



Technical University of Košice

Institute of Montannistical Sciences and Environment Protection



 FACULTY OF MINING, ECOLOGY, PROCESS CONTROL AND GEOTECHNOLOGY



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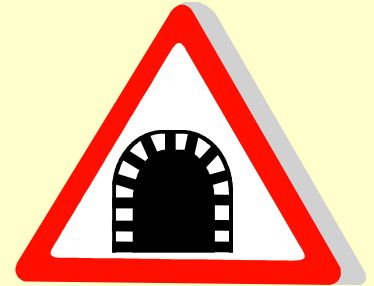
Safety risks and tunnelling systems

St. Peterburg, European Forum 2007



Safety of Underground Construction

- ***Tunnel construction***
- ***Tunnel traffic space***
- ***Safety***
- ***Hazzard*** – unexpected negative effect
- ***Threat*** –disposing to hazzard activate
- ***Risk*** – probability of negative effect and consequence
- ***Risk factorrs*** –technical and human parameters of hazzard affecting objects
- ***Risk analysis*** – hazzard , threat and risk detection
- ***Risk control*** – check of safety system
- ***Risk rating*** – risk procedure assessment by threatment
- ***Acceptable risk*** – operating and human condition risk tolerable



Slovak Legislation in Force

Projecting, equipment and operation of tunnels there are in Slovak Republic in force the following legislative regulations :

- **STN 73 7507 - Tunnel projecting on land roads,**
- **TP 04/2006 - Safety fire of road tunnel,**
- **Act No. 513/1996 Z. z. - About traffic on the land roads**
- **Notice Ministry of Building SR No. 90/1997 Z. z. - About traffic on the land roads**

At the present the legislation regulations in SR does not contain integrated directive focused on tunnel safety only.



EU Legislation Framework

By the year 2010 EU calculate with several legislative modifications
Implementation of safety regulations – generally 60 in the field:

- railway,
- shipping and river transport,
- road and highway traffic,
- combined transport.



EU Instructions

There are several regulations, most important is:

- **INSTRUCTION OF EUROPEAN PARLIAMENT AND COUNCIL 2004/54/ES from 29. April 2004 – Respecting basic safety requirements at tunnels in the transeuropean roads network.**

Instruction enhances the requirements on road and railway tunnels safety.

By 20 articles sets the requirements on tunnel building holding the same tunnel safety over the EU.

Describe the technical requirements for compulsory safety facilities in tunnels longer than 500 m.

STN deals the tunnels at short , middle and long.

Tunnels Safety

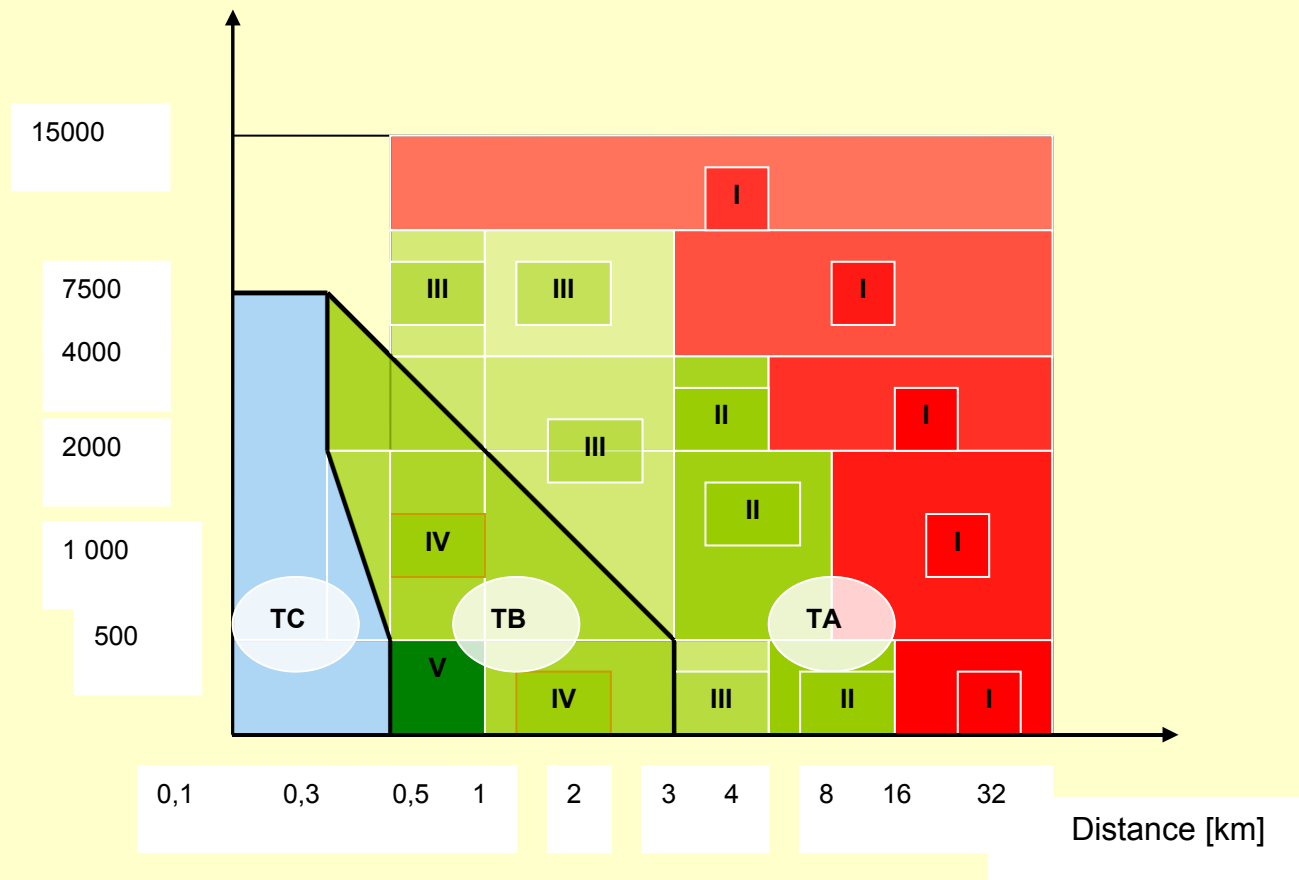
The basic standard for setting the tunnel categories from equipment of safety devices and systems point of view there are two main parameters :

- long of tunnel
- traffic volume

The technical directives of SSC a STN divides the tunnels to the three classes of safety - I., II., III.

- I. a II. class of tunnels – loaded by traffic very strong and long more than 3 km (in Czech Republic are up to category TA)
- III. class of tunnels – are up tunnels under 500 m
- IV. a V. class of tunnels – the category of short tunnels with low traffic volume

Long of Tunnel and Traffic Volume



Tunnel Categories and Safety Facilities

Arise form two main regarding :

- analysis of existing engineering systems by tunnel building and operating
- tunnel utilization

Tunnels safety equipment results from their categorisation and from the decisive factors:

- Tunnel purpose (*traffic, hydrotechnical, watering another*),
- Reason of tunnel construction (*building barriers – under water, ground and other*),
- Tunnel shape and incline (*line building, surface, caverns and other*),
- Building technology (*TBM, deeping, combinated, special another*).

Tunnels Safety Equipment and Categories

Division of underground buildings		Level of safety
Purpose	transport	Middle to higt
	defense	Middle to higt
	Hydrotechnical	Low to middle
	Water environment and healthy	Low to middle
	safety	Low to middle
	special	Middle to higt
Obstacle	mountain	Middle to higt
	deceitfull	Middle to higt
	Civic	Middle to higt
	ecological	Middle to higt
	defence	Middle to higt
Shape and inclination	line	Middle to higt
	areal	Low to middle
	caverny	Low to middle
Technology of building up	drifting	Middle to higt
	deeped	Middle to higt
	combination	Middle to higt
	Realizing of special technology	Middle to higt

Tunelling Methods and Enigneering Systems

Tunelling Methods - standard and modern

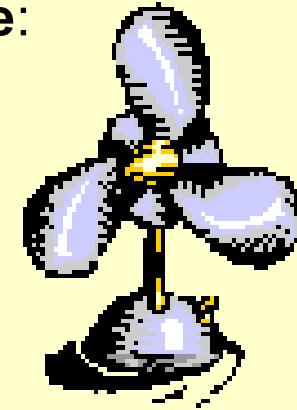
There are seven basic classes according to next table

Basic tunneling system	Dependent tunneling systems
I. Drifting on full fell without reinforce	-
II. Drifting on full fell with reinforcing on full profile	-
III. Drifting with multiple fell without reinforce	-
IV. Drifting with multiple fell with reinforce on full profile	a) fluently b) bord
V. Drifting with multiple fell with shell reinforce	a) nuclear b) underspinning
VI. Drifting moving fell with reinforce on full profile	a) Shield tunneling b) Extruding
VII. Combinate drifting	-

Tunnels Safety and Ventilation

Tunnel ventilation during operation **must insure:**

- pollutants concentration dilution,
- better visibility by tunnel traffic,
- heat and fire smoke impacts reducing,
- controlled tunnel pollutants dispersal
- pollutant load reduction.



By dimension ventilation is considerable regard characteristic delivery cases:

case 1 – ideal case fast moving traffic

case 2 – hanging traffic,

case 3 – in tunnel generate convoy of cars

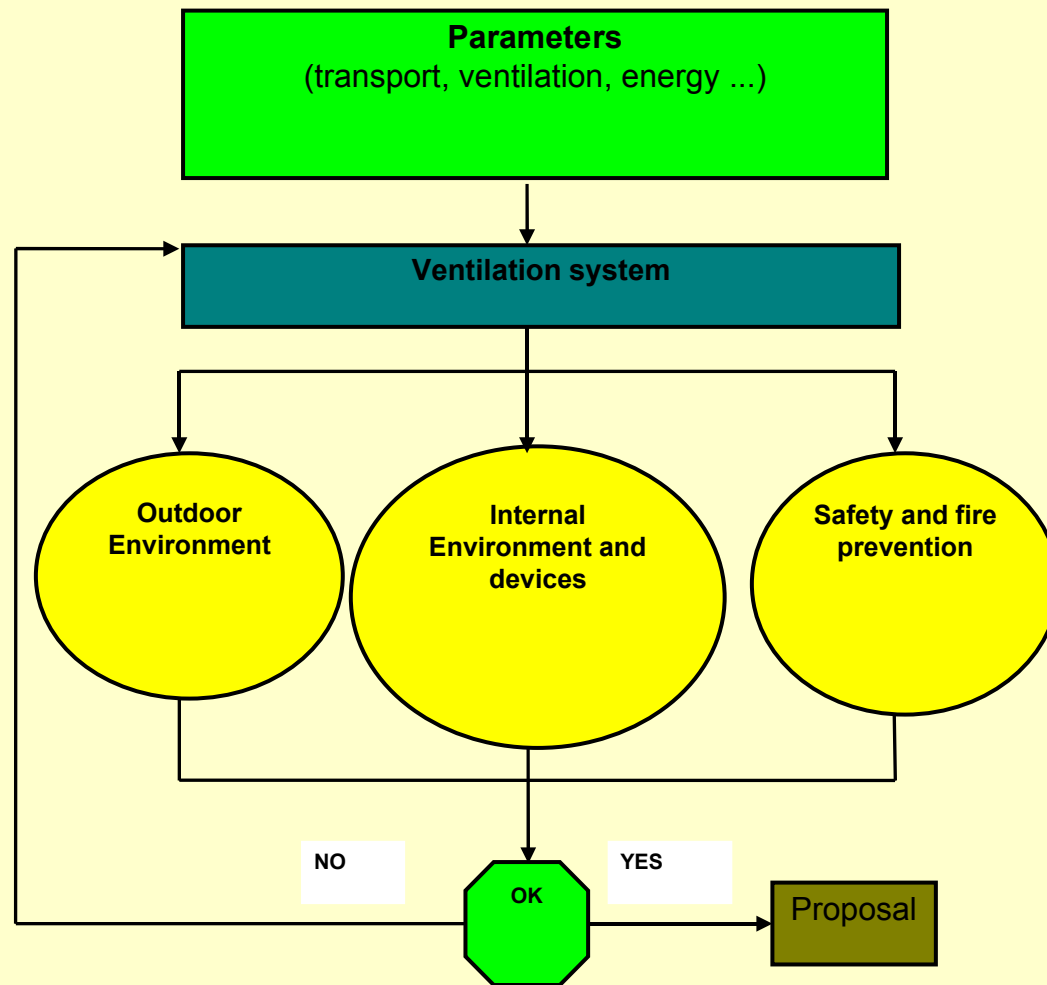
Number of pollutants in tunnel

Number of allowable exhalations planning in SR

Typ vozidla	Cars 2000		Cars 2005		Cars 2010	
	CO (m ³ .h ⁻¹ , voz)	Opacita (m ² .h ⁻¹ , voz)	CO (m ³ .h ⁻¹ , voz)	Opacita (m ² .h ⁻¹ , voz)	CO (m ³ .h ⁻¹ , voz)	Opacita (m ² .h ⁻¹ , voz)
Person cars	0,35	-	0,25	-	0,20	-
Cars diesel	0,08	40	0,05	30	0,02	20
Cargo cars .6t	0,15	95	0,13	75	0,12	60
Cargo cars .10t	0,25	160	0,22	125	0,20	100
Cargo cars.20t	0,40	250	0,35	200	0,30	160
Cargo cars.30t	0,58	370	0,50	290	0,46	230

Quantity of exhalation is minimize with increase of number cars with catalyzators.

Layout of control tunnel ventilation



Technical systems of transport tunnels

- Technical systems of road tunnel
- Technical systems of railway tunnel
- Technical systems of special tunnel's underground tasks

Analysis of technical systems tunnel during plant

During tunnel operation is equipped with technical facilities, that are serve on removal safety risks.

Technological outfit of tunnel:

- Supply of electric energy,
- Ventilation of tunnel,
- Lighting of tunnel,
- Communication and couplers,
- System of videocontrol,
- Transport system,
- Central system,
- Device of SOS call,
- Fire safety,
- Device for maintenance.

Energy system:

- Daily, weekly a yearly consumption of energy,
- Backup of electrical devices.



Vetilation system:

- concentration CO in air,
- opacity,
- temperature and presure of air in tunnel,
- direction and size of flow air.

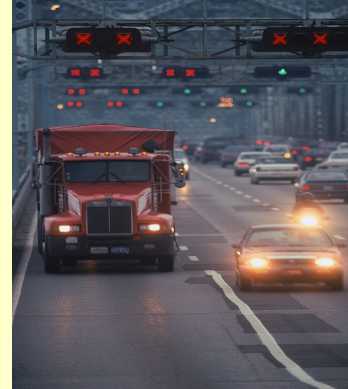
Lighting:

- preclusion of lighting,
- restriction vibration of light,
- Light technical characteristics.



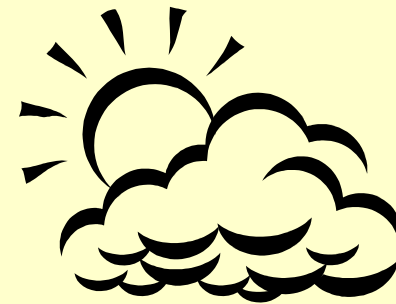
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- **Transport system:**
- Static and dynamic transport model,
- Data about transport in tunnel,
- Composition of transport,
- Daily, weekly and yearly number of cars,
- Intensity of transport.

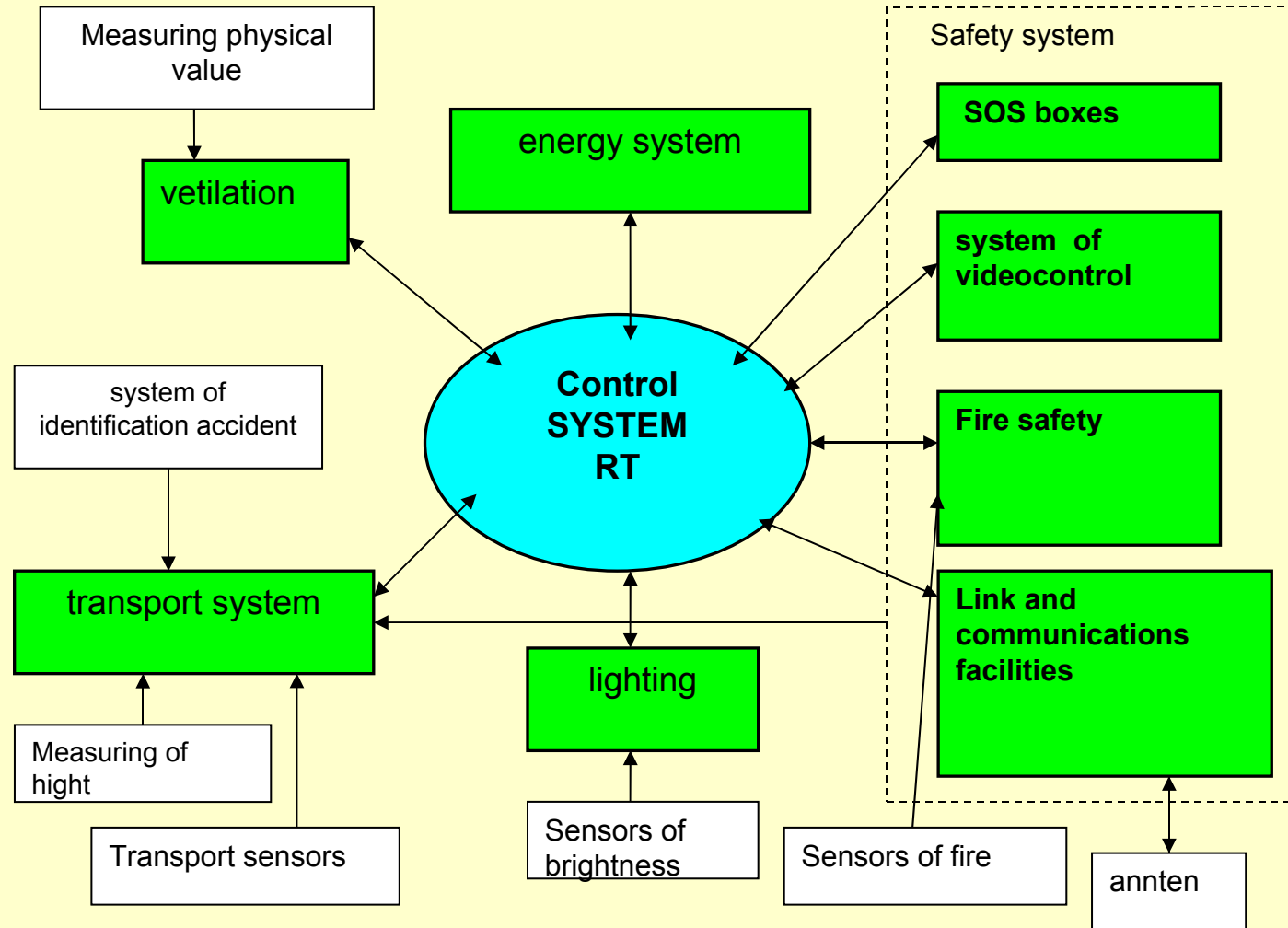


- **Safety system:**
- Function SOS box, coupler devices a videocontrol,
- Fire safety.

- **Outdoor environment:**
- Atmospheric condition around tunnel,
- Meteorological condition around tunnel,
- Environmental condition around tunnel,
- Temperature and pressure of air before enter into tunnel,
- Intensity of sun brightnees on portal.



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Incorporation control systemu of tunnela to hight whole

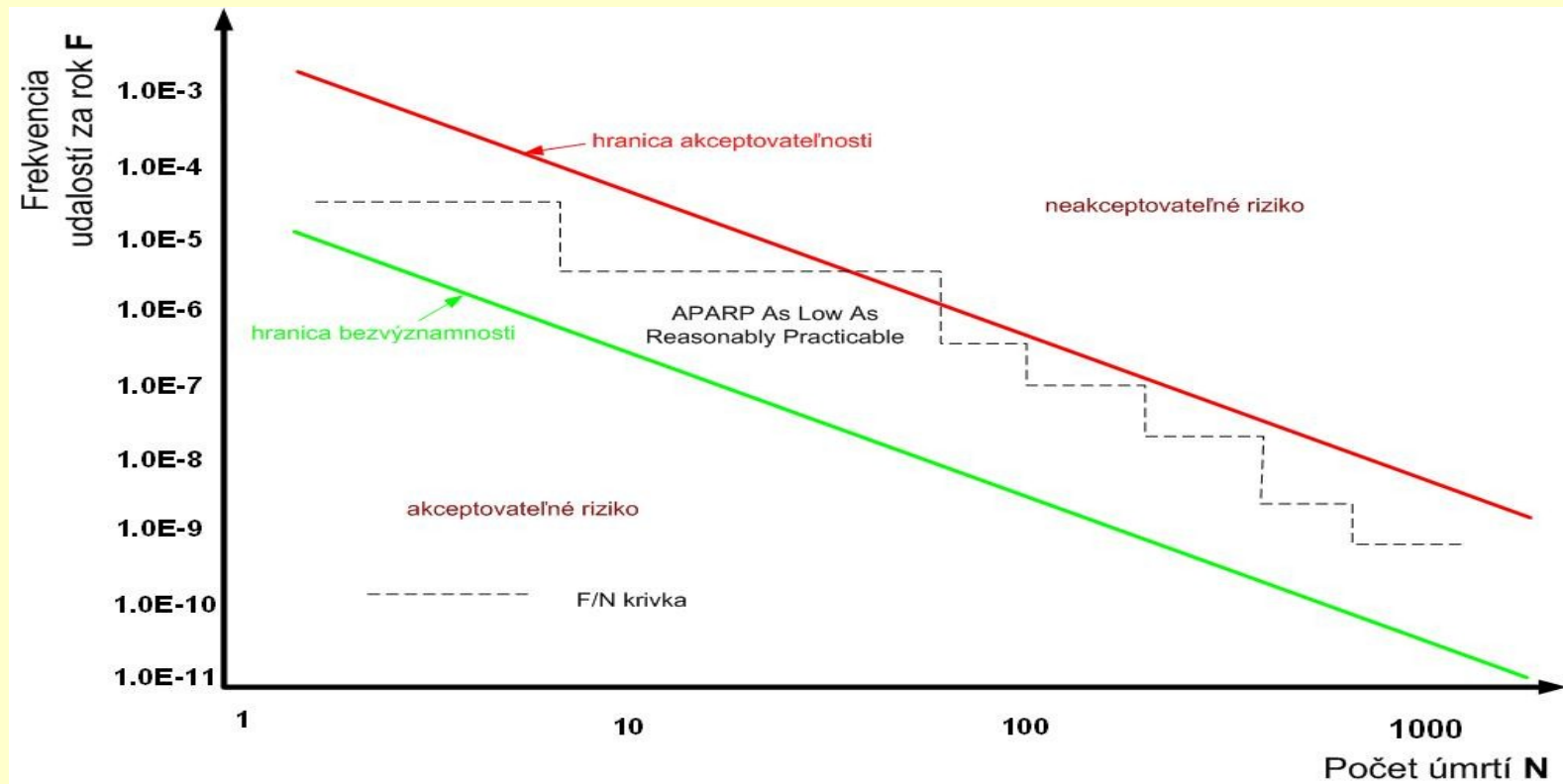
Statistic ranking cause of creation crash in tunnels

Positive effect of tunnel by safety transport, that eliminate risk:

- tunnel is closing system, that eliminate blokades of way object, that are fallen threes,
- atmospheric condition in tuneli are invariable – none rain, snow,
- tunnel have simply route – without ramp, crossing,
- tunnely are good lighted and often controll, fastness of traffic is controlled.



Identification of jeopardy in tunnels



Evaluation and minimizing of risk in tunnel

Evaluation of risk is possible only then, when we know sources of risk and their function.

Minimizing of risk is process, whose effort is form measure, who hinder loss.

Risk of creation negative event is expresion of equation:

$$R = f(P,D)$$

$$R = \sum_{i=1}^n x_i (P,D)$$

R – risk

P – probability of negative effect

D – implication of negative effect

x_i – function $x_i (P,D)$

Method of risk analyzis

- Method FMEA/ FMECA
- Catalogue letters
- Combination method of risk advisement:
 1. komplex method – IVSS,
 2. point method,
 3. method of net risk graph.

Method asigned on identification jeopardy during building up or operation of tunnel must relate causal dependence.

In same cases is needs combinate more method.

THANK YOU FOR YOUR ATTENTION

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