal process performance across a range of operating conditions, including both low and high-temperature scenarios.

The water loop simulates a source of residual heat between 20ºC and 180ºC and serves as the cold sink for the HTHP operation. The main components in the water loop are the following. T-001 is the water buffer tank, which acts as a thermal storage unit to stabilize the water temperature in the loop and supplies water to the circulation system at a controlled temperature and pressure. A sufficiently high pressure is required to ensure that the water remains in the liquid phase, even at elevated temperatures. P-001 is the water circulation pump, which pumps water from the buffer tank (T-001) through the heating and cooling components of the system, ensuring a continuous flow rate of 1.0 kg/s in all conditions as per the balance tables. The water is heated using an electric water heater (E-001), which initially heats the water to the desired temperature and further maintains the water temperature constant in the range between 20°C and 180°C.

The molten salt loop is responsible for storing and transferring high-temperature energy for heating purposes. It includes two storage tanks and multiple heating/cooling components for molten salts. T-002 is the cold molten salt tank, which stores molten salts at lower temperatures, ranging from 239.1°C in low temperature mode to 389.1°C in high temperature mode. P-002, the cold molten salt pump, pumps molten salts from the cold tank (T-002) into the heat pump (C-001). The heat pump (C-001) transfers heat from the water loop to the molten salt loop, raising the temperature of the molten salts. In order to be able to control the inlet temperature of the HTHP accurately, an inlet heater, E-002, is inlcuded in the design. E-004, the MS booster heater, provides additional heating to the molten salts if needed to achieve the desired operating temperature and is capable of boosting molten salt temperatures up to 400°C. T-003 is the hot molten salt tank, which stores molten salts at elevated temperatures and acts as the high-temperature reservoir with temperatures reaching between 250°C and 400°C. P-003, the hot molten salt pump, pumps molten salts from the hot tank (T-003) to E-003, the MS air cooler, which rejects heat from the molten salt loop. This cooler ensures that the temperature of the cold MS fed to cold MS tank remains slightly below the target temperature which is then adjusted usinf E-002.

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3. Basis of Design

In the following paragraphs, the main design criteria for the heat pump, the molten salts and the water loop are summarized. This information is the result of the analyses and assessments performed in WP2 and WP3.

3.1 Heat Pump Operation

The expected operating conditions of the heat pump are shown in Table 2. The heat pump is designed to provide a heating load of 40 kW to the molten salts loop with an estimated Coefficient of Performance (COP) between 1.2 and 2. This means that the heat pump can generate between 1.2 and 2 units of thermal energy for each unit of electrical energy consumed. This implies that the heat pump itself will need to operate at 20 to 34 kW and that 6 to 20 kW is extracted from the cold sink depending on the COP.

Table 2: Expected operating conditions of the HTHP

Parameter	Unit	Design Value
Q_heating	kW	40
COP	-	1.2 - 2
HTHP Power	kW	34 - 20
Q_cooling	kW	6 - 20

3.2 Water Loop Operation

The Water Loop acts as the cold sink for the HTHP. Below and in Table 3 are the operational parameters of the water loop:

- The water will operate within a temperature range of 20 ºC to 180 ºC.
- The water system will operate at a pressure of 12 barg to ensure sufficient margin with the saturation pressure at 180ºC.
- The water flow in the system can be varied from 1 kg/s to 5 kg/s, these flow rates has been calculated to ensure sufficient velocity in the system and hence adequate heat transfer. The higher flow rates will be used for lower water temperatures as per the information received from ENERIN.

Table 3: Operating range for the water loop

Parameter	Unit	Design Value
Temperature	ºC	20-180
Pressure	barg	12
Flow Rate	kg/s	1-5
	m^3/h	4.1-18.0

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3.3 Molten Salt Loop Operation

The Molten Salt Loop operates with molten salts that allow for the storage and transfer of thermal energy. The following parameters (see also Table 4) have been defined for the salt loop:

- The salt loop will operate within a temperature range of 185 ºC to 400 ºC. This high-temperature range is typical for systems that require efficient heat storage and transfer at elevated temperatures.
- The system will operate at ambient pressure. Because of the low vapour pressure of the molten salts no pressurization is required . This helps simplify the design and reduce the operational complexity of the system.
- The flow rate is set at 3 kg/s, which corresponds to the amount of molten salt circulating through the system to transfer heat.

Table 4: Operating parameters for the molten salts loop

Parameter	Unit	Design Value
Temperature	ºC	185-400
Pressure	barg	1
Flow Rate	kg/s	3

For molten salts to operate in the temperature range and with the design data in Table 4, ternary salts must be used to be able to operate at such low temperatures. Binary salts are excluded because of their freezing point at 220°C.

Table 5: Ternary Salt (YARA Salt) properties

		185ºC	400ºC
Density	kg/m3	2063.0	1918.8
Cp	kj/kgK	1.53	1.53
Viscosity	cP	32.40	2.42

4. Basic Engineering

In this section, the heat and mass balance for the water and the molten salt loop is presented. Also, the hydraulic calculations for both loops in different operating conditions are shown.

4.1 Heat and Mass Balance

The heat and mass balance calculations are based on the numbered PFD that is shown in Figure 2. The heat and mass balance are calculated for the water and molten salts loop separately considering for each loop the full operation range. In the results tables, flow numbers without an apostrophe refer to the heat and mass balance for the coldest expected

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operating temperatures whereas the flow numbers with apostrophe refer to the maximum operating temperature.

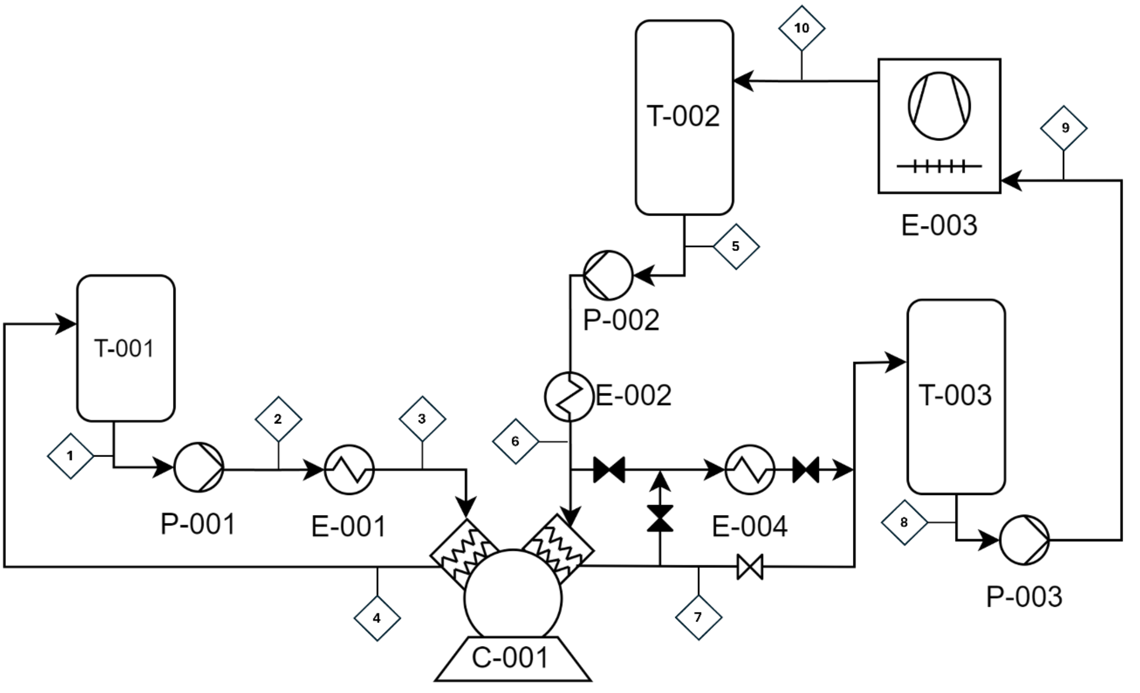

Figure 2: PFD with numbered flows for the Heat and Mass Balance

The water loop calculations are set up so as to obtain a controlled temperature of 20ºC (Table 6) and 180ºC (Table 7) at the inlet of the HTHP. The COP of the HTHP is considered to be 2 in these calculations as this caused the largest temperature difference and hence the highest duty for the electrical heater E-001 (20 kW).

As stated in Section 3.2, a higher water flow rate (5 kg/s) is foreseen for low water temperatures (20ºC) whilst a lower flowrate is expected for the high temperature range. This is reflected in the mass balance calculations below.

Even though the high pressure set point of 12 barg in T-001 that is used for maintaining the water in the liquid state at 180ºC is not required at ambient temperatures because of the low vapour pressure, all simulations were carried out at the same pressure for simplifying the design calculations.

Table 6: Heat and Mass Flows for the water loop at low (1-2-3-4) operational temperatures considering a COP of 2.0 and a heat output of 40 kW to the molten salt loop

		1	**2**	**3**	**4**
Medium	-	Wat	Wat	Wat	Wat
Temperature	ºC	19	19	20.0	19
Pressure	barg	12.1	13.0	12.8	12.3
Saturation Pressure	bara	0.022	0.022	0.023	0.022
Density	kg/m^3	998.5	998.5	998.2	998.5
Flow Rate	kg/s	5.0	5.0	5.0	5.0
	m^3/h	18.03	18.03	18.03	18.03
Viscosity	cP	1.03	1.03	1.00	1.03

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Specific Heat	kJ/kgK	4.18	4.18	4.18	4.18

Table 7: Heat and Mass Flows for the water loop at high (1'-2'-3'-4') operational temperatures considering a COP of 2 and a heat output of 40 kW to the molten salt loop

		1'	**2'**	**3'**	**4'**
Medium	-	Wat	Wat	Wat	Wat
Temperature	ºC	172.2	172.2	180.0	172.2
Pressure	barg	12.1	12.9	12.7	12.2
Saturation Pressure	bara	8.34	8.34	10.03	8.34
Density	kg/m^3	895.5	895.5	887.3	895.5
Flow Rate	kg/s	1.0	1.0	1.0	1.0
	m^3/h	4.02	4.02	4.06	4.02
Viscosity	cP	0.16	0.16	0.15	0.16
Specific Heat	kJ/kg	2.56	2.56	2.59	2.56

The molten salt loop heat and mass balance does not depend on the COP and was performed for a continuous heat output of the HTHP of 40 kW. The balance was calculated for heating the molten salt up to 250ºC (see Table 8) and 400ºC (see Table 9).

Table 8: Heat and Mass Flows for the molten salt loop at low operational temperatures considering a COP of 1.2 and a heat output of 40 kW to the molten salt loop

		5	**6**	**7**	**8**	**9**	**10**
Medium	-	MS	MS	MS	MS	MS	MS
Temperature	ºC	241.3	241.3	250.0	250.0	250.0	241.3
Pressure	barg	0.3	2.3	1.8	0.3	2.3	1.8
Density	kg/m^3	2025.2	2025.2	2019.4	2019.4	2019.4	2025.2
Flow Rate	kg/s	3	3	3	3	3	3
	m^3/h	5.3	5.3	5.3	5.3	5.3	5.3
Viscosity	cP	13.3	13.3	11.8	11.8	11.8	13.3
Specific Heat	kJ/kgK	1.53	1.53	1.53	1.53	1.53	1.53

Table 9: Heat and Mass Flows for the molten salt loop at high operational temperatures considering a COP of 1.2 and a heat output of 40 kW to the molten salt loop

		5'	**6'**	**7'**	**8'**	**9'**	**10'**
Medium	-	MS	MS	MS	MS	MS	MS
Temperature	ºC	391.3	391.3	400.0	400.0	400.0	391.3
Pressure	barg	0.3	2.3	1.8	0.3	2.3	1.8
Density	kg/m^3	1924.7	1924.7	1918.8	1918.8	1918.8	1924.7
Flow Rate	kg/s	3	3	3	3	3	3
	m^3/h	5.61	5.61	5.63	5.63	5.63	5.61
Viscosity	cP	2.61	2.61	2.42	2.42	2.42	2.61
Specific Heat	kJ/kgK	1.53	1.53	1.53	1.53	1.53	1.53

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4.2 Hydraulic Calculations

The hydraulics have been investigated for the water and molten salt loops separately.

4.2.1 Water loop hydraulics

The water pump discharge is equipped with a flow control valve to regulate the water loop circulation flow rate at between 1 kg/s and 5 kg/s. The pump will operate at a fixed speed and needs to deliver a head of 19.52 m at 180ºC (see Figure 3) and 19.48 m at 15ºC (see Figure 4).

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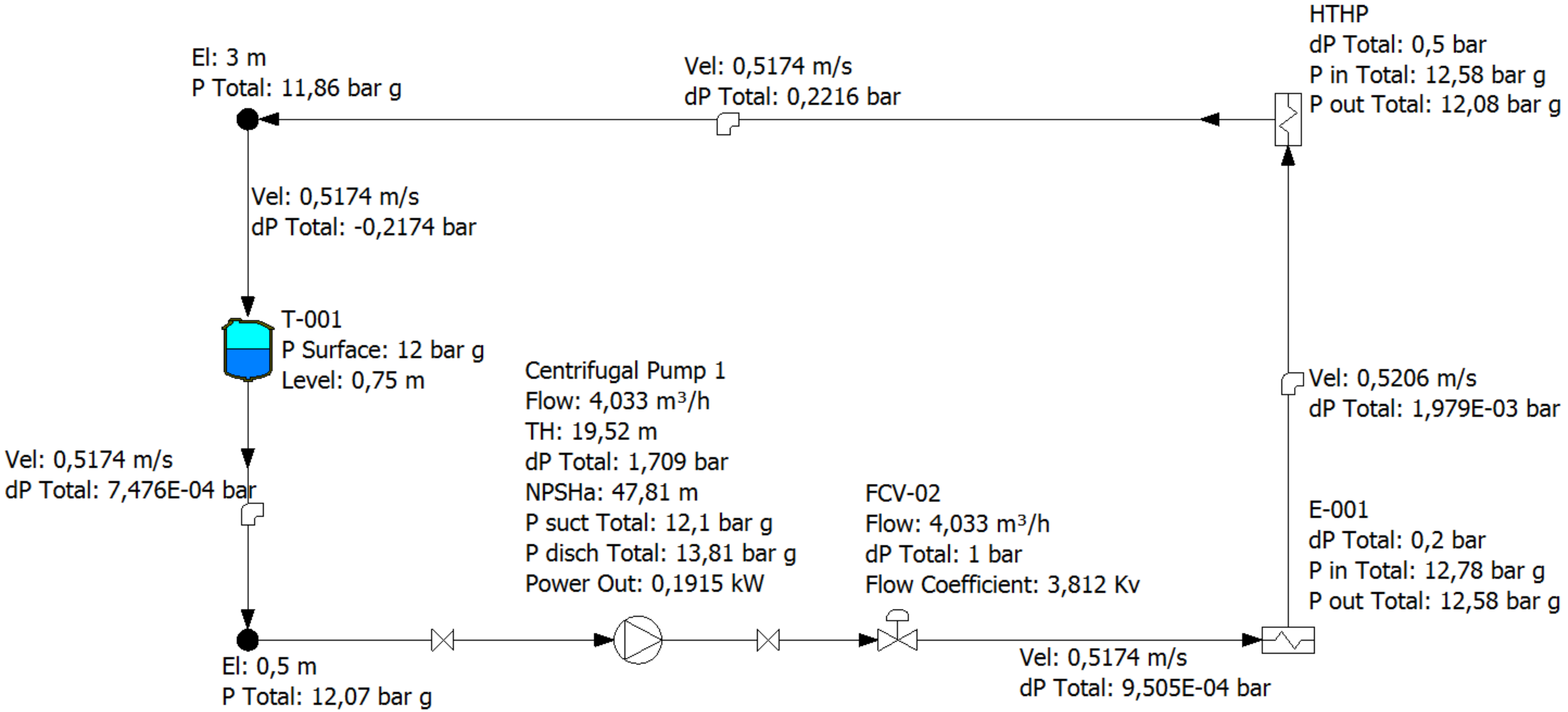

Figure 3: Water Loop Hydraulic calculations at 180ºC

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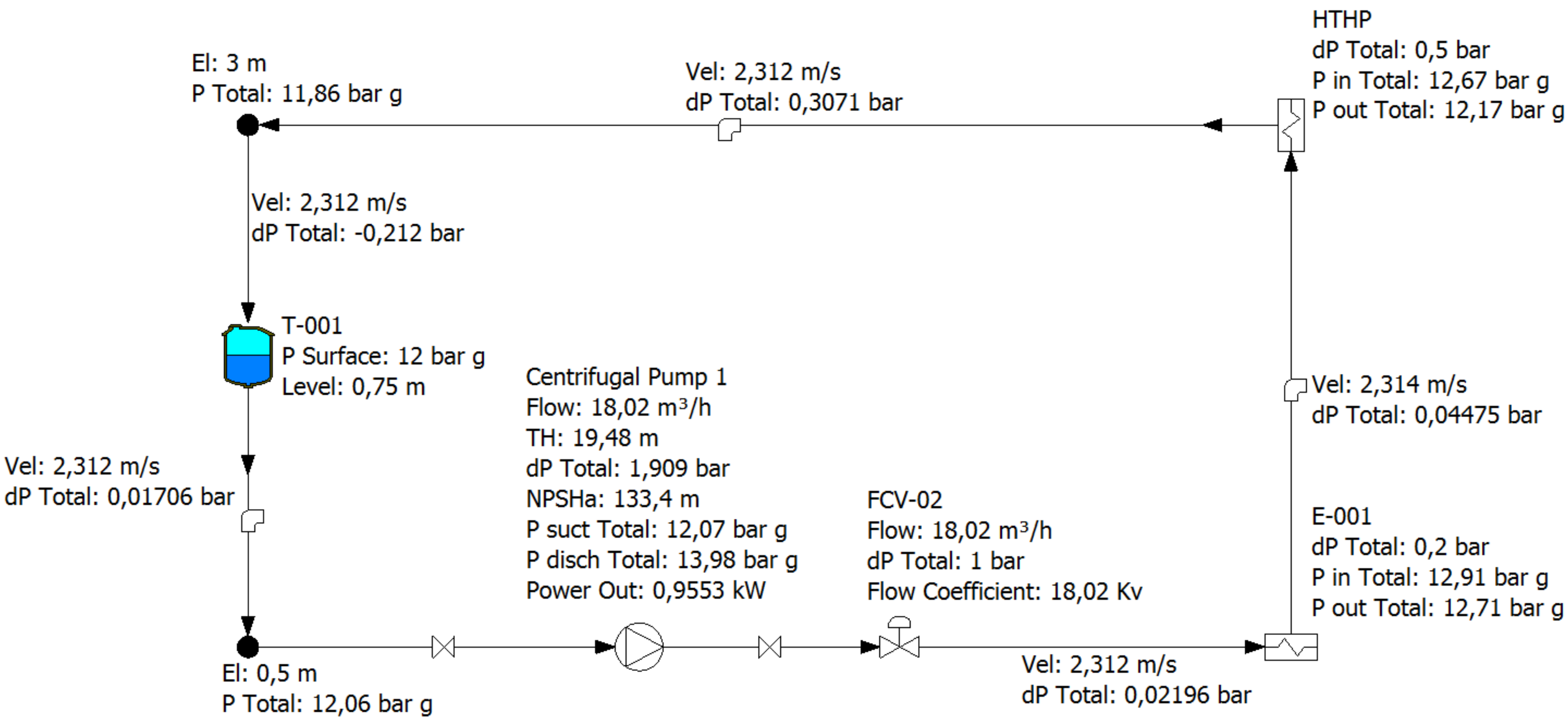

Figure 4: Water Loop Hydraulic calculations at 15ºC and 5 kg/s

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4.2.2 Molten salts loop hydraulics

The hydraulics of the molten salt loop are calculated based on the available equipment at the KYOTO facilities: 2 molten salts tanks (see 6.3.1) and the Klaus-Union pump that is suitable for high temperatures as hot and cold pump (see 6.3.2). The air cooler and the electric heater are modelled as fixed pressure drop equipment.

To assess the performance of the existing pump, a hydraulic modelling of the circuit was performed using this pumps curve for both the hot and the cold molten salts system. The system parameters for these simulations are shown in Table 10.

Table 10: Hydraulic simulation set-up

		P-002 (cold MS)	P-003 (hot MS)
Line lengths (all 1")			
From discharge to tank	m	6	6
From tank to suction	m	3	3
Line fittings (90º bend)			
From discharge to tank	-	4	4
From tank to suction	-	1	1
Equipment pressure drop	bar	0.5	0.5
MS Tank pressure	barg	0.0	0.0

The simulation results at 400ºC (Figure 5) and at 250ºC (Figure 6) show that the available pump is capable of delivering the required flow in the MS loop. As the obtained flow is very close to the target flow, the system can run in the absence of control valves and only a manual globe valve in the pump discharge is needed to adjust the hydraulics of the system. In order to maintain a good balance between both MS tanks, similar pressure drops for the cold and the hot molten salts circuits are required. This can be done by constructing both circuits as similar as possible.

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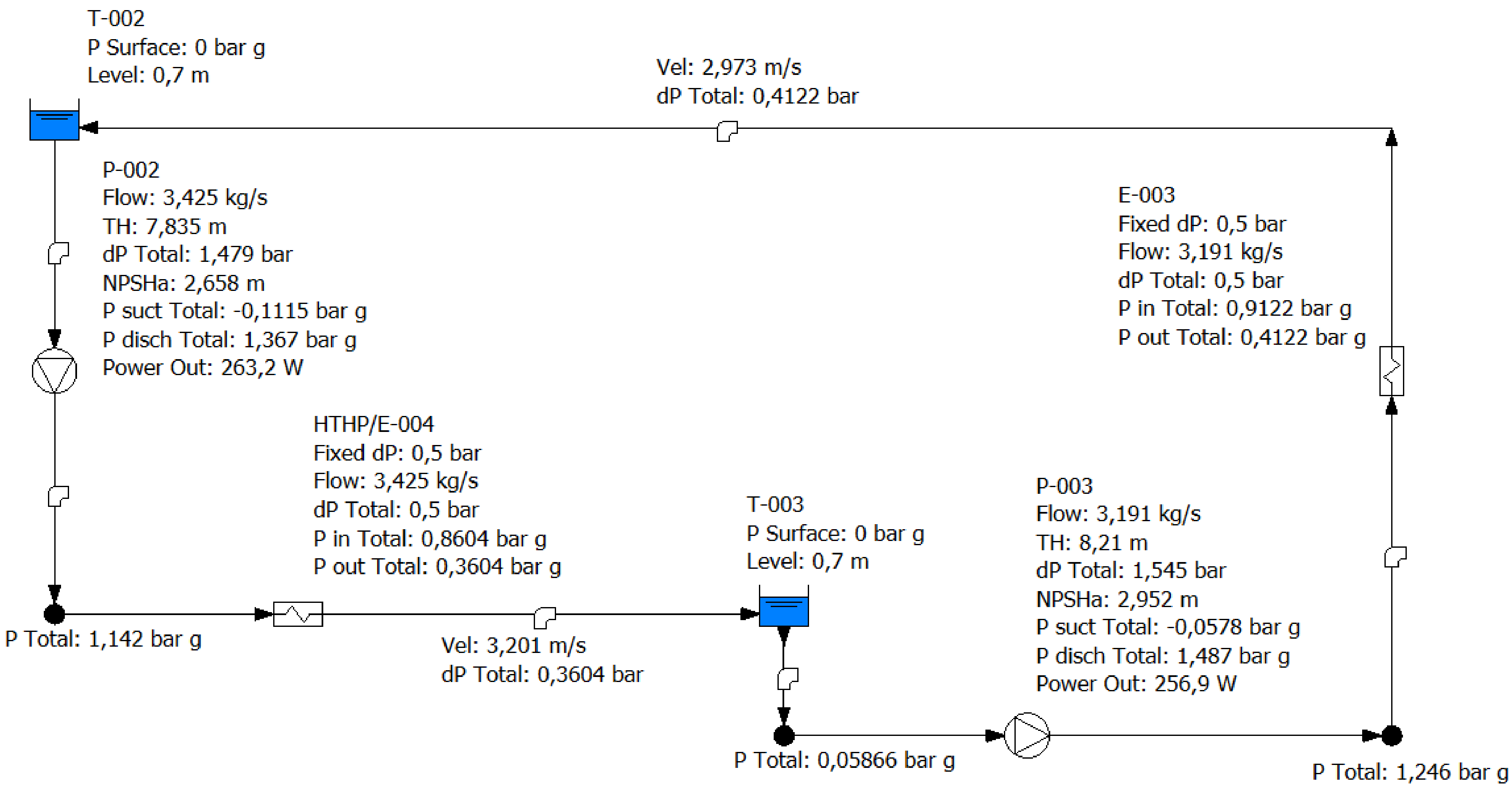

Figure 5: Molten salts Loop Hydraulic calculations at 400ºC for the system setup as defined in Table 10

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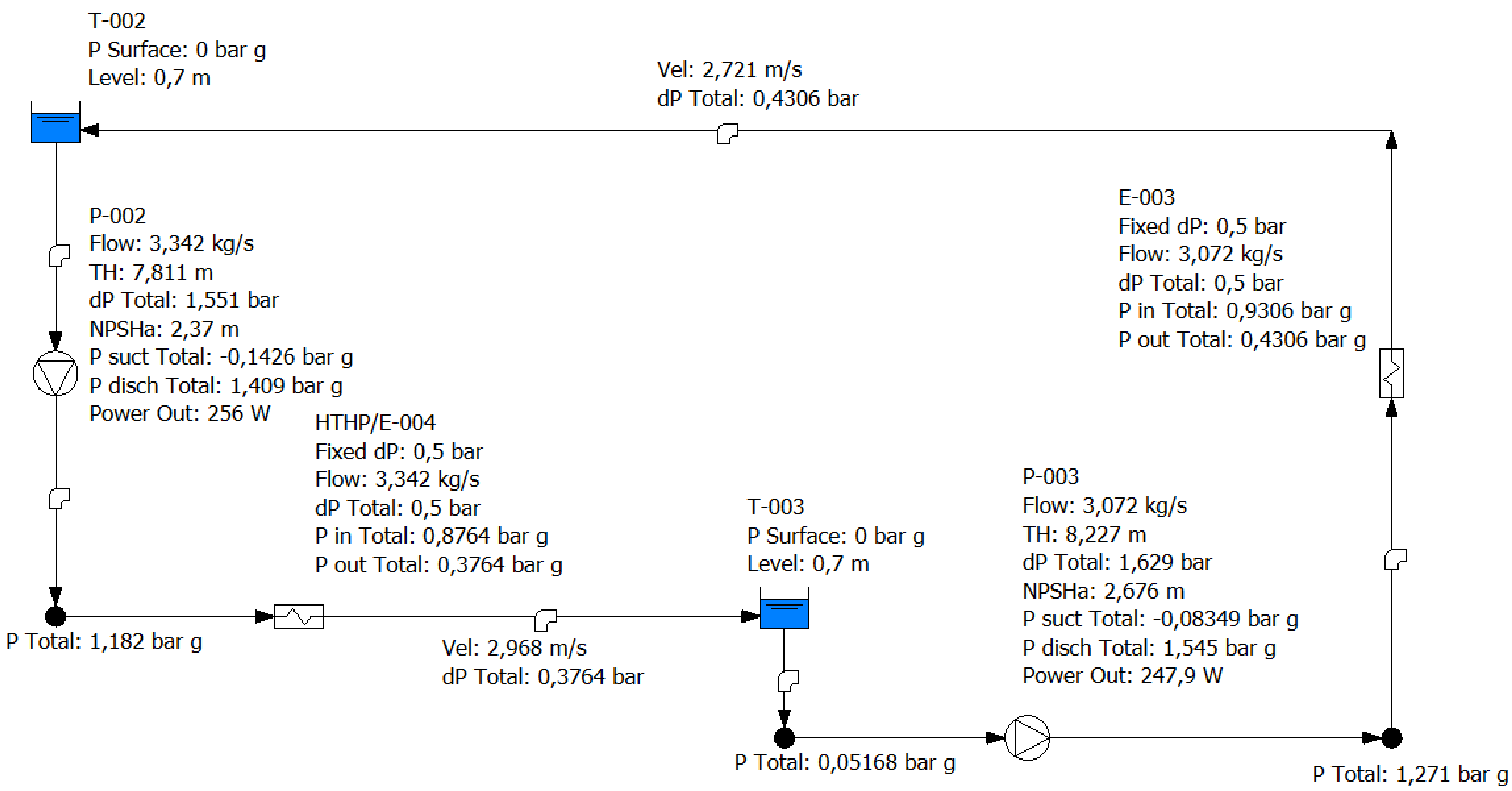

Figure 6: Molten salts Loop Hydraulic calculations at 250ºC for the system setup as defined in Table 10

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5. Engineering Drawings

5.1 Piping and Instrumentation Diagram

The Piping and Instrumentation Diagrams are added to this deliverable as Annex 10.1.

5.2 Layout

The final layout of the pilot plant will depend on the construction details of the HTHP container. As stated in Section 4.2.2, it is crucial to design the hot and cold molten salt piping as hydraulically similar as possible.

A preliminary layout proposal is shown in Figure 7. It is important to note that the position of the water loop is very flexible due to its small size. Depending on the access requirements for the HTHP container, the proposed layout from Figure 7 can be optimized further to be more compact.

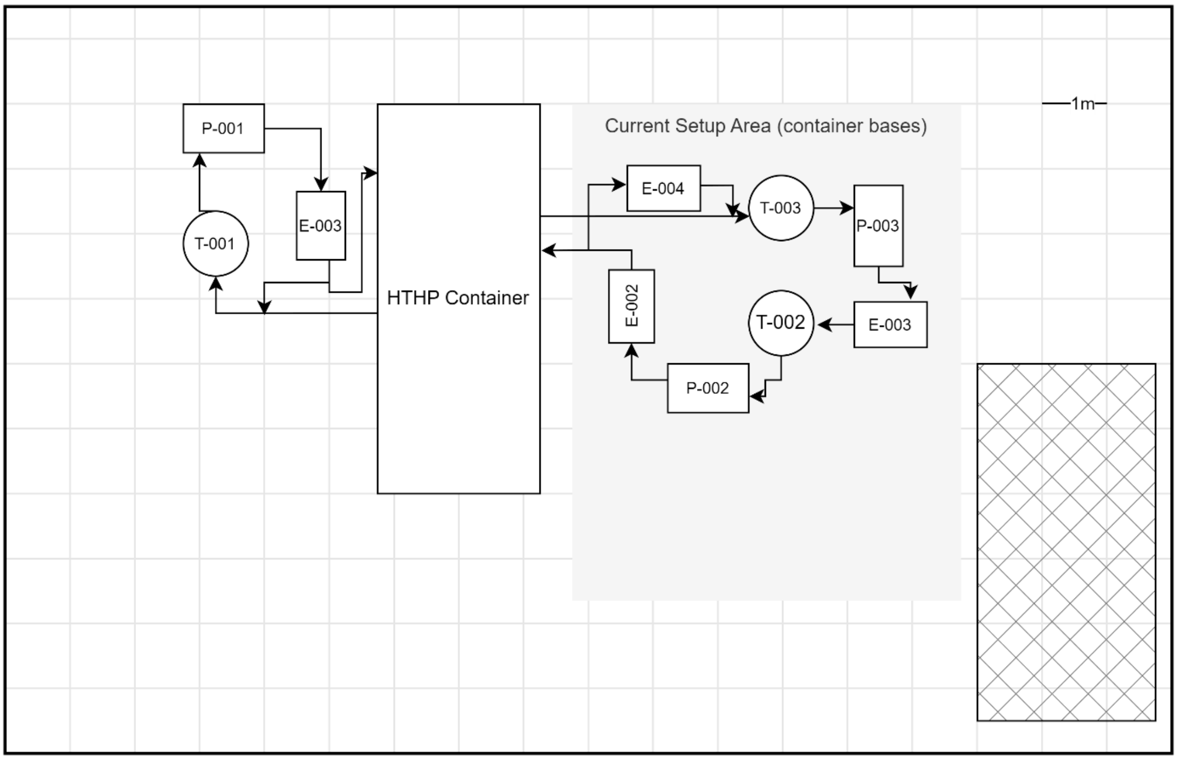

Figure 7: Possible layout for the I-UPS pilot plant

6. Technical Specifications and Datasheets

6.1 Equipment List and Electrical Consumption List

A detailed equipment list is included in Annex 10.2. In Table 11, an overview of the equipment is given with the indication whether the equipment is available in the KYOTO facilities and can

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be reused for the I-UPS pilot or whether the equipment has to be procured. The list of electric consumers is added as Annex 10.3.

Table 11: Equipment list indicating which items need to be procured and which can be reused

Eq. Number	Eq. Name	Procure?
E-001	Water Heater	Yes
E-002	HTHP Inlet heater	Yes
E-003	MS Air Cooler	TBC
E-004	MS Booster Heater	Yes
P-001	Water Circulation Pump	Yes
P-002	Cold MS Pump	No
P-003	Hot MS Pump	Yes
T-001	Water Buffer Tank	Yes
T-002	Cold MS Tank	No
T-003	Hot MS Tank	No

6.2 Water Loop

The water loop will be designed to deliver water at temperatures between ambient and 180ºC at a pressure of 12 barg in the water tank T-001 to ensure the liquid phase. The target water flowrate can be altered between 1 kg/s and 5 kg/s.

6.2.1 T-001 Water Buffer Tank

The water buffer tank is designed to store the return water from the HTHP, to act as a buffer drum before the pump and to serve as the pressuring vessel for the water circuit. The buffer time is 10 minutes at 1 kg/s and 2 minutes at 5 kg/s to allow for a quick stabilization of the temperature. The tank drawing is shown in Figure 8, the full tank datasheet can be found in Annex 10.4.

The tank selection and installation height of 0.5m above the floor also ensure that the water loop operates within the allowed pressure range for the pump as shown in Section 6.2.2.

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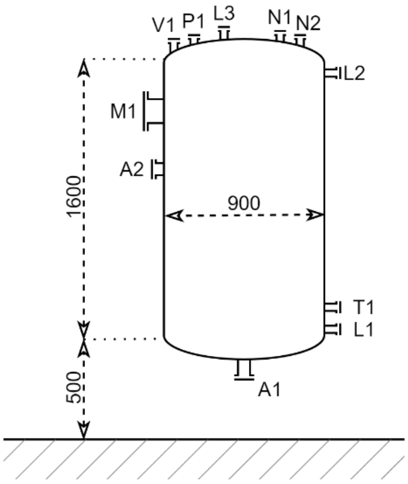

Figure 8

The design temperature will be 15ºC above the maximal operations temperature and is hence put at 195ºC. The vessel will be protected by a PSV with set point at 16 barg which corresponds to the maximum discharge pressure of the pump (see Section 6.2.1).

6.2.2 P-001 Water Circulation Pump

Based on the hydraulic calculations presented in Section 4.2.1, a datasheet has been composed to facilitate the procurement of a suitable pump for the I-UPS pilot plant. The datasheet is attached as Annex 10.5.

6.2.3 E-001 Water Heater

The water heater is designed to keep the water loop at a constant temperature between 20ºC and up to 180ºC, compensating for the heat that is transferred to the HTHP. Considering the COP of the HTHP (see Section 3.1), a heater of 25 kW is selected. This corresponds to a COP of 2.7 whilst delivering 40 kW to the molten salt system. The heater datasheet is included as Annex 10.6.

6.2.1 Water loop piping design conditions

The piping design pressure in the water loop is determined by the shut-off head of the pump and the maximal suction head.

Assuming the water tank is 100% full, a maximum water height of 2.55 m at the suction is taken into account. This converts in a pressure of 2.55*998.2*9.81/100000=0.25 barg at 18ºC.

As the process is a loop, the normal operating pressure with a 10% margin is taken as the maximal pressure in the vessel for calculating the maximal discharge pressure of the pump: 13.2 barg. Adding this value to the pressure from the static height results in a maximal P-001 suction pressure of 13.45 barg.

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For the pump shut-off head, the maximal operations head is multiplied by a safety factor of 1.2. For a flow of 5 kg/s at 180ºC, the head needed is 21.98 m so the shut-off head is estimated as 26.3m as per the safety factor.

This 26.3m corresponds to a maximal pressure increase of 2.6 bar in the pump and a maximal discharge pressure of 16.0 barg. This pressure will be the set pressure of the PSV on the Water Buffer Tank (see 6.2.1).

With this set pressure, the design pressure of the piping downstream from the pump P-001 and upstream from the flow control valve FV-01 can be calculated. Using 16 barg of PSV pressure, 0.25 barg pressure from the water height at the suction and maximal 2.6 bar pressure gain over the pump, the design pressure of the lines from the pump to the flow valve is 18.85 barg.

The design temperature of the piping will be 15ºC above the maximal operations point and is set at 195ºC.

6.3 Molten Salts Loop

6.3.1 T-002/T-003 Cold/Hot MS Tank

KYOTO own 2 identical tanks of 700 L that are suitable for this project from a previous pilot set-up. They have an internal diameter of 88 cm and a height of 135 cm.

During operations, these tanks are assumed to be 50% full. This corresponds to 1.48 Tons of salt per tank at 250ºC.

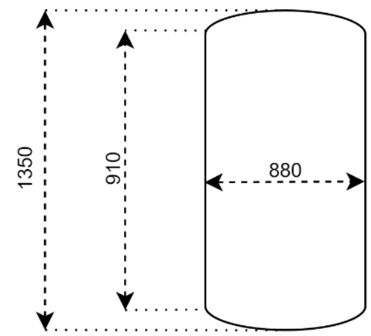

Figure 9

The tanks will be operated at ambient pressure at temperatures between 250ºC and 400ºC.

6.3.2 P-002/P-003 MS Pump

The Klaus Union pump that is available at the KYOTO facilities is suitable for use as the hot MS pump. The pump is designed for delivering 4.5 m3/h of molten salts at 450ºC which suits well with the design of the I-UPS pilot. The pump data is added to this deliverable as Annex 10.7.

The shut-off head is taken from the pump curve as 10.2 m (head at minimal flow).

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Assuming the suction drum to be at 0 barg and representing 2 meters of salts height in total (vessel + suction line) and the maximal density for the salts (2019.4 kg/m^3), the maximum outlet pressure of the pump corresponds to 12.2m or 2.42 barg.

6.3.3 P-002 Cold MS Pump

Because of the low temperature increase that is to be realised in the molten salts/helium exchanger of the HTHP, the cold MS pump will be operating at nearly the same conditions as the hot MS pump.

Therefore, in the hydraulic calculations in section 4.2.2, the data of the hot pump from the previous section 6.3.2 was used for both pumps in the circuit. The recommendation is to procure exactly the same pump as the one that is already available to facilitate the equal functioning of the cold and hot section of the MS loop.

6.3.4 E-003 MS Air Cooler

A finned tube air cooler is available at the KYOTO facilities that could be suitable for use in the I-UPS project. Awaiting confirmation of the operation of the equipment, a datasheet is added in Annex 10.9 in case the available one would not comply with the process needs.

For confirming the possibility to operate using a finned air cooler on molten salts, suppliers have been asked to provide solutions based on this datasheet. One supplier (AITESA) has replied with a positive answer to this request and provided the option that is shown in Figure 10. The full datasheet of their proposal is included as Annex 10.10.

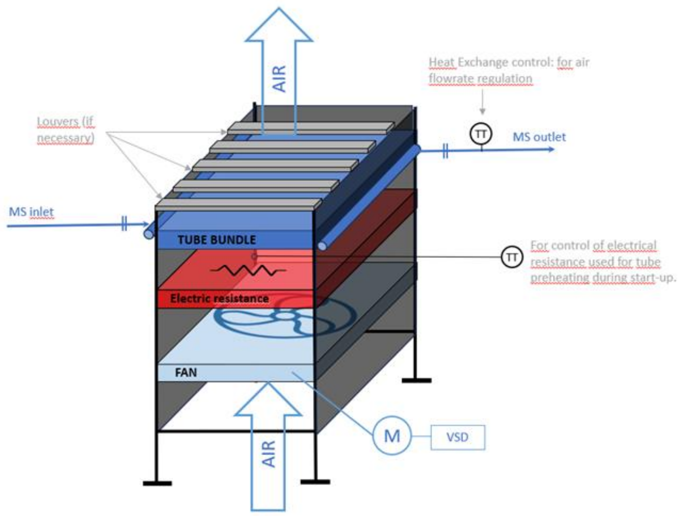

Figure 10: Sketch of AITESA finned air cooler for molten salts

A plain tube AC can be designed to meet both requirements of inner wall temperature >200ºC and max air outlet temperature <60ºC. The design has been made according to most limiting operation case (molten salt inlet T=250ºC). The pressure drop on the tube side exceeds the maximum allowable dP of 0,1 bar in the original datasheet. To achieve a dP<0,1 bar, the

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molten salt would have to be around 0,7 m/s. The supplier recommendation is to keep the minimum velocity at around 1m/s to prevent molten salt solidification issues. This slight increase in pressure drop will not have impact on the process performance given the margins that were taken in the hydraulic calculations in Section 4.2.2.

The AC tubes will need to be preheated before start-up to prevent molten salt solidification. The proposed solution would be to use air heated with an electrical resistance to preheat the tubes. The electrical resistance would only be used during start-up. During start-up, the outlet air temperature will exceed 60ºC.

6.3.5 E-002 and E-004 MS Electric Heaters

The two electric heaters at the entrance and exit of the HTHP can be used in several operational modes. The normal operation mode is using E-002 to control the HTHP inlet temperature and E-004 to boost the outlet temperature of the MS from the HTHP. Running both heaters together will also allow to bypass the HTHP and allow to run the system independently.

For operational flexibility, the design basis for these heaters is chosen so that both together have a similar power output as the HTHP. When both heaters have a power of 25 kW, this corresponds to a temperature increase of 5.4ºC per heater when operating at the nominal flow of 3 kg/s. Decreasing the flowrate to 2 kg/s would result in a temperature raise of 8.2ºC per heater and a 16.3ºC temperature increase can be obtained at 1kg/s. These flowrates lie well within the possibilities of the pump as defined in Sections 6.3.2 and 6.3.3.

The datasheet for both E-002 and E-004 are added as Annex 10.11.

7. Detailed Engineering

The Detailed Engineering section provides a breakdown of the system's key components. It begins with the Line List, which catalogues all piping lines, specifying their function, materials, and classifications. The Piping Class, Tracing Specification, and Thermal Insulation Specification further refine these elements, ensuring compatibility with thermal and mechanical requirements.

The Instrumentation subsection details all control and monitoring devices, including Automatic and Manual Valves Lists, and the Instrumentation List. Additionally, Instrumentation Specifications define the technical requirements for these components, ensuring integration with the overall control system. This section serves as a critical reference for system design, procurement, and construction.

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7.1 Line List and piping class

The line list is added to this deliverable in Annex 10.12. The piping class for each line is indicated in the line list. An overview of the different piping classes is added as Annex 10.13.

7.2 Instrumentation

The design criteria, operating conditions and technical requirements for the instrumentation and different valves as indicated on the P&IDs (see Section 5.1) are grouped on the different lists in this section.

7.2.1 Automatic, Manual, and Non-Return Valves List

For ease of operation and operator safety, the automatic valves in the pilot installation are electrically driven. The specifications of all manual, automatic, and non-return valves are given in Annex 10.14.

7.2.2 Instruments List

The list of instruments and their specifications is included as Annex 10.15. The pressure safety valves are listed and specified in Annex .

7.3 Control System

This section provides a comprehensive overview of the control system implemented across the various loops, describing the key components and their functions to ensure the optimal operation.

7.3.1 Water loop Control description

The control system of the water loop is designed to ensure efficient and safe regulation of temperature, pressure and flow, ensuring a stable process for heat transfer. The detailed operation of this loop's control is described below.

The Water Buffer Tank (T-001) is connected to a nitrogen bottle station via an automatic pressure regulator PCV-01 valve with a setpoint of 12 barg. In order to control the maximum pressure in the tank, Pressure Transmitter PT-01 monitors the internal pressure and Pressure Indicator Controller PIC-01 will open the control valve PV-01 if the pressure gets high. To avoid spurious action from the control loops, the set point for the pressure relief controller PIC-01 is 0.2 barg higher than the set point of PCV-01.

Water circulation is ensured by the Water Circulation Pump (P-001), which keeps a continuous flow in the circuit. In the pump discharge, the flow is measured by Flow Transmitter FT-01 and controlled by Flow Indicator Controller FIC-01 which acts on the control valve FCV-01.

At the outlet of the Water Heater E-001, there is a Temperature Transmitter TT-01 and a Temperature Indicator Controller TIC-01. This control loop works with E-001 to keep the water at the right temperature.

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7.3.2 Molten salts loop Control Description

The main control parameters for the MS loop are the various temperature controllers that ensure a stable operation as the salts subsequently cool down and warm up in the loop.

At the discharge of the cold MS pump, P-002, the temperature is measured by TT-06 and the corresponding controller, TIC-03, regulates the power of the electric HTHP inlet heater E-002 to ensure a stable inlet temperature during experiments.

At the outlet or in bypass of the HTHP, the temperature is measured by TT-08 and the corresponding controller, TIC-04, regulates the power of the electric MS booster heater E-004.

At the outlet of the MS Air Cooler E-003, Temperature Transmitter TT-02 and Temperature Indicator Controller TIC-04 control the operation of E-003 to cool the salts to the required temperature.

7.3.3 Interlocks and operational safety

The following operational interlocks are included in the design for avoiding dry running of the pumps:

Table 12: Operational Interlock Overview

Trigger	*Action*
LT-01 HH	Stop P-001
LSL-02 activated	Stop P-002
LSL-01 activated	Stop P-003

7.3.4 I/O List

To ensure seamless integration and proper functionality of the system, a comprehensive I/O (Input/Output) list is essential. This document provides a detailed inventory of all input and output signals required for system control, monitoring, and automation. The I/O signals list is included as Annex 10.16.

7.4 Electrical installation

In Annex 10.18, a Single Line diagram is included that illustrates the power distribution setup, showing key elements such as transformers, circuit breakers, and load connections. This diagram serves as a reference for understanding the overall system architecture and assessing its reliability and performance.

7.5 Operating Modes

7.5.1 Normal operation

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In normal operation mode, the water loop is running, and water is circulating through the HTHP. The HTHP bypass line is closed. For the MS loop, normal operation includes the HTHP inlet heater and the HTHP. The bypass lines and the MS booster heater E-004 are not used.

Manual Valve position

The manual valves status (open or closed) is shown in Table 13.

Table 13: Manual Valve Position in Normal Operation mode

ID	Location	System	Status
VG-01	P-001 suction	Water Loop	Open
VG-02	P-001 discharge	Water Loop	Open
VG-03	HTHP inlet	Water Loop	Open
VG-04	HTHP outlet	Water Loop	Open
VG-05	HTHP bypass	Water Loop	Closed
VG-06	T-001 return line	Water Loop	Open
VG-07	T-001 fill line	Water Loop	Closed
VG-08	T-001 drain	Water Loop	Closed
VG-09	Water Loop drain	Water Loop	Closed
VG-10	N2 bottle	Water Loop	Open
VG-11	N2 bottle	Water Loop	Closed
VG-12	P-003 suction	MS Loop	Open
VG-13	P-003 discharge	MS Loop	Open
VG-14	P-002 suction	MS Loop	Open
VG-15	P-002 discharge	MS Loop	Open
VG-16	HTHP inlet	MS Loop	Open
VG-17	HTHP bypass	MS Loop	Closed
VG-18	HTHP outlet	MS Loop	Open
VG-19	E-004 inlet	MS Loop	Closed
VG-20	E-004 bypass	MS Loop	Open
VG-21	E-004 outlet	MS Loop	Closed

Controller set points

The set points for the controllers are represented in Table 14.

Table 14: Controller Setpoints in Normal Operation mode

ID	Instrument Description	System	Set point (low T)	Set point (high T)
FIC-01	Water loop flow controller	Water Loop	5 kg/s	1 kg/s

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PIC-01A	T-001 high SP pressure controller	Water Loop	12.2 barg	12.2 barg
PIC-01B	T-001 low SP pressure controller	Water Loop	12.0 barg	12.0 barg
TIC-01	Water loop temperature controller	Water Loop	20ºC	180ºC
TIC-02	Air Cooler outlet Temperature Controller	MS Loop	170°C	388ºC
TIC-03	HTHP Inlet Temperature Controller	MS Loop	171.3ºC	391.3ºC
TIC-04	MS Booster Temperature Controller	MS Loop	Not used	Not used

7.5.2 System startup

Before using the heat pump, it is necessary to start up of each of the loops separately. This can be done independently of each other and independently of the HTHP. The procedure to start up both loops independently are shown in Table 15 for the MS loop and in Table 16 for the water loop.

Table 15: MS Loop startup

1	Verify that the system is ready to receive molten salts
2	Switch on the electric tracing system on all MS lines and equipment
3	Confirm that the temperature of the lines gradually rises above the melting point of the salts (131°C)
4	Once the temperature is sufficiently high in the system (>170ºC), fill the cold MS tank T-002 up to 80%.
5	Check that the system is aligned to pass salt through E-002 and via the bypass of the HTHP and of E-004 to the hot MS tank T-003
6	Set TIC-03 to elevate the MS temperature slightly
7	Start the Cold MS Pump (P-002) and regulate the flowrate at 1-2 m3/h
8	Once the hot MS tank reaches 60% filling, stop P-002
9	Start the Hot MS Pump (P-003) and regulate the flowrate at 1-2 m3/h
10	Once the hot MS tank reaches 20%, stop P-003.
11	Line out the system through the MS booster heater E-004
12	Refill the cold MS tank T-002 to 80%
13	Start the Cold MS Pump (P-002) and regulate the flowrate at 1-2 m3/h
14	Start the Hot MS Pump (P-003) and regulate the flowrate at 1-2 m3/h
15	Regulate the flows to maintain constant levels in both MS tanks

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Table 16: Water Loop startup

1	Verify that the system is ready to receive water
2	Fill the Water Buffer Tank T-001 until 60%
3	Align the pressure control system (PCV-01 @ 12,0 barg and PIC-01 with a 12,3 barg SP)
4	Line out the system to circulate water through the HTHP bypass
5	Turn on the Water Circulation Pump (P-001) and take FIC-01 in service
6	Commission the Water Heater (E-001) by gradually increasing the SP on TIC-01

7.6 Heat Tracing

The tracing system is used for heating the molten salt system and maintaining the temperature of the pipes, equipment, valves and instruments to prevent freezing of the molten salts and thermal stress on materials and components. It will have its own automatic and independent control system for monitoring and to allow modifications to the circuit.

It is designed based on the heat loss through the insulation of the entire system, considering the minimum design temperate.

The heat tracing of equipment and pipes containing molten salts serves 2 goals:

- Ensuring that the system is always above 175 ºC to avoid freezing of the salt
- Preheating the empty system to 175ºC prior to introducing molten salt.

In Table 17, the tracing needs are summarized for all the MS components for compensating the heat losses. Considering the volume of metal that is needed for the construction of the MS loop, heating the system from 20°C to 200°C would take around 9 hours which is acceptable.

Table 17: Tracing needs per MS Loop part

Item	Tracing needs (kW)
EQUIPMENT	
T-002/T-002	0.27
P-002/P-003	0.40
E-002/E-004	0.17
PIPING	0.33
VALVES	0.11
TOTAL	**1.96**

7.7 System insulation

The hot surfaces in the pilot unit shall be isolated to avoid thermal losses that are detrimental to plant performance, to prevent burn injuries to personnel or to avoid excessive heating of the environment.

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There are two kinds of hot surfaces depending on the fluid in the system:

- Molten Salts Loop with a temperature range of 180°C-400°C.
- Water Loop with a temperature range of 20°C -180°C.

For the heat preservation insulation, the following design criteria have been established for thermal losses and insulation thickness calculation:

- Maximum allowed surface temperature: 60 °C.
- Emissivity: 0.05 (TBC).
- Design minimum ambient temperature: See Site Conditions (Chapter 2.1).
- Maximum heat losses allowed in mechanical equipment:
    - MS and water Tank: 50 W/m2.
    - Heat Exchangers: 50 W/m2.
    - Electric Heaters: 50 W/m2.
    - MS Pump (discharge elbow and flange): 150 W/m2.
- Maximum heat losses allowed in piping: 150 W/m2, resulting in maximum 11.97 W/m for 1” piping.

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8. Safety Review

The safety review was carried out using the "What if…" method which is explained in this chapter. The results of the analysis include P&ID modifications which are explained in this section.

8.1 "What if…" analysis

The What-If analysis presented for the I-UPS project is a Process Hazard Analysis (PHA) method originally developed in the 1960s by the British chemical industry as a simpler alternative to the HAZOP method. Its objective is to systematically identify and analyze the major hazards of a system, focusing on hazard exposure scenarios, causes, deviations, and weaknesses. This is done by involving a multi-skilled team to approach the analysis from different perspectives.

The What-If analysis process follows several structured steps. First, the context is defined by describing the operating parameters of the system's loops—in this case, a water loop and a molten salts loop. The water loop operates between 20ºC and 180ºC, while the molten salts loop operates between 250ºC and 400ºC, with detailed information provided for temperature, pressure, density, viscosity, flow rates, and specific heat in both loops.

Once the context is set, What-If questions are generated for each loop, considering potential deviations across different categories such as human factors, utilities, equipment, measurement errors, and personal protection. Examples include scenarios like using an incorrect concentration of material, incorrect valve operation sequence, power failures or automatic restoration, equipment over-pressurization, measurement errors, and exposure to hazardous materials.

Following the generation of What-If questions, each scenario is evaluated, and the associated risks are assessed. Risks are classified based on their severity into four levels: low, medium, serious, and high, with corresponding actions ranging from discretionary measures to urgent intervention. Possible actions to mitigate risks include the use of personal protective equipment (PPE), revised operating procedures, installation of alarms, implementation of interlocks, and even design modifications.

Finally, the What-If analysis includes the development of recommendations, prioritization of actions based on risk ratings, and the assignment of follow-up actions to ensure that all identified risks are managed appropriately. This structured and proactive approach aims to enhance the operational safety of the I-UPS high-temperature heat pump system under development.

8.2 Safety Review Results

The results from the safety review meeting that was held on 23/04/2025 are added in Annex 10.19. In the safety review, additional drain valves were added for operating purposes and several alarm values were added to the instrumentation already present in the P&ID. The

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latest revision of the P&ID that is included in Annex 10.1 already includes all the recommendations from the safety review.
Additionally, several recommendations were made for the further development of operating procedures and regarding the use of personal protective equipment (PPE).

9. Testing Plan

9.1 Testing objectives

The pilot tests should result in the following results:

- Validate the operational stability and efficiency of the heat pump in transferring energy between the water and molten salts loops.
- Measure the coefficient of performance (COP) across different operating conditions.
- Evaluate heat transfer efficiency and system response to load variations.
- Assess the long-term behaviour of molten salts and water under cyclic heating and cooling.

9.2 Test Setup and Instrumentation

9.2.1 Water Loop

The performance of the water loop can be analysed up using the following measurements:

Instrument	Measured	Calculated
TT-01	Water temperature to P-001 HTHP outlet temperature	Water density
FT-01	Volumetric flowrate to P-001	Mass flow rate
TT-02	E-001 outlet temperature	Heater power COP

The power usage of the E-001 water heater can also be used to estimate the HTHP heat removal once the system is operating in steady-state.

9.2.2 Molten Salts Loop

The performance of the molten salt loop can be analysed up using the following measurements:

Instrument	Measured	Calculated
TT-03	Hot MS temperature to P-002	Hot MS density
TT-04	Cold MS temperature to P-002	Cold MS density
FT-02	Volumetric flowrate to P-002	Mass flow rate
FT-03	Volumetric flowrate to P-003	Mass flow rate
TT-06 **TT-07**	HTHP Inlet and Outlet Temperature	HTHP heat transfer COP

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PT-06 **P7-07**	HTHP Inlet and Outlet Pressure	Pressure Loss through HTHP
TT-05 **TT-06**	E-002 inlet and outlet temperature	Heating duty
TT-06/TT-07 **TT-08**	E-004 inlet and outlet temperature	Heating duty
TT-03 **TT-04**	E-003 inlet and outlet temperature	Cooling duty

9.3 Warm-up and stabilization

Run the water loop and the molten salt loop at their start-up temperatures and slowly increase the temperature set point of E-002 and/or E-004 to assess the stability and performance of the system.

Monitor the stability of the levels in T-002 (LT-02) and T-003 (LT-03) and manually adjust the globe valves FV-02 and FV-03 to obtain a balanced flow. Keep the flowrates on the lower side of the pump curve.

9.4 Baseline testing

The baseline case for the pilot plant is running the cold MS system at 250ºC and the water loop at 20ºC.

9.5 Variable load testing

Once the baseline test data is recorded, different operational points can be investigated. Temperature variations are best carried out by selecting a cold MS temperature and starting the water loop at the lowest temperature. During the experiment, the water temperature can be increased step by step.
The water loop needs to cool down before another series of similar steps can be performed on a different MS temperature.

For every MS/Water temperature combination, heat pump parameters can be modified.

9.6 Transient testing

Step-changes on the water inlet temperature can be realized by changing the set point of the E-001 outlet temperature controller TIC-01. The electric heater will respond relatively quickly and the full water loop will follow the temperature change.

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For realizing step changes in the MS inlet temperature, the E-002 HTHP inlet heater outlet temperature can be altered by changing the set point of TIC-03.

9.7 Long-Duration testing

The design of the pilot plant allows in principle 24h continuous operation so there is no limit on long-duration testing from a technical point of view.

10. Annex

10.1 Piping and Instrumentation Diagrams

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Valves

General valve	Three way valve
Gate valve	Three way globe valve
Globe valve	Three way ball valve
Ball valve	Vacuum seal valve
Diaphragme valve	Automatic recirculation valve
Needle valve	Pressure safety relief valve
Butterfly valve	
Plug valve	Vacuum relief valve
Check valve	
Angle valve	Pressure & vacuum relief valve
	Rupture disc

Types of actuators

Electric motor actuator	Hydraulic actuator
Pneumatic actuator	Pressure reducing regulator
Solenoid actuator	Back pressure regulator

Valve positions

Manual valve with mechanical blocking: Locked Close/ Locked Open

Normally open.

Normally closed.

F.C F.O F.L Fail closed/open/last

Flowmeters

Orifice flowmeter.

Venturi flownozzle.

Tube of pitot.

Coriolis flowmeter.

Magnetic flowmeter.

Positive displacement flowmeter.

Ultrasonic flowmeter.

Vortex flowmeter.

Rotameter

Turbine Flowmeter

V cone.

Equipment

Air cooler

Centrifugal Pump

Electric heater

Vertical pressure vessel

Shell and Plate Cooler

Miscelaneos symbols.

Concentric reductor.	Safety shower and eye wash.
Eccentric reductor.	
Hose connection.	Water channel.
Thread end.	
Welded cap.	Calibration pot.
Blind flange.	Drain.
Sight glass	Goose neck.
Flexible connection.	Basket strainer.
Spectacle blind flange ("Figure 8 blind flange") Normaly opened.	"Duplex" strainer.
Spectacle blind flange ("Figure 8 blind flange") Normaly closed	Hose reel.
Orifice plate between orifice flanges.	Rupture disc.
Multiple restricted orifice.	Trifuncional vent.
Expansion joint.	
Ball joint.	Cartridger filter.
Dielectrical joint	
Steam trap.	Pulsation dampener
Silencer.	
"Y"strainer.	
"T"strainer.	
Rupture disc.	Level gauge.

Process or Utility lines

Capillary line.

Pneumatic line.

Supplier scope line.

Controll signal.

Software or data link.

Traced line or equipment.

> MIN MAX Values of signal.

Pipe slope tag.

Underground — Underground line.

Contractor scope / Scope by others — Interface point

Process line.

Line, Equipment and Element Codification

Equipment Codification:

P-001B
- Suffix for redundant equipment
- Sequential number
- Equipment type

Equipment Type:

EH Electric Heater
HEX Heat Exchanger
P Pump
T Tank
D Vessel
A Air Cooler
R Electric Resistance
EVA Evaporator
TS Screw
ST Screw Conveyor
C Compressor

Nozzles Type:

A: Inlet line
B: Inlet for temporary facilities
J: Pump nozzle
L: Level
M: Manhole/ Chimney
P: Pressure
S: Spare
T: Temperature
V: Vent line
W: PSV/VB

Element Valve Codification:

RD-01
- Element sequential number
- Valve/Element type

Element & Manual Valve Types:

AA Steam trap
AT Filter
BP Orifice plate
BZ Expansion joint
RD Rupture disc
VB Ball valve
VC Check valve
VD Diaphragm valve
VG Gate valve
VL Globe valve
VN Needle valve
VM Butterfly valve
VW 3-way valve
VY Y-type valve
VZ Other kind of valve

Codification for Automatic Valves & Instrumentation

LG 102 — Discrete instrument. Field Mounted.

PIC 101 — Shared display and control (DCS). Normally accessible to operator..

Codification for Automatic Valves:

P&ID Sheet — XV 101 — Automatic valve type; Valve sequential number

Codification for Instrumentation:

P&ID Sheet — LT 102 — Instrument type; Sequential number

Automatic Valve Types:

AV Analysis valve
FV Flow valve
LV Level valve
PV Pressure valve
TV Temperature valve
XV On/Off valve

Instrument Types:

FI Flow indicator
FT Flow transmitter
LG Level gauge
LI Level indicator
LT Level transmitter
PDI Differential pressure indicator
PDT Differential pressure transmitter
PG Pressure gauge
PI Pressure indicator
PT Pressure transmitter
TI Temperature indicator
TT Temperature transmitter

Drawing lines and symbols
- Molten Salt
- Condensate and Feed water
- Nitrogen

Notes:
Note 1.-Water connection.
Note 2.-Location suitable for system draining.

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02	01/04/2025	ISSUE AFTER SAFETY REVIEW	JLP	BDS	PSP
01	01/04/2025	FIRST ISSUE	CCG	BDS	PSP

Client: I-UPS

Supplier Eng.: RPOW

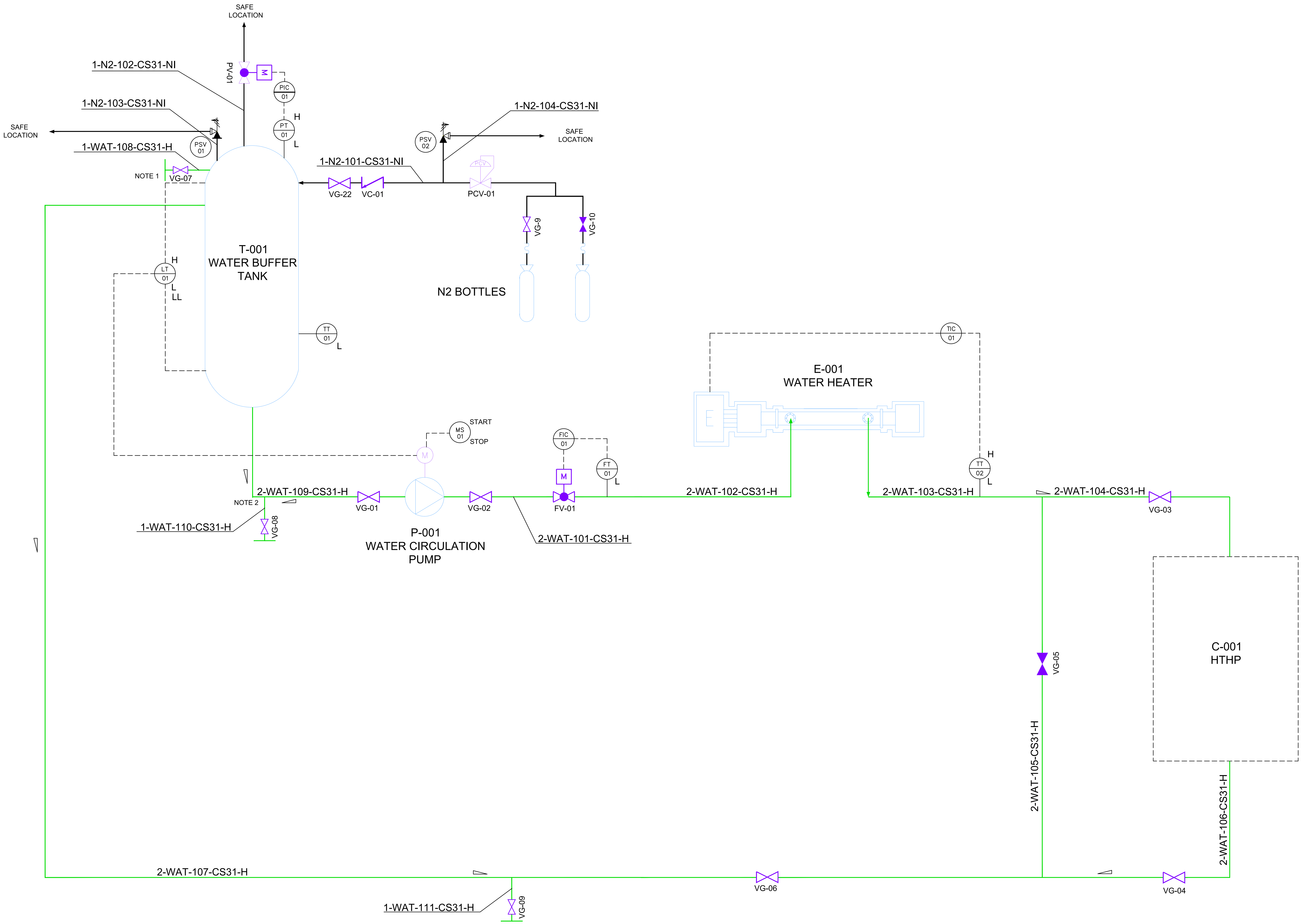
Scale: N/E

Title and Subtitles: PROCESS FLOW DIAGRAM — SYMBOLOGY

Project: I-UPS

Drawing No.: i2313-DRA-RPOW-104-002

Sheets: 03 Sheet No.: 01



Drawing lines and symbols

- Molten Salt
- Condensate and Feed water
- Nitrogen

Notes:
Note 1.–Water connection.
Note 2.–Location suitable for system draining.

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Supplier Eng.: RPOW

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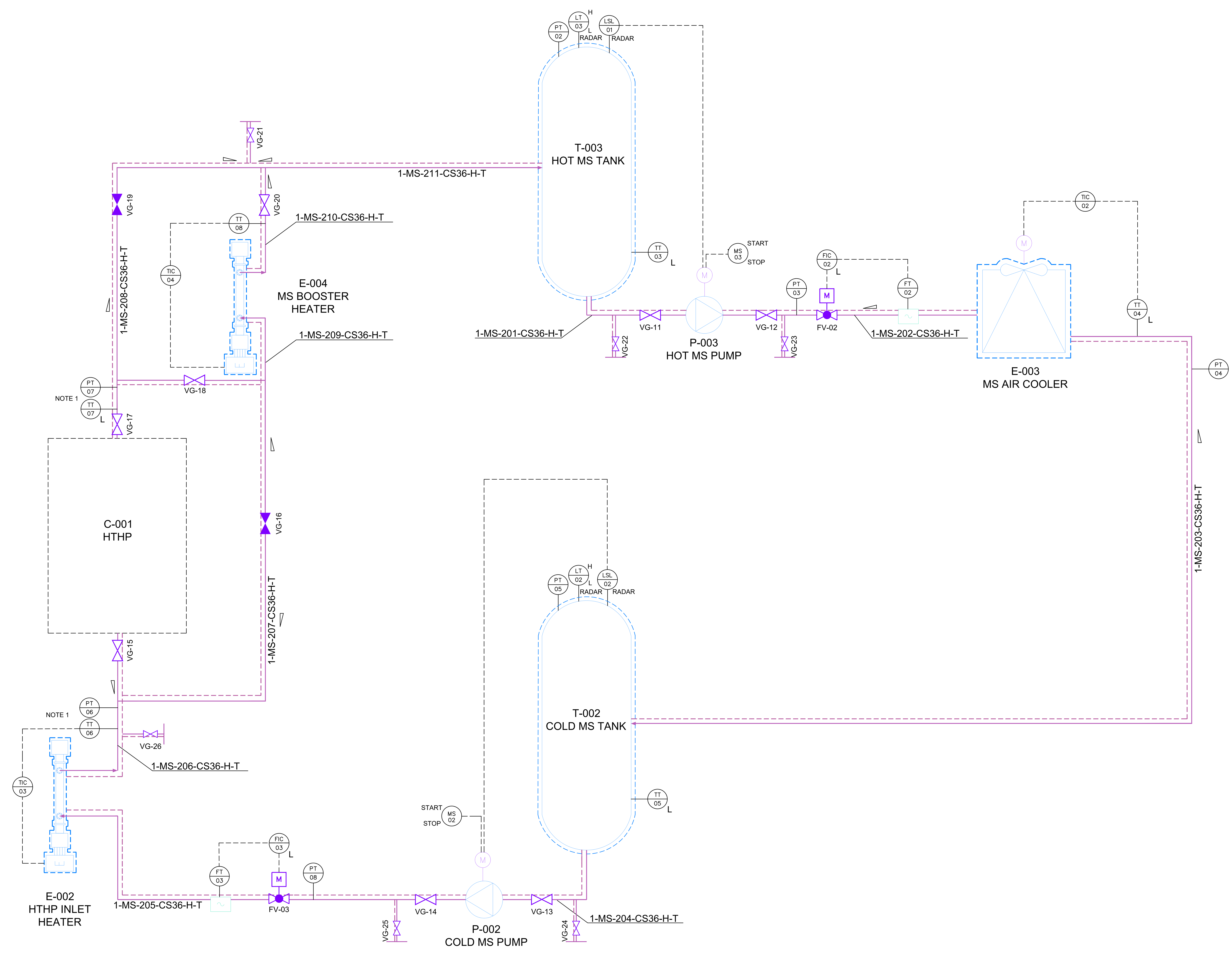
Title and Subtitles: PROCESS FLOW DIAGRAM — WATER LOOP

Project: I–UPS

Drawing No.: i2313–DRA–RPOW–104–002

Sheets: 03 | Sheet No.: 02



Drawing lines and symbols
- Molten Salt
- Condensate and Feed water
- Nitrogen

Notes:
Note 1.–Water connection.
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			Signature	Signature	Signature

Client: I-UPS

Supplier Eng.: RPOW

Scale: N/E

Title and Subtitles: PROCESS FLOW DIAGRAM
MS LOOP

Project: I–UPS

Drawing No.: i2313–DRA–RPOW–104–002

Sheets: 03 Sheet No.: 03

10.2 Equipment List

Item	TAG	Equipment description	P&ID	P&ID sheet	P&ID Rev	Material of construction		Design conditions		Notes
						Shell / Casing	Tube/Impeller	Temperature (ºC)	Pressure (barg)	
1	E-001	Water Heater	i2313-DRA-RPW-107-002	02	01	By vendor	By vendor	195	16	
2	E-002	HTHP Inlet Heater	i2313-DRA-RPW-107-002	03	01	Stainless steel	-	415	2,5	
3	E-003	MS Air Cooler	i2313-DRA-RPW-107-002	03	01	By vendor	By vendor	415	2,5	KYOTO equipment
4	E-004	MS Booster Heater	i2313-DRA-RPW-107-002	03	01	Stainless steel	-	415	2,5	
5	P-001	Water Circulation Pump	i2313-DRA-RPW-107-002	02	01	By vendor	By vendor	195	16	
6	P-002	Cold MS Pump	i2313-DRA-RPW-107-002	03	01	EN 1.4581	EN 1.4581	415	2,5	KYOTO equipment
7	P-003	Hot MS Pump	i2313-DRA-RPW-107-002	03	01	EN 1.4581	EN 1.4581	415	2,5	
8	T-001	Water Buffer Tank	i2313-DRA-RPW-107-002	02	01	By vendor	By vendor	195	16	
9	T-002	Cold MS Tank	i2313-DRA-RPW-107-002	03	01	Stainless steel	Stainless steel	415	2,5	KYOTO equipment
10	T-003	Hot MS Tank	i2313-DRA-RPW-107-002	03	01	Stainless steel	Stainless steel	415	2,5	KYOTO equipment

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10.3 Electric Consumers List

Tag	Description	Rated power (kW)	Rated voltage (V)	Wires	Current type	Load type	Rated power factor	Starting power factor	Simultaneity factor	Starting type	Supply type	Fed from	Rev
P-001	Water Circulation Pump	0,6	230	1P+N+PE	a.c.	Motor	0,8	0,8	1	DOL	Normal	MCC I-UPS	01
P-002	Cold MS Pump	2,2	400	3P+N+PE	a.c.	Motor	0,8	0,8	1	VFD	Normal	MCC I-UPS	01
P-003	Hot MS Pump	2,2	400	3P+N+PE	a.c.	Motor	0,8	0,8	1	VFD	Normal	MCC I-UPS	01
											Normal	MCC I-UPS	01
E-001	Water Heater	25	400	3P+N+PE	a.c.	Other	1	1	1				01
E-002	HTHP Inlet Heater	20	400	3P+N+PE	a.c.	Other	1	1	1				01
E-003	MS Air Cooler	40,00	400	3P+N+PE	a.c.	Motor	0,8	0,8	1	DOL	Normal	MCC I-UPS	01
E-004	MS Booster Heater	20,00	400	3P+N+PE	a.c.	Other	1	1	1		Normal	MCC I-UPS	01
ET-01	Electrical Tracing	2,40	230	1P+N+PE	a.c.	Other	1	1	1		Normal	MCC I-UPS	01
CS-01	Control system	1,00	230	1P+N+PE	a.c.	Other	0,8	0,8	1		UPS	MCC I-UPS	01

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101147078.

10.4 T-001 Water Buffer Tank Datasheet

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101147078.

VENDOR

CLIENT

PROJECT

I-UPS

01	18/03/2025	First issue	CC	BDS	AMQ
REV	***DATE***	***DESCRIPTION***	***DONE***	***CHECKED***	***APPROVED***

DOCUMENT NUMBER

i2314-DSH-RPW-150-003

SUBCONTRACTOR DOCUMENT NUMBER

DOCUMENT NAME

T-001 Water Buffer Tank Datasheet

Vendor:	Document Name	i2314-DSH-RPW-150-003			
	T-001 Water Buffer Tank Datasheet	Rev No.	01		
		Page	1	of	2

1	**General**				
	Codification		T-001		
	Service		Water Buffer Tank		
	Units		1		
	Configuration		Vertical		
	Heads		ASME 2:1 elliptical (1)		
	Body		Cilindrical		
	Useful life				
	Useful capacity				
	Total capacity				
	Liquid hold-up capacity		10-90%		
	Thickness		By vendor		
	Height (TL-TL)		1600 mm		
	Total Height		2000 mm (1)		
	Internal Diameter		900 mm		
2	**Operation Process conditions**				
	Fluid		Water		
	Operating Pressure		12 barg		
	Operating Temperature		20-180ºC		
	Density		998.2 kg/m3 at 20 °C / 907,5 kg/m3 at 180 °C		
	Viscosity		1.00 cP at 20 °C / 0.15 cP at 180 °C		
	Blanketing (Yes/No-Gas)		Yes - Nitrogen		
3	**Design information**				
	Design Code		ASME Sec. VIII Div. 1		
	Design pressure - internal		16 barg		
	Design pressure - external		FV		
	Test pressure		As per code		
	Design temperature		195ºC		
	Corrosion Allowance		1.6 mm		
	Thermal insulation (type/density/thick.)		Note 4		
	Max wind velocity				
	Seismic Group		As per code	Seismic Parameters	N/A
	Radiografic NDT		SPOT	Welding Efficiency	As per code
	Certification		As per code		
	Heat Treatment		By Code ASME Sec. VIII Div. 1		
4	**Material Specification**				
	Component		Material		Thickness (By vendor)
	Shell		Carbon Steel A516 Gr.70		*
	Head		Carbon Steel A516 Gr.70		*
	Tank supports		Carbon Steel A516 Gr.70		*
	Internal supports		By vendor		*
	Stiffeners rings		By vendor		*
	Plates		By vendor		*
	Base rings		By vendor		*
	Gaskets (RF/RTJ) (10)		Graphite spiral wound		*
	Nozzles	Flanges/fittings	A-105		*
		Necks of pipes	By vendor		*
		Neck of metal sheets	Carbon Steel A106 Gr.B		*
	Internal elements	Profiles	N/A		*
		Pipes	A106 Gr.B		*
		Fittings	A 105 / A234 WPB		*
		Plates	Carbon Steel A516 Gr.60		*
		Meshes	N/A		*
		Accesories	A 105 / A234 WPB		*
	Bolts/Nuts	External	A 193 B7 / A 194 2H		*
		Internal	N/A		*
5	**Surface treatment**				
	Internal		By Vendor		
	External		By Vendor		
	Cleaning		By Vendor		
	Internal painting		No		
	External painting		By Vendor		

Vendor: RPOW	Document Name	i2314-DSH-RPW-150-003		
	T-001 Water Buffer Tank Datasheet	Rev No.	01	
		Page	2 of 2	

6 Construction information (By vendor)

Description	Supplied by	Assembly by
Blind flanges,screws, ext joints and davit	By vendor	By vendor
Insulation clips	By vendor (2)	By vendor
Identification plate	By vendor. Stainless Steel	By vendor
Saddle	Fixed and sliding supportation	By vendor
Connections for groundings and lighting rod	By vendor	By vendor
Lifting lugs	By vendor	By vendor

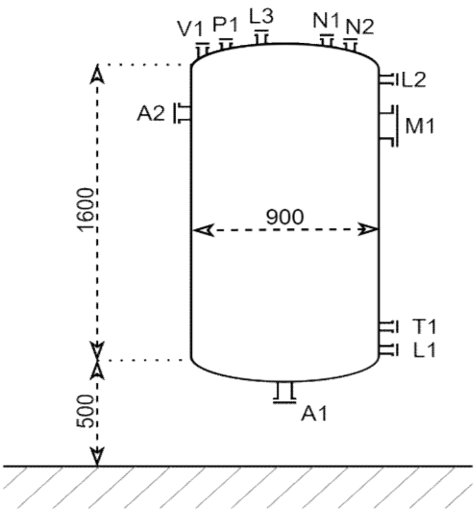
Weight and Capacity (By vendor)

Insulation Weight (kg)	By vendor
Assembly Weight (kg)	By vendor
Content Weight (kg)	By vendor
Operating Weight (kg)	By vendor
Weight full of water (kg)	By vendor

7 NOTES

(1) To be confirmed/defined by Vendor.
(2) Insulation clips shall be designed to allow tank to grow without restraining the vessel or causing compressive stresses.
(3) Manway size and location TBC by vendor.
(4) Thermal insulation material and thinkness shall be calculated by thermal insulation vendor,

8 Tank Sketch



9 Nozzle Data (TBC)

Mark number	Place	Description	Quantity	Size (NPS)	Rating	Type	Code	Position (2)			Notes
								Height (ft)	Angle (º)	Radius (in)	
								h	α	R	
A1	Bottom Head	Water outlet	1	2"							
A2	Shell	Water Inlet	1	2"							
L1	Shell	Delta P level	1	2"							
L2	Shell	Delta P level	1	2"							
L3	Shell	Radar level	1	2"							
M1	Shell	Manhole	1	24"							(3)
N1	Upper Head	Air inlet		1"							
N2	Upper Head	Vent	1	1"							
P1	Upper Head	Pressure Transmitter	1	2"							
T1	Shell	Temperature Transmitter	1	1"							
V1	Upper Head	PSV	1	2"							

10.5 P-001 Water Circulation Pump Datasheet

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101147078.

SUPPLIER

CLIENT

PROJECT

I-UPS

01	18/03/2025	First Issue	BDS	AMQ	AMQ
REV	***DATE***	***DESCRIPTION***	***DONE***	***CHECKED***	***APPROVED***

DOCUMENT NUMBER	***DOCUMENT NAME***
i2313-DSH-RPW-202-004	**Water Circulation Pump**
SUBCONTRACTOR DOCUMENT NUMBER	

Supplier:	Document Name	i2313-DSH-RPW-202-004	
	WATER CIRCULATION PUMP DATA SHEET	Rev. No.	1
		Page	1 of 2

Client I-UPS **Item No.**

Area Water Loop **Unit name :** Water Circulation Pump **Location**

No.		
1	Note: ❍ Indicates Information to be Completed by Purchaser	☐ By Manufacturer
2	Service Hot and cold water	
3	No. Pumps Req'd. 1 No. Motors Req'd. 1	Provided by Vendor Mtd. by
4	No. Turbines Req'd.	Provided by Mtd. by
5	Pump Mfr.	Size & Type
6	**OPERATING CONDITIONS**	**PERFORMANCE**
7	Fluid Water / m³/h at PT mi (2) Rated (2)	Proposal Curve No.
8	PT = Pumping Temperature / Disch. Press. bar g (2)	No. of Stages rpm
9	PT °C Min (2) Max. (2) / Suct. Press. bar g Ma› (2) Norm (2)	Suction ● Single ❍ Double
10	Density at PT kg/m3 Min (2) Max. (2) / Diff. Press. bar (2)	NPSH Req'd. (water)m
11	Vap. Press. at PT bara (2) / Diff. Head m (@ OP flow) (2)	Des. Eff. % kW Rated
12	Visc. at PT cP Min (2) Max. (2) / NPSH Avail. m at Pump C.L. (2)	Max. kW Rated Imp. kW Nor.
13	Corr./Eros. Caused By N/A / Hydraulic Power (2)	Max. Head Rated Imp. m
14	**CONSTRUCTION**	Min. Continuous m³/h
15	NOZZLES / SIZE / RATING / FACING / LOCATION	Rotation Facing Coupl. ☐ cw ☐ ccw
16	Suction / By Vendor / 300# (3) / RTJ / END	Shutt-off Pressure bar g
17	Discharge / By Vendor / 300# (3) / RTJ / TOP	**MATERIALS**
18	Case -Mount ☐ Centerline ☐ Foot ☐ Bracket ☐ Vertical	Pump Casing Carbon Steel (1)
19	-Split ☐ Axial ☐ Radial	Impeller SS316 (1)
20	-Type ☐ Single Volute ☐ Double Volute ☐ Diffuser	Wear Rings
21	-Press. ☐ Max. Allow. bar g °C ☐ Hydrotest bar g	Shaft/Sleeve
22	-Connect. ☐ Vent ■ Drain Valved ☐ Gage	Base Plate
23	Impeller Dia. Rated mm Max. mı Type:	**SHOP TESTS**
24	-Mount ☐ Between Bearings ☐ Overhung	● Performance ● Witnessed
25	Bearing Type ☐ Radial ☐ Thrust	● Hydraulic ❍ Witnessed
26	-Lube ☐ Ring Oil ☐ Flood ☐ Oil Mist ☐ Flinger	❍ NPSH required ❍ Witnessed
27	☐ Pressure bar g ☐ Constant Level Oiler	● Shop Inspection ❍ Vibrations
28	Coupl. & Guard ☐ Mfr. ☐ Model	❍ Dismant. & Insp. after Test
29	Driver Half Mtd. by ❍ Pump Mfr. ❍ Driver Mfr. ❍ Purchaser	❍ Other
30	SHELL DESIGN: TEMP. (ºC) PRESS (barg)	**VERTICAL PUMPS**
31	**SEALING ARRANGEMENT**	❍ Pit or Sump Depth mm
32	❍ Packing ☐ Mfr. & Type ☐ Size/No. of Rings	☐ Min. Submerge Required mm
33	❍ Magnetic ☐ Mfr. & Type	Column Pipe ☐ Flanged ☐ Threaded
34	● Mech. Seal ☐ Mfr. & Model API Class Code	Line Shaft ☐ Open ☐ Enclosed
35	If mechanical seal ● Single ❍ Double ❍ Tandem	BRGS ☐ Bowl ☐ Line Shaft
36	❍ Canned Pump ❍ Sealless (Magnetic drive)	BRGS Lube ☐ Water ☐ Oil ☐ Grease
37	**AUXILIARY PIPING**	Float & Rod Material ❍
38	☐ C.W. Pipe Plan ☐ Material	☐ Float Switch
39	☐ Total C.W. Req'd. ☐ Sight F.I. Req'd.	☐ Pump Thrust kg ☐ Up ☐ Down
40	☐ Pack. Cool. Inj. Req'd. ☐ Total ☐ bar g	**WEIGHTS**
41	☐ Seal Flush Pipe Plan ☐ Material	Pump & Base kg
42	☐ Ext. Seal Flush Fluid ☐ m³/h ☐ bar g	Motor kg Turbine kg
43	☐ Aux. Seal Plan ☐ Material	**APPLICABLE SPECIFICATIONS**
44	☐ Aux. Seal Quench Fluid	● Pumps ❍ Piping Class
45		❍ Motors
46	**MOTOR DRIVER**	❍ Painting
47	kW rpm Frame 400 V 3 pH 50 Hz	❍ Noise Abat.
48	Mfr. Type	**SITE DATA**
49	Bearings Lube Full Load AMP's	Installation ❍ Indoors ● Outdoors
50	Insul. Encl. °C	Duty ● Continuous ❍ Intermittent
51	❍ VHS ❍ VSS Vert. Thrust Cap. kg. Lock. Rotor AMP's	(hours) (Min.)/Day
52	Area Classification: Zone Group Temperature	☐ **HEATING JACKET**
53	**TURBINE DRIVER**	Elect. V. Ph. Hz. kW
54	kW rpm	Steam at barg °C Quant kg/h
55	Mfr. Type	☐ **GEAR**
56		Mfr.
57		Type
58		Service Factor Ratio
59	**PROTECTIVE INSTRUMENTATION**	
60	Leak Detection Yes	Mfg. & Model
61	Power monitoring Yes	Mfg. & Model
62	Temperature monitoring Yes	Mfg. & Model
63	Dry run protection Yes	Mfg. & Model
64	Bearing(s) Yes	Mfg. & Model
65	Other (By Vendor) Yes No	Mfg. & Model
66		
67		
68	**REMARKS :**	
69		
70	(1) To be confirmed by Vendor.	
71	(2) See Table on Page 2/2	
72		
73		
74		
75		
76		
77		
78		
79		

Supplier:	Document Name	i2313-DSH-RPW-202-004	
	MOLTEN SALT PUMPS DATA SHEET	Rev. No.	1
		Page	2 of 2

Client I-UPS **Item No.**

Area Water Loop **Unit name :** Water Circulation Pump **Location**

Note: ❍ Indicates Information to be Completed by Purchaser ☐ By Manufacturer

Service Hot and cold water

No. Pumps Req'd. No. Motors Req'd. Provided by Mtd. by

No. Turbines Req'd. Provided by Mtd. by

Pump Mfr. Size & Type

Pump Operating Conditions

		Case 1	Case 2
		Operating	Operating
umping Temperature	ºC	15	180
Density	kg/m^3	999,1	887,2
Vapour pressure	bara	0,02	10,03
Viscosity	cP	1,14	0,15
Flow rate	m3/h	18,0	4,0
Discharge Pressure	barg	13,98	13,81
Suction Pressure	barg	12,07	12,10
Differential Pressure	bar	1,91	1,71
Differential Head	m	19,48	19,52
NPSH available	m	133,4	47,81
Hydraulic Power	kW	0,96	0,19

REMARKS :

10.6 E-001 Electric Water heater datasheet

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101147078.

VENDOR

CLIENT

PROJECT

I-UPS

01	18/03/2025	First issue	CCG	BDS	AMQ
REV	***DATE***	***DESCRIPTION***	***DONE***	***CHECKED***	***APPROVED***

DOCUMENT NUMBER

i2313-DS-RPW-203-008

SUBCONTRACTOR DOCUMENT NUMBER

DOCUMENT NAME

Electric Water Heater Data Sheet

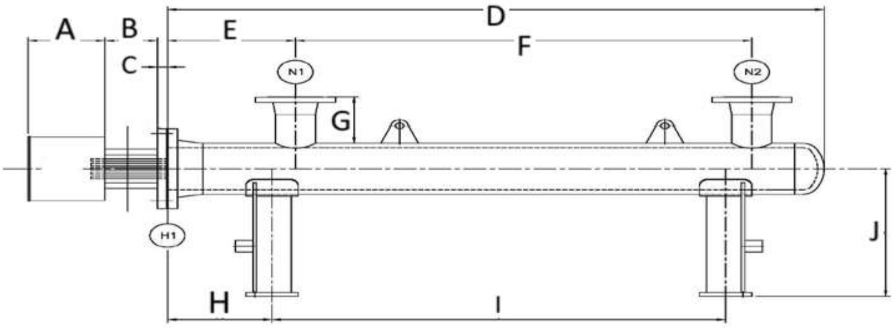
VENDOR	Document Name		i2313-DS-RPW-203-008		
RPOW	Electric Heater Datasheet	Rev No.	01		
		Page	1	of	2

1	**General**		
	Codification	E-001	
	Service	Water Heating	
	Trains	1	
	Lifetime (years)		
	Units per train (Vessels)		
	Duty Heater (kW)		
2	**Process Details**		
	Fluid	Water	
	Operational scenarios	Inlet/Outlet (Low temp case)	Inlet/Outlet (High temp case)
	Mass Flow rate (kg/s)	5.00/5.00	1.00/1.00
	Inlet/Outlet temperature (ºC)	19/20	172/180
	Specific heat (kJ/kg.K)	4.18/4.18	2.56/2.59
	Thermal conductivity (w/m.K)		
	Density (kg/m3)	998.5/998.2	903.1/907.5
	Enthalpy (kJ/kg)	79.9/83.9	742.6/762.6
	Viscosity (cP)		
	Heat exchanged (kW)	9 - 25 kW	
	Pressure drop (bar)	Max. 0.2 bar	
	Operating pressure (barg)	12,00	12,00
	Minimum flow rate (kg/s)	0,25	
	Minimum Load (kW)		
3	**Element Details**		
	No. Active / Type	By Vendor	By Vendor
	No. Spare	By Vendor	
	No. Stages / Circuits	By Vendor	
	No. Active Elements per stage	By Vendor	
	Diameter (mm)	By Vendor	
	Active 'U' (mm)	By Vendor	
	Total Load (kW)	By Vendor	
	Element Load (kW)	By Vendor	
	Electrical supply (V / Hz / Ph)	400 / 50 Hz / 3 Ph	
	Flux (W/SQ.CM)	By Vendor	
	Safe Area	Yes	
	Sheath Temperature (ºC)	By Vendor	
4	**Baffle Details**		
	Baffle Arrangement	By Vendor	
	Baffle Pitch (mm)	By Vendor	
	Buffle Cut	By Vendor	
	Baffle Thk (mm)	By Vendor	
	No. Of Tie Rods	By Vendor	
	Tie Rods Diameter (mm)	By Vendor	
5	**Design Data**		
	Design Code	EN 13445 / ASME VIII Div 1 (Not U-Stamp)	
	PED Compliant	YES - CAT 1	
	Equipment orientation	Horizontal	
	Design Pressure (barg)	16	
	Design Temperature (ºC)	195	
	Corrosion Allowance (mm)	1.6	
	Radiagrphy (%)	SPOT	
	Ambient Temperature (ºC)	-6 / 45 ºC	
	Certification	As per code	
6	**Heat Transfer Data**		
	Total Surface area (m2)	By Vendor	
	Heat Transfer Coefficient (w/m2·ºC)	By Vendor	
	Mean Temperature Difference (ºC)	By Vendor	
7	**Weights**		
	Heater Bundle Weight (kg)	By Vendor	
	Total - Empty Weigth (kg)	By Vendor	
	Test Weigth (kg)	By Vendor	
	Vessel diameter (mm)	By Vendor	
	Total lenght (mm)	By Vendor	
8	**Materials (5)**		
	Shell	Carbon Steel	
	Head	By Vendor	
	Flanges	By Vendor	
	Plate	By Vendor	
	Bolts/Nuts	By Vendor	
	Baffles / Tie Rods	By Vendor	
	Gasket	By Vendor	
	Element type	By Vendor	

9	**Instrumentation Summary**				
		Quantity	Type	Material	Other
	Element sensor	By Vendor	By Vendor	By Vendor	
	Process Sensor	By Vendor	By Vendor	By Vendor	
	Flange Sensor	By Vendor	By Vendor	By Vendor	
	T- Box sensor	By Vendor	By Vendor	By Vendor	
	Junction box	By Vendor	By Vendor	By Vendor	
	Transmitter	By Vendor	By Vendor	By Vendor	

VENDOR	Document Name	i2313-DS-RPW-203-008			
RPOW	Electric Heater Data Sheet	Rev No.	01		
		Page	2	of	2

10 **Electric Heater Sketch**



Vendor shall provide above dimensions or other if relevent.
Vendor shall provide slope of the vessels to be fully drained (min 3%).

11 **Connections (Note 4)**

Mark number	Description	Quantity	Size	Rating	Type	Code	Notes
H1	HEATER	1	TBD				
N1	INLET	1	2"				
N2	OUTLET	1	2"				
N3	DRAIN	1	1/2"				TBC
N4	VENT	1	1/2"				TBC
Others	PSV	1	1/2"				TBC

12 **Power Control Panel Features**

Number of cabinets	By Vendor	
Control panel duty (kW)	By Vendor	
Voltage / Phase / Frecuency (V / ph / Hz)	400 / 3 ph / 50	
Main Incoming current (Amp)	By Vendor	
Height (mm)	By Vendor	
Width (mm)	By Vendor	
Depth (mm)	By Vendor	
Weight (kg)	By Vendor	
Heat generated by panel (W)	By Vendor	
Type of electrical panel	By Vendor	
Identification plate	Stainless steel	
Connections for groundings	By Vendor	
Lifting lugs	By Vendor	
Protection Class (IP)	IP 66	
Safe Area	Yes	
Case material	Steel	
Calour (RAL)	By Vendor	
Panel Mounting	Floor mounting	
Cooling	By Vendor	
Power control (Note 2/Note 4)	By vendor	
Temperature regulation (Local / Remote)	From load control panel / From DCS 4-20 mA signal	
Temperature regulation range (°C) (1)	15,2	180

13 **Outgoing signals from Panel to DCS (Note 4)**

Signal Designation	From	To	Type
Feedback panel status (ON/OFF)	Control Panel	DCS	Dry contact
Common fault	Control Panel	DCS	Dry contact
Earth leakage	Control Panel	DCS	Dry contact
Heating element over temp.	Control Panel	DCS	Dry contact
Vessel over temp.	Control Panel	DCS	Dry contact
Local / Remote Status	Control Panel	DCS	Dry contact
Thyrisitr load failure	Control Panel	DCS	Dry contact
Fan failure	Control Panel	DCS	Dry contact
Others	Control Panel	DCS	By Vendor

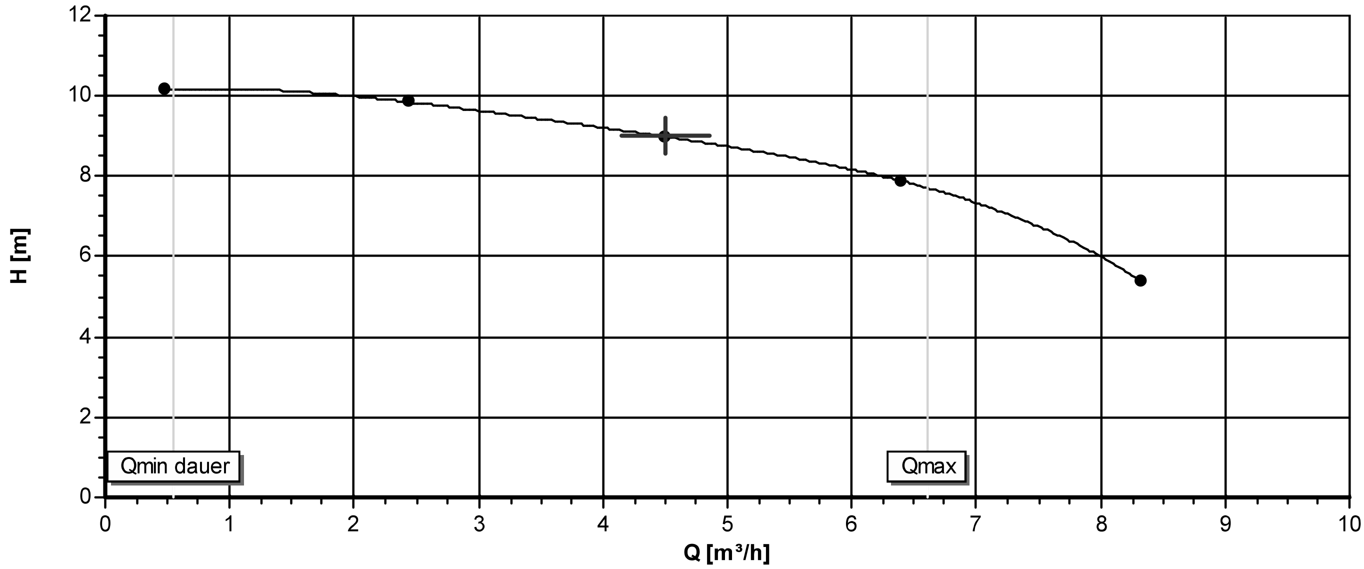
Note 1: Upper and Lower operational conditions are shown.

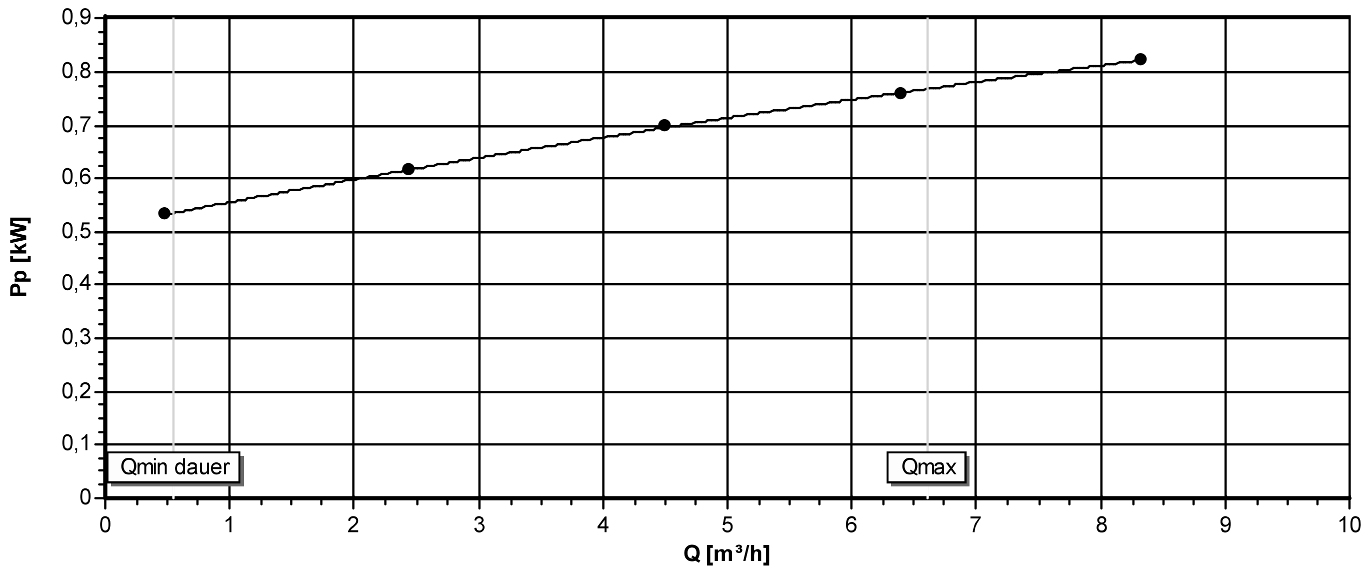
10.7 Existing Klaus Union Pump datasheet from KYOTO

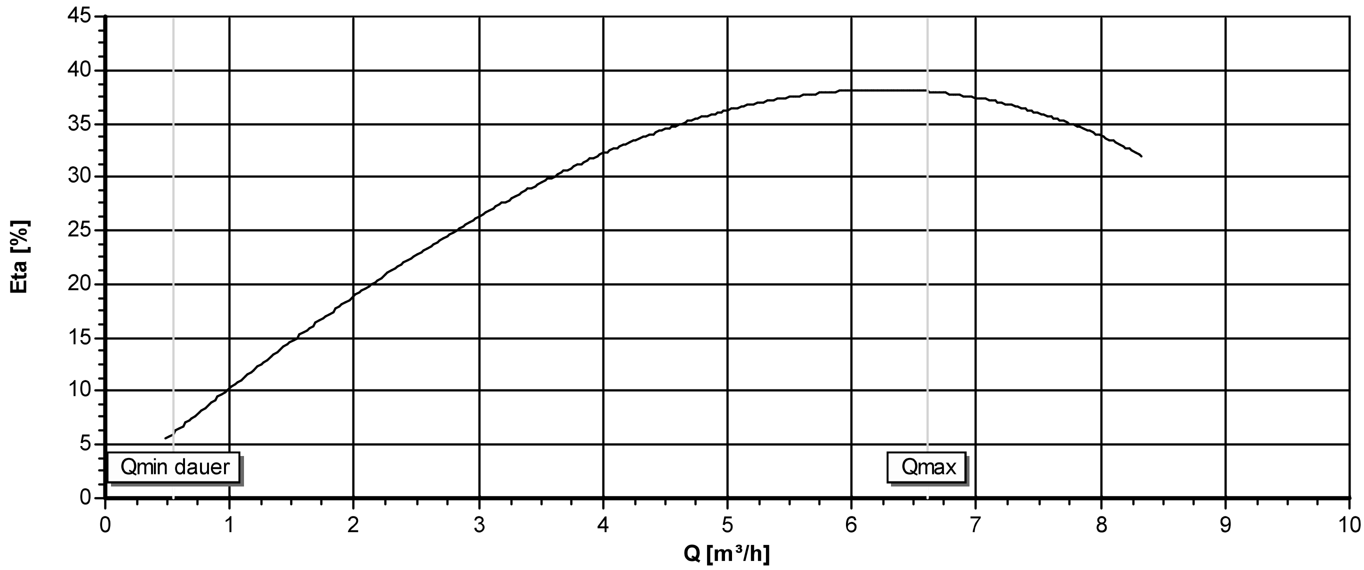
This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101147078.

KLAUS UNION	Pump type:	**SLM NHO 040-025-160-09T02**		
	Customer:	**Nordic Flow AS**	KU job No.:	**1.068022.0001**
	P.O. No.:	**20210102**	Item No.:	**0**
Service data	Item No.:		Serial No.:	**SN0089835**

Q:	4,50 [m³/h]	n:	1450 [1/min]	Density:	2,137 [kg/dm³]	Curve No.:	**AV 64.474 ka**
H:	9,00 [m]	t:	450 [°C]	Viscosity:	2,10 [mPas]	Date:	02.03.2022
P:	0,64 [kW]	Dia. D2:	168 [mm]	D2 act	168/ 168/ 168 [mm]	Tester:	







Data sheet
Centrifugal pump with magnet drive

KLAUS UNION

Prepared by	I. Flöhren
Date	2022-04-07

JOB DATA					
Customer	Nordic Flow AS		Job No.	1.068022-1.0.0	
Purchase Order No.	20210102		Serial Nos.	SN0089835	
Item Customer			Sectional dwg.	5013.0179	
Pump Type	SLM NHO 040-025-160-09T02 F		Dimensional dwg.	5913.0348	

FLUID					
Fluid	Liquid Molten Salt		Viscosity	2,10	mPas
Operating temp.	450,00	°C	Vapour pressure	N/A	bar(a)
Density	2137,00	kg/m³	NPSHA	N/A	m

PUMP DATA						
ATEX Ex II Kat. Gc Temp.	Kat. 2G Temp. T1-4		Head of Qmin		Refer to curve	m
Number of stages	1		Lubrication			
Self-priming	No		Min. rate of flow		0,55	m³/h
Speed	1450	1/min	Impeller diameter	Min	140	mm
Rated rate of flow	4,50	m³/h		Rated	168	mm
Rated delivery head	9,00	m		Max	168	mm
NPSHR	0,80	m	Design	10,00 bar	450,00	°C
Shaft power	0,64	kW	Nominal pressure	25,00 bar	120,00	°C
Efficiency	36,85	%	Test pressure	24,00 bar	20	°C
Loss of power	0,08	kW	Tightening Torque Screw Isolation Shell		20,000	Nm

CONNECTIONS					
Suction nozzle	Nominal pressure	PN 25	Drain	Nominal pressure	PN 40
	Nominal diameter	40		Nominal diameter	15
	Standard	DIN EN 1092-1		Standard	DIN EN 1092-1
Discharge nozzle	Nominal pressure	PN 25	Heating	Nominal pressure	N/A
	Nominal diameter	25		Nominal diameter	N/A
	Standard	DIN EN 1092-1		Standard	ohne

MATERIALS			
Casing	1.4408	Intermediate lantern	1.0619
Impeller	1.4408	Isolation shell/flange	1.4571/4404/2.4610
Wear ring, casing	1.4571	Magnet carrier	1.4571
Wear ring, impeller	N/A	Magnet	Samarium Cobalt
Pump shaft	1.4462	Inside bearing	1.4571/CRC // 1.4571/FH42A
Drive shaft	1.7227	Coupling guard	N/A
Casing gasket	KINGER MILAM PSS200	Base plate	N/A
Bearing support	1.0619		

10.8 P-002/P-003 Molten Salt Pumps Datasheet

This project has received funding from the European Union’s Horizon Europe research and innovation programme under grant agreement No 101147078.

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PROJECT

Innovative High Temperature Heat Pump for Flexible Industrial Systems

01	26/03/2025	First Issue	BDS	PSP	AMQ
REV	***DATE***	***DESCRIPTION***	***DONE***	***CHECKED***	***APPROVED***

DOCUMENT NUMBER **i2313-DSH-RPW-202-014**	***DOCUMENT NAME*** **MS Pumps Data Sheet**
SUBCONTRACTOR DOCUMENT NUMBER	

Supplier:	Document Name	i2313-DSH-RPW-202-014
RPOW CONSULTING	MOLTEN SALT PUMPS P-002/P-003 DATA SHEET	Rev. No. 01
		Page 1 of 2

Client I-UPS **Item No.**

Area MS Loop **Unit name :** P-002/P-003 **Location**

Note: ○ Indicates Information to be Completed by Purchaser ☐ By Manufacturer

Service Molten Salts

No. Pumps Req'd. 2 No. Motors Req'd. 2 Provided by Vendor Mtd. by

No. Turbines Req'd. Provided by Mtd. by

Pump Mfr. Size & Type

OPERATING CONDITIONS EACH PUMP		PERFORMANCE
Fluid Ternary Salts (Yara MOST) (1)	m³/h at PT Nc (3) Rated (3)	Proposal Curve No.
PT = Pumping Temperature	Disch. Press. bar g (3)	No. of Stages rpm
PT °C Min. (3) Max. (3)	Suct. Press. bar g Max (3) Norm (3)	Suction ● Single ○ Double
Density at PT kg/m3 Min. (3) Max. (3)	Diff. Press. bar (3)	NPSH Req'd. (water)m
Vap. Press. at PT bara N/A	Diff. Head m (@ OP flow) (3)	Des. Eff. % kW Rated
Visc. at PT cP Min. (3) Max. (3)	NPSH Avail. m at Pump C.L. (3)	Max. kW Rated Imp. kW Nor.
Corr./Eros. Caused By N/A	Hydraulic Power (3)	Max. Head Rated Imp. m

CONSTRUCTION					Min. Continuous m³/h
NOZZLES	SIZE	RATING	FACING	LOCATION	Rotation Facing Coupl. ☐ cw ☐ ccw
Suction	By Vendor	150#	RTJ	END	Shutt-off Pressure bar g
Discharge	By Vendor	150#	RTJ	TOP	**MATERIALS (2)**

Case -Mount ☐ Centerline ☐ Foot ☐ Bracket ☐ Vertical	Pump Casing Carbon Steel
-Split ☐ Axial ■ Radial	Impeller SS316
-Type ■ Single Volute ☐ Double Volute ☐ Diffuser	Wear Rings
-Press. ☐ Max. Allow. bar g °C ☐ Hydrotest bar g	Shaft/Sleeve
-Connect. ☐ Vent ■ Drain Valved ☐ Gage	Base Plate
Impeller Dia. Rated mm Max. mm Type:	**SHOP TESTS**
-Mount ☐ Between Bearings ■ Overhung	● Performance ○ Witnessed
Bearing Type ☐ Radial ☐ Thrust	● Hydraulic ○ Witnessed
-Lube ☐ Ring Oil ☐ Flood ☐ Oil Mist ☐ Flinger	○ NPSH required ○ Witnessed
☐ Pressure bar g ☐ Constant Level Oiler	● Shop Inspection ○ Vibrations
Coupl. & Guard ☐ Mfr. ☐ Model	○ Dismant. & Insp. after Test
Driver Half Mtd. by ○ Pump Mfr. ○ Driver Mfr. ○ Purchaser	○ Other
SHELL DESIGN: TEMP. (ºC) PRESS (barg)	**VERTICAL PUMPS**
SEALING ARRANGEMENT	○ Pit or Sump Depth mm
○ Packing ☐ Mfr. & Type ☐ Size/No. of Rings	☐ Min. Submerge Required mm
● Magnetic ☐ Mfr. & Type	Column Pipe ☐ Flanged ☐ Threaded
○ Mech. Seal ☐ Mfr. & Model API Class Code	Line Shaft ☐ Open ☐ Enclosed
If mechanical seal ○ Single ○ Double ○ Tandem	BRGS ☐ Bowl ☐ Line Shaft
○ Canned Pump ● Sealless (Magnetic drive)	BRGS Lube ☐ Water ☐ Oil ☐ Grease
AUXILIARY PIPING	Float & Rod Material ○
☐ C.W. Pipe Plan ☐ Material	☐ Float Switch
☐ Total C.W. Req'd. ☐ Sight F.I. Req'd.	☐ Pump Thrust kg ☐ Up ☐ Down
☐ Pack. Cool. Inj. Req'd. ☐ Total ☐ bar g	**WEIGHTS**
☐ Seal Flush Pipe Plan ☐ Material	Pump & Base kg
☐ Ext. Seal Flush Fluid ☐ m³/h ☐ bar g	Motor kg Turbine kg
☐ Aux. Seal Plan ☐ Material	**APPLICABLE SPECIFICATIONS**
☐ Aux. Seal Quench Fluid	● Pumps ○ Piping Class
	○ Motors
MOTOR DRIVER	○ Painting
kW rpm Frame 400 V 3 pH 50 Hz	○ Noise Abat.
Mfr. Type	**SITE DATA**
Bearings Lube Full Load AMP's	Installation ● Indoors ○ Outdoors
Insul. Encl. °C	Duty ● Continuous ○ Intermittent
○ VHS ○ VSS Vert. Thrust Cap. kg. Lock. Rotor AMP's	(hours) (Min.)/Day
Area Classification: Zone Group Temperature	☐ **HEATING JACKET**
TURBINE DRIVER	Elect. V. Ph. Hz. kW
kW rpm	Steam at barg °C Quant kg/h
Mfr. Type	☐ **GEAR**
	Mfr.
	Type
	Service Factor Ratio

PROTECTIVE INSTRUMENTATION			
Leak Detection	Yes		Mfg. & Model
Power monitoring	Yes		Mfg. & Model
Temperature monitoring	Yes		Mfg. & Model
Dry run protection	Yes		Mfg. & Model
Bearing(s)	Yes		Mfg. & Model
Other (By Vendor)	Yes	No	Mfg. & Model

REMARKS :

(1) Ternary Molten Salts data:

Composition: Calcium Nitrate=41-43% mass; Potassium Niotrate=42-44 mass; Sodium Nitrate=14-16% mass

pH (10% in water)= 7-8 (202C)

Melting point: 130-135 °C

Solidification: Delayed due to super-cooling effect

Thermal decomposition: > 525 °C

Impurities: Water insoluble < 500 ppm, Chloride < 1000 ppm; Ammonium < 300 ppm

(2) Vendor shall confirm material selection.

(3) See Table on Page 2/2

Supplier: RPOW	Document Name	i2312-DSH-RPW-142-62-001			
	MOLTEN SALT PUMPS DATA SHEET	Rev. No.	1		
		Page	2	of	2

Client I-UPS **Item No.**

Area MS Loop **Unit name :** Cold MS Pump **Location**

Note: ❍ Indicates Information to be Completed by Purchaser ☐ By Manufacturer

Service Cold Molten Salts

No. Pumps Req'd. No. Motors Req'd. Provided by Mtd. by

No. Turbines Req'd. Provided by Mtd. by

Pump Mfr. Size & Type

Pump Operating Conditions

		P-002		P-003	
umping Temperature	ºC	241,3	391,3	250	400
Density	kg/m^3	2025	1925	2019	1919
Viscosity	cP	13,3	2,6	11,8	1,4
Flow rate	kg/s	3,0	3,0	3,0	3,0
Discharge Pressure	barg	1,54	1,49	1,61	1,64
Suction Pressure	barg	-0,07	-0,03	-0,07	-0,02
Differential Pressure	bar	1,61	1,52	1,68	1,66
Differential Head	m	8,1	8,1	8,5	8,7
NPSH avail.	m	2,7	3,1	2,7	3,1
Hydraulic Power	kW	0,24	0,24	0,25	0,26

REMARKS :

10.9 MS Air cooler datasheet

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101147078.

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PROJECT

I-UPS

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DOCUMENT NUMBER

i2313-DSH-RPW-229-009

SUBCONTRACTOR DOCUMENT NUMBER

DOCUMENT NAME

MS AIR COOLER DATA SHEET

Supplier: RPOW	Document Name					i2313-DSH-RPW-229-009
	Air-Cooler Data Sheet				Rev No.	01
					Page	1 of 1

No.						
1	Client	I-UPS		Job . Ref		
2	Project	I-UPS		Proposal Ref.		
3	Plant Location	Norway		PID number		i2313-DRA-RPOW-104-002
4	Installation Location	Indoor		Equipment Tag No.		E-003
5	Service of Unit	MS Air cooler		Type/Number of units		Finned Tube Air Cooler / 1
6	Size/Type (Hor/Vert)	By Vendor		Connected In		
7	Surface/Unit (Gross./Eff) m2	By Vendor		Surf/Shell (G/E) m2		By Vendor
8	**Performance of the Unit**					
9	Fluid Allocation		Tube Side		Air Side (3)	
10			In	Out	In	Out
11	Fluid Name		Yara salt		Air	
12	Fluid Quantity Total	kg/s	3		(2)	
13	Gas (In/Out)	kg/s			(2)	(2)
14	Liquid (In/Out)	kg/s	3	3		
15	Vapor (In/Out)	kg/s				
16	Water (In/Out)	kg/s				
17	Non-Condensable (In/Out)	kg/s				
18	Temperature (In/Out) (1)	°C	250 / 400	241.3 / 391.3 (4)	(2)	(2)
19	Density (1)	kg/m3	2019.4 / 1918.8	2025.2 / 1924.7	(2)	(2)
20	Viscosity (1)	cP	11.8 / 2.42	13.3 / 2.61		
21	Molecular Weight, Vapor					
22	Molecular Weight, Noncondensable					
23	Specific Heat	kJ/kg °C	1.53	1.53	(2)	(2)
24	Thermal Conductivity	W/m °C	0.52	0.52	(2)	(2)
25	Enthalpy (1)	kJ/kg	382.5 / 612	369.2 / 598.67	(2)	(2)
26	Inlet pressure	barg	2.3		(2)	
27	Velocity	m/s	By Vendor	By Vendor	By Vendor	By Vendor
28	Pressure drop Allowed/Calculated	bar	0.1		(2)	
29	Fouling Resistance (Min.)	m2 °C/W	TBD		(2)	
30	Heat Exchanged (calculated/Design)	kW	40,0		40,0	
31	**Construction of One Unit**				**Sketch (Bundle/Nozzle Orientation)**	
32			Tube Side	Air Side		
33	Design/Test Pressure	barg	2.5	By Vendor		
34	Design Temperature	°C	415	By Vendor		
35	Certification	-	Safe area			
36	**Design, Material and Construction**					
37	Tube bundle					
38	Size (width x length):	m	By Vendor	Bundles in parallel:	-	By Vendor
39	Number of bundles/bay:	-	By Vendor	Bundles In series:	-	By vendor
40	Number of tube rows:		By Vendor	Structure mounting:	-	By Vendor
41	Tube					
42	Material	-	By Vendor	Number of tube /bundle:	-	By Vendor
43	Tube type	-	By Vendor	Length	m	By Vendor
44	Outside diameter	mm	By Vendor	Pitch	mm	By Vendor
45	Minimum wall thickness	mm	By Vendor	Layout	-	By Vendor
46	Fin					
47	Type	-	By Vendor	Selection temperature	°C	By Vendor
48	Material	-	By Vendor	Outside diameter	mm	By Vendor
49	Stock thickness:	mm	By Vendor	Fin density	/m	By Vendor
50	Header					
51	Split Headers:	-	By Vendor	Type	-	Plug / By Vendor
52	Header Plate Material	-	By Vendor	Plug Sheet Material	-	By Vendor
53	Tube Sheet Material	-	By Vendor	Corrosion Allowance	mm	
54	No. Of Passes	-	By Vendor	Tube Slope	mm/m	
55	Plug Material	-	By Vendor	Gasket Material	-	By Vendor
56	Nozzle (Note 6)					
57	Inlet nozzle quantity		By Vendor	Outlet nozzle quantity		By Vendor
58	Inlet nozzle size	in	By Vendor	Outlet nozzle size	in	By Vendor
59	Inlet nozzle rating and facing			Outlet nozzle rating and facing		
60	Vent nozzle quantity		By Vendor	Drain nozzle quantity		By Vendor
61	Vent nozzle size	in	By Vendor	Drain nozzle size	in	By Vendor
62	Vent nozzle rating and facing			Drain nozzle rating and facing		
63	Temperature indicator nozzle size :	in	By Vendor	Temperature Indicator nozzle rating and facing		
64	Pressure indicator nozzle size	in	By Vendor	Pressure Indicator nozzle rating and facing		
65	Chemical cleaning nozzle size :	in	By Vendor	Chemical cleaning nozzle rating and facing		
66	Operation points - N/A					
67	Flow	kg/s				
68	Temperature (In/Out)	°C				
69	Enthalpy (In/Out)	kJ/kg				
70	Heat Exchanged	kW				
71	Remarks					
72	Note 1: Upper and Lower operational conditions are shown.					
73	Note 2: To be confirmed by vendor					
74	Note 3: Air-cooler operates with ambient air. Maximal outlet temperature to stay below 60ºC.					
75	Note 4: Inner surface temperature to stay above 200ºC at all times					
76						
77						
78						

10.10 AITESA datasheet for MS Air Cooler

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101147078.

API Sheet

Air-Cooled Heat Exchanger Specification Sheet

Company: RPOW									
Location: Norway									
Service of Unit: MS Air cooler	Our Reference: 25056								
Item No.: E-003	Your Reference: I-UPS								
Date:	Rev No.: 0	Job No.:							
Size & Type	1,45	/	1,005	m	Type	Forced	Number of Bays	1	
Surf/Unit-Finned Tube	2,3	m²	Bare area/bundle	2,3	m²	Ratio (Total/Bare)	1		
Heat exchanged	34318	kcal/h		MTD, Eff	222,75	°C			
Transfer Rate-Finned	83,6	Bare, Service	67,3	Clean	85,2	kcal/(h-m²-C)			

PERFORMANCE DATA - TUBE SIDE

Fluid Circulated		Yara salt					In	/	Out
Total Fluid Entering	kg/h	10800			Density, Liq	kg/m³	2019,4	/	2025,2
		In	/	Out	Density, Vap	kg/m³		/	
Temperature	°C	250	/	241,3	Specific Heat, Liq	kcal/(kg-C)	0,3654	/	0,3654
Liquid	kg/h	10800	/	10800	Specific Heat, Vap	kcal/(kg-C)		/	
Vapor	kg/h	0	/	0	Therm. Cond, Liq	kcal/(h-m-C)	0,52	/	0,52
Noncondensable	kg/h	0	/	0	Therm. Cond, Vap	kcal/(h-m-C)		/	
Steam	kg/h		/		Freeze Point	°C			
Water			/		Bubble / Dew point	°C		/	
Molecular wt, Vap			/		Latent heat	kcal/kg			
Molecular wt, NC					Inlet pressure (abs)	bar	3,313		
Viscosity, Liq	cp	11,8	/	13,3005	Pres Drop, Allow/Calc	bar	0,1	/	0,19289
Viscosity, Vap	cp		/		Fouling resistance	m²-h-C/kcal	0,0001		

PERFORMANCE DATA - AIR SIDE

Air Quantity, Total	25000	kg/h	Altitude	90	m
Air Quantity/Fan	5,827	m³/s	Temperature In	20	°C
Static Pressure	7,76	mmH2O	Temperature Out	25,71	°C
Face Velocity 8,01 m/s	Mass velocity 9,55	kg/s/m²	Design Ambient	0	°C

DESIGN-MATERIALS-CONSTRUCTION

Design/Vac./Test Pres	2,5	/	/	bar	Design temperature 415	°C

TUBE BUNDLE			Header		Tube	
Size	m	1,45	Type	Manifold	Material	SA-213 TP347H
Number/bay	1		Material	Carbon Steel	Specifications	
Tube Rows	3		Passes	9	OD 31,75	Min Thk. 3,05 mm
Arrangement			Plug Mat.		No./Bun 27	Lng 0,85 m
Bundles	1	par	Gasket Mat.		Pitch 90 / 77,94	30 Degrees
Bays	1	par	Corr. Allow.	mm	**FIN**	
Bundle frame			Inlet nozzle (1)	42,85 mm	Type	Plain tubes
MISCELLANEOUS			Outlet nozzle (1)	42,85 mm	Material	
Struct. Mount.			Special Nozzles		OD	Tks mm
Surf.Prep			Rating	Program	No. #/in	Design Temp °C
Louvers			TI	PI	Code	ASME Code Sec VIII Div
Vibration Switches			Chem Cleaning		Stamp Yes	Specs

MECHANICAL EQUIPMENT

Fan,Mfr., Model		Driver, Type Program	Speed Reducer, Type
No./Bay 1	RPM	Mfr.	Mfr.&Model
Dia. 0,8 m	Blade(s)	No./Bay	No./Bay
Pitch	Angle	RPM	Rating hp
Blade(s)	Hub	Enclosure	Ratio
hp/Fan 0,77 kW	MinAmb	V/Phase/Hz / /	Support

Control Action on Air Failure-			Louvers
Degree Control of Outlet Process Temperature			
Recirculation			Steam Coil No
Plot Area m²	Drawing No.	Wt.Bundle 119,1	Wt. Unit 119,1 kg
Notes:			

10.11 MS Electric heaters datasheet (E-002 and E-004)

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DOCUMENT NUMBER

i2313-DSH-RPW-203-010

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DOCUMENT NAME

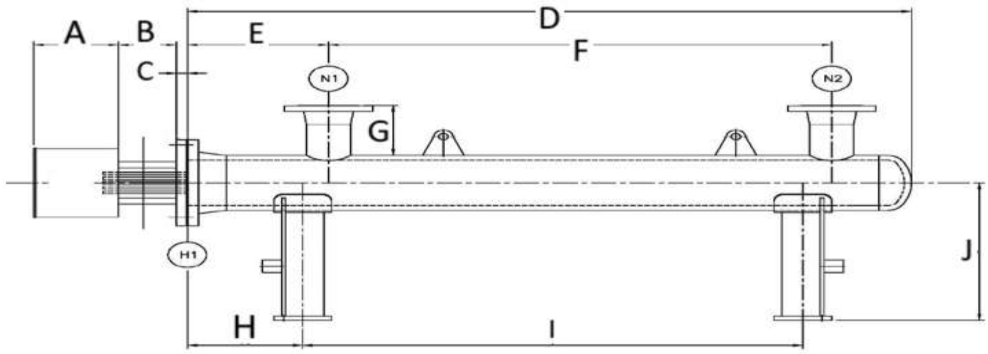
MS Electrical Heaters Data Sheet

VENDOR	Document Name	I2313-DSH-RPW-203-010			
RPOW	Molten Salts Electric Heaters Datasheet	Rev No.	01		
		Page	1	of	2

1	**General**		
	Codification	E-002 and E-004 (identical)	
	Service	Molten Salts Electric Heater	
	Trains		
	Lifetime (years)		
	Units per train (Vessels)		
	Duty Heater (kW) Total	20 kW each	
2	**Process Details**		
	Mass Flow rate (kg/s)	3,0	
	Minimum flow rate (kg/s)	1,0	
	Fluid	Yara Salt	
	Inlet/Outlet temperature (°C)	180-390	190-400
	Specific heat (kJ/kg.K)	1,53	1,53
	Thermal conductivity (w/m.K)	0,52	0,520
	Density (kg/m3)	2066,3-1925,5	2066,3-1918,8
	Viscosity (cP)	35,5-2,66	35,5-2,42
	Pressure drop (bar)	Max. 0.2 bar	
	Operating pressure (bara)	2,30	
	Minimum Load (kW)	1	
	Heat exchanged (kW)	20	
3	**Element Details**		
	No. Active / Type	By Vendor	By Vendor
	No. Spare	By Vendor	
	No. Stages / Circuits	By Vendor	
	No. Active Elements per stage	By Vendor	
	Diameter (mm)	By Vendor	
	Active 'U' (mm)	By Vendor	
	Total Load (kW)	By Vendor	
	Element Load (kW)	By Vendor	
	Electrical supply (V / Hz / Ph)	400 / 50 Hz / 3 Ph	
	Flux (W/SQ.CM)	By Vendor	
	Safe Area	Yes	
	Sheath Temperature (°C)	By Vendor	
4	**Baffle Details**		
	Baffle Arrangement (Note 3)	Helical (continuous) or plates (By vendor). Low/zero flow areas not permitted	
	Baffle Pitch (mm)	By Vendor	
	Buffle Cut	By Vendor	
	Baffle Thk (mm)	By Vendor	
	No. Of Tie Rods	By Vendor	
	Tie Rods Diameter (mm)	By Vendor	
5	**Design Data**		
	Design Code	EN 13445 / ASME VIII Div 1 (Not U-Stamp)	
	PED Compliant	YES - CAT 1	
	Equipment orientation	Horizontal	
	Design Pressure (barg)	3.5	
	Design Temperature (°C) (Note 5)	450	
	Corrosion Allowance (mm)	0.5	
	Radiagrphy (%)	SPOT	
	Ambient Temperature (°C)	-6 / 45 ºC	
	Certification	As per code	
6	**Heat Transfer Data**		
	Total Surface area (m2)	By Vendor	
	Heat Transfer Coefficient (w/m2·°C)	By Vendor	
	Mean Temperature Difference (°C)	By Vendor	
7	**Weights**		
	Heater Bundle Weight (kg)	By Vendor	
	Total - Empty Weigth (kg)	By Vendor	
	Test Weigth (kg)	By Vendor	
	Vessel diameter (mm)	By Vendor	
	Total lenght (mm)	By Vendor	
8	**Materials (5)**		
	Shell	By Vendor	
	Head	By Vendor	
	Flanges	By Vendor	
	Plate	By Vendor	
	Bolts/Nuts	By Vendor	
	Baffles / Tie Rods	By Vendor	
	Gasket	By Vendor	
	Element type	By Vendor	

9	**Instrumentation Summary**				
		Quantity	Type	Material	Other
	Element sensor	By Vendor	By Vendor	By Vendor	
	Process Sensor	By Vendor	By Vendor	By Vendor	
	Flange Sensor	By Vendor	By Vendor	By Vendor	
	T- Box sensor	By Vendor	By Vendor	By Vendor	
	Junction box	By Vendor	By Vendor	By Vendor	
	Transmitter	By Vendor	By Vendor	By Vendor	

10 Electric Heater Sketch



Vendor shall provide above dimensions or other if relevent.
Vendor shall provide slope of the vessels to be fully drained (min 3%).

11 Connections (Note 4)

Mark number	Description	Quantity	Size	Rating	Type	Code	Notes
H1	HEATER	1	TBD				
N1	INLET	1	1"				
N2	OUTLET	1	1"				
N3	DRAIN	1	1/2"				
N4	VENT	1	1/2"				
Others	PSV	1	1/2"				

12 Power Control Panel Features

Number of cabinets	By Vendor
Control panel duty (kW)	By Vendor
Voltage / Phase / Frecuency (V / ph / Hz)	400 / 3 ph / 50
Main Incoming current (Amp)	By Vendor
Height (mm)	By Vendor
Width (mm)	By Vendor
Depth (mm)	By Vendor
Weight (kg)	By Vendor
Heat generated by panel (W)	By Vendor
Type of electrical panel	By Vendor
Identification plate	Stainless steel
Connections for groundings	By Vendor
Lifting lugs	By Vendor
Protection Class (IP)	IP 66
Safe Area	Yes
Case material	Steel
Calour (RAL)	By Vendor
Panel Mounting	Floor mounting
Cooling	By Vendor
Power control (Note 2)	By vendor
Temperature regulation (Local / Remote)	From load control panel / From DCS 4-20 mA signal
Temperature regulation range (°C)	180-400

13 Outgoing signals from Panel to DCS

Signal Designation	From	To	Type
Feedback panel status (ON/OFF)	Control Panel	DCS	Dry contact
Common fault	Control Panel	DCS	Dry contact
Earth leakage	Control Panel	DCS	Dry contact
Heating element over temp.	Control Panel	DCS	Dry contact
Vessel over temp.	Control Panel	DCS	Dry contact
Local / Remote Status	Control Panel	DCS	Dry contact
Thyrisitr load failure	Control Panel	DCS	Dry contact
Fan failure	Control Panel	DCS	Dry contact
Others	Control Panel	DCS	By Vendor

Notes

10.12 Line List

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VENDOR

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PROJECT

I-UPS

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DOCUMENT NUMBER

i2313-LIS-RPW-107-005

SUBCONTRACTOR DOCUMENT NUMBER

DOCUMENT NAME

Line list

VENDOR	Document Name	i2313-LIS-RPW-107-005	
	Line list	Revision Number	01

ID	Line code								Line name	Tracing temperature (°C)	P&ID	P&ID Sheet Number	P&ID Rev	Description	Design conditions		Operating conditions		Notes
	Diameter (")	Length (m) (1)	Fluid	System	Number	Piping Class	Insulation code	Tracing							Pressure (barg)	T (°C)	Pressure (barg)	T (°C)	
1	1	2	N2	Nitrogen	101	CS31	NI	N/A	1-N2-101-CS31-NI	-	i2313-DRA-RPW-104-002	02	01	T-001 N2 supply line	16	195	12	15ºC-180ºC	
2	1	0,5	N2	Nitrogen	102	CS31	NI	N/A	1-N2-102-CS31-NI	-	i2313-DRA-RPW-104-002	02	01	T-001 N2 outlet line	16	195	12	15ºC-180ºC	
3	1	0,2	N2	Nitrogen	103	CS31	NI	N/A	1-N2-103-CS31-NI	-	i2313-DRA-RPW-104-002	02	01	T-001 PSV-01 line	16	195	12	15ºC-180ºC	
4	1	0,5	N2	Nitrogen	104	CS31	NI	N/A	1-N2-104-CS31-NI	-	i2313-DRA-RPW-104-002	02	01	PSV-02 line	16	195	12	15ºC-180ºC	
5	2	0,5	WAT	Water Loop	101	CS31	H	N/A	2-WAT-101-CS31-H	-	i2313-DRA-RPW-104-002	02	01	P-001 discharge	18,85	195	12	10ºC-175ºC	
6	2	1	WAT	Water Loop	102	CS31	H	N/A	2-WAT-102-CS31-H	-	i2313-DRA-RPW-104-002	02	01	E-001 inlet line	16	195	12	10ºC-175ºC	
7	2	1,5	WAT	Water Loop	103	CS31	H	N/A	2-WAT-103-CS31-H	-	i2313-DRA-RPW-104-002	02	01	E-001 outlet line	16	195	12	15ºC-180ºC	
8	2	1,5	WAT	Water Loop	104	CS31	H	N/A	2-WAT-104-CS31-H	-	i2313-DRA-RPW-104-002	02	01	HTHP inlet line	16	195	12	15ºC-175ºC	
9	2	3	WAT	Water Loop	105	CS31	H	N/A	2-WAT-105-CS31-H	-	i2313-DRA-RPW-104-002	02	01	HTHP bypass connection	16	195	12	15ºC-180ºC	
10	2	1,5	WAT	Water Loop	106	CS31	H	N/A	2-WAT-106-CS31-H	-	i2313-DRA-RPW-104-002	02	01	HTHP outlet line	16	195	12	15ºC-180ºC	
11	2	8	WAT	Water Loop	107	CS31	H	N/A	2-WAT-107-CS31-H	-	i2313-DRA-RPW-104-002	02	01	T-001 return line	16	195	12	15ºC-180ºC	
12	2	0,2	WAT	Water Loop	108	CS31	H	N/A	2-WAT-108-CS31-H	-	i2313-DRA-RPW-104-002	02	01	T-001 water fill line	16	195	12	15ºC-180ºC	
13	2	1,5	WAT	Water Loop	109	CS31	H	N/A	2-WAT-109-CS31-H	-	i2313-DRA-RPW-104-002	02	01	P-001 suction line	16	195	12	10ºC-175ºC	
13	1	0,2	WAT	Water Loop	110	CS31	H	N/A	1-WAT-110-CS31-H	-	i2313-DRA-RPW-104-003	02	01	Water drain in P-001 suction lline	16	195	12	15ºC-180ºC	
13	1	0,2	WAT	Water Loop	111	CS31	H	N/A	1-WAT-111-CS31-H	-	i2313-DRA-RPW-104-003	02	01	Water drain in T-001 return line	16	195	12	15ºC-180ºC	
14	1	1	MS	MS Storage System	201	CS36	H	T	1-MS-201-CS36-H-T	175	i2313-DRA-RPW-104-002	03	01	P-003 suction line	2,5	415	2	185ºC-400ºC	
15	1	1,5	MS	MS Storage System	202	CS36	H	T	1-MS-202-CS36-H-T	175	i2313-DRA-RPW-104-002	03	01	E-003 inlet line	2,5	415	2	185ºC-400ºC	
16	1	3	MS	MS Storage System	203	CS36	H	T	1-MS-203-CS36-H-T	175	i2313-DRA-RPW-104-002	03	01	E-003 outlet line to Cold MS Tank	2,5	415	2	185ºC-395ºC	
17	1	1	MS	MS Storage System	204	CS36	H	T	1-MS-204-CS36-H-T	175	i2313-DRA-RPW-104-002	03	01	P-002 suction line	2,5	415	2	185ºC-395ºC	
18	1	1,5	MS	MS Storage System	205	CS36	H	T	1-MS-205-CS36-H-T	175	i2313-DRA-RPW-104-002	03	01	P-002 discharge to E-002	2,5	415	2	185ºC-395ºC	
19	1	1	MS	MS Storage System	206	CS36	H	T	1-MS-206-CS36-H-T	175	i2313-DRA-RPW-104-002	03	01	E-002 to HTHP	2,5	415	2	185ºC-395ºC	
20	1	3	MS	MS Storage System	207	CS36	H	T	1-MS-207-CS36-H-T	175	i2313-DRA-RPW-104-002	03	01	HTHP bypass	2,5	415	2	185ºC-395ºC	
21	1	2	MS	MS Storage System	208	CS36	H	T	1-MS-208-CS36-H-T	175	i2313-DRA-RPW-104-002	03	01	HTHP outlet line	2,5	415	2	185ºC-400ºC	
22	1	0,5	MS	MS Storage System	209	CS36	H	T	1-MS-209-CS36-H-T	175	i2313-DRA-RPW-104-002	03	01	E-004 inlet line	2,5	415	2	185ºC-395ºC	
23	1	0,5	MS	MS Storage System	210	CS36	H	T	1-MS-210-CS36-H-T	175	i2313-DRA-RPW-104-002	03	01	E-004 outlet line	2,5	415	2	185ºC-400ºC	
24	1	3	MS	MS Storage System	211	CS36	H	T	1-MS-211-CS36-H-T	175	i2313-DRA-RPW-104-002	03	01	T-003 return line	2,5	415	2	185ºC-400ºC	

Notes

01 Line lengths to be confirmed during project execution

10.13 Piping Class

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101147078.

VENDOR

CLIENT

PROJECT

I-UPS

01	18/03/2025	First issue	CCO	BDS	AMQ
REV	***DATE***	***DESCRIPTION***	***DONE***	***CHECKED***	***APPROVED***

DOCUMENT NUMBER

i2313-SPC-RPW-061-012

SUBCONTRACTOR DOCUMENT NUMBER

DOCUMENT NAME

Piping Class Specification

Fittings:
Elbow 45° LR /SR
Elbow 90° LR /SR
Cap
Concentric Reducer
Concentric Swage Nipple
Coupling
Eccentric Swage Nipple
Elbolet
Equal Tee
Excentric Reducer
Half Coupling
Nipple 100/150/200/250 mm length. Ends: NPT-NPT, NPT-Plain, Plain-Plain.
Reducer Insert
Reducing Coupling
Reducing Tee
Sockolet
Sweepolet
Weldolet

General Notes:

For caps in drains and vents can be used threaded connection if they are located downstream of a closed vent or bleed valve as a cap or plug

Flanges connected to the equipment will be the same type as the equipment flanges

Reducers must indicate the schedule of the inlet and outlet

All Spiral wound gaskets need to have an inner ring.

Fluids

CS31	Nitrogen Class 300
CS31	Water Class 300
CS36	Molten Salts Class 300

	Document name	i2313-SPC-RPW-061-012	
RPOW	Piping Class Specification	CS31	Rev No. 01

Piping Code B31.3	Class 300	Material Group 1.1

Pipe size "	Temp [°C]	-28/37,77	93	149	204	260	316	343	371	399	Carbon Steel
1/2" - 40"	Pres [barg]	34,08	34,08	34,08	34,08	34,08	34,08	34,08	31,09	25,91	

Pipe

Size			Material	Description	Schedule	Ends
1/2"	-	2"	A106 GR.B	ASME B36.10	40	SW
2 1/2"	-	24"	A106 GR.B	ASME B36.10	40	BW
28"	-	30"	API 5L GR.B	ASME B36.10	14.27 mm	BW
	32"		API 5L GR.B	ASME B36.10	15,88 mm	BW
	36"		API 5L GR.B	ASME B36.10	17,48 mm	BW
	40"		API 5L GR.B	ASME B36.10	19,05 mm	BW

Note 1: Corrosion allowance 1.6 mm.
Note 2: 22" - not apply.
Note 3: 28" - 44": API 5L GR.B shall be 100% radiographed (SAW, GMAW or combined GMAW, SAW)
Note 4: Material and Sch of Nipples will be according to the pipe.

Flanges

Size			Material	Description	Rating	Ends
1/2"	-	2"	A105	SW ASME B16.5	300#	RF 125-250 AARH
2 1/2"	-	24"	A105	WN ASME B16.5	300#	RF 125-250 AARH
28"	-	40"	A105	WN ASME B16.47 SERIE B	300#	RF 125-250 AARH
1/2"	-	24"	A105	BLIND ASME B16.5	300#	RF 125-250 AARH
28"	-	40"	A105	BLIND ASME B16.47 SERIE B	300#	RF 125-250 AARH
1/2"	-	24"	A515 GR.70	SPECTACLE BLIND ASME B16.48	300#	RF 125-250 AARH
1/2"	-	14"	A105	WN ORIFICE	300#	RF 125-250 AARH

Note 5: Use SW ASME B16.5 A105 300# FF flanges for butterfly valves
Note 6: Use WN ASME B16.5 A105 300# FF flanges for butterfly valves
Note 7: WN flanges shall be designed with the same schedule as the pipe attached.
Note 8: Flanges, gasket and valves may be extended to 600# in case of leakage risk.

Fittings

Size			Material	Description	Rating	Ends
1/2"	-	2"	A105	ASME B16.11	3000#	SW
2 1/2"	-	40"	A234 GR.WPB (SEAMLESS)	ASME B16.9	According to pipe	BW

Note 9: Fittings shall be designed with the same schedule as the pipe attached.
Note 10: The accessories type "olet" which connect pipes with diameters greater shall be appointed indicating the schedules of the main pipe and the bra
Note 11: In accesories type "olet" the aplicable normative is MSS-SP-97. Reducing inserts accordig to MSS-SP-79
Note 12: Material and dimensions of Swaged Nipples will be according to MSS-SP-95. Sch will be according to pipe.

Gaskets

Size			Material	Description
1/2"	-	40"	316L SS	GRAPHITE CAMPROFILE ASME B16.20 300#

Screws and bolts

	Material	Description
Stud Bolts	A193 GR.B7 BICHROMATED	ASME B16.5 or ASME B16.47
Nuts	A194 Gr.2H BICHROMATED	ASME B18.2.2
Washers	F436	ASME B18.22.1

Branch

See Branch table 1.

Document name			i2313-SPC-RPW-061-012
RPOW	Piping Class Specification	CS36	Rev No. 01

Piping Code B31.3	Class 300	Material Group 1.1

Pipe size "	Temp [°C]	-28/37,77	93	149	204	260	316	343	371	399	Carbon Steel
1/2" - 40"	Pres [barg]	45,42	45,42	45,42	45,42	45,42	45,42	45,42	41,44	34,53	

Pipe

Size			Material	Description	Schedule	Ends
1/2"	-	2"	A106 GR.B	ASME B36.10	40	BW
2 1/2"	-	24"	A106 GR.B	ASME B36.10	40	BW
	28"		API 5L GR.B	ASME B36.10	17,48 mm	BW
30"	-	32"	API 5L GR.B	ASME B36.10	19,05 mm	BW
	36"		API 5L GR.B	ASME B36.10	22,23 mm	BW
	40"		API 5L GR.B	ASME B36.10	23,83 mm	BW

Note 1: Nominal corrosion allowance 1,25 mm

Note 2: 28"-40": API 5L GrB shall be 100% radiographed (SAW, GMAW or combined GMAW, SAW)

Note 3: 22" - not apply.

Note 4: Material and Sch of Nipples will be according to the pipe.

Flanges

Size			Material	Description	Rating	Ends
1/2"	-	2"	A105	WN ASME B16.5	300#	RTJ < 63AARH
2 1/2"	-	24"	A105	WN ASME B16.5	300#	RTJ < 63AARH
28"	-	40"	A105	WN ASME B16.47 SERIE B	300#	RTJ < 63AARH
1/2"	-	24"	A105	BLIND ASME B16.5	300#	RTJ < 63AARH
28"	-	40"	A105	BLIND ASME B16.47 SERIE B	300#	RTJ < 63AARH
1/2" -		24"	A515 GR.70	SPECTACLE BLIND ASME B16.48	300#	RTJ < 63AARH
2" -		14"	A105	WN ORIFICE	300#	RTJ < 63AARH
28" -		40"	A105	BLIND ASME B16.47 SERIE B	300#	RF (125-250 AARH)

Note 5: WN flanges shall be designed with the same schedule as the pipe attached.

Note 6: Flanges, gasket and valves may be extended to 600# in case of leakage risk.

Fittings

Size			Material	Description	Rating	Ends
1/2"	-	2"	A234 GR.WPB (SEAMLESS)	ASME B16.9	According to pipe	BW
2 1/2"	-	40"	A234 GR.WPB (SEAMLESS)	ASME B16.9	According to pipe	BW

Note 7: Fittings shall be designed with the same schedule as the pipe attached.

Note 8: The accessories type "olet" which connect pipes with diameters greater shall be appointed indicating the schedules of the main pipe and the branch pipe.

Note 9: In accesories type "olet" the aplicable normative is MSS-SP-97. Reducing inserts accordig to MSS-SP-79

Note 10: Material and dimensions of Swaged Nipples will be according to MSS-SP-95. Sch will be according to pipe.

Gaskets

Size			Material	Description
1/2"	-	2 1/2"	Soft iron <90 BHN	OVAL RING JOINT STYLE R ASME B16.20 300#
3"	-	40"	Soft iron <90 BHN	OVAL RING JOINT STYLE R ASME B16.20 300#

Screws and bolts

	Material	Description
Stud Bolts	A193 GR.B7 BICHROMATED	ASME B16.5 or ASME B16.47
Nuts	A194 GR.2H BICHROMATED	ASME B18.2.2
Washers	F436	ASME B18.22.1

Branch

See Branch table 2.

Branch Table 1

1/2	3/4	1	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	26	28	30	32	36	40	
STSW	RTSW	RTSW	RTSW	RTSW	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	1/2
	STSW	RTSW	RTSW	RTSW	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	3/4
		STSW	RTSW	RTSW	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	1
			STSW	RTSW	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	1 1/2
				STSW	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	2
					STBW	RTBW	RTBW	RTBW	W	W	W	W	W	W	W	W	W	W	W	W	W	W	2 1/2
						STBW	RTBW	RTBW	W	W	W	W	W	W	W	W	W	W	W	W	W	W	3
							STBW	RTBW	RTBW	W	W	W	W	W	W	W	W	W	W	W	W	W	4
								STBW	RTBW	RTBW	RTBW	W	W	W	W	W	W	W	W	W	W	W	6
									STBW	RTBW	RTBW	RTBW	RTBW	W	W	W	W	W	W	W	W	W	8
										STBW	RTBW	RTBW	RTBW	RTBW	RTBW	W	W	W	W	W	W	W	10
											STBW	RTBW	RTBW	RTBW	RTBW	RTBW	RTBW	W	W	W	W	W	12
												STBW	RTBW	RTBW	RTBW	RTBW	RTBW	RTBW	W	W	W	W	14
													STBW	RTBW	RTBW	RTBW	RTBW	RTBW	RTBW	RTBW	W	W	16
														STBW	RTBW	RTBW	RTBW	RTBW	RTBW	RTBW	RTBW	RTBW	18
															STBW	RTBW	RTBW	RTBW	RTBW	RTBW	RTBW	RTBW	20
																STBW	RTBW	RTBW	RTBW	RTBW	RTBW	RTBW	24
																	STBW	RTBW	RTBW	RTBW	RTBW	RTBW	26
																		STBW	RTBW	RTBW	RTBW	RTBW	28
																			STBW	RTBW	RTBW	RTBW	30
																				STBW	RTBW	RTBW	32
																					STBW	RTBW	36
																						STBW	40

STSW	Straight Tee Socket Weld
RTSW	Reducing Tee Socket Weld
S	Sockolet, Latrolet or Elbolet
RTBW	Reducing Tee Butt Weld
W	Weldolet or Elbolet
STBW	Straight Tee Butt Weld
SWT	Sweepolet
Wd	Weldolet or Elbolet, Available on Application . Not standard.

Branch Table 2

1/2	3/4	1	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	28	30	32	36	40	
STBW	RTBW	RTBW	RTBW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	1/2
	STBW	RTBW	RTBW	RTBW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	3/4
		STBW	RTBW	RTBW	RTBW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	UNW	1
			STBW	RTBW	RTBW	RTBW	RTBW	Rp	Rp	Rp	Rp	Rp	Rp	Rp	Rp	Rp	Rp	Rp	Rp	Rp	Rp	1 1/2
				STBW	RTBW	RTBW	RTBW	Rp	Rp	Rp	Rp	Rp	Rp	Rp	Rp	Rp	Rp	Rp	Rp	Rp	Rp	2
					STBW	RTBW	RTBW	RTBW	W	W	W	W	W	W	W	W	W	W	W	W	W	2 1/2
						STBW	RTBW	RTBW	W	W	W	W	W	W	W	W	W	W	W	W	W	3
							STBW	RTBW	RTBW	W	W	W	W	W	W	W	W	W	W	W	W	4
								STBW	RTBW	RTBW	RTBW	W	W	W	W	W	W	W	W	W	W	6
									STBW	RTBW	RTBW	RTBW	RTBW	W	W	W	W	W	W	W	W	8
										STBW	RTBW	RTBW	RTBW	RTBW	RTBW	W	W	W	W	W	W	10
STSW	Straight Tee Socket Weld										STBW	RTBW	RTBW	RTBW	RTBW	RTBW	W	W	W	W	W	12
RTSW	Reducing Tee Socket Weld											STBW	RTBW	RTBW	RTBW	RTBW	RTBW	W	W	W	W	14
S	Sockolet, Thredolet, Latrolet or Elbolet												STBW	RTBW	RTBW	RTBW	RTBW	RTBW	RTBW	W	W	16
RTBW	Reducing Tee Butt Weld													STBW	RTBW	RTBW	RTBW	RTBW	RTBW	RTBW	RTBW	18
W	Weldolet or Elbolet														STBW	RTBW	RTBW	RTBW	RTBW	RTBW	RTBW	20
STBW	Straight Tee Butt Weld															STBW	RTBW	RTBW	RTBW	RTBW	RTBW	24
SWT	Sweepolet																STBW	RTBW	RTBW	RTBW	RTBW	28
Wd	Weldolet or Elbolet, Available on Application . Not standard.																	STBW	RTBW	RTBW	RTBW	30
UNW	Unreinforced nozzle Weld																		STBW	RTBW	RTBW	32
Rp	Reinforced nozzle with pad																			STBW	RTBW	36
																					STBW	40

10.14 Automatic and Manual valves List

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101147078.

VENDOR

CLIENT

PROJECT

I-UPS

2	29/04/2025	Revision after safety review	CCG	BDS	AMQ
01	17/03/2025	First issue	CCG	BDS	AMQ
REV	***DATE***	***DESCRIPTION***	***DONE***	***CHECKED***	***APPROVED***

DOCUMENT NUMBER

i2313-LIS-RPW-224-011

SUBCONTRACTOR DOCUMENT NUMBER

DOCUMENT NAME

Automatic and Manual valve lists

i2313-LIS-RPW-224-011

RPOW

Automatic and Manual Valve Lists

Nº of Revision: 02

Item	ID	Service description	P&ID/ Sheet	Fluid	Fluid direction	CV	Valve						Positioner/ Solenoide	Limit switches	Actuator				Schedule line	Process connection	Type of leakage	Hazardous area classification	Type of TRIM	TRIM Features	Minimum operating conditions				Normal operating conditions				Maximum operating conditions				Design conditions	
							Type	Size	Piping class	Line code	Material	Rating			Type	Failure position	Opening time	Closing time							Flow (kg/s)	Inlet pressure (barg)	Diferential pressure (bar)	Temperature (ºC)	Flow (kg/s)	Inlet pressure (barg)	Diferential pressure (bar)	Temperature (ºC)	Flow (kg/s)	Inlet pressure (barg)	Diferential pressure (bar)	Temperature (ºC)	Pressure (barg)	Temperature (ºC)
01	PCV-01	PCV on the N2 bottle line	2	N2	1 direction	(01)	PCV	1''	CS31	1-N2-101-CS31-NI	A-105	#300	-	No	-	-	-	-	40	SW	-	Safe area	(01)	(01)	-	(02)	(02)	20	-	-	-	-	-	200	188	30	16	50
02	PV-01	T-001 pressure control valve	2	N2	1 direction	(01)	Globe	1''	CS31	1-N2-102-CS31-NI	A-105	#300	Digital positioner	No	Electric	FO	-	-	40	SW	class VI	Safe area	(01)	(01)	-	12	12	20	-	-	-	-	-	12	12	180	16	195
03	VG-9	N2 supply manual valve	2	N2	1 direction	(01)	Ball	1''	CS31	1-N2-101-CS31-NI	A-105	#300	-	No	-	-	-	-	40	SW	-	Safe area	(01)	(01)	-	200	0	20	-	-	-	-	-	200	200	30	16	50
04	VG-10	N2 supply manual valve	2	N2	1 direction	(01)	Ball	1''	CS31	1-N2-101-CS31-NI	A-105	#300	-	No	-	-	-	-	40	SW	-	Safe area	(01)	(01)	-	200	0	20	-	-	-	-	-	200	200	30	16	50
05	VG-22	Manual valve on the N2 bottle line	2	N2	1 direction	(01)	Ball	1''	CS31	1-N2-101-CS31-NI	A-105	#300	-	No	-	-	-	-	40	SW	-	Safe area	(01)	(01)	-	12	0	20	-	-	-	-	-	12	12	180	16	195
06	VC-01	Non-return valve	2	N2	1 direction	(01)	Check	1''	CS31	1-N2-101-CS31-NI	A-105	#300	-	No	-	-	-	-	40	SW	-	Safe area	(01)	(01)	-	12	0	20	-	-	-	-	-	12	min	180	16	195
07	FV-01	E-001 inlet line control valve	2	WAT	1 direction	(01)	Globe	2''	CS31	2-WAT-101-CS31-H	A-105	#300	Digital positioner	No	Electric	FO	-	-	40	SW	class VI	Safe area	(01)	(01)	5	14,4	1	19	-	-	-	-	1	13,9	1	172,2	18,85	195
08	VG-01	P-001 suction line manual valve	2	WAT	1 direction	(01)	Gate	2''	CS31	2-WAT-109-CS31-H	A-105	#300	-	No	-	-	-	-	40	SW	-	Safe area	(01)	(01)	5	12,1	0	19	-	-	-	-	1	12,1	0	172,2	16	195
09	VG-02	P-001 discharge line manual valve	2	WAT	1 direction	(01)	Gate	2''	CS31	2-WAT-101-CS31-H	A-105	#300	-	No	-	-	-	-	40	SW	-	Safe area	(01)	(01)	5	14,4	0	19	-	-	-	-	1	13,9	0	172,2	18,85	195
10	VG-03	E-001 outlet line manual valve	2	WAT	1 direction	(01)	Gate	2''	CS31	2-WAT-104-CS31-H	A-105	#300	-	No	-	-	-	-	40	SW	-	Safe area	(01)	(01)	5	13,1	0	20	-	-	-	-	1	12,7	0	180	16	195
11	VG-04	HTHP outlet	2	WAT	1 direction	(01)	Gate	2''	CS31	2-WAT-106-CS31-H	A-105	#300	-	No	-	-	-	-	40	SW	-	Safe area	(01)	(01)	5	13,1	0	19	-	-	-	-	1	12,7	0	172,2	16	195
12	VG-05	HTHP bypass connection manual valve	2	WAT	1 direction	(01)	Gate	2''	CS31	2-WAT-105-CS31-H	A-105	#300	-	No	-	-	-	-	40	SW	-	Safe area	(01)	(01)	5	13,1	0	20	-	-	-	-	1	12,7	0	180	16	195
13	VG-06	T-001 return line manual valve	2	WAT	1 direction	(01)	Gate	2''	CS31	2-WAT-107-CS31-H	A-105	#300	-	No	-	-	-	-	40	SW	-	Safe area	(01)	(01)	5	13,1	0	19	-	-	-	-	1	12,7	0	172,2	16	195
14	VG-07	Water connection manual valve	2	WAT	1 direction	(01)	Gate	2''	CS31	2-WAT-108-CS31-H	A-105	#300	-	No	-	-	-	-	40	SW	-	Safe area	(01)	(01)	-	-	-	-	-	1,1	0	20	-	-	-	-	16	195
15	VG-08	Draining system manual valve	2	WAT	1 direction	(01)	Gate	1''	CS31	2-WAT-110-CS31-H	A-105	#300	-	No	-	-	-	-	40	SW	-	Safe area	(01)	(01)	-	1	1	19	-	-	-	-	-	12,1	12,1	172,2	16	195
16	VG-09	Draining system manual valve	2	WAT	1 direction	(01)	Gate	1''	CS31	2-WAT-111-CS31-H	A-105	#300	-	No	-	-	-	-	40	SW	-	Safe area	(01)	(01)	-	1	1	19	-	-	-	-	-	12,7	12,1	172,2	16	195
17	FV-02	E-003 inlet line control valve	3	MS	1 direction	(01)	Globe	1''	CS36	1-MS-202-CS36-H-T	A-216 Gr. WCB	#300	Digital positioner	No	Electric	FO	-	-	40	BW	class VI	Safe area	(01)	(01)	3	2,3	1	241,3	-	-	-	-	3	2,3	1	400,0	2,5	415
18	FV-03	P-002 discharge to E-005 control valve	3	MS	1 direction	(01)	Globe	1''	CS36	1-MS-205-CS36-H-T	A-216 Gr. WCB	#300	Digital positioner	No	Electric	FO	-	-	40	BW	class VI	Safe area	(01)	(01)	3	2,3	1	241,3	-	-	-	-	3	2,3	1	391,3	2,5	415
19	VG-11	P-003 suction manual valve	3	MS	1 direction	(01)	Gate	1''	CS36	1-MS-201-CS36-H-T	A-216 Gr. WCB	#300	-	No	-	-	-	-	40	BW	-	Safe area	(01)	(01)	3	0,3	0	250,0	-	-	-	-	3	0,3	0	400,0	2,5	415
20	VG-12	P-003 discharge manual valve	3	MS	1 direction	(01)	Gate	1''	CS36	1-MS-202-CS36-H-T	A-216 Gr. WCB	#300	-	No	-	-	-	-	40	BW	-	Safe area	(01)	(01)	3	2,3	0	250,0	-	-	-	-	3	2,3	0	400,0	2,5	415
21	VG-13	P-003 suction manual valve	3	MS	1 direction	(01)	Gate	1''	CS36	1-MS-204-CS36-H-T	A-216 Gr. WCB	#300	-	No	-	-	-	-	40	BW	-	Safe area	(01)	(01)	3	0,3	0	241,3	-	-	-	-	3	0,3	0	391,3	2,5	415
22	VG-14	P-002 discharge manual valve	3	MS	1 direction	(01)	Gate	1''	CS36	1-MS-205-CS36-H-T	A-216 Gr. WCB	#300	-	No	-	-	-	-	40	BW	-	Safe area	(01)	(01)	3	2,3	0	241,3	-	-	-	-	3	2,3	0	391,3	2,5	415
23	VG-15	HTHP inlet manual valve	3	MS	1 direction	(01)	Gate	1''	CS36	1-MS-206-CS36-H-T	A-216 Gr. WCB	#300	-	No	-	-	-	-	40	BW	-	Safe area	(01)	(01)	3	2,3	0	241,3	-	-	-	-	3	2,3	0	391,3	2,5	415
24	VG-16	HTHP bypass manual valve	3	MS	1 direction	(01)	Gate	1''	CS36	1-MS-207-CS36-H-T	A-216 Gr. WCB	#300	-	No	-	-	-	-	40	BW	-	Safe area	(01)	(01)	3	2,3	0	250,0	-	-	-	-	3	2,3	0	400,0	2,5	415
25	VG-17	HTHP outlet manual valve	3	MS	1 direction	(01)	Gate	1''	CS36	1-MS-208-CS36-H-T	A-216 Gr. WCB	#300	-	No	-	-	-	-	40	BW	-	Safe area	(01)	(01)	3	1,8	0	250,0	-	-	-	-	3	1,8	0	400,0	2,5	415
26	VG-18	HTHP bypass manual valve	3	MS	1 direction	(01)	Gate	1''	CS36	1-MS-207-CS36-H-T	A-216 Gr. WCB	#300	-	No	-	-	-	-	40	BW	-	Safe area	(01)	(01)	3	2,3	0	241,3	-	-	-	-	3	2,3	0	391,3	2,5	415
27	VG-19	HTHP outlet line manual valve to T-003	3	MS	1 direction	(01)	Gate	1''	CS36	1-MS-208-CS36-H-T	A-216 Gr. WCB	#300	-	No	-	-	-	-	40	BW	-	Safe area	(01)	(01)	3	1,8	0	250,0	-	-	-	-	3	1,8	0	400,0	2,5	415
28	VG-20	E-004 outlet line manual valve	3	MS	1 direction	(01)	Gate	1''	CS36	1-MS-210-CS36-H-T	A-216 Gr. WCB	#300	-	No	-	-	-	-	40	BW	-	Safe area	(01)	(01)	3	1,8	0	250,0	-	-	-	-	3	1,8	0	400,0	2,5	415
29	VG-21	HTHP outlet drain valve	3	MS	1 direction	(01)	Gate	1''	CS36	1-MS-211-CD36-H-T	A-216 Gr. WCB	#300	-	No	-	-	-	-	40	BW	-	Safe area	(01)	(01)	3	1,8	0	250,0	-	-	-	-	3	1,8	0	400,0	2,5	415
30	VG-22	P-003 suction drain valve	3	MS	1 direction	(01)	Gate	1''	CS36	1-MS-201-CS36-H-T	A-216 Gr. WCB	#300	-	No	-	-	-	-	40	BW	-	Safe area	(01)	(01)	3	1,8	0	250,0	-	-	-	-	3	1,8	0	400,0	2,5	415
31	VG-23	P-003 discharge drain valve	3	MS	1 direction	(01)	Gate	1''	CS36	1-MS-202-CS36-H-T	A-216 Gr. WCB	#300	-	No	-	-	-	-	40	BW	-	Safe area	(01)	(01)	3	1,8	0	250,0	-	-	-	-	3	1,8	0	400,0	2,5	415
32	VG-24	P-002 suction drain valve	3	MS	1 direction	(01)	Gate	1''	CS36	1-MS-204-CS36-H-T	A-216 Gr. WCB	#300	-	No	-	-	-	-	40	BW	-	Safe area	(01)	(01)	3	1,8	0	250,0	-	-	-	-	3	1,8	0	400,0	2,5	415
33	VG-25	P-002 discharge drain valve	3	MS	1 direction	(01)	Gate	1''	CS36	1-MS-205-CS36-H-T	A-216 Gr. WCB	#300	-	No	-	-	-	-	40	BW	-	Safe area	(01)	(01)	3	1,8	0	250,0	-	-	-	-	3	1,8	0	400,0	2,5	415
34	VG-26	HTHP inlet drain valve	3	MS	1 direction	(01)	Gate	1''	CS36	1-MS-206-CS36-H-T	A-216 Gr. WCB	#300	-	No	-	-	-	-	40	BW	-	Safe area	(01)	(01)	3	1,8	0	250,0	-	-	-	-	3	1,8	0	400,0	2,5	415

Notes

01 By vendor

02 Minimal allowable header pressure to be confirmed by vendor

10.15 Instrument List

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101147078.

VENDOR

CLIENT

PROJECT

I-UPS

01	17/03/2025	First issue	CCG	BDS	AMQ
REV	***DATE***	***DESCRIPTION***	***DONE***	***CHECKED***	***APPROVED***

DOCUMENT NUMBER	***DOCUMENT NAME***
i2313-LIS-RPW-406-006	**Instrument list**
SUBCONTRACTOR DOCUMENT NUMBER	

VENDOR

Document Name

Instrument List

i2313-LIS-RPW-406-006

Rev. Nº 01

Item	TAG	Instrument Type	Service	P&ID	Fluid	Hazardous area classification	Transmitter						Process connection	Line/ Equipment service ID	Size (")	Minimum operating conditions			Normal operating conditions			Maximum operating conditions			Design conditions		Notes
							Type	Accuracy	Power supply	Minimum measurement range	Maximum measurement range	Unit				Pressure (barg)	Temperature (ºC)	Flow (kg/s)	Pressure (barg)	Temperature (ºC)	Flow (kg/s)	Pressure (barg)	Temperature (ºC)	Flow (kg/s)	Pressure (barg)	Temperature (ºC)	
02	FT-01	Flow transmitter with Display	Flow transmitter in E-001 inlet line	i2313-DRA-RPW-107-002 SH02	WAT	Safe area	Vortex with p,T comp	±0.1% measuring range	230 VAC	0	20	m3/h	Flanged	1-WAT-102-CS31-H	2	14,4	19	5				13,9	172.2	1	16	195	
03	LT-01	Level indicator	T-001 Level indicator	i2313-DRA-RPW-107-002 SH02	WAT	Safe area	Delta P	±0.2% measuring range	24V DC loop	0	2000	mm	Flanged	T-001	1	12,1	15,2	-				12,1	172.2	-	16	195	
05	PT-01	Pressure transmitter with Display	T-001 Pressure transmitter	i2313-DRA-RPW-107-002 SH02	WAT	Safe area	Relative Pressure	±0.075% of calibrated range	24V DC loop	0	16	barg	membrane / TBC flange size with supplier	T-001	-	12,1	15,2	-				12,1	172.2	-	16	195	
01	TT-01	Temperature indicator	T-001 Temperature indicator	i2313-DRA-RPW-107-002 SH02	WAT	Safe area	TC Type -E	±0.1% measuring range	24V DC loop	0	200	ºC	Flanged	T-001	-	12,1	15,2	-				12,1	172.2	-	16	195	
07	TT-02	Temperature transmitter with Display	Temperature transmitter in E-001 outlet line	i2313-DRA-RPW-107-002 SH02	WAT	Safe area	TC Type -E	±0.1% measuring range	24V DC loop	0	200	ºC	Flanged	1-WAT-103-PC-H	1	12,1	20	-				12,1	180	-	16	195	
13	FT-02	Flow transmitter with Display	Flow transmitter in E-003 inlet line	i2313-DRA-RPW-107-002 SH03	MS	Safe area	Ultrasonic	±0.1% measuring range	230 VAC	0	10	m3/h	In line, full bore	1-MS-202-CS36-H-T	1	2,3	250	3				2,3	400	3	2,5	415	
24	FT-03	Flow transmitter with Display	Flow transmitter in P-002 discharge to E-005	i2313-DRA-RPW-107-002 SH03	MS	Safe area	Ultrasonic	±0.1% measuring range	230 VAC	0	20	m3/h	In line, full bore	1-MS-205-CS36-H-T	1	2,3	241,3	3				2,3	391,3	3	2,5	415	
12	LSL-01	Radar Level Switch	Radar Level Switch in T-003	i2313-DRA-RPW-107-002 SH03	MS	Safe area	Radar antenna	±0.2% measuring range	24V DC loop	0	2000	mm	2" Flanged WN RF 150#	T-003	-	2,3	250	3				2,3	400	3	2,5	415	
21	LSL-02	Radar Level Switch	Radar Level Switch in T-002	i2313-DRA-RPW-107-002 SH03	MS	Safe area	Radar antenna	±0.2% measuring range	24V DC loop	0	2000	mm	2" Flanged WN RF 150#	T-002	-	2,3	241,3	3				2,3	391,3	3	2,5	415	
20	LT-02	Radar Level indicator	T-002 Radar Level indicator	i2313-DRA-RPW-107-002 SH03	MS	Safe area	Radar antenna	±0.2% measuring range	24V DC loop	0	2000	mm	2" Flanged WN RF 150#	T-002	-	2,3	250	3				2,3	400	3	2,5	415	
11	LT-03	Radar Level indicator	T-003 Radar Level indicator	i2313-DRA-RPW-107-002 SH03	MS	Safe area	Radar antenna	±0.2% measuring range	24V DC loop	0	2000	mm	2" Flanged WN RF 150#	T-003	-	2,3	241,3	3				2,3	391,3	3	2,5	415	
10	PT-02	Pressure indicator	T-003 Pressure indicator	i2313-DRA-RPW-107-002 SH03	MS	Safe area	Relative Pressure	±0.075% of calibrated range	24V DC loop	0	5	barg	membrane / TBC flange size with supplier	T-003	-	2,3	250	3				2,3	400	3	2,5	415	
15	PT-03	Pressure indicator	Pressure indicator in P-003 discharge	i2313-DRA-RPW-107-002 SH03	MS	Safe area	Relative Pressure	±0.075% of calibrated range	24V DC loop	0	5	barg	membrane / TBC flange size with supplier	1-MS-202-CS36-H-T	1	2,3	250	3				2,3	400	3	2,5	415	
18	PT-04	Pressure indicator	Pressure indicator in E-003 outlet line	i2313-DRA-RPW-107-002 SH03	MS	Safe area	Relative Pressure	±0.075% of calibrated range	24V DC loop	0	5	barg	membrane / TBC flange size with supplier	1-MS-203-CS36-H-T	1	1,8	241,3	3				1,8	391,3	3	2,5	415	
22	PT-05	Pressure indicator	T-002 Pressure indicator	i2313-DRA-RPW-107-002 SH03	MS	Safe area	Relative Pressure	±0.075% of calibrated range	24V DC loop	0	5	barg	membrane / TBC flange size with supplier	T-002	-	0.3	241,3	-				0,3	391,3	-	24,7	450	
27	PT-06	Pressure indicator	Pressure indicator in E-002 outlet	i2313-DRA-RPW-107-002 SH03	MS	Safe area	Relative Pressure	±0.075% of calibrated range	24V DC loop	0	5	barg	membrane / TBC flange size with supplier	1-MS-206-CS36-H-T	1	2,3	241,3	3				2,3	391,3	3	2,5	415	
29	PT-07	Pressure indicator	Pressure indicator in HTHP outlet line	i2313-DRA-RPW-107-002 SH03	MS	Safe area	Relative Pressure	±0.075% of calibrated range	24V DC loop	0	5	barg	membrane / TBC flange size with supplier	1-MS-208-CS36-H-T	1	1,8	250	3				1,8	400	3	2,5	415	
15	PT-08	Pressure indicator	Pressure indicator in E-002 HTHP inlet heater	i2313-DRA-RPW-107-002 SH03	MS	Safe area	Relative Pressure	±0.075% of calibrated range	24V DC loop	0	5	barg	membrane / TBC flange size with supplier	1-MS-205-CS36-H-T	1	2,3	250	3				2,3	400	3	2,5	415	
09	TT-03	Temperature transmitter with Display	T-003 Temperature indicator	i2313-DRA-RPW-107-002 SH03	MS	Safe area	Skinpoint / TC Type -E	±0.1% measuring range	24V DC loop	0	450	ºC	(01)	T-003	-	0,3	250	-				0,3	400	-	2,5	415	
16	TT-04	Temperature transmitter with Display	Temperature transmitter in E-003 outlet line	i2313-DRA-RPW-107-002 SH03	MS	Safe area	TC Type -E	±0.1% measuring range	24V DC loop	0	450	ºC	(01)	1-MS-203-CS36-H-T	1	1,8	241,3	3				1,8	391,3	3	2,5	415	
19	TT-05	Temperature transmitter with Display	T-002 Temperature indicator	i2313-DRA-RPW-107-002 SH03	MS	Safe area	Skinpoint / TC Type -E	±0.1% measuring range	24V DC loop	0	450	ºC	(01)	T-002	-	0.3	241,3	-				0,3	391,3	-	2,5	415	
25	TT-06	Temperature transmitter with Display	Temperature indicator in E-005 outlet	i2313-DRA-RPW-107-002 SH03	MS	Safe area	TC Type -E	±0.1% measuring range	24V DC loop	0	450	ºC	(01)	1-MS-206-CS36-H-T	1	2,3	241,3	3				2,3	391,3	3	2,5	415	
28	TT-07	Temperature transmitter with Display	Temperature indicator in HTHP outlet line	i2313-DRA-RPW-107-002 SH03	MS	Safe area	TC Type -E	±0.1% measuring range	24V DC loop	0	450	ºC	(01)	1-MS-208-CS36-H-T	1	1,8	250	3				1,8	400	3	2,5	415	
30	TT-08	Temperature transmitter with Display	Temperature transmitter in E-004 outlet	i2313-DRA-RPW-107-002 SH03	MS	Safe area	TC Type -E	±0.1% measuring range	24V DC loop	0	450	ºC	(01)	1-MS-210-CS36-H-T	1	1.8	250	3				1.8	400	3	2,5	415	

01 Thermowell: Drilled bar (1/2" NPT-M). Welded 1 1/2" SW. Material: A 106 GR B

10.16 PSV List

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101147078.

I-UPS

PSV List

Rev nº 01

Item	TAG	Loop	Service	P&ID / Sheet	Rev	Line/Equipment	ATEX?	Installation	Entrance diameters	Exit diameter	Operation Conditions								Set pressure	Allowed overpressure	Backpressure	Orifice		Notes
											Liquid	Max Op Temp	Design Temp	Calc flow	Density (design/oper)	Viscosity (design/oper)	Vapor press (design/oper)	Max op pressure				Calc area	Selected area	
												ºC	ºC	kg/h	kg/m3	mPa*s	bara	barg	barg	%	barg	mm2	mm2	
1	PSV-01	Water	Intermitent	i2313-DRA-RPW-104/SH03	01	T-001	Safe Area	Flanged	By Vendor	By Vendor	Steam	180	195	55	7,1/5,2	0,0155/0,0150	13,99/10,03	12	16	10	0	By vendor	By vendor	PSV to release pressure buildup from external fire
2	PSV-02	Water	Intermitent	i2313-DRA-RPW-104/SH03	01	1-N2-101-CS31	Safe Area	Flanged	By Vendor	By Vendor	Nitrogen	20	195	-	12,2/15,0	0,0250/0,0178	-	12	16	10	0	By vendor	By vendor	PSV to release full pressure of 2 bottles

Notes

01

10.17 I/O list

This project has received funding from the European Union’s Horizon Europe research and innovation programme under grant agreement No 101147078.

VENDOR

CLIENT

PROJECT

Molten Salts Electric Heater Test Loop

2	29/04/2025	Rev after afety review	BDS	PSP	AMQ
01	28/02/2025	First issue	AFR	BS	AMQ
REV	***DATE***	***DESCRIPTION***	***DONE***	***CHECKED***	***APPROVED***

DOCUMENT NUMBER

i2313-LIS-RPW-407-013

SUBCONTRACTOR DOCUMENT NUMBER

DOCUMENT NAME

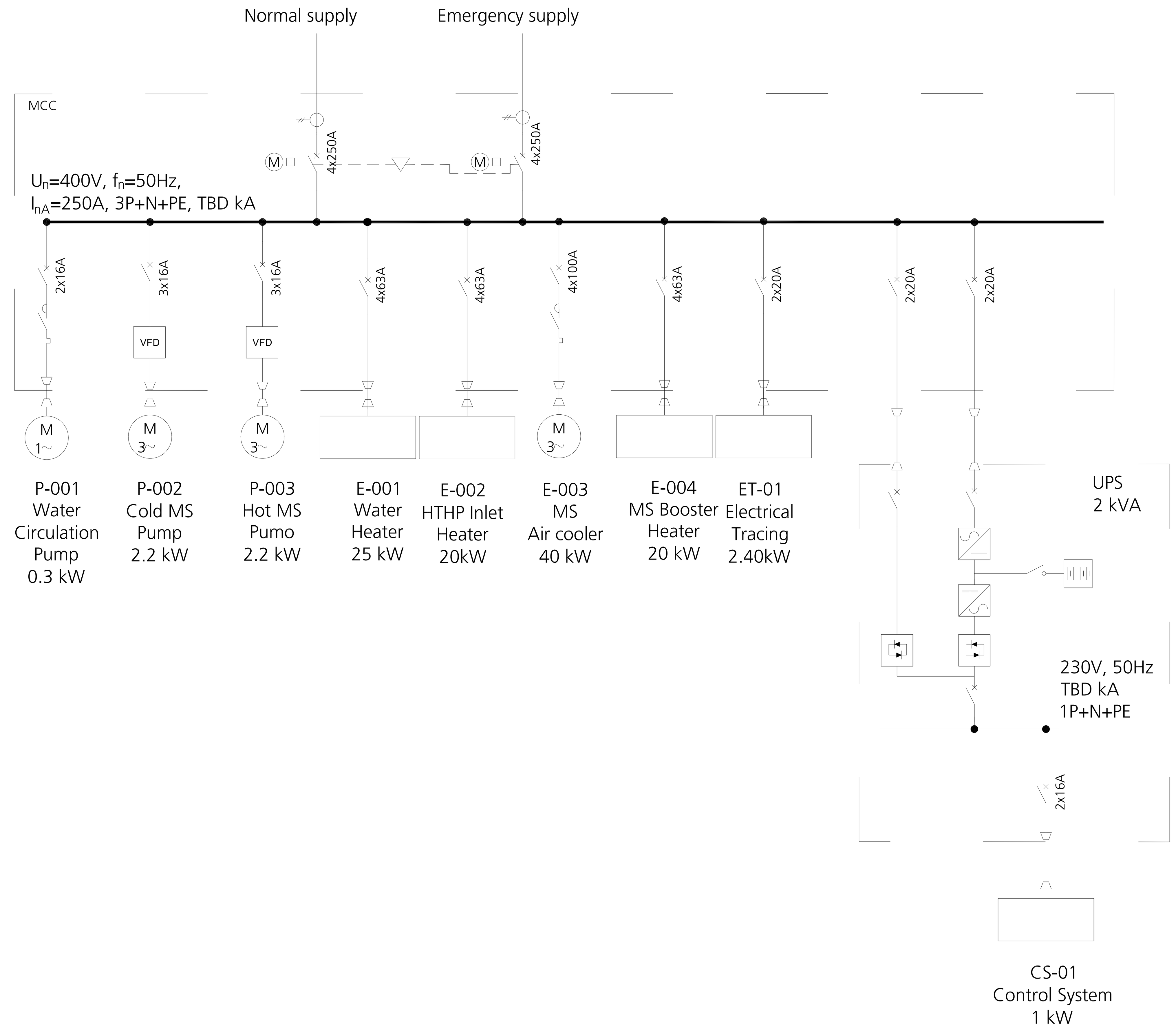
I/O Signal List

ЯPOW		I/O SIGNAL LIST	References	i2313-LIS-RPW-407-013
				Rev No. 01

Rev	Plant	Process	Type	Line	SEQTL	Group	Signal	SIS	Tag	Tag (abstract)	DESCRIPTION	Control_loop	Type	Elect_level	Elect_supply	SOE	URV	LRV	Unit_USC	Controller	Alarms	ALARM_HHH	ALARM_HH	ALARM_H	ALARM_L	ALARM_LL	ALARM_LLL	ADJUST	State	P&ID	Sheet	LOGIC_DIAGRAM	CABINET/JB	N_TERMINAL	CABLE_NAME	N_pair	Pair	Alarm_prior	Notes_I/O
01	01	Water Loop	TT	2	01		XQ01		**TT-201-XQ01**	TT-01	T-001 Temperature transmitter		AI	4-20mA	DCS		0	200	ºC	WS	YES				TBD					i2313-DRA-RPW-104-002	02								
01	01	Water Loop	PT	2	01		XQ01		**PT-201-XQ01**	PT-01	T-001 Pressure transmitter	PIC-01	AI	4-20mA	DCS		0	18	barg	WS	YES			TBD	TBD					i2313-DRA-RPW-104-002	02								
01	01	Water Loop	LT	2	01		XQ01		**LT-201-XQ01**	LT-01	T-001 Level transmitter		AI	4-20mA	DCS		0	2000	mm	WS	YES			TBD	TBD	TBD				i2313-DRA-RPW-104-002	02								
01	01	Water Loop	FT	2	01		XQ01		**FT-201-XQ01**	FT-01	Flow transmitter in E-001 inlet line	FIC-01	AI	4-20mA	DCS		0	20	m3/h	WS	YES				TBD					i2313-DRA-RPW-104-002	02								
01	01	Water Loop	TT	2	02		XQ01		**TT-202-XQ01**	TT-02	Temperature transmitter in E-001 outlet line	TIC-01	AI	4-20mA	DCS		0	200	ºC	WS	YES			TBD	TBD					i2313-DRA-RPW-104-002	02								
2	####	Rev after afety review	FV	BDS	PSP	AMQ	YR01		**FV-PSPAMQ-YR01**	FV-01-SP	Water circulation flow control motor valve set point position	FIC-01	AO	4-20mA	DCS		0	100	%	WS										i2313-DRA-RPW-104-002	02								
01	01	Water Loop	FV	2	01	AMQ	XQ01		**FV-01AMQ-XQ01**	FV-01-PV	Water circulation flow control motor valve feedback position	FIC-01	AI	4-20mA	DCS		0	100	%	WS										i2313-DRA-RPW-104-002	02								
01	01	Water Loop	PV	2	01		YR01		**PV-01-YR01**	PV-01-SP	Water tank vent pressure control motor valve set point position	PIC-01	AO	4-20mA	DCS		0	100	%	WS										i2313-DRA-RPW-104-002	02								
01	01	Water Loop	PV	2	01		XQ01		**PV-01-XQ01**	PV-01-PV	Water tank vent pressure control motor valve feedback position	PIC-01	AI	4-20mA	DCS		0	100	%	WS										i2313-DRA-RPW-104-002	02								
01	01	Water Loop	E	2	01		XQ01		**E-01-XQ01**	E-01-PV	Water heater feeder, power feedback	TIC-01	AI	4-20mA	EXT		0	100	%	MS										i2313-DRA-RPW-104-002	02								
01	01	Water Loop	E	2	01		XG02		**E-01-XG02**	E-01-AVL	Water heater feeder, CB not triped and available		DI	-	Dry contact					TBD									1 OK	i2313-DRA-RPW-104-002	02								
01	01	Water Loop	E	2	01		XB02		**E-01-XB02**	E-01-CL	Water heater feeder, CB closed		DI	-	Dry contact					TBD									1 CLOSED	i2313-DRA-RPW-104-002	02								
01	01	Water Loop	E	2	01		XB21		**E-01-XB21**	E-01-REM	Water heater feeder, VFD selector in remote		DI	-	Dry contact					TBD									1 REMOTE	i2313-DRA-RPW-104-002	02								
01	01	Water Loop	E	2	01		XB40		**E-01-XB40**	E-01-RDY	Water heater feeder, VFD available cabinet (inserted, non-tripped, remote)		DI	-	Dry contact					TBD									1 AVAILABLE	i2313-DRA-RPW-104-002	02								
01	01	Water Loop	E	2	01		YC01		**E-01-YC01**	E-01-STC	Water heater feeder, VFD start/stop command		DO	-	Dry contact					TBD										i2313-DRA-RPW-104-002	02								
01	01	Water Loop	E	2	01		YR01		**E-01-YR01**	E-01-SP	Water heater feeder, VFD power set point		AO	4-20mA			0	100	%	MS										i2313-DRA-RPW-104-002	02								
01	01	Water Loop	E	2	01		XA01		**E-01-XA01**	E-01-RNN	Water heater feeder, VFD heating		DI	-	Dry contact					TBD									1 RUNNING	i2313-DRA-RPW-104-002	02								
01	01	Water Loop	E	2	01		XB13		**E-01-XB13**	E-01-FLT	Water heater feeder, VFD common failure		DI	-	Dry contact					TBD	YES								1 ALARM	i2313-DRA-RPW-104-002	02								
01	01	Water Loop	P	2	01		XG02		**P-01-XG02**	P-01-AVL	Water circulation pump, CB not triped and available		DI	-	Dry contact					MS									1 OK	i2313-DRA-RPW-104-002	02								
01	01	Water Loop	P	2	01		XB21		**P-01-XB21**	P-01-REM	Water circulation pump, selector in remote		DI	-	Dry contact					MS									1 REMOTE	i2313-DRA-RPW-104-002	02								
01	01	Water Loop	P	2	01		YC01		**P-01-YC01**	P-01-STC	Water circulation pump, start/stop command		DO	-	Dry contact					MS										i2313-DRA-RPW-104-002	02								
01	01	Water Loop	P	2	01		XA01		**P-01-XA01**	P-01-RNN	Water circulation pump, running		DI	-	Dry contact					MS									1 RUNNING	i2313-DRA-RPW-104-002	02								
01	01	MS Storage System	TT	3	03		XQ01		**TT-303-XQ01**	TT-03	T-003 Temperature transmitter		AI	4-20mA	DCS		0	450	ºC	MS	YES				TBD					i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	PT	3	02		XQ01		**PT-302-XQ01**	PT-02	T-003 Pressure transmitter		AI	4-20mA	DCS		0	9	barg	MS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	LT	3	02		XQ01		**LT-302-XQ01**	LT-02	T-003 Radar Level transmitter	LSL-01	AI	4-20mA	DCS		0	2000	mm	MS	YES			TBD	TBD					i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	FT	3	02		XQ01		**FT-302-XQ01**	FT-02	Flow transmitter in E-003 inlet line	FIC-02	AI	4-20mA	DCS		0	20	m3/h	MS	YES				TBD					i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	PT	3	03		XQ01		**PT-303-XQ01**	PT-03	Pressure transmitter in E-003 inlet line		AI	4-20mA	DCS		0	9	barg	MS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	TT	3	04		XQ01		**TT-304-XQ01**	TT-04	Temperature transmitter in E-003 outlet line to Cold MS Tank	TIC-02	AI	4-20mA	DCS		0	450	ºC	MS	YES				TBD					i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	PT	3	04		XQ01		**PT-304-XQ01**	PT-04	Pressure transmitter in E-003 outlet line to Cold MS Tank		AI	4-20mA	DCS		0	9	barg	MS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	TT	3	05		XQ01		**TT-305-XQ01**	TT-05	T-002 Temperature transmitter		AI	4-20mA	DCS		0	450	ºC	MS	YES				TBD					i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	LT	3	03		XQ01		**LT-303-XQ01**	LT-03	T-002 Radar Level transmitter	LSL-02	AI	4-20mA	DCS		0	2000	mm	MS	YES			TBD	TBD					i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	PT	3	05		XQ01		**PT-305-XQ01**	PT-05	T-002 Pressure transmitter		AI	4-20mA	DCS		0	9	barg	MS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	FT	3	03		XQ01		**FT-303-XQ01**	FT-03	Flow transmitter in P-002 discharge line	FIC-03	AI	4-20mA	DCS		0	20	m3/h	MS	YES				TBD					i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	TT	3	06		XQ01		**TT-306-XQ01**	TT-06	Temperature transmitter in E-002outlet	TIC-03	AI	4-20mA	DCS		0	450	ºC	MS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	PT	3	06		XQ01		**PT-306-XQ01**	PT-06	Pressure transmitter in E-002 outlet		AI	4-20mA	DCS		0	9	barg	MS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	TT	3	08		XQ01		**TT-308-XQ01**	TT-08	Temperature transmitter in E-004 outlet	TIC-04	AI	4-20mA	DCS		0	450	ºC	MS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	TT	3	07		XQ01		**TT-307-XQ01**	TT-07	Temperature transmitter in HTHP outlet line		AI	4-20mA	DCS		0	450	ºC	MS	YES				TBD					i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	PT	3	07		XQ01		**PT-307-XQ01**	PT-07	Pressure transmitter in HTHP outlet line		AI	4-20mA	DCS		0	9	barg	MS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	FV	3	02		YR01		**FV-02-YR01**	FV-02-SP	Hot molten salt flow control motor valve set point position	FIC-02	AO	4-20mA	DCS		0	100	%	WS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	FV	3	02		XQ01		**FV-02-XQ01**	FV-02-PV	Hot molten salt flow cotrol motor valve feedback position	FIC-02	AI	4-20mA	DCS		0	100	%	WS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	FV	3	03		YR01		**FV-03-YR01**	FV-03-SP	Cold molten salt flow control motor valve set point position	FIC-03	AO	4-20mA	DCS		0	100	%	WS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	FV	3	03		XQ01		**FV-03-XQ01**	FV-03-PV	Cold molten salt flow control motor valve feedback position	FIC-03	AI	4-20mA	DCS		0	100	%	WS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	P	3	02		XG02		**P-02-XG02**	P-02-AVL	Cold molten salt pump, CB not triped and available		DI	-	Dry contact					MS									1 OK	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	P	3	02		XB21		**P-02-XB21**	P-02-REM	Cold molten salt pump, selector in remote		DI	-	Dry contact					MS									1 REMOTE	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	P	3	02		YC01		**P-02-YC01**	P-02-STC	Cold molten salt pump, start/stop command	LSL-02	DO	-	Dry contact					MS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	P	3	02		XA01		**P-02-XA01**	P-02-RNN	Cold molten salt pump, running		DI	-	Dry contact					MS									1 RUNNING	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	P	3	03		XG02		**P-03-XG02**	P-03-AVL	Hot molten salt pump, CB not triped and available		DI	-	Dry contact					MS									1 OK	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	P	3	03		XB21		**P-03-XB21**	P-03-REM	Hot molten salt pump, selector in remote		DI	-	Dry contact					MS									1 REMOTE	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	P	3	03		YC01		**P-03-YC01**	P-03-STC	Hot molten salt pump, start/stop command	LSL-01	DO	-	Dry contact					MS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	P	3	03		XA01		**P-03-XA01**	P-03-RNN	Hot molten salt pump, running		DI	-	Dry contact					MS									1 RUNNING	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	03		YR01		**E-03-YR01**	E-03-PV	Air cooler speed feedback	TIC-02	AI	4-20mA	EXT		0	100	%	MS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	03		XG02		**E-03-XG02**	E-03-AVL	Air cooler feeder, CB not triped and available		DI	-	Dry contact					MS									1 OK	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	03		XB02		**E-03-XB02**	E-03-CL	Air cooler feeder, CB closed		DI	-	Dry contact					MS									1 CLOSED	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	03		XB21		**E-03-XB21**	E-03-REM	Air cooler feeder, VFD selector in remote		DI	-	Dry contact					MS									1 REMOTE	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	03		XB40		**E-03-XB40**	E-03-RDY	Air cooler feeder, VFD available cabinet (inserted, non-tripped, remote)		DI	-	Dry contact					MS									1 AVAILABLE	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	03		YC01		**E-03-YC01**	E-03-ST CMD	Air cooler feeder, VFD start/stop command		DO	-	Dry contact					MS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	03		YR01		**E-03-YR01**	E-03-SP	Air cooler feeder, VFD speed set point	TIC-02	AO	4-20mA			0	100	%	MS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	03		XA01		**E-03-XA01**	E-03-RNN	Air cooler feeder, VFD running		DI	-	Dry contact					MS									1 RUNNING	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	03		XB13		**E-03-XB13**	E-03-FLT	Air cooler feeder, VFD common failure		DI	-	Dry contact					MS	YES								1 ALARM	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	04		XQ01		**E-04-XQ01**	E-04-PV	Booster heater speed feedback	TIC-04	AI	4-20mA	EXT		0	100	%	MS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	04		XG02		**E-04-XG02**	E-04-AVL	Booster heater feeder, CB not tripped and available		DI	-	Dry contact					MS									1 OK	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	04		XB02		**E-04-XB02**	E-04-CL	Booster heater feeder, CB closed		DI	-	Dry contact					MS									1 CLOSED	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	04		XB21		**E-04-XB21**	E-04-REM	Booster heater feeder, VFD selector in remote		DI	-	Dry contact					MS									1 REMOTE	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	04		XB40		**E-04-XB40**	E-04-RDY	Booster heater feeder, VFD available cabinet (inserted, non-tripped, remote)		DI	-	Dry contact					MS									1 AVAILABLE	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	04		YC01		**E-04-YC01**	E-04-ST CMD	Booster heater feeder, VFD start/stop command		DO	-	Dry contact					MS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	04		YR01		**E-04-YR01**	E-04-SP	Booster heater feeder, VFD speed set point	TIC-04	AO	4-20mA			0	100	%	MS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	04		XA01		**E-04-XA01**	E-04-RNN	Booster heater feeder, VFD running		DI	-	Dry contact					MS									1 RUNNING	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	04		XB13		**E-04-XB13**	E-04-FLT	Booster heater feeder, VFD common failure		DI	-	Dry contact					MS	YES								1 ALARM	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	02		XQ01		**E-02-XQ01**	E-04-PV	HTHP inlet heater speed feedback	TIC-03	AI	4-20mA	EXT		0	100	%	MS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	02		XG02		**E-02-XG02**	E-04-AVL	HTHP inlet heater feeder, CB not tripped and available		DI	-	Dry contact					MS									1 OK	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	02		XB02		**E-02-XB02**	E-04-CL	HTHP inlet heater feeder, CB closed		DI	-	Dry contact					MS									1 CLOSED	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	02		XB21		**E-02-XB21**	E-04-REM	HTHP inlet heater feeder, VFD selector in remote		DI	-	Dry contact					MS									1 REMOTE	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	02		XB40		**E-02-XB40**	E-04-RDY	HTHP inlet heater feeder, VFD available cabinet (inserted, non-tripped, remote)		DI	-	Dry contact					MS									1 AVAILABLE	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	02		YC01		**E-02-YC01**	E-04-ST CMD	HTHP inlet heater feeder, VFD start/stop command		DO	-	Dry contact					MS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	02		YR01		**E-02-YR01**	E-04-SP	HTHP inlet heater feeder, VFD speed set point	TIC-03	AO	4-20mA			0	100	%	MS										i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	02		XA01		**E-02-XA01**	E-04-RNN	HTHP inlet heater feeder, VFD running		DI	-	Dry contact					MS									1 RUNNING	i2313-DRA-RPW-104-002	03								
01	01	MS Storage System	E	3	02		XB13		**E-02-XB13**	E-04-FLT	HTHP inlet heater feeder, VFD common failure		DI	-	Dry contact					MS	YES								1 ALARM	i2313-DRA-RPW-104-002	03								

10.18 Single Line Diagram

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101147078.



Symbol	Description	Symbol	Description
	Cable		Ground Connection
	Busbar connection		Surge Arrestor
	Cable connection		Circuit Breaker
	Branch point		Circuit Breaker with thermal and overcurrent relay
	Direct Current		Off load disconnector switch
	Alternative Current		On Load Disconnector Switch
	InterLock (M: Mechanical; E: Electrical)		Circuit Breaker with Ground Protection
VFD	Variable Frequency Driver		3 Ph Induction Motor
	Instrumentation Current transformer		Electrical Motor Actuator
	Voltage transformer		
	Fuse		

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Client:

Supplier Eng.:

ЯPOW

Scale: NTS

Title and Subtitles:
Electrical
Single line diagram
Motor Control Center

Project:

Drawing No.: 2XXX-DRW-RPW-000-XX-000X

Sheets: 001

Sheet No.: 001

10.19 “What if…” analysis results

This project has received funding from the European Union’s Horizon Europe research and innovation programme under grant agreement No 101147078.

Project:		**I-UPS**
Date:		**23/04/2025**
Participants:		**RPOW (Bart De Sterck, Patricia Santamaría Prado), KYOTO (James Brown, Sharat Pathi, Torstein Halvorsen), ENERIN(Eirik Topp, Arne Hoeg)**

Area	Case	What if...	What If... / Hazard	Consequences (without safeguards)	Current Safeguards	Likelihood	Severity	Risk rating	Risk	Recommendations/Actions	Corrected Likelihood	Corrected Rating	Risk2
Water	1.0	High Pressure	What if PCV-01 fails and pressure in T-001 goes up.	T-001 overpressure, tank rupture, hot water/steam release. Operator exposure,	PIC-01 to vent off N2 if pressure goes up. PSV-02 to be designed for the case of relieveing the pressure from the bottles.	1	3	3	Low		1	3	Low
Water	2.0	Low Pressure	What if PV-01 fails and opens, or gas bottle pressure is low?	1. Hot liquid starts boiling 2. Pump cavitation, pump damage 3. Hot steam release through PV-01	None	3	2	6	Medium	Low Pressure alarm on PT-01 Routine checks on N2 bottle presssure Procedure to always have a 2nd bottle ready to connect	2	4	Medium
Water	3.0	No Flow	What if one of the valves in P-001 outlet closed by error (control or operator error)	1. Piping reaches maximum pressure from pump 2. No flow through E-001. 3. No flow through HTHP. Possible damage to heat pump HEX?	1. Piping designed to take pump head + T-001 pressure 2. None 3. None	3	1	3	Low	Low Flow Alarm on FT-01. Check HTHP instrumentation for additional safeguards. Tag manual valves open or close to avoid mistakes.	2	2	Low
Water	4.0	High Level	What if the tank is overfilled (manual operations error)	Water expansion during heating, tank overfilling, hot water in outlet lines or in N2 inlet line.	High level alarm T-001 top outlet lines go to safe location NRV on N2 line N2 piping class suited for high T	1	2	2	Low	Tank filling and pump start-up SOP to include target level and checks. Tank drain valve VG-08 can be used to correct level.	1	2	Low
Water	5.0	Low Level	What if the level in T-001 is too low (from insufficient filling) and there is not enough NPSHa for the pump?	Pump running dry, pump damage	Low level alarm on T-001 (LT-01)	2	1	2	Low	Tank filling and pump start-up SOP to include target level and checks.	2	2	Low
Water	6.0	High Temperature	What if the water heater overshoots the maximum operations temperature of the loop.	1. Water overheating, vapour formation, pump cavitation, pump damage 2. Possible damage to HTHP	None	2	2	4	Medium	E-001 scope to include temperature limitation. High temperature on TT-02 alarm at max operating value.	1	2	Low
Water	7.0	Low Temperature	What if the water heater stops working and the HTHP keeps extracting heat from the water loop and water freezes.	1. Blockage in HTHP exchanger 2. No flow scenarios (see 3.0)	None	2	2	4	Medium	Low temperature alarms on TT-01 and TT-02	1	2	Low
Water	8.0	Personal Exposure	What if an operator gets exposed to hot steam or N2 during manual operations like adding water to T-001, draining or in case of release through a PSV	Personal Injury	1. Vents and PSV outlets go to safe location, either outside the building or to the ground. 2. None for filling operation or draining	3	3	9	Serious	Water refilling and draining procedure to include removing pressure from T-001 and blocking in N2 source. Lock water inlet valve closed by procedure before pressurizing the vessel. PPE to be mandatory for such operations	1	3	Low
General	9.0	Wrong Measurement	What if the temperature and/or flow measurements give erroneous values	Erroneous results, unreliable conclusions	None	2	1	2	Low	Set up cross-validation between, temperatures, flows and heater power	2	2	Low
MS	10.1	No Flow	What if one of the valves in P-002 outlet closed by error	1. No flow to E-002 2. No flow to HTHP - temperature increase 3. No flow to T-003 And equipment damage from running empty 4. Level increase in T-002 (see 11.0)	1+3. None 2. HTHP control system will detect and stop the HTHP 4. See 11.0	2	2	4	Medium	Add low alarms on FT-03	1	2	Low
MS	10.2	No Flow	What if one of the valves in P-003 outlet closed by error	1. No flow to E-003 - no consequence 2. Level increase in T-003 (see 11.0)	1. None 2. See 11.0	2	2	4	Medium	Add low alarms on FT-02	1	2	Low
MS	11.0	High Level	What if the level in T-002 or T-003 increases because of no outlet available	Level increase in T-002 or T-003 Low level in T-002 or T-003 will trip the pump P-02 or P-003	Salt inventory is limited LSL-01 and LSL-02 LT-02 and LT-03 high alarm	1	1	1	Low		1	1	Low
MS	12.0	Low Level	similar to high level cases					0	None		0	0	None
MS	13.0	High Temperature	What if an eletric heater overshoots the maximum operations temperature of the loop.	Surpassing design temperature of the system, damage to equipment (pump, HTHP,...) Salt decomposition	None	2	3	6	Medium	Electric heater scope to include temperature limitation	1	3	Low

MS	14.0	Low Temperature	What if the temperature drops below the allowed one for solidification because of 1. Air cooler outlet too cold 2. Tracing falure	Line freezing, stop operations, equipment damage	1. Tracing 2. None	2	3	6	Medium	TT-04 to be equipped with low alarm Heat tracing to be equipped with alarm on case of malfunctioning. Drain valves to be added to the salt loop to evacuate the salt when the system stops for longer times.	1	3	Low
General	15.1	No Power	What if the power fails to the pilot plant MS loop?	Pumps stop - No flow (see 10.0) Heaters stop Tracing Stops - Line freezing (see 14.0) Damage to piping and equipment due to salt freezing.	Power supply from different sources reduces the risk of general power loss significantly.	1	3	3	Low		1	3	Low
General	15.2	No Power	What if the power fails to the pilot plant water loop?	Pump stop - No flow Heater stops - No heat	HTHP control system to stop the HTHP	1	2	2	Low	Interface with HTHP for possible protective measurements	1	2	Low
General	15.3	No Power	What if the power fails to the HTHP?	Water loop: no consequences MS loop: possible lack of heating when operating without EH and salt freezing	None	1	3	3	Low	Equip TTs with low temperature alarm for preventing salt freezing	1	3	Low
Water	16.0	High Concentration	What if there is a leak in the water/He HEX and He enters the water circuit	He will enter the water lines and will accumulate at the highest point in the system. Water flow will start to oscillate because of the gas bubble and can potentially damage the pump. The system pressure will increase and can overpressure the vessel/lines leading to rupture and hot water/steam release.	1. Double seals with ventilation in the HTHP should evauate the leak - amount of He in HTHP is monitored. 2. Rising system pressure will be released by PIC-01 and PV-01	1	3	3	Low	Check PSV-01 to include He release Add high alarm to PT-01 Check with HTHP supplier	1	3	Low
MS	17.0	High Concentration	What if there is a leak in the MS/He HEX and He enters the MS circuit	He will enter the MS lines and will accumulate at the highest point in the system. When entering one of the MS tanks, He will exit the tank as they are atmospheric. He trapped in the heaters or in the lines can cause flow fluctuations and possible pump damage.	1. Double seals with ventilation in the HTHP should evauate the leak - amount of He in HTHP is monitored.	2	2	4	Medium	Check with HTHP supplier Add high alarm to PT-02 and PT-03	2	4	Medium