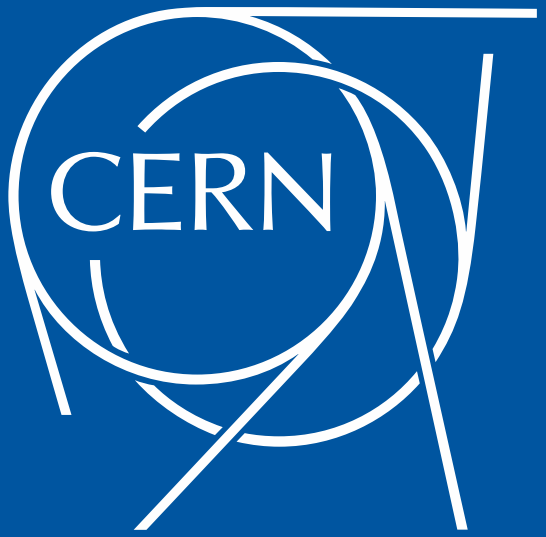

CERN

Feedback from POPS-B explosion analysis

LIU-PSB Meeting 186 07 February 2017

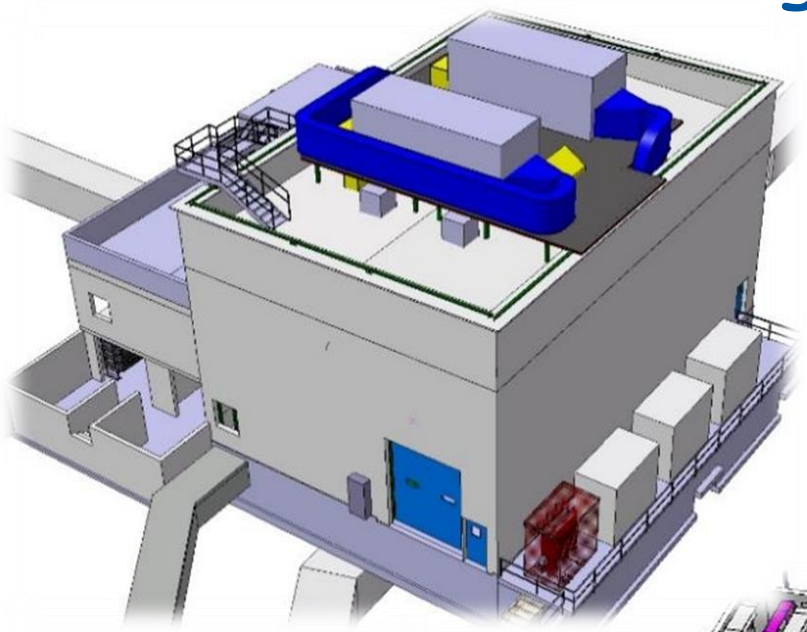
Fulvio Boattini TE/EPC

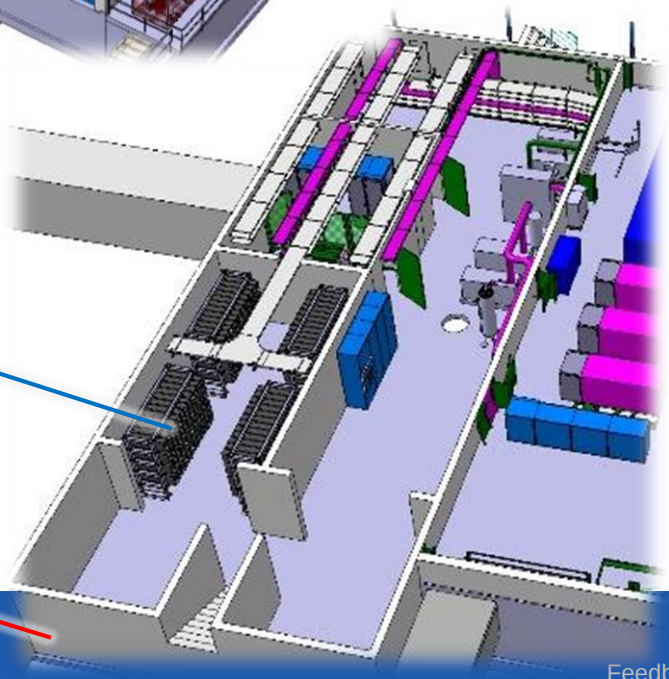
Recall

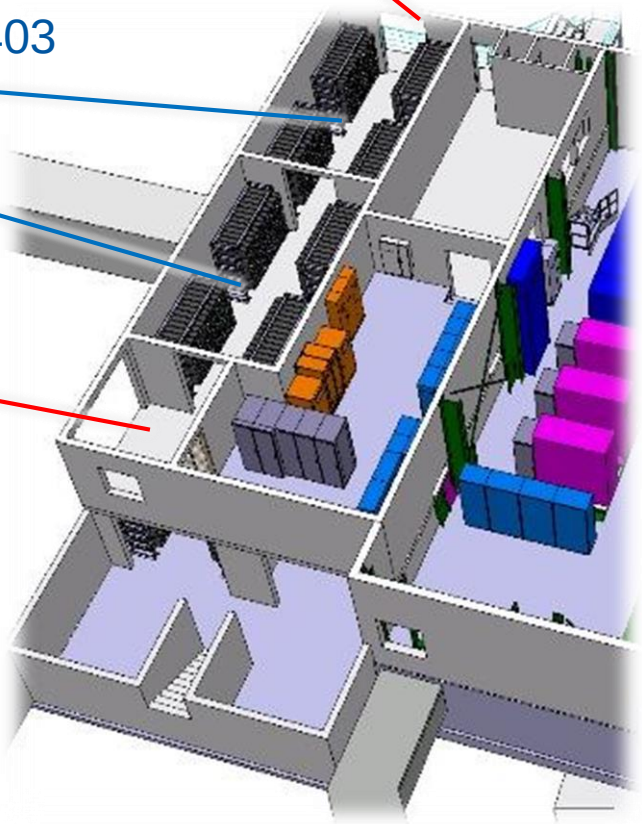
April 2016: POPS storage capacitors went short circuited. An explosion resulted

POPS-B storage capacitors are in a building. An explosion risk analysis was triggered in November 2016.

B245 Storage capacitor location







Stairs

Room: R-403

Room: R-401

Entry area

Room: S-401

Parking area

B245 Explosion risk: aim of the Study

- Determine the effect of the explosion of one capacitor on the concrete structure;

- Eliminate all risks for personnel. Inside and outside the B245;

- Minimize effects on equipment. Restart after one explosion.

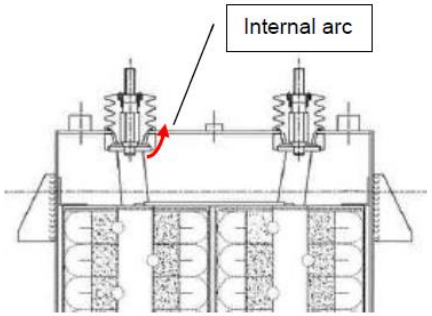
Analysis performed by external consultant: FCSolutionS

B245 Explosion risk: the approach

- A short circuit in the capacitor generates an arc;

Arc Energy calculation

Arc length: 50 mm
Arc voltage: 400 V



- The arc turns oil into gas (1lt -> 100kJ);

Gas type and quantity calculation

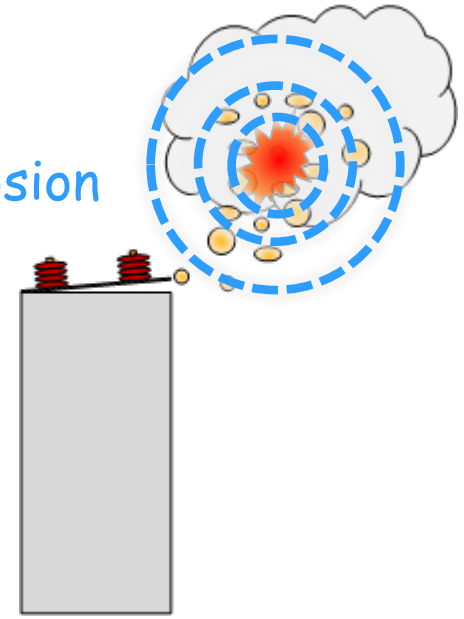
$$C_{10}H_{22} = 10.60H_2 + 0.06CH_4 + 0.23C_2H_2 + 0.02C_2H_4 + 9.43C$$

- Gases exit from capacitors and lead to secondary explosion;

Gas burning and CFD simulation

Ignition source

Secondary explosion

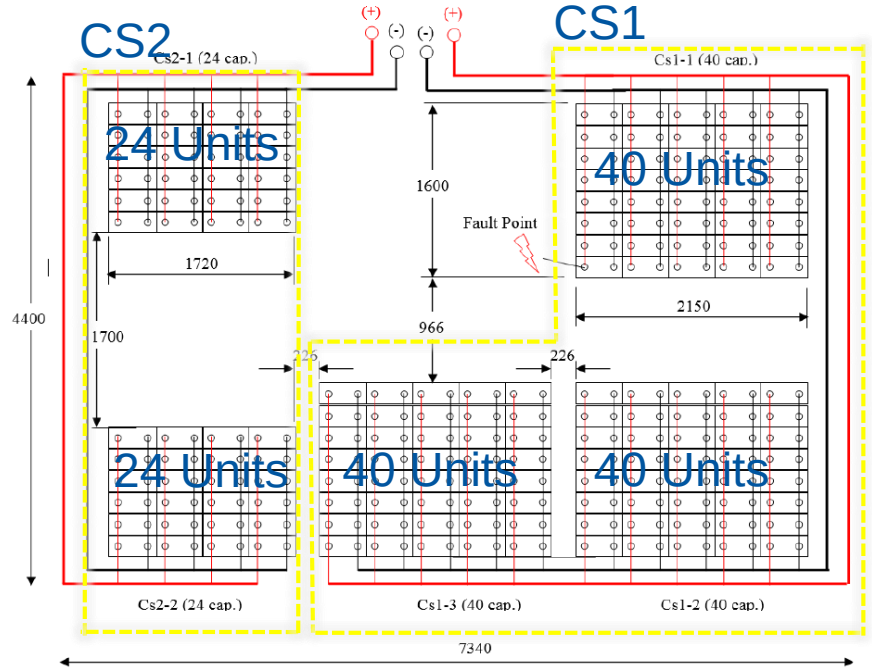


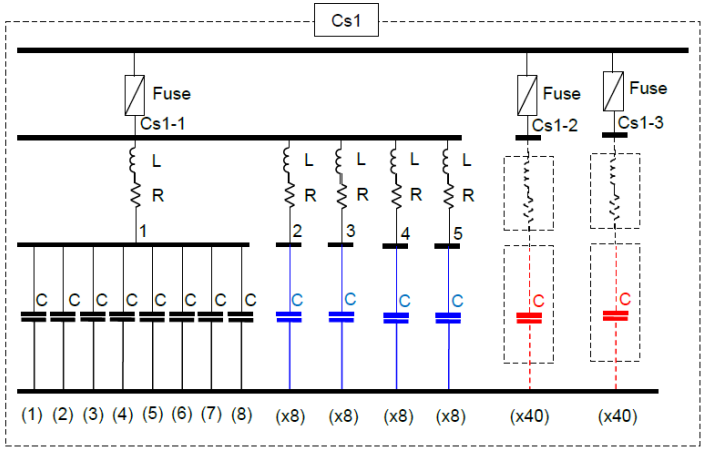
- Secondary explosion generates pressure wave in the room.

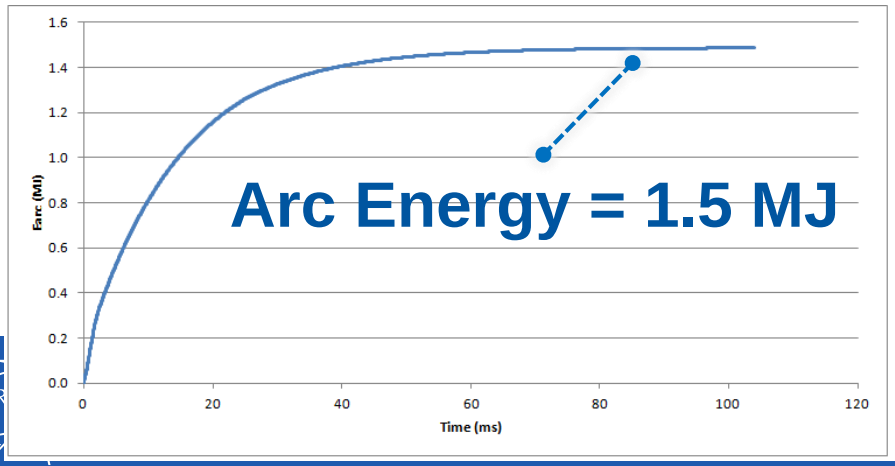
Structural analysis of concrete

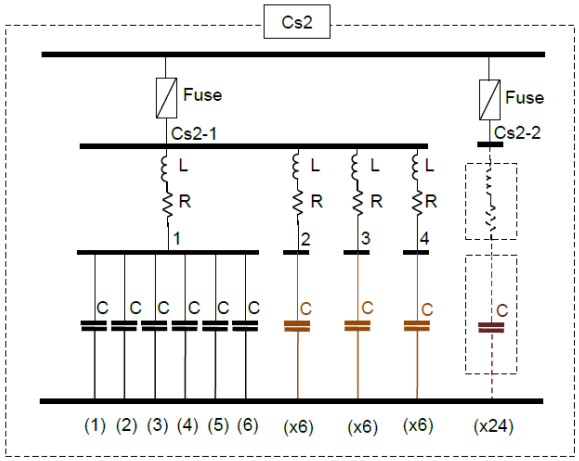
Arc Energy calculation

168 capacitor units divided into 5 blocks each protected by a single fuse.









Gas type and quantity calculation

Dati di base definizione scenario		
energia d'arco	1.50	MJ
Rapporto energia olio/gas (decano eq)	0	

COMPOSIZIONE MISCELA		
Gas	***%Vgas***	***%Vtot***
Idrogeno	73.0	12.377
Acetilene	20.7	3.510
Metano	3.5	0.593
Etilene	2.1	0.356
Decano (olio eq)	0.000	0.000

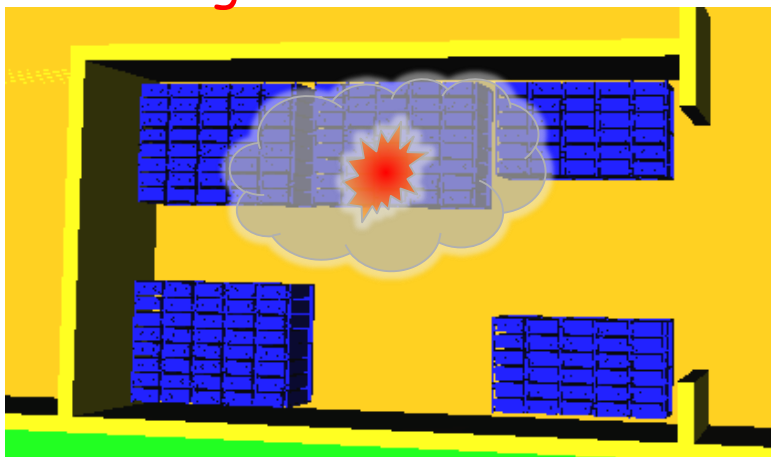
COSTANTI FISICHE		
Vol/Amount	22.415	m3/Kmol
rapporto VolN2/VolO2 in aria	3.83	

Mainly Hydrogen and Acetylene

Gas burning: "Well mixed"

- "Well mixed" approach;
  - "All the flammables produced during the primary explosion (hydrocarbons and oil mist) are supposed to come out from the enclosure and be perfectly mixed with air at stoichiometric concentration and ambient pressure"

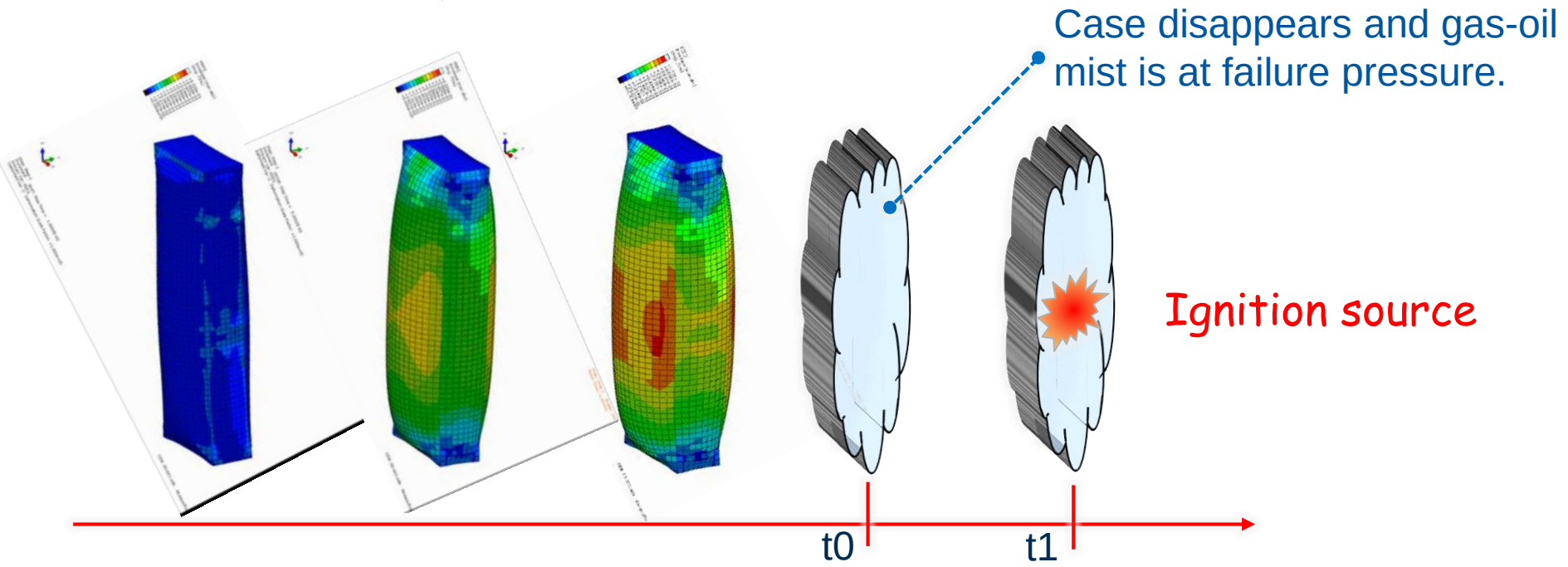
Ignition source



The gas-oil mist cloud is placed on top of capacitors and ignited

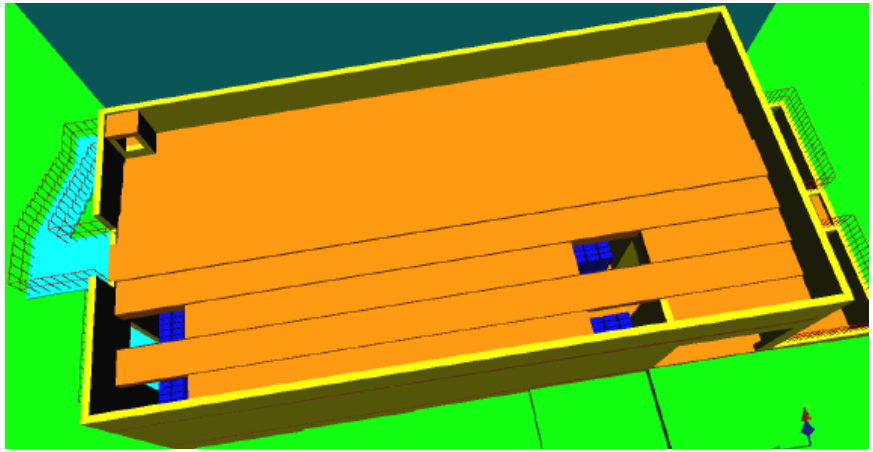
Gas burning: "Burst"

- "Burst" Approach;
  - "The enclosure is supposed to instantaneously disappear at failure pressure value (30bar). All flammables produced during the accident and the primary explosion phase (hydrocarbons and oil mist) are compressed in an initial volume, at pressure equal to failure pressure of the enclosure, and 100% concentration"

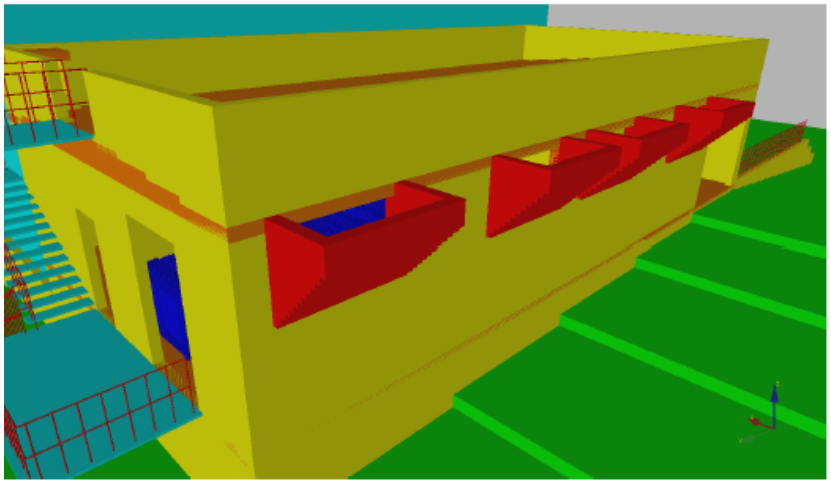


Gas burning: Results

Vents on the roof 2 x 1mt x 2mt (per room)



Vents on the side 2 x 1mt x 2mt (per room)



digit	#1	#2	#3	#4	#5	#6
value	faultcell	geometry	approach	cloudpos	ign delay	oil x
0		current	setup P30		no ignition	0
1	R401	vent1roof	standard	low-left	5msec	1
2	R403	vent2roof	setup P15	low-right	10msec	2
3	S401	vent1wall		up-right	20msec	4
4		vent2wall		up-left	40msec	8
5		shield1		central		16
6		shield2				
7		bunker				
8						
9						

Six parameters sensitivity analysis: 60 analysis in total

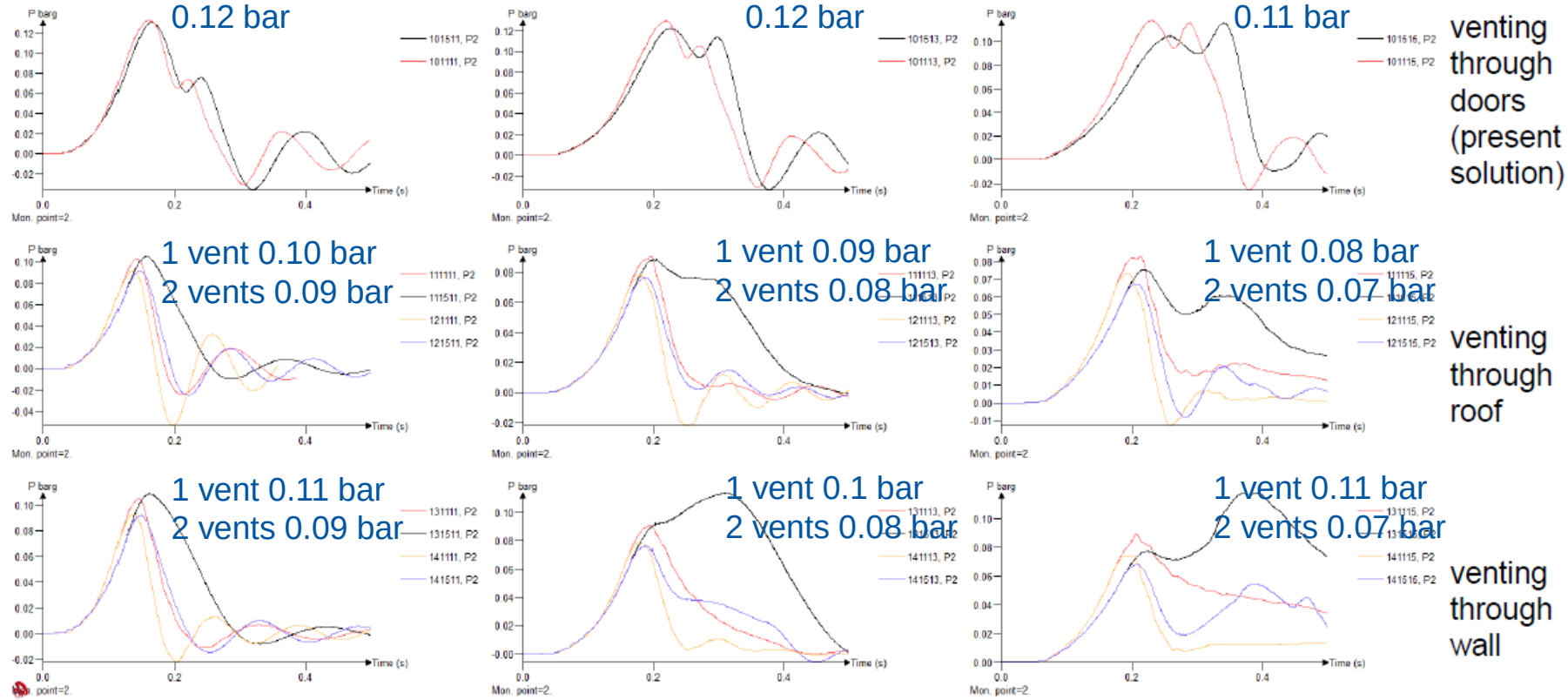
Gas burning: Results

"Well Mixed" room R-401.
With Vents, doors are replaced with blast resistant doors.

Results - Sensitivity on oil mist amount and venting scheme

- both 1 and 2 vents; well mixed approach

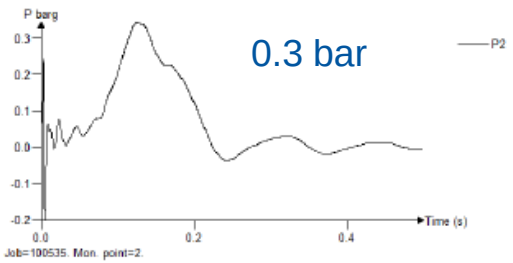
	oil x1	oil x4	oil x16	
	0.12 bar	0.12 bar	0.11 bar	venting through doors (present solution)
	1 vent 0.10 bar 2 vents 0.09 bar	1 vent 0.09 bar 2 vents 0.08 bar	1 vent 0.08 bar 2 vents 0.07 bar	venting through roof
	1 vent 0.11 bar 2 vents 0.09 bar	1 vent 0.1 bar 2 vents 0.08 bar	1 vent 0.11 bar 2 vents 0.07 bar	venting through wall



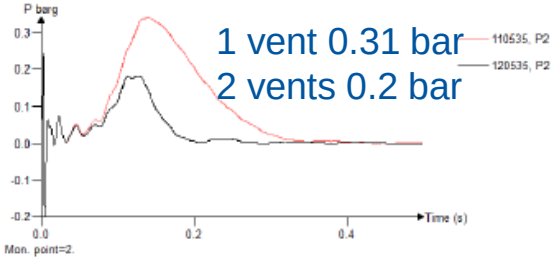
Gas burning: Results

"Burst" room R-401.
With Vents, doors are replaced with blast resistant doors.

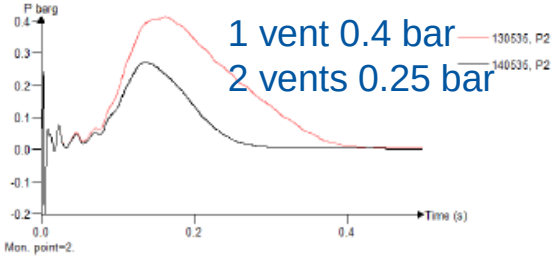
oil x16



venting through doors (present solution)



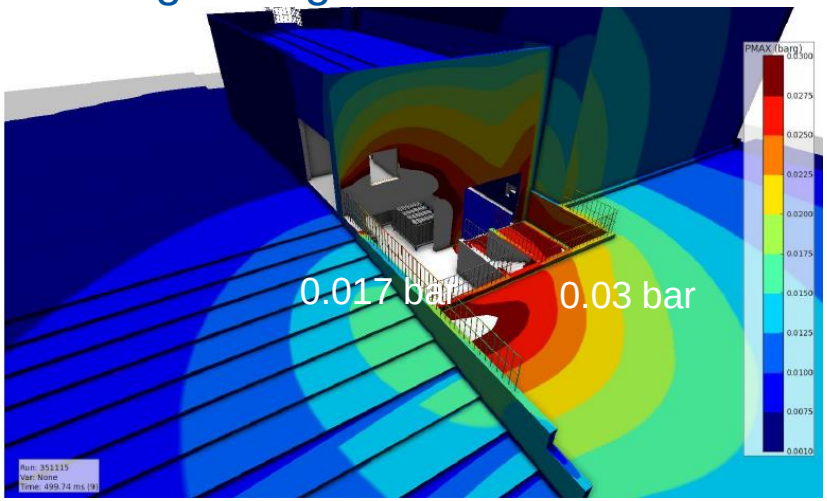
venting through roof



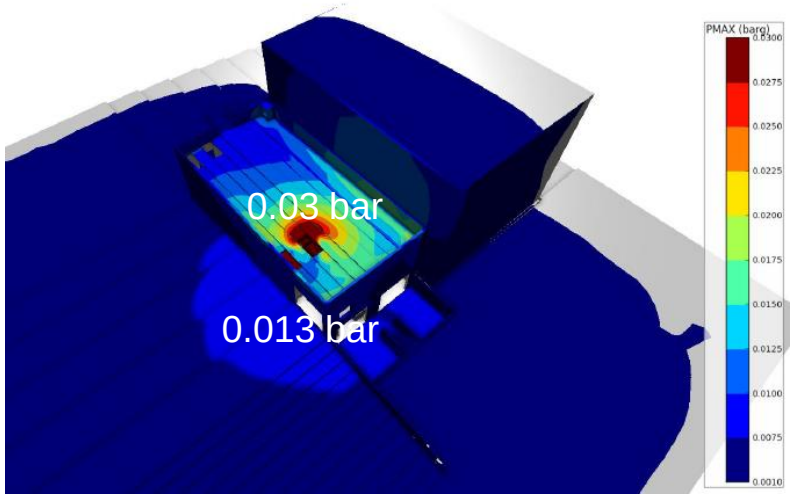
venting through wall

Gas burning: Results

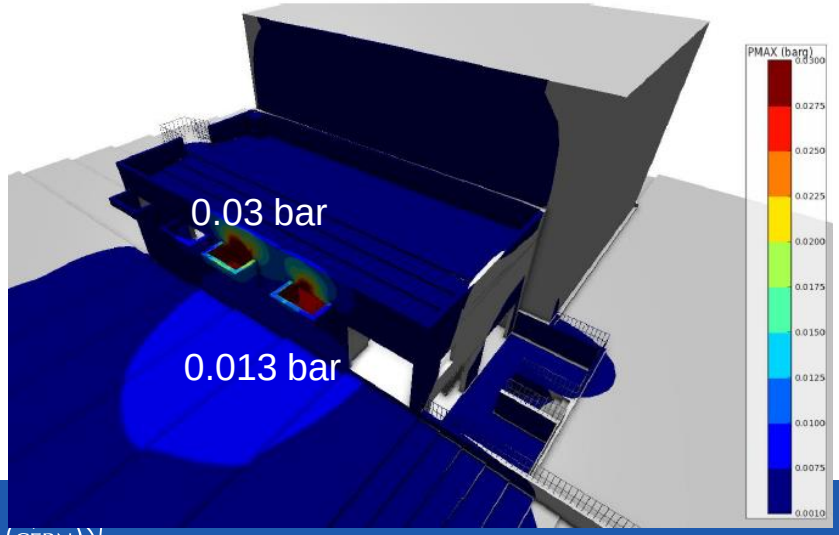
Venting through doors S-401



Venting through roof R-401 R-403



Venting through walls R-401 R-403



Direttiva Seveso 82/501/CEE

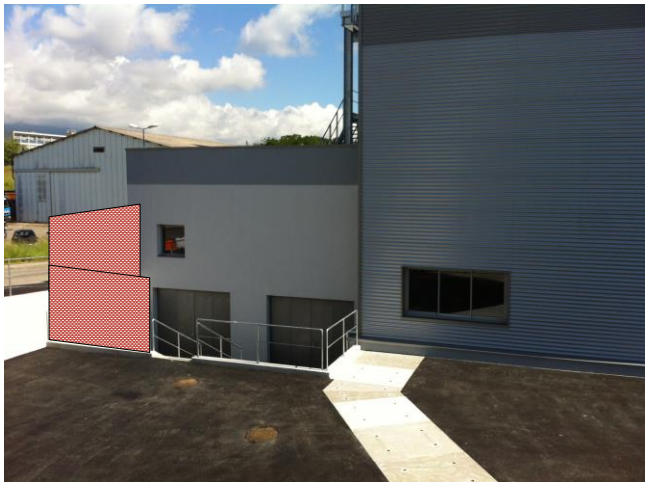
Level	Stationary Radiation	Non – stationary Radiation	Overpressure
No effect	1,6 kW/m^2		
Small effects	< 3 – < 5 kW/m^2	< 125 kJ/m^2	< 30 mbar
Reversible effects	< 3 – < 5 kW/m^2	125 – < 200 kJ/m^2	30 - < 50 mbar
Irreversible effects	5 – 7 kW/m^2	200 - 350 kJ/m^2	50 – 140 mbar
Lethality	> 7 kW/m^2	> 350 kJ/m^2	> 140 mbar

Venting through doors S-401 requires a wall.

Venting through walls R-401 & R-403 is better.

B245 Explosion risk: first conclusions

- Room S-401 is vented via the door;
  - A containment wall for people safety;



- Venting from the walls seems the best option for R-401 & R-403;

- Capacitor room doors replaced with blast resistant;

B245 Explosion risk: Planning

Complete on February 2017

- Choice of venting device and final dimensions;
- Structural analysis of the concrete structure;

Complete on April 2017

- As built drawings of modifications following explosion analysis;
- Specification of modification required by CV;

Complete on Septembre 2017

- Realization of all B245 modifications by a general contractor coordinated by SMB

CB: 76805 ?

Thank you for your attention
Questions ?