



Einstein Telescope
2nd SPB WORKSHOP
Security issues for underground infrastructures
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Security issues for underground infrastructures

Reference legislation does not adequately adapt to the ET

FIRE SAFETY

WORKER SAFETY

CRYOGENICS PLANTS

ELECTRIC PLANTS

ROAD AND RAILWAY TUNNELS

UNDERGROUND AND METROPOLITAN WORKS

a Risk Analysis and event simulation must be implemented for ET's safety strategy

Risk Analysis: what are the main risks to analyze?

➤ On Surface:

- cryogenic liquids hazard
- Fire and explosion
- Standard security issues

➤ Tunnel:

- Laser hazard
- Vacuum system hazard
- Radon
- Fire and explosion
- Standard security issues

➤ Caverns:

- cryogenic liquids hazard
- Laser hazard
- Vacuum system hazard
- Radon
- Fire and explosion
- Standard security issues

➤ Floods

Risk Probability Definition

- The risks can be assessed according to the P-I (Probability – Impact) model [Aven, 2016]
 - ❑ the risk is the result of the combination of the probability or frequency of occurrence of an unwanted event and the extent of the consequences it could cause
 - ❑ a numerical value representing the level of risk associated with an event is usually calculated by multiplying the frequency and severity values of the consequences.

Aven T., Risk assessment and risk management: Review of recent advances on their foundation, European Journal of Operational Research, Volume 253, Issue 1, 2016, Pages 1-13.

Event Probability Definition

Level	Probability (P)	Definition
1	Unlikely	$P=0$ The event is almost impossible
2	Remote	$P < 10^{-6}$. It is possible to assume that the event should not happen along the lifetime of the infrastructure
3	Occasionally	$P > 10^{-6}$. The Event can be considered improbable along the lifetime of infrastructure
4	Probable	$P > 0.001$. The Event may happen more than once along the lifetime of the infrastructure
5	Frequent	$P > 0.1$. The Event is supposed to happen frequently

Event Impact Definition

Level	Impact (I)	Target	Definition
1	Negligible	People	Minor injury. No first aid needed.
		Goods	No damage
		Environment	No damage
2	Marginal	People	First aid needed. Short recovery time.
		Goods	Maintenance needed.
		Environment	Minimal effects
3	Critical	People	People seriously injured, with chronic damage and possible victims
		Goods	Serious damage to property, interruption of system operativity and no more access to the buildings
		Environment	Medium-term effects
4	Catastrophic	People	Multiple serious injuries or more than one victim
		Goods	Extremely serious and extensive damage to property, system operations no more possible, no more access to the buildings
		Environment	Long-term effects

Risk Matrix

Risk Characterization		Impact (I)			
		1.Negligeble	2.Marginal	3.Critical	4.Catastrophic
Probability (P)	1. Unlikely	1	2	3	4
	2. Remote	2	4	6	8
	3. Occasionally	3	6	9	12
	4. Probable	4	8	12	16
	5. Frequent	5	10	15	20

Risk Level Assessment

Points	Risk acceptability
1-5	Acceptable risk but all possible measures must be taken to further reduce it. Conditions that could contribute to the occurrence of the event should be monitored.
6-9	Appropriate risk reduction measures must be established and their monitoring must be implemented.
10-20	Unacceptable risk. The activities cannot proceed/be started until the prevention, protection and emergency management measures have been planned and implemented.

Emergency ventilation

in case of fire: emergency ventilation must remove smoke

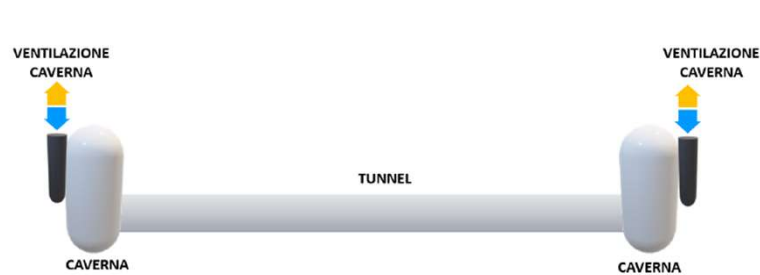


Figura. Sistema di ventilazione di tipo push and pull per le opere in sotterraneo



Figura 9. Ipotesi di incendio in una caverna



Figura 8. Funzionamento del sistema di ventilazione longitudinale in caso di incendio nel tunnel

in case of fire:

When does emergency ventilation start?

How much air does emergency ventilation move?

a simulation of the events must be implemented!

Emergency Escape

in case of emergency: staff has escape strategy, and safe places

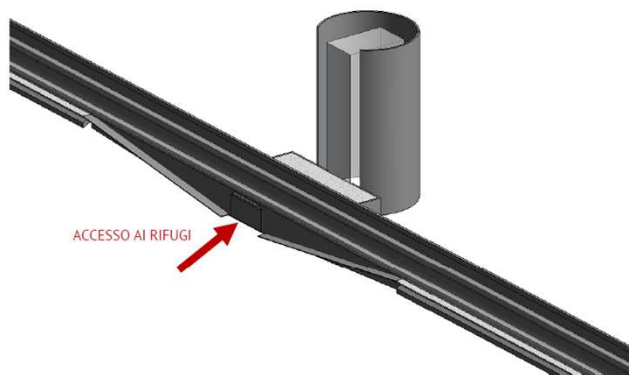


Figura 12. Accesso ai rifugi con e senza ascensore mediante abbassamento del piano di calpestio

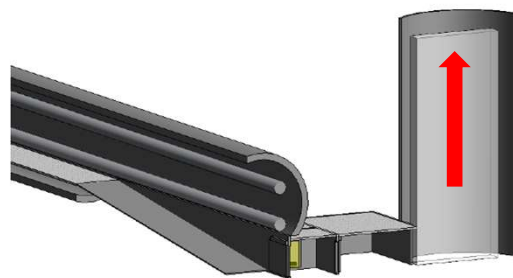


Figura 15. Sezione del tunnel in corrispondenza del rifugio con ascensore

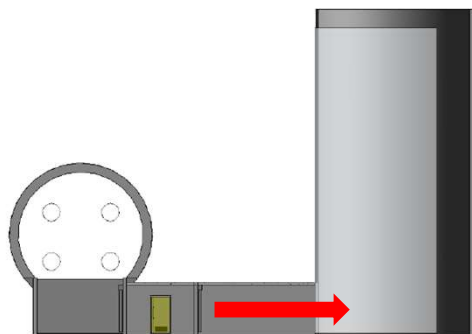


Figura 17. Sezione trasversale tunnel in corrispondenza del rifugio dotato di ascensore

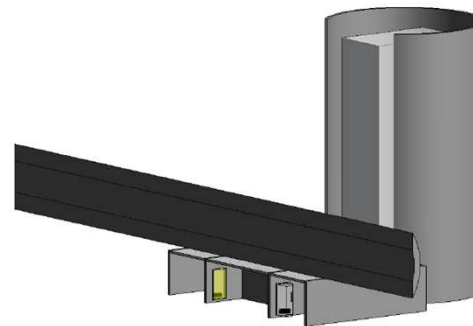


Figura 16. Sezione della zona filtro con eventuali locali tecnici ai lati

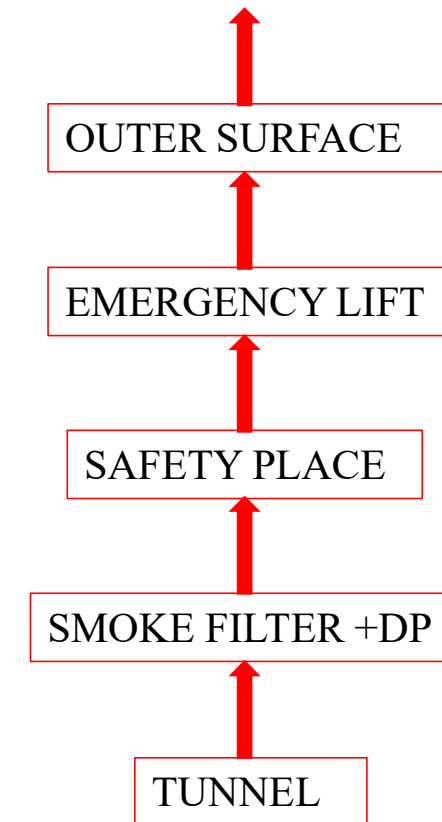
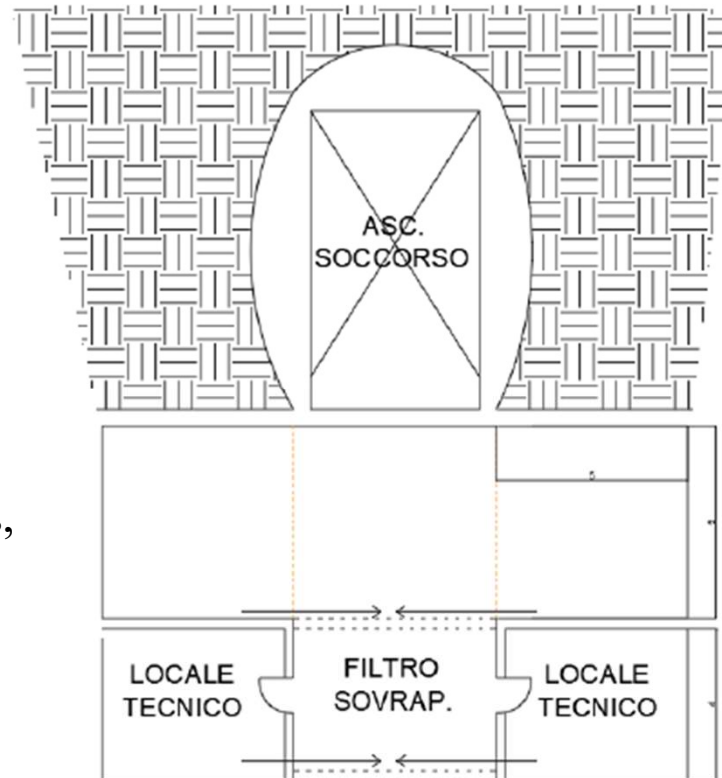
The staff can safely:

- escape the tunnel,
- enter in a safe place,
- wait for the emergency crews,
- exit to the outer surface.

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Results

	A Protected vehicle	B Not Protected vehicle	C not protected vehicle fire compartmentation
Emergency exits/shafts	every 5 km	every 2,5 km	every 5 km
Safe places	every 2,5 km	every 1,25 km	every 2,5 km
Height -3 m in correspondence with Safe places and emergency exits	yes	yes	yes
Safety masks	No	yes	yes
Staff geolocation	yes	yes	yes
vehicle for ordinary operations	Yes	Yes	yes
vehicle for emergency operations	Yes	No	No
vehicle during fire emergency	Yes	No	No
vehicle maintenance	Yes	Yes	Yes
Safety masks maintenance	No	Yes	Yes
Possibility to drive remotely	Yes	Integrabile	Integrabile
Inspections and small unmanned maintenance activities	Yes	Integrabile	Integrabile