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TS/CV Detector Cooling Project Document No.
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TECHNICAL FOLDER

ALICE – HMPID COOLING PLANT HYDRAULIC PART FCUL-00007

General description and functionalities

This plant supplies cooling water to the front-end electronics of the High Momentum Particle Identification Detector, HMPID, of the ALICE experiment. In nominal operating conditions, the plant delivers 4.2m^3/h of water at 18ºC and 1bar(a) to the detector inlet (the pressure throughout the detector is sub-atmospheric). The cooling plant is expected to remove some 4.9kW (7circuits×700W) from the detector.

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History of Changes

Rev. No.	***Date***	***Pages***	***Description of Changes***
2	04/2009	All	Document reviewed

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1. GENERAL DESCRIPTION

The plant consists of a reservoir, a pump, a heat exchanger connected to the EN/CV mixed water network, one supply manifold and one return manifold. The manifolds comprise 7 circuits with common flow and temperature both remotely adjusted at any given instant. Temperature adjustment is done by changing the set point on the PID regulating the flow of mixed water, within a possible range of 16ºC to 20ºC. Flow adjustment is done by changing the (set point on the PID controlling the) pump speed. This also ensures a constant pressure in the supply manifold despite of the number of circuits open at any given instant. All regulation loops as well as other plant control operations are done by a *Programmable Logical Controller* (PLC).

Figure 1.1. HMPID Cooling Plant - FCUL-00007. Location: UX25 cavern.

The plant works on the *Leakless* Operation Mode, i.e., the hydraulics of the system is such that water pressure within the detector is below atmospheric. This is done by keeping the reservoir below atmospheric pressure by means of a vacuum pump, (typically -600mbar) and minimizing the pressure drop inside the detector and in the return lines. Should a leak arise within the detector or in the return pipes, air will infiltrate into the plant and accumulate in the reservoir. By measuring the build-up in pressure, the PLC decides whether to stop the installation or carry on cooling. If the leak stays small the installation can carry on cooling *ad infinitum*. Should a leak occur in the part of the circuit above atmospheric pressure (between the pump and the detector inlet), a level transmitter in the reservoir will detect the loss of water and stop the circulator pump. This brings the whole installation to sub-atmospheric pressure and therefore stops the leakage of water.

2. HYDRAULIC DOSSIER

The heat dissipated by the front-end electronics amounts to ~700W per RICH, i.e. 7×700W=4.9kW for the whole HMPID detector. This heat must not be released to the surrounding air nor conduct to the detector itself, where the temperature has to be kept in the vicinity of 20°C. Hence, one water circuit per RICH has been foreseen to remove the heat from the front end electronics. The expected water temperature increase is 1.5ºC, and so the minimum flow required is ~6.7l/min per RICH.

2.1 GENERAL SCHEME

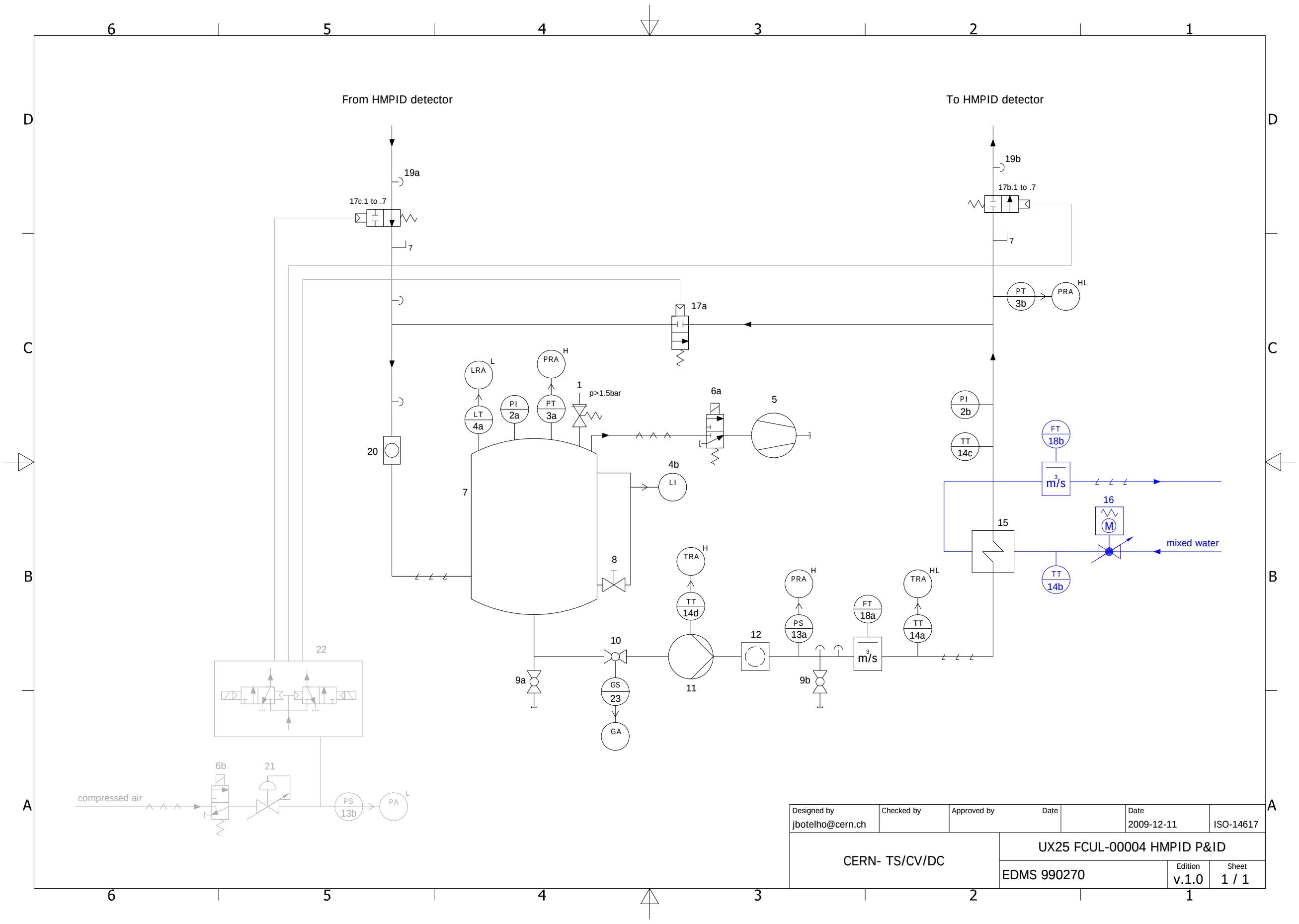


Figure 2.1. HMPID Cooling Plant P&I diagram (https://edms.cern.ch/file/990270/1/HMPID_FCUL_00004.pdf) according to ISO 14617.

2.2 PART LIST & D7I NAMING

SYSTEM	P&I Ref.	Component	D7I
HMPID	1	Safety valve	FCPSV-00001
HMPID	2a	Manometer	FCPG-00007
HMPID	2b	Manometer	FCPG-00008
HMPID	3a	Pressure transmitter	FCPT-00037
HMPID	3b	Pressure transmitter	FCPT-00038
HMPID	4a	Level transmitter	FCLSL-00001
HMPID	4b	Level indicator	FCLIC-00001
HMPID	5	Vacuum pump	FCP-00023
HMPID	6a	Electrovalve	FCV-00055
HMPID	6b	Electrovalve	FCV-00056
HMPID	7	Tank	FCEE-00006
HMPID	8	Ball valve	FCV-00057
HMPID	9a	Ball valve	FCV-00058
HMPID	9b	Ball valve	FCV-02808
HMPID	10	Ball valve	FCV-00059
HMPID	11	Pump	FCP-00024
HMPID	11.V	Pump variator	FVAR-00001
HMPID	12	Strainer/Filter	FCF-00008
HMPID	13a	Pressure switch	FCPS-00005
HMPID	13b	Pressure switch	FCPS-00006
HMPID	14a	Temperature transmitter	FCTS-00001
HMPID	14b	Temperature transmitter	FCTS-00002
HMPID	14c	Temperature transmitter	FCTS-00003
HMPID	14d	Temperature transmitter	FCTS-00024
HMPID	15	Heat exchanger	FCE-00009
HMPID	16	Control valve	FCV-00060
HMPID	17a	Pneumatic valve	FCV-00061
HMPID	17b.1	Pneumatic valve	FCV-00062
HMPID	17b.2	Pneumatic valve	FCV-00063
HMPID	17b.3	Pneumatic valve	FCV-00064
HMPID	17b.4	Pneumatic valve	FCV-00065
HMPID	17b.5	Pneumatic valve	FCV-00066
HMPID	17b.6	Pneumatic valve	FCV-00067
HMPID	17b.7	Pneumatic valve	FCV-00068
HMPID	17c.1	Pneumatic valve	FCV-00069
HMPID	17c.2	Pneumatic valve	FCV-00070
HMPID	17c.3	Pneumatic valve	FCV-00071
HMPID	17c.4	Pneumatic valve	FCV-00072
HMPID	17c.5	Pneumatic valve	FCV-00073
HMPID	17c.6	Pneumatic valve	FCV-00074
HMPID	17c.7	Pneumatic valve	FCV-00075
HMPID	18a	Flowmeter	FCFT-00001
HMPID	18b	Flowmeter	FCFT-00002
HMPID	19	Schraeder valve	

HMPID	20	Sight glass	FCFG-00006
HMPID	21	Pressure regulator	FCPCV-00004
HMPID	22	Pneumatic pressure control unit	FCPG-00125
HMPID	23	Contact switch	FCEZE-00001

2.3 CIVIL ENGINEERING INTEGRATION

The services required by this cooling plant are:

- 5 m^3/h at dp=2bar of mixed water
- 4kVA, 400V from the TS-CV standard power distribution
- 440W, 220V from TS-CV UPS power distribution
- Compressed air at 6bar (consumption is negligible).
- TCP/IP connection

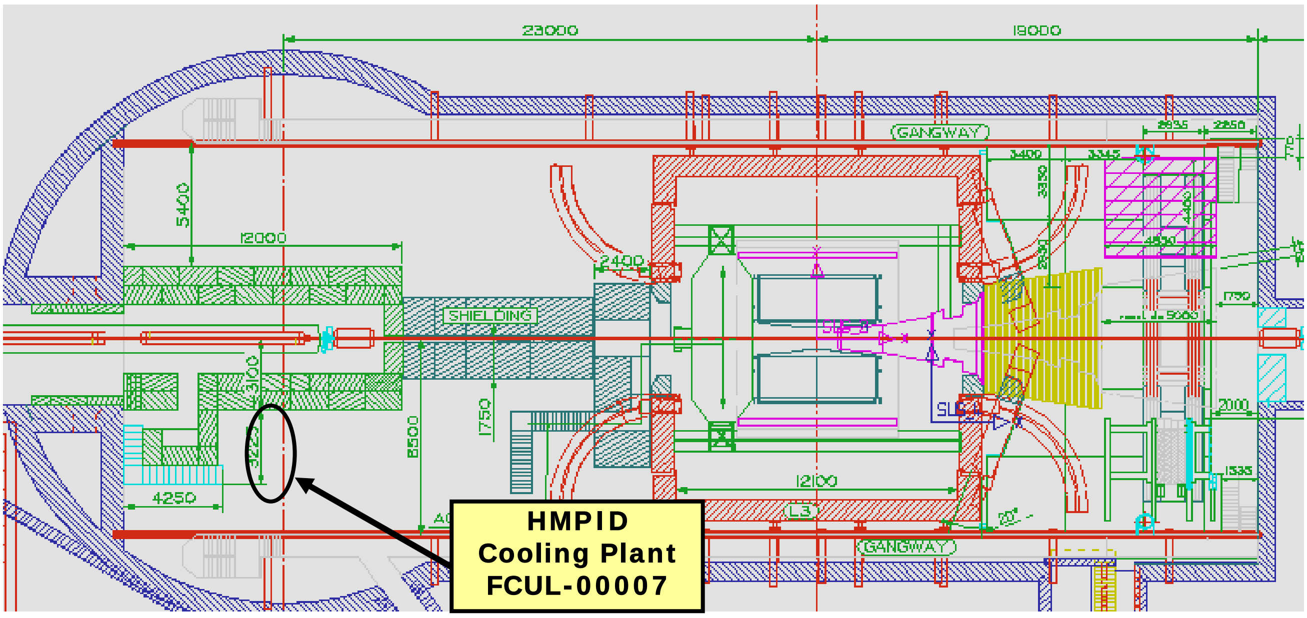


Figure 2.1. HMPID Cooling Plant location on UX25.

2.4 CONSTRUCTION AND ASSEMBLY DRAWINGS

Reference to the CDD numbers & copy of the drawings on paper

3. USER MANUAL

Most of the operation of the HMPID cooling plant is done via a PLC interface panel (Magelis XBT) shown below:

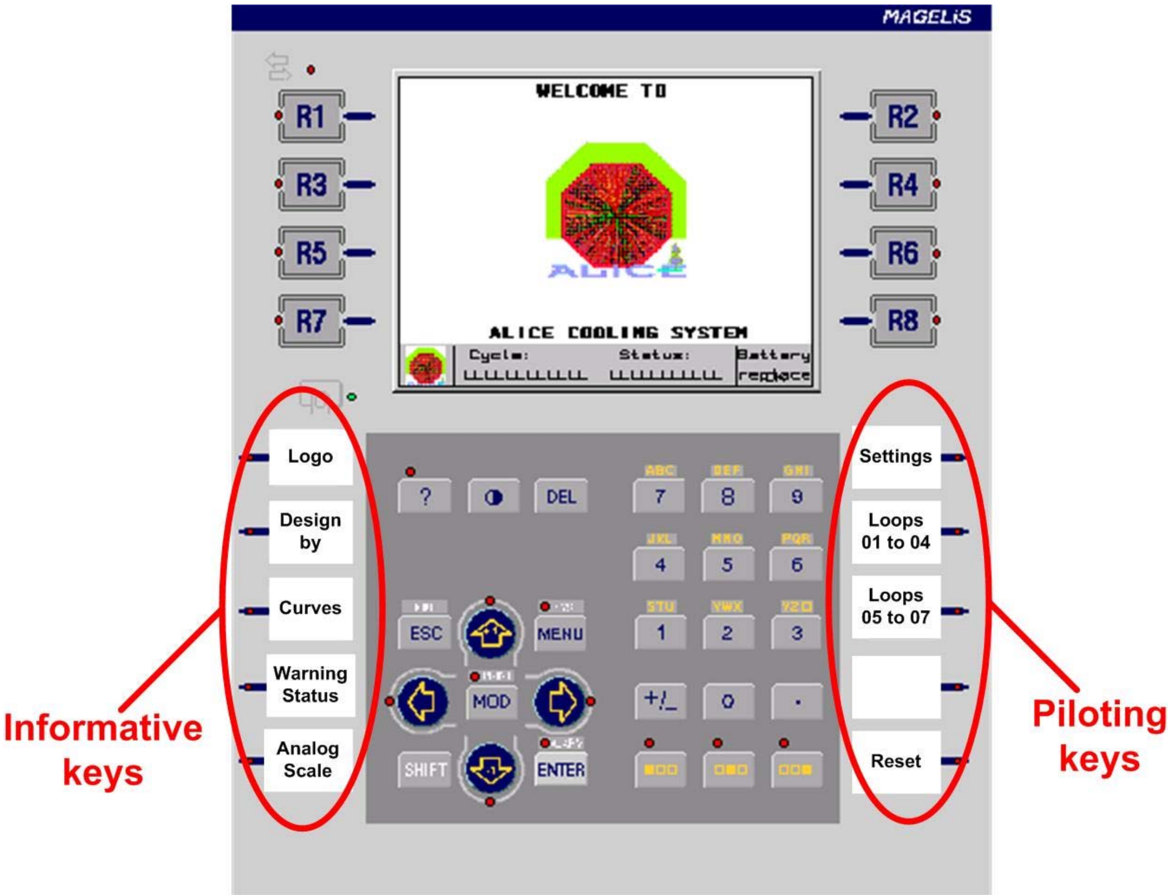


Figure. 3.1. XBT-Magelis Interface Panel.

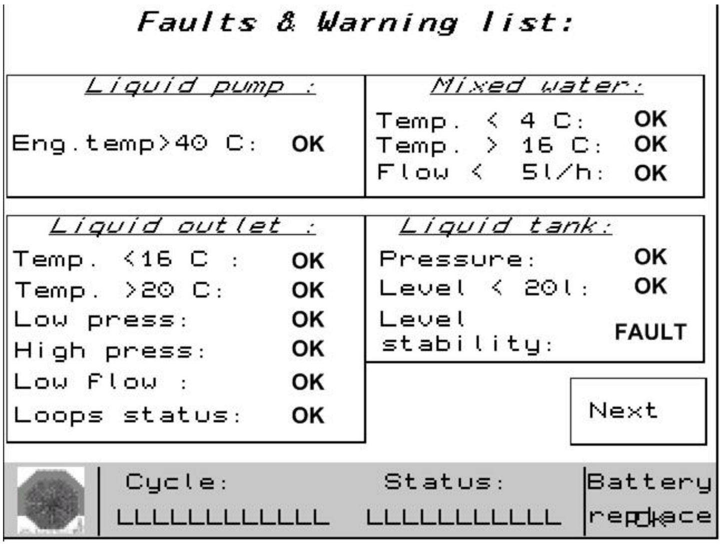
The buttons on the left of the panel (***Logo***, ***Design by***, ***Curves***, ***Warning Status*** and ***Analog Scale***) provide the user with varied information on cooling parameters, faults and alarms as well as handling of sensor outputs.

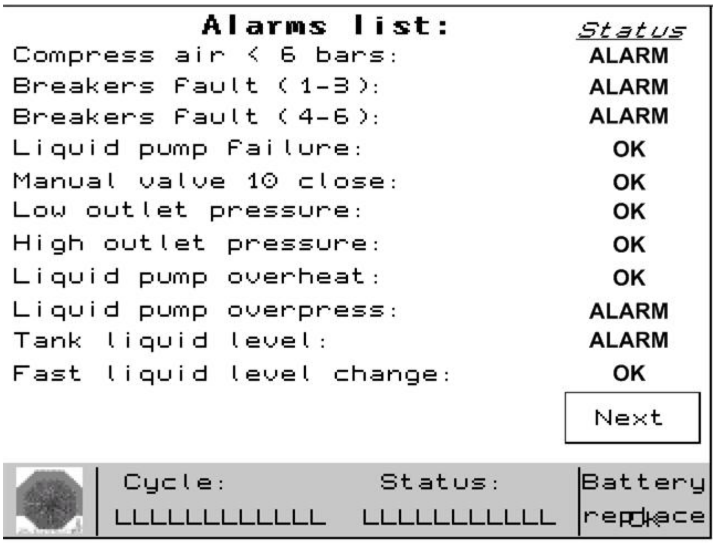
The buttons on the right of the panel (***Settings***, ***Loops 01…07***) allow the user to choose the flow rate and temperature and open and close valves.

All pages displayed on the screen bear information on the ***Cycle*** and the ***Status***. The former can assume 3 different values: ***Stop***, ***Stand-by***, and ***Run***. The letter can either display ***Warning*** or ***Alarm***.

The default ***Cycle*** when the plant is powered ON is **STOP.** In this cycle the circulator pump is idle; all circuits (supply and return valves) are closed; the reservoir is at atmospheric pressure; the mixed water valve is closed.

When the plant is powered ON, the ***Status*** is likely to be indicating **ALARM**. The exact list of alarms can be obtained by pressing ***Warning Status*** on the panel. Three pages appear (press ***Next*** and ***Return*** to move between pages). The first page lists all the ***faults***, the following two pages list the ***alarms***.





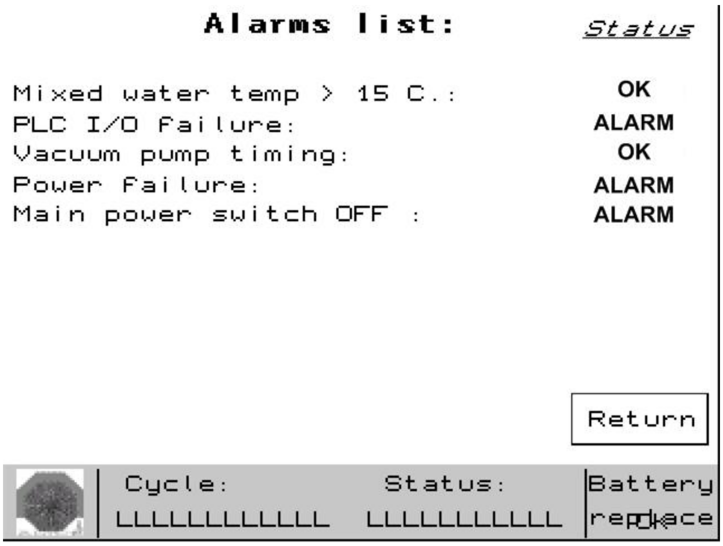


Figure. 3.2. Faults and Alarm list pages.

In general, a ***FAULT*** occurs when a continuous variable (pressure, temperature, flow) goes beyond a defined threshold. If the variable attains a second threshold, then the ***FAULT*** turns into an ***ALARM***.

For some continuous variables however, only ***ALARM*** or ***FAULT*** thresholds were defined. Obviously, this is also the case for binary (boolean) variables (pressure switches, shut off valves, circuit breakers etc).

Once the origin of a ***FAULT*** has been corrected (i.e. the variable is back within its normal range or to its normal logical value) the indication ***OK*** appears by itself.

Once the origin of an ***ALARM*** has been corrected, the user must push the ***Reset*** button on the panel and only then the indication ***OK*** appears.

IMPORTANT:

- **An Alarm should only be reset after its cause has been fully understood.**
- **If the Alarm persists after it has been reset, do not keep on pushing the Reset button repeatedly as this may damage the cooling plant.**

When all alarms have been cleared, the ***Status*** will indicate ***Warning*** (if at least one fault persists) or ***OK*** if all faults were resolved.

The PLC will only allow the ***Run Cycle*** once the ***Status*** is ***Warning*** or ***OK***. As long as the ***Status*** is Alarm, the only possible ***Cycles*** are ***Stand-by*** and ***Stop***.

3.1 COOLING SETTINGS

Water flow rate and temperature are set when the plant is in ***Stand-by Cycle****.*

To select the ***Stand-by Cycle***, use buttons on the panel as exemplified below:

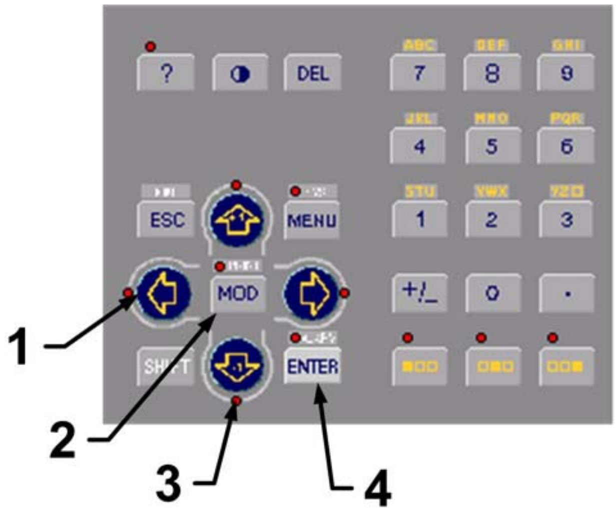


Figure. 3.3. Keyboard.

1: Move the intermittent area using the arrows.

2: push the ***MOD*** button

3: scroll up or down until ***Stand-by*** appears.

4: validate your choice by hitting ***Enter***

Once the ***Stand-by Cycle*** has been selected, hit the ***Setting*** button on the panel. This will open the page shown below:

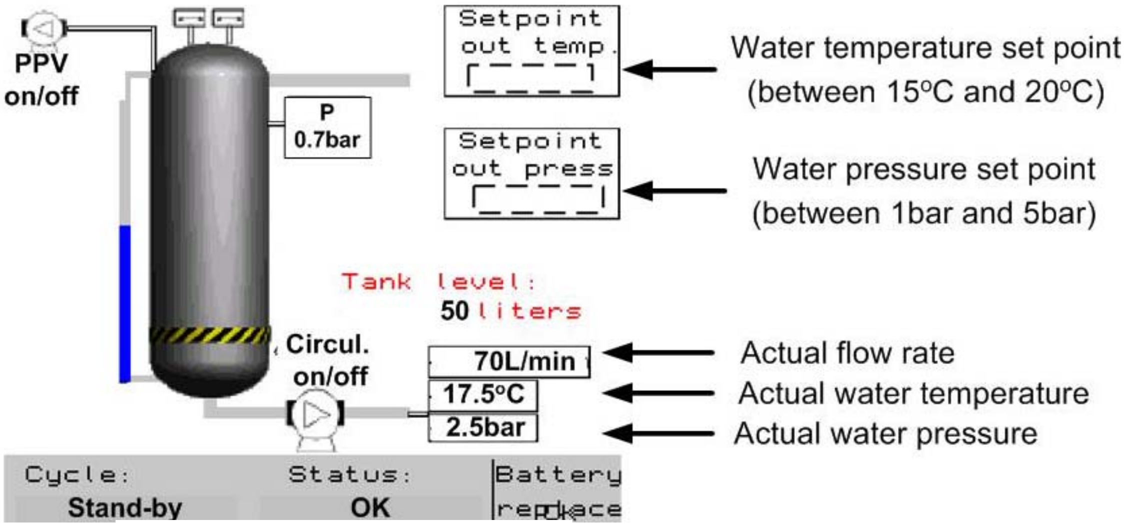


Figure. 3.4. Settings page.

In this page the user has the possibility to choose the water temperature and pressure set points. Later on, when the system will be in ***RUN CYCLE***, this page will also provide information on the actual values of these two variables.

Given the correlation between flow rate and pressure (loosely $\Delta P \sim FlowRate^2$), the user should adjust the pressure set point while minding the flow rate reading. While the plant is in ***Stand-by***, the circulator pump is idle so no reading is available yet. It is prudent to start out with a low pressure set point and increase it gradually once the plant is in ***Run***.

After temperature and pressure set-points have been selected, the user should turn his attention to the exact cooling circuits he plans to flow water through. This is done by hitting the ***Loops 01 to 04*** and ***Loops 05 to 07*** keys on the panel.

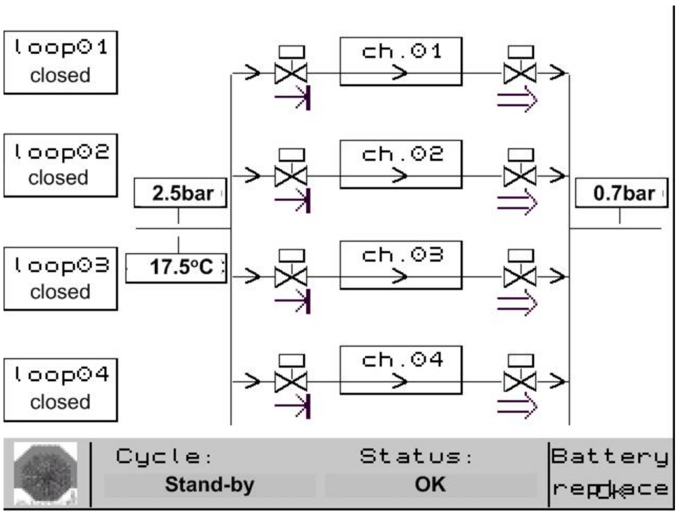


Figure. 3.5. Distribution manifolds page

Any given cooling circuit (loop) can display one of three states:

- **Locked**: supply and return valves are closed. This is the state you should select for un-used outlets. This state is available in ***STAND-BY*** and ***RUN CYCLES***.
- **Open**: supply and return valves are open, hence the right configuration for water to flow through this circuit. This state is only available in ***RUN CYCLE***. When the cooling plant goes to ***STAND-BY*** or ***STOP CYCLE*** the state goes automatically to ***closed***.
- **Closed**: supply valve is closed but return valve is open. This is also the state in which a circuit should remain if it is piped to the detector and contains water left inside. By letting the return valve open, the whole circuit will be kept below atmospheric pressure and thereby prevent any water spill out through possible leaks in the detector.

When a cooling circuit changes from locked to open, there is a 6 sec time delay between the opening of the return and the supply valve. Similarly, when an open circuit is to be locked, the return valve is shut 6 sec after the supply valve.

Note that when the cooling plant is in ***Stand-by***, the pressure in the reservoir is kept sub-atmospheric by a vacuum pump. This pressure is controlled by switching ON the vacuum pump when the pressure surges 50mbar and OFF when it is back at its set point. Therefore, when the volume of a cooling circuit is for the first time put in contact with the reservoir volume, (example: **locked → closed** or **locked → open**), the vacuum pump will have to remove that additional air from the reservoir.

In case of a major air infiltration causing the pressure to rise above 0.9bar, the ***Pressure Fault*** will appear in the ***Warnings*** page and the circulator pump stops (if the plant happens to be in ***Run*** at that moment). When the pressure drops below 0.9bar the circulator pumps restarts.

However, after 20 minutes of continuous pumping, the ***Vacuum pump timing ALARM*** will make the system go to ***Stand-by*** (thus bringing the circulator pump to a definitive halt). Nevertheless, as implied by the ***Stand-by Cycle***, the reservoir pressure regulation stays active so the vacuum pump carries on working to bring the pressure down to the set point.

3.2 STARTING COOLING

Upon selecting the ***RUN Cycle***, the circulator pump starts working and the mixed water valve begins cooling the heat exchanger. Both of these processes are piloted by a PID control algorithm in which the controlled variables are respectively the pressure and the temperature at the supply manifold. The set points for these closed-loop controls are selected on the ***Settings*** page.

If all the cooling circuits are closed or locked when the circulator pump starts working (i.e. when the ***RUN Cycle*** is selected), then the by-pass valve (17a) shall divert the flow from the supply manifold to the return manifold and the ***Loops Status*** displays ***Fault*** in the warnings page. However, starting pumping through the by-pass before opening any circuit is in fact the safest way to proceed, as it will prevent any initial pressure or temperature spike to propagate to the detector.

Once at least one cooling circuit is open, the by-pass valve will close.

3.3 THE “LEAKLESS” PROTECTION

When the cooling plant is in ***Stand-by***, the whole system (plant + piping + detector) is below atmospheric pressure whereas in ***Run***, only the return pipes and the detector is below atmospheric pressure. Therefore, should a leak occur, it may either lead to water spillage or air infiltration, depending on its location.

3.3.1 WATER LEAKAGE

Leakage of water can be detected and stopped early in time. This is done by continuously measuring the water level in the reservoir and stopping the circulator pump when a significant drop is detected. As soon as the pump stops, the by-pass valve opens and the sub-atmospheric pressure prevails throughout the whole system (system = cooling plant + piping + detector), thereby stopping the water spillage.

Nonetheless, the water level in the reservoir may drop without necessarily meaning that water is being spilled out somewhere. This the case when the plant goes from ***Stand-by*** to ***Run*** and/or when cooling(s) circuits are put into service (more water leaves the reservoir to fill-up new volumes outside the plant) or when the pumped flow varies (altering the pressure set point). It is quite often the case that air trapped inside the detector piping itself takes time to be flushed down to the reservoir, so new volumes of water are still being filled outside the plant, long after the pumping has started. These three water level disturbances (opening circuits, pump start/stop and change of flow throughput) are acknowledged by the PLC and do not set off the ***Fast liquid level change ALARM***. However, after one of these disturbances has occurred, the PLC needs to rememorize a new stable level. Level is considered suitable to be memorized if it remains within a +- 0.5L margin of a given level for the 10 minutes following the reading of that level. Once a new level is memorized, the surveillance is reactivated and any level drop of more than 2L will give rise to the ***Fast liquid level change ALARM*** and take the system to ***Stand-by***.

The evolution of water level during all these events is shown below:

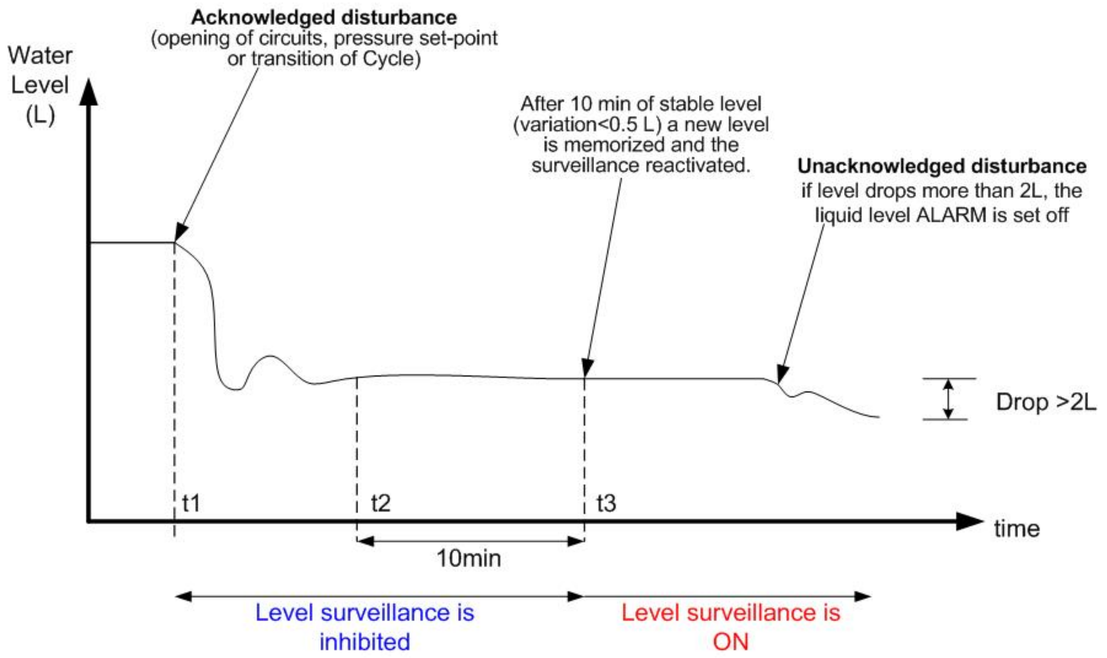


Figure. 3.6. Normal and abnormal variations of the water level in the reservoir

During the surveillance inhibition period, the ***Level stability Fault*** will appear (Faults & Warnings page). Once the Level surveillance is back on, this fault will disappear.

Make sure you repair the leak before reseting the ***Fast liquid level change ALARM***. Failure to do so may lead to substancial leakage of water as the alarm is inhibited waiting for the level to stabilize again.

3.3.2 AIR INFILTRATION

Air infiltration is not a problem *per se* but may become one if it is big enough. It may equalize the pressure to atmospheric and thereby allow water to spill out.

In case of a major air infiltration causing the air pressure to rise above 0.9bar, the ***Pressure Fault*** will appear in the Warnings page and the circulator pump stops (if the plant happens to be in ***Run*** at that moment). When the pressure drops below 0.9bar the circulator pumps restarts.

However, after 20 minutes of continuous vacuum pump working, the ***Vacuum pump timing ALARM*** will make the system go to ***Stand-by*** (thus bringing the circulator pump to a definitive halt). Note however that in ***Stand-by*** the reservoir pressure regulation is still ON, so the vacuum pump carries on working to bring the pressure down to the set point.

3.4 FAULTS AND ALARMS

Fault	**Cause**	**Outcome**	**Cycles in which it is active**	
			Stand-by	**Run**
Liquid Pump: Eng.temp > 45°C	The motor temperature is higher than 45ºC. If the temperature rises above 50ºC, this fault converts into an alarm (see alarm list below).	none	•	•
Liquid outlet: Temp. < 16°C	The temperature of the water at the supply manifold is below 16ºC	none		•
Liquid outlet: Temp. > 20°C	The temperature of the water at the supply manifold is above 20ºC	none		•
Liquid outlet: Low press.	The pressure at the supply manifold is below 1bar(a). If it falls below 0.8bar this fault converts into an alarm (see alarm list below)	none		•
Liquid outlet: High press.	The pressure at the supply manifold is above 5.5bar(a). If it surges above 6bar this fault converts into an alarm (see alarm list below)	Halts circulator pump		•
Liquid outlet: Low Flow	The cooling water flow is lower than 1L/min	none		•
Loops status	All cooling circuits are either closed or locked	Opens by-pass valve.		•

Mixed water: temp<8ºC	The mixed water temperature is lower than 8ºC.	none		•
Mixed water: temp>16ºC	The mixed water temperature is higher than 16ºC.	none		•
Mixed water: Flow<5L/h	The mixed water flow is lower than 5L/h.	none		•
Liquid Tank: Pressure	Air pressure in the reservoir is above 0.9bar	Halts circulator pump (if in Run)	•	•
Liquid Tank: Level<20L	The volume of water in the reservoir is less than 20L. If it drops below 10L this fault converts into an alarm (see alarm list below)	none	•	•
Liquid Tank: Level stability	Following an acknowledged disturbance, the level surveillance is inhibited while a new stable level is being memorized.	none	•	•

Alarm	Cause	Outcome	Cycles in which it is active	
			Stand-by	Run
Compress air < 6bar(g)	The pneumatic supply pressure is below 6bar(g).	Goes to Stand-by		●
Breakers fault 1-3	The circuit breakers of the Emergency Power Supply tripped	Goes to Stop	●	●
Breakers fault 4-6	The main circuit breakers tripped	Goes to Stand-by		●
Liquid Pump Failure	The frequency inverter detected a surge in the current (caused for instance by mechanical obstruction of the pump axis)	Goes to Stand-by		●
Manual Valve 10 closed	The reservoir containment valve is closed	Goes to Stand-by		●
Low outlet Pressure	Following the fault threshold at 1bar, the pressure has now dropped below 0.8bar	Goes to Stand-by		●
High outlet Pressure	Following the fault threshold at 5.5bar, the pressure has now surged above 6bar	Goes to Stand-by		●
Liquid pump overheat	Following the fault threshold at 45ºC, the temperature has now risen above 50ºC.	Goes to Stand-by		●
Tank liquid level	Following the fault threshold at 20L, the level has further dropped below 10L.	Goes to Stand-by		●
Fast Liquid level change	Following an unacknowledged disturbance, the level drops more than 2L	Goes to Stand-by		●
Mixed water temperature > 15C	If the mixed water supply is at a temperature higher than 15ºC for more than 20min	Goes to Stand-by		●
PLC I/O failure	Communication or out of range input signal	Goes to Stop	●	●
Vacuum pump timing	Vacuum pump works continuously for more than 20min	Goes to Stand-by		●
Power failure	Power outage from normal network	Goes to Stand-by (on EPS power)		●
Main power switch OFF	The user switched off the power		●	●

3.5 MONITORING OF PARAMETERS

Real time information on several parameters is available from the ***Curves*** key on the left of the panel. Type the page number using the panel keyboard to obtain 1h and 48h plots.

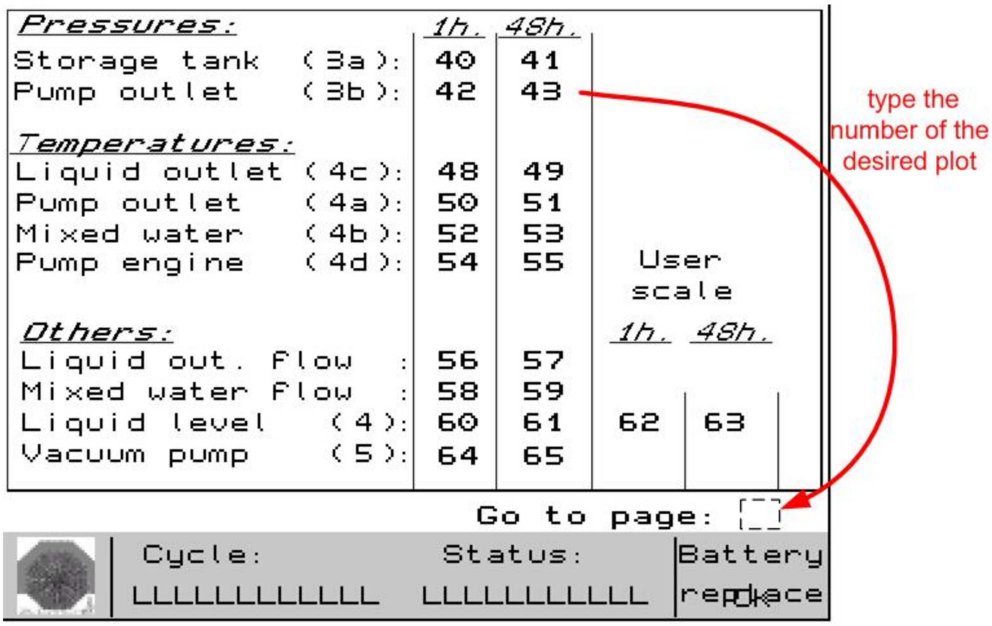


Figure. 3.7. Real time information on several parameters.

3.6 STOP PROCEDURE

The user can select ***Stop*** from any of the other cycles. When doing so, the circulator stops, the mixed water, the supply and the by-pass valves shut and the return valves open. The negative pressure in the reservoir is no longer maintained.

The cooling plant can remain safely in ***Stand-by*** or ***Stop*** and it should not be powered off unless it is to remain unused for a long period.

4. REGULATION PARAMETERS

Parameters signalled with * require access to the PLC source code file and therefore can only be modified by EN/CV/DC.

4.1 REGULATION OF PRESSURE IN RESERVOIR

Type: ON/OFF
Set-point=0.8bar
Regulation band = 50mbar
Maximum pumping time = 20min

4.2 REGULATION OF TEMPERATURE

Type: PID
Set point=16~20ºC
P=see source PL7 code
I= see source PL7 code
D= see source PL7 code

4.3 REGULATION OF WATER PRESSURE

Type: PID
Set point=1.2~5.0 bar
P= see source PL7 code
I= see source PL7 code
D= see source PL7 code

5. MAINTENANCE

This chapter describes, where applicable, the maintenance procedures to be foreseen to operate the installation.

There are two types of maintenance to be applied on the cooling plant: Corrective maintenance and preventive maintenance.

As for the corrective maintenance, a spare part list (Maintenance Agreement signed between TS department and the Experiments) is to be maintained case malfunctions on the equipment are observed. This list can be found at the EDMS portal: https://edms.cern.ch/document/848184/1.

As for the Preventive Maintenance, the two categories: Programed and Condicioned are applied. The Conditioned Preventive Maintenance activity is based on the observation/monitoring of the cooling plant (EN/CV/DC SCADA system) used to predict malfunctions on the equipment so that an action can be taken (to replace the vaccum pump membranes case the pumping efficiency decrease as an example). The Programed Preventive Maintenance action plan is the following:

Equipment	Title	Instruction List	Every 6 months	Every Year
FCE-00009	Heat Exchanger	CONTROLES ENCRASSEMENT PAR ΔT ET ΔP, ETANCHEITE		X
FCEE-0006	Tank with 180 liters capacity	CONTRÔLE ETAT GENERAL, BON FONCTIONNEMENT (PRESSION, NIVEAU), ETANCHEITE		X
FCF-00008	Strainer	ISOLATION HYDRAULIQUE, VIDANGE, OUVERTURE FILTRE, DEMONTAGE ELEMENT FILTRANT ET EVACUATION, REMONTAGE NOUVEL ELEMENT FILTRANT, REMPLISSAGE, PURGER FILTRE, MISE EN SERVICE		X
FCPSV-00001	Tank pressure relief safety valve	ISOLATION HYDRAULIQUE, DEMONTAGE, CONTROLE BATTANT (RESSORT OU MEMBRANE)-REMPLACEMENT SI NECESSAIRE, REMPLACEMENT DES JOINT (FILASSES), MISE EN EAU, ESSAI ET MISE EN SERVICE		X
FCV-00055	Vacuum pump electro valve (normaly closed)	CONTROLES: POSITIONNEUR, FIN DE COURSE, LIMITEUR EFFORT, ETANCHEITE. GRAISSAGE DE AXES, MANŒUVRE VANNE		X
FCV-00056	Pneumatic air supply electrovalve			X
FCV-00060	Mixed water 2-way control valve	CONTROLES: POSITIONNEUR, FIN DE COURSE, LIMITEUR EFFORT, ETANCHEITE. GRAISSAGE DE AXES, MANŒUVRE VANNE		X
FCV-00061	Pneumatic bypass valve			X
FCV-00062	Pneumatic shut-off valve, supply channel 1			X
FCV-00063	Pneumatic shut-off valve, supply channel 2			X

FCV-00064	Pneumatic shut-off valve, supply channel 3		X
FCV-00065	Pneumatic shut-off valve, supply channel 4		X
FCV-00066	Pneumatic shut-off valve, supply channel 5		X
FCV-00067	Pneumatic shut-off valve, supply channel 6		X
FCV-00068	Pneumatic shut-off valve, supply channel 7		X
FCV-00069	Pneumatic shut-off valve, return channel 1		X
FCV-00070	Pneumatic shut-off valve, return channel 2		X
FCV-00071	Pneumatic shut-off valve, return channel 3		X
FCV-00072	Pneumatic shut-off valve, return channel 4		X
FCV-00073	Pneumatic shut-off valve, return channel 5		X
FCV-00074	Pneumatic shut-off valve, return channel 6		X
FCV-00075	Pneumatic shut-off valve, return channel 7		X
FCP-00023	Tank's vacuum pump	Service contract with KNF	
FCP-00024	Circulation Pump	CONTROLES : ETAT GENERAL, ROULEMENTS PAR ROTATION MANUELLE, VIBRATIONS AVEC ENREGISTREMENTS, ACCOUPLEMENT, PRESSE-ETOUPE AVEC RAJOUT DE TRESSE EVENTUELLE, CHANGEMENT HUILE/ GRAISSE	X
		CONTRôLE TEMPERATURE ET BRUITS ANORMAUX, MESURE ISOLEMENT BOBINAGE ET RESISTANCE DE SURCHAUFFE, GAISSAGE DES ROULEMENTS SI POSSIBLE	X
FCPCV-00004	Pressure Regulator for pneumatic air supply	CONTROLES: POSITIONNEUR, FIN DE COURSE, LIMITEUR EFFORT, ETANCHEITE. GRAISSAGE DE AXES, MANŒUVRE VANNE	X
FCTIR-00008	electrical Cabinet	VERIFICATION DES CONNECTIONS,BORNIERS, CONTACTEUR, CONTRÔLE DES PROTECTIONS ET DES VOYANTS	X
		THERMOGRAPHIE DES CONNECTIONS	
FCTIR-00054	electrical Cabinet	VERIFICATION DES CONNECTIONS,BORNIERS, CONTACTEUR, CONTRÔLE DES PROTECTIONS ET DES VOYANTS	X
		THERMOGRAPHIE DES CONNECTIONS	
FVAR-00001	Circulation pump Variator	VERIFICATION SIGNAL ENTREE, SIGNAL SORTIE, DE LA CONFIGURATION, DES PROTECTIONS, TEST + NETTOYAGE ET CONTROLE VENTILATEUR	X
FCSC-00010	Speed Controller	VERIFICATION SIGNAL ENTREE, SIGNAL SORTIE, DE LA CONFIGURATION, DES	X

		PROTECTIONS, TEST + NETTOYAGE ET CONTROLE VENTILATEUR	
FCIC-00008	Power supply	Reference module: TSX PSY xxx	X
FCIC-00009	Power supply (no pile)	Reference pile de rechange: TSX PLP 01	X
FCIC-00010	Power supply (no pile)	Frequence de remplacement: chaque annee.	X
FCIC-00045	Power supply (no pile)		X
FCIC-00046	Power supply (no pile)	Procedure:	X
FCIC-00047	Power supply (no pile)	Enlever la pile usagee	X
		Mettre une pile neuve	
		Mettre une etiquette avec la date du remplacement.	
FCUC-00007	Processor	Reference module: TSX Pxxx (processor) Reference pile de rechange: TSX BAT M02 +	X
FCUC-00008	Processor (no pile)	TSX BAT M03 Frequence de remplacement: chaque annee.	X
FCUC-00037	Processor	Procedure: Connecter la console de programmation directement au PLC (prise TER). Verifier et sauvegarder si necessaire la version de programme embarque. Sauvegarder les variables courantes a l'aide de la commande : AP\Transferer donnees\Automate vers fichier Enregistrer le fichier sous le nom: Backup_"system"_"mois"_"annee".dat (ex: Backup_HMPID_10_2008.dat) Passer PL7 en mode "Local". Arreter les systemes de cooling depuis XBT. Couper l'alimentation des racks PLCs (Disjoncteur) Enlever la carte memoire du processeur. Remplacer la pile principale "TSX BAT M02" Remplacer la pile auxilliaire "TSX BAT M03" Remettre la carte memoire en place. Remettre le PLC sous tension (disjoncteur) Reconnecter la console de programmation et verifier la version de programme. Recharger les variables courante dans le PLC a l'aide de la commande: AP\Transferer donnees\Fichier vers Automate. Controler l'absence de defaut "Piles PLC" Redemarrer les systemes de cooling. Sauvegarder le fichier de variables courantes sur Detcool. Note: -Toujours remplacer les piles l'une apres l'autre pour conserver le programme en memoire. -L'ensemble de ces operation prend environs 10 minutes dont 5 avec arret du refroidissement	X

6. COMPONENT SELECTION

6.1 CIRCULATOR PUMP

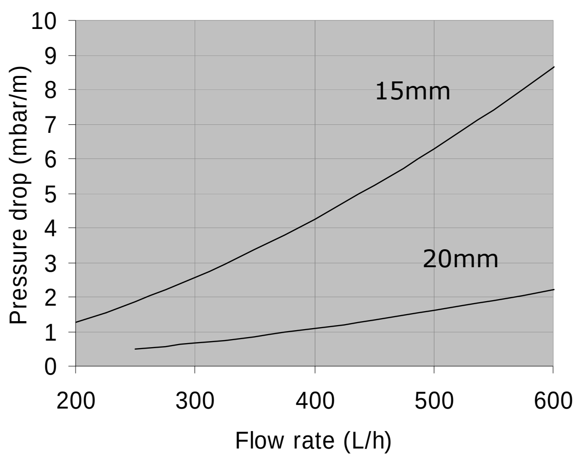
6.1.1 CALCULATION OF PRESSURE DROP IN THE CIRCUIT

The approximate length of pipe between cooling plant and the detector is ~30m (assuming access through RB24 side). Additionally to the friction losses brought about by the length of pipe, some localized losses must also be considered:

- Shut-off valve (ball valve) when fully open: equivalent frictional loss ≈ 45×ID
- ~ 10 elbows between cooling plant and detector, equivalent frictional loss≈50×ID/elbow

Thus the additional length due to localized losses is: (45+10×50)×ID =545×ID and the total equivalent frictional length is ~38m and ~41m, for inner diameters between 15mm and 20mm respectively.

Pressure drop per meter of return/supply line vs flow rate



The calculated pressure drop for 600L/h is:

Pdrop (ID=15mm)=
8.5mbar/m×38m≈**323 mbar**

Pdrop (ID=20mm)=
2.3mbar/m×41m≈**94 mbar**

The diameter 15mm has been adopted for the supply lines.
The diameter 20mm has been adopted for the return lines.

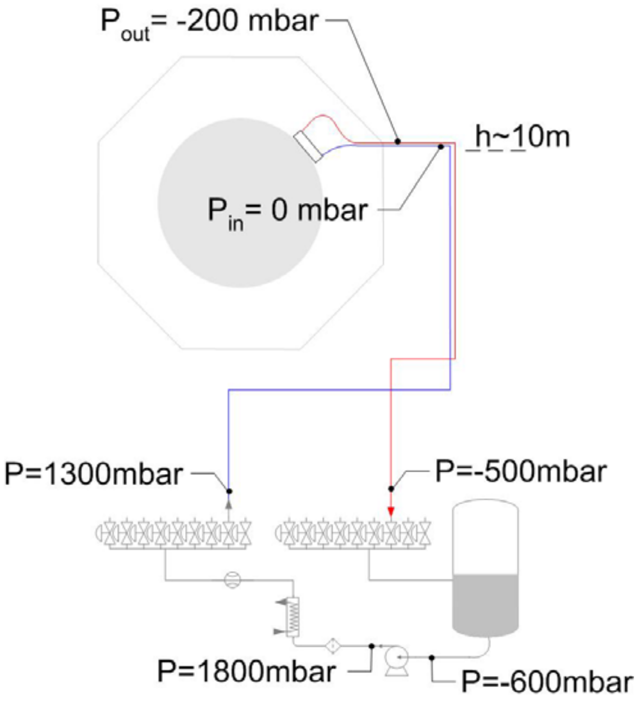
The pressure drop between the pump outlet and the supply manifold is:

220 mbar (Heat exchanger) + 100 mbar (flowmeter) + 100mbar (strainer) + 50mbar (piping) ≈ **500mbar**

6.1.2 CALCULATION OF REQUIRED PUMP HEAD

Applying the Bernoulli equation between the pump outlet and the detector inlet:

$$\frac{P_{PUMP\_OUT}}{100} - (500mbar + 300mbar) = \frac{1000Kg/m3 \times 10m \times 9.81m/s^{-2}}{100} - Patmospheric$$



Hence, the pressure required at the pump inlet is 1.8bar.

The pump must supply **2.4bar** for a flow rate of **4.2m^3/h**.

6.1.3 CALCULATION OF REQUIRED NPSH

For non occurrence of cavitation, the minimum head required at the pump inlet or Net positive suction head NPSH, must be

$$\frac{P\tan k}{\rho g} - hf + \Delta y - \frac{Psatvap(Tamb)}{\rho g} > NPSH$$

assuming the friction in the pipe to be cancelled by the difference in level, i.e.

$$-hf + \Delta y = 0$$

and with $\frac{Psatvap(25^o C)}{\rho g} \approx 0.3m$ and Ptank=400mbar, it must then be:

$$NPSH \leq 4m - 0.3m = 3.7m$$

The chosen pump verifies this condition.

6.2 RESERVOIR

Total volume of water in installation:

supply pipes: ID=15mm
return pipes: ID=20mm
length of pipe ~30m (assuming access through RB24 side)

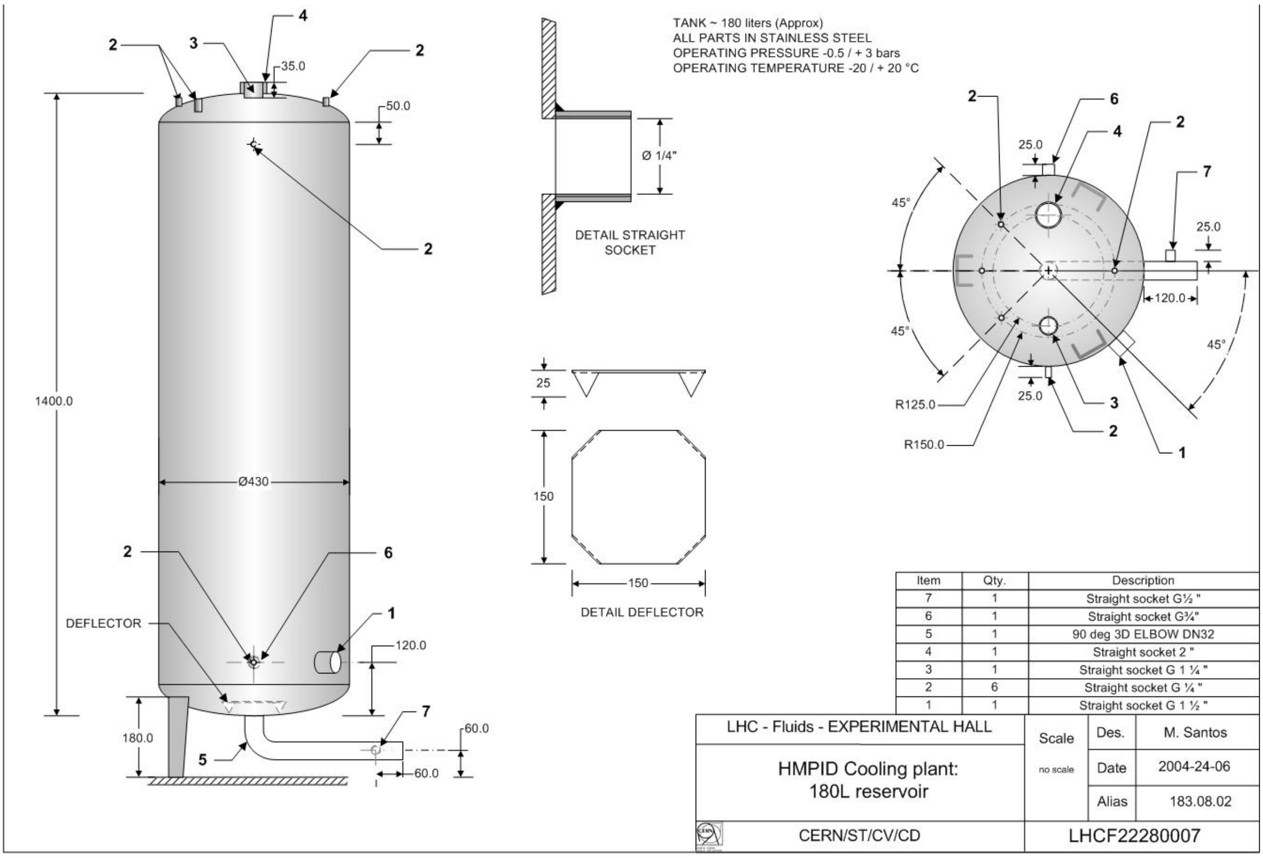
Total volume of water in supply + return pipes = $30\text{m} \times (9+9) \times \pi/4 \times (0.015^2+0.02^2) \approx 132\text{L}$

Supply and return manifolds + heat exchanger + pump inner volume $\approx$ 10L

Volume in the detector $\approx$ 5 L

Thus, the total volume of water moving through the installation at anytime is $\approx$147L

With a 180L reservoir, the maximum amount of water stocked inside during operation will be 180-147=33L, which will bring the water level to about 1/5 of the total reservoir height – enough to obtain a stable level surface.



6.3 HEAT EXCHANGER

Consumption of mixed water 13-18ºC = flow of water to be cooled if ΔT=5K for both sides (22-17ºC).
Data for selection of Heat Exchanger:

	Cooling water	Mixed water
Tin °C	22	13
Tout °C	17	18
Flow rate	5.4	5.4
Heat exchanged	~31kW	

The heat exchanged is much greater than the HMPID dissipation (~5kW). The plant can cope with heat picked up from the environment along supply and return pipes.

6.4 MIXED WATER VALVE

ΔP available in the cavern is **2bar** (information source: B. Pirollet)

Perte de charge echangeur	Débit nominal	Perte de charge que la vanne doit introduire pour le débit nominal	Kv correspondant au débit nominal	% ouverture pour le débit nominal si Kvs=10 et vanne lineaire
22kPa	5.4m^3/h	178kPa	4	40

6.5 VACUUM PUMP

The pump must be able to bring the reservoir (180L) pressure from atmospheric to 600mbar in less than 10min.

Minimum Flow rate required at intermediate pressure (800mbar)= 180L/10min =18L/min

7. PHOTO GALLERY

Fig. 6.2.1 – Pump, containement valve and drain

Fig. 6.2.2 –Heat Exchanger, regulation valve and flowmeter

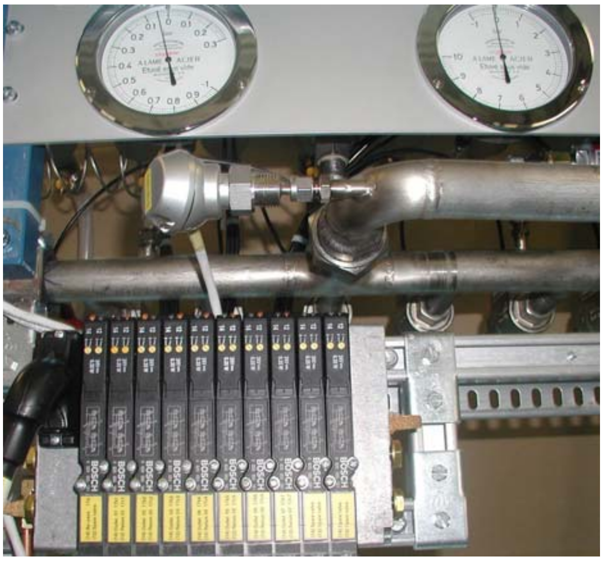


Fig. 6.2.3 – Pneumatic commutation array, temperature sensor and manometers

Fig. 6.2.4 – top of the Reservoir (from left to right): vacuum port, blow-off valve, Pressure transmitter and Level sensor

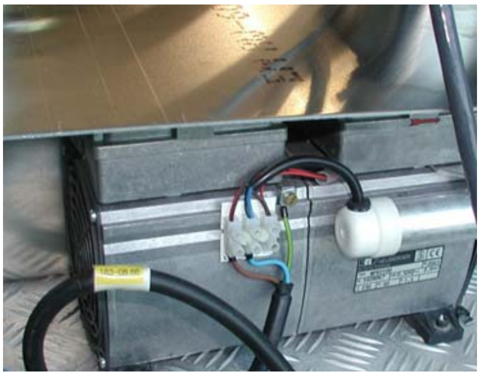


Fig. 6.2.5 – Vacuum pump

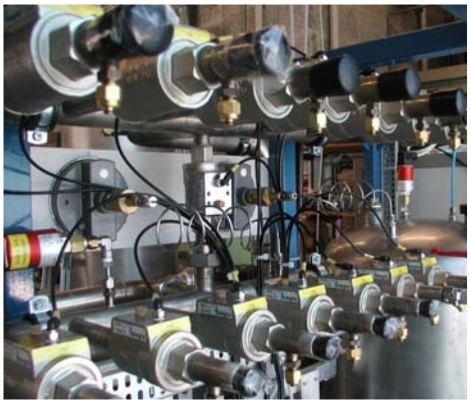


Fig. 6.2.6 – Manifolds

Fig. 6.2.8 – Frequency inverter and 24Vcd power supply

Fig. 6.2.7 – PLC and Electrical rack

Fig. 6.2.10 – back of the PLC rack, including level transmitter

ANNEXES

- Offers & DAI’s
- Components User Manuals

* Available on paper version