CHAPTER 8

COOLING AND VENTILATION

8.1 INTRODUCTION

In this chapter the cooling and ventilation equipment for the LHC-machine and experimental areas are explained system by system. In many areas, the cooling and ventilation systems in use for the LEP machine have been extensively re-used, thus limiting the investment needed for LHC. All cooling and ventilation systems are controlled by PLC-systems and a local (SCADA) supervision system. Alarms are transmitted via an Ethernet communication network to central servers, presently installed in the TCR.

8.2 PRIMARY WATER SYSTEMS

A typical layout of a primary water circuit is shown in Fig. 8.1.

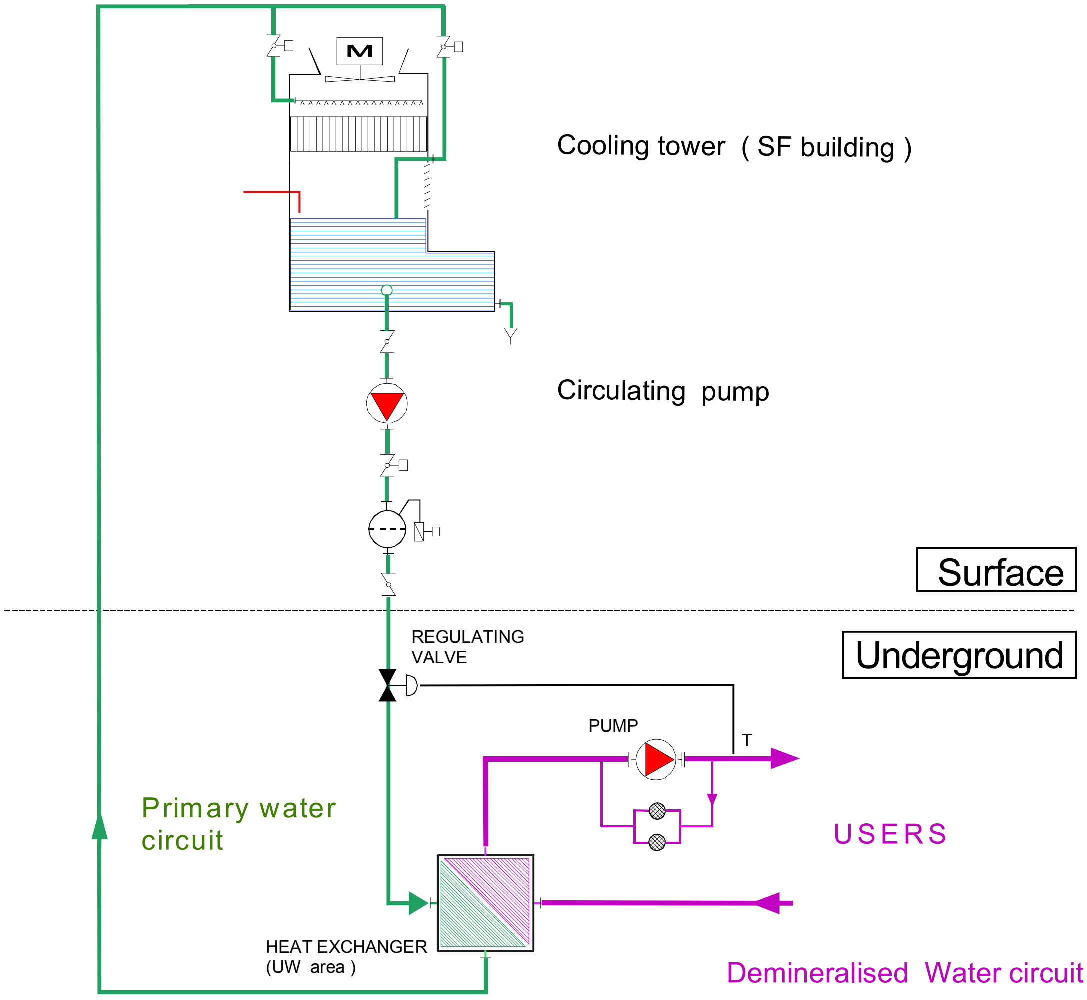

Figure 8.1: Primary Water System layout

The primary water is supplied from the LHC cooling towers and principally provides a heat sink for the following users:

- Cryogenic components, such as compressors, cold boxes etc.,
- The demineralised water circuits serving the underground areas,
- The condensers of chillers located in the surface buildings.

Each primary water loop is an open circuit. The water is cooled by cooling towers and distributed to users by pumps installed in pumping stations. The cooling towers are of an open atmospheric type, built as modular concrete structures, with each one having a cooling capacity of 10 MW. The pumping stations are directly attached to the cooling tower structure and are also constructed in reinforced concrete. The choice of this structure was determined by the need to limit the noise to the environment in the neighbourhood around CERN. The water temperature of the primary water at the cooling tower has been set as follows:

Inlet	34 ºC (tolerance ±1 ºC)
Outlet	24 ºC

These figures, taken together with the normal atmospheric conditions in the Geneva area (maximum 21°C wet bulb temperature and 32°C outside temperature) corresponds to dimensioning data for the primary cooling system. The available pressure difference, on the user side is typically 3 bar. The maximum cooling power capacity per point is shown in Tab. 8.1.

Table 8.1: Maximum Primary Cooling Power Capacity per LHC Point

POINT	AREA	BUILDING	FLOW RATE [m^3/h]	COOLING CAPACITY [MW]
1	Cryogenics	SH	344	4.0
	ATLAS	USA	86	1.0
	Air-Conditioning	SUX	1050	12.3
18	Cryogenics *	BA7	20	0.23
		SHM	630	7.32
		PM	20	0.23
2	Demineralised Water	UW	1385	16.1
	Cryogenics	SH	540	6.3
		SD	10	0.1
		US	30	0.35
	Air-Conditioning	SU	475	5.5
4	Demineralised Water	UW	2150	25.0
	Cryogenics	SHM	540	6.3
		SH	540	6.3
		SD	30	0.35
		US, UX	40	0.47
	Air-Conditioning	SU	475	5.5
5	Cryogenics	SH	175	2.0
	CMS	USC	215	2.9
	Air-Conditioning	SUX	1050	12.2
6	Demineralised Water	UW	400	4.6
	Cryogenics	SHM	540	6.3
		SH	540	6.3
		SD	30	0.35
		US, UX	40	0.47
	Air-Conditioning	SU	475	5.5
8	Demineralised Water	UW	1085	12.6
	Cryogenics	SHM	540	6.3
		SH	540	6.3
		SD	30	0.35
		US, UX	40	0.47
	Air-Conditioning	SU	475	5.5

* This circuit is cooled by the SPS cooling loop

Each pumping station is equipped with an auxiliary circuit for filtering the water in the basins. The filters are self cleaning and of the sand-bed variety. The circuit is also fitted with a heater and circulation pumps for frost protection.

Each distribution circuit is designed for two pumps; one in use and one as stand-by. For the first phase of LHC, the stand-by pump will not be installed, but some spare pumps will be stored at CERN, in order to limit the repair time to a maximum of two days in case of a breakdown.

8.3 DEMINERALISED WATER SYSTEMS

Demineralised water is used in underground areas to cool:

- Power converters, cables, warm magnets and auxiliary equipment in the LHC tunnel (Machine circuit),
- The ATLAS, CMS, ALICE and LHC-B Experiments,
- The radio frequency system at point 4,
- The injection tunnels and magnets installed in TI 2 and TI 8.

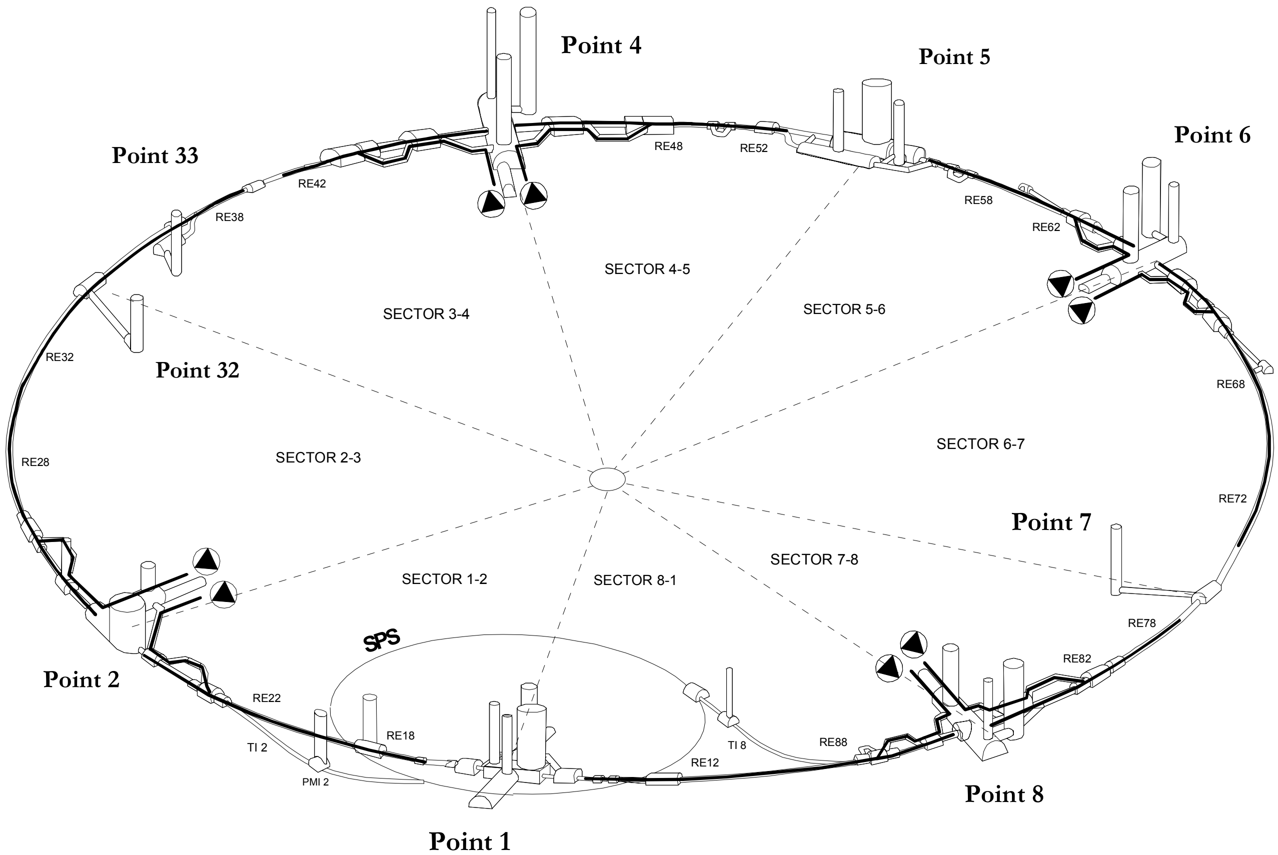

Figure 8.2: “Machine circuit” of demineralised water of the LHC

Each demineralised water system is a closed circuit and equipped with a pump, heat exchanger, expansion vessel, filter, ion cartridge (demineraliser) and all the necessary control and regulating devices. This equipment is installed in the UW caverns at LHC Points 2, 4, 6 and 8. The thermal load of the demineralised water network is extracted to the primary water system. The main characteristics of the demineralised water system are as follows:

Inlet design temperature	27 ºC (tolerance ±1 ºC)
Set point	26 ºC
Design pressure	16 bar
Conductivity	<0.5 µS/cm

Tab. 8.2 gives the demineralised water cooling capacity in the different parts of the LHC accelerator, divided into the cooling stations in the technical caverns (UW-caverns) in Points 2, 4, 6 and 8.

The layout of the machine circuit of the demineralised water is shown schematically in Fig. 8.2. From each UW-cavern, the demineralised water is distributed to the adjacent sectors of the machine. For example, the station in point 4 (UW 45) supplies water to sector 3-4 and to sector 4-5. Moreover, the transfer tunnel (warm magnets) TI 2, is supplied from point 2, while TI 8 is supplied from Point 8. The detailed heat-load by user and by sector of the LHC machine has been described elsewhere [2].

Table 8.2 Demineralised water cooling capacities

POINT	COOLING LOAD IN UW AREAS [MW]
2	13.95
4	23.8
6	4.6
8	12.6

Table 8.3: Cooling capacities, chilled water in the LHC Points

POINT	AREA	BUILDING	FLOW RATE [m^3/h]	COOLING CAPACITY [kW]
1	Ventilation	SU	101	710
		SR	150	1050
	Electrical Racks for Power Converters	UJ14	0.4	3
		UJ16	0.4	3
1 ATLAS	Ventilation	SCX-SGX-SH	150	1050
		SX-SD-SU	258	1806
		SUX	243	1701
	Heat Exchangers	USA	206	1442
2 ALICE	Ventilation	SU	395	2765
		SR	0	0
		UA23	17	120
		UA27	17	120
	Heat Exchangers	PM-PX	387	2709
	Electrical Racks for Power Converters	UA23	1	7
		UA27	1	7
32	Ventilation	SU	4	28
		SR	60	420
33	Ventilation	SU	16	112
	Ventilation	PM-PX	43	301
4	Ventilation	SU	440	3080
		SR	0	0
		SX	0	0
		UX45	17	120
		UA43	17	120
		UA47	17	120
	Heat Exchangers	PM-PX	57	399
	Electrical Racks for Power Converters	UA43	0.6	4
		UA47	0.6	4

POINT	AREA	BUILDING	FLOW RATE [m^3/h]	COOLING CAPACITY [kW]
5 CMS	Ventilation	UA47	0.6	4
		SR-SH-SGX	134	938
	Heat Exchangers	SUX-SX	345	2415
	Electrical Racks for Power Converters	USC	72	504
		USC	0.4	3
6	Ventilation	SU	362	2534
		SR	0	0
		SX	0	0
		UA63	17	120
		UA67	17	120
	Heat Exchangers	PM-PX	57	399
	Electrical Racks for Power Converters	UA63	0.6	4
		UA67	0.6	4
7	Ventilation	SU	47	330
		SR	38	266
	Heat Exchangers	PM-PX	14	98
8 LHC-B	Ventilation	SU	220	1540
		SR	0	0
		SUX	151	1057
		UA83	19	135
		UA87	19	135
	Heat Exchangers	PM-PX	345	2415
	Electrical Racks for Power Converters	UA83	1	7
		UA87	1	7

8.4 CHILLED AND MIXED WATER SYSTEMS

Chilled and mixed water are produced in the LHC surface buildings in water-chillers, using the primary water from the cooling towers as a cooling source. The chilled and mixed water is used in the LHC surface buildings in air handling units and in underground areas of UW and US in the heat exchangers. Chilled water is produced at the temperature of 5±0.5°C. Mixed water is produced at 13±0.5°C. The cooling capacities of the chilled water (Δt= 6°C) in different LHC points are shown in Tab. 8.3 while the mixed water cooling capacities (Δt= 5°C) in the different LHC points are shown in Tab. 8.4.

Table 8.4: Cooling capacities for mixed water in the different LHC Points

POINT	BUILDING / CAVERN	FLOW RATE [m^3/h]	COOLING CAPACITY [kW]
1	USA	600	3500
2	Experiments and underground areas	172	1000
5	SCX	54	315
	USC	388	2263
8	Experiments and underground areas	215	1500

The four experiments are also large consumers of chilled and mixed water.

8.5 FIRE FIGHTING WATER SYSTEMS

The LHC fire fighting system includes the water distribution pipes inside the tunnel access areas and LHC experiment caverns. The distribution circuit has to provide water at 7 bar to the RIA (Robinet d'Incendie Armée) fire fighting hose-wheel. Fig. 8.3 presents a schematic view of a typical fire fighting circuit installation.

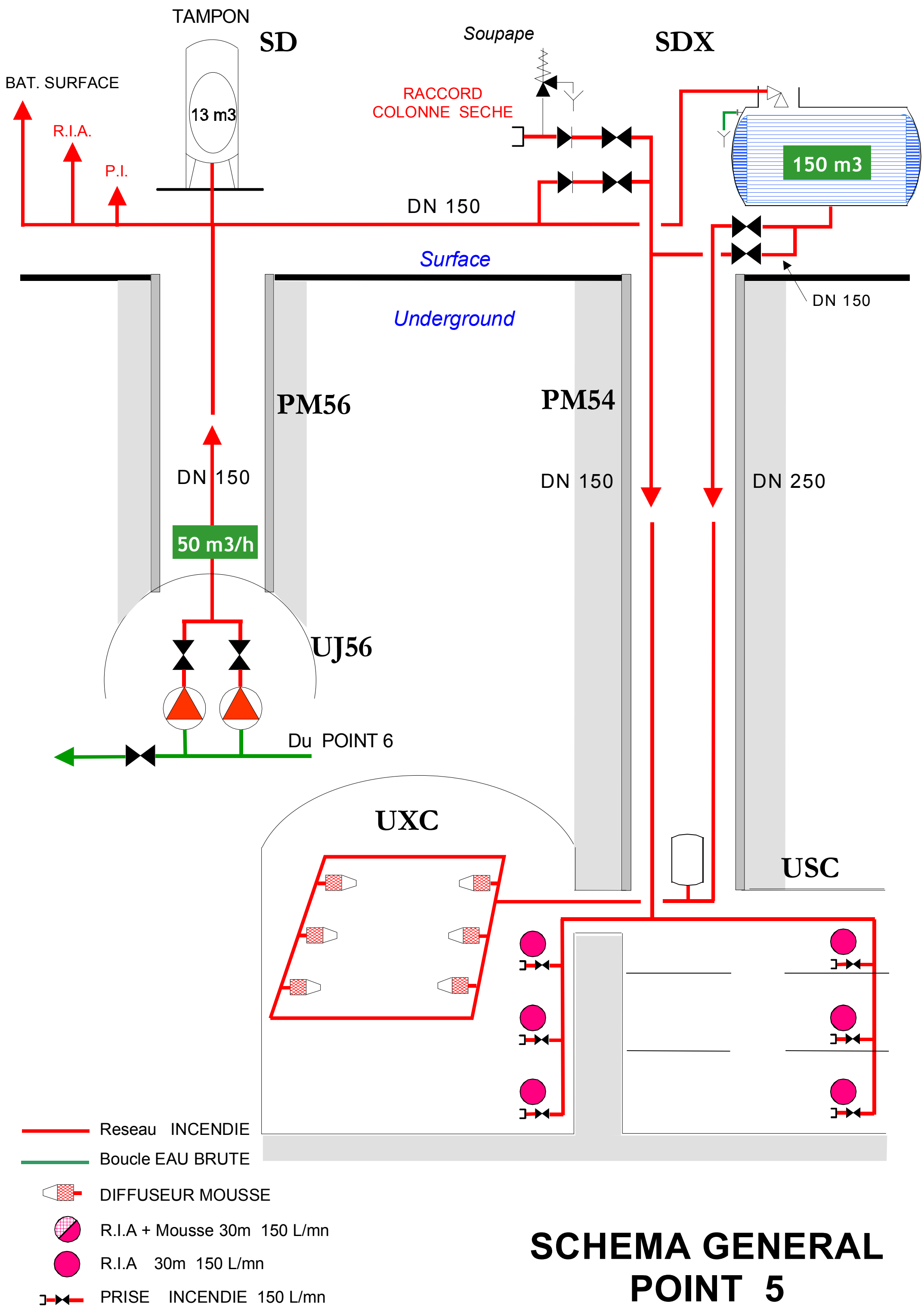

Figure 8.3: Schematic view of a fire fighting water installation

8.6 COMPRESSED AIR SYSTEMS

The main distribution locations for the compressed air are at points 1, 2, 4, 6 and 8 of LHC. There are additional compressed air plants at Point 1.8 and at Point 5. From each plant, the compressed air is passed around the LHC sectors as illustrated in Fig 8.4. The main consumers of the compressed air are the LHC cryogenics and vacuum systems. On the experimental sites the detector groups also use compressed air.

Table 8.5 Compressed air demand at each LHC point

	Cryogenics	**CV**	**EXPERIMENTS**	**TOTAL**
Point	**Flow rate [m^3/h]**	**Flow rate [m^3/h]**	**Flow rate [m^3/h]**	**Flow rate [m^3/h]**
1 (ATLAS)	USA15 : 159 UX15 : 57 SH1 : 40	SU1: 30		286
1.8	BA7: 40 PM18: 70 SD18: 60 SHM18: 40			210
2 (ALICE)	SD2: 20 SH2: 30 US1: 110 Sector 1-2: 285 Sector 2-3: 285	SU2: 30	UX: 10	770
4	SD4: 20 SDH4: 60 SH4: 30 SHM4: 30 US: 40 UX: 90 Sector 3-4 : 285 Sector 4-5 : 285	SU4: 30		870
5 (CMS)	SH: 5 SHL: 15 SX5: 2 USC55: 15 UXC55: 2			39
6	SD6: 20 SH6: 30 SHM6: 30 SUH6: 60 US: 40 UX: 90 Sector 5-6 : 285 Sector 6-7 : 285	SU6: 30		870
8 (LHCb)	SD8: 20 SDH8: 60 SH8: 30 SHM8: 30 US: 40 UX: 90 Sector 7-8 : 285 Sector 8-1 : 285	SU8:30		870
TOTAL:	**3755**	**150**	**10**	**4005**

The compressed air plants are located either in SU- (points 2, 4, 6, 8), SH- (points 1 and 5) and SHM- and SW- buildings (Point 18). The total demand of compressed air is distributed across the different points of LHC as shown in Tab. 8.5.

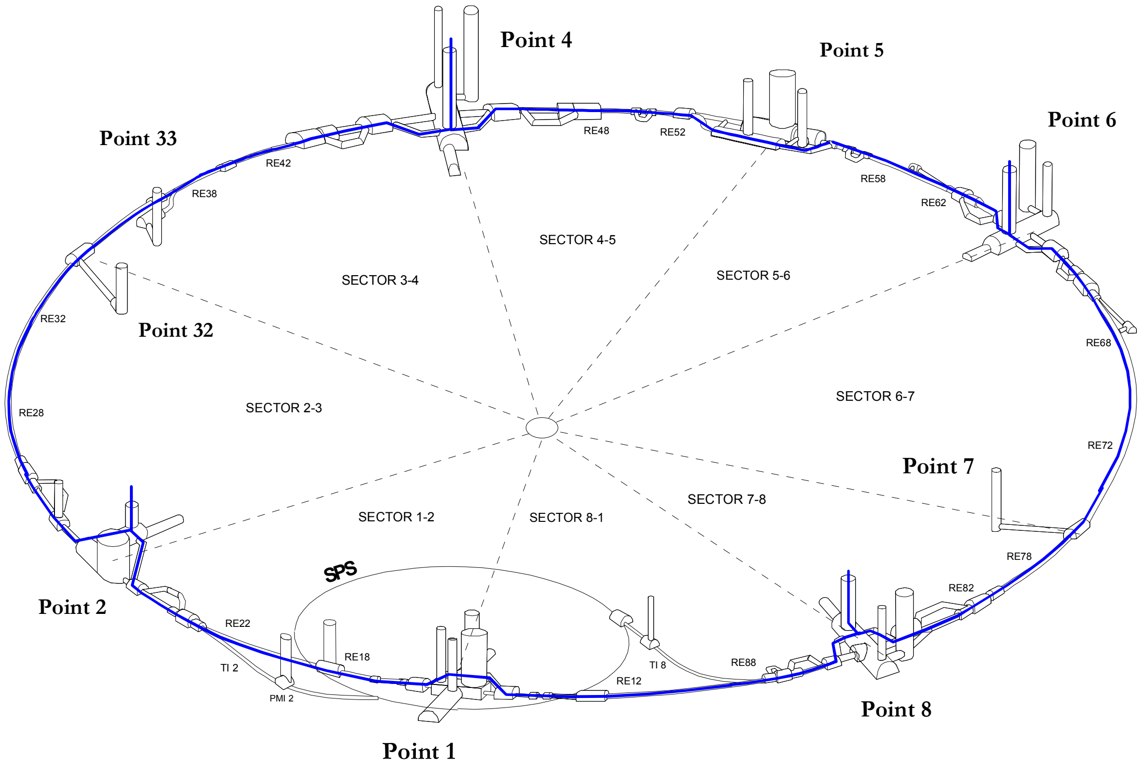

Figure 8.4: The LHC compressed air plants

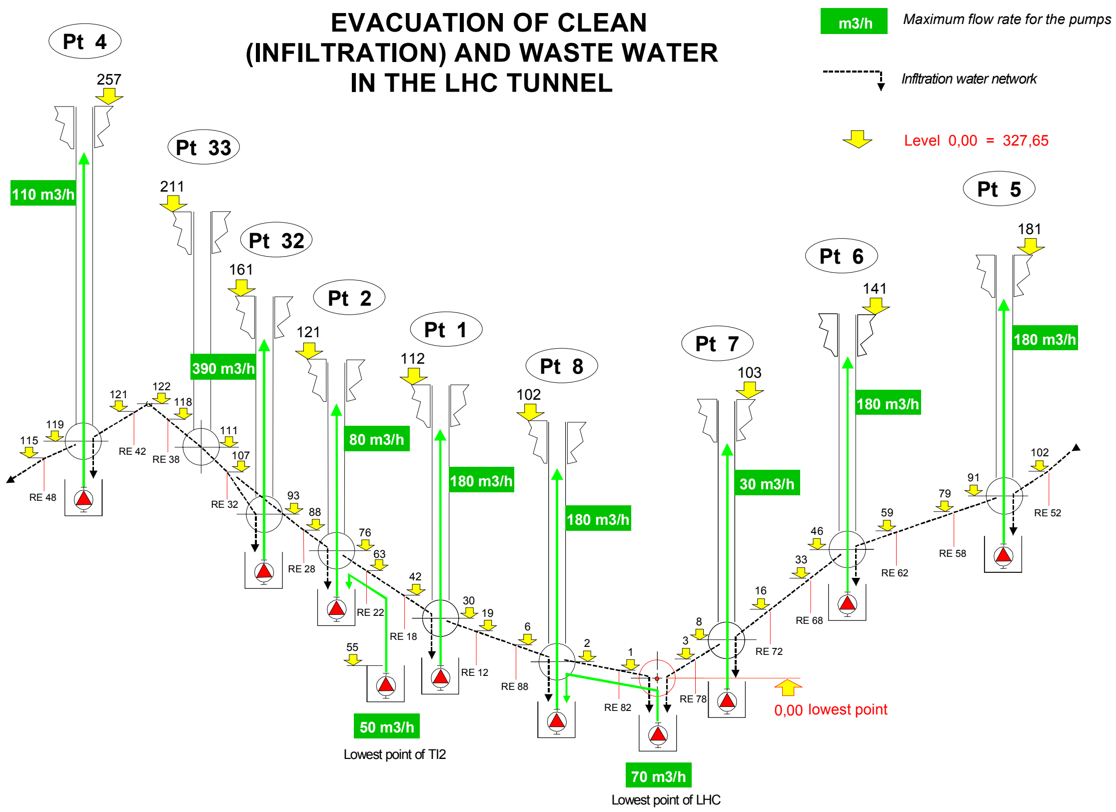

Figure 8.5: LHC pumping stations for clean and waste water

8.7 CLEAN AND WASTE WATER SYSTEMS

The clean water is mainly ground water which comes from the stub tunnels, by infiltration through the tunnel walls and occasionally from leaking pipes. Such water is calcareous and may carry traces of hydrocarbons. It flows in the machine tunnel drain to a sump at the next lower LHC access point.

The waste water comes from lavatories (with waste grinders), urinals and wash basins. It is collected in sumps, diluted and pumped up to the surface, then discharged to the communal waste water network. In order to ensure that surface water does not leave the CERN sites carrying dirt and oil, water treatment plants have been installed. These include flocculation, neutralisation, settling and oil removing tanks/systems. Should a change in pH be detected, the electronic monitors trigger an alarm in the Technical Control Room.

Fig. 8.5 presents the locations of the clean and waste water pumping stations, while Fig. 8.6 presents a typical installation schema.

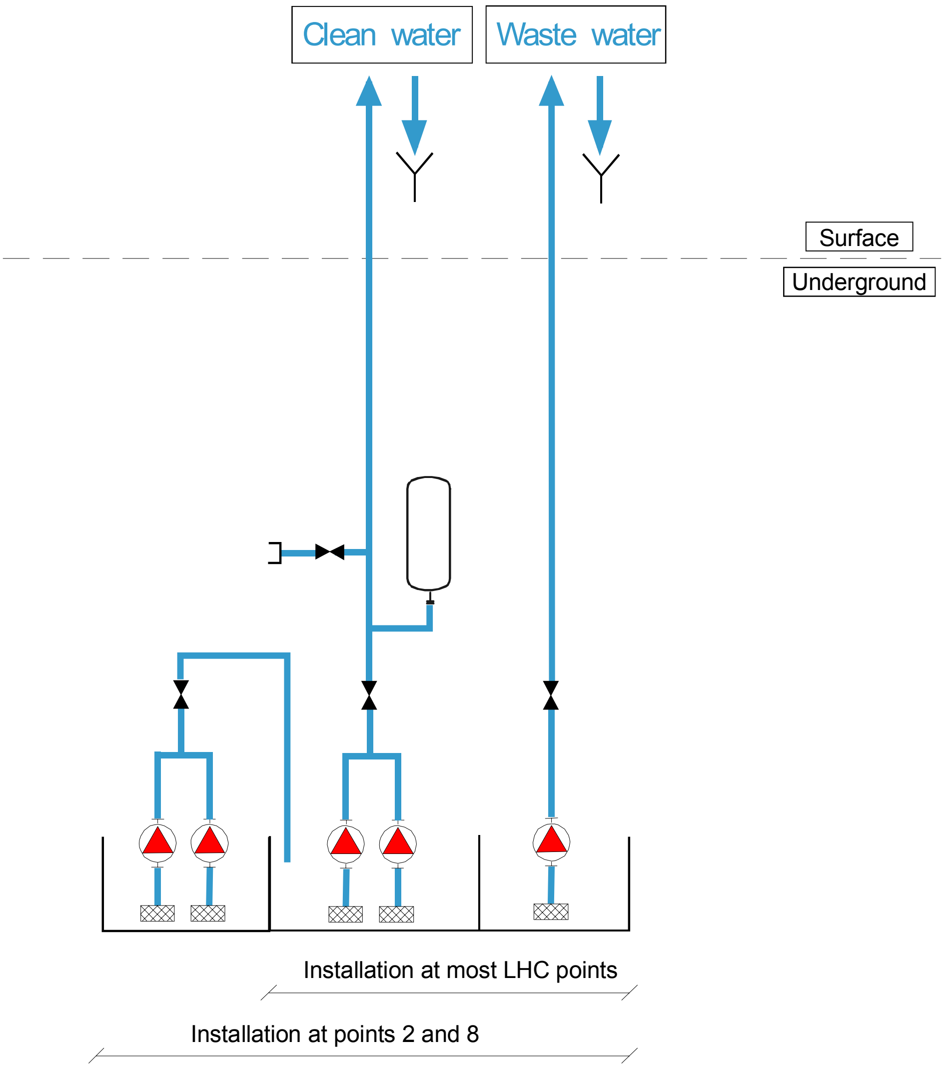

Figure 8.6 Schematic of the principal clean and waste water equipment of the LHC

8.8 VENTILATION OF THE LHC TUNNEL AND ITS TECHNICAL AREAS

This section concerns the ventilation system of the LHC tunnel itself, with associated technical underground areas: the RR caverns, the beam-dump region and the RE alcoves. In addition, the UA caverns, as well as the UX45 cavern which will house the machine radio frequency equipment.

The main tunnel is divided into eight independent volumes, called sectors which are treated separately. Two air handling units supply air at each even point of a sector, while two extraction units remove air at the odd points of the corresponding sector. The generalised air flow is shown schematically in Fig. 8.7.

The air is supplied via air handling units located in the surface buildings SU2, SU4, SU6 and SU8. The treated air is transported by air ducts, via PM25, PM45, PM65 and PM85 shafts down to the UJ24, UJ26, UJ44, UJ46, UJ64, UJ66, UJ84 and UJ86 junction chambers. The air is pulsed into the tunnel on the machine side of these junction chambers. The exhaust air is extracted from the odd points via the UJ14, UJ16, UJ32, UJ561, UP56, and UJ76 junction chambers. In UJ32, UP56 and UJ76, partitions separate the airflows coming from points 2 and 4, points 4 and 6, and points 6 and 8.

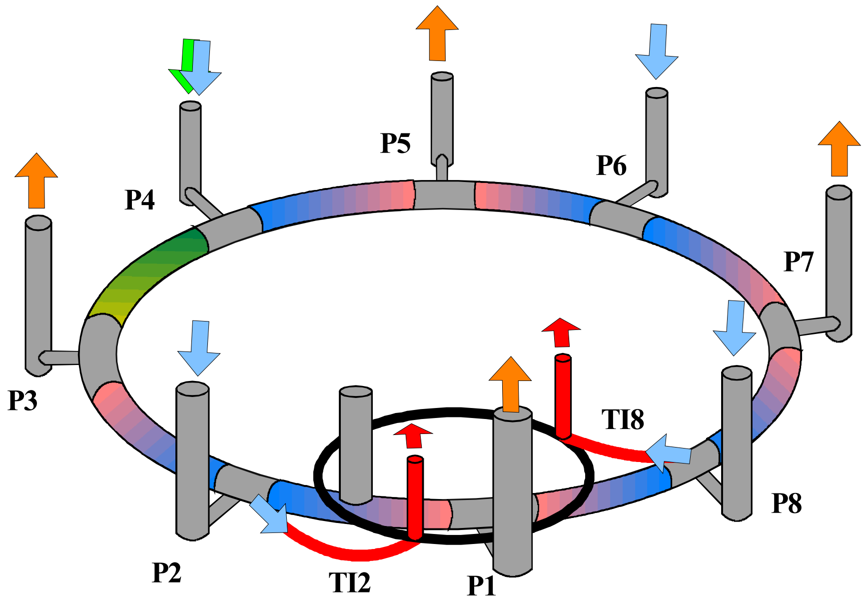

Figure 8.7: Schematic layout of the air-flows in the LHC tunnel.

In the design of the air handling installations, one of the most important aspects is the heat load which can only be evacuated via the ventilation air. As a general rule the maximum possible heat generated by equipment should be removed by water cooling. The remainder comes from such sources as warm cabling, and the heated surface of equipment. In addition to the heat load, many other functions must also be taken into account:

- Supply fresh air for people,
- Provide heating and ventilation,
- De-Stratify the air and maintain a suitable temperature of the equipment,
- Dehumidify to prevent condensation,
- Permit cold smoke extraction,
- Purge the air in the tunnel before access,
- Filter the exhaust air,
- Attenuate sound emissions associated with the exhaust air.

In each sector of the tunnel, four operating modes are provided. With the corresponding air flow rates shown in Tab. 8.6.

The cooling capacity of the ventilation system is partially determined by the inlet air parameters. The remaining heat load is cooled by local air-conditioning units, connected to the chilled water network in the various technical areas. Components which dissipate heat to underground air are: magnets (warm), cables, transformers, orbit correctors, electronic cells, electronic racks and powers converters. Indoor conditions as well as the total heat dissipation in all the sectors are shown in Tab. 8.7.

It can be seen from Tab. 8.7 that there is a gradient of the temperature and humidity along each sector, in the direction of the air flow. With a dew point < 10 °C the absolute humidity is 8.2 g/kg, whereas with a dew point < 5°C the absolute humidity will be 5.1 g/kg. A more precise breakdown of how much each component contributes to the total heat balance is available [3].

Table 8.6: Air flow rate per tunnel sector

Tunnel sector	Reduced Consumption mode [m³/h]	Tunnel Accessible mode[1] [m³/h]	Tunnel Not Accessible mode [m³/h]	Emergency Sector mode [m³/h]
1-2	9 000	18 000	36 000 22 500[2]	64 000
2-3	9 000	18 000	36 000	64 000
3-4 [3]	9 000	18 000	45 000	64 000
4-5	9 000	18 000	36 000	64 000
5-6	9 000	18 000	36 000	64 000
6-7	9 000	18 000	36 000	64 000
7-8	9 000	18 000	36 000	64 000
8-1	9 000	18 000	36 000 22 500[2]	64 000

Table 8.7: Indoor conditions per tunnel sector

Tunnel sector	Total heat Dissipation [kW]	Dry bulb temperature, even input [°C]	Dew point at the even input [°C]	Dry bulb temperature odd output[4] [°C]
1-2	125	18 ±1	< 10	23 ±6
2-UJ32	41	18 ±1	< 10	20 ±2
UJ32-4	233	18 ±1	< 5	25 ±7
4-5	111	18 ±1	< 10	22 ±6
5-6	118	18 ±1	< 10	23 ±6
6-7	117	18 ±1	< 10	23 ±6
7-8	109	18 ±1	< 10	22 ±4
8-1	117	18 ±1	< 10	22 ±6

UA Galleries

The UA galleries are ventilated with a supply overpressure in the gallery compared to the tunnel volume while a separate circuit provides cold smoke extraction in case of emergency. The local heat dissipation in the gallery is treated by additional local air handling units cooled using chilled water.

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[1] *This air flow rate may be chosen between 9000m³/h and 18 000 m³/h per sector.*
[2] *Reduced air flow rate in the adjacent sector when the injection lines, TI2 and TI 8 are operating.*
[3] *The air flow rates are different from those proposed in the "Rapport Préliminaire du Sûreté LHC". The higher air flow rate is needed to cope with the heat dissipation.*
[4] *The calculation of the resulting temperature is based on an adiabatic tunnel. The maximum temperature will be reached when there is maximum heat dissipation.*

Beam dumps

The beam dump caverns (UP, UD) are ventilated via relay fans. As a result the heat loads generated in these areas are taken into account as part of the ventilation of the main tunnel.

Alcoves

The 16 alcoves are ventilated and air-cooled by three air-handling units in each one. As there is no chilled water available in the alcoves, these air handling units each contain a refrigeration compressor unit, in which the condenser is cooled by demineralised water.

Outdoor conditions

The following extreme outdoor atmospheric conditions have been considered when dimensioning the air handling equipment:

- Summer: Dry bulb temperature: 32 °C
  Relative humidity: 40 %
- Winter: Dry bulb temperature: -12 °C
  Relative humidity: 90 %

8.9 VENTILATION OF THE LHC TRANSFER TUNNELS

During the beam injection from SPS to LHC, the TI2 and TI8 injection tunnels are in operation. A fraction of the air flow available in sectors 1-2 and 1-8 will be deviated to the injection tunnels via dedicated extraction units. An extraction plant located in SUI2, composed of two extraction units, one for normal extraction with filters, and a second for emergency and cold smoke extraction, will provide extraction at the end of the TI2 tunnel. The same principle will apply for TI8, for which the extraction plant is located in building SUI8. In each injection tunnel, the ventilation system will run in four operating modes, as shown in Tab. 8.8.

Table 8.8: Air flow rate per injection tunnel

Injection Tunnel	Reduced consumption mode [m^3/h]	Accessible mode [m^3/h]	Non Accessible mode [m^3/h]	Emergency mode [m^3/h]
TI2	7 500	9 000	22 500	45 000
TI8	7 500	9 000	22 500	45 000

8.10 VENTILATION OF THE EXPERIMENTAL CAVERNS

This section describes the heating, ventilation and air conditioning of the detector caverns and their associated services and the operation modes, design values and corresponding ventilation parameters. The ventilation functionalities listed in the previous chapter are also valid for the ventilation of the detector and service caverns. In general, the ventilation works on the principle of an air displacement system for the supply and a central extraction duct with grills distributed on the ceiling of the cavern. In general, the extraction systems for the experimental areas are fitted with absolute filters.

8.10.1 Point 1: ATLAS

The experimental cavern UX15

The design values for the experimental cavern UX15 are as follows:

	Temperature (°C)	Dew point temperature (°C)	Thermal load (kW)	Air volume (m^3)	Surface at floor level (m^2)
UX15	18-30	<12	<180	47 000	1 590

The UX15 cavern is air conditioned and ventilated by a mechanical supply and extraction of air, it also has dedicated smoke, Argon and gas extraction systems. As the gas extraction system works continuously, the UX15 cavern is always at a lower atmospheric pressure than the adjacent USA15 cavern. The main air extraction is done at the upper levels by means of extraction plenums. The air handling units for UX15 are housed in the surface building SUX1. Ducts in the PX14 shaft link the units to the supply and extraction points in the cavern. The surface and underground arrangement is illustrated in Fig. 8.8. The air flow values in the different networks and for the different operation modes are listed in Tab. 8.9.

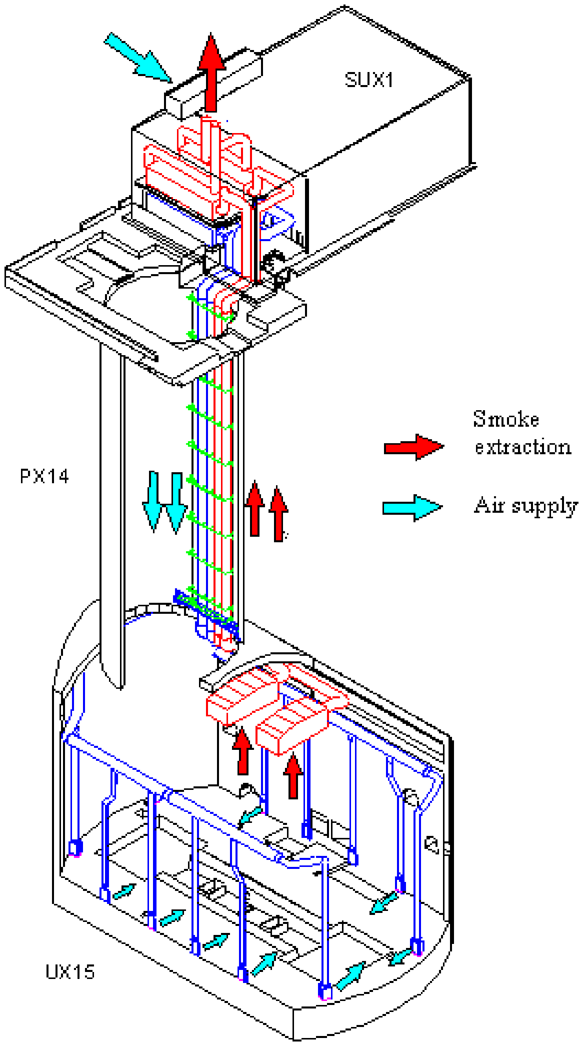

Figure 8.8: Ventilation of UX15

Table 8.9: Air flow values in different networks and different operation modes

	Air supply (m^3/h)	**Air extraction (m^3/h)**	**Smoke extraction (m^3/h)**	**Gas extraction (m^3/h)**	**Argon extraction (m^3/h)**
Access mode	60 000	60 000	0	5 000	8 000
No access mode	60 000	60 000	0	5 000	8 000
In case of fire in UX15	120 000	0	120 000	5 000	16 000
In case of Argon leak	120 000	0	120 000	5 000	32 000

The USA15 technical cavern

As well as the main ventilation system, the USA15 cavern has dedicated air conditioning systems for the transformer, cryogenics and electronic racks areas. Moreover, a smoke extraction network, fitted with dampers to target particular zones, takes care of the different areas. The ventilation systems for USA15 are shown in Fig. 8.9.

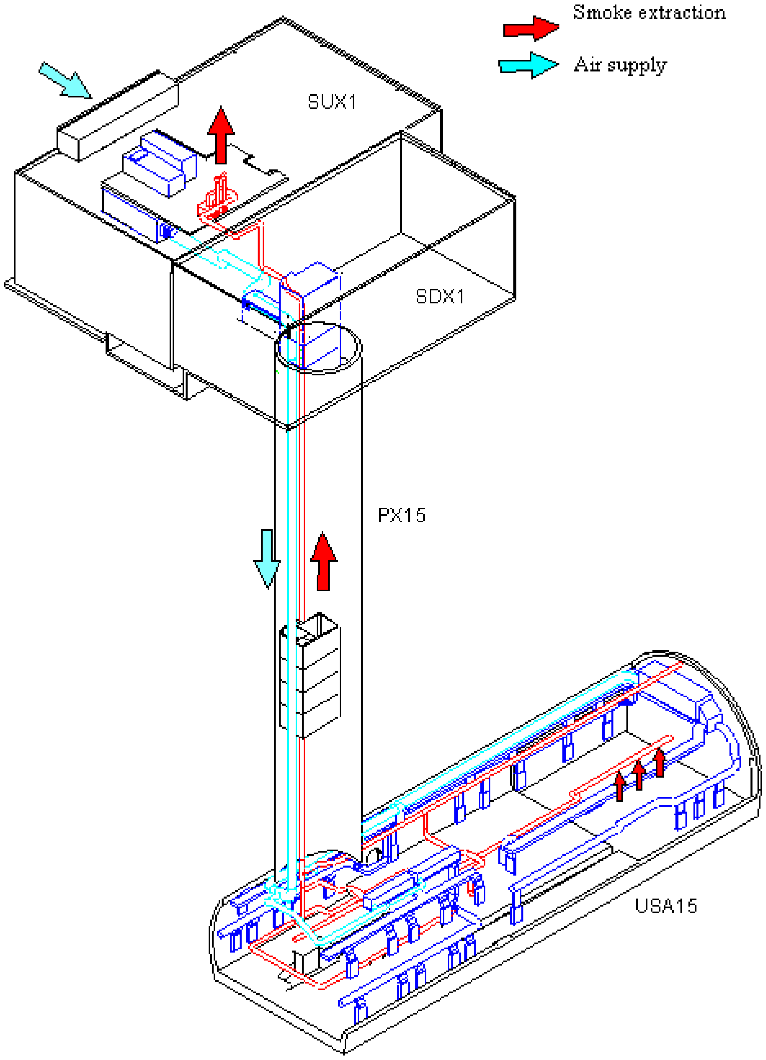

Figure 8.9: Ventilation of USA15

Table 8.10: Design values for USA15

AREA	Temperature (°C)		Dew point temperature (°C)	Thermal load (kW)	Air supply and extraction (m^3/h)
	Winter	Summer			
USA15 Electronic racks room	19 ±1	26 ±1	<12	125	4 x 10 000
USA15 Service area	19 ±1	26 ±1	<12	120	40 000
USA15 Safe room	19 ±1	26 ±1	<12	5	500
USA15 Transformers room	19 ±1	30 ±1	<12	<80	26 000
PX15	19 ±1	22 ±1	-	0	0

In the event of a fire, the ventilation is automatically stopped in the affected zone. The smoke extraction system is manually switched on, once the personnel have been evacuated and the fire controlled. For this purpose, priority manual commands for the fire brigade are installed both on the surface and underground.

The access galleries UPX14 and UPX16 and the service corridor are used as escape passages towards the UX15 cavern, they are therefore over pressurised with respect to USA15. The concrete modules in PX15 will also be pressurised because they are safe zones in case of fire.

The design values for the USA15 and the air flow rate for the particular air-conditioning systems are given in Tab. 8.10.

The main ventilation system in USA15 has the only mechanical supply. The extraction occurs as a result of the pressure difference between USA15 and the surface building SDX1 and between USA15 and UX15. The main ventilation parameters are presented in Tab. 8.11

Table 8.11: Air flow rates for the USA15 cavern

	Main air supply (m^3/h)	**Gas mixture extraction (m^3/h)**	**Smoke extraction (m^3/h)**
Access mode	26 000	5 000	0
In case of fire in USA15	26 000	5 000	10 000

8.10.2 Point 2 : ALICE

The experimental cavern UX25

The experimental cavern UX25 has the following thermal requirements:

	Air Temperature (°C)	
	Dry bulb	Dew point
Supply	17	<10
Extraction	<27	<12

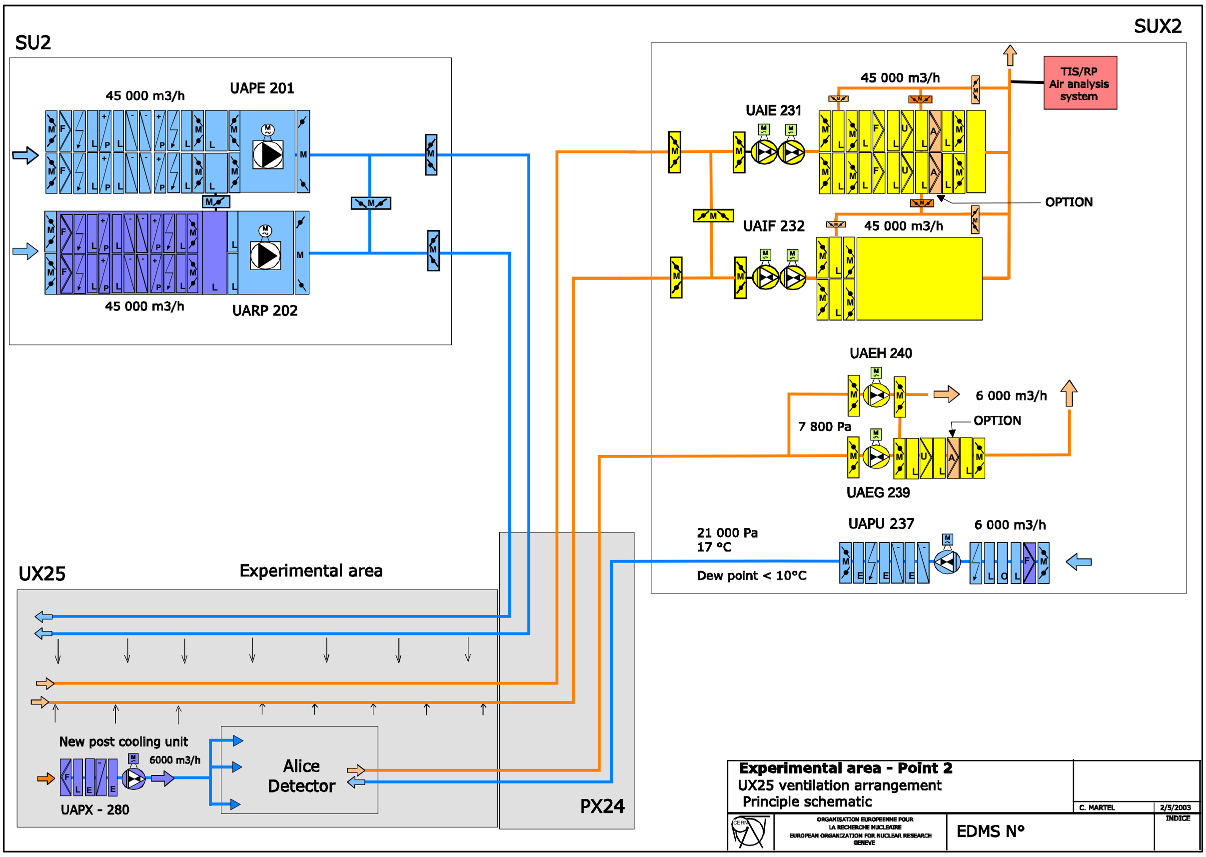

Figure 8.10: Ventilation of UX25

The maximum capacity for heat dissipation to the cavern is 100kW. The main ventilation system has two supply units located in building SU2 which are connected to the UX25 cavern through ducts traversing SUH2 and the PX24 shaft. The extraction units are in building SUX2 and the link with the cavern is also done through PX24. The arrangement is illustrated schematically in Fig. 8.10.

The air extraction system will also be used for smoke extraction. The filters in the experimental area air extraction system can be by-passed in order to avoid clogging and to ensure good operation during smoke extraction. The air supply and extraction is 45 000 m^3/h during normal operation which will be doubled in the event of a fire.

The shaft PX24

There are 3 air handling units located in the SU2 building serving the PX24 shaft. An air handling unit provides air conditioning in the PX24 hut where the air flow rate is 15 000 m^3/h. Another unit pressurises the concrete modules to permit access to the hut and has an air flow rate of 12 000 m^3/h. A third unit pressurises the stairs and lift with an air flow rate of 8 000 m^3/h. The 2 pressurization units are backed up by a fourth unit.

8.10.3 Point 5: CMS

The experimental cavern UXC55

The design values for the experimental cavern UXC55 are as follows:

	Temperature (°C)	Dew point temperature (°C)	Thermal load (kW)	Air volume (m^3)	Surface at floor level (m^2)
UXC55	18-30	<12	<100	28 000	1300

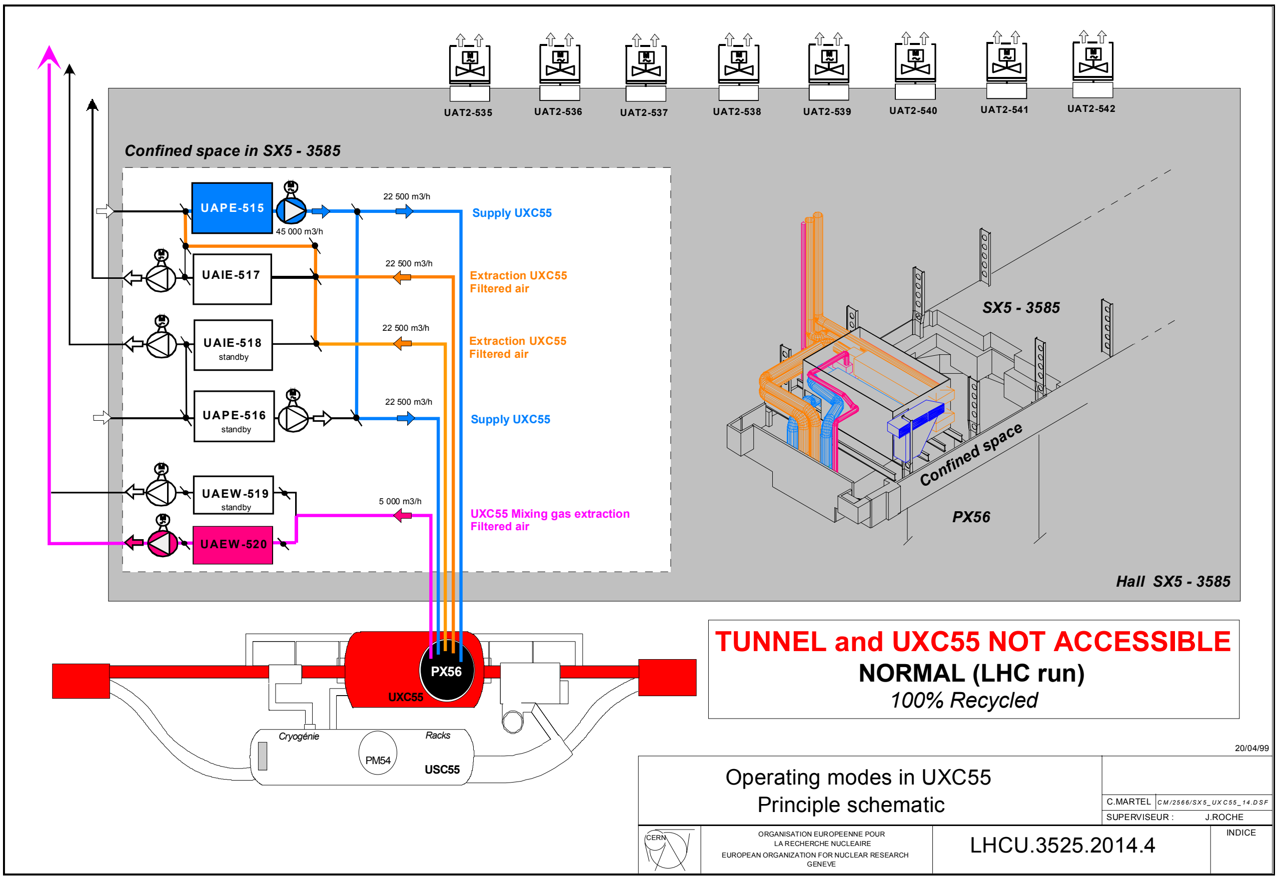

Figure 8.11: Ventilation of UXC55

The UXC55 cavern is air conditioned and ventilated by a mechanical supply and extraction of air as with UX15, the UXC55 cavern has dedicated smoke, Argon and gas extraction systems. The gas extraction system works continuously and because of this, the UXC55 cavern is always at a lower atmospheric pressure than the adjacent USC55 cavern. The main air extraction is done at the upper levels by means of extraction plenums. The air handling units for UXC55 are housed in the surface building SX5. Ducts in the PX56 shaft link the units to the supply and extraction points in the cavern.

The surface and underground arrangement is illustrated in Fig. 8.11. The air flow values in the different networks and for the different operation modes are listed in Tab. 8.12.

Table 8.12: Air flow values in different networks and different operation modes

	Air supply (m^3/h)	**Air extraction (m^3/h)**	**Smoke extraction (m^3/h)**	**Gas extraction (m^3/h)**
Access mode	45 000	45 000	0	5 000
No access mode	45 000	45 000	0	5 000
In case of fire or gas leakage in UXC55	90 000	0	90 000	5 000

The technical cavern USC55

As well as the main ventilation system, the USC55 cavern has dedicated air conditioning systems for the transformer, cryogenics and electronic racks areas. Moreover, a smoke extraction network, fitted with dampers to target particular zones, takes care of the different areas.

In the event of a fire, the ventilation is automatically stopped in the affected zone. The smoke extraction system is manually switched on, once the personnel have been evacuated and the fire controlled. For this purpose, priority manual commands for the fire brigade are installed both on the surface and underground. The access galleries and access shafts PM54 and PM56 are used as escape passages towards the UXC55 cavern. They are therefore over pressurised with respect to USC55. The concrete modules in PM54 will also be pressurised as they are considered a safe zone in case of fire. The design values for the USC55 and the air flow rate for the particular air-conditioning systems are given in Tab. 8.13.

Table 8.13: Design values for the USC55 Ventilation System

AREA	**Temperature (°C)**		**Dew point temperature (°C)**	**Thermal load (kW)**	**Air supply and extraction (m^3/h)**
	Winter	**Summer**			
USC55 Electronic racks rooms	19 ±1	26 ±1	<12	125	2 x 20 000
USC55 Service area	19 ±1	26 ±1	<12	100	40 000
USC55 Safe room	19 ±1	26 ±1	<12	8	500
USC55 Transformers room	19 ±1	30 ±1	<12	<80	26 000
PM54	19 ±1	22 ±1	-	0	12 000

The main ventilation system in USC55 has the only mechanical supply. The extraction occurs by pressure differences between USC55 and the surface building SDX5 and between USC55 and UXC55. The main ventilation parameters are presented in Tab. 8.14.

Table 8.14: Air flow rates for the USC55cavern

	Main air supply (m^3/h)	**Gas mixture extraction (m^3/h)**	**Smoke extraction (m^3/h)**
Access mode	12 000	5 000	0
In case of fire in USC55	12 000	5 000	10 000

8.10.4 Point 8: LHC-b

The experimental cavern UX85 is physically divided into two separate volumes each of which needs its own ventilation system. These volumes are:

- An experimental area which will house the LHCb detector,
- A protected area for the LHCb counting rooms and the Delphi barrel exhibition which is always accessible.

The design parameters are similar to those for the UX25 cavern and are as follows:

	Air Temperature (°C)	
	Dry bulb	Dew point
Supply	17	<10
Extraction	<27	<12

The maximum heat dissipation in each of the areas is 50 kW. The supply units for both areas are located in building SUX8 and the extraction unit for the protected area is also located in SUX8. See Fig. 8.12.

The extraction duct is placed below the cavern ceiling and is divided in two parts for the two different zones. For the experimental area, the extraction is done by fans located in the technical gallery TU84 which extract the air from the cavern to the PX84 shaft. At the same time, fans in SX8 which have a filtration section, extract the air from the PX84 shaft to the outside. The air extraction system will also be used for smoke extraction. The filters in air extraction for the experimental area can be by-passed in order to avoid clogging and to ensure good operation during the smoke extraction. In both areas the air supply and extraction is 22500m^3/h in normal operation and is doubled in the event of a fire.

Both areas are equipped with a gas extraction network and ducts from both parts of the cavern are connected to gas extraction units placed in TU84 gallery. The units blow the gasses to the PX84 shaft and the main extraction system blows them outside. The gas flow rate is 5 000m^3/h.

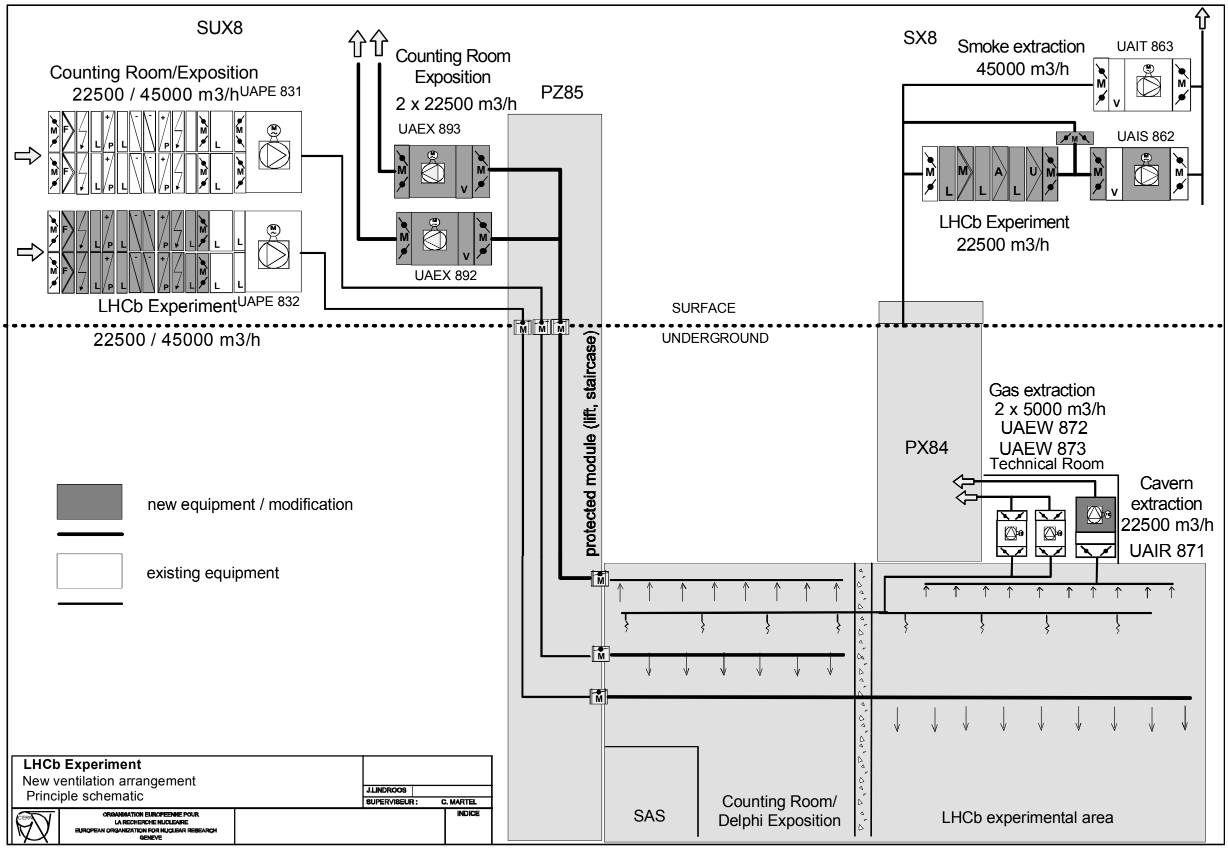

Figure 8.12: The ventilation system of UX 85

8.11 HEATING, VENTILATION AND AIR-CONDITIONING FOR THE SURFACE BUILDINGS

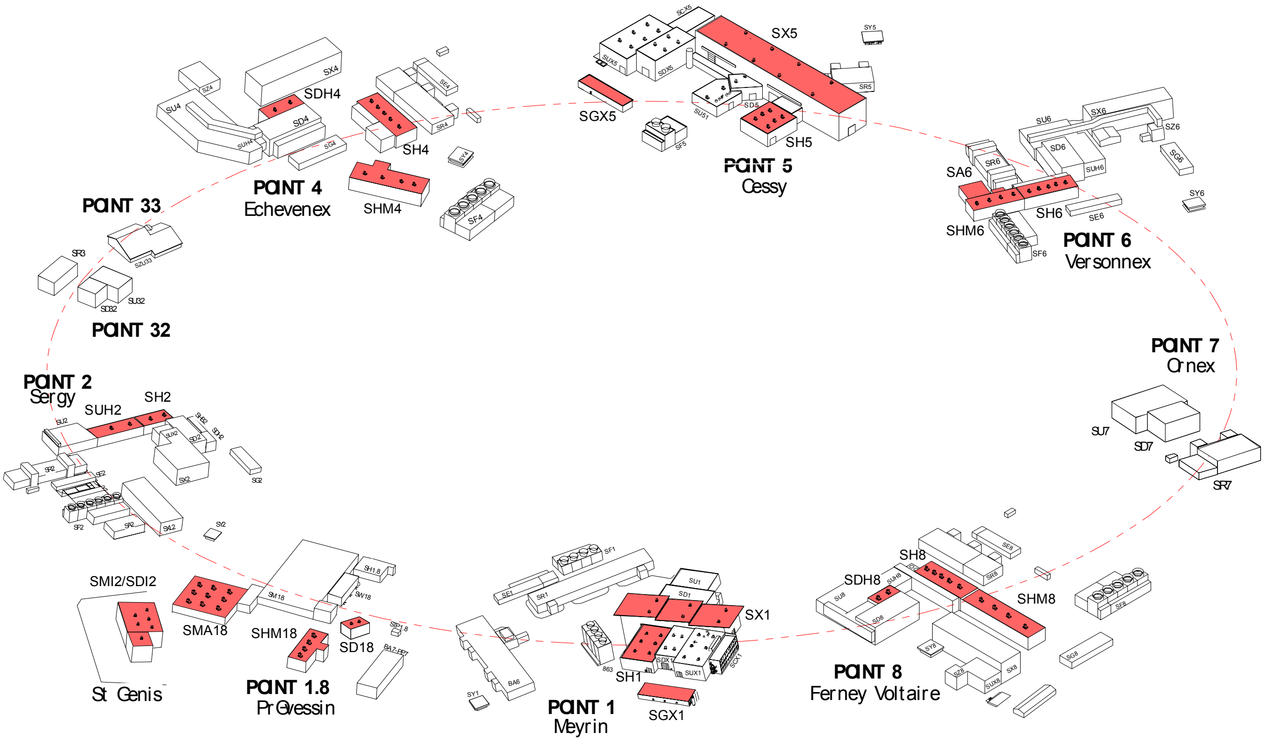

Figure 8.13: LHC Surface buildings

Table 8.15: Heating, ventilation and air-conditioning equipment by building

LHC buildings	HVAC equipment
SA (Points 2 and 6)	Heating and Ventilation
SD (Points 1-8)	Heating, ventilation and smoke extraction
SD (Point 1.8)	Heating, ventilation, smoke extraction and PM18 pressurisation
SDH (Points 4 and 8)	Heating, ventilation and passive smoke evacuation
SDX (Points 1 and 5)	Heating, ventilation and smoke extraction
SEM-SES	Heating, ventilation and cooling
SF (Points 1, 2, 4, 5, 6, 8)	Heating, ventilation and passive smoke evacuation
SG (Points 2, 4, 6, 8)	Heating, ventilation, cooling, gas extraction and heat recovery
SH (Points 1, 2, 4, 5, 6, 8)	Heating, ventilation and smoke extraction
SHM (Points 1.8, 4, 6, 8)	Heating, ventilation and smoke extraction
SR (Points 1-8)	Heating, ventilation, cooling and smoke extraction
SU (Points 1-8)	Heating, ventilation and passive smoke evacuation
SUH (Points 2, 4, 6, 8)	Heating, ventilation and passive smoke evacuation
SUX (Point 1, 2, 5)	Heating, ventilation and passive smoke evacuation
SX (Points 1, 2, 4, 5, 6, 8)	Heating, ventilation and smoke extraction
SY (Points 1, 2, 4, 5, 6, 8)	Heating, ventilation and smoke extraction
SZ (Points 4, 6, 8)	Heating, ventilation and smoke extraction
SCX (Points 1 and 5)	Heating, ventilation and air-conditioning
SGX (Points 1 and 5)	Heating, ventilation, cooling, gas extraction and heat recovery
SMA (Point 1.8)	Heating, ventilation and passive smoke evacuation
SW (Point 1.8)	Heating, ventilation and smoke extraction

There are 118 surface buildings at the LHC sites as illustrated in Fig 8.13. A total of twenty buildings (indicated by shaded roofs) were constructed specifically for the LHC project and the others were from LEP. They are all equipped with various types of air handling equipment. A total of 80 buildings only have a heating and ventilation system, whereas the remainder are equipped with a more sophisticated air-conditioning system. All buildings have electric heating, except building SMA 18 which is heated by hot water from the central heating system at the Meyrin site. Where applicable, the cooling media is chilled water. According to the contents of the buildings, some are equipped with active (mechanical) or passive (air-louvers) smoke evacuation devices. Under winter conditions, the general set point for the indoor temperature is 17°C. A summary of how the various types of buildings are equipped is presented in Tab. 8.15. More details on the purpose and volume of each of those buildings may be found in chapter 2.

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