



Project acronym: GROUND-MED

Project title: Advanced ground source heat pump systems for heating and cooling in Mediterranean climate

Start date of project: 1 January 2009

Duration: 60 months

**Deliverable D5.5: Engineering design of University Polytechnic of Valencia demo system in Spain**

Version: Final

Due date of deliverable: 31 October 2010

Actual submission date: 31 October 2010

Organisation name of lead contractor for this deliverable:

**Universidad Politécnica de Valencia**

Project co-funded by the European Commission within FP7 Programme		
Dissemination level		
<b>PU</b>	Public	<b>X</b>
<b>PP</b>	Restricted to other programme participants (including the Commission Services)	
<b>RE</b>	Restricted to a group specified by the Consortium (including the Commission Services)	
<b>CO</b>	Confidential, only for members of the consortium (including the Commission Services)	

**GROUND-MED WP5 DELIVERABLE  
DEMO SITE ENGINEERING DESIGN**

**D5.5 VALENCIA**

# ENGINEERING DESIGN OF THE DEMO SITE

## Chapter I. Air Conditioned Spaces and Building Characteristics

### I.1 Building Location, Type and Use

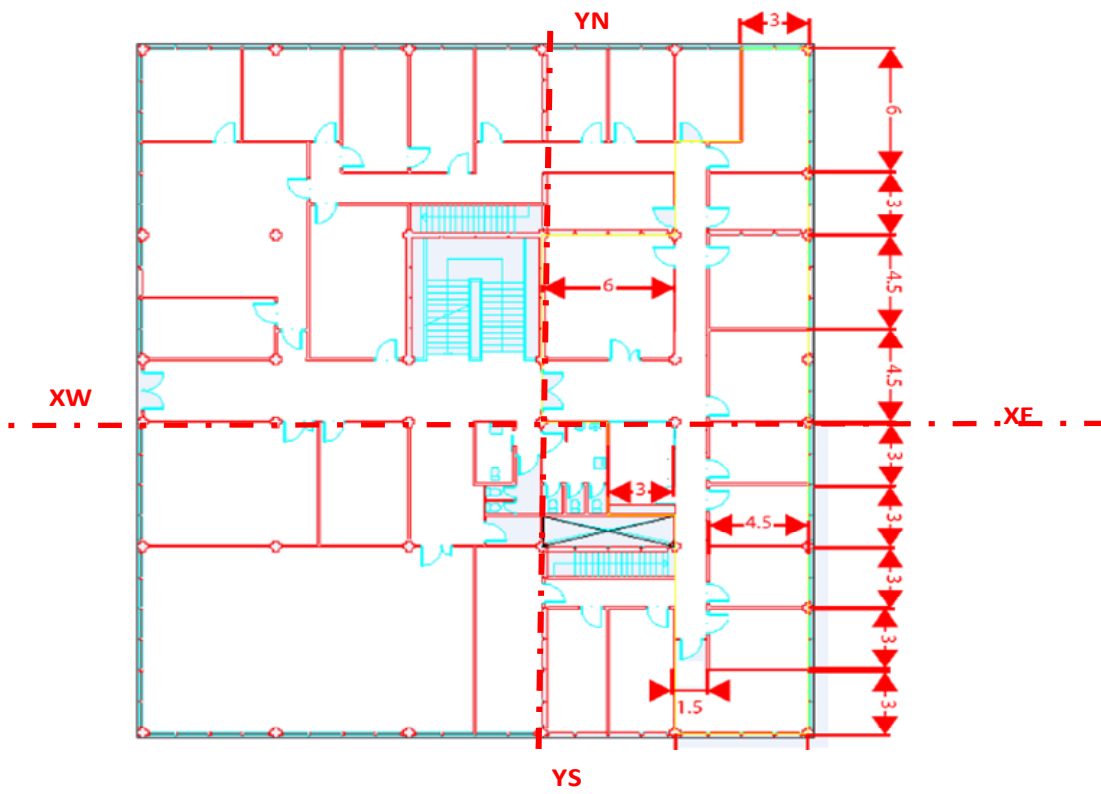
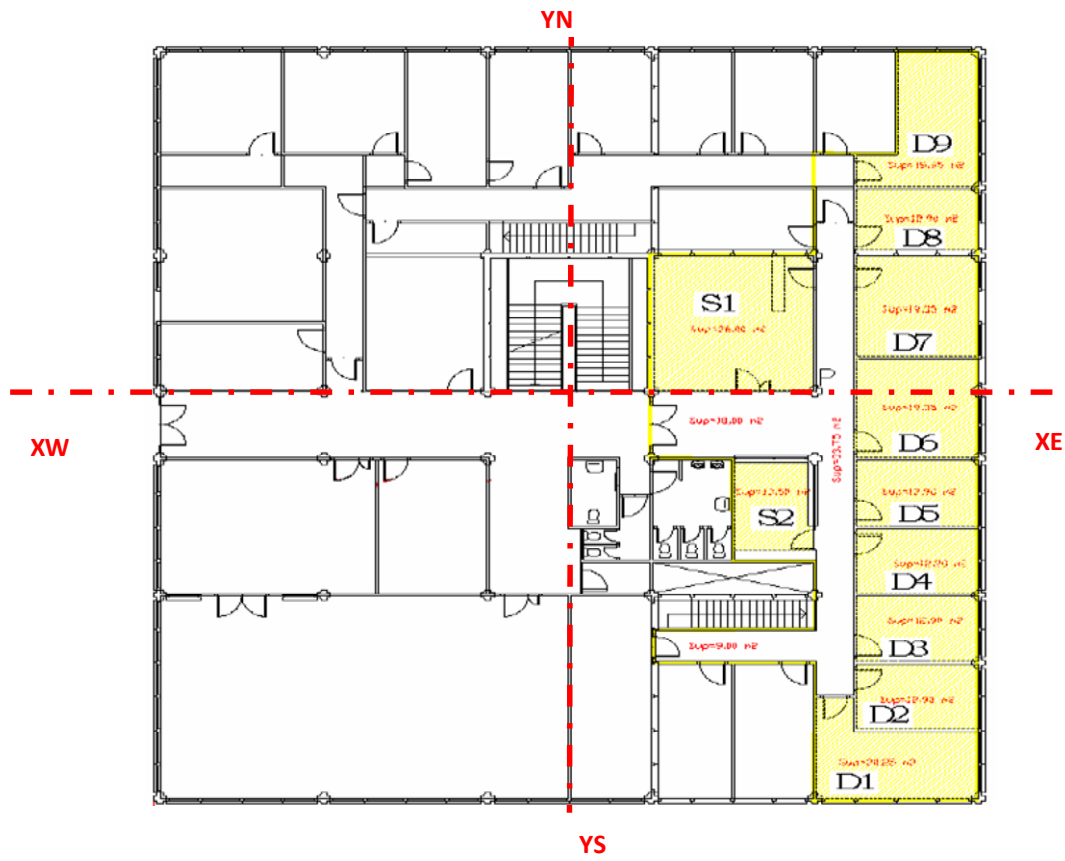
The GSHP system is located in an institutional building at the Universidad Politécnica de Valencia, Valencia, Spain.

Geographical location: City (Country)	Valencia (Spain)
Latitude	39.48°N
Longitud	0.38°W
Altitude	20 m
Building use	University education
Building type	Offices

### I.2 Building Constructive Data



The building which is heated and cooled with the ground source heat pump (GSHP), comprises approximately 250 m<sup>2</sup> floor area and includes a corridor, nine offices (located on the east façade of the building), a computer room “S1” and a service room “S2” with office equipment and other internal loads. The geometrical characteristics of each conditioned area are detailed in the figure below.



BUILDING ZONES	CEILING(m <sup>2</sup> )	FLOOR(m <sup>2</sup> )	HEIGHT (m)
ZONE D1	20.25	20.25	3
ZONE D2	13.5	13.5	3
ZONE D3	20.25	20.25	3
ZONE D4	20.25	20.25	3
ZONE D5	13.5	13.5	3
ZONE D6	13.5	13.5	3
ZONE D7	13.5	13.5	3
ZONE D8	13.5	13.5	3
ZONE D9	20.25	20.25	3
ZONE S1	36	36	3
ZONE S2	13.5	13.5	3
CORRIDOR	51.6	51.6	3

### I.3 Windows

#### *External Windows*



In the tables below the area of the windows and its thermal characteristics are presented for each latitude of the air conditioned spaces.

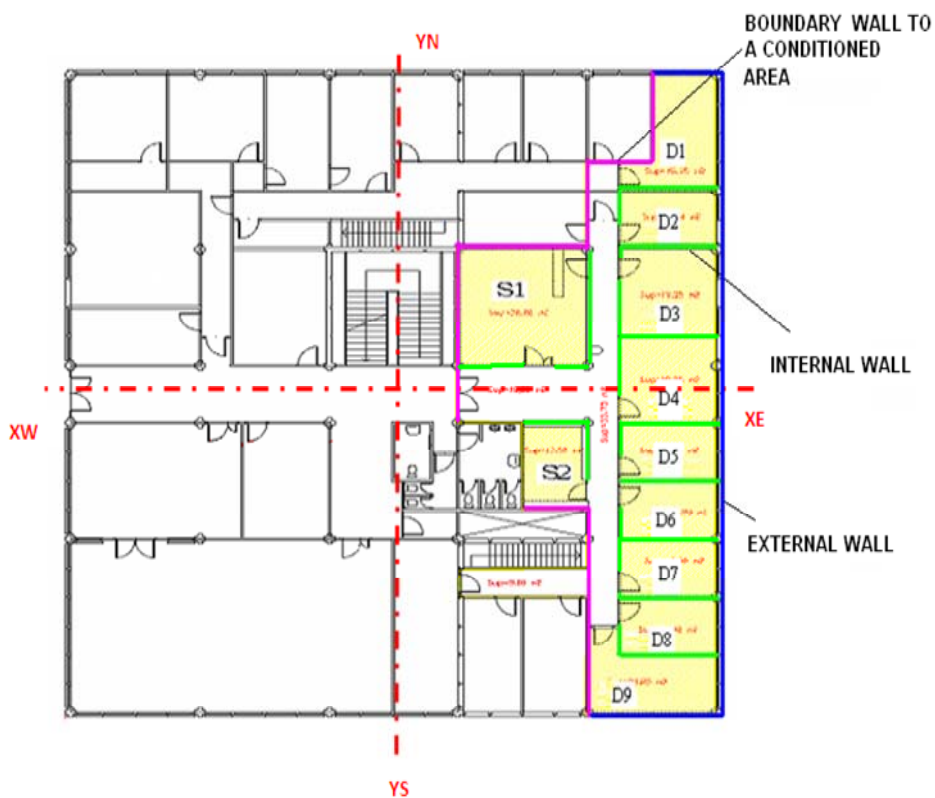
BUILDING ZONES	YN(m <sup>2</sup> )	YS (m <sup>2</sup> )	XE(m <sup>2</sup> )	XW(m <sup>2</sup> )
ZONE D1	4.392		8.784	
ZONE D2			2.928	
ZONE D3			5.856	
ZONE D4			5.856	
ZONE D5			4.392	
ZONE D6			4.392	
ZONE D7			2.098	
ZONE D8			2.098	
ZONE D9		4.195	2.098	
ZONE S1				
ZONE S2				

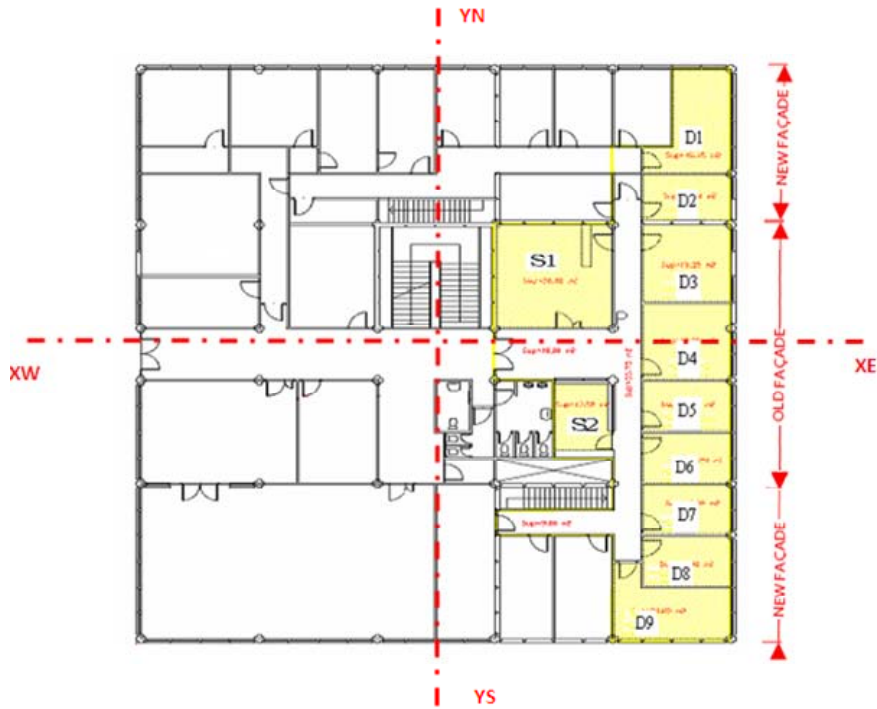
THERMAL CHARACTERISTICS			
U(WINDOW)	5.74	W/m <sup>2</sup> ·K	
g(WINDOW)	0.837		
U(FRAME)	5.88	W/m <sup>2</sup> ·K	
A (m <sup>2</sup> )	EXTERNAL BLIND	INTERNAL BLIND	FRAME FRACTION %
2.928	YES	NO	13.043
1.464	YES	NO	13.043
2.098	YES	NO	13.043

### Indoor Windows

There are no internal windows considered

### I.4 Walls





There are two different kinds of façade, an old one corresponding to the original structure and a new one corresponding to expansion works in the building.

### Outdoor Walls

External walls area versus orientation:

ZONES	YN (m <sup>2</sup> )	YS (m <sup>2</sup> )	XE(m <sup>2</sup> )	XW(m <sup>2</sup> )
ZONE D1	9		18	
ZONE D2			9	
ZONE D3			13.5	
ZONE D4			13.5	
ZONE D5			9	
ZONE D6			9	
ZONE D7			9	
ZONE D8			9	
ZONE D9		18	9	
ZONE S1				
ZONE S2				
CORRIDOR				

Building wall type (old façade)					
	Thickness (m)	Conductivity (kJ/hmK)	Density (kg/m <sup>3</sup> )	Specific heat (kJ/kgK)	Resistance (hm <sup>2</sup> K/kJ)
Gypsum	0.015	1.44	900	1	∅
Hollow brick	0.07	1.6	1000	1	∅
Concrete	0.075	3.32	860	1	∅
Air layer	0.05	∅	∅	∅	0.025
Concrete	0.085	3.32	860	1	∅

Building wall type (new façade)					
	Thickness (m)	Conductivity (kJ/hmK)	Density (kg/m <sup>3</sup> )	Specific heat (kJ/kgK)	Resistance (hm <sup>2</sup> K/kJ)
Gypsum	0.015	1.44	900	1	∅
Hollow brick	0.07	1.6	1000	1	∅
Concrete	0.1	3.32	860	1	∅
Polystyrene	0.03	0.15	40	1	∅
Concrete	0.11	3.32	860	1	∅

### Indoor Walls

Interior walls: air conditioned spaces and adjacent areas

ZONES	ZONE D1	ZONE D2	ZONE D3	ZONE D4	ZONE D5	ZONE D6	ZONE D7	ZONE D8	ZONE D9	ZONE S1	ZONE S2	CORRIDOR
ZONE D1	X	13.5										4.5
ZONE D2	13.5	X	13.5									9
ZONE D3		13.5	X	13.5								13.5
ZONE D4			13.5	X	13.5							13.5
ZONE D5				13.5	X	13.5						9
ZONE D6					13.5	X	13.5					9
ZONE D7						13.5	X	13.5				9
ZONE D8							13.5	X	18			4.5
ZONE D9								18	X			4.5
ZONE S1										X		36
ZONE S2											X	22.5
CORRIDOR	4.5	9	13.5	13.5	9	9	9	4.5	4.5	36	22.5	X

Building wall type (interior and boundary walls)					
	Thickness (m)	Conductivity (kJ/hmK)	Density (kg/m <sup>3</sup> )	Specific heat (kJ/kgK)	Resistance (hm <sup>2</sup> K/kJ)
Gypsum	0.015	1.44	900	1	∅
Solid brick	0.055	3.71	2140	1	∅
Gypsum	0.015	1.44	900	1	∅

### Boundary Condition Walls

Boundary walls to a conditioned area:

ZONES	A (m <sup>2</sup> )
ZONE D1	18
ZONE D2	
ZONE D3	
ZONE D4	
ZONE D5	
ZONE D6	
ZONE D7	
ZONE D8	
ZONE D9	13.5
ZONE S1	36
ZONE S2	22.5
CORRIDOR	54

Building wall type (interior and boundary walls)					
	Thickness (m)	Conductivity (kJ/hmK)	Density (kg/m <sup>3</sup> )	Specific heat (kJ/kgK)	Resistance (hm <sup>2</sup> K/kJ)
Gypsum	0.015	1.44	900	1	∅
Solid brick	0.055	3.71	2140	1	∅
Gypsum	0.015	1.44	900	1	∅

## Ceiling and Ground

Floor wall type					
Thickness (m)	Conductivity (kJ/hmK)	Density (kg/m3)	Specific heat (kJ/kgK)	Resistance (hm2K/kJ)	
Concrete	0.2	3.32	860	1	∅

Ceiling wall type					
Thickness (m)	Conductivity (kJ/hmK)	Density (kg/m3)	Specific heat (kJ/kgK)	Resistance (hm2K/kJ)	
Concrete	0.2	3.32	860	1	∅

## I.5 Use, Occupancy and Thermal loads calculations

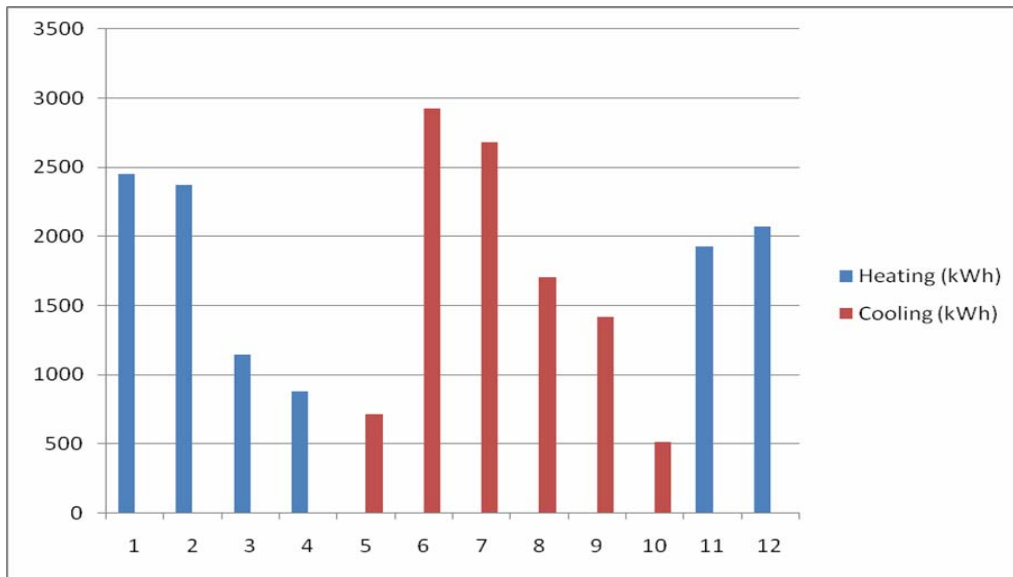
### I.5.1 Internal gains, ventilation, infiltration, air coupling

ZONES	Num.People	Num.Computers	Zone A (m2)	People (W)	Computers (W)	Artificial Lighting (W)
ZONE D1	1	1	20.25	150	230	263.25
ZONE D2	1	1	13.5	150	230	175.5
ZONE D3	1	1	20.25	150	230	263.25
ZONE D4	1	1	20.25	150	230	263.25
ZONE D5	2	2	13.5	300	460	175.5
ZONE D6	1	1	13.5	150	230	175.5
ZONE D7	1	1	13.5	150	230	175.5
ZONE D8	1	1	13.5	150	230	175.5
ZONE D9	1	1	20.25	150	230	263.25
ZONE S1	5	5	36	750	1150	468
ZONE S2	0	3	13.5	0	690	175.5
CORRIDOR	0	0	51.6	0	0	670.8

<b>Ventilation (renovation per hours)</b>
<b>outside air</b>
1 renovation ( in all office rooms)
<b>Infiltration (renovation per hours)</b>
<b>outside air</b>
0.1 ( in all office rooms)
1 (hall)
<b>Air coupling between zones (renovation per hours)</b>
0 (between contiguous office rooms)
0.25(between corridor and office rooms)

### I.5.2 Thermal loads results (Peak loads and monthly loads)

	PEAK LOAD (kW)	PEAK DAY
SUMMER PEAK LOAD (kW)	15	July 16th
WINTER PEAK LOAD (kW)	17	January 14th



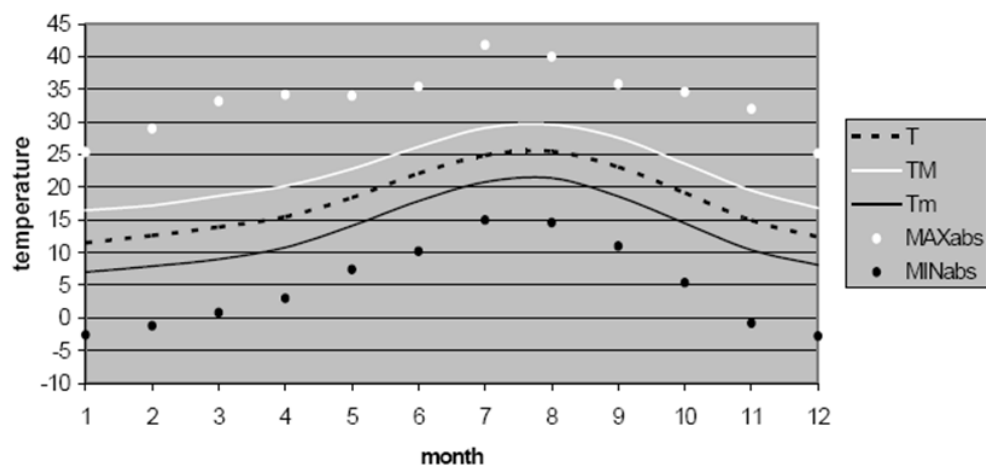
	Monthly Loads [kW·h]		Peak Loads [kW]	
	Heating	Cooling	Heating	Cooling
January	2451.820345	0	15.7085842	0
February	2371.835952	0	15.7123471	0
March	1147.21733	0	14.1345309	0
April	879.048358	0	14.8156383	0
May	0	711.5977539	0	11.3976524
June	0	2926.880735	0	11.3976524
July	0	2680.095148	0	12.8886657
August	0	1706.638243	0	12.382995
September	0	1417.191694	0	12.7994871
October	0	515.9126629	0	11.976506
November	1928.386186	0	16.513	0
December	2068.598742	0	16.386	0

## Chapter II. Climate Description and Geology

### II.1 Demo site Climate Description ( template data)

#### II.1.2 Temperature

Weather data	Latitude	39.48°N
	Longitude	0.38°W
	Altitude	20 m
	Average annual air temperature (°C)	17.3
	Average annual air Relative Humidity (%)	0.68

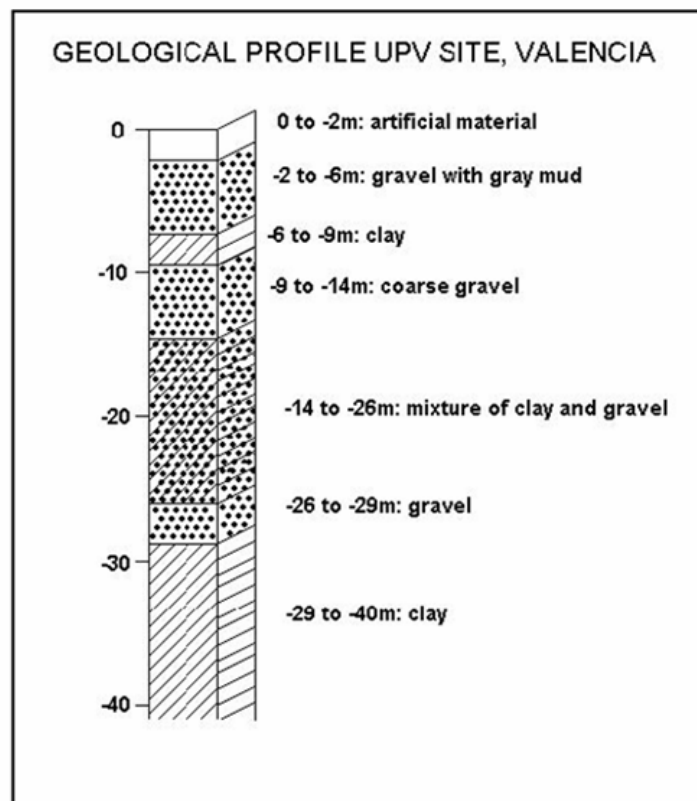


## II.2 Soil and Geology

### II.2.1 General Geology

	Soil Parameters	
Location type (rural, build up, field or paved)	field	
General soil profile	damp gravel and clay	
Estimate of Conductivity	2	W/m*K
Estimate of Volumetric Heat Capacity	3000	kJ/K*m3
Ground water flow (qualitative: no, high,low)	high	
Freatic groundwater level	3.5	m

### II.2.2 Geological Profile



## Chapter III. System Description

### III.1 Heat Pump Description

#### *III.1.1 Water temperature conditions considered for the design*

User Side Water Temperatures (Chiller) IN/OUT	[°C]	15/10
User Side Water Temperatures (Heat Pump) IN/OUT	[°C]	35 / 40
Source Side Water Temperatures (Chiller)	[°C]	26 / 32
% of eth. glycol	[%]	0%
Source Side Water Temperatures (Heat Pump)	[°C]	15/10
% of eth. glycol	[%]	0%

#### **III.1.2 Heat Pump Capacity and nominal flow rate for cooling and heating mode**

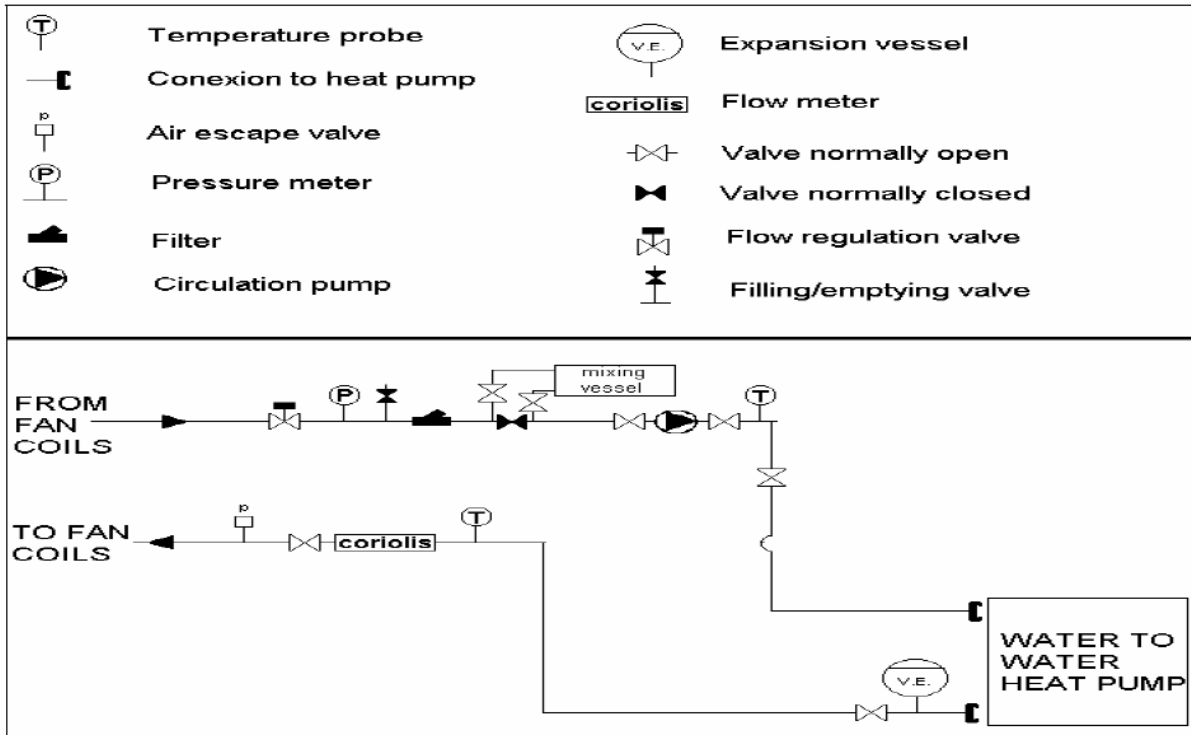
Selected Model		<b>GSH212SX</b>	
<b>Chiller</b>	Cooling Capacity @ 15/10°C ; 32/26°C	[kW]	<b>17,2</b>
	Compressor Absorbed Power	[kW]	2,8
	Compressor Absorbed Current	[A]	6,3
	EER	[-]	6,1
	User side water-flow	[l/h]	2.958
	User side pressure drops	[kPa]	14
	Source side water-flow	[l/h]	2.847
	Source side pressure drops	[kPa]	12
<b>Heat-Pump</b>	Heating Capacity @ 35/40°C ; 15/10°C	[kW]	<b>19,2</b>
	Compressor Absorbed Power	[kW]	3,6
	Compressor Absorbed Current	[A]	7,2
	COP	[-]	5,3
	User side water-flow	[l/h]	3.302
	User side pressure drops	[kPa]	15
	Source side water-flow	[l/h]	2.718
	Source side pressure drops	[kPa]	12

## III. 2 Indoor Loop Description

### *III.2.1 Hydraulic Loop Description*

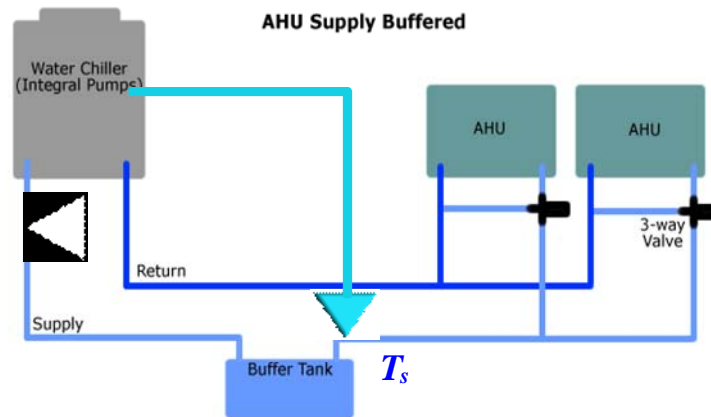
This loop pumps the conditioned water to the fan coils network  
It basically comprises the following parts:

- Circulating Pump.
- Coriolis mass flow meter.
- Manometers.
- Expansion vessels.



### III.2.2 Internal Tank: volume and position

The tank is located at the outlet of the heat pump on the supply line to fan coils and its volume is 189 l.

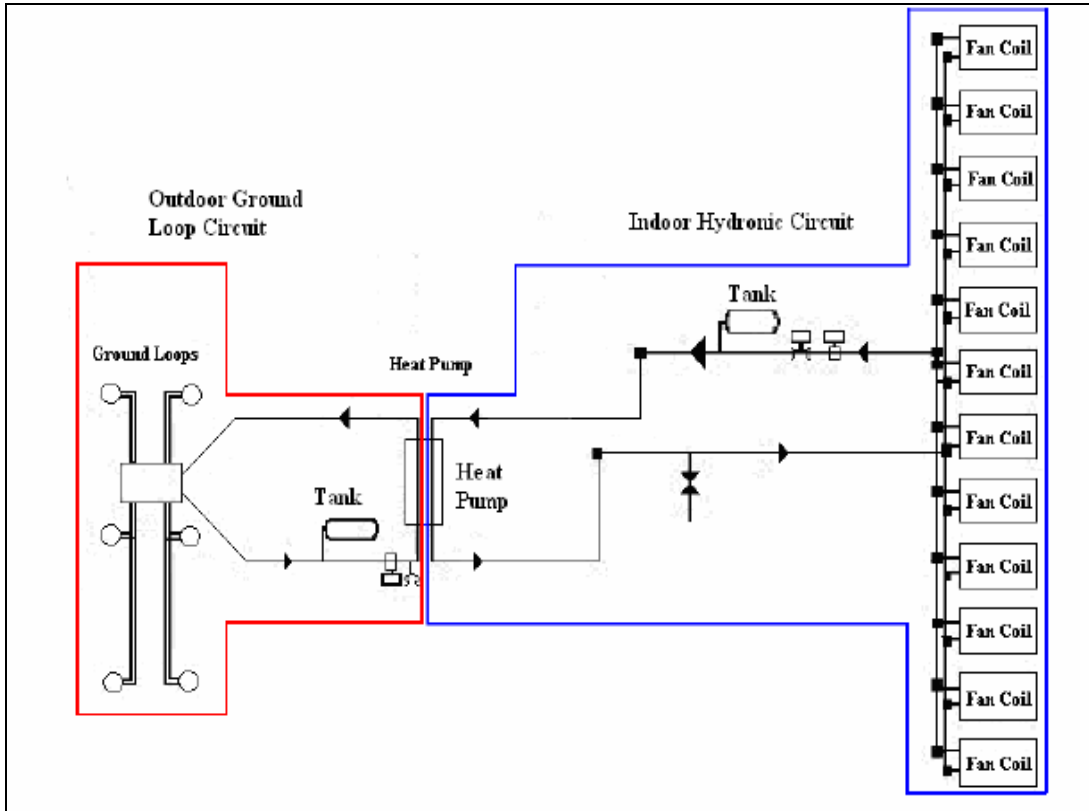


### III.2.3 Location of the control temperature sensor for the heat pump

The thermostat control for the heat pump is located at the outlet of the tank.

*III.2.4 Hydraulic pipes distribution system: schema of the distribution specifying external and internal diameter and flow rate.*

GSHP system schematic



The length and diameter of the different elements belonging to the indoor loop are given in the following table, also including the characterisation and number of the main accessories.

RG	DESCRIPTION	UNIT	
1	COPPER PIPE 3/4"	m	7
2	COPPER ELBOW DE 3/4"	Nº	3
3	3/4" THREADED VALVE	Nº	3
4	THREADED BRONZE FILTER 2"	Nº	1
5	SAFETY VALVE 3/4"	Nº	1
6	COPPER PIPE 2"	m	12
7	BRONZE THREADED ELBOW 2"	Nº	15
8	HIGH PRESSURE GOOSE	m	2
9	BRONZE THREADED JOINT 2 "	Nº	2
10	EXPANSION TANK 20 LITRES	Nº	2
11	CORILIS FLOW METER MASSFLO TYPE MASS 6000	Nº	1
12	GRUNDFOSS PUMP CH 2 30 AA CVBE, 2.5 M <sup>3</sup> /H, H = 28 M	Nº	1
13	VALVE 2"	Nº	1
14	THREADED VALVE 2"	Nº	8
15	MANOMETER 0 TO 6 BAR	Nº	1
16	ANALOGICAL TEMPERATURE PROBE 0 TO 60°C	Nº	1
17	AIR PURGING WITH COPPER JOINT 2 "	Nº	1
18	MIXING TANK	Nº	1
19	ELECTRO VALVE 1 <sup>1/2</sup> "	Nº	4

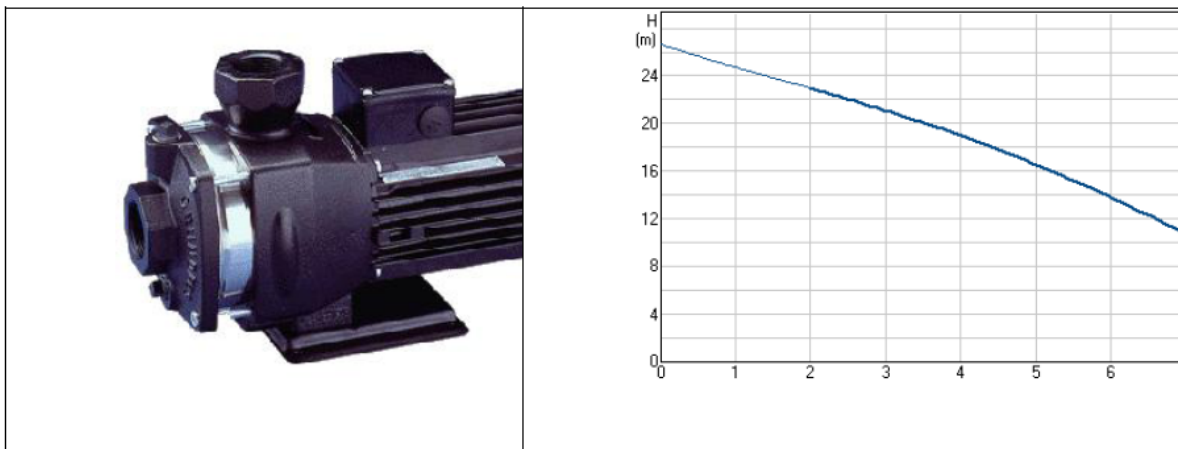
### III.2.5 Circulation pump selected:

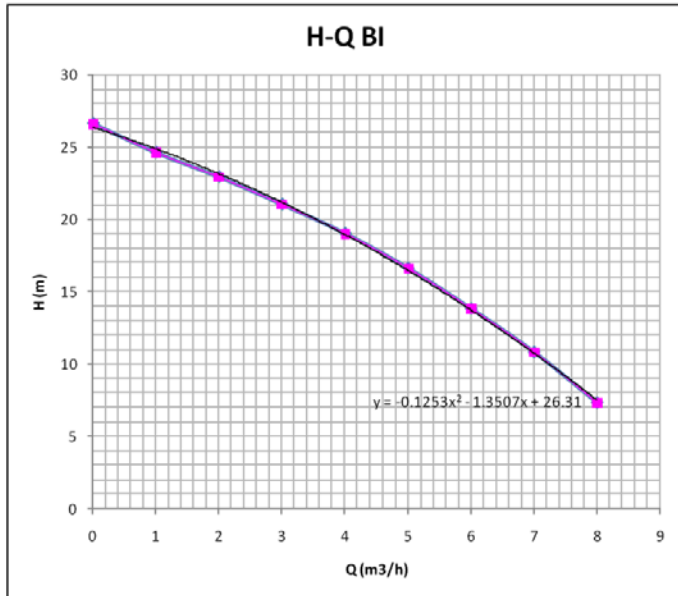
*Specify the total pressure drop and water flow rate that must be provided by the circulation pump.*

Pressure drop= 20m ; Flow rate=3.302 m<sup>3</sup>/h

*Manufacturer, model, type (fixed velocity or variable velocity) and catalogue data (performance curves)*

The circulation pumps for the internal hydraulic circuit is manufactured by Grundfos. It is a variable velocity one and can work at different frequencies from 20 Hz up to 60 Hz. The model is CH4-30 with threephase electrical supply.





### III.2.3 Fan Coil/ AHU Technical Description

#### Manufacturer & Model selected

The manufacturer is CIAT and the selected model corresponds to MAJOR-329 CH.



#### Catalogue performance data

Its air flow rate, cooling and heating capacity, and power demand values are shown in the table below:

FAN SPEED	AIR VOLUME FLOW (m³/h)	HEATING POWER (kW) (1)		COOLING POWER (kW) (1)		POWER CONSUMPTION (W)
		90/70°C	45/50°C	Total	Sensible	
V1	290	4.63	2.30	2.03	1.44	61
V2	430	6.42	3.33	2.78	2.04	
V3	590	7.69	4.36	3.47	2.64	

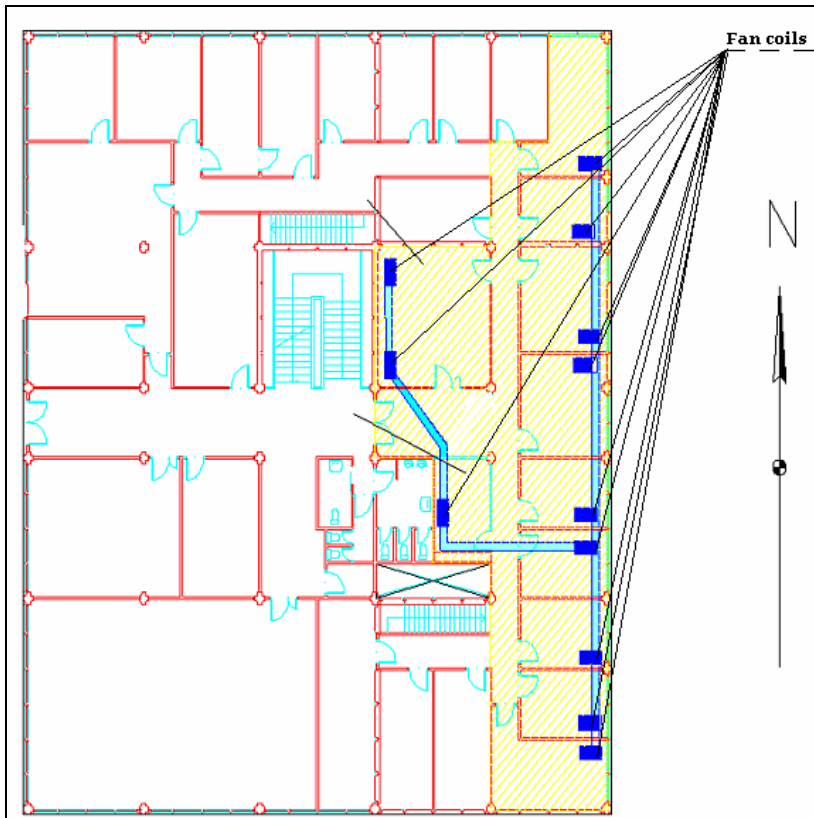
(1) Heating power for 20 °C air temperature. Cooling Power for 27°C air and 48% Relative Humidity and 7 –12 °C water temperature

### *Water Flow rate*

There are 12 fan coils connected in parallel. Therefore, the water flow rate will be the internal circuit flow rate divided by 12; it is to say, the water flow rate at each fan coil unit is  $0.275 \text{ m}^3/\text{h}$ .

### *Location in the building (Schematic Distribution)*

Each office, along with the service room, is equipped with one fan coil, except for the computer room which has two installed fan coils. The corridor does not have a fan coil unit present.



### *Control system*

Each fan coil can be individually regulated by means of a thermostat and comfort temperature and fan speed can be selected by the user. The control for each fan coil is governed by a three way valve that allows the heating/cooling water to be modulated through the fan coil. The valve is controlled by the thermostat of the room.

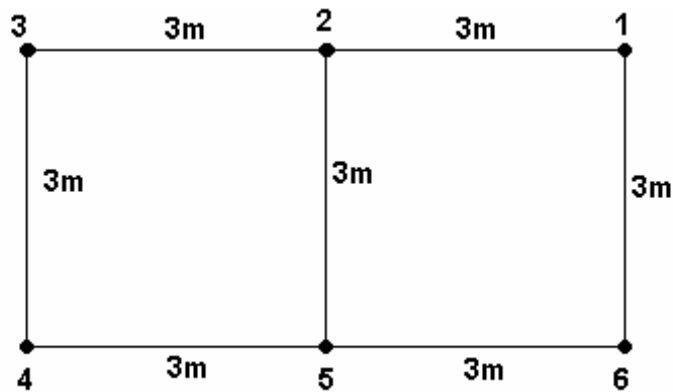


### III.3 Outdoor Loop Description

#### III.3.1 Ground Source Heat Exchanger Description

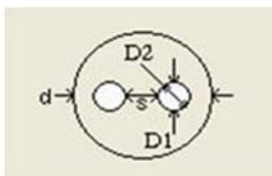
*Type of configuration (rectangular, line....etc)*

The GSHX itself consists of six vertical boreholes connected in a balanced parallel configuration. The six boreholes are arranged in a 2x3 rectangular grid (18 m<sup>2</sup>).



*Single U or Double U (specifying diameters with drawings)*

#### U TUBE



Borehole diameter (d)	150	mm
Pipe internal diameter (D2)	23.4	mm
Pipe external diameter (D1)	25.4	mm
Shank spacing (s)	70	mm

*Borehole depth*

Each borehole is 50 m deep.

*Borehole spacing*

There is a 3 m separation between boreholes.

*Grout material and conductivity*

The grout material is bentonite and it has a conductivity of 1.3W/mK.

*Depth below surface*

There is 1 m space between the surface and the top of the ground storage.

*Pipe material*

The material used in pipes is high density polyethylene HDPE.

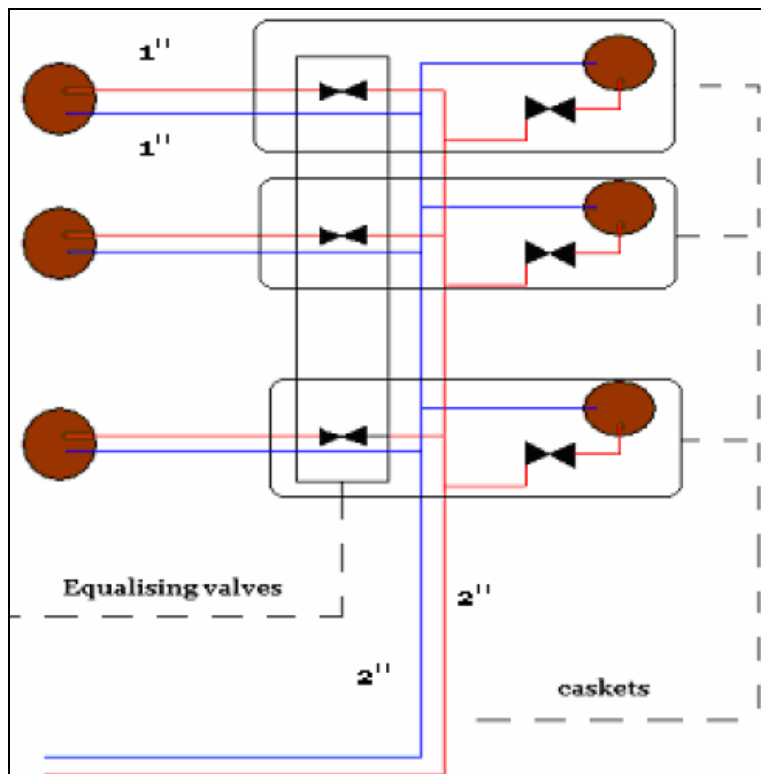
*Working fluid*

Pure water is used as the working fluid.

*III.3.2 Hydraulic Loop Description*

*III.3.3 Hydraulic pipes distribution system: schema of the distribution specifying external and internal diameter and flow rate.*

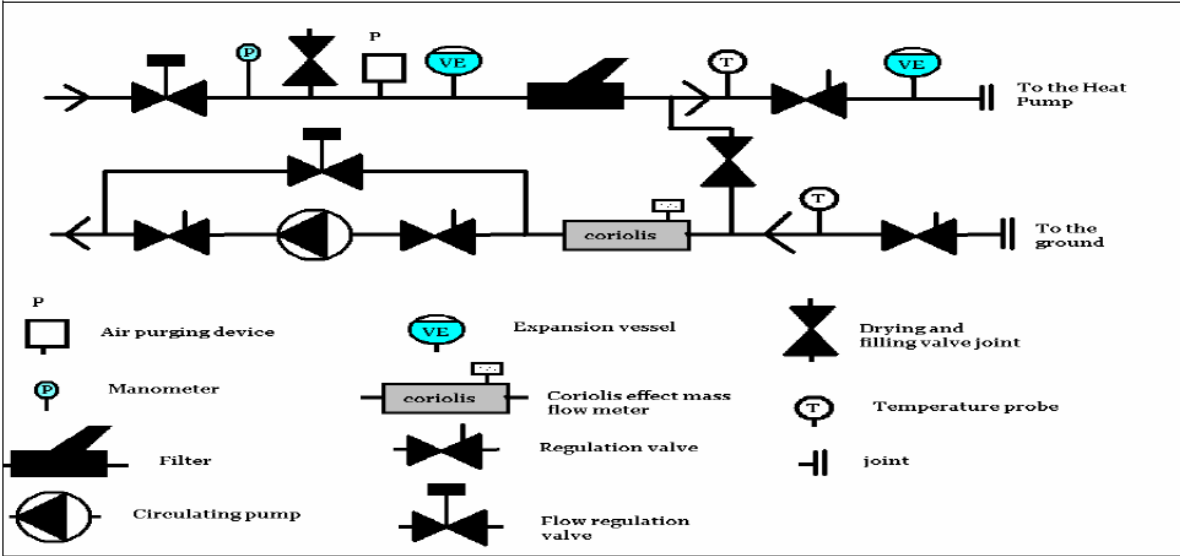
The outdoor loop goes through three different caskets distributing and receiving the water from each borehole. Each one of the borehole circuits incorporates an equalizing valve in order to balance the flow throughout the six boreholes.



There are six boreholes connected in parallel and balanced with several equalising valves. The total external flow rate is 2.847 m<sup>3</sup>/h. So, the flow rate at each borehole will be 0.475 m<sup>3</sup>/h.

The outer hydraulic group consists of the following components:

- A circulating pump (Grundfoss)
- A mass flow meter (Coriolis effect, Danfoss).
- Manometers.
- Expansion vessels.
- Regulating and equalising valves.



The length and diameter of the different elements belonging to the outdoor loop are given in the following table, also including the characterization and number of the main accessories.

RG	DESCRIPTION	UNIT	
1	HIGH DENSITY POLYETHYLENE PIPE DN32 (1" INDOOR)	m	620
2	HIGH DENSITY POLYETHYLENE PIPE DN65 (2" INDOOR)	m	125
3	HIGH DENSITY POLYETHYLENE 90° ELBOW DN32 (1" INDOOR)	N°	12
4	HIGH DENSITY POLYETHYLENE 180° ELBOW DN32 (1" INDOOR)	N°	6
5	HIGH DENSITY POLYETHYLENE 90° ELBOW DN65 (2" INDOOR)	N°	18
6	HIGH DENSITY POLYETHYLENE TEE DN65 (2" INDOOR)	N°	12
7	HIGH DENSITY POLYETHYLENE TEE DN32 (1" INDOOR)	N°	12
8	HIGH DENSITY POLYETHYLENE JOINT FROM 2" TO 1"	N°	12
9	HIGH DENSITY POLYETHYLENE STRAIGHT JOINT DN32	N°	10
10	HIGH DENSITY POLYETHYLENE STRAIGHT JOINT DN32	N°	20
11	THREADED VALVE 1 "	N°	12
13	4 WIRED THERMO RESISTANCE PT-100	N°	12
14	4 WIRED THERMO RESISTANCE PT-100	N°	28
15	SIGNAL TRANSMITTER WIRE	m	3500
16	PIPING FOR THE SIGNAL TRANSMITTER WIRE	m	80
18	VALVE 1 " TOUR ANDERSON	N°	6
19	THERMAL INSULATING FOAM ARMAFLEX AF 2 ½" E=19 MM	m	10
20	PURGING DEVICES	N°	7
21	COPPER PIPE ¾"	m	17
22	COPPER ELBOW ¾"	N°	8
23	COPPER JOINT FROM ¾" TO ½"	N°	1
24	TANK 370 L, LAPESA G370L-E4	N°	1
25	THREADED POLYETHYLENE JOINT 2 "	N°	4
26	THREADED VALVE ¾"	N°	2
27	THREADED VALVE ¾"	N°	1
28	CLAMPS DN65 (2" INDOOR)"	N°	30
29	COPPER STRAIGHT JOINT DE ¾"	N°	10
30	TYPEY THREADED BRONZE FILTER 2"	N°	1
31	SAFETY VALVE ¾"	N°	1
32	COPPER TUBING 2"	m	6
33	COPPER TUBING ½"	m	2
34	BRONZE THREADED ELBOW 2"	N°	6
35	HIGH PRESSURE GOOSE 2 "	m	7
36	THREADED COPPER JOINTS 2 "	N°	4
37	EXPANSION TANK 8 L	N°	2
38	CORILIS FLOW METER MASSFLO TYPE MASS 6000	N°	1
39	GRUNDFOSS PUMP CH 2 30 AA CVBE, 2.5 M <sup>3</sup> /H, H = 28 M	N°	1
40	THREADED VALVE 2"	N°	2
41	THREADED VALVE	N°	3
42	MANOMETER 0 TO 6 BAR	N°	1
43	ANALOGICAL TEMPERATURE PROBE 0 TO 60°C	N°	1

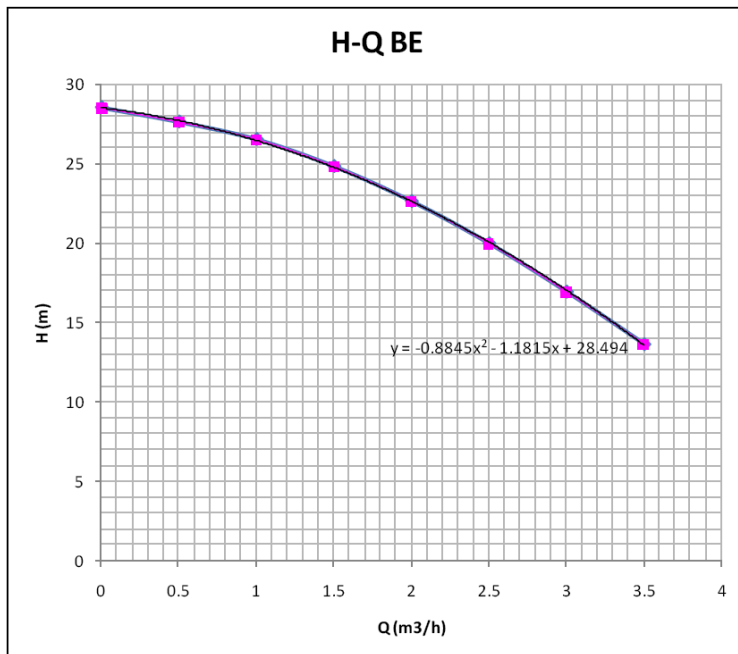
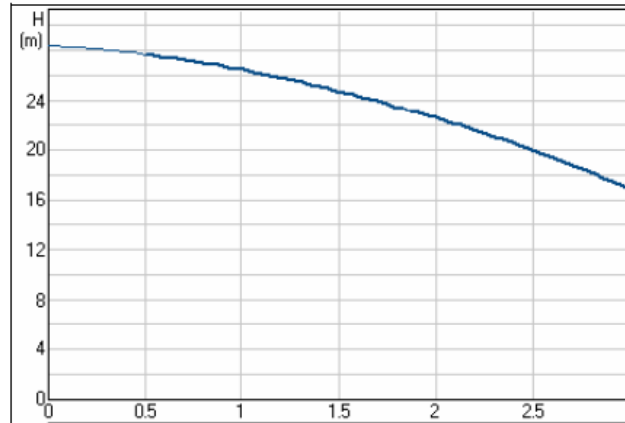
### III.3.4 Circulation pump selected:

Total pressure drop and water flow rate that must be provided by the circulation pump.

Pressure drop= 18.5m ; Flow rate=2.73 m<sup>3</sup>/h.

Manufacturer, model, type (fixed velocity or variable velocity) and catalogue data (performance curves)

The circulation pumps for the external hydraulic circuit is manufactured by Grundfos. It is a variable velocity one and can work at different frequencies from 20 Hz up to 60 Hz. The model is CH2-30 with threephase electrical supply.



## Chapter IV. OPEN ISSUES (design or construction decisions not solved yet)

There are no open issues.