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VENTILATION AND AIR-CONDITIONING CONCEPT FOR CNGS UNDERGROUND AREAS

J. Lindroos

Abstract

The aim of the CNGS project is to prove the existence of neutrino oscillation by generating an intense neutrino beam from CERN in the direction of the Gran Sasso laboratory in Italy, where two large neutrino detectors are built to detect the neutrinos. All the components for producing the neutrino beam will be situated in the underground tunnels, service galleries and chambers. The ventilation and air-conditioning systems installed in these underground areas have multiple tasks. Depending on the operating mode and structure to be air-conditioned, the systems are required to provide fresh air, cool the machine, dehumidify areas housing sensible equipment or assure the smoke removal in a case of a fire. This paper presents the technical solutions foreseen to meet these requirements.

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1 INTRODUCTION

The design, installation and different operating modes of the air-conditioning system serving the CNGS infrastructure needs to take into consideration the interdependence of the underground structures. The tunnels, target areas and technical equipment areas are closely connected to each other. The long distance from the access point to the target area requires the decentralization of the system.

The aim of these installations is to assure the ventilation, air-conditioning and smoke extraction functions in different underground areas.

1.1 CNGS Infrastructure

The following surface and underground structures are part of the CNGS ventilation infrastructure:

Table 1: The volumes and lengths of the CNGS structures

Structures	Length (m)	Volume (m^3)	Diameter (m)
SUI8 building (existing)			
PAM4 shaft (existing)			
ECA4 cavern (existing)			
Access Gallery TAG41	769	5850	3.1m
Access Gallery TAG42	115	870	3.1m
Proton beam Tunnel TT41	590	4000	3.1m
Target Chamber	115	3450	6.5m
Service Gallery	148	1200	3.4m
Ventilation Chamber			
Decay Tunnel	992	9600	2.45
Hadron stop	26	850	6 m
Muon Chamber	3.5	110	6 m
Connection Galleries to TI8	340	2570	3.1m

2 DIMENSIONING CRITERIA

2.1 Extreme Outside Conditions

The following extreme outside conditions are used for dimensioning of the equipment :

Table 2: The extreme outside conditions

Period	Dry bulb temp.	Relative humidity	Dew point temp.
Summer	+32°C	40%RH	+15,5°C
Winter	-12°C	90%RH	-13°C

2.2 Required Ambient Conditions

The following ambient conditions are the basis for the system design:

Table 3: The required ambient conditions

Structures	Dry temperature (°C)	Dew point (°C)	Supply air (°C)
Access Gallery TAG41	not specified	not specified	+17 ⁺ 1°C
Access Gallery TAG42	not specified	not specified	transfer air TAG41
Proton beam Tunnel TT41	+25 ± 2°C	10	+17 ± 1°C
Target Chamber	+24 ± 1°C	0	+17 ± 1°C
Service Gallery	+24 ± 1°C	0	+17 ± 1°C
Ventilation Chamber	+20 ± 2°C	10	+17 ± 1°C
Hadron stop	not specified	not specified	From TI8
Muon Chamber	not specified	not specified	From TI8

2.3 Loads

The following heatloads and humidity loads are generated by the machine and underground structures:

Table 4: The internal loads

Structures	Heat loads (kW)	Humidity load (kg/h))	Note
Proton beam Tunnel TT41	90	negligible	no hum. control
Target Chamber	150	2,2	hum. control
Service Gallery	25	1,45	hum. control
Hadron stop	negligible	negligible	no hum. control
Muon Chamber	negligible	negligible	no hum. control

3 AIR-CONDITIONING AND VENTILATION

Due to the long air distribution distance from the surface to the underground areas, the final air treatment will be done close to the conditioned structures. The Ventilation Chamber in the Target area houses the air-conditioning units for the Target Chamber and the Proton Beam tunnel. The pre-treated outside air from SUI8 will be supplied via ducting in the Access Gallery to the units in the Ventilation Chamber and post treated according to the specific needs in these areas. The extracted air will follow the same routing and will be blown outside by the dedicated extraction units in SUI8. This same extraction system is used for smoke extraction in a case of a fire.

The Hadron Stop area, being physically separated from the other CNGS structures, will have its own ventilation system. This system will get its air from the LHC TI8 tunnel. For these structures ventilation and smoke extraction is required.

3.1 Provisional Ventilation during the Works

Provisional ventilation is needed during the installation of the Decay Tube and general services starting from the beginning of 2003. Civil engineering contractor is responsible for ventilation during his excavation works.

The basis for the provisional ventilation are the laws and requirements in force concerning the works in underground areas. A minimum fresh air flow of 30m3/h is required for the workers. In addition a sufficient air speed is required in the tunnel to remove the dust and pollution, but not exceeding the comfort limit. An air speed of 0.3 m/s will be used over the tunnel section. This means an air flow of 7500m3/h through the tunnels.

The system itself will comprise of fresh air supplies from two points and a common extraction from one point. First, an air handling unit will be installed in the SUI8 building. This unit supplies air to the access tunnels TAG41 (partially), TAG42 and Proton Beam tunnel. Second, a ventilator that supplies fresh air from TI8 tunnel to the Hadron Stop area and Decay Tunnel and Target Chamber will be installed in the junction of TI8 and Hadron Stop access gallery. These air flows will join in the Ventilation Chamber and be extracted from the tunnel TAG41. Partition walls will be constructed in the tunnel TAG41 just before access shaft PGCN, between Proton Beam tunnel and Target Chamber and between TI8 and Hadron Stop access gallery to make sure that air flows are going to right direction.

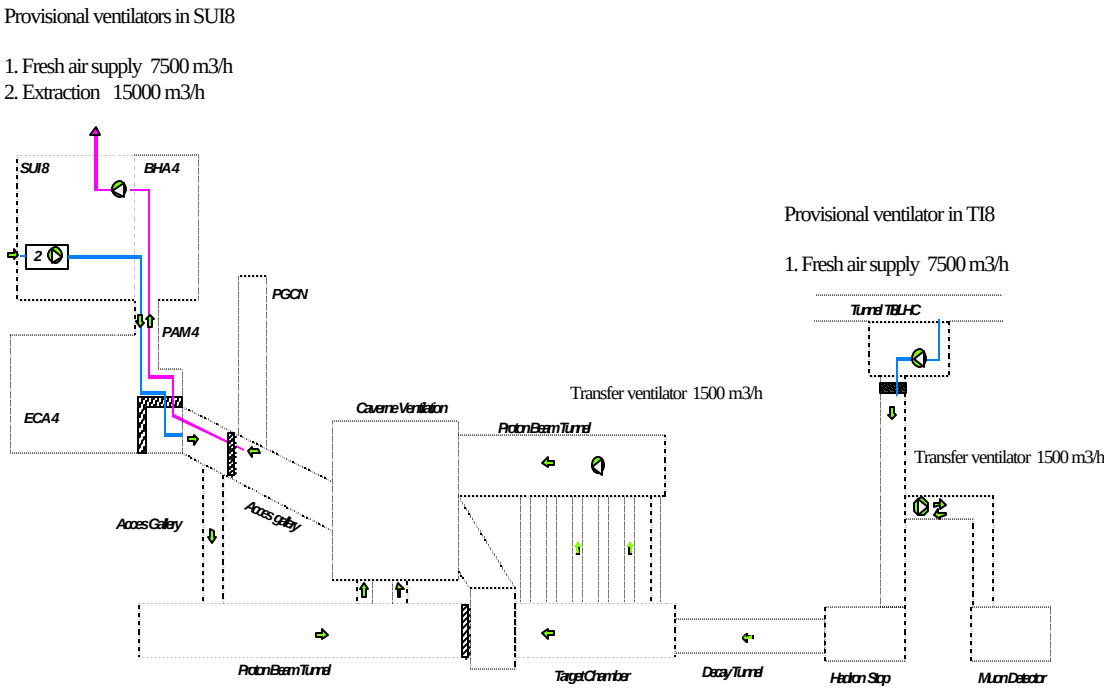

Figure 1: **Provisional ventilation arrangement**

3.2 SUI8 Building

The SUI8 building is an annex to the BHA4 building in the SPS point BA4. It was built to house the ventilation and air-conditioning equipment needed for the CNGS underground structures and TI8 tunnel extraction system. The equipment will be installed in two levels so that the TI8 extraction system is on the ground floor and all equipment for CNGS on the first floor.

The CNGS air-conditioning and ventilation equipment consists of one supply air unit (16000m^3/h) with heating and cooling functions, two extractors (à 16000m^3/h) for normal extraction and smoke extraction functions, and a small extractor (500m^3/h) for a leak air flow during the machine run. All the extractors, exept smoke extractor, are equipped with fine and absolute filters.

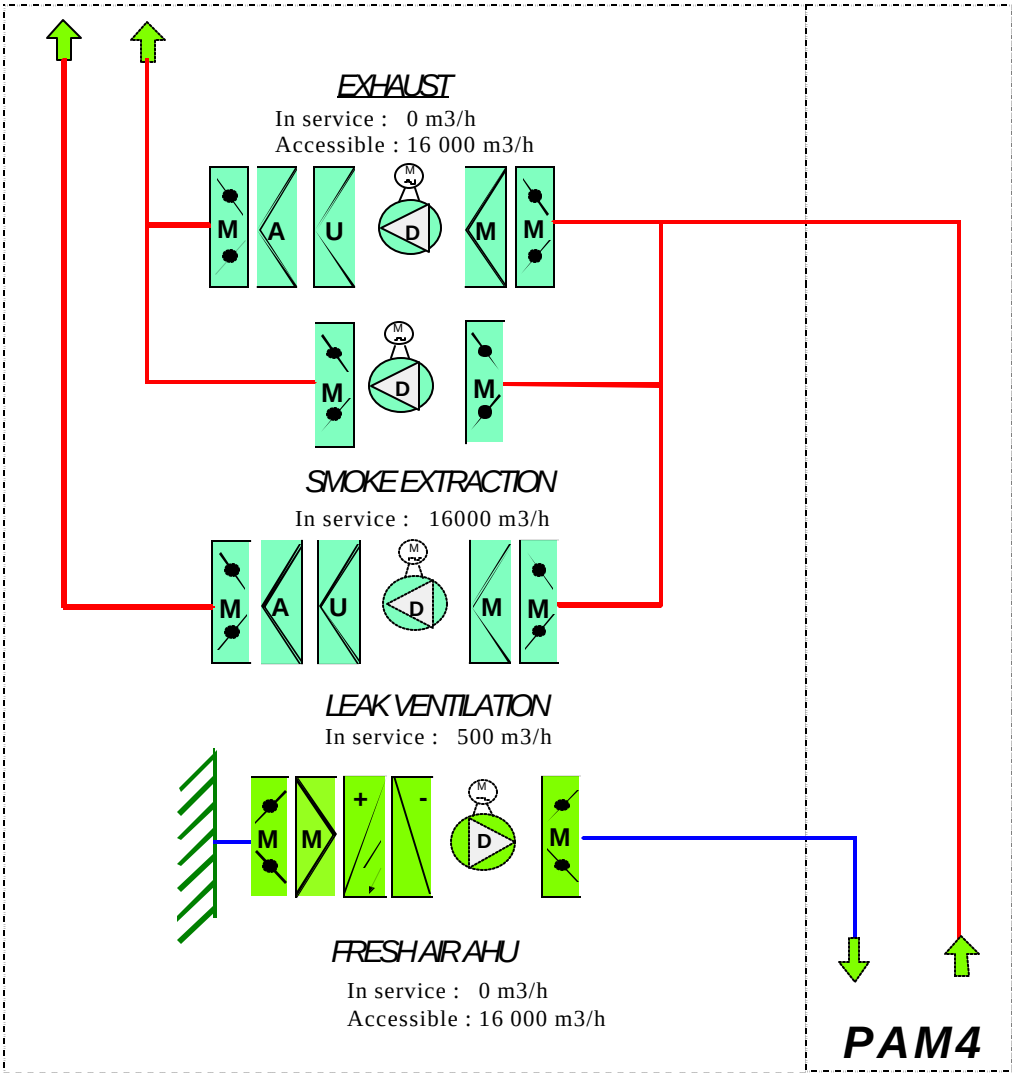

Figure 2: **Equipment in SUI8 building**

3.3 Access Tunnels

The Access Tunnels TAG41 and TAG42 serve as access ways in the different machine- and experimental areas. The Access Gallery TAG41 serves as the main way to the target area and the tunnel TAG42 was constructed mainly to advance faster with the civil engineering works, but could serve later other access purposes also.

3.3.1 Access Gallery TAG41

This tunnel is the main access to the Target zone. Most of the general services going to the Target area are installed in this tunnel. The ventilation ducting from the surface building SUI8, different fluid networks and electrical cable trays are installed on the sides of the tunnel. The space for the general services installations is restricted. To have the required free space for the transport of the Horn and the Reflector, it is necessary to use rectangular ducting.

The ventilation of this tunnel is related to each operating mode. When the machine is functioning, a small leak air flow (500m^3/h) will traverse the tunnel. In a case of an access, the fresh air system will supply the tunnel with 6000m^3/h of fresh air to guarantee sufficient ventilation. The tunnel is also provided with smoke removal possibility.

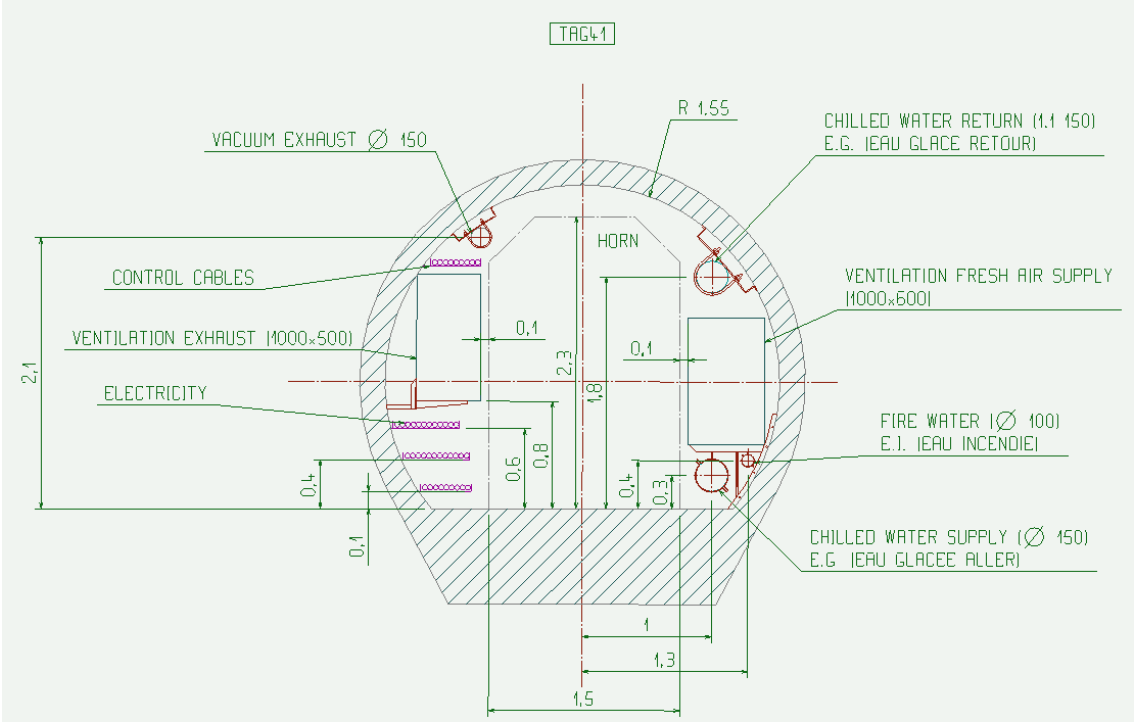

Figure 3: **General services in TAG41**

3.3.2 Access Gallery TAG42

This tunnel was created as the work was already on-going. The purpose of the tunnel was to speed up the civil engineering works in the Proton Beam Tunnel. For the moment it will not be equipped to be an access tunnel after the works. However, a small ventilation by means of a transfer ventilation from TAG41 is foreseen in this tunnel.

3.4 Proton Beam Tunnel

The Proton Beam Tunnel is used to direct the proton beam that is extracted from the SPS in the Target. The beam line consists mainly of dipoles and quadrupoles that are supplied by electricity in intervals of 6 seconds or more.

The air-conditioning of this tunnel is carried out by an air handling unit located in the Ventilation Chamber. The objective of the air-conditioning is to cool down the heat loads from the magnets. The primary cooling system of the magnets is demineralized water, but about 5% of the total total heat load is calculated to be dissipated into the air. No humidity control is foreseen.

When the machine is operating the air-conditioning functions in 100% recirculation mode. During access periods fresh air is supplied to the system by the fresh air unit in SUI8. The tunnel is connected to the smoke extraction system.

The distribution of supply air is done by a duct that will be fixed on the ceiling in the middle of the tunnel. The duct will go all the way to the other end of the tunnel. Air will be blown in the tunnel through grilles. There will be only one point for extraction on the wall separating the Ventilation Chamber and Proton Beam Tunnel.

3.5 Target Chamber and Service Gallery

The Target Chamber houses the target which consists of small graphite cylinders, secondary beam line with two focusing horns (Horn and Reflector) and the entrance window to the Decay Tunnel. In the Service Gallery is located the various electrical, cooling etc. equipment serving the target elements.

The objective of the air-conditioning is to cool down the heat loads from the target shielding in the Target Chamber and the equipment in the Service Gallery.

The air-conditioning of these structures is carried out on the other hand by a principal air handling unit located in the Ventilation Chamber and on the other hand by two dedicated cooling units for Target Chamber located in the Service Gallery. The principal unit takes mostly care of the ventilation and dehumidification of the structures whereas the cooling units in the Service Gallery are used only during the machine run to cool down the Target shielding. To avoid any risk of condensation and rust on the equipment installed in these structures, the humidity will be controlled by a silicagel wheel installed in the principal unit. The set value for the dew point is 0°C.

When the machine is operating the air-conditioning functions in 100% recirculation mode. During access periods fresh air is supplied to the system by the fresh air unit in SUI8. These structures are connected to the smoke extraction system.

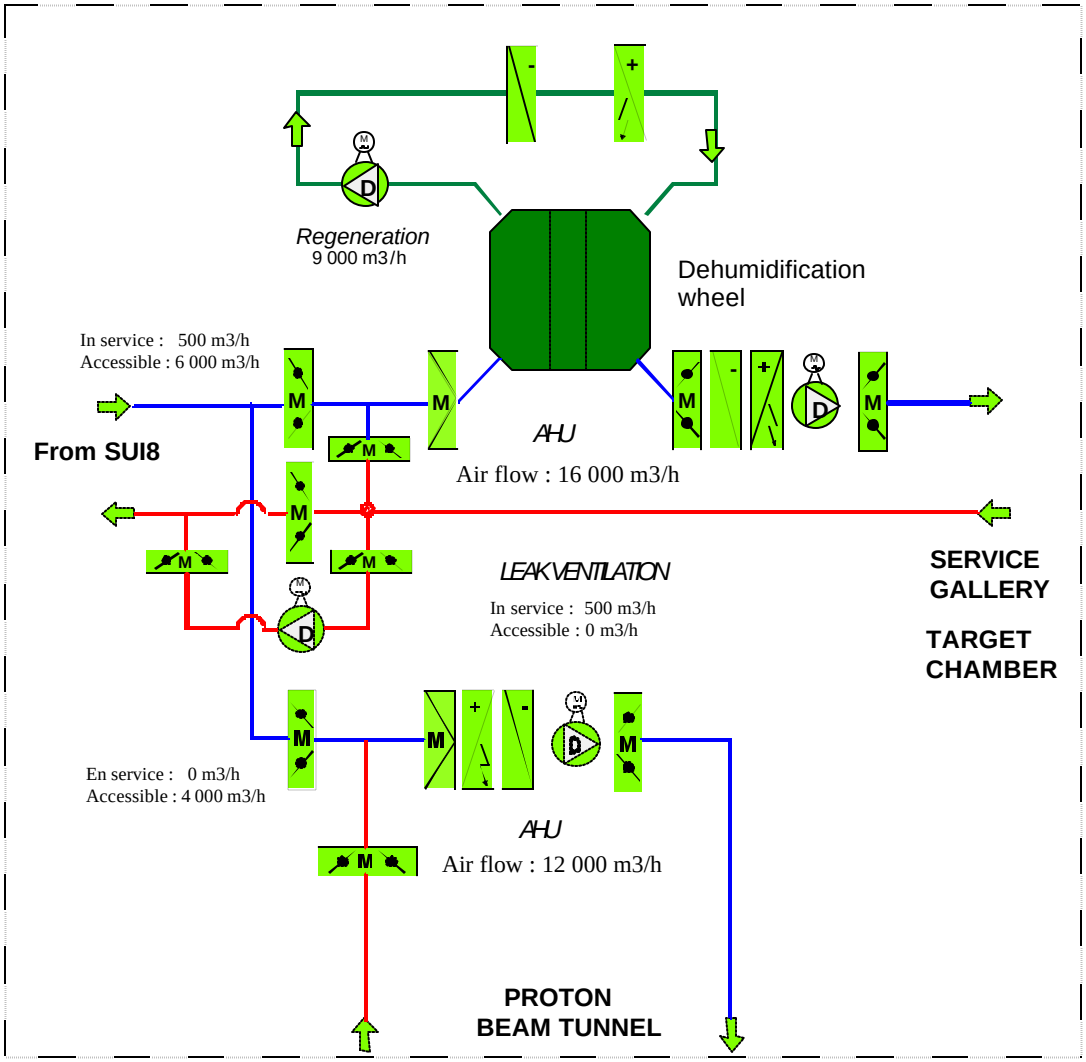

Figure 4: **Equipment in the Ventilation Chamber**

3.6 Hadron Stop and Muon Detector

The Hadron Stop area consists of two separate chambers, the hadron stopper chamber and the muon detector chamber. The Hadron Stop is intended to stop all protons that have not interacted in the target or horns. The Muon Detector are used for checking the position of the neutrino beam by measuring the trajectory of the muons.

The objective of the ventilation is to ventilate the the different structures of Hadron Stop area by taking air from the TI8 tunnel and pulsing it to the hadron and muon chambers. The air comes back to TI8 through the access tunnels by overpressure. A dedicated equipment area will be built in the junction with the TI8 tunnel. All the ventilation equipment will be placed there. For ventilation there will be one two speed supply air fan and for smoke extraction two extractors equipped with filters.

During the machine operation the supply air fan will operate at half speed. When the area is accessible the ventilation works at full speed.

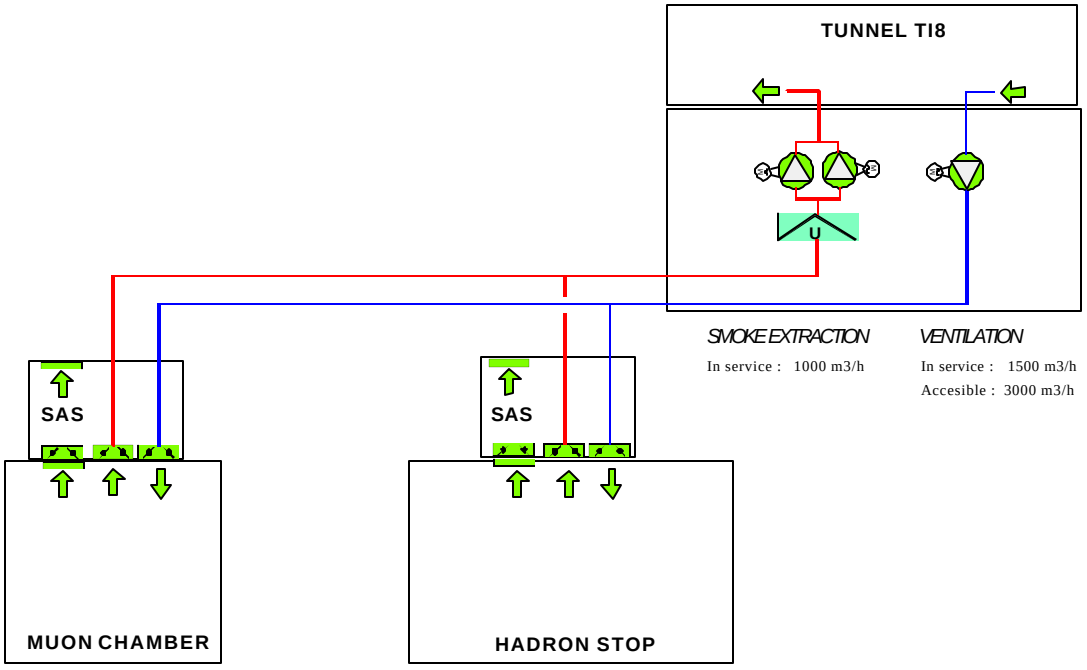

Figure 5: **Ventilation of Hadron Stop area**

4 OPERATING MODES

4.1 Machine Operating

When the machine is working the AHU's for Target Chamber and Proton Beam Tunnel operate in 100% recirculation mode. No fresh air is supplied from SUI8. A small (500m3/h) leak air flow is extracted from the Target Chamber and pulsed to the Access Gallery TAG41 from where it is extracted to the outside by a dedicated fan in SUI8.

The 2 dedicated cooling units for Target Chamber are operational.

The access tunnels are not ventilated.

The supply fan for Hadron Stop area will be operating in half speed (1500m3/h).

4.2 Machine Accessible

When the machine is accessible, the AHU in the SUI8 will supply pre-treated (heating/cooling) fresh air to the air handling units in the Ventilation Chamber. Part of the fresh air is pulsed in the Access Gallery TAG41. The extraction unit in SUI8 will be operating.

The 2 dedicated cooling units for Target Chamber are stopped.

The access tunnels are ventilated.

The supply fan for Hadron Stop area will be operating in full speed (3000m3/h).

4.3 Smoke Extraction

The smoke extraction will be started manually by the fire brigade. The system is divided into several zones. The Access Gallery, Proton Beam Tunnel, Target Chamber and Service Gallery will be separate zones. Hadron Stop area is treated with its own system.

In the case of smoke extraction, the dedicated extraction unit in SUI8 starts to operate and by means of opening and closing of dampers the extraction is concentrated in the zone in question. The supply air unit serving the fire area will be shut down. The unit serving the adjent areas will continue to operate supplied by the fresh air unit in SUI8 to create overpressure in these areas.

In case of a smoke extraction in one the Hadron Stop area, the supply air fan will overpressurise the safety SAS in the entrance to the chamber, the fire dampers will close and the smoke extractors will suck the smoke, filter it and blow it to the TI8 tunnel.

5 CONTROL AND REGULATION

The local monitoring, control and communication architecture for these facilities will keep homogeneity with other local monitoring systems existing at CERN.

5.1 Principle of the Control System

The control and operation of the installations is done by a PLC located in the SUI8 building. The systems are supervised by means of a laptop computer, locally connected to the PLC or remotely through the network. This control and monitoring PLC will be linked to the CERN Ethernet TCP/IP Services network. The whole of the mimic diagrams and of alarm list from the monitoring station are available remotely by the Ethernet TCP/IP Services network.

The installations shall be integrated in the remote monitoring system of the CERN Technical Control Room by means of the CERN Services Ethernet TCP/IP network by using the equipment controller module. The Technical Control Room (TCR) is responsible for the overall supervision of the CERN technical infrastructure. The Technical Data Server (TDS) will integrate all the data coming from the different systems as cooling and air conditioning, control and safety systems, etc. This data is then available for equipment responsible and other CERN control rooms.

6 HEATING AND COOLING

6.1 Heating

The energy used for heating the fresh air and post treatment in the units will be electricity. The coils will get their supplies from the general services network. A thyristor will regulate the power of each coil.

6.2 Cooling

A dedicated chilled water station will be built for CNGS installations. This station will be located in the existing surface building 930. The units will be supplied with water at 6/12°C. Chilled water is used for cooling and dehumidification.

7 CONCLUSION

This document defines the technical concept of different ventilation and air-conditioning installations dedicated to the CNGS structures. The various criteria (ambient conditions, internal heat loads,

operating modes and security) that will be definitively defined by the groups in charge of the machine and related equipment, will allow the preparation of the technical specification and the call for tender in 2003. The installations will be operational in summer 2005.

REFERENCES

[1] General description of the CNGS project, 2000

[2] Technical Specifications LHC

[3] ASHRAE Handbooks