High Expansion Foam System Requirements for CMS and ATLAS

General rules according ti NFPA 11A and Règle APSAD R12:

1) All piping to each foam generator shall be subjected to a 2-hours hydrrostatic test at 200psi or 50 psi in excess of the maximum pressure anticipated, wichever is greater.(NFPA 11A- 1-8.4.2)

2) Inspection and tests at least annually by a competent engineer inspector.(NFPA 11A- 1-13.1)

3) The minimum total depth of foam shall be not less than **1.1** times the heigh of the highest hazard but in no case less than 0.6 m over this hazard. (NFPA 11A- 2-3.2.1). In our case we will t **1.1**

4) Compensation factor (C_N) for normal foam shrinkage shall be **1.15** (NFPA 11A- 2-3.5.2) if no other experimental values are available, but from J.Fivet tests we got a factor C_N**=** **1.4**

5) Compensation factor (C_d) for foam destruction by heat and smoke (this comes from CERN tests on polluted air at the fan inlet that can destroy the growing bubble of foam) shall be: **1.2**

6) Compensation factor (C_L) for loss of foam **1.2** (NFPA 11A- 2-3.5.2) for ATLAS that has a big free volume inside the muon chambers. For CMS previous calculations did not considered the trenches underneeth the detector and took this factor equal to 1! I think also CMS should take **1.2**

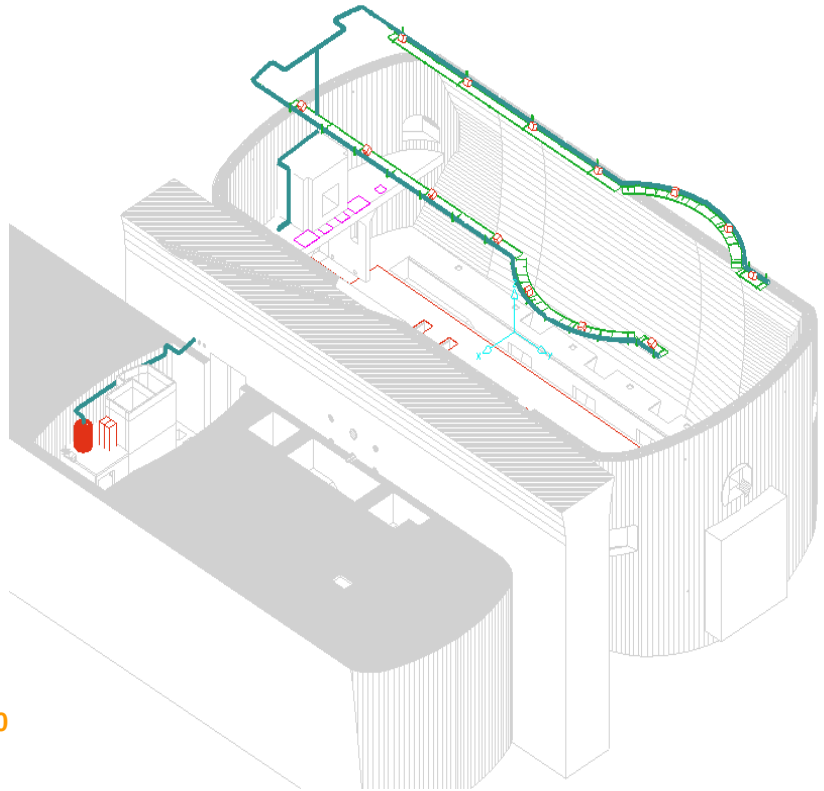
7) The maximum flooding time should not exeed: **10 min**

According to those rules the total flow rate of foam needed should be calculated by the following equation:

$$D=(V/t)*C_N*C_d*C_L$$

CMS

Total Cavern volume	25000 m^3
Volume above the fire denger height(25m*50m*2m)	2500 m^3
Detector volume	6000 m^3
Volume to be filled	**16500** m^3



Foam Flow rate: D=(19000/10)*1.4*1.2*1.2

D= 3326.4 m^3/min

Most common High Expansion Foam have an expansion factor of 600

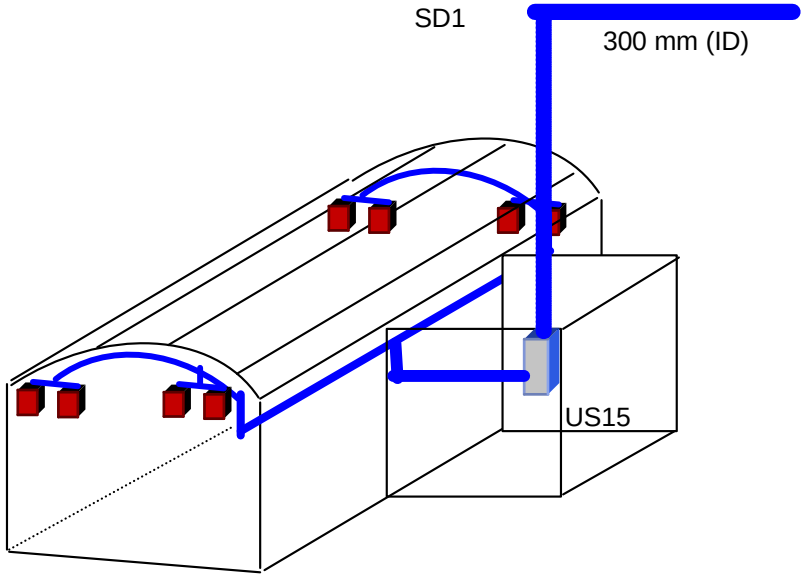
Therefore the before the generation of the foam the flow rate should be of: **332.64 m^3/h**

ATLAS

Volume of the cavern (24m*1.1*43m*30m)	34056 m^3
Various Equipment Volume	2500 m^3
Detector volume	13500 m^3
Volume to be filled	**18056** m^3

Foam Flow rate: D=(19000/10)*1.4*1.2*1.2

D= 3640.1 m^3/min



Most common High Expansion Foams have expansion factor of : 600

Therefore the before the generation of the foam the flow rate should be of: **364.01 m^3/h**

Water flow rate needed

The various firme are usually working with proportioning ratio ranging between 2 and 3 % . This is the percent of concentrated foam liquid in water.
Considering the most critical case (2%) that is the one requiring the largest amount of water we come to: the following flow rates needed :

CMS: 325.99 m^3/h
ATLAS: 356.73 m^3/h

Pressures needed

The highest the pressure is the best it is! A pressure of 8 bar at the inlet of each foam generator seems to be the best compromise for most of the firms but can fullfil our flow rates requirements also with 6 bar. Others firms are requiring a maximal pressure of 6 bar.

SOLUTIONS
1) If the water comes from the surface the 100 m water column give enough pressure to provide the solution at 8 bar
2) If the LHC uncutted line is provided at 6 bar but in the underground a pump is needed.

Pressure drop Calculation for solution 1):

ATLAS:

6	bar driving pressure in the water line.
-1	bar of pressure drop between inlet and outlet of the bladder (still to be decided if it will be in SD1 or US15)
-0.4	bar of pressure in 120m (from surface to underground) of 300mm (ID) pipe (already installed!)
9	bar of hydrostatic pressure on 90m of fall
-2	bar of pressure drop in 30m of 170mm pipe between the bladder (or 300mm pipe in US15) and the branching in UX15.
-3.3	bar of pressure drop in each one of the two branches of different diameter to have equal flow in the two lines. Each line is 30 m long and the pipes diameter is 120mm.
-1.3	bar in the two final sections. Each one of these section is composed by a main pipe (20m of 110 mm pipe) and the four branches feeding the blowers (two/corner, 2m long and 80 mm)
7	**bar at each fan inlet**

TOTAL