MYRRHA phase 1 implementation

MINERVA

SCK CEN Ref.: =NA.PS02_PDB501
Third Party Ref.: 092-423-RM-M-14100

PS02 Water Preparation and Supply System Description

Contract name: Design Engineering Contract
Project phase: Basic Design
SBS level: MYRRHA - MINERVA ACC - Nuclear Facilities – Process systems, equipment and piping

REV.	YY/MM/DD	ISSUED FOR	AUTHOR(S)	REVIEWER(S)	APPROVER	VALIDATED BY SCK CEN
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CLASSIFICATION

Contains information for the design of structures, systems or components: Yes ☒ No ☐
Design verification : Not applicable ☐ Head of OU/Supervisor ☒ Verifier Level 1 ☐ Level 2 ☐

CONTROL OF MODIFICATIONS

Issue	Modifications
3	Updated for Basic Design (IIB), according to SCK CEN comments and new input data. Changes marked with vertical line on the left side.
4	Udated according to the agreements adopted at the meeting held the 23/03/28 (resolution of the comments included in the CS). Changes marked with vertical line on the left side.o vi

PRELIMINARY OR PENDING INFORMATION

Issue	Paragraphs	Subject	Status
4	8.1 8.1.2 and 9.3.1	Configuration of the package production plants of PS02 Location in Clean room (MCB L0) of one softened water connection to other potentially users	Preliminary Preliminary

DISTRIBUTION

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C/Magallanes 3, 28015, Madrid, Spain

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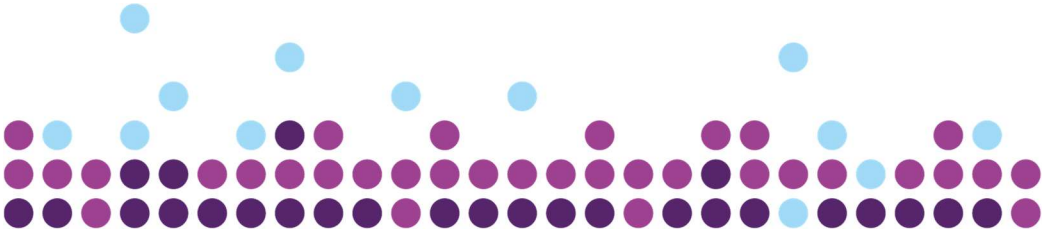


Table of Content

1 Introduction

The MINERVA project is embedded in the overall MYRRHA programme. Following the phased MYRRHA implementation strategy, the first facility that will be constructed at SCK CEN, Mol (Belgium) will be the first part of the 600 MeV MYRRHA LINAC that will deliver intense proton beams up to 100 MeV. The 100 MeV accelerator together with the proton target facility and FPF is named MINERVA (MYRRHA Isotopes productioN coupling the linEar acceleRator to the Versatile proton target fAcility).

Tractebel together with its Consortium Partner Empresarios Agrupados will act as Design Engineer of all the Structures, Systems and Components (SSC) necessary to operate the MINERVA Accelerator, and covered under the term Nuclear Facilities (NF), except for the accelerator systems themselves, which are excluded from the Design. The Design Engineer mission covers the Design, Assistance with procurement and support during Construction.

The framework and more details about this project can be found in the Project Execution Plan Ref. [7].

2 Scope and Purpose

This document describes the main configuration and functions of the PS02 Water Preparation and Supply System. It also defines the system's instrumentation and control, its interfaces with other systems and the most important characteristics of its major components, including also Operation and Control and normal functionality (see Chapters 8 and 9).

3 Acronyms

The complete list of acronyms used in the MINERVA project is included in the SCK CEN document "Abbreviations, Glossary and symbols", SCK CEN\8905079 Ref. [1].

4 Assumptions

The following assumptions has been taken into account in the design of the system:

[1] Location of Purified rainwater production plant in MCB building, Level 0, in the non supervised and controlled area.

[2] Location of the Ultra high purified (UHP) demineralized water production plant in the specific rooms where it is needed by their consumers: Clean room (level 0) and Vacuum room (level 2), both located in MCB.

5 Input Data List

Nº	Original Document			Data	Status
	Nº	Ed.	Title		
1	SCK·CEN/30215225	18-08-22	NA.PS02_MEC001 - Water Supply - Functional Specifications	System functional specifications and requirements	V
2	NA.AA_BEB501 - MINERVA/4NT/0691961/000/02	1	Nuclear Safety Specification	Nuclear Safety Classification of the SSC	V
3	SCK·CEN/30216414	01-03-19	Process Systems Project Requirements	Process systems basic requirements	V
4	SCK·CEN/30220178	01-03-19	Process Equipment Project Requirements	Process equipment general basic requirements	V
5	SCK·CEN/51855847	09-11-22	NA.PS discipline meeting	ACC NF design to consider water from Lagoon as the primary source of softened water	V

Nº	Original Document			Data	Status
	Nº	Ed.	Title		
6	NA.PS_PDB012 NA.PS-ID1179	01-12-20	=NA.PS_PDB012 - Answer to RFI -	Demineralized water demand at FPF building	V
7	SCK CEN/48336200 NA.PS-ID1172	18-07-22	Water requirements for ACC, PTF / FTS systems and other facilities (ej.Laboratories, clean room) : water quality & supply conditions. -Purified rainwater conditions for greenery irrigation and/or cleaning	Water requirements for ACC_PTF_FTS	V
8	=NA.PS02_PDB501 R03 CS Ref: 092-423-CE-EAI-SCK-23/0233	28-03-23	Comment Sheet (CS) resolution PS02 Water Preparation and Supply System Description (rev 3)	Final agreements on description content	V

6 System Functions and Configuration

The PS02 Water Preparation and Supply System provides water of the requested quality and in the required quantity to the different SSC's according to Ref. [5] (Potable water) and Annex 11 (Softened and Demineralized water, and Purified rainwater). There are several sources of raw water that will be used in the installation Ref. [6]. On-site there will be further purification of the different water sources to comply with the required quality at the end users.

The sources of water consist of municipal drinking water, surface water from a lagoon and rainwater. The Water Preparation and Supply System will use these sources to provide the different consumers with the requested quality of water.

6.1 System Functions

The main function of the Water Preparation and Supply System are:

- Municipal drinking water subsystem (NA.PS02.GKB10) for the distribution of drinking water and back-up supply for softened water
- Softened (NA.PS02.GKC10) water subsystem for the production, storage and distribution of softened water
- Demineralized (NA.PS02.GHC10) water subsystem for the production, storage and distribution of demineralized water
- Purified rainwater subsystem (NA.PS02.GUD10) for the production and distribution of purified rainwater

6.2 System List

To accomplish the required system functions, and taking into account the different qualities of water to be produced and/or distributed, several subsystems have been considered into the Water Preparation and Supply System.

The list of subsystems and equipment that comprise the system will be included in the MINERVA ACC NF SCC List, Ref. [14].

6.3 Fluid Characterization

The different process media that are considered in the PS02 Water Preparation and Supply System, attending to the different water qualities required, are the following:

- Drinking water. The Municipal drinking water analysis, is included in Ref. [5] and Ref. [10].
- Demineralized water. The most relevant demineralized quality parameters are included in Annex 11.2.
- Softened water. The most relevant softened quality parameters are included in Annex 11.1.
- Raw water from the Large Lagoon. The water analysis is included in Ref. [10].
- Purified rainwater. The most relevant demineralized quality parameters are included in Annex 11.3.

All these process media will be included in the MINERVA ACC NF Fluid List, Ref. [17].

Stream information of the main process lines of the system, including the process fluid and their operating conditions, is included in the system Process Flow Diagram (PFD), Ref. [3] and in the Line List, Ref. [20].

7 System Boundaries and Interfaces

The interfaces of the system with other systems or related equipment are described below. The interfaces are classified into those that are necessary for the system or operation - support systems - and those that are supplied by the system and needed so that other systems can perform their function - dependent systems.

The systems which interface with the Water Preparation and Supply System are set out below:

7.1 Support systems

- Municipal drinking water comes from the SCK CEN drinking water circuit, (I.D.1).
- Rainwater intake to the Rainwater Purification subsystem comes from the rainwater storage tank (outdoors).
- Low voltage system, necessary for the operation of system equipment including electrical components such as the pressure units and pumps.
- PS03 Waste water Treatment system, for PS02 drains collection.
- PS05 Industrial gases (Compressed air subsystem), for the pneumatic valves of the system.
- Instrumentation and Control (I&C) system.

7.2 Dependent Systems

- Cooling Systems (PS01): Adiabatic coolers are fed with softened water. Primary cooling loops of ACC equipment are filled with demineralized water. The make up water fluid for the water-glycol loops and intermediate cooling loops shall be softened water, (I.D.1).
- Plumbing and Sewers Systems: PS02 supplies municipal drinking water for toilets and purified rainwater for WC's in the MINERVA ACC NF, (I.D.1).
- MAC: PS02 supplies demineralized and softened water to the MAC NF. Additionally municipal drinking water is also foreseen to be connected to the MAC NF users, (I.D.1).
- ACC systems and other consumers in ACC NF. Demineralized water connections are provided for the different consumers in the ACC NF.

7.3 Terminal Point List

The different terminal points of the PS02 Water Preparation and Supply System with the site external facilities, ACC systems and MAC will be included in the MINERVA ACC NF Terminal Point List, Ref. [18].

These terminal points are also dentified and numbered in the System Process Flow Diagram, Ref. [3] and P&ID, Ref. [4].

8 System Design Description

8.1 Design Description

8.1.1 Municipal drinking water sybsystem (NA.PS02.GKB10)

The objective of the Municipal drinking water subsystem is to supply and distribute municipal water to the sanitary equipment. Furthermore, municipal drinking water will be also used as a back-up source for the production of softened water in the softening treatment plant. On the other hand, the MAC building will be individually connected to the drinking water net (I.D.1) to provide their users.

Drinking water will be connected to the SCK CEN drinking water circuit, (I.D.1).

Municipal drinking water quality is given in Ref. [5].

8.1.1.1 Component description and arrangement

8.1.1.1.1 Potable water pressure group unit (NA.PS02.GKB10.AP010)

The Potable water pressure unit (NA.PS02.GKB10.AP010) comprises the following main components:

- Two (2 x 100%) motor-driven pumps units, each capable of 24 m^3/h.
- One (1) pressurizing tank of 200 l (to be confirmed by the package supplier of the pressure group).
- One (1) pressure transmitter at the discharge of the pumps.

The function of the municipal drinking water pressure unit is to pressurize the potable water system with the pumps and store it into a pressurized tank, so that the water can be channelled to the different services at the required pressure. It is located in the Water Treatment room of the AUB, Ref. [12].
The design conditions are given in Ref. [10].

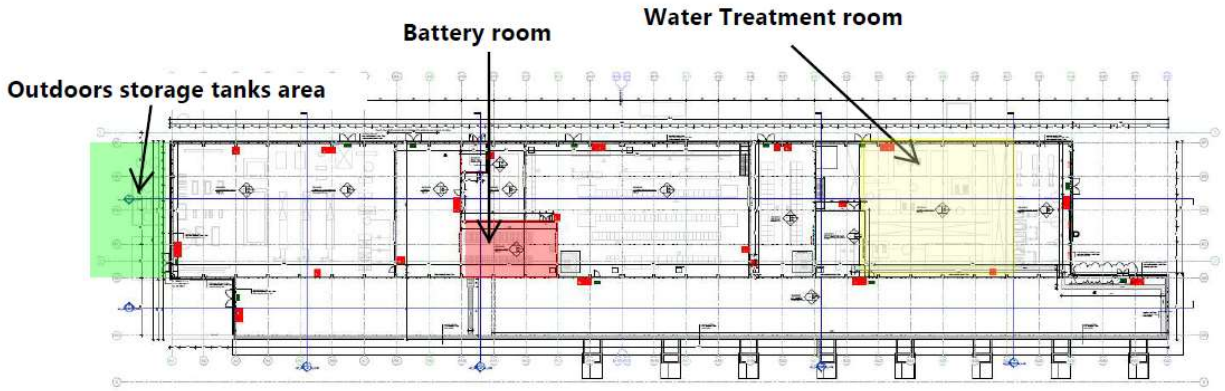


Figure 1 – Location of the pressure group unit NA.PS02.GKB10.AP010 and its users, in AUB (L0)

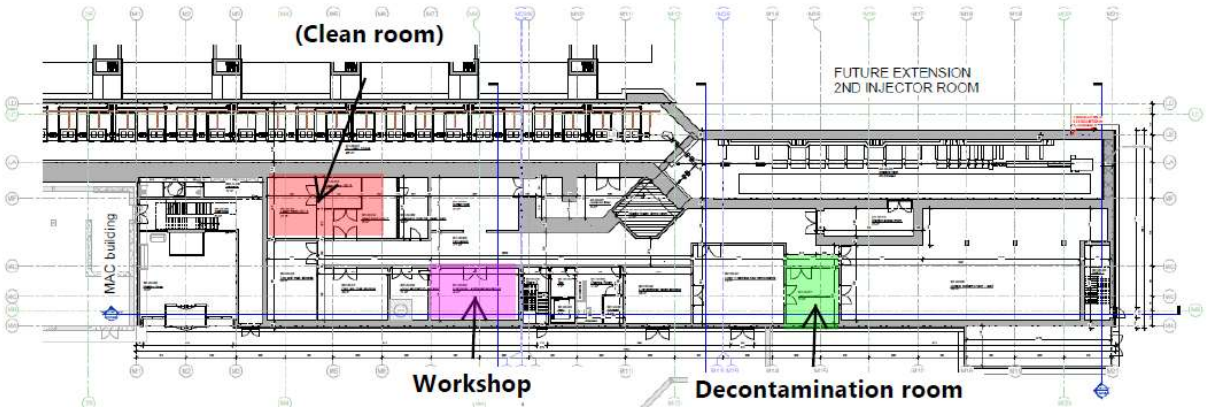


Figure 2 – Location of the NA.PS02.GKB10.AP010 pressure group unit users, in MCB L0

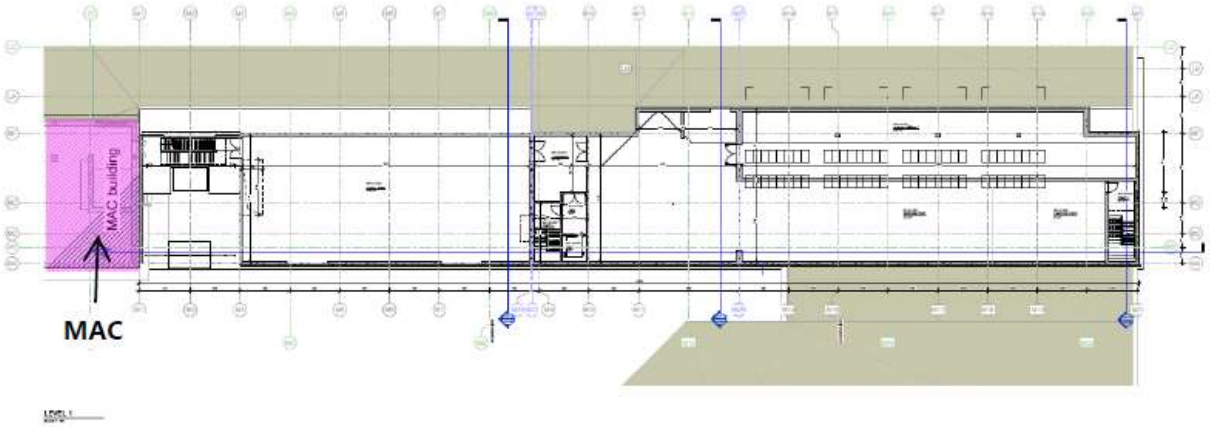


Figure 3 – Location of the NA.PS02.GKB10.AP010 pressure group unit users, in MCB (L1)

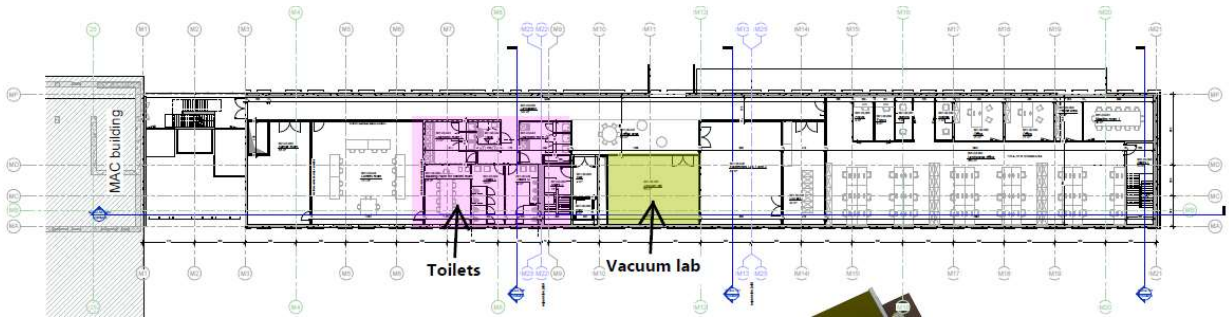


Figure 4 – Location of the NA.PS02.GKB10.AP010 pressure group unit users, in MCB (L2)

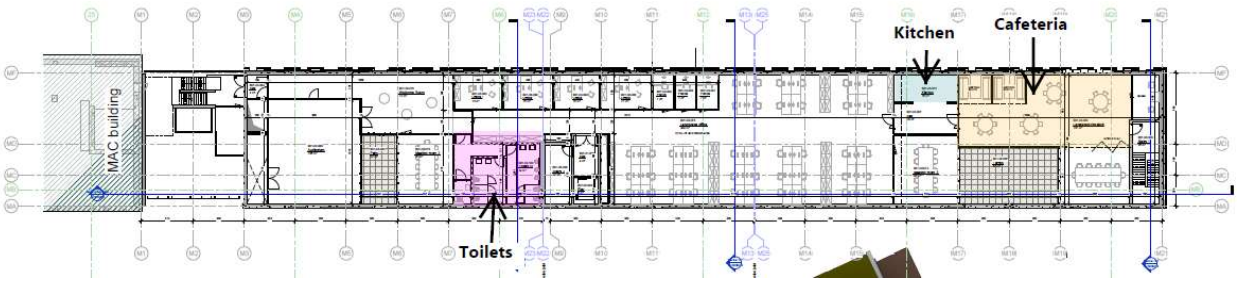


Figure 5 – Location of the NA.PS02.GKB10.AP010 pressure group unit users, in MCB (L3)

8.1.2 Softened water Subsystem (NA.PS02.GKC10)

The basic functions of the Softened water subsystem at the MINERVA facility will be to supply water as make-up water to the adiabatic coolers and feed the water/glycol cooling loops as make-up water. Softened water is also the source of water for the Demineralization production plant, Ref. [3] and Ref. [4]. Additionally, connections to the MAC building will be provided as (I.D.1). Finally, it has been foreseen one connection (normally closed (NC)) in Clean room (preliminary) for other potentially users in Level 0 of MCB.

The main source of softened water will originate from surface water and will be provided at the MINERVA facility by a new supply line directly from the Large Lagoon, located near SCK CEN, Ref. [6].

In order to comply with the minimum quality requirements of the make-up water to the adiabatic coolers, included in Annex 11.2.2, and taking into account the water quality provided for the surface water from the lagoon, Ref. [9] and Ref. [10], one disinfection process plus filtration in filters is likely to be enough to prevent the presence of particles, scaling, corrosion and fouling of pipes and installations as to ensure their requested lifetime.

The disinfection water treatment equipment will be located near the lagoon to limit the length of pipes that are exposed to untreated water.

On the other hand, dedicated filters will be located in the Water Treatment Plant room at the AUB (Level 0), Ref [12].

In addition, one back-up source from Municipal drinking water is provided in the MINERVA ACC NF, in case the water extraction pipe from the Lagoon is out of service. For this use, municipal drinking water will be treated in order to decrease its total hardness, included in Ref. [5] and Ref. [6]. By means of a Softening process, calcium salts from the municipal drinking water will be removed by passing this source of water through cationic resins that retain them and exchange them for sodium ions. The final total hardness at the exit of the Softening Treatment Plant will be no higher than 140 mg/l $CaCO_3$.

The ion-exchange resins shall be regenerated by washing with a concentrated solution of sodium chloride NaCl that releases the retained calcium ions by evacuating them to the Industrial drains subsystem (PS03).

Softened water will be finally stored in a tank.

8.1.2.1 Component description and arrangement

8.1.2.1.1 Lagoon water intake pumps (NA.PS02.GKC10.AP031/32)

The Lagoon water intake pumps (NA.PS02.GKC10AP031/32) are (2 x 100%) pumps (one on standby), of 17 m^3/h flow capacity that supply water for cooling water purposes after being treated in a dedicated treatment plant. Lagoon water pumps are located in a basin structure, next to the lagoon.
The design pressure and temperature conditions are given in Ref. [10].
The Lagoon water intake pumps are submersible type. It is foreseen that operate completely submerged.
The water intake structure for collecting water from the lagoon is a fixed installation. To install such a pump, a fixed self-connecting coupling must be anchored to the ground as shown in figures 6 and 7. Guide rails must also be used to direct the pump as it is lowered into place. Visibility is not required during this operation as the pump connects automatically to the self-connecting coupling thanks to its own weight. Removing the pump is just as easy, as it can be disconnected by simply pulling the pump upwards with the lifting chain. This means that both connection and disconnection can be carried out quickly, thus facilitating both pump installation and inspection.

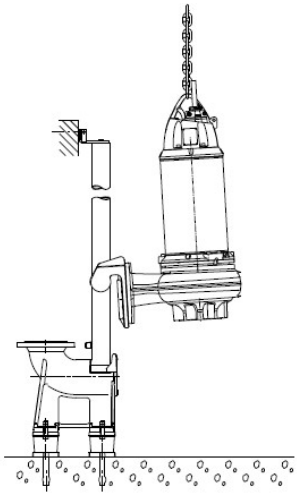


Figure 6 - Submersible pump installation 1

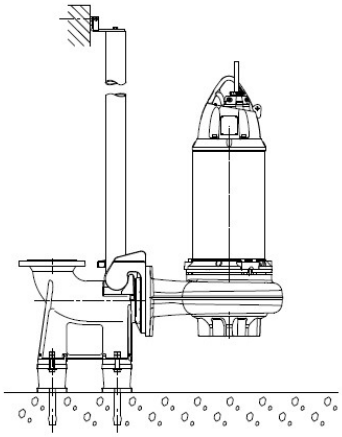


Figure 7 - Submersible pump installation 2

Submersible pumps can be equipped with filters in their suctions. Given the characteristics of the water in the lagoon, a filter integrated into the suction of the proposed submersible pump and a bar screen on the water intake pipe (see description below) should be enough to filter the water correctly.

As previously mentioned, the pump's fixed coupling must be anchored to the ground, which means it will be necessary to provide a simple intake structure for its installation. Such a structure is also advisable to ensure the correct hydraulic operation of the pumps. It will also allow for emptying, maintenance and inspection operations of the bottom and thus help avoid the operating problems that would derive from the accumulation of sludge in the vicinity of the suction as a result of the suction force of the pump. In fact, without this structure, these operations would be impossible to carry out.

The proposed water intake structure is shown schematically in figures 8 and 9:

The intake structure will be located as close as possible to the edge of the lagoon.

Water enters the intake structure through a pipe. This pipe should be positioned below the minimum water level of the lagoon, but as high as possible above the bottom to ensure that the water enters at a shallow point that has as good quality water as possible, with characteristics as close as possible to the available data, as per reference Ref. [6] .

As mentioned above, a bar screen will be placed at the end of the intake pipe to prevent objects such as leaves, branches, etc., from entering the pump house.

A deflector could be installed downstream of the pipe to minimise the entry of air with the water that enters the pump house and thus prevent the formation of vortices. The incoming water flow would hit the deflector and be forced downwards through the space between the floor and the deflector and distributed evenly towards the intakes of all the pumps. This deflector should be high enough to ensure that water does not overflow it. The final need for this deflector, as well as that of any other anti-vortex elements that may be required in the collection structure, will be determined based on the needs of the pump and the final characteristics of the installation, and will be studied with the pump supplier.

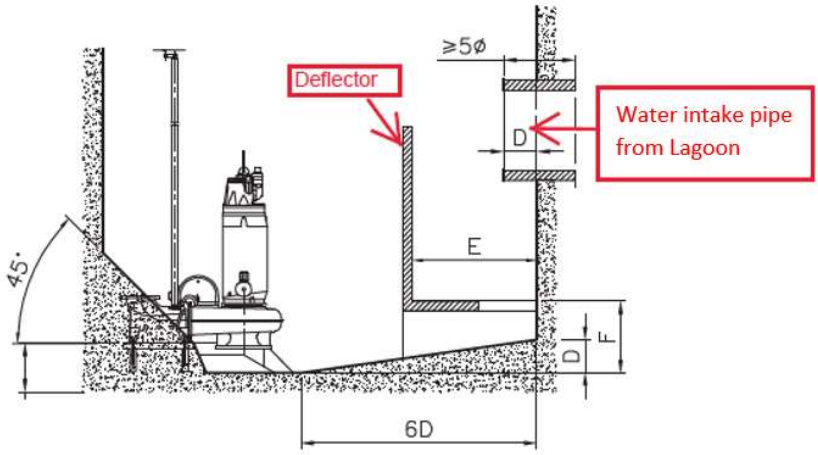


Figure 8 - Intake structure – elevation view

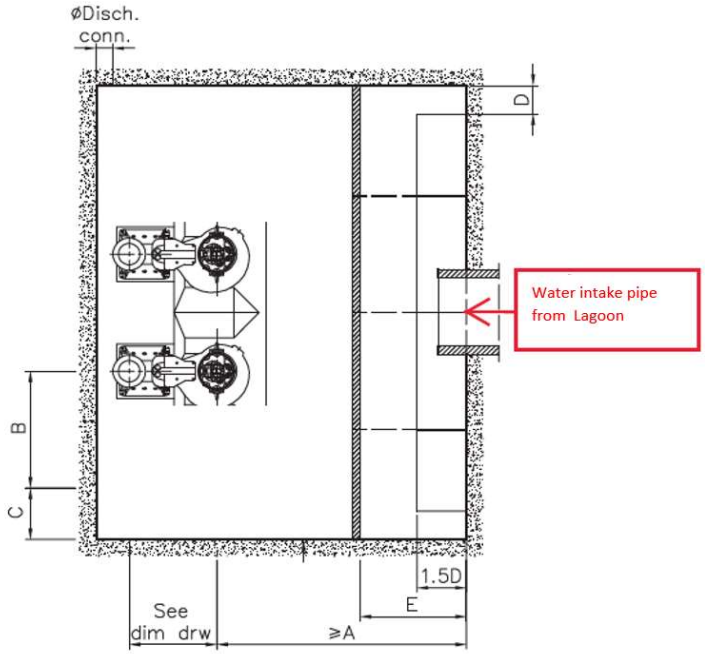


Figure 9 - Intake structure – plan view

8.1.2.1.2 Softened water storage tank (NA.PS02.GKC10.BB010)

The Softened water storage tank (NA.PS02.GKC10BB010) is an atmospheric water storage tank with an useful capacity of 15 m^3 and located in the Water Treatment room, in the AUB, specifically in the NF technical sector of N0, Ref. [12]. Its function is to store the softened water that is required by the different plant consumers.
The design conditions are given in Ref. [10].

8.1.2.1.3 Softened water pressure group unit to the cooling water loops (NA.PS02.GKC10.AP010)

The Softened water pressure unit (NA.PS02.GKC10.AP010) comprises the following main components:

- Two (2 x 100%) motor-driven pumps units, each capable of 4 m^3/h.
- One (1) pressurizing tank of 100 l (to be confirmed by the package supplier of the pressure group).
- One (1) pressure transmitter at the discharge of the pumps.

The function of the softened water pressure unit is to feed the close cooling softened water loops of the MINERVA ACC NF. It is located close to the Softened water storage tank, in the Water Treatment room, Ref. [12].
The design conditions are given in Ref. [10].

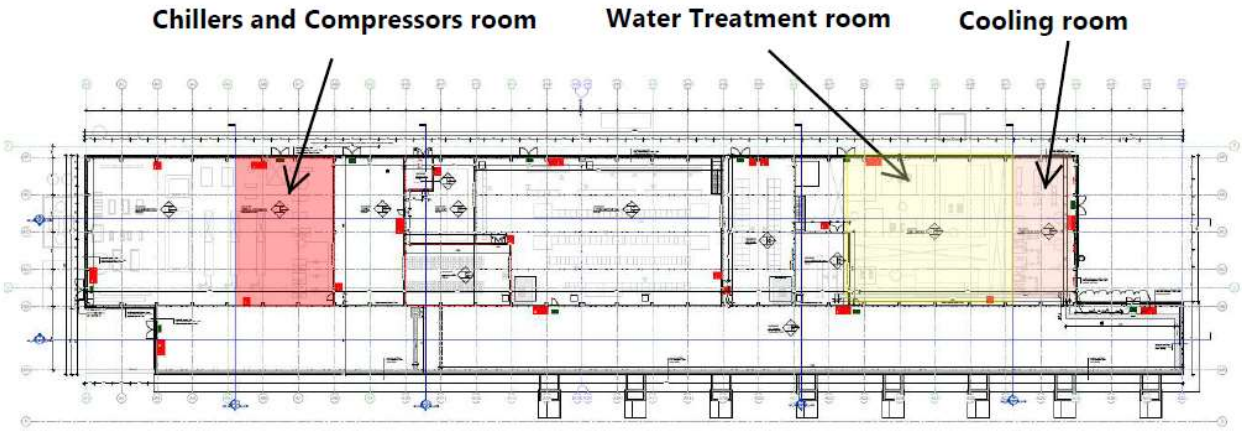


Figure 10 – Location of the NA.PS02.GKC10.AP010 pressure group unit users, in AUB (L0)

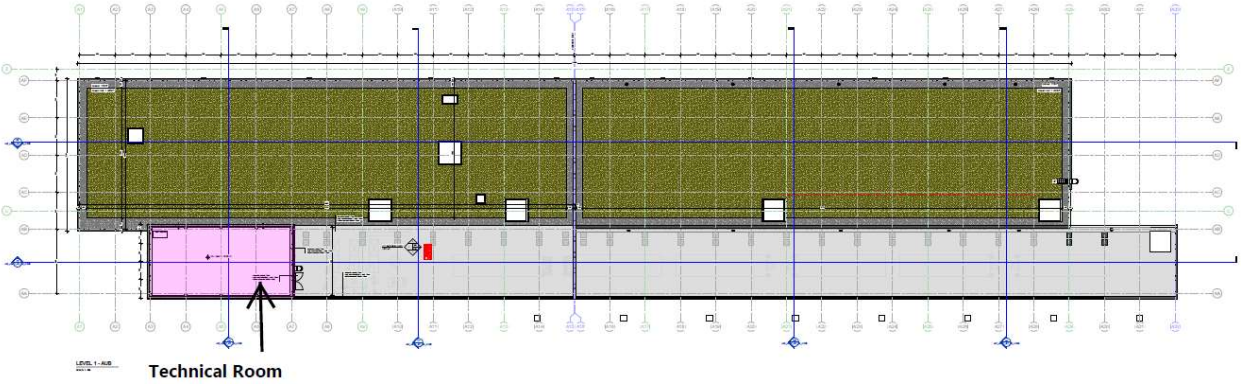


Figure 11 – Location of the NA.PS02.GKC10.AP010 pressure group unit users, in AUB (L1)

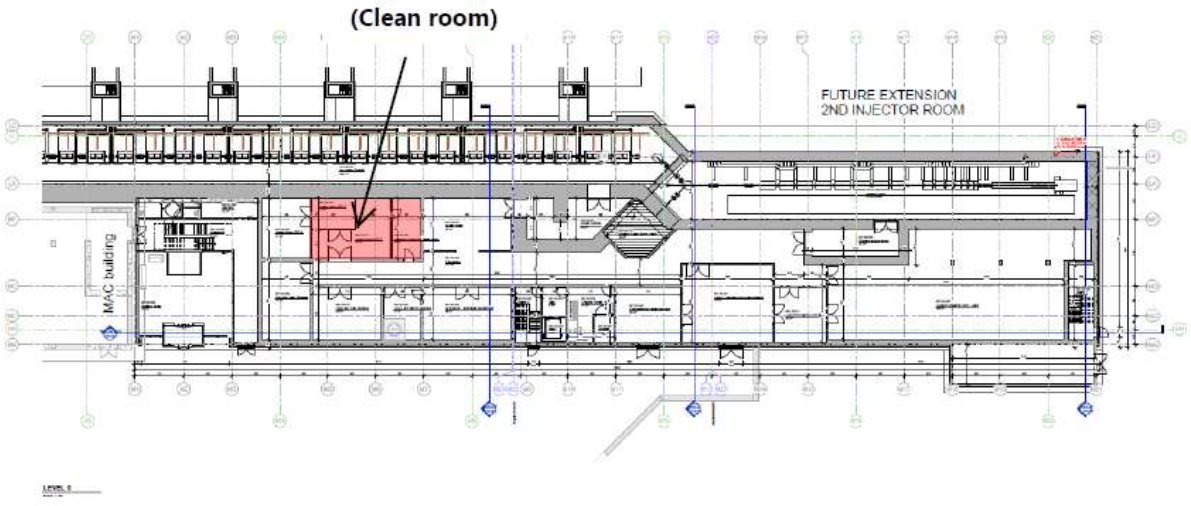


Figure 12 – Preliminary Location of the NA.PS02.GKC10.AP010 pressure group unit potentially users, in MCB (L0)

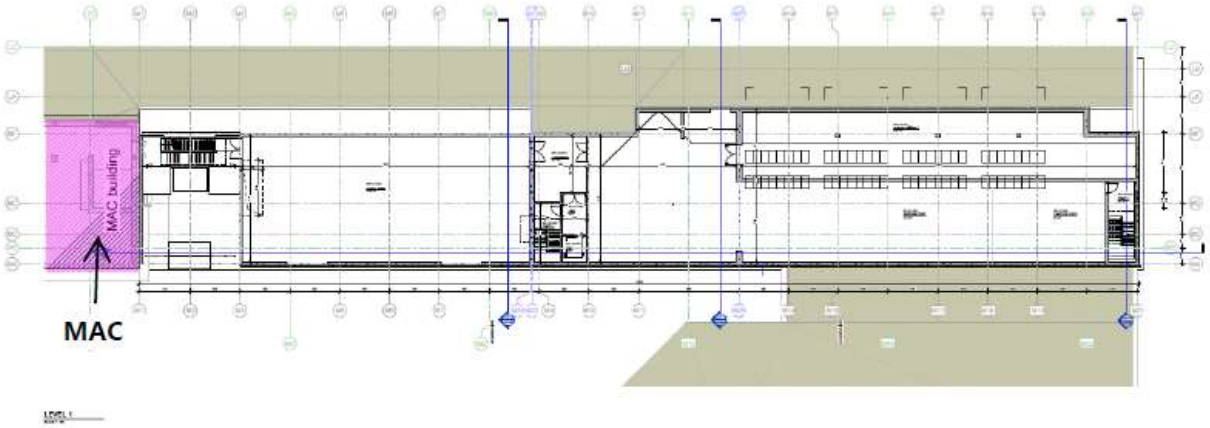


Figure 13 – Location of the NA.PS02.GKC10.AP010 pressure group unit users, in MCB (L1)

8.1.2.1.4 Softened water pressure group unit to adiabatic coolers (NA.PS02.GKC10.AP020)

The Softened water pressure unit (NA.PS02.GKC10.AP020) comprises the following main components:

- Two (2 x 100%) motor-driven pumps units, each capable of 17 m^3/h.
- One (1) pressurizing tank of 1000 l (to be confirmed by the package supplier of the pressure group).
- One (1) pressure transmitter at the discharge of the pumps.

The function of the softened water pressure group unit (NA.PS02.GKC10AP020) is to take suction from the Softened water storage tank for the adiabatic coolers make-up. It is located close to the Softened water storage tank, in the Water Treatment room, Ref. [12].
The design conditions are given in Ref. [10].

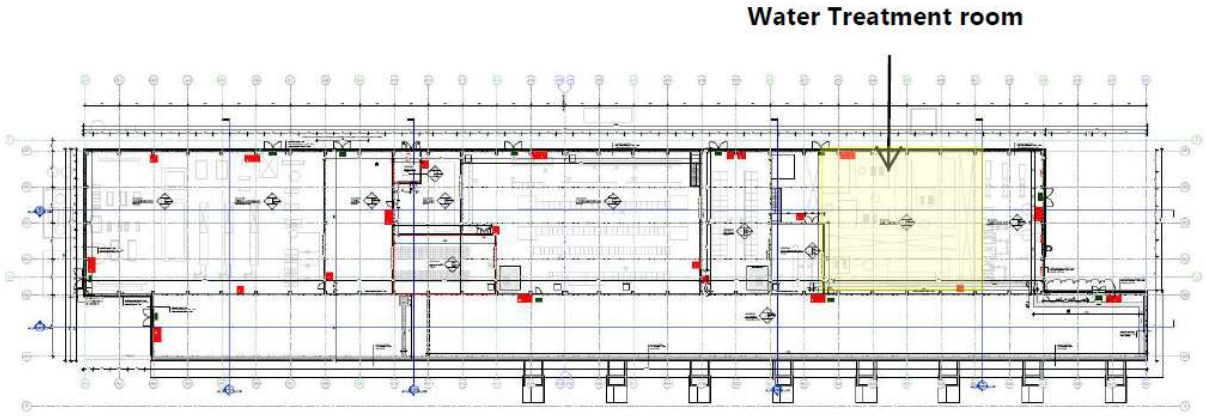


Figure 14 –Location of the NA.PS02.GKC10.AP020 pressure group unit, in AUB (L0)

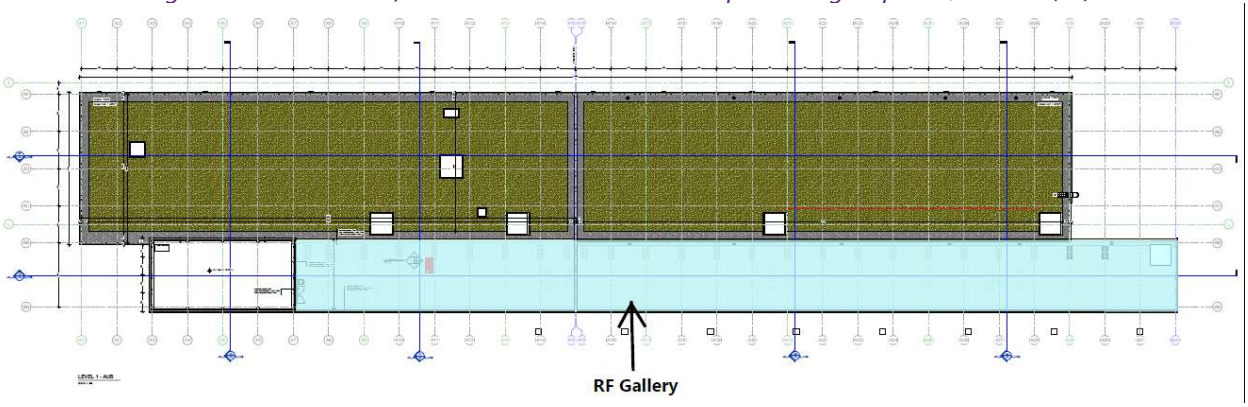


Figure 15 –Location of the NA.PS02.GKC10.AP020 pressure group unit users, in AUB (L1)

8.1.2.1.5 Softened water production package plant (NA.PS02.GKC10.AW010)

The Softened water production plant (NA.PS02.GKC10.AW010) will treat water coming from the lagoon (main source) or from the municipal drinking water network (back-up source of water).

Treatment will be specific depending on the source of water that enters the plant:

This treatment and equipment shall be confirmed by the package supplier as well as the specific requirements from the adiabatic coolers manufacturer are defined.

1. When treating lagoon water, the Softened water treatment plant will consist of:
   - One disinfection process located near the lagoon, in order to remove the biological growth in the pipeline that runs along the plant, from the lagoon to the Softened water storage tank. It is made up by:
     - Two (2 x100%) biocide chemical injection pumps
     - One (1) free chlorine analyser.
     - Two (2 x 100%) filters installed in the Water Treatment room, Ref. [12], to prevent water from the presence of particles.
2. On the other hand, the Softened water production plant will be able to decrease the hardness content when treating the Municipal drinking water, which is the back-up source of softened water when Lagoon water is not available. The hardness reduction process is foreseen to be located in the Water Treatment room, Ref. [12]. It will be equipped with:
     - Two (2x100%) cationic resin exchangers (one on standby), in order to remove the calcium salts and retain them for sodium ions.
     - Two (2x100%) regeneration pumps (one on standby). Two (2 x 100%) vacuum ejectors for the injection of regenerative chemicals may be also considered by the supplier of the package plant as an alternative to the regeneration pumps if terms of increasing the efficiency of the plant and economic aspects.
     - One (1) regeneration chemical (NaCl) storage tank

Optionally, Lagoon water may be treated for hardness decrease through the cation exchange resins, if needed.

The design conditions in the pipeline are given in Ref. [10].

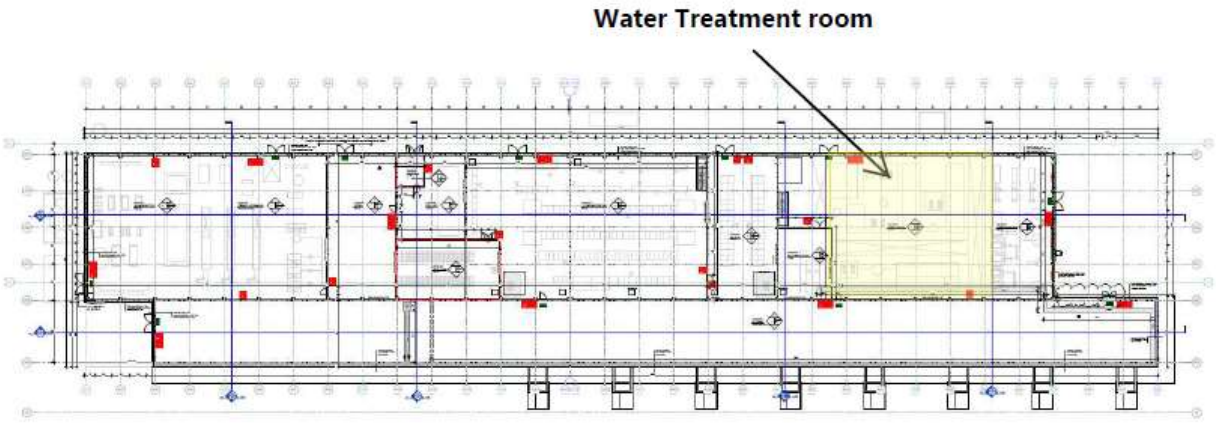


Figure 16 –Location of the Softened water production plant, NA.PS02.GKC10.APW10, in AUB (L0)

8.1.3 Demineralized water subsystem (NA.PS02.GHC10)

The basic functions of the demineralized water at the MINERVA facility will be to produce and distribute demineralized water to the demineralized water cooling circuits and laboratory facilities, as well as other consumers that might require demineralized water in the facility (accelerator and non-accelerator consumers, the MAC building), according to Ref. [6].

Demineralized water will be produced from softened water by passing the water current through a battery of cation-anion resin exhangers and mix beds. Equipment involved in the demineralized water production is related in chapter 8.1.3.1.

The resins are housed in two different bottles. The water passes first through the cation resin, where the cations are removed and they are replaced by H^+ and later the water passes through the anion resin where the acids are removed combining them with OH^-. To regenerate the resins, hydrochloric acid (HCl) is passed through the cation resin and soda (NaOH) through the anion resin. After regeneration, the resins must be rinsed before starting a new cycle.

A mixed bed with a regenerable resin will be placed at the exit of the ion-exchange resins in order to remove the remains of salts and comply with the characteristics of the required demineralized water.

Two chains of resins (one on standby) may be required if demineralized water production is needed in continuous operation, so that demineralized water production does not stop during regeneration of one of those chains. In addition, two mixed beds (one on standby) may be also to be considered for the final refinement, so that demineralized water production does not stop when the mixed bed runs out and must be exchanged. Otherwise, since the expected continuous flow rate of demineralized water is so low (preliminarily 200 l/day for the FPF, (I.D.6)), one chain of resin + mixed bed could be also foreseen, so that FPF consumer is fed by the water stored in the Demineralized Water storage tank during regeneration. Final configuration of the plant, attending to these considerations, will be confirmed by the package supplier of the demineralization water plant.

The demineralized water produced is stored in a Demineralized water storage tank. A CO_2 absorber with overpressure will be considered in the vent of the demineralized water storage tank to prevent air to enter the tank and allow that the content of oxygen in the demineralized water not to rise above the permitted limits, as indicated in Annex 11.2.

The main header of the demineralized water pressure group discharge is routed all along the different consumers, being the FPF the last user. Taking into account that this service is basically continuous, a minimum circulation all along the main header of the system is guaranteed at any time. With this configuration, only the lines going to each service, whose length is mimimized as much as possible, would require drainage after use to avoid water stagnation and, therefore, potential loss of water properties.

8.1.3.1 Component description and arrangement

8.1.3.1.1 Demineralized water production package plant (NA.PS02.GHC10.AW010)

The Demineralized water production plant (NA.PS02.GHC10.AW010) is made up by:

- Two (2 x 100%) suction pumps (one on standby) that transfer softened water at a rate of 4 m^3/h from the storage tank to the resin exchangers
- Two (2 x 100%) column ion-exchange resins (cationic + anionic), that will remove the most part of salts (TDS concentration)
- One (1 x 100%) CO_2 stripping tower, if required

- Two (2 x 100%) regenerable mixed beds for the final refinement in order to get the required demineralized water quality, Annex 11.2
- One (1) CO_2 trap located in the vent of the demineralized water tank to avoid the ingress of air and comply with the water quality referred in Annex 11.2
- One (1) neutralization basin with two (2 x 100%) neutralization pumps
- Two (2 x 100%) chemical regeneration storage tanks of HCl and NaOH
- Two (2 x 100%) regeneration pumps (or vacuum ejectors, according to the best option evaluated by the package supplier of the plant) connected each to one chemical regeneration storage tank

The Demineralized water production plant is located in the Water Treatment room, which is located in the AUB, specifically in the NF technical sector of N0, Ref. [12].

The design conditions at the inlet of the plant are given in Ref. [10].

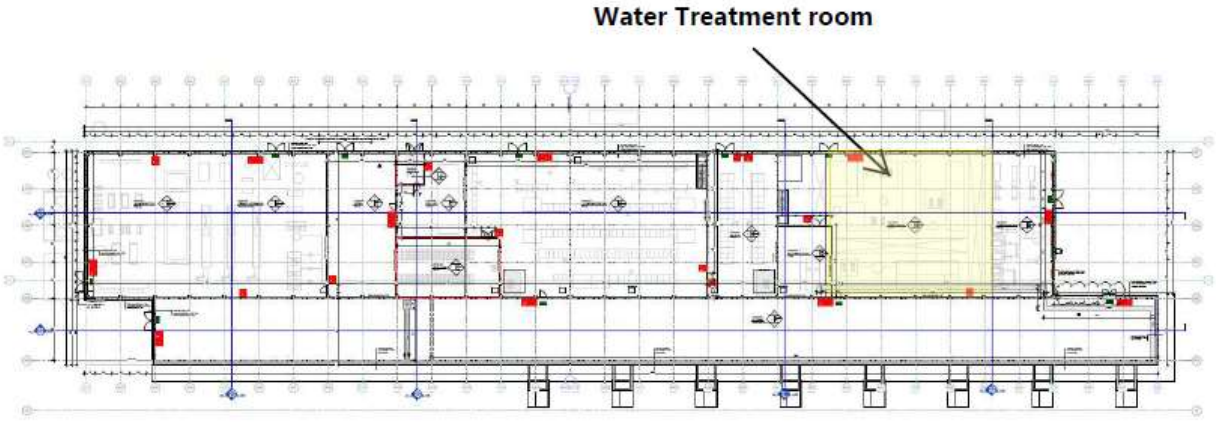


Figure 17 –Location of the Demineralized water production plant, NA.PS02.GHC10.APW10, in AUB (L0)

8.1.3.1.2 Ultra High purified demineralized water production package plant (NA.PS02.GHC10.AW020/30)

For the Vacuum lab and Clean room it may be needed one additional treatment based on some extra refinement in an Ultra high purified (UHP) demineralized water production plant. The plant will consist on the refinement of the demineralized water current coming from the main demineralized water header (water produced in NA.PS02.GHC10.AW010), through one (1 x 100%) removable mix bed of 300 l/day capacity (I.D.7). One independent treatment plant will be considered in each room to provide UHP demineralized water for the specific users, assumption [2].

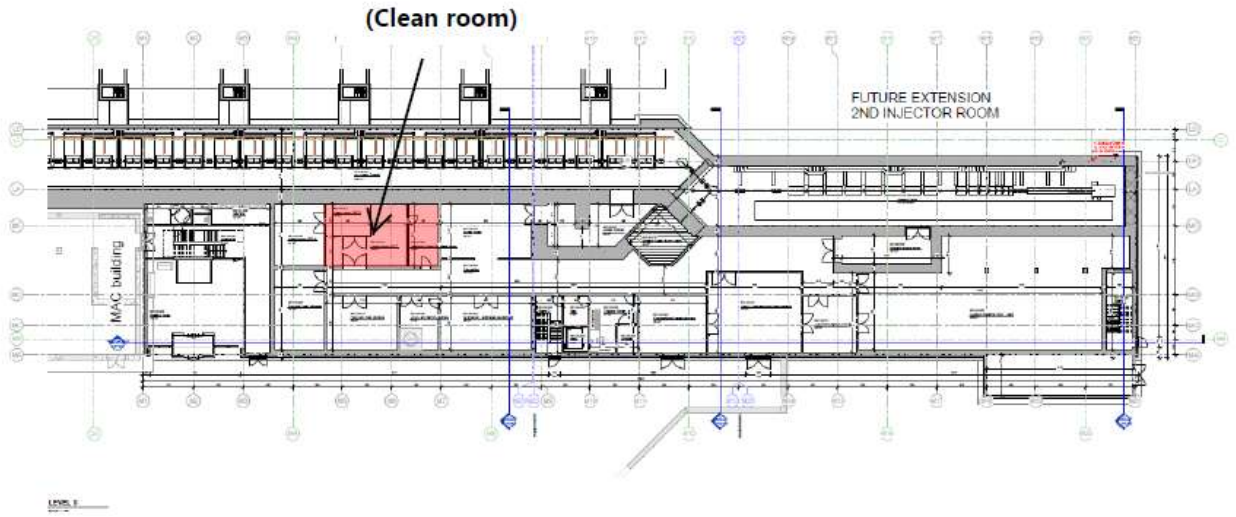


Figure 18 –Location of the UHP Demineralized water production plant, NA.PS02.GHC10.APW20, in MCB (L0)

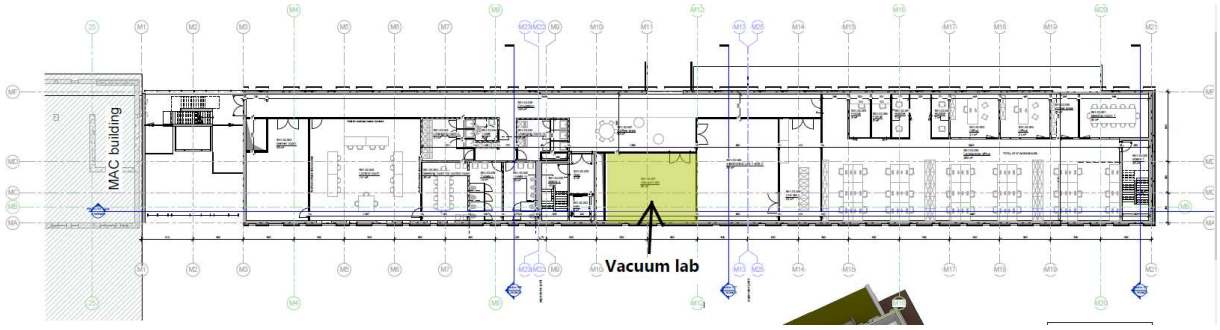


Figure 19 –Location of the UHP Demineralized water production plant, NA.PS02.GHC10.APW30, in MCB (L2)

8.1.3.1.3 Demineralized water storage tank (NA.PS02.GHC10.BB010)

The Demineralized water storage tank (NA.PS02.GHC10.BB010) is an atmospheric water storage tank with an useful capacity of 2.5 m^3 and located in the Water Treatment room, which is located in the AUB, specifically in the NF technical sector of N0, Ref. [12]. Its function is to store the demineralized water that is required by the different plant consumers. The storage tank is equipped with a CO_2 trap, placed in the vent of the tank, to avoid the entrance of air and therefore allow the oxygen required in the water not to rise, as per Annex 11.2.
The design conditions are given in Ref. [10].

8.1.3.1.4 Demineralized water pressure group unit (NA.PS02.GHC10.AP010)

The Demineralized water pressure unit (NA.PS02.GHC10.AP010) comprises the following main components:

- Two (2 x 100%) motor-driven pumps units, each capable of 4 m^3/h.
- One (1) pressurizing tank of 100 l (to be confirmed by the package supplier of the pressure group).
- One (1) pressure transmitter at the discharge of the pumps.

The function of the demineralized water pressure group unit (NA.PS02.GHC10.AP010) is to feed the closed cooling demineralized water loops of the MINERVA ACC NF and other sporadic consumers (laboratories and ACC users). It is located next to the Demineralized water storage tank, in the Water Treatment room, Ref. [12].
The design conditions are given in Ref. [10].

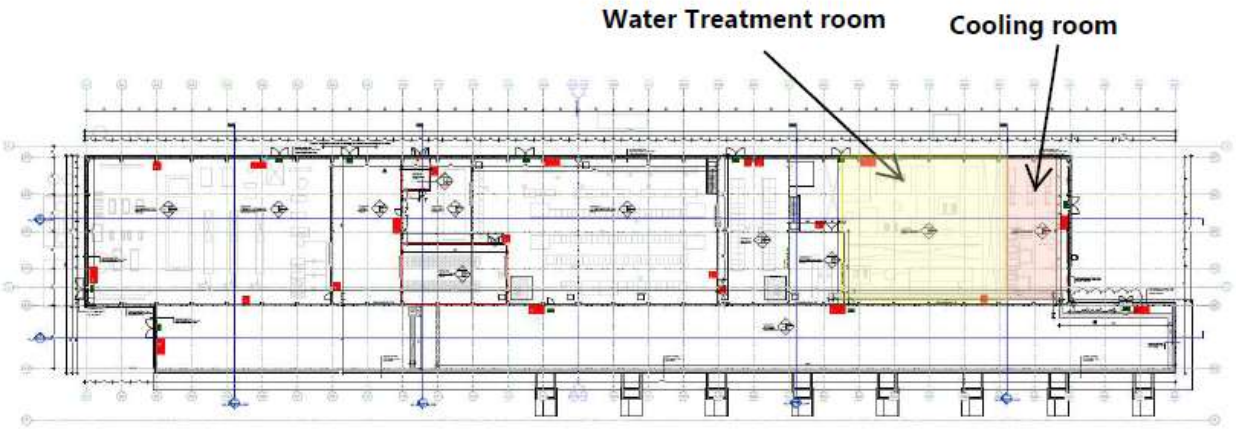


Figure 20 – Location of the storage tank NA.PS02.GHC10.BB010 and the NA.PS02.GHC10.AP010 pressure group unit users, in AUB (L0)

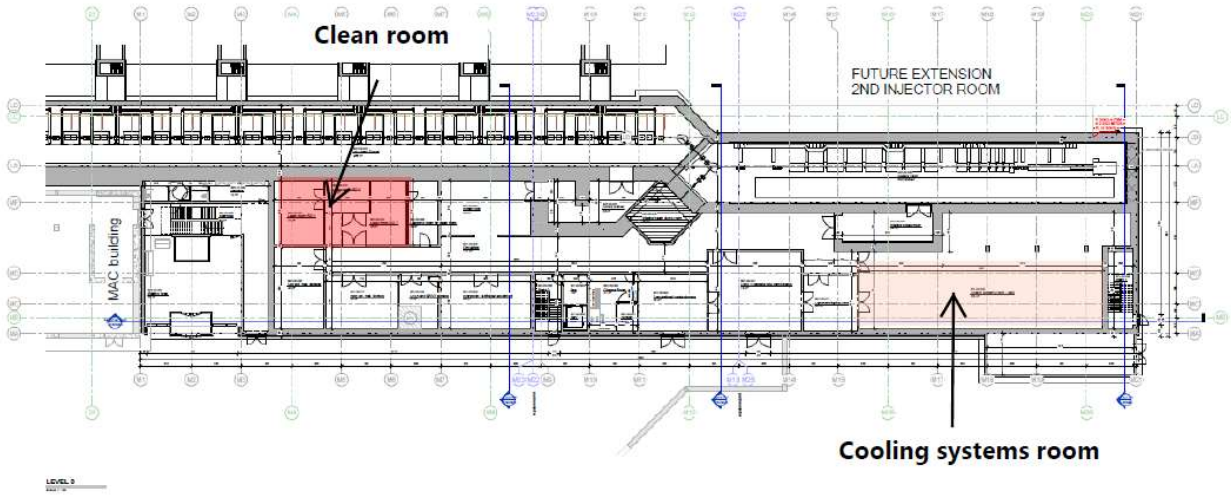


Figure 21 – Location of the NA.PS02.GHC10.AP010 pressure group unit users, in MCB (L0)

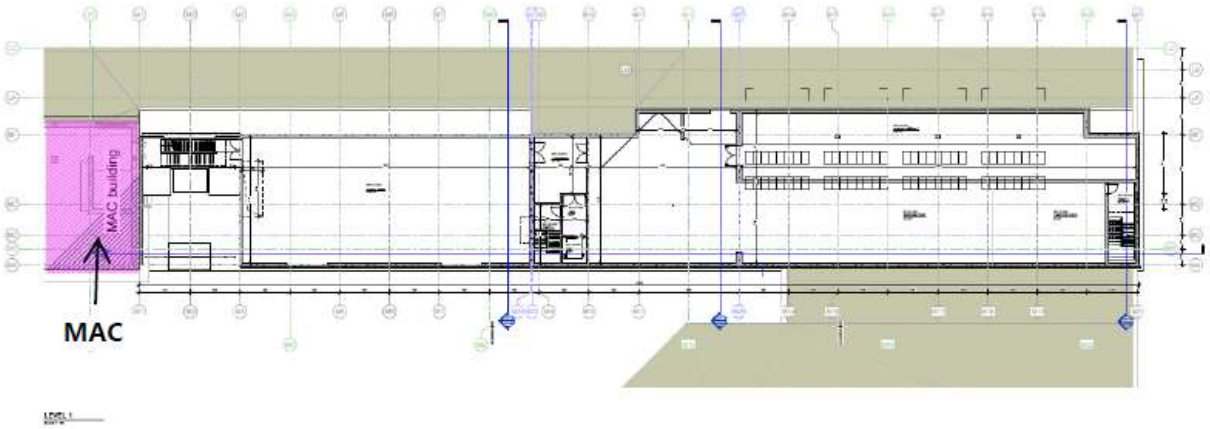


Figure 22 – Location of the NA.PS02.GHC10.AP010 pressure group unit users, in MCB (L1)

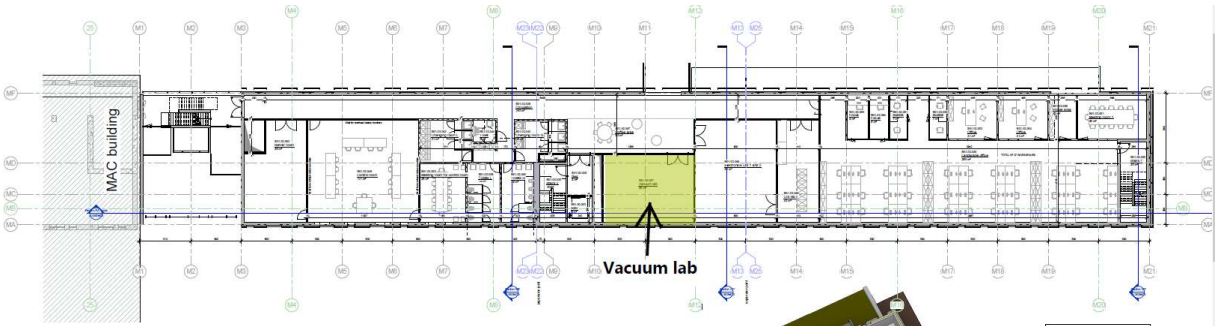


Figure 23 – Location of the NA.PS02.GHC10.AP010 pressure group unit users, in MCB (L2)

8.1.4 Purified rainwater subsystem (NA.PS02.GUD10)

Purified water will be produced by the treatment of the rainwater collected in the roofs of the MINERVA ACC NF for its distribution to the MCB sanitary rooms whenever it is required.

Rainwater will be collected and stored in a buffer tank located outdoors for its posterior purification and distribution in the PS02 Water Preparation and Supply systems.

The rainwater treatment will consist of a moderately demanding filtration and disinfection made up by the equipment described in 8.1.4.1.1.

8.1.4.1 Component description and arrangement

8.1.4.1.1 Purified rainwater production package plant (NA.PS02.GUD10.AW010)

The Purified rainwater production plant (NA.PS02.GUD10.AW010) will consist of the following equipment:

- Two (2 x 100%) standard filters (one on standby), for the removal of suspended solids. Type of filters to be detailed by the package supplier of the rainwater purification plant, in order to get an appropriate particle filtration for the users to which it is destined (WC's).
- One active carbon filter (if required).
- One disinfection process which shall ensure the limit values of bacteria are below the ones indicated in Annex 11.3. To achieve the required water quality, one ultra violet (UV) disinfection process may be used. UV disinfection consists of the appropriate killing of a variety of microorganisms by exposing them to concentrated ultraviolet radiation from a lamp, usually inside an opaque tube. Disinfection by one biocide chemical injection, instead of UV disinfection, may be also considered by the package supplier of the plant in terms of selecting the most appropriate process treatment.

The Purified rainwater production plant is located in the non supervised and controlled area of the MCB (assumption [1]), at level 0.

The design conditions at the inlet of the plant are given in Ref. [10].

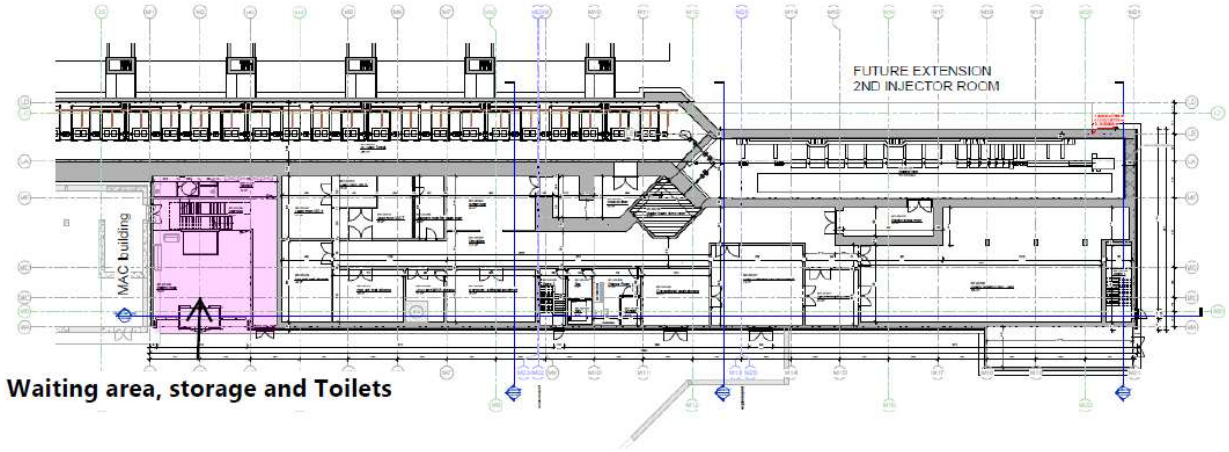


Figure 24 – Preliminary location of the NA.PS02.GHC10.APW10 Rainwater purification plant and users, in MCB (L0)

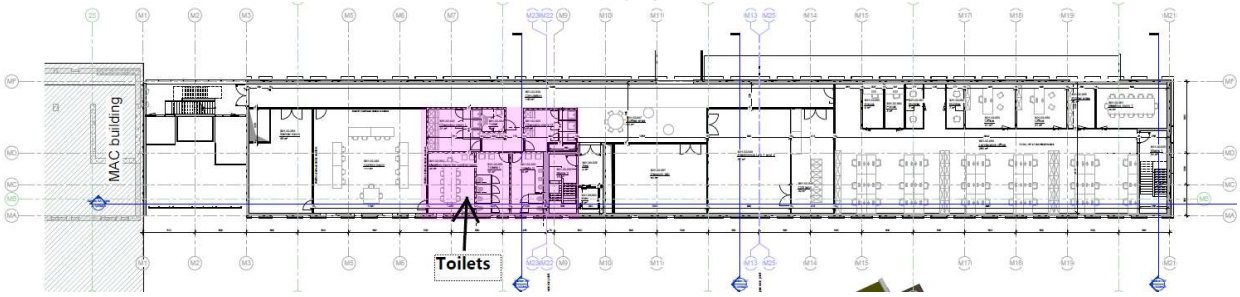


Figure 25 –Location of the Rainwater purification users, in MCB (L2)

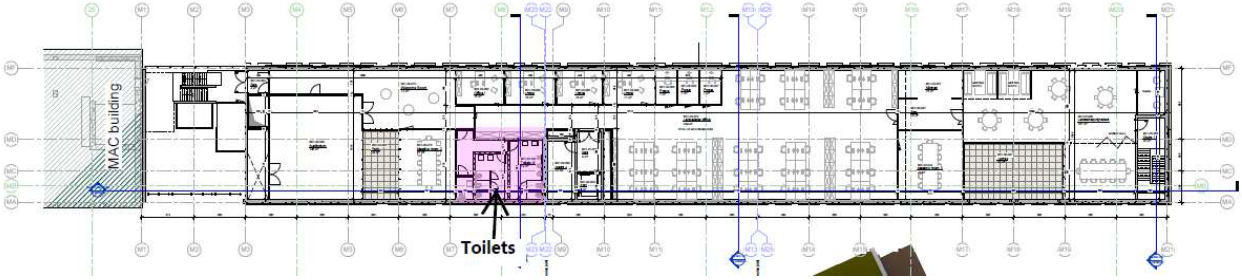


Figure 26 –Location of the Rainwater purification users, in MCB (L3)

9 Instrumentation and Control

The intruments and mechanical equipments will be identified in the system P&IDs (=NA.PS02.PFB503) and the signals associated to the devices are listed in the UBMS Control Interface Principle Ref. [17].

In the case of the package supplies such as the Potable Water Pressure Group Unit (NA.PS02.GKB10.AP010), the package devices shall be provided with the signals and alarms necessary for the satisfactory operation and supervision of the package. The control will be specified by the package supplier.

The PS02 Water Preparation and Supply System Control Diagram Ref. [18] will provide with all detail about control, protections, alarms and graphical representation of the system.

9.1 Control General Criteria

9.1.1 Drivers Control Modes

All system drivers are monitored and controlled from the Conventional Control System HMI of the operator station located in the Control Room.

All drivers have two modes of operation: AUTOMATIC and MANUAL. The operator could press the AUTOMATIC/MANUAL buttons in the devices' faceplate. When the individual driver is in manual mode, it is operated and monitored by the operator from the Conventional Control System HMI, pressing the START/STOP or OPEN/CLOSE pushbuttons.

START/STOP or OPEN/CLOSE commands during operation in automatic mode come from immediately superior automatic control level. The automatic mode will be the normal mode for the normal operation.

The devices will be operated remotely or locally by the operator by the previous selection in the LOCAL/REMOTE faceplate selector:

- REMOTE mode means that all the orders come from the control system from the Control Room by means of the Conventional Control System HMI by acting on the devices' faceplate OPEN/CLOSE pushbuttons located in the corresponding valve´s faceplate.
- LOCAL means that all orders come acting on the OPEN/CLOSE or START/STOP pushbuttons located on field at the device control box.

9.1.2 Functional Group and Selector

The control system has a hierarchical control level structure based on functional groups (FG). The system can also be controlled from the lower hierarchical levels, either from functional subgroups (FSG) or from actuating directly on the different equipment as it is indicated in Section 9.1.1.

In order to control and supervise the groups, the system includes AUTOMATIC/MANUAL buttons in the groups' faceplates, used by the operator to select the control mode (automatic or manual), modify the setpoints and actuate manually on the demand to the final control element. In order to actuate upon the different parameters.

When a functional group or equipment is in automatic mode, it is not possible to control it from their faceplate located on the graphic display of each system, and it will only follow the automatic orders from a higher hierarchical levels.

When a functional group or equipment is in manual mode, the operator has responsibility for control, since it will only be possible to control it from the control faceplate located on the graphic display of each system, and it ignores any automatic orders it receives from higher hierarchical levels.

Whenever there are redundant functional subgroups or equipment, a dedicated selector shall decide (following the operator previous selection) which equipment shall be started and which shall be on standby. If the system is started through the functional group and during operation the main equipment has a problem that prevents it from operating properly, the selector will automatically start up the standby equipment, stop the equipment in problems and change the selection, turning the standby equipment into main equipment, and vice versa. Once the problem is solved, and the equipment that suffered the problem is transferred to automatic mode, this equipment becomes the standby one, ready for any problem in the main equipment.

When a system is started from its functional group, all the actuators controlled by it shall be transferred to AUTO to ensure they all will follow the higher level commands.

Regardless of the control mode, the necessary startup permissives, protections and interlocks shall be programmed into the control system to prevent any type of actuation that could cause damage to the system equipment or dependent systems.

The functional group start permissive has to be defined in such a way that prevents the group to be started if due to their equipment status, it shall not be able to perform its main task properly.

9.1.3 HMI

All system drivers are monitored and controlled from the Conventional Control System HMI of the operator station located in the Control Room.

The user name will be included in the status bar of the Main Display Area – Mimic.

For more details about HMI see SCADA HMI Guideline NA.CN_EDB503.

9.1.4 On maintenance status

The Operator will set maintenance status in the faceplate of the devices in the Conventional Control System HMI. The representation of the maintenance status will be by the letter L in WHITE on a RED background on the graphic display of the equipment meaning that the equipment is not controllable by the Operator (equipment out of order).

The use of a password shall be required for operators to be able to configure out the system during the maintenance period.

Other maintenance activities will be described in the corresponding supplier maintenance procedures.

The maintainability has been taken into account in the design of the system.

9.1.5 PID Controller

A PID controller continuously calculates an error value as the difference between a desired setpoint (SP) and a measured process variable (PV) and applies a correction based on proportional, integral, and derivative terms (denoted P, I, and D respectively). A direct PID output tends to increase as the PV signal increases. A reverse PID output tends to decrease as the PV signal increases.

9.1.6 Anomally

When an equipment has any problem that makes it unable to be controlled by the control system, its state switches to ANOMALY. An alarm is then generated to warn the operator to solve the problem.

An equipment in ANOMALY is rejected to manual and does not have permissives to be actuated until the cause is solved. Some causes to set an equipment in ANOMALY would be: electrical cabinet (or MOV actuator) not available, feedback anomaly, command failure, any kind of trip, etc.

An equipment in ANOMALY has to be acknowledged prior to be restored to AUTO control mode. The equipment cannot be acknowledged until the cause that generates the anomaly state has disappeared.

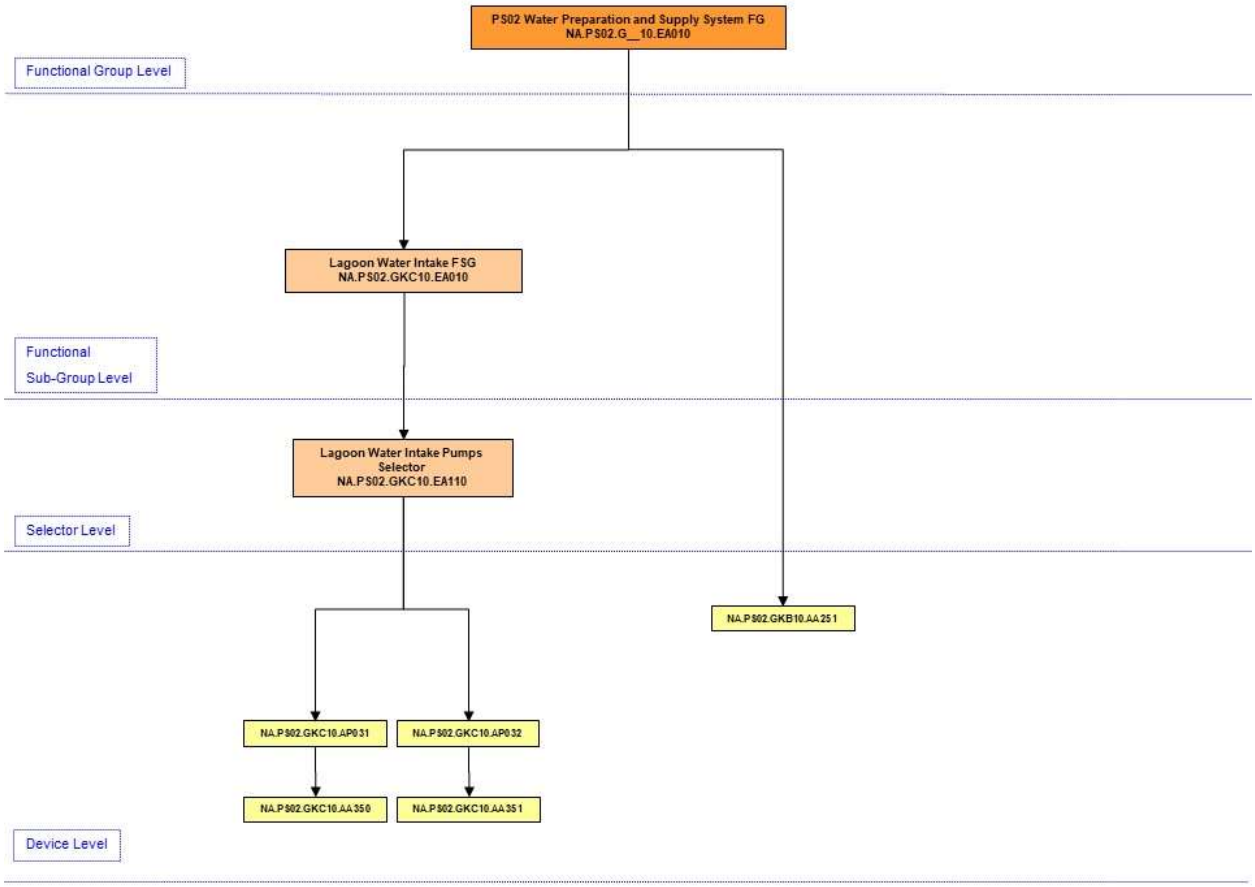
9.1.7 Forced Commands

When any equipment is set in manual control mode and the operator does not take care of its control, the necessary forced actuations shall be programmed in order to avoid any system equipment or dependent system equipment damage.

The forced commands shall actuate even if the corresponding actuation permissives are not met. When a forced command it shall be signalled through an alarm to warn operator about the anomaly situation. For any equipment forced to any state, the commands to override this state, either AUTO or MANUAL, are not permitted.

9.2 System Control

The hierarchical control structure is described in the following block diagram:



9.3 Operation Modes

9.3.1 Normal operation

9.3.1.1 Municipal Drinking Water Subsystem NA.PS02.GKB10

The two main consumers of potable water are all different consumers of the Potable Water Pressure Group Unit (NA.PS02.GKB10.AP010) and the Softened Water Production Plant NA.PS02.GKC10.AW010 (as a back-up source of water).

The control valve NA.PS02.GKB10.AA251 shall open to fill the Softened Water Storage Tank NA.PS02.GKC10.BB010 with potable water when the level in the tank NA.PS02.GKC10.LT011/LT012 is under a low level and the Lagoon Water Intake Pumps (NA.PS02.GKC10.AP031/AP032) are not available.

The consumption of potable water shall be measured by the totalizer flow transmitter NA.PS02.GKB10.FQT010 and the pressure with a pressure transmitter NA.PS02.GKB10.PT010 .

The Potable Water Pressure Group Unit (NA.PS02.GKB10.AP010) will be controlled by a dedicated local control panel provided by the package plant supplier. The only remote monitoring in the UBMS Conventional Control System HMI will be at least two signals indicating the 'Potable Water Pressure Group Unit No operational availability' and 'Potable Water Pressure Group Unit No fault'. The package plant shall be provided with the signals and alarms necessary for the satisfactory operation and supervision of the package plant in the UBMS Conventional Control System HMI.

The two pumps 2x100% are controlled and monitored by a microprocessor control unit. The pump selected as the main pump is started up when the pressure falls below the pre-set start-up pressure, while the other shall remain on standby, awaiting actuation in the event any problem is detected in the main pump.

The pumps are automatically started up in a different order for each new cycle to equally distribute the pump operating hours.

9.3.1.2 Softened Water Subsystem NA.PS02.GKC10

The Lagoon Water Intake Pumps (NA.PS02.GKC10.AP031/AP032) will provide water to the Softened Water Storage Tank NA.PS02.GKC10.BB010 from the lagoon after being treated in the Softened Water Production Plant NA.PS02.GKC10.AW010.

The Lagoon Water Intake Pumps (NA.PS02.GKC10.AP031/AP032) shall start when the level in the Softened Water Storage Tank NA.PS02.GKC10.BB010 is under a low level measured by NA.PS02.GKC10.LT011/LT012.

The Lagoon Water Intake Pumps (NA.PS02.GKC10.AP031/AP032) will start against each discharge motor operated valve close NA.PS02.GKC10.AA350/351. Once the pump is running, its corresponding discharge motor operated valve will open.

The Lagoon Water Intake Pumps (NA.PS02.GKC10.AP031/AP032) are 2x100%. The pump selected as the main pump is started up when the level in the Softened Water Storage Tank falls below the low level, while the other shall remain on standby, awaiting actuation in the event any problem is detected in the main pump. A pump operating hours counter will be programmed in the software in order that the operator can equally distribute the Lagoon Water Intake Pumps operating hours.

The lagoon water level in the intake structure will be measured by NA.PS02.GKC10.LT021/LT022.

The water pressure will be measured downstream the Lagoon Water Intake Pumps (NA.PS02.GKC10.AP031/AP032) by NA.PS02.GKC10.PT230.

The consumption of lagoon water shall be measured by a totalizer flow transmitter NA.PS02.GKC10.FQT040 and the consumption of water from the Softened Water Production Plant (NA.PS02.GKC10.AW010) by a totalizer flow transmitter NA.PS02.GKC10.FQT030.

The Softened Water Production Plant (NA.PS02.GKC10.AW010) will be controlled by a dedicated local control panel provided by the package plant supplier. The only remote monitoring in the UBMS Conventional Control System HMI will be at least two signals indicating 'Softened Water Production Plant No operational availability' and 'Softened Water Production Plant No fault'. The package plant shall be provided with the signals and alarms necessary for the satisfactory operation and supervision of the package plant in the UBMS Conventional Control System HMI.

The Adiabatic Cooling Water Pressure Group Unit (NA.PS02.GKC10.AP020) will be controlled by a dedicated local control panel provided by the package plant supplier. The only remote monitoring in the UBMS Conventional Control System HMI will be at least two signals indicating the 'Adiabatic Cooling Water Pressure Group Unit No operational availability' and 'Adiabatic Cooling Water Pressure Group Unit No fault'. The package plant shall be provided with the signals and alarms necessary for the satisfactory operation and supervision of the package plant in the UBMS Conventional Control System HMI.

The two pumps 2x100% are controlled and monitored by a microprocessor control unit. The pump selected as the main pump is started up when the pressure falls below the pre-set start-up pressure, while the other shall remain on standby, awaiting actuation in the event any problem is detected in the main pump.

The pumps are automatically started up in a different order for each new cycle to equally distribute the pump operating hours.

The Adiabatic Cooling Water Pressure Group Unit (NA.PS02.GKC10.AP020) shall provide with water to the Adiabatic Coolers make-up valves (NA.PS01.PAB11.AA251/252/253/254/255/256 and NA.PS01.PAB12.AA251/252) as soon as one is opened.

The consumption of water supply to the Adiabatic Coolers shall be measured by the totalizer flow transmitter NA.PS02.GKC10.FQT010.

The pressure downstream the Adiabatic Cooling Water Pressure Group Unit (NA.PS02.GKC10.AP020) will be measured by NA.PS02.GKC10.PT110.

The Softened Water Pressure Group Unit (NA.PS02.GKC10.AP010) will be controlled by a dedicated local control panel provided by the package plant supplier. The only remote monitoring in the UBMS Conventional Control System HMI will be at least two signals indicating the 'Softened Water Pressure Group Unit No operational availability' and 'Softened Water Pressure Group Unit No fault'. The package plant shall be provided with the signal and alarms necessary for the satisfactory operation and supervision of the package plant in the UBMS Conventional Control System HMI.

The two pumps 2x100% are controlled and monitored by a microprocessor control unit. The pump selected as the main pump is started up when the pressure falls below the pre-set start-up pressure, while the other shall remain on standby, awaiting actuation in the event any problem is detected in the main pump.

The pumps are automatically started up in a different order for each new cycle to equally distribute the pump operating hours.

The consumption of water supply to the different consumers shall be measured by the totalizer flow transmitter NA.PS02.GKC10.FQT020.

The pressure downstream the Softened Water Pressure Group Unit (NA.PS02.GKC10.AP010) will be measured by NA.PS02.GKC10.PT120.

9.3.1.3 Demineralized Water Subsystem NA.PS02.GHC10

The Demineralized Water Pressure Group Unit (NA.PS02.GHC10.AP010) will be controlled by a dedicated local control panel provided by the package plant supplier. The only remote monitoring in the UBMS

Conventional Control System HMI will be at least two signals indicating the 'Demineralized Water Pressure Group Unit No operational availability' and 'Demineralized Water Pressure Group Unit No fault'. The package plant shall be provided with the signals and alarms necessary for the satisfactory operation and supervision of the package plant in the UBMS Conventional Control System HMI.

The two pumps 2x100% are controlled and monitored by a microprocessor control unit. The pump selected as the main pump is started up when the pressure falls below the pre-set start-up pressure, while the other shall remain on standby, awaiting actuation in the event any problem is detected in the main pump.

The pumps are automatically started up in a different order for each new cycle to equally distribute the pump operating hours.

The pressure downstream the Demineralized Water Pressure Group Unit (NA.PS02.GHC10.AP010) will be measured by NA.PS02.GHC10.PT060.

The differential pressure in the Demineralized Water Storage Tank's filter is measured by the NA.PS02.GHC10.PDT010.

The Demineralized Water Treatment Plant (NA.PS02.GHC10.AW010) will be controlled by a dedicated local control panel provided by the package plant supplier. The only remote monitoring in the UBMS Conventional Control System HMI will be at least two signals indicating the 'Demineralized Water Treatment Plant No operational availability' and 'Demineralized Water Treatment Plant No fault'. The package plant shall be provided with the signals and alarms necessary for the satisfactory operation and supervision of the package plant in the UBMS Conventional Control System HMI.

The Demineralized Water Treatment Plant (NA.PS02.GHC10.AW010) shall start when the level in the Demineralized Water Storage Tank (NA.PS02.GHC10.BB010), measured by NA.PS02.GHC10.LT011/LT012, is low.

The Mixed Bed Demineralized Water Refinement Supplier (NA.PS02.GHC10.AW020 and NA.PS02.GHC10.AW030) will send to the UBMS the signals to monitorise the water conductivity, as indicated in Table 3 of Annex 11.2.

9.3.1.4 Purified rainwater Subsystem NA.PS02.GUD10

The pressure in the system is measured by NA.PS02.GUD10.PT010.

The Rainwater Tank Pumps shall start and they shall stop depending on the low or high pressure measured in the Purified Rainwater Membrane Tank NA.PS02.GUD10.BB010

9.3.2 Abnormal operation

- Low pressure in the municipal drinking water main header (NA.PS02.GKB10.PT010) (L).
- No operational availability of the Potable Water Pressure Group Unit
- Fault of the Potable Water Pressure Group Unit.
- Low low level in the lagoon water intake (NA.PS02.GKC10.LT021/LT022) (LL).
- Low low level in the Softened Water Storage Tank NA.PS02.GKC10.BB010, measured with NA.PS02.GKC10.LT011/LT012, (LL).
- High level in the Softened Water Storage Tank NA.PS02.GKC10.BB010, measured with NA.PS02.GKC10.LT011/LT012, (H).
- Softened Water Production Plant (NA.PS02.GKC10.AW010) no operational availability.
- Softened Water Production Plant (NA.PS02.GKC10.AW010) fault.
- Adiabatic Cooling Water Pressure Group Unit (NA.PS02.GKC10.AP010) no operational availability.
- Adiabatic Cooling Water Pressure Group Unit (NA.PS02.GKC10.AP010) fault.

- High pressure downstream the Adiabatic Cooling Water Pressure Group Unit measured with NA.PS02.GKC10.PT110 (H).
- Low pressure downstream the Adiabatic Cooling Water Pressure Group unit measured with NA.PS02.GKC10.PT110 (L).
- High pressure downstream the Softened Water Pumps measured with NA.PS02.GKC10.PT120 (H).
- Low pressure downstream the Softened Water Pumps measured with NA.PS02.GKC10.PT120 (L).
- High level in the Demineralized Water Storage Tank measured with NA.PS02.GHC10.LT011/LT012 (H).
- Low low level in the Demineralized Water Storage Tank measured with NA.PS02.GHC10.LT011/LT012 (LL).
- High high differential pressure in the Demineralized Water Storage Tank vent measured with NA.PS02.GHC10.PDT010 (HH).
- High pressure downstream the Demineralized Water Pumps measured with NA.PS02.GHC10.PT060 (H).
- Low pressure downstream the Demineralized Water Pumps measured with NA.PS02.GHC10.PT060 (L).
- Demineralized Water Pressure Group Unit (NA.PS02.GHC10.AP010) no operational availability.
- Demineralized Water Pressure Group Unit (NA.PS02.GHC10.AP010) fault.
- Demineralized Water Treatment Plant (NA.PS02.GHC10.AW010) No operational availability
- Demineralized Water Treatment Plant (NA.PS02.GHC10.AW010) fault.
- Demineralized Water Treatment Plant (NA.PS02.GHC10.AW020) High conductivity.
- Demineralized Water Treatment Plant (NA.PS02.GHC10.AW030) High conductivity.
- Low pressure in the purified rainwater main header (NA.PS02.GUD10.PT010) (L).

9.4 System Control

The different controls developed for the system are described in more detail below, however, all details about system control, protections, interlocks, alarms and automatic actions will be depicted in the corresponding system control diagram.

9.4.1 Analogue Control and Regulation

9.4.1.1 Municipal Drinking Water Subsystem NA.PS02.GKB10

Not applicable. There is no analogue control and regulation loop.

9.4.1.2 Softened Water Subsystem NA.PS02.GKC10

Not applicable. There is no analogue control and regulation loop.

9.4.1.3 Demineralized Water Subsystem NA.PS02.GHC10

Not applicable. There is no analogue control and regulation loop.

9.4.1.4 Purified rainwater Subsystem NA.PS02.GUD10

Not applicable. There is no analogue control and regulation loop.

9.4.2 Logic Control and Protections

When the PS02 Water Preparation and Supply System is started up via its Functional Group (NA.PS02.G__10.EA010) by the operator acting on the Conventional Control System HMI, the following actions will be carried out automatically:

- All drivers controlled by the functional group will be switched to automatic control mode.

In order to ensure that the functional group starts-up/stops only when it is able to fulfill their purpose, and to do it in a safe way for the equipment and for their dependent systems, the following start-up/stop permissives will be programmed:

- Start Permissives
  - Lagoon Water Intake FSG NA.PS02.GKC10.EA010 is available.
  - NA.PS02.GKB10.AA250 is available.
- Stop Permissive
  - Not applicable, the functional group shall always have the stop permissive.

The shutdown of the system through the functional group, by the operator acting on the Conventional Control System HMI, shall stop automatically all the pumps in operation.

All the drivers of the PS02 Water Preparation and Supply System will remain in automatic control mode unless express action by the operator.

9.4.2.1 Municipal Drinking Water Subsystem NA.PS02.GKB10

9.4.2.1.1 On-Off valve NA.PS02.GKB10.AA251

The function of this valve is to supply potable water to the Softened Water Storage Tank NA.PS02.GKC10.BB010.

- Automatic Open
  - The valve opens automatically if:
    - level in the Softened Water Storage Tank NA.PS02.GKC10.BB010 is low, measured with NA.PS02.GKC10.LT011/LT012, (L); AND
    - the Lagoon Water Intake Pumps (NA.PS02.GKC10.AP031/AP032) are not available.
- Automatic Close
  - The valve closes automatically if level in the Softened Water Storage Tank NA.PS02.GKC10.BB010 is high, measured with NA.PS02.GKC10.LT011/LT012, (H).
- Opening Permissives
  - Low level in the Softened Water Storage Tank NA.PS02.GKC10.BB010, measured with NA.PS02.GKC10.LT011/LT012, (L).
- Closing Permissives
  - The valve is always permitted to close.
- Forced Open
  - Low low level in the Softened Water Storage Tank NA.PS02.GKC10.BB010, measured with NA.PS02.GKC10.LT011/LT012, (LL).

9.4.2.2 Softened Water Subsystem NA.PS02.GKC10

9.4.2.2.1 Lagoon Water Intake FSG NA.PS02.GKC10.EA010

When the Lagoon Water Intake Subsystem is started up via its Functional Subgroup (NA.PS02.GKC10.EA010) by the operator acting on the Conventional Control System HMI or from a command coming from a higher hierarchical level (PS02 Water Preparation and Supply System FG (NA.PS02.G__10.EA010)), the following actions will be carried out automatically:

- All drivers controlled by the Functional Subgroup (NA.PS02.GKC10.EA010) will be switched to automatic control mode.
- It will command the operation of the associated Lagoon Water Intake pumps (NA.PS02.GKC10.AP031/AP032) through a selector (NA.PS02.GKC10.EA110), so that it can manage the start-up and the stop of these pumps depending on the state of the system at any time.

- The Lagoon Water Intake Pumps Selector shall start-up the pump selected as main by operator on the Conventional Control System HMI. Once the Softened Water Storage Tank NA.PS02.GKC10.BB010 is under a low level, the Selector shall start the pump previously selected as main.
- The Lagoon Water Intake Pumps Selector shall stop the pump running once the Softened Water Storage Tank NA.PS02.GKC10.BB010 is above a high level.

In order to ensure that the Functional Subgroup starts-up only when it is able to fulfill their purpose, and to do it in a safe way for the equipment and for their dependent systems, the following start-up permissives will be programmed:

- Start Permissives
  - At least one Lagoon Water Intake Pump and its discharge MOV are available.
  - Not low level in the lagoon measured with NA.PS02.GKC10.LT021/LT022, (L).
  - The level in the lagoon measured with NA.PS02.GKC10.LT021/LT022, is available (not in bad quality).
  - The level in the Softened Water Storage Tank NA.PS02.GKC10.BB010, measured with NA.PS02.GKC10.LT011/LT012, is available (not in bad quality).
- Stop Permissive
  - Not applicable. The Functional Subgroup shall always have the stop permissive.

The shutdown of the system through the Functional Subgroup, either by operator acting on the Conventional Control System HMI or from a command coming from a higher hierarchical level (PS02 Water Preparation and Supply System FG (NA.PS02.G__10.EA010)), shall stop automatically the Lagoon Water Intake Pump in operation.

All the drivers of the Functional Subgroup will remain in automatic control mode unless express action by the operator.

9.4.2.2.2 Lagoon Water Intake Pumps (NA.PS02.GKC10.AP031/AP032)

The function of these pumps is to supply water from the lagoon to the Softened Water Storage Tank NA.PS02.GKC10.BB010.

- Automatic Start
  - The pump starts automatically if the level in the Softened Water Storage Tank NA.PS02.GKC10.BB010 is low, measured with NA.PS02.GKC10.LT011/LT012, (L).
- Automatic Stop
  - The pump stops automatically if the level in the Softened Water Storage Tank NA.PS02.GKC10.BB010 is high, measured with NA.PS02.GKC10.LT011/LT012, (H).
- Start Permissives
  - Not low level in the lagoon intake structure measured with NA.PS02.GKC10.LT021/LT022, (L).
- Stop Permissives
  - The pumps are always permitted to stop.
- Trip conditions. The pump will be tripped when any of the following conditions are reached:
  - Low low level in the lagoon intake structure measured with NA.PS02.GKC10.LT021/LT022, (LL).
- Forced stop
  - Not applicable.

9.4.2.2.3 Lagoon Water Intake Pumps Discharge MOV (NA.PS02.GKC10.AA350/351)

The function of these valves is to close when its corresponding lagoon water intake pump (NA.PS02.GKC10.AP031/AP032) starts and to open once that the pump is started.

- Automatic Open
  - The valve opens automatically when its corresponding lagoon water intake pump (NA.PS02.GKC10.AP031/AP032) has started.
- Automatic Close
  - The valve closes automatically when its corresponding lagoon water intake pump (NA.PS02.GKC10.AP031/AP032) stops.
- Opening Permissives
  - There is always opening permissive.
- Closing Permissives
  - Its corresponding lagoon water intake pump (NA.PS02.GKC10.AP031/AP032) is stopped
- Forced Closed
  - Not applicable

9.4.2.2.4 Softened water pressure group unit to the adiabatic coolers (NA.PS02.GKC10.AP020)

The Softened Water Storage Tank level measured by the transmitter NA.PS02.GKC10.LT011/LT012 will be sent to the Adiabatic Cooling Water Pressure Group Unit (NA.PS02.GKC10.AP020).

9.4.2.2.5 Softened Water pressure group unit to the cooling water loops (NA.PS02.GKC10.AP010)

The Softened Water Storage Tank level measured by the transmitter NA.PS02.GKC10.LT011/LT012 will be sent to the Softened Water Pressure Group Unit (NA.PS02.GKC10.AP010).

9.4.2.3 Demineralized Water Subsystem NA.PS02.GHC10

The Demineralized Water Storage Tank level measured by the transmitter NA.PS02.GHC10.LT011/LT012 will be sent to the Demineralized Water Pressure Group Unit (NA.PS02.GHC10.AP010) and the Demineralized Water Treatment Plant (NA.PS02.GHC10.AW010).

9.4.2.4 Purified rainwater Subsystem NA.PS02.GUD10

The pressured measured by the transmitter NA.PS02.GUD10.PT010 will be sent to the Rainwater Tank Pumps (by others).

9.5 Sequence

The higher hierarchical level for the PS02 Water Preparation and Supply System is the PS02 Water Preparation and Supply System (NA.PS02.G__10.EA010).

9.5.1 Start-up sequence

The operator will select the main pump to start on the Sector`s (NA.PS02.GKC10.EA110) faceplate.

The Functional Group (NA.PS02.G__10.EA010) will be switched to automatic control mode by operator acting on the FG faceplate on the Conventional Control System HMI and the FSG (NA.PS02.GKC10.EA010) along with their dependent equipment will be in auto mode too.

The PS02 Water Preparation and Supply System will be ready to regulate itself in automatic mode. The pumps start when their control loops require them to start.

9.5.2 Shutdown sequence

The operator by acting on the Functional Group (NA.PS02.G__10.EA010) faceplate' stop button on the Conventional Control System HMI, will stop automatically all the pumps in operation.

All the drivers of the PS02 Water Preparation and Supply System will remain in automatic control mode unless express action by the operator.

9.6 Alarms

Hereafter are listed the PS02 Water Preparation and Supply System alarms due to the process, however, the whole alarm´s list with all details related to the alarms as tag-name, description, priority will be presented in the Alarm List [19] document. A few of the below alarms will be pre-alarms of the abnormal operation indicated in section 9.3.2.

- Low pressure in the municipal drinking water supply pipe (NA.PS02.GKB10.PT010) (L).
- Bad quality in the municipal drinking water supply pipe pressure (NA.PS02.GKB10.PT010).
- Bad quality in the municipal drinking water supply pipe totalizer flow measure (NA.PS02.GKB10.FQT010).
- No operational availability of the Potable Water Pressure Group Unit
- Fault of the Potable Water Pressure Group Unit.
- Low level in the Lagoon Water Intake (NA.PS02.GKC10.LT021/LT022) (L).
- Low low level in the Lagoon Water Intake (NA.PS02.GKC10.LT021/LT022) (LL).
- Bad quality in the Lagoon Water Intake (NA.PS02.GKC10.LT021).
- Bad quality in the Lagoon Water Intake (NA.PS02.GKC10.LT022).
- Lagoon Water Intake Pumps (NA.PS02.GKC10.AP031) tripped.
- Lagoon Water Intake Pumps (NA.PS02.GKC10.AP031) not available.
- Lagoon Water Intake Pumps (NA.PS02.GKC10.AP032) tripped.
- Lagoon Water Intake Pumps (NA.PS02.GKC10.AP032) not available.
- Lagoon Water Intake Pumps Discharge MOV (NA.PS02.GKC10.AA350) not available.
- Lagoon Water Intake Pumps Discharge MOV (NA.PS02.GKC10.AA351) not available.
- Bad quality in the pressure downstream the Lagoon Water Intake Pumps (NA.PS02.GKC10.AP031).
- Bad quality in the totalizer flow measure downstream the Lagoon Water Intake Pumps (NA.PS02.GKC10.FQT040)
- Bad quality in the totalizer flow measure downstream the Softened Water Production Plant (NA.PS02.GKC10.FQT030).
- High level in the Softened Water Storage Tank (NA.PS02.GKC10.LT021/LT022) (H).
- Low level in the Softened Water Storage Tank (NA.PS02.GKC10.LT021/LT022) (L).
- Low low level in the Softened Water Storage Tank (NA.PS02.GKC10.LT021/LT022) (LL).
- Bad quality in the Softened Water Storage Tank (NA.PS02.GKC10.LT011).
- Bad quality in the Softened Water Storage Tank (NA.PS02.GKC10.LT012).
- No operational availability of the Softened Water Production Plant (NA.PS02.GKC10.AW010).
- Fault of the Softened Water Production Plant (NA.PS02.GKC10.AW010).
- Adiabatic Cooling Water Pressure Group Unit (NA.PS02.GKC10.AP020) no operational availability.
- Adiabatic Cooling Water Pressure Group Unit (NA.PS02.GKC10.AP020) fault.
- High pressure downstream the Adiabatic Cooling Water Pressure Group Unit (NA.PS02.GKC10.PT110) (H).
- Low pressure downstream the Adiabatic Cooling Water Pressure Group Unit (NA.PS02.GKC10.PT110) (L).
- Bad quality in the downstream pipe pressure downstream the Adiabatic Cooling Water Pressure Unit (NA.PS02.GKC10.PT110).
- Bad quality in the totalizer flow measured downstream the Adiabatic Cooling Water Pumps (NA.PS02.GKC10.FQT010).
- Softened Water Pressure Group Unit (NA.PS02.GKC10.AP010) no operational availability.

- Softened Water Pressure Group Unit (NA.PS02.GKC10.AP010) fault.
- High pressure downstream the Softened Water Pressure Group Unit measure NA.PS02.GKC10.PT120 (H).
- Low pressure downstream the Softened Water Pressure Group unit measure NA.PS02.GKC10.PT120 (L).
- Bad quality in the pipe pressure downstream the Softened Water Pressure Group unit (NA.PS02.GKC10.PT120).
- Bad quality in the totalizer flow measured downstream the Softened Water Pumps (NA.PS02.GKC10.FQT020).
- High level in the Demineralized Water Storage Tank (NA.PS02.GHC10.LT011/LT012) (H).
- Low level in the Demineralized Water Storage Tank (NA.PS02.GHC10.LT011/LT012) (L).
- Low low level in the Demineralized Water Storage Tank (NA.PS02.GHC10.LT011/LT012) (LL).
- Bad quality in the Demineralized Water Storage Tank (NA.PS02.GHC10.LT011).
- Bad quality in the Demineralized Water Storage Tank (NA.PS02.GHC10.LT012).
- High high differential pressure in the Demineralized Water Storage Tank vent (NA.PS02.GHC10.PDT010) (HH).
- High differential pressure in the Demineralized Water Storage Tank vent (NA.PS02.GHC10.PDT010) (H).
- Bad quality in the differential pressure in the Demineralized Water Storage Tank filter (NA.PS02.GHC10.PDT010).
- Demineralized Water Pressure Group Unit (NA.PS02.GHC10.AP010) no operational availability.
- Demineralized Water Pressure Group Unit (NA.PS02.GHC10.AP010) fault.
- High pressure downstream the Demineralized Water Pressure Group Unit (NA.PS02.GHC10.PT060) (H).
- Low pressure downstream the Demineralized Water Pressure Group Unit (NA.PS02.GHC10.PT060) (L).
- Bad quality in the pressure downstream the Demineralized Water Pressure Group Unit (NA.PS02.GHC10.PT060).
- No operational availability of the Demineralized Water Treatment Plant (NA.PS02.GHC10.AW010).
- No fault of the Demineralized Water Treatment Plant (NA.PS02.GHC10.AW010).
- High conductivity in the Demineralized Water Treatment Plant (NA.PS02.GHC10.AW020) (H).
- High conductivity in the Demineralized Water Treatment Plant (NA.PS02.GHC10.AW030) (H).
- Low pressure in the purified rainwater supply pipe (NA.PS02.GUD10.PT010) (L).
- Bad quality in the purified rainwater supply pipe pressure (NA.PS02.GUD10.PT010).
- High pressure in the purified rainwater supply pipe (NA.PS02.GUD10.PT010) (H).

10 References

[1] SCK CEN\8905079 - Abbreviations, Glossary and Symbols

[2] Applicable Codes and Standards (=NA.AA_BEB501 - MINERVA/4NT/0691961/000/02)

[3] PS02 Water Preparation and Supply PFD (=NA.PS02_PFB502 - 092-423-DP-M-14100-B)

[4] PS02 Water Preparation and Supply P&ID (=NA.PS02_PFB503 - 092-423-DT-M-14100)

[5] Pidpa report - Potable water quality SCK-CEN

[6] Process Systems, Equipment and Piping Design Criteria (=NA.PS_PDB501 - 092-423-R-M-00400)

[7] Project Execution Plan (MINERVA/4AV/0693237/000)

[8] 16_20200313_20130507 rpt oppwater lagune BR2.nl.en

[9] 20200611_meetrapport oppervlaktewater Lagune

[10] Sizing, Design and Capacity Calculations Water Preparation and Supply System (=NA.PS02_PDD501 - 092-423-F-M-14100)

[11] Requirements Allocation Sheet (=NA.AC_BEB502 - MINERVA_4NT_701812_000_00)

[12] AUB Architectural Drawings_v6 (october 2022)

[13] MCB Architectural Drawings_Draft (March 2023)

[14] MINERVA ACC NF SCC List (=NA.AA_BPB502)

[15] MINERVA ACC NF Fluid List (=NA.AA_BPB503)

[16] MINERVA ACC NF Terminal Point List (=NA.AA_BPB501)

[17] UBMS Control Interface Principle (=NA.CN_EDB502).

[18] PS02 Water Preparation and Supply System Control Diagram (=NA.CN_EDB520)

[19] Alarm List (=NA.CN_EPB502)

[20] Line List (=NA.PS_PPB501 - 092-423-LE-M-40400)

11 Annexes

11.1 Softened water quality required

Table 1- Softened water quality parameters

Parameter	Unit	Range advised
Conductivity	µS/cm.	50-600
TSS	mg/l	<25
pH		6.5 – 9 (*)
TDS	mg/l	<1000
Total hardness	mg/l	140
Chloride	mg/l	<125

(*) For softened water coming from cation resin exchangers (municipal drinking water is the source of water entering the softened water production plant), pH advised shall be not higher than pH 7

11.2 Demineralized water quality required

Table 2- Demineralized water quality parameters achieved in NA.PS02.GHC10.AW010

Parameter	Unit	Range advised
Conductivity	µS/cm	<0.5
pH		7.5 - 8
Dissolved oxygen	ppb	< 20
CO_2	ppb	Nill
Fe	ppb	< 5
Cu	ppb	< 1
TSS	mg/l	Nill
Oil	mg/l	Nill

Table 3- UHP Demineralized water quality parameters achieved in NA.PS02.GHC10.AW020/30

Parameter	Unit	Range advised
Conductivity	µS/cm	0.055

11.3 Purified rainwater required

Table 4- Purified rainwater quality parameters

Parameter	Unit	Range advised
Conductivity	µS/cm.	50-600
TSS	mg/l	Nill
pH		7.5 - 8
Chloride	mg/l	<50
Bacteria	UFC/ml	<1000