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Technical specifications

**ATLAS INNER DETECTOR COOLING
FULL SCALE TEST PHASE 2
MONOPHASE COOLING UNIT -20°C**

Objectives

This document defines the main characteristics of the cooling unit in order to purchase the components and to proceed to its construction.

Abstract

In the frame of the full scale test of the cooling system for the ATLAS Pixel and SCT detectors a monophasic cooling system is foreseen for the thermal barrier between the SCT and the TRT. This monophasic unit will also be used for the second stage subcooling of the liquid C3F8 lines from the distribution rack to the cold box (tracers).

Technical characteristics and LCS v.2 functions are given in this document.

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Distribution

List

History of Changes

Rev. No.	Date	Pages	Description of Changes
1	2001/07/17	7	Materials for insulation added

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1. INTRODUCTION

The cooling system is designed to evacuate 4 kW from the thermal screens between the SCT and the TRT detectors of ATLAS. Required temperatures are Inlet -25°C to Outlet -20°C . It will also be used to cool down the C3F8 liquid lines of the evaporative system from -10°C to -25°C (tracers). The unit is a closed liquid circuit working according to the LCS v.2 principle and connected to a primary circuit through a heat exchanger. The working fluid is a perfluorocarbon C8F18. A small Programmable Logical Controller controls the operation.

This is working package N°3 in the document ATLAS Cooling projects.

2. TECHNICAL SPECIFICATIONS

2.1 Fridge circuit

The primary (fridge) circuit is a closed evaporative circuit with a hermetic Scroll compressor, an air-cooled condenser, a refrigerant tank and a coaxial evaporator. The liquid refrigerant pressure is reduced through an expansion valve at the entrance of the evaporator.

The compressor is equipped with oil sight glass, crankcase heater and 3 ways valves. It is protected on both high and low pressure by a switch automatic reset.

- Fridge power: 4100 W with evaporative temperature -25°C and condensing temperature $+32^{\circ}\text{C}$.
- Refrigerant: R404A (HFC). A filter drier (molecular sieve 3A) and a sight glass control the humidity of the fluid.

2.2 Secondary circuit

The secondary is a closed liquid circuit connected to the thermal screens inside the detector and to the tracers. A circulator pump moves the fluid from a pressurized storage tank to the exchangers through a resistance heater and the coaxial evaporator.

The operating pressure and flow are controlled by the storage tank pressure and the circulator speed.

The pressure of the storage tank is controlled by a membrane vacuum pump and 2 vacuum switches:

Vacuum pump:	KNF N026ANE - max. flow: 20 [l/mn] / min.pressure: 100 [mbar.a]
Vacuum switch:	HUBA 625.64301121 - Range -50/-600 [mbar]

Magnetic drive centrifugal pump associated with a variable speed control (3 phase frequency converter):
Flow: 2 m³/h at head max 19m. Type Iwaki MDH-F423 CAEW with special impeller for high gravity fluid.

An autotuning PID controller adjusts the temperature of the fluid by regulating the electrical resistance heater from a RTD Pt100.

Resistance power: 6 kW.

Temperature controller: CAL 9500 PID autotuning

LCD display

Sampling cycle 2 sec.

Accuracy $0.25\% \pm 1^{\circ}\text{C}$

Output SSR drive (pulse voltage) + relay + 4-20mA

5 alarms points

Evaporator: Coaxial finned copper tube WIELAND Type WKE 10.

A discharge valve DANFOSS AVDO between outlet and return manifold controls the differential pressure and assumes a minimum flow in the system to prevent any ice in the evaporator.

Storage tank: Stainless steel 35 liters capacity with visual liquid level and a capacitive float level.
Fluid: C8F18.

Outlet and inlet manifolds in the rack for 4 channels (1 X 1/2", 2X 3/8", 1X 1/4"). Each channel is equipped with control valve on the outlet line and ON/OFF valve on the return line. Flowmeters are in option.

2.3 Insulation

The C8F18 will run at -25°C and this part of the circuit is carefully insulated to avoid ice. As shown on the drawing 186.12.01 the whole C8F18 circuit including the tank, the pump and the heat exchangers is located in an insulated box with flushing of Nitrogen or dry air inside to avoid condensation and ice. The valves on the outlet and return pipes are in a separated box with easy access. Insulation is made with polyurethane panel 50mm thickness.

2.4 Controls

2.4.1 P.L.C.

A small Programmable Logical Controller controls the parameters of the Leakless 2 cooling system and gives alarms:

- SIEMENS LOGO! 24[V]
- 1 terminal LCD display
- 12 digital inputs
- 8 output relay

2.4.2 Other controls

- 1 manometer on the control box for the vacuum in the storage tank.
- 1 manometer on the control box for the outlet pressure of the pump.
- 1 show glass on the return line before the tank.
- Liquid outlet temperature displayed by the controller on the control box.
- Visual liquid level in the tank.
- Speed of the circulator adjustable by the variable speed drive.

2.4.3 Remote controls

Remote controls: 2 connectors available on the control box (see 186/9a.0205):

- From the temperature controller:
 - Alarms.
- From the PLC !LOGO:
 - Common signal for the 5 alarms managed.
 - Vacuum pump ON; it give the possibility to record the pumping time and their frequency, therefore the evolution of the leaks with the time for the whole system.

2.4.4 Alarms and safety

2.4.4.1 Alarms

- Alarms managed by the PLC !LOGO (lamp flashing on the control box with special identification for each. See label on the control box or message on the !LOGO display):
 - Switch float level on the tank.
 - High pressure switch on the tank.
 - Protection on the vacuum pump.
 - Default on the frequency controller / main protection
- Other alarms for internal use only (automatic or manual reset):

High / Low pressure on the fridge.
High temperature switch off on the heater.

2.4.4.2 Safety

Relief valve on the storage tank: 10 mbar.
Adjustable thermostat switch-off on the heater: 0/100°C.
HP/LP pressostat on the fridge compressor.

3. INSTRUCTIONS

3.1 LCS v.2 operating principle

The liquid is held in a storage tank (3) maintained below atmospheric pressure by a vacuum pump (2). A check valve (5) discharges any excess air in the event of drainage and prevents the pressure in the storage tank from rising above atmospheric pressure. The liquid is moved into the exchangers (1) incorporated through the electronic system by a circulator (4).

The pressure at the various points of the circuit depends on the head losses and hydrostatic pressures.

At start-up, if the pressure in the storage tank is not low enough the vacuum pump is activated. While the later is in operation, in the event of an air intake for instance, the circulator cannot run. The pressure throughout the circuit still equal to the pressure in the storage tank.

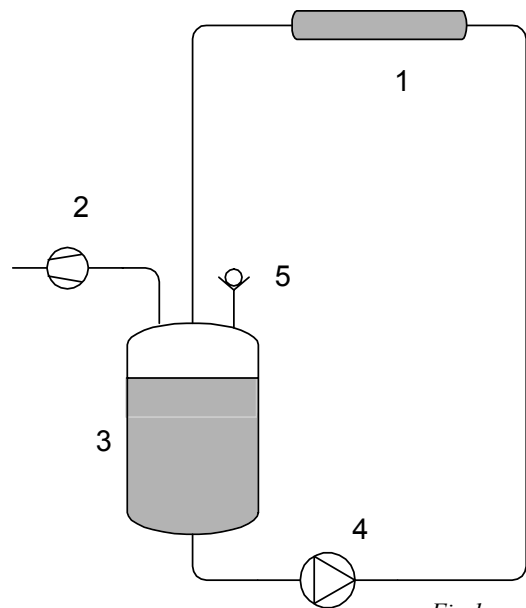


Fig.1

3.2 Operation

The liquid is held in the storage tank below atmospheric and this pressure is controlled by the vacuum pump via a pressure switch.

A second switch fixes a maximum pressure point to stop the circulator (case of main leak).

The whole system is stopped and needs to be resetted if the vacuum pump works for more than 20 minutes.

If the pressure value is contained between the operating setting point and the upper point (switching difference) the circulator and the temperature regulation (controller and heater) run. The vacuum pump and the electrovalve are off. This is the running mode.

If the pressure goes higher than the upper point of the vacuum switch the vacuum pump starts, the 3 ways electrovalve is actuated after 2 sec. and the pressure goes down to the lowest setting point pressure (the minimum admissible pressure). The circulator and the temperature regulation are still running.

A manual vacuum pump switch lets the operator to active it in order to gas out the circuit or to fill the storage tank with fluid (3 positions switch on PPV).

The outlet pressure of the circulator is controlled by a pressure sensor via the PID 3-phase frequency converter. The set point can be adjusted by a manual potentiometer (Pump setpoint).

3.3 Operating functions

- The circulator is on if:
 - The pressure in the circuit is correct or the vacuum pump works for less than 10 mn.
 - The temperature switch off of the heater is not activated.
 - The liquid level in the storage tank is correct.
- The temperature regulation is on if:
 - The pressure in the circuit is correct or the vacuum pump works for less than 10 mn.
 - The temperature switch off of the heater is not activated.
 - The liquid level in the storage tank is correct.
- The fridge is on if:
 - HP/LP pressostat of the compressor is not activated.
 - The pressure in the circuit is correct or the vacuum pump works for less than 10 mn.
 - The temperature switch off of the heater is not activated.
 - The liquid level in the storage tank is correct.
 - The temperature liquid is above 10°C in the evaporator.
- The vacuum pump is on if:
 - The pressure in the circuit is higher than the setting point.
 - The continuous time of pumping is under 10 mn.
 - Its manual switch is on.
- The 3 ways electrovalve is on if:
 - The vacuum pump is activated since 1 seconde.

3.4 Starting procedure

(Assuming the system is leaktight)

- Switch on the main power (I) on the control box.
- Switch the 3-position switch on ON; the vacuum pump starts; the circulator will start after the pressure in the tank reaches [700mbar.a]. If starting from the atmospheric pressure it will take about 30 [mn].
- The pumping time of the vacuum pump is limited to 20 [mn]. If it stops and the fault lamp flashes press the RESET button.
- Adjust the outlet pressure of the circulator with the potentiometer PUMP SETPOINT.
- To adjust the set point on the TEMPERATURE CONTROLLER go to the CAL 9500 instruction manual.
- To stop the circulation switch the 3 positions switch on PPV; the system stays under pressure control and the 3 ways valve is closed.
- To stop the system switch the 3 positions switch on STOP; the pressure will rise to the atmospheric one depending of the leak rate of the system. One can break the vacuum with the switch valve PURGE on the control box.

4. LIST OF COMPONENTS AND PRICE

ATLAS TRACKER COOLING PHASE 2
MONOPHASE UNIT OPOCNO

ITEMS	SUPPLIER	Unit Price	Quantity	Price	Drawing	Re p.
Reservoir 35 litres	-	1000	1	1000	186.12.01	1
Niveau visuel	-		1	0	186.12.01	2
Thermoplongeur 6kw - M45X200	VULCANIC	356.97	1	356.97	186.12.01	10
Bague a souder inox M45X200	VULCANIC	62.82	1	62.82	186.12.01	10
Check valve 10mbar	40.10.30.106.3	75	1	75	186.12.01	15
Contacteur de niveau capacitif 3/8G	DIMAT	239.45	1	239.45	186.12.01	3
Electrovanne 131M14	BACHOFEN	58.5	1	58.5	186.12.01	6
Vacuum pump KNF N026 220v	KNF (CH) NEUBERGER AG	366.8	1	366.8	186.12.01	7
Vanne Whitey Laiton dia. 6, 2 voies.	ARBOR	50.3	3	150.9	186.12.01	8
Pompe IWAKI MDH-423 CAEW DF IEC	IWAKI AG (suisse)	2952	1	2952	186.12.01	9
Evaporateur Wieland WKE10	Danfoss Kuster	395.10	1	395.10	186.12.01	11
Detendeur TMV R 404 A KOMB	Paulus AG	52.2	1	52.2	186.12.01	17
Buse 3.3 kW 404	Paulus AG	16.35	1	16.35	186.12.01	17
Groupe Scroll/Air 4.1kW @-25°C	Paulus AG	2357	1	2357	186.12.01	20
Type MC-P8-ZB30KE						
Voyant 1/4" ODF	Paulus AG	22.6	1	22.6	186.12.01	18
Deshydrateur filtre 1/4 FLARE	Paulus AG	12.8	1	12.8	186.12.01	19
Logo 12E8S relai 24v s/horl avec alim	RS Composants radiospare	435.78	1	435.78	186.12.01	22
Regulateur CAL 9500	RADIOSPARES	438.46	1	438.46	186.12.01	23
Vanne de bypass AVDO 15	RIBAT	58.88	1	58.88	186.12.01	30
Filtre a tamis pour eau bronze 1/2"	40.15.10.108.1	9.6	1	9.6	186.12.01	26
Deshydrateur DN053s 10mm	Danfoss Kuster	12.6	1	12.6	186.12.01	12
Voyant SGN10s pour R404A	Danfoss Kuster	21.88	1	21.88	186.12.01	13
Ball valve brass 1"	40.40.64.216.6	19	1	19	186.12.01	25
Rack	Opcno	1000	1	1000		
Press.Huba -50/-600 - Art.625.64301121	Huba Control	67	2	134	186.12.01	4
Sonde pt100 L100	Radiospares composants	29.21	1	29.21	186.12.01	14
Manometre WIKA -1/0 bar	Typ.111.12.040	20	1	20	186.12.01	21
Manometre WIKA 0/10 bar	Typ.111.12.040	20	1	20	186.12.01	16
Transmetteur de pression -1/5 bar	Huba Control	217.4	1	217.4	186.12.01	5
Variateur de freq.VARISPEED mini C 0,4kw	MEIER+ CO AG	525	1	525	186.12.01	24
Vanne de reglage bronze 1/2"	40.40.30.408.1	40.5	1	40.5	186.12.01	31
Vanne de reglage bronze 3/8"	40.40.30.406.3	33.5	2	67	186.12.01	32
Vanne de reglage laiton 6mm	40.40.30.640.5	27.5	1	27.5	186.12.01	33
Vanne boisseau Legris 1/2"	40.40.64.208.6	7.2	1	7.2	186.12.01	34
Vanne boisseau Legris 3/8"	40.40.64.206.8	6.3	2	12.6	186.12.01	35
Vanne boisseau Legris 1/4"	40.40.64.204.0	9.6	1	9.6	186.12.01	36
Polyurethan pannel 50mm thick. with double aluminium face	MULTIJOINT ALPORIT	23	10m2	230		37
Aluminium tape 50mm X 50m	04.95.20.250.9	54	1	54		38
C8F18 / PF5080	3M Suisse	70	50 kg	3500		
Miscellaneous electrical comp.	Cern Stores	500	1	500		
TOTAL LIST				15509	CHF	
Without Manpower						