GATE 2027

DAY - 1

"Cleaner Air Stronger Future"

MINING ENGINEERING (MN)

SURFACE ENVIRONMENT

Air Pollution – Fundamentals

SAR TUTORIAL ACADEMY HYDERABAD

Learn Prepare Achieve

GATE Focus
Concepts
Numericals
MCQs

1. What is Air Pollution ?

- Air pollution is the presence of undesirable substances (solid, liquid or gaseous) in the atmosphere in such concentration and for such duration as to be injurious to human beings, other living organisms, materials and the environment.

> "Any change in the physical, chemical or biological characteristics of air that adversely affects life or property"

2. Air Pollutant

- A substance present in air in concentration higher than the natural level and causes harmful affects.

3. Classification of Air Pollutants

Air Pollutants

Primary Pollutants (Emitted directly into atmosphere)

- Particulate matter (PM)
- SO_2
- NO
- CO
- CO_2
- Hydrocarbons (HC)
- VOCs
- NH_3

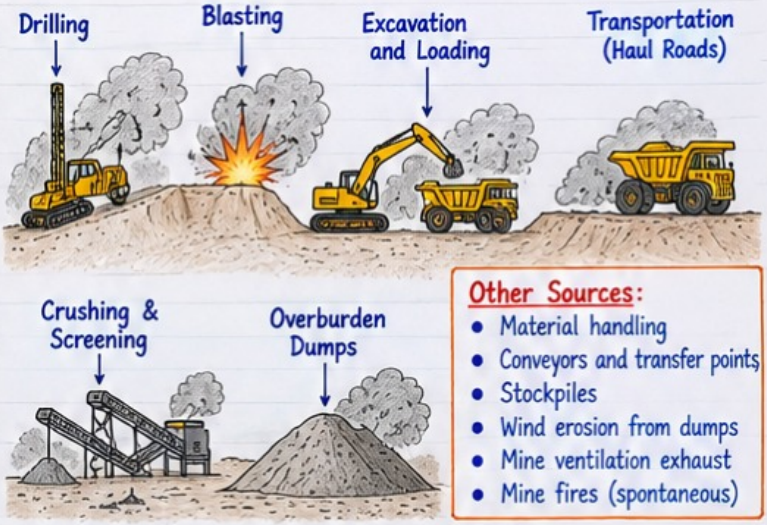
Secondary Pollutants (Formed in the atmosphere due to chemical reactions)

- O_3 (Ozone)
- PAN (Peroxyacetyl nitrate)
- H_2SO_x (Sulphuric acid)
- HNO_3 (Nitric acid)
- Secondary aerosols
- Photochemical smog

4. Common Air Pollutants and Their Effects

Pollutant	Sources (Mining related)	Major Effects
Particulate Matter (PM_{10}, $PM_{2.5}$)	Drilling, blasting, crushing, hauling	Respiratory problems, dust diseases
SO_2	Diesel machinery, blasting (sulphur in explosives)	Acid rain, respiratory irritation
NO_x (NO, NO_2)	Diesel engines, blasting	Respiratory problems, photochemical smog
CO	Incomplete combustion	Reduces oxygen carrying capacity of blood
CO_2	Combustion of fuels	Greenhouse effect (climate change)
Hydrocarbons (VOCs)	Fuel evaporation, incomplete combustion	Smog formation, carcinogenic effects

5. Major Sources of Air Pollution in Mining



Other Sources:

- Material handling
- Conveyors and transfer points
- Stockpiles
- Wind erosion from dumps
- Mine ventilation exhaust
- Mine fires (spontaneous)

6. Characteristics of Particulate Matter

- Size range : 0.1 μm to 100 μm
- PM_{10} : particles with diameter ≤ 10 μm (respirable)
- $PM_{2.5}$: particles with diameter ≤ 2.5 μm (more harmful)
- Causes : drilling, blasting, hauling, wind erosion
- Effects : respiratory and cardiovascular diseases

7. GATE Focus Points

- ✓ Primary pollutants are emitted directly.
- ✓ Secondary pollutants are formed by chemical reactions in air.
- ✓ Particulate matter is the major pollutant in mining.
- ✓ SO_2 and NO_x are important gaseous pollutants.
- ✓ Mining activities → mainly increase particulate matter (dust).
- ✓ Secondary pollutants like ozone and PAN are formed by photochemical reactions.
- ✓ Know the effect of each pollutant and typical sources.

8. GATE Level MCQs

1. Which of the following is a secondary pollutant?
   (A) SO_2 (B) NO
   (C) O_3 (D) CO

2. The major air pollutant generated during drilling and blasting in mines is
   (A) SO_2 (B) NO_x
   (C) Particulate matter (D) CO_2

3. Which of the following is NOT a typical source of air pollution in open cast mining?
   (A) Drilling
   (B) Crushing and screening
   (C) Overburden dumps
   (D) Smelting

9. Quick Revision

- ☐ Air pollution = harmful change in air composition
- ☐ Primary vs Secondary pollutants
- ☐ Particulate matter is the key pollutant in mining
- ☐ Know sources, effects and control (next class)

"Control Dust Today, Breathe Better Tomorrow"

GATE 2027

DAY - 2

MINING ENGINEERING (MN)

SURFACE ENVIRONMENT

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"Clean Air Safe Mines Sustainable Future"

Air Quality Standards & Dispersion

Quality Parameters | Standards | Dispersion Mechanisms

GATE Focus Concepts Numericals MCQs

1. Air Quality Parameters

- Concentration of pollutants in air is used to assess air quality.
- Expressed in $\mu g/m^3$ or mg/m^3.
- Important parameters :
  - Particulate Matter (PM_{10}, $PM_{2.5}$)
  - SO_2
  - NO_x (NO, NO_2)
  - CO
  - O_3
  - Lead (Pb)
  - Total Suspended Particulates (TSP)
  - Volatile Organic Compounds (VOCs)

2. Ambient Air Quality Standards (NAAQS - CPCB)

Pollutant	Time Weighted Average	Standard Concentration ($\mu g/m^3$)
PM_{10}	24 hours	100
$PM_{2.5}$	24 hours	60
SO_2	24 hours	80
NO_2	24 hours	80
CO	8 hours	2000 ($\mu g/m^3$) (= 2 mg/m^3)
O_3	8 hours	100
Pb	Annual	0.5

Note: Standards may be updated by CPCB. Always refer to latest notifications for GATE.

3. Emission Standards (Mining – Typical)

Source	Particulate Emission Limit (mg/Nm^3)
Drills	100 – 150
Crushers	50 – 100
Screening units	50 – 100
Conveyors (transfer points)	50 – 100
Thermal power plants (for mines)	50

Note: Values are typical and indicate the order of magnitude.

4. Units and Conversions

- 1 mg/m^3 = 1000 $\mu g/m^3$
- 1 ppm (at 25°C, 1 atm) = 1.88 mg/m^3 (approx)
- 1 $\mu g/m^3$ = 10^{-6} g/m^3
- Nm^3 – volume at 0°C and 1 atm (standard conditions).

5. Dispersion of Air Pollutants

- After release, pollutants get diluted and dispersed in atmosphere due to wind and turbulence.
- Dispersion depends on :
  - Wind speed and direction
  - Atmospheric stability
  - Mixing height
  - Terrain and surface roughness
  - Source characteristics (height, emission rate)
  - Physical and chemical properties of pollutant

6. Gaussian Plume Model (Most Common)

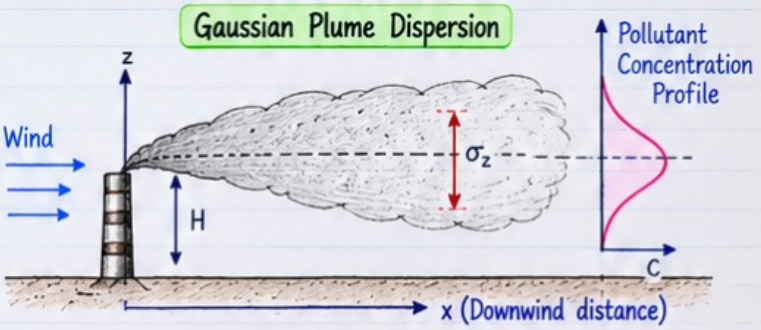
For a continuous point source, the ground level concentration on centreline (y = 0, z = 0) is

$$C(x,0,0) = \frac{Q}{(2\pi u \sigma_y \sigma_z)} \exp\left(-\frac{H^2}{2\sigma_z^2}\right)$$

Where,

- C = pollutant concentration at downwind distance x (g/m^3)
- Q = emission rate (g/s)
- u = mean wind speed (m/s)
- H = effective stack height (m)
- σ_y = horizontal dispersion coefficient (m)
- σ_z = vertical dispersion coefficient (m)

Gaussian Plume Dispersion



7. Atmospheric Stability (Pasquill-Gifford)

Class A	Very unstable
Class B	Unstable
Class C	Slightly unstable
Class D	Neutral
Class E	Slightly stable
Class F	Stable

8. Dispersion Coefficients (σ_y, σ_z)

- Depend on downwind distance (x) and stability class.
- Generally increase with distance.
- Values are available in standard tables (Turner, Pasquill-Gifford).

9. GATE Level MCQs

1. Which of the following most influences the ground level concentration in Gaussian plume model?
   (A) Stack diameter
   (B) Emission rate
   (C) Wind speed
   (D) Gas molecular weight

2. The stability class in which vertical dispersion is minimum is
   (A) A
   (B) B
   (C) D
   (D) F

10. Quick Revision

- ✓ Know air quality parameters and units
- ✓ CPCB ambient standards
- ✓ Basic emission limits
- ✓ Gaussian plume equation
- ✓ Effect of wind and stability
- ✓ σ_y and σ_z increase with x
- ✓ Use latest standards for GATE

GATE 2027

DAY - 3

MINING ENGINEERING (MN)

SURFACE ENVIRONMENT

Water Pollution

Sources | Pollutants | Water-Quality Parameters | Mining Contamination

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Concepts
Numericals
MCQs

1. What is Water Pollution ?

- Water pollution is the undesirable change in the physical, chemical or biological characteristics of water due to addition of pollutants, making it harmful for life and unfit for use.

"Clean Water Supports Life, Polluted Water Destroys It"

2. Sources of Water Pollution

- Mine drainage (acid mine drainage)
- Runoff from overburden dumps
- Leachate from waste rock and tailings
- Sediment from excavation and haul roads
- Spillage of fuels, oils and lubricants
- Explosives and chemicals (nitrates)
- Domestic sewage from mining colonies
- Industrial effluents from processing plants
- Surface runoff during rains (erosion)

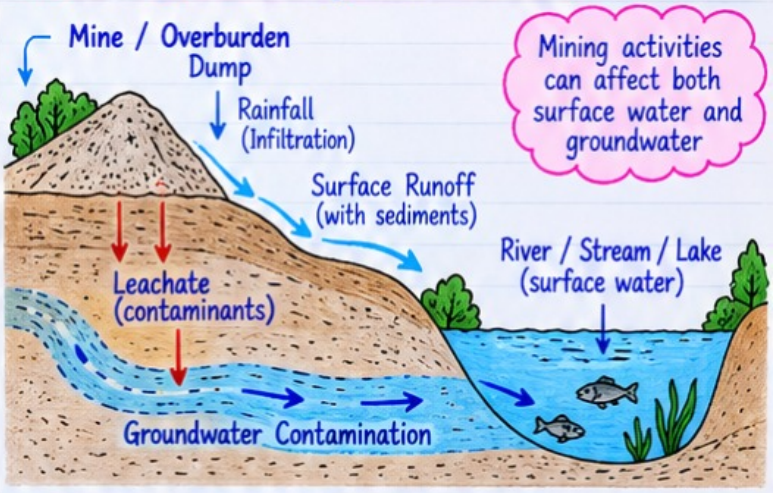
3. Major Pollutants (Mining Related)

- Suspended solids (silt, clay, fine particles)
- Dissolved solids (TDS)
- Acidic drainage (low pH, high sulphates)
- Heavy metals (Fe, Mn, Pb, Cd, As, Hg)
- Nitrates (from explosives)
- Oils and grease (from machinery)
- Process chemicals (e.g., cyanide in gold mining)

4. Water-Quality Parameters

Parameter	Symbol/Unit	Significance
pH	–	Acidity/alkalinity
Turbidity	NTU	Suspended particles
Total Dissolved Solids	TDS (mg/L)	Dissolved salts
Total Suspended Solids	TSS (mg/L)	Sediment load
Biochemical Oxygen Demand	BOD (mg/L)	Organic pollution
Chemical Oxygen Demand	COD (mg/L)	Total oxidizable matter
Dissolved Oxygen	DO (mg/L)	Aquatic life support
Hardness	mg/L (as $CaCO_3$)	Ca^{2+}, Mg^{2+} salts
Heavy metals	mg/L	Toxicity

5. Pathways of Mining Contamination



6. Acid Mine Drainage (Important)

- Generated due to oxidation of sulphide minerals (e.g., pyrite).
- Results in low pH and high sulphate concentration.
- Dissolves heavy metals → toxic to aquatic life.

$$2FeS_2 + 7O_2 + 2H_2O \rightarrow 2Fe^{2+} + 4SO_4^{2-} + 4H^+$$

7. Effects of Water Pollution

- Kills aquatic life (fish, plants, microorgansims).
- Makes water unfit for drinking and irrigation.
- Causes bioaccumulation of heavy metals.
- Affects human health (e.g., lead, arsenic).
- Damages soil fertility (when used for irrigation).

8. GATE Level MCQs

1. Acid mine drainage is mainly due to oxidation of :
   (A) Limestone
   (B) Pyrite
   (C) Quartz
   (D) Bauxite

2. Which parameter indicates the amount of biodegradable organic matter in water ?
   (A) DO
   (B) BOD
   (C) TDS
   (D) Turbidity

9. Quick Revision

- ✓ Know sources and typical pollutants in mining.
- ✓ Remember important water-quality parameters and units.
- ✓ Acid mine drainage → low pH, high sulphates, heavy metals.
- ✓ Mining can contaminate both surface water and groundwater.
- ✓ Water pollution affects aquatic life, agriculture and human health.

GATE 2027

DAY - 4

"Clean Water
Safe Mines
Sustainable Future"

MINING ENGINEERING (MN)

SURFACE ENVIRONMENT

Water Pollution – Control

Contamination Pathways | Treatment Methods | GATE Problems

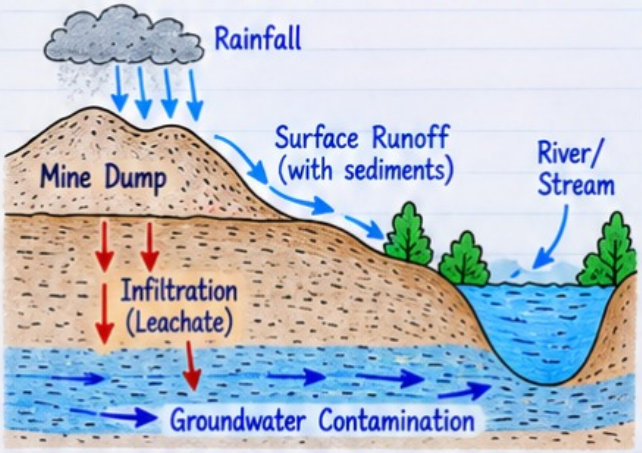
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MCQs

1. Contamination Pathways

- Surface runoff from mine dumps and exposed areas.
- Leachate through waste rock and tailings.
- Seepage to groundwater.
- Spillage during handling, transport and storage.
- Acid mine drainage (AMD).
- Sediment transport to streams and rivers.



2. Control Strategy (Hierarchy)

Prevent at Source
(Better mining and waste management)

↓

Contain
(Liners, drainage, collection systems)

↓

Treat
(Physical, chemical, biological methods)

↓

Monitor
(Water quality, compliance with standards)

3. Treatment / Control Methods

Method	Application
Sedimentation	Removal of suspended solids (silt, clay)
Filtration	Polishing of suspended solids
Neutralization	Increase pH of acidic mine drainage (using lime/limestone)
Precipitation	Removal of heavy metals (as hydroxides)
Adsorption	Removal of dissolved organics/heavy metals (using activated carbon)
Biological treatment	Degradation of organic matter (indigenous/ engineered systems)
Constructed wetlands	Polishing and nutrient removal
Lining and drainage	Prevent leachate from tailings/dumps

4. Acid Mine Drainage (AMD) Control

- Caused by oxidation of sulphide minerals (e.g., pyrite).
- Generates acidic water with high sulphate and dissolved metals.
- Control methods:
  - Prevent exposure of sulphides (proper waste dump design).
  - Use of impermeable liners and covers.
  - Diversion of surface water.
  - Collection and treatment (lime neutralization, active/passive treatment systems).
  - Use of alkaline materials (limestone drains).
  - Revegetation and proper mine closure.

5. Important Formulas

(a) Lime requirement for neutralization :

$$L = 50 \times A \times Q \quad (kg/day)$$

Where,
A = acidity (mg/L as $CaCO_3$)
Q = flow rate (m^3/day)

(b) Removal efficiency :

$$\eta = \frac{C_{in} - C_{out}}{C_{in}} \times 100$$

Where,
C_{in} = influent concentration
C_{out} = effluent concentration

(c) Dilution in receiving water :

$$C_d = \frac{C_s \times Q_s}{Q_s + Q_r}$$

Where,
C_d = concentration after mixing
C_s = source concentration
Q_s = source flow rate
Q_r = river/stream flow rate

6. GATE Level Numerical

A mine drainage with an acidity of 300 mg/L (as $CaCO_3$) is flowing at 2000 m^3/day. Calculate the daily lime requirement for neutralization.

Solution :

$L = 50 \times A \times Q$
$= 50 \times 300 \times 2000$
$= 30{,}000{,}000$ kg/day
$= 30{,}000$ tonnes/day

Answer :
30,000 tonnes/day

7. GATE Level MCQs

1. The most commonly used reagent for neutralization of acid mine drainage is :
   (A) Sulphuric acid
   (B) Lime ($Ca(OH)_2$)
   (C) Sodium chloride
   (D) Activated carbon

2. In a mixing zone, a pollutant source with concentration 50 mg/L and flow rate 2 m^3/s mixes with a river having flow rate 8 m^3/s with no pollutant. The resulting concentration (mg/L) is :
   (A) 5 (B) 10
   (C) 20 (D) 50

8. Quick Revision

- ✓ Mine activities can contaminate surface and groundwater.
- ✓ Control → Prevent → Contain → Treat → Monitor.
- ✓ Neutralization, sedimentation, filtration and biological methods are common.
- ✓ Follow standards and continuous monitoring for sustainable mining.

Protect
Water
Protect Life

GATE 2027

DAY - 5

"Healthy Soil Healthy Future"

MINING ENGINEERING (MN)

SURFACE ENVIRONMENT

Soil Pollution

Sources | Contaminants | Dispersion | Effects | Control

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Numericals
MCQs

1. What is Soil Pollution ?

- Presence of harmful substances (solid, liquid or gaseous) in soil in quantities that adversely affect soil quality, living organisms, plants, water bodies and human health.

> "Polluted Soil Reduces Productivity and Harms Ecosystems"

2. Sources of Soil Pollution (Mining Related)

- Overburden dumps and waste rock dumps
- Spillage of fuels, oils and lubricants
- Mine tailings and processing wastes
- Acid mine drainage (AMD)
- Use of explosives and chemicals
- Dust deposition from drilling, blasting and hauling
- Improper disposal of solid and hazardous wastes
- Leakage from fuel storage tanks and workshops

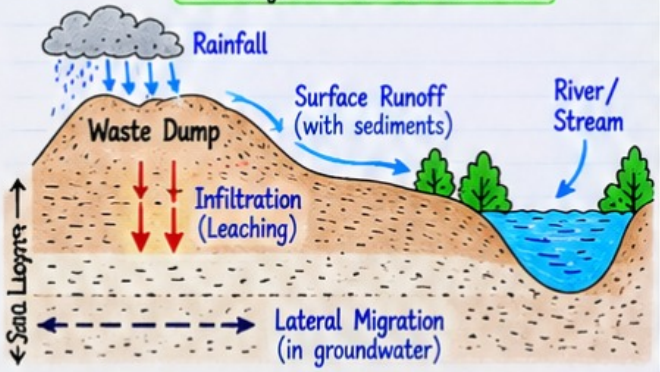
3. Major Contaminants

Type of Contaminant	Examples
Heavy metals	Fe, Mn, Pb, Cd, As, Hg, Cr, Ni
Metalloids	As, Se
Nutrients (excess)	Nitrates, Phosphates
Petroleum hydrocarbons	Diesel, Oils, Grease, PAHs
Process chemicals	Cyanide, Flotation reagents
Acidic/alkaline wastes	Acid mine drainage (sulphates)
Radioactive elements	U, Th (in some mines)
Solid wastes	Tailings, Slag, Fly ash

4. Dispersion / Migration in Soil

- Through leaching with rainfall (downward movement)
- Surface runoff and erosion (horizontal movement)
- Capillary rise (upward movement)
- Adsorption and ion exchange with soil particles
- Complexation and precipitation (reduces mobility)
- Depends on soil texture, pH, organic matter and redox conditions.

Pathways of Soil Contamination



5. Effects of Soil Pollution

- Reduces soil fertility and crop productivity
- Toxicity to plants, microorganisms and animals
- Accumulation of heavy metals in food chain
- Contaminates surface water and groundwater
- Affects soil structure and biodiversity
- Long-term ecological damage and land degradation
- Human health risks (through food and water)

Healthy Soil Healthy Life



6. Important Relationships / Formulas

(a) Contaminant concentration in soil :

$$C = \frac{M}{V}$$

Where,
C = concentration (mg/kg)
M = mass of contaminant (mg)
V = mass of soil (kg)

(b) Soil adsorption (Freundlich isotherm) :

$$q = K_f C^n$$

Where,
q = amount adsorbed (mg/kg)
C = equilibrium concentration (mg/L)
K_f, n = empirical constants

7. Control and Remediation Methods

Method	Description
Source control	Proper waste management, lined dumps, spill prevention
Soil stabilization	Use of lime, cement, fly ash to immobilize metals
Phytoremediation	Use of plants to absorb or stabilize contaminants
Soil washing	Removal of contaminants using water/chemicals
Containment	Impermeable liners, covers and barriers
Bioremediation	Use of microorganisms to degrade organics
Topsoil management	Separate storage and reuse during reclamation
Proper land reclamation	Revegetation and monitoring

8. GATE Level Numerical

A soil sample of 5 kg contains 250 mg of lead (Pb). Calculate the concentration of lead in the soil (mg/kg).

Solution : $C = \frac{M}{V} = \frac{250}{5}$

$= 50$ mg/kg

Answer : 50 mg/kg

9. GATE Level MCQs

1. Which of the following is a major cause of soil pollution in mining areas ?
   (A) Acid mine drainage
   (B) Combustion of natural gas
   (C) Nuclear power generation
   (D) Domestic sewage only

2. The downward movement of contaminants through soil due to rainfall is called :
   (A) Erosion
   (B) Leaching
   (C) Adsorption
   (D) Evaporation

10. Quick Revision

- ✓ Know sources, contaminants and their effects.
- ✓ Understand dispersion/migration mechanisms.
- ✓ Remember control and remediation methods.
- ✓ Soil pollution affects agriculture, water and human health.
- ✓ Important for mine closure and sustainable development.

Clean Soil Greener Tomorrow

GATE 2027

DAY - 6

"Less Noise More Life"

MINING ENGINEERING (MN)

SURFACE ENVIRONMENT

Noise Pollution & Control

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GATE Focus
Concepts
Numericals
MCQs

1. What is Noise Pollution ?

- Unwanted or unpleasant sound which causes discomfort or harmful effects on human beings and the environment.
- Measured in decibel (dB).
- Common in mining due to heavy machinery, blasting, material handling etc.

"Control Noise, Ensure Safe and Healthy Working Environment"

2. Sources of Noise in Mining

- Drilling and blasting
- Crushers and screening plants
- Excavators, dozers and loaders
- Haulage trucks and dumpers
- Conveyors and material transfer points
- Generators, compressors and fans
- Workshop and processing plants



3. Noise Level and Decibel Scale

- Sound intensity (I) is measured in W/m^2.
- Sound level in decibel (dB) is a logarithmic scale.

$$L = 10 \log_{10}\left(\frac{I}{I_0}\right) \text{ (dB)}$$

Where, I = sound intensity (W/m^2)

I_0 = reference intensity = 10^{-12} W/m^2

- Increase of 10 dB → 10 times increase in intensity.
- Increase of 3 dB → approximately 2 times increase in intensity.

4. Addition of Noise Levels

- For two noise sources with levels L_1 and L_2 :

$$L_T = 10 \log_{10}\left(10^{L_1/10} + 10^{L_1/10}\right)$$

- If the difference between two levels > 10 dB, higher level dominates (lower can be neglected).
- For n identical sources :

$$L_T = L + 10 \log_{10}(n)$$

5. Typical Noise Levels (Mining)

Source / Equipment	Typical Noise Level (dB(A)
Normal conversation	50 – 60
Drilling	90 – 110
Blasting (at 100 m)	100 – 120
Excavator / Loader	85 – 105
Haul truck (moving)	85 – 100
Crusher / Screening plant	90 – 110
Conveyor	80 – 95
Generators / Compressors	85 – 100
Mine ventilation fans	85 – 105

Prolonged exposure above 85 dB can cause hearing loss.

6. Effects of Noise Pollution

- Hearing impairment (temporary or permanent)
- Stress, fatigue and irritability
- Reduced concentration and efficiency
- Interference with communication
- Sleep disturbance (near mining areas)
- Adverse effects on wildlife and local communities



Noise Hurts
Protect Your Ears

7. Control Techniques

Method	Description	Examples
At source	Modify equipment, use low-noise machines	Acoustic enclosures, silencers, maintenance
Along path	Reduce noise transmission through barriers	Noise barriers, berms, green belts, building design
At receiver	Protect exposed persons	Ear plugs, ear muffs, limit exposure time
Administrative	Work scheduling, rotation of workers	Avoid exposure during high noise periods
Planning	Proper mine layout, zone separation	Locate noisy units away from habitations

8. GATE Level Numerical

Two machines produce noise levels of 90 dB and 85 dB. What is the combined noise level?

Solution :

$$L_T = 10 \log_{10}(10^{9}) + 10^{8.5})$$
$$= 10 \log_{10}(10^{9} + 10^{8.5})$$
$$= 10 \log_{10}(10^{9} + 3.16 \times 10^{8})$$
$$= 10 \log_{10}(1.316 \times 10^{9})$$
$$= 10\,(9.12) = 91.2 \text{ dB}$$

Answer : 91.2 dB

9. GATE Level MCQs

1. An increase in noise level from 70 dB to 80 dB means the sound intensity has increased by a factor of :
   (A) 2 (B) 5
   (C) 10 (D) 100

2. Which of the following is NOT an effective method for noise control in mines ?
   (A) Acoustic enclosure
   (B) Green belt
   (C) Worker rotation
   (D) Increasing blasting charge

10. Quick Revision

- ✓ Noise level : $L = 10 \log_{10}\left(\frac{I}{I_0}\right)$ dB.
- ✓ Increase of 10 dB → 10 times intensity.
- ✓ Main sources: drilling, blasting, crushers, haulage, fans.
- ✓ Control: at source, along path, at receiver, planning.
- ✓ Prolonged exposure > 85 dB is harmful.

Silence Today Safer Tomorrow

GATE 2027

DAY - 7

"Reclaim Land Restore Life"

MINING ENGINEERING (MN)

SURFACE ENVIRONMENT

Land Reclamation

Reclamation Principles | Mine-land Restoration | Methods and Sequence

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Concepts
Numericals
MCQs

1. What is Land Reclamation ?

- Process of restoring disturbed land to a stable, productive and environmentally acceptable condition after mining.
- Aims to bring the land as close as possible to its original or a better use.
- Includes physical, chemical, biological and aesthetic improvement.

"Disturbed Land Today Productive Land Tomorrow"

2. Objectives of Reclamation

- Ensure land stability and safety
- Control erosion and sedimentation
- Restore soil quality and fertility
- Re-establish vegetation and ecosystem
- Improve aesthetics and social acceptance
- Enable alternative and sustainable land use

3. Sequence of Reclamation Activities

Mine Closure Planning
(Concurrent with mining)

↓

Backfilling and Regrading
(Restore original contours)

↓

Topsoil Management
(Separate, preserve and replace)

↓

Soil Amendment
(Organic matter, nutrients, pH correction)

↓

Revegetation / Afforestation
(Grasses, shrubs, trees)

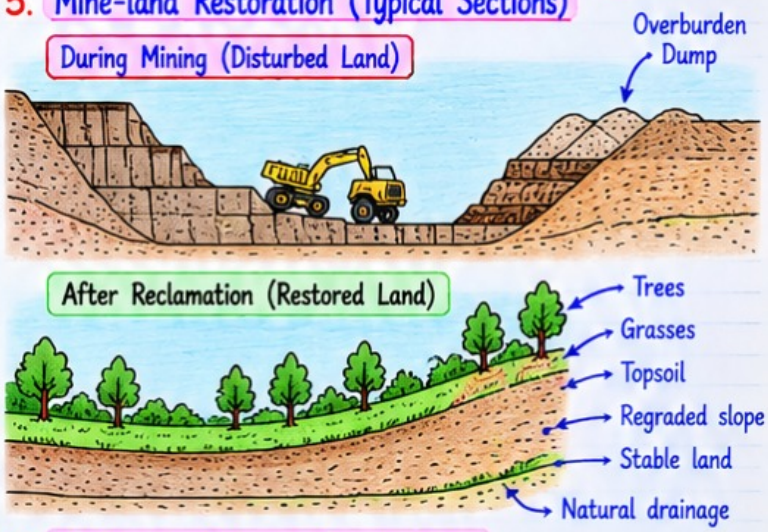
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Monitoring and Maintenance
(Ensure long-term stability)

4. Reclamation Principles

- Plan reclamation at the design stage.
- Minimize disturbance and conserve topsoil.
- Re-establish natural drainage and stable slopes.
- Use native species for plantation.
- Ensure long-term monitoring and maintenance.
- Integrate with regional land-use planning.
- Follow legal and regulatory requirements.

5. Mine-land Restoration (Typical Sections)



6. Methods of Land Reclamation

Method	Description / Example
Backfilling	Filling of voids with overburden / waste
Regrading	Reshaping land to stable slopes and natural contours
Topsoil management	Separate storage and spreading of topsoil
Soil amendment	Addition of organic matter, lime, fertilizers
Revegetation	Planting of grasses, shrubs and trees
Drainage control	Surface and sub-surface drainage systems
Erosion control	Terracing, contour bunds, mulching, silt fences
Creation of alternative land use	Agriculture, forestry, water reservoir, recreation

7. Important Points

Reclaim
Restore
Reuse
Sustain

- Topsoil is a valuable resource – preserve it.
- Use fast-growing, native and hardy species.
- Control erosion until vegetation is established.
- Acidic/alkaline soils may need treatment (lime/gypsum).
- Monitor soil, water and vegetation for several years.
- Reclaimed land can be used for agriculture, forestry, wildlife habitat, recreation or industrial use.

8. GATE Level MCQs

1. The first step in land reclamation is generally :
   (A) Topsoil application
   (B) Backfilling
   (C) Mine closure planning
   (D) Revegetation

2. Which of the following is NOT typically used for erosion control ?
   (A) Contour bunds
   (B) Mulching
   (C) Terracing
   (D) Deep mining of adjacent area

9. Quick Revision

- ✓ Reclamation = physical + biological + aesthetic improvement.
- ✓ Sequence: plan → backfill → topsoil → soil treatment → vegetation → monitoring.
- ✓ Control erosion and restore natural drainage.
- ✓ Use native species and ensure long-term stability.
- ✓ Reclaimed land supports environment, economy and society.

Green Mines Bright Futures

GATE 2027

DAY - 8

"Assess Impacts
Act Responsibly
Sustain Tomorrow"

MINING ENGINEERING (MN)

SURFACE ENVIRONMENT

EIA + Complete Revision

EIA Process | Mining Case Study | MCQs | Key Points

SAR TUTORIAL ACADEMY HYDERABAD

Learn
Prepare
Achieve

GATE Focus
Concepts
Numericals
MCQs

1. What is EIA ?

- Environmental Impact Assessment (EIA) is a systematic process to identify, predict, evaluate and mitigate the environmental impacts of a proposed project before implementation.
- Helps in decision making for sustainable development.

"Assess Impacts Today
for a Better Tomorrow"

2. Objectives of EIA

- Identify and assess potential environmental impacts.
- Suggest mitigation and management measures.
- Ensure sustainable and environmentally acceptable development.
- Integrate environmental concerns in project planning and design.
- Enhance transparency and public participation.

3. Steps in EIA Process

Project Proposal
(Concept and details)
↓
Screening
(Is EIA required?)
↓
Scoping
(Identify key issues)
↓
Baseline Data Collection
(Environmental status)
↓
Impact Identification & Prediction
(Assess significance)
↓
Mitigation Measures
(Avoid, Minimize, Restore, Compensate)
↓
Environmental Management Plan (EMP)
(Monitoring and implementation)
↓
Public Consultation
(Stakeholder involvement)
↓
Appraisal and Decision
(Approval with conditions)
↓
Post-Project Monitoring
(Compliance and audit)

4. Important Environmental Components in Mining EIA

Component	Key Aspects
Air Environment	Dust, gaseous emissions (NO_x, SO_2), air quality
Water Environment	Surface & groundwater, mine drainage, TDS, pH, heavy metals
Soil/Land	Soil erosion, land use change, contamination
Noise & Vibration	Machinery, blasting
Ecology & Biodiversity	Flora, fauna, habitat loss
Socio-economic	Population, health, employment, resettlement
Visual / Aesthetic	Landscape, mine voids, dumps
Risk Assessment	Accidents, tailings dam failure, mine fires
Cumulative Impacts	Combined effect with nearby projects

Responsible
Mining
Sustainable
Future

5. Mining EIA Case Study (Example)

A proposed opencast coal mine of 5 MTPA is located near a village. Major issues: dust, noise, land degradation and groundwater contamination. Suggest key mitigation measures.



Suggested Mitigation Measures :

- Water sprinkling on haul roads, use of covered trucks (dust control).
- Proper blasting design and restricted blasting hours (noise/vibration).
- Topsoil preservation and progressive reclamation (land degradation).
- Garland drains, siltation ponds and proper mine drainage management (water quality).
- Green belt development and afforestation.
- Health monitoring and community development programs.

6. GATE Level MCQs

1. Which of the following is NOT a step in the EIA process ?
   (A) Screening (B) Scoping
   (C) Blasting (D) Appraisal

2. In mining EIA, cumulative impact refers to ::
   (A) Impact of a single mine only
   (B) Combined impact of multiple projects
   (C) Impact during mine closure only
   (D) Impact on workers only

3. Which is an effective measure for dust control in mines ?
   (A) Increasing haul speed
   (B) Water sprinkling on haul roads
   (C) Open dumping of overburden
   (D) Higher blasting charge

4. EIA is primarily intended to :
   (A) Maximize production
   (B) Minimize environmental impacts
   (C) Replace mining lease
   (D) Increase blasting frequency

7. Mixed GATE Revision (Fill in the Blanks)

1. Environmental Impact Assessment helps in _____ development.
2. _____ + and _____ are commonly used for dust control in mines.
3. Topsoil should be _____ before mining and _____ during reclamation.
4. Cumulative impacts consider the effect of _____ projects.
5. Post-project monitoring ensures _____ of environmental conditions.

Plan
Protect
Reclaim
Sustain

8. Key Takeaways

- ✓ EIA integrates environment with development.
- ✓ Follow the stepwise EIA process.
- ✓ Focus on air, water, soil, noise, ecology and socio-economic impacts.
- ✓ Mitigation, monitoring and public consultation are essential.
- ✓ Sustainable mining ensures long-term benefits.



GATE 2027

DAY - 1

"Breathe Safe
Mine Safe
Mine Better"

MINING ENGINEERING (MN)

MINE VENTILATION

Underground Atmosphere

Mine air | Composition | Contaminants | Permissible Limits

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GATE Focus
Concepts
Numericals
MCQs

1. What is Underground Atmosphere ?

- Air present in underground mines is called mine air or underground atmosphere.
- It differs from normal atmospheric air due to presence of various gases, dust and vapours.
- Quality of mine air directly affects the health, safety and productivity of miners.

"Good Ventilation Dilutes Contaminants and Provides Fresh Air for Safe Mining"

2. Composition of Air (by volume)

Component	Normal Air (%)	Mine Air (%)
Nitrogen (N_2)	78.08	≈ 78
Oxygen (O_2)	20.95	Usually lower
Argon (Ar)	0.93	≈ 1
Carbon dioxide (CO_2)	0.04	Higher
Other gases (Ne, He, CH_4 etc.)	0.01	Variable
Water vapour (H_2O)	0 - 4	Higher (humid)

3. Important Gases in Mines

Gas	Formula	Source in Mines	Effect
Methane	CH_4	Coal seams, strata	Explosive (5-15%)
Carbon dioxide	CO_2	Respiration, blasting, oxidation	Asphyxiant (headache)
Carbon monoxide	CO	Incomplete combustion	Toxic (binds with Hb)
Oxygen deficiency	O_2	Displacement by other gases	Asphyxiation
Hydrogen sulphide	H_2S	Decomposition of organics	Toxic, foul smell
Oxides of nitrogen	NO_x	Blasting, diesel equipment	Irritation, lung damage
Other gases	(H_2, SO_2 etc.)	Fires, chemical reactions	Toxic/irritant

4. Permissible Limits (Typical)

Gas / Parameter	Permissible Limit	Remarks
Oxygen (O_2)	Not less than 19.5%	Below 16% dangerous
Carbon dioxide (CO_2)	≤ 0.5% (5000 ppm)	Higher causes headache
Carbon monoxide (CO)	≤ 25 ppm	Toxic
Methane (CH_4)	≤ 1%	Explosive (5-15%)
Hydrogen sulphide (H_2S)	≤ 10 ppm	Toxic, eye irritation
Oxides of nitrogen (NO_x)	≤ 5 ppm	Irritant
Respirable dust	As per statutory limits	Varies (country specific)
Temperature	≤ 30 °C (DBT)	Higher temp causes strain
Relative humidity	≤ 70%	For comfort

Note : Permissible limits may vary as per DGMS / national regulations. Always follow statutory limits.

5. Sources of Contaminants

- Respiration of workers
- Blasting operations (CO, NO_x, fumes)
- Diesel/mobile equipment (CO, NO_x, particulates)
- Coal/strata (CH_4, CO_2)
- Spontaneous heating and fires (CO, CO_2, smoke)
- Use of explosives and chemicals
- Decomposition of organic matter (H_2S)
- Dust from drilling, loading and haulage
- Lack of proper ventilation

Identify
Control
Monitor
Stay Safe

6. Effects on Human Health

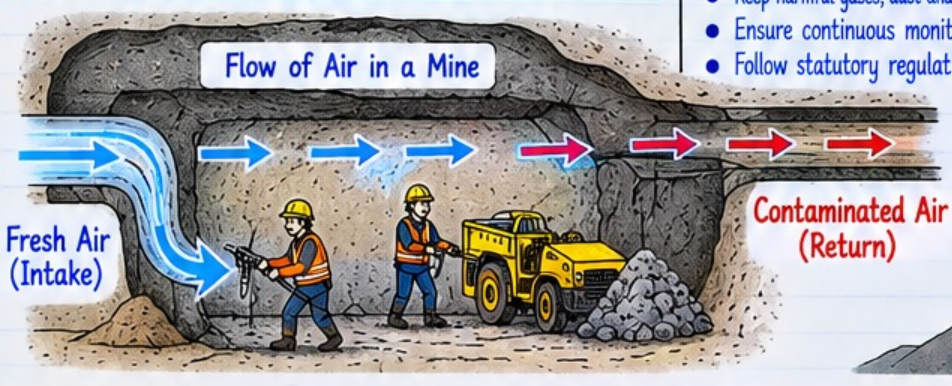
- Oxygen deficiency → headache, dizziness, unconsciousness
- Carbon monoxide → reduces blood's oxygen carrying capacity
- Carbon dioxide → headache, breathing difficulty
- Methane → explosive hazard
- Hydrogen sulphide → eye irritation, respiratory failure
- Dust → lung diseases (pneumoconiosis)
- High temperature & humidity → heat stress, fatigue

Clean Air
Healthy Miners
Higher
Productivity

7. Ventilation Principle

- Supply sufficient fresh air to dilute and remove contaminants.
- Maintain oxygen above 19.5%.
- Keep harmful gases, dust and temperature within permissible limits.
- Ensure continuous monitoring.
- Follow statutory regulations and best practices.

Ventilate
Monitor
Protect
Productivity



Safe Mines
Sustainable Mining
Stronger Tomorrow



GATE 2027

DAY - 2

MINING ENGINEERING (MN)

MINE VENTILATION

Heat Load & Thermal Environment

Sources of Heat | Temperature | Humidity | Psychrometric Concepts

"Control Heat
Control Climate
Ensure Safety"

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GATE Focus
Concepts
Numericals
MCQs

1. Why Thermal Environment is Important ?

- Underground mines are generally hotter than surface due to geothermal heat, lack of solar radiation loss and heat generated by mining activities.
- High temperature and humidity cause heat stress, reduce productivity and may lead to heat stroke.
- Proper ventilation and cooling are essential to maintain safe and comfortable working conditions.

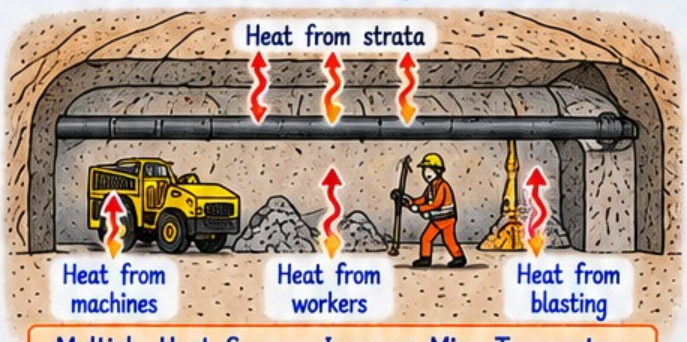
"Manage Heat, Improve Comfort, Increase Productivity"

2. Sources of Heat in Mines

Source	Description	Relative Contribution
Geothermal heat	Heat from surrounding rock strata	High (in deeper mines)
Auto-compression	Compression of air in downcast shafts	Significant
Machinery and equipment	Diesel engines, electric motors, conveyors, etc.	Significant
Blasting	Heat from explosives	Moderate
Oxidation	Oxidation of coal/ore (spontaneous heating)	Moderate
Human beings	Body heat from workers	Small (but local)
Lighting and electrical systems	Power consumption	Moderate
Friction	Belt conveyors, mechanical equipment	Moderate
Other sources	Hot water inflow, chemical reactions	Variable

3. Heat Transfer in Mines

- Conduction – from hot strata to air
- Convection – due to movement of air
- Radiation – from hot surfaces and equipment
- Auto-compression – raises air temperature in downcast shafts
- Heat from services – machines, lights, humans etc.



Multiple Heat Sources Increase Mine Temperature

7. GATE Level Question

If the dry bulb temperature is 35 °C and the wet bulb temperature is 28 °C, the relative humidity is approximately :

(A) 30% (B) 50% (C) 70% (D) 90%

4. Important Temperature Terms

Term	Symbol	Meaning
Dry Bulb Temperature	DBT	Actual air temperature (°C)
Wet Bulb Temperature	WBT	Temperature indicated by a wet thermometer (°C)
Dew Point Temperature	DPT	Temperature at which air becomes saturated (°C)
Effective Temperature	ET	Combined effect of temperature and humidity
Globe Temperature	GT	Indicates radiant heat effect
Relative Humidity	RH	Amount of moisture in air relative to saturation (%)
Absolute Humidity	AH	Mass of water vapour per unit volume (kg/m³ or g/m³)
Specific Humidity	SH	Mass of water vapour per unit mass of dry air (kg/kg)

5. Humidity Relationships

- Relative humidity (RH) :

$$RH = \frac{p_v}{p_{ws}} \times 100\%$$

p_v = partial pressure of water vapour
p_{ws} = saturation vapour pressure
(%)

- Absolute humidity (AH) :

$$AH = \frac{m_v}{V}$$

m_v = mass of water vapour (kg)
V = volume of moist air (m^3)
(kg/m^3)

- Specific humidity (SH) :

$$SH = \frac{m_v}{m_{da}}$$

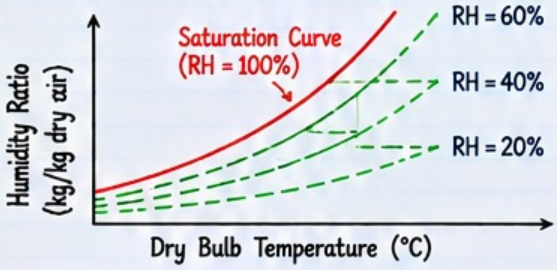
m_v = mass of water vapour (kg)
m_{da} = mass of dry air (kg)
(kg/kg of dry air)

Higher Temperature + Higher Humidity = Heat Stress

6. Psychrometric Concepts (Basics)

- Psychrometric chart shows the relation between DBT, WBT, RH, humidity ratio and enthalpy.
- Used to analyse air cooling, heating, humidification and dehumidification.
- Key processes :
- Sensible heating / cooling (horizontal line)
- Humidification (upward / right)
- Dehumidification (downward / left)

Psychrometric Chart is Essential for Mine Air Cooling Analysis



Use Psychrometric Chart for Mining Numericals

8. Quick Revision

- ✓ Know all sources of heat in mines.
- ✓ Understand DBT, WBT, DPT, RH, AH and SH.
- ✓ Use psychrometric chart for solving numerical problems.
- ✓ High temperature and humidity reduce productivity and cause heat stress.
- ✓ Proper ventilation and cooling are essential for safe mining.

Cool Mines
Safe Miners
Bright Future

GATE 2027

DAY - 3

MINING ENGINEERING (MN)

MINE VENTILATION

Air Cooling

"Cool Mines
Safe Miners
Productive Mines"

Cooling Requirements | Refrigeration | Cooling Capacity & Numericals

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GATE Focus
Concepts
Numericals
MCQs

1. Why Air Cooling is Needed ?

- Underground mines are hotter due to geothermal heat and heat from mining activities.
- High temperature reduces productivity, causes heat stress and safty hazards.
- Cooling maintains comfortable working conditions and improves efficiency.

"Control Heat – Improve Comfort
Increase Productivity"

2. Sources of Heat Load (recap)

- Geothermal heat from strata
- Auto-compression of air in downcast shafts
- Diesel engines, electric motors and machinery
- Blasting and chemical reactions
- Friction in belts, conveyors and equipment
- Human metabolism
- Lighting and electrical systems
- Hot water inflow from strata

3. Cooling Requirements

- Maintain dry bulb temperature within permissible limits (≈ 26–28 °C at workplaces).
- Maintain relative humidity at comfortable levels (50–70%).
- Remove both sensible heat (temperature) and latent heat (moisture).
- Provide adequate air quantity and proper distribution.
- Design based on total heat load and required underground temperature.

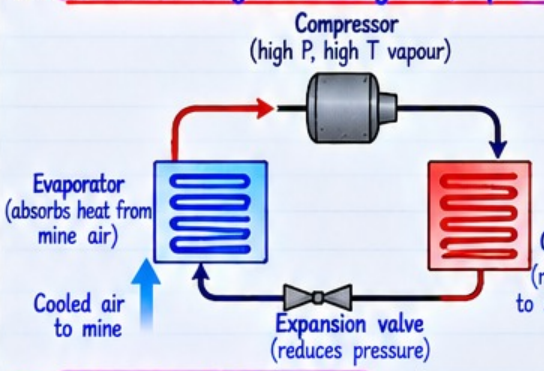
4. Types of Mine Cooling Systems

Type	Description	Application
Surface refrigeration	Refrigeration plant at surface, chilled water pumped underground	Large and deep mines
Underground refrigeration	Refrigeration units installed underground	Medium size mines
Chilled water system	Chilled water circulated through pipes, air coolers	Common method
Direct air cooling	Cooled air supplied through air coolers / heat exchangers	Local cooling
Evaporative cooling	Uses water evaporation	Limited use (high humidity)

Cooling is an Investment in People, Productivity and Mine Life.



5. Basic Refrigeration Cycle (Vapour Compression)



Refrigeration removes heat from mine air and rejects it to atmosphere

6. Important Formulas

Sensible heat :
$$Q_s = m_a\ C_p\ (T_1 - T_2)$$

Latent heat :
$$Q_l = m_a\ h_{fg}\ (\omega_1 - \omega_2)$$

Total heat load :
$$Q = Q_s + Q_l$$

Cooling capacity :
$$TR = \frac{Q}{3.517}$$

Coefficient of Performance (COP) :
$$COP = \frac{\text{Refrigeration effect}}{\text{Work input}}$$

$$COP = \frac{Q_L}{W}$$

Q_s = sensible heat (kW)
m_a = mass flow rate of air (kg/s)
C_p = specific heat (≈ 1.005 kJ/kg·°C)
T_1, T_2 = initial and final temperature (°C)
Q_l = latent heat (kW)
h_{fg} = latent heat of vaporization (≈ 2500 kJ/kg)
ω_1, ω_2 = humidity ratio (kg/kg dry air)
Q = total heat load (kW)
TR = refrigeration capacity (Tons of Refrigeration)
1 TR = 3.517 kW

7. Example Numerial – 1 (Sensible Heat)

A mine requires 200 m^3/s of air to be cooled from 35 °C to 25 °C. Air density = 1.2 kg/m^3, C_p = 1.005 kJ/kg·°C. Find the sensible heat load.

Solution :

$m_a = \rho \times Q = 1.2 \times 200 = 240$ kg/s

$Q_s = m_a C_p (T_1 - T_2) = 240 \times 1.005 \times (35 - 25)$

$Q_s = 240 \times 1.005 \times 10 =$ **2412 kW (≈ 2.41 MW)**

8. Example Numerical – 2 (Cooling Capacity)

Total heat load of a mine is 3500 kW. Find the refrigeration capacity in TR.

Solution :

$$TR = \frac{Q}{3.517} = \frac{3500}{3.517} =$$ **995.7 TR (≈ 996 TR)**

9. Key Takeaways

- ✓ Identify all sources of heat before design.
- ✓ Calculate sensible and latent heat separately.
- ✓ Select appropriate cooling system based on mine size and depth.
- ✓ Provide sufficient cooling capacity with margin.
- ✓ Regular monitoring and maintenance ensure effective cooling.

Cool Air
Safe Work
High Productivity
Sustainable Mining

GATE 2027

DAY – 4

MINING ENGINEERING (MN)

MINE VENTILATION

Mechanics of Airflow

"Good Ventilation Builds Safer Mines"

Pressure | Velocity | Continuity | Energy Relationships | Resistance

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GATE Focus
Concepts
Numericals
MCQs

1. What is Mechanics of Airflow ?

- Study of movement of air through mine openings and its behaviour.
- Helps to determine air quantity, pressure loss and resistance.
- Essential for proper ventilation design and planning.
- Basis for distribution of air in mine networks.

"Understand Airflow, Design Better Ventilation"

2. Key Properties of Mine Air

Property	Symbol	Typical Value (at 20°C, 1 atm)
Density	ρ	1.2 kg/m^3
Viscosity	μ	1.8×10^{-5} Pa·s
Compressibility	–	Nearly incompressible (at low velocities)

3. Continuity Equation

- For steady flow of air :

$$Q = A\,V$$

Q = quantity of air (m^3/s)
A = cross-sectional area (m^2)
V = average velocity (m/s)

- For variable area :

$$A_1V_1 = A_2V_2 = Q$$

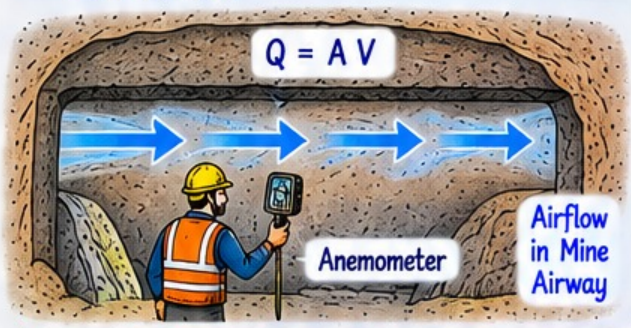
4. Pressure in Mine Ventilation

- Air flows from high pressure to low pressure.
- Pressure is measured in:
  - Pascal (Pa), kPa
  - mm of water gauge (mm WG)
  - kg/m^2

1 mm WG ≈ 9.81 Pa ≈ 0.001 kPa

5. Velocity

- Average velocity : $V = Q / A$
- In irregular openings, velocity is non-uniform.
- For accurate measurement, use traverse method with anemometer.



6. Energy Relationships (Bernoulli's Equation)

For airflow through mine openings (incompressible flow) :

$$\frac{P_1}{\rho} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho} + \frac{V_2^2}{2g} + z_2$$

P = pressure (Pa)
ρ = air density (kg/m^3)
V = velocity (m/s)
z = elevation (m)
g = 9.81 m/s^2

- In horizontal mine workings ($z_1 = z_2$) :

$$P_1 + \frac{1}{2}\rho V_1^2 = P_2 + \frac{1}{2}\rho V_2^2$$

Increase in velocity leads to decrease in static pressure

7. Airway Resistance

- Resistance is the opposition offered by the airway to the flow of air.
- For turbulent flow in mines (commonly used) :

$$P = R\,Q^2$$

P = pressure loss (Pa or mm WG)
R = airway resistance (Pa/(m^3/s)^2)
Q = quantity of air (m^3/s)

- Straight airway resistance :

$$R = k\frac{L}{A^3}$$

k = friction factor (depends on shape and roughness)
L = length of airway (m)
A = cross-sectional area (m^2)

Longer airway or smaller area → higher resistance

8. Factors Affecting Resistance

- Length of airway (L)
- Cross-sectional area (A)
- Shape of airway (circular < arched < rectangular)
- Surface roughness
- Obstructions (doors, regulators, bends, etc.)
- Air density and velocity

Relative Roughness (Typical k values)

Surface	k (approx.)
Smooth concrete	0.003 – 0.005
Rough rock	0.010 – 0.020
Timbering	0.015 – 0.030
Brick/Shotcrete	0.008 – 0.015

9. Shock Losses (Minor Losses)

Losses due to sudden change in area, bends, junctions, doors, etc.

$$P_s = K\frac{\rho V^2}{2}$$

K = loss coefficient (depends on fitting)
V = air velocity (m/s)
ρ = air density (kg/m^2)

Bends, doors and junctions increase pressure loss

10. GATE Level Questions

Q1. An airway 4 m^2 in area carries 12 m^3/s of air. What is the average velocity of air?

(A) 2 m/s (B) 3 m/s (C) 4 m/s (D) 6 m/s

Q2. A mine airway of length 500 m and area 6 m^2 has a resistance of 0.02 Pa/(m^3/s)^2. If the quantity of air is 20 m^3/s, the pressure loss will be :

(A) 4 Pa (B) 8 Pa (C) 12 Pa (D) 16 Pa

Quick Formula Recap

- ✓ $Q = A\,V$
- ✓ $A_1V_1 = A_2V_2$
- ✓ $P = R\,Q^2$
- ✓ $R = k\,L / A^3$
- ✓ $P_s = K\,\rho V^2/2$
- ✓ Bernoulli eqn.

Practice Numericals
Improve Concepts
Score Higher

GATE 2027

DAY - 5

MINING ENGINEERING (MN)

MINE VENTILATION

Airflow Distribution

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"Good Ventilation Sustainable Mining"

Airway Resistance | Pressure Losses | Regulators | Air Quantity Distribution

GATE Focus
Concepts
Numericals
MCQs

1. What is Airflow Distribution ?

- Distribution of air in a mine is the division of total air quantity among different workings based on their resistances.
- Air always takes the path of least resistance.
- Proper distribution ensures adequate air at all working places and improves safety and productivity.

"Right Quantity of Air to the Right Place at the Right Time"

2. Airway Resistance

- Resistance is the opposition offered by the airway to the flow of air.
- It depends on length, area, shape and surface roughness.
- General relationship :

$$P = R Q^2$$

Pressure loss increases with length and roughness

P = pressure loss (Pa)
R = airway resistance (Pa/(m³/s)²)
Q = quantity of air (m³/s)

3. Factors Affecting Resistance

Factor	Effect on Resistance
Length (L)	$R \propto L$ (longer length → higher R)
Cross-sectional area (A)	$R \propto \frac{1}{A^3}$ (smaller area → higher R)
Shape	Circular < Arched < Rectangular
Surface roughness	Rough surface → higher R
Obstructions	Doors, bends, regulators → higher R
Air density	Higher density → higher R

4. Pressure Losses in Airways

- Frictional losses – due to wall friction (major)
- Shock losses – due to sudden changes in area (minor losses)
- Losses at bends, junctions, doors, regulators, etc.
- Total pressure loss in a circuit is the sum of all individual losses.

$$P_{total} = \sum R_i Q_i^2 \quad \text{(for series)}$$

Reduce Losses → Better Distribution → Higher Productivity

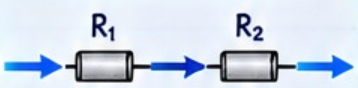


Smooth Airways Better Airflow

5. Air Quantity Distribution

- Air divides itself in different branches according to resistance.
- In series airways → same quantity flows through all.
- In parallel airways → pressure loss is same, quantities are inverse to square root of resistance:

Series Airways

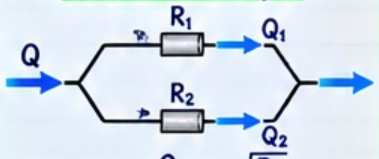


$$Q_1 = Q_2 = Q$$

$$P_{total} = (R_1 + R_2) Q^2$$

Same quantity flows, pressures add.

Parallel Airways



$$P_1 = P_2 \qquad \frac{Q_1}{Q_2} = \sqrt{\frac{R_2}{R_1}}$$

$$Q = Q_1 + Q_2$$

Same pressure loss, quantities divide inversely as $\sqrt{R}$

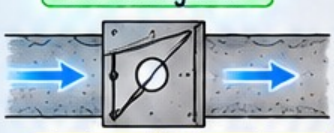
6. Regulators

- Regulators are used to control and distribute the required quantity of air.
- Types: (i) Door regulator (ii) Orifice regulator (iii) Vane regulator
- Used to increase resistance in low resistance airways.

Door Regulator



Orifice Regulator



Creates artificial resistance using an orifice plate.

7. Example Numerical – 1 (Parallel Airways)

Two parallel airways have resistances $R_1 = 0.04$ and $R_2 = 0.09$ Pa/(m³/s)². The total quantity of air is 30 m³/s, Find the quantity in each airway.

Solution :

$$\frac{Q_1}{Q_2} = \sqrt{\frac{R_2}{R_1}} = \sqrt{\frac{0.09}{0.04}} = 1.5$$

$$Q_1 = 1.5\, Q_2$$

$$Q = Q_1 + Q_2 = 2.5\, Q_2 = 30$$

$$Q_2 = 12 \text{ m}^3/\text{s} \quad , \quad Q_1 = 18 \text{ m}^3/\text{s}$$

Air follows the path of least resistance

8. Example Numerical – 2 (Series Airways)

Two airways in series have resistances $R_1 = 0.05$ and $R_2 = 0.08$ Pa/(m³/s)². If quantity of air is 20 m³/s, find the total pressure loss.

Solution :

$$P_{total} = (R_1 + R_2) Q^2 = (0.05 + 0.08) \times (20)^2$$

$$= 0.13 \times 400 = 52 \text{ Pa}$$

Simple but important GATE level concept

9. Key Takeaways

- ✓ Air distribution depends on relative resistances.
- ✓ Use regulators to control excess air.
- ✓ Minimize pressure losses for efficient ventilation.
- ✓ Ensure adequate air quantity at all working places.
- ✓ Solve series and parallel airway problems for GATE.

Well Distributed Air
Safer Mines
Higher Output

GATE 2027

DAY - 6

MINING ENGINEERING (MN)

MINE VENTILATION

SAR TUTORIAL ACADEMY HYDERABAD

Learn Prepare Achieve

"Good Ventilation Healthy Mines Sustainable Future"

Natural & Mechanical Ventilation

Natural Ventilation Pressure | Mechanical Ventilation Principles

GATE Focus
Concepts
Numericals
MCQs

1. Introduction

- Ventilation in mines can be achieved by natural means or by mechanical means.
- Natural ventilation occurs due to natural pressure differences (temperature, density, wind).
- Mechanical ventilation uses fans to create and maintain required airflow.
- Both are important for safe, healthy and productive mining operations.

"Use Nature when Possible, Use Machines when Necessary"

2. Natural Ventilation

- Movement of air in mines due to natural forces without using mechanical equipment.
- Driven by temperature difference, density difference, wind action and atmospheric pressure.
- More effective in shallow mines and during favourable climatic conditions.

3. Natural Ventilation Pressure

- Driven by stack effect (temperature difference) and wind effect.

$$P_n = g\,H\,(\rho_{out} - \rho_{in})$$

P_n = natural ventilation pressure (Pa)
g = 9.81 m/s²
H = vertical height between inlet and outlet (m)
ρ_{out} = density of outside air (kg/m³)
ρ_{in} = density of mine air (kg/m³)

Hot air is lighter → rises → creates upward flow

- **Density relation :**

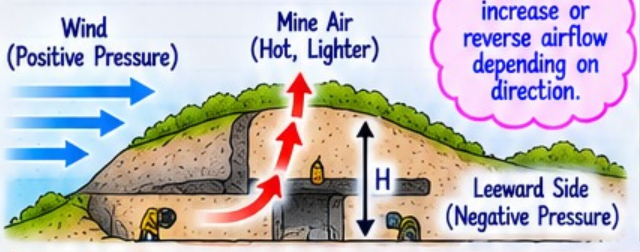
$$\rho = \frac{P}{RT}$$

P = atmospheric pressure (Pa)
R = 287 J/kg·K (for air)
T = absolute temperature (K)

4. Wind Effect

- Wind blowing across the mine openings creates a positive pressure on windward side and negative pressure on leeward side.
- This pressure difference also helps in natural ventilation.

Wind can increase or reverse airflow depending on direction.



5. Limitations of Natural Ventilation

- Depends on climatic conditions (temperature, wind).
- Not reliable in deep mines.
- Air quantity cannot be accurately controlled.
- May be insufficient for gaseous and dusty mines.
- Direction of airflow may change with season.

Unreliable for deep mines → Mechanical ventilation required

6. Mechanical Ventilation

- Use of fans, ducts and auxiliary equipment to create and control airflow in mines.
- Provides adequate air quantity, pressure and direction.
- Essential for deep mines, high heat, gas and dust conditions.
- Can be designed for intake and exhaust systems.

Mechanical Ventilation gives Control, Consistency and Safety

7. Basic Components

- Fans – create pressure difference
- Airways – deliver air to working places
- Regulators – control and distribute air quantity
- Auxiliary fans – used for local ventilation
- Ducts – guide air to specific locations
- Monitoring systems – measure air quantity, pressure, temperature and gas levels

8. Working Principle

- Fan creates a pressure difference (ΔP) between inlet and outlet.
- Air flows from high pressure to low pressure.
- Total resistance of mine airways must be overcome by the fan.

$$\text{Fan Pressure } \Delta P = R\,Q^2$$

ΔP = fan pressure (Pa)
R = total resistance (Pa/(m³/s)²)
Q = air quantity (m³/s)

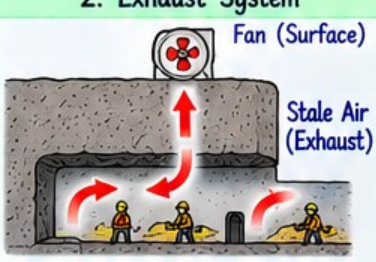
9. Types of Mechanical Ventilation Systems

1. Intake System



Fresh air is pushed into the mine

2. Exhaust System



Stale air is sucked out from the mine

10. Key Takeaways

- ✓ Natural ventilation is economical but unreliable in deep mines.
- ✓ Natural ventilation pressure is due to temperature and wind effects.
- ✓ Mechanical ventilation ensures required air quantity and safety.
- ✓ Selection of ventilation system depends on mine depth, heat, gas and dust.
- ✓ Proper design and control of ventilation improves safety, health and productivity.

Good Ventilation Saves Lives

GATE 2027

DAY - 7

MINING ENGINEERING (MN)

MINE VENTILATION

Mine Fans & Usage

Fan Types | Characteristics | Pressure–Quantity Curves | Fan Laws

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GATE Focus
Concepts
Numericals
MCQs

"Good Ventilation Safer Mines Brighter Future"

1. Role of Fans in Mines

- Fans provide the driving force for mine ventilation by creating a pressure difference.
- Used for intake, exhaust or auxiliary ventilation.
- Help to supply fresh air, dilute harmful gases, remove dust and control temperature.
- Proper selection and operation of fans ensures safety, productivity and energy efficiency.

> "Right Fan, Right Airflow, Right Environment for a Safer Mine"

2. Types of Mine Fans

Axial Flow Fan



- Air flows parallel to shaft axis
- High quantity, low pressure
- Used for main ventilation (surface and large mines)

Centrifugal Fan



- Air flows radially (outward)
- Moderate quantity, high pressure
- Used for underground and auxiliary ventilation

Mixed Flow Fan



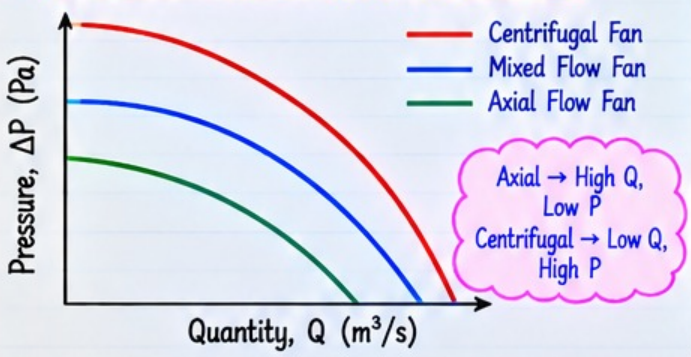
- Combination of axial and centrifugal
- Moderate quantity and pressure
- Used where both high quantity and moderate pressure are required

3. Fan Characteristics

- Total Pressure (ΔP) developed by the fan (Pa)
- Quantity of air delivered (Q) (m^3/s)
- Power required (kW)
- Efficiency (η)
- Noise level and durability
- Operating speed (N) (rpm)

Fan selection depends on mine resistance and required air quantity.

4. Pressure – Quantity (P-Q) Curves



Axial → High Q, Low P
Centrifugal → Low Q, High P

5. Fan Laws (Affinity Laws)

When the speed (N) or diameter (D) of a fan changes, the performance changes according to fan laws.

1. Effect of Speed (N)

$$Q_2 = Q_1 \left(\frac{N_2}{N_1}\right)$$

$$\Delta P_2 = \Delta P_1 \left(\frac{N_2}{N_1}\right)^2$$

$$P_2 = P_1 \left(\frac{N_2}{N_1}\right)^3$$

2. Effect of Diameter (D)

$$Q_2 = Q_1 \left(\frac{D_2}{D_1}\right)^3$$

$$\Delta P_2 = \Delta P_1 \left(\frac{D_2}{D_1}\right)^2$$

$$P_2 = P_1 \left(\frac{D_2}{D_1}\right)^5$$

Q = quantity of air (m^3/s)
ΔP = total pressure (Pa)
P = power (kW)
N = fan speed (rpm)
D = fan diameter (m)

Small change in speed or diameter can significantly affect fan performance (power $\propto N^3$)

6. Fan Selection Guidelines

- ✔ Determine required air quantity (Q) and pressure (ΔP).
- ✔ Consider mine resistance (R).
- ✔ Select fan type based on pressure and quantity needs.
- ✔ Check efficiency, power requirement and cost.
- ✔ Ensure reliable operation, easy maintenance and durability.
- ✔ Provide suitable control (dampers, regulators, VFD).

7. Numerical Example

A fan delivers 50 m^3/s at 600 rpm and develops 800 Pa. Find the new quantity, pressure and power if the speed is increased to 750 rpm. (Assume power at 600 rpm is 40 kW)

Solution : $N_1 = 600$ rpm $N_2 = 750$ rpm $\frac{N_2}{N_1} = \frac{750}{600} = 1.25$

$$Q_2 = 50 \times 1.25 = 62.5 \ m^3/s$$

$$\Delta P_2 = 800 \times (1.25)^2 = 800 \times 1.5625 = 1250 \ Pa$$

$$P_2 = 40 \times (1.25)^3 = 40 \times 1.953 = 78.1 \ kW$$

8. Key Takeaways

- ✔ Fans create pressure difference to move air in mines.
- ✔ Axial → high quantity, low pressure.
- ✔ Centrifugal → high pressure, low quantity.
- ✔ Performance changes follow fan laws ($Q \propto N$, $\Delta P \propto N^2$, $P \propto N^3$).
- ✔ Select and operate fans based on mine resistance and ventilation needs.
- ✔ Proper fan selection improves safety, air quality and energy efficiency.

Efficient Fans
Clean Air
Safe Miners
Higher Productivity

GATE 2027

DAY - 8

MINING ENGINEERING (MN)

MINE VENTILATION

Auxiliary Ventilation

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GATE Focus
Concepts
Numericals
MCQs

"Good Ventilation Safer Mines Sustainable Future"

Auxiliary Fans | Ducts | Forcing / Exhausting Systems | Development Headings

1. What is Auxiliary Ventilation ?

- Ventilation provided to specific areas such as development headings, stopes, dead ends and workplaces away from the main airways.
- Used when natural or main ventilation is insufficient.
- Supplied by auxiliary fans through ducting.
- Essential for safe working, removal of fumes, dust and heat.

"Auxiliary Ventilation Brings Fresh Air to Every Working Place"

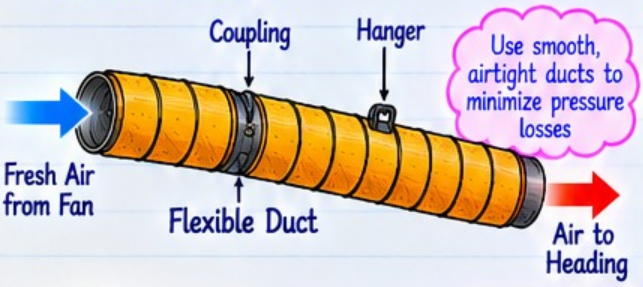
2. Auxiliary Fans

- Smaller capacity fans used to ventilate specific areas such as headings, stopes and short workings.
- Types: Axial flow, Centrifugal flow, Portable fans.
- Selected based on required air quantity, pressure and ease of handling.

Axial Fan	Centrifugal Fan	Portable Fan
		
• High quantity Low pressure • Light weight • Commonly used in headings	• Moderate quantity High pressure • Used for long ducts or higher resistance	• Compact, easy to move • Used for short duration / small workings

3. Ducts and Accessories

- Ducts carry fresh or return air to and from the working place.
- Made of flexible canvas, PVC or metal.
- Accessories: couplings, bends, branches, hangers, airtight joints.
- Proper installation reduces pressure losses and improves efficiency.

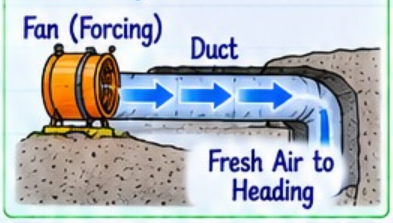


Use smooth, airtight ducts to minimize pressure losses

4. Forcing and Exhausting Systems

Forcing System (Blowing)

- Fan pushes fresh air through duct to the heading.
- Positive pressure at the fan.
- Used when clean fresh air is required at the face.
- Common in development headings.



Exhausting System (Suction)

- Fan sucks polluted air from the heading through duct.
- Negative pressure at the fan.
- Used to remove fumes, dust and harmful gases.
- Common in short headings and hazardous conditions.



5. Application in Development Headings

Auxiliary ventilation is mainly used in:

- ✓ Tunnels, cross-cuts and drive headings
- ✓ Stopes and raises
- ✓ Dead end workings
- ✓ Construction sites and maintenance areas
- ✓ Locations with diesel equipment or blasting fumes

Essential in development workings where main ventilation does not reach



6. Development of Auxiliary Ventilation

Steps for proper design and operation:

1. Determine air quantity (Q) required at the face.
2. Estimate total resistance (R) of duct + fittings + heading.
3. Select suitable fan (based on Q and pressure, $P = RQ^2$).
4. Choose duct size and type, ensure airtight installation.
5. Provide regulators (dampers) if branching is required.
6. Monitor airflow, adjust and maintain regularly.

Proper design ensures sufficient air, removes hazards and improves productivity

7. Key Takeaways

- ✓ Auxiliary fans are used for local ventilation.
- ✓ Ducts must be properly installed and airtight.
- ✓ Forcing and exhausting systems are chosen based on site conditions.
- ✓ Auxiliary ventilation is essential for development headings and dead ends.
- ✓ Correct design and regular monitoring ensure safety and efficient operation.

Good Air At Every Face Means Safe Miners And Higher Productivity

GATE 2027

DAY - 9

MINING ENGINEERING (MN)

MINE VENTILATION

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Learn Prepare Achieve

Ventilation Survey & Planning

"Measure Plan Ventilate For a Safer Tomorrow"

Quantity/Pressure Measurement | Instruments | Survey Procedure | Planning

GATE Focus
Concepts
Numericals
MCQs

1. Importance of Ventilation Survey

- Determines the actual air quantity, pressure and air quality in the mine.
- Helps identify leakages, high resistance zones and dead ends.
- Provides data for design, improvement and safety planning.
- Regular surveys ensure adequate ventilation and compliance with statutory limits.

"You Cannot Manage What You Do Not Measure"

2. Measurement of Air Quantity (Q)

- Air quantity is measured to determine the volume of air flowing through an airway.
- Expressed in m^3/s (SI) or m^3/min.
- Common methods:
  1. Anemometer method (velocity × area)
  2. Pitot tube method
  3. Vane anemometer
  4. Orifice meter / Flow nozzle

$$Q = A \times V$$

Q = air quantity (m^3/s)
A = cross-sectional area (m^2)
V = average air velocity (m/s)

Accurate measurement is the foundation of proper ventilation planning

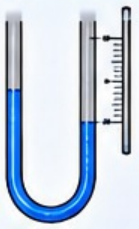
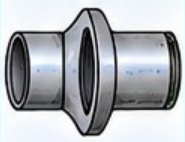
3. Measurement of Pressure (ΔP)

- Pressure measurement helps to find resistance, leakages and fan performance.
- Measured using manometers or electronic pressure gauges.
- Expressed in Pa, kPa or mm WG (water gauge).
- Types:
  1. U-tube manometer
  2. Inclined manometer
  3. Digital pressure gauge
  4. Micromanometer (for low pressures)

$$\Delta P = P_1 - P_2$$

Even small pressure differences are important in mine ventilation

4. Instruments Used in Ventilation Survey

Anemometer	Pitot Tube	Manometer	Flow Nozzle (Orifice Meter)
			
• Measures air velocity • Digital/rotating vane type • Simple & widely used	• Measures velocity from velocity pressure • Used in large airways • High accuracy	• Measures pressure difference (ΔP) • U-tube / inclined type • Simple and reliable	• Measures air quantity (Q) • Used in main airways • Provides permanent measurement

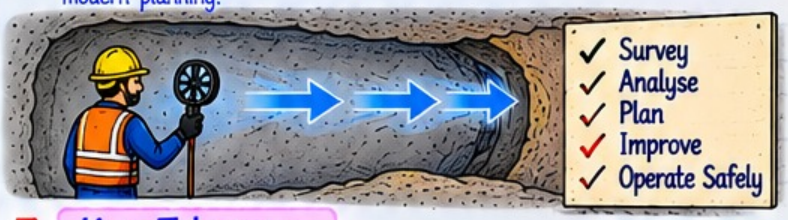
5. Ventilation Survey Procedure

Step 1	Plan the survey – prepare mine ventilation map and select survey stations.
Step 2	Measure air quantity – using anemometer / pitot tube at each station.
Step 3	Measure pressure – across key airways, regulators and auxiliaries.
Step 4	Record environmental data – temperature, humidity, gas concentration.
Step 5	Identify problems – leakages, high resistance, dead ends, inadequate air.
Step 6	Analyze results – compare with design values and statutory limits.
Step 7	Suggest improvements – additional fans, sealing, regulators, ducting.
Step 8	Prepare survey report – with data, observations and recommendations.

6. Ventilation Planning

- Objective: to provide required quantity and quality of air at all working places economically and safely.
- Based on: mine layout, production rate, heat, gas, dust, equipment and future development.
- Involves: selection of ventilation system, fans, ducts, regulators and control devices.
- Allows for future expansion and changing mining conditions.
- Use of simulation software (e.g., Ventsim) is common in modern planning.

Good Planning Ensures Safe, Healthy and Productive Mines



7. Key Takeaways

- ✓ Measure air quantity and pressure accurately.
- ✓ Use proper instruments and standard procedures.
- ✓ Regular surveys help identify ventilation problems early.
- ✓ Scientific planning ensures safe, healthy and productive mines.
- ✓ Survey data is the basis for design, improvement and future expansion.

Measure
Assess
Plan
Ventilate
Grow Safely

GATE 2027

DAY – 10

MINING ENGINEERING (MN)

MINE VENTILATION

Ventilation Networks + Master Revision

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Learn Prepare Achieve

"Good Ventilation Safer Mines Brighter Future"

Series/Parallel Networks | Network Analysis | Numericals | Mixed GATE

GATE Focus
Concepts
Numericals
MCQs

1. Ventilation Network

- A ventilation network is a system of interconnected airways through which air flows in a mine.
- Pressure differences are created by main or auxiliary fans.
- Air distributes itself based on resistance of different routes.
- Network analysis helps to find air quantities, pressures and identify problem areas (low air, high resistance, short circuits etc.).

"Analyse the Network – Ensure Proper Air Distribution"

2. Series and Parallel Networks

Series Network



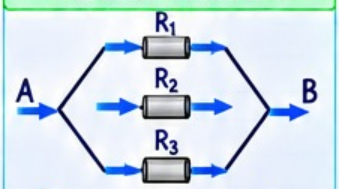
Q_{same} through all branches

$$R_{total} = R_1 + R_2 + R_3$$

$$\Delta P_{total} = Q^2(R_1 + R_2 + R_3)$$

Same quantity flows, pressures add.

Parallel Network



ΔP_{same} across all branches

$$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$Q_{total} = Q_1 + Q_2 + Q_3$$

Same pressure drop, quantities add.

3. Network Analysis Methods

1. **Hardy Cross Method (most common)**
   - Assume initial air quantities.
   - Calculate pressure drops.
   - Apply corrections and repeat until balance.
2. **Kirchhoff's Laws (Node & Loop method)**
   - ΣQ at a node = 0
   - $\Sigma \Delta P$ around a closed loop = 0
3. **Simulation Software (Ventsim, etc.)**
   - Used for large and complex networks.
   - Quick and accurate results.
4. **Trial and Error (simple problems)**
   - Used for small networks.

4. Important Formulae

- Pressure drop in an airway : $\Delta P = R\,Q^2$
- Quantity : $Q = A \times V$
- Resistance : $R = K \times \left(\frac{L}{A^3}\right)$ (Atkinson's equation)
  - L = length (m)
  - A = cross-sectional area (m^2)
  - K = resistance factor (depends on shape, roughness)
- Total quantity : $Q_{total} = \sum Q_i$

Resistance $\propto$ Length and inversely $\propto$ Area^3

5. Numerical Example – 1 (Series Network)

Three airways in series have resistances 0.02, 0.03 and 0.05 $Pa/(m^3/s)^2$. If 15 m^3/s of air flows through the network, find the total pressure drop.

Solution :

$$R_{total} = 0.02 + 0.03 + 0.05 = 0.10$$

$$\Delta P = Q^2 R_{total} = (15)^2 \times 0.10 = 225 \times 0.10 = 22.5\ Pa$$



$Q = 15\ m^3/s$ (same in all airways)

$\Delta P_{total} = 22.5\ Pa$

In series Q same ΔP adds

6. Numerical Example – 2 (Parallel Network)

Two parallel airways have resistances $R_1 = 0.04$ and $R_2 = 0.09$ $Pa/(m^3/s)^2$. The total quantity of air is 30 m^3/s. Find the quantity in each airway and the common pressure drop.

Solution :

$$\frac{1}{R_{total}} = \frac{1}{0.04} + \frac{1}{0.09} = 25 + 11.11 = 36.11$$

$$R_{total} = \frac{1}{36.11} = 0.0277$$

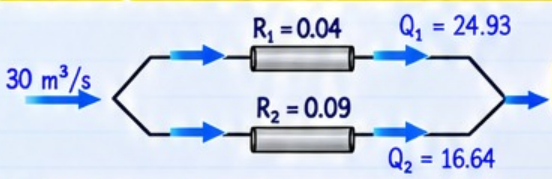
$$\Delta P = Q_{total}^2 \times R_{total} = (30)^2 \times 0.0277 = 900 \times 0.0277 = 24.93\ Pa$$

$$Q_1 = \sqrt{\frac{\Delta P}{R_1}} = \sqrt{\frac{24.93}{0.04}} = 24.93\ m^3/s$$

$$Q_2 = \sqrt{\frac{\Delta P}{R_2}} = \sqrt{\frac{24.93}{0.09}} = 16.64\ m^3/s$$

In parallel ΔP same Q adds

Check : $Q_1 + Q_2 = 24.93 + 16.64 = 30\ m^3/s$ ✓



7. Mixed GATE Practice Question

A network consists of two parallel branches. Branch 1 has two airways in series each of resistance 0.03 $Pa/(m^3/s)^2$. Branch 2 has a single airway of resistance 0.08 $Pa/(m^3/s)^2$. Total quantity is 40 m^3/s. Find the quantity in each branch and the total pressure drop.

Think Analyse Apply Succeed

8. Master Revision – Key Takeaways

- ✓ Understand series and parallel network behaviour.
- ✓ Use Hardy Cross method for network analysis.
- ✓ Be comfortable with numericals (R, Q, ΔP calculations).
- ✓ Know important formulae and assumptions.
- ✓ Interpret results for real mine ventilation problems.
- ✓ Practice previous GATE questions and mock tests.

Plan
Analyse
Solve
Revise
Repeat
Crack GATE

GATE 2027

DAY - 1

"Safe Mines
Healthy Miners
Bright Future"

MINING ENGINEERING (MN)

UNDERGROUND HAZARDS

Mine Gases – Fundamentals

Mine Atmosphere | Classification of Gases | Sources | Properties | Physiological Effects

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Learn
Prepare
Achieve

GATE Focus
Concepts
Numericals
MCQs

1. Mine Atmosphere

- Air in underground mines is a mixture of gases, water vapour and dust.
- Normal air at surface: 78% N_2, 21% O_2, 0.04% CO_2 + trace gases.
- In mines, composition changes due to respiration, blasting, oxidation, spontaneous heating, fires and other sources.
- Main concerns: oxygen deficiency, presence of harmful and explosive gases.
- Good ventilation maintains safe and breathable atmosphere.

"Clean Air is a Basic Right for Every Miner"

2. Classification of Mine Gases

As per Effect	As per Origin	As per Occurrence	As per Behaviour
• Inert gases (do not support life)	• Natural gases (gerological origin)	• Major gases (N_2, O_2, CO_2)	• Lighter than air (CH_4, H_2)
• Toxic gases (harmful to health)	• Generated gases (mining activities like blasting, oxidation, fires, diesel engines etc.)	• Minor gases (CH_4, CO, H_2S etc.)	• Heavier than air (CO_2)
• Asphyxiant gases (reduce oxygen)		• Trace gases (NO_x, SO_2, H_2 etc.)	• Same as air (CO_x, N_2, O_2)
• Explosive gases (burn or explode)			

3. Sources of Mine Gases

- Methane from coal seams and surrounding strata.
- Carbon dioxide from respiration, oxidation, blasting and fires.
- Carbon monoxide from incomplete combustion (diesel, fires, blasting).
- Hydrogen sulphide from sulphide minerals and stagnant water.
- Nitrogen oxides from explosives and diesel engines.
- Hydrogen from chemical reactions and batteries.
- Reduction of oxygen due to respiration, fires and oxidation.

Major Sources



Coal Seam (CH_4) | Blasting (CO, NO_x) | Diesel Engine (CO, NO_x) | Spontaneous Heating / Fire (CO, CO_2) | Water & Sulphides (H_2S)

4. Important Mine Gases and Their Properties

Gas	Symbol	Major Properties	Relative Density (Air = 1)	Flammability / Explosion Limits (Vol % in air)
Methane	CH_4	Colourless, odourless, explosive, lighter than air	0.55	LEL 5 UEL 15
Carbon Monoxide	CO	Colourless, odourless, very toxic, same density as air	0.97	LEL 12.5 UEL 74
Carbon Dioxide	CO_2	Colourless, odourless, non-combustible, heavier than air	1.52	Not combustible
Oxygen	O_2	Colourless, odourless, supports combustion and life	1.10	Supports fire (not combustible)
Nitrogen	N_2	Colourless, odourless, inert, dilutes oxygen	0.97	Not combustible
Hydrogen Sulphide	H_2S	Colourless, rotten egg smell, very toxic, heavier than air	1.19	LEL 4.3 UEL 46
Hydrogen	H_2	Colourless, odourless, very light, explosive	0.07	LEL 4 UEL 75

5. Physiological Effects on Human Body

Gas	Effect on Human Body	Typical Limits / Remarks
Oxygen (O_2)	• Essential for life • < 19.5% – unsafe • < 16% – impaired judgment • < 10% – unconsciousness • < 6% – death	Normal: 20.9% Safe: 19.5 – 23.5%
Carbon Monoxide (CO)	• Binds with haemoglobin, reduces oxygen supply in blood • Causes headache, dizziness, unconsciousness, death	Permissible: 25 ppm Dangerous: > 200 ppm
Carbon Dioxide (CO_2)	• Causes headache, breathlessness • High concentration → drowning	Normal: 0.04% Permissible: 0.5% Dangerous: > 3%
Methane (CH_4)	• Does not directly affect health (simple asphyxiant), but explosive	LEL: 5% UEL: 15%
Hydrogen Sulphide (H_2S)	• Irritates eyes and respiratory tract • High concentration → loss of smell → collapse → death	Permissible: 10 ppm Dangerous: > 100 ppm
Nitrogen (N_2)	• Simple asphyxiant, displaces oxygen	High concentration reduces oxygen level

6. Key Takeaways

- ✔ Mine atmosphere composition changes continuously.
- ✔ Identify gases based on properties, origin and effects.
- ✔ Methane is explosive; CO and H_2S are highly toxic.
- ✔ Maintain adequate ventilation to ensure safe oxygen level.
- ✔ Regular monitoring and gas detection are essential.
- ✔ Know permissible limits and common sources for GATE.

Identify
Control
Prevent
Stay Safe

GATE 2027

DAY – 2

MINING ENGINEERING (MN)

UNDERGROUND HAZARDS

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"Detect Control Stay Safe Work Tomorrow"

Mine Gases – Detection & Control

O_2 Deficiency | CH_4 | CO | CO_2 | H_2S | NOx | Detection | Sampling | Monitoring | Permissible Limits

GATE Focus
Concepts
Numericals
MCQs

1. Importance of Gas Detection & Control

- Helps in early identification of hazardous conditions.
- Prevents explosions, fires, poisoning and suffocation.
- Ensures safe working environment and compliance with statutory limits.
- Regular monitoring is essential in underground mines.

"Detect Early – Control Timely – Save Lives"

2. Major Mine Gases and Their Hazards

Gas	Symbol	Main Hazard	Source in Mines
Oxygen	O_2	Deficiency → suffocation	Consumed by respiration, fires
Methane	CH_4	Explosive	Coal seams, strata, goaf
Carbon Monoxide	CO	Toxic (binding with haemoglobin)	Incomplete combustion (diesel, fires, blasting)
Carbon Dioxide	CO_2	Asphyxiant	Respiration, fires, blasting, strata
Hydrogen Sulphide	H_2S	Highly toxic, rotten egg smell	Sulphide minerals, stagnant water
Nitrogen Oxides	NO_x (NO, NO_2)	Toxic, lung irritant	Blasting, diesel engines, fires

3. Permissible Concentrations (Typical)

Gas	Symbol	Permissible Limit	Remarks
Oxygen	O_2	19.5 – 23.5 %	< 19.5% unsafe
Methane	CH_4	< 1% (routine)	Explosive range 5 – 15%
Carbon Monoxide	CO	< 25 ppm (8 hr)	> 200 ppm dangerous
Carbon Dioxide	CO_2	< 0.5% (5000 ppm)	> 3% hazardous
Hydrogen Sulphide	H_2S	< 10 ppm	> 100 ppm dangerous
Nitrogen Dioxide	NO_2	< 3 ppm	Irritation at low levels
Nitric Oxide	NO	< 25 ppm	Forms NO_2 in air

Permissible limits may vary slightly as per different regulations (DGMS/MSHA).

4. O_2 Deficiency – Effects

- Normal O_2 in air = 20.9% (≈ 21%)
- < 19.5% → unsafe for continuous work
- 16 – 19% → impaired judgment
- 10 – 16% → nausea, dizziness, unconsciousness
- 6 – 10% → collapse, death
- < 6% → death within minutes

Check O_2 before entry in any confined work area

5. Gas Detection Instruments

Flame Safety Lamp



- Detects methane
- Flame height changes with CH_4 concentration
- Simple and reliable

Catalytic Bead Meter



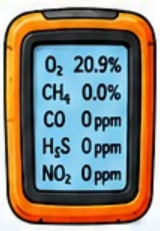
- Measures % LEL (methane)
- Quick response
- Widely used

Infrared (NDIR) Gas Analyzer



- Used for CO_2 (and some gases)
- Non-dispersive infrared
- Accurate & stable

Multi-Gas Detector



- Detects multiple gases (O_2, CH_4, CO, H_2S, NO_x)
- Used for personal safety monitoring

6. Gas Sampling Methods

Sample from different places and depths for accurate results

- Grab sampling – single sample at a point in time.
- Continuous sampling – real-time monitoring.
- Sampling locations – intakes, returns, workings, goaf areas, near diesel equipment and blasting sites.
- Use of gas sampling bags, evacuated bottles or electronic sensors.

7. Control Measures for Mine Gases

Control at Source
Monitor Regularly
Maintain Ventilation

- ✓ Proper ventilation and adequate air quantity.
- ✓ Pre-drainage of methane from coal seams.
- ✓ Control of diesel emissions (use low-emission engines).
- ✓ Regular monitoring using multi-gas detectors.
- ✓ Use of ventilation sealing, inertisation and stone dusting (for explosions).
- ✓ Removal of stagnant water (to prevent H_2S).
- ✓ Adequate maintenance of equipment and avoidance of incomplete combustion.
- ✓ Training, awareness and strict compliance with safety procedures.

8. Numerical Example

A mine atmosphere contains 0.8% CH_4, 0.1% CO_2 and 19.8% O_2. Check if the atmosphere is safe with respect to permissible limits.

Solution :

CH_4 = 0.8% (< 1%) → Safe ✓

CO_2 = 0.1% (< 0.5%) → Safe ✓

O_2 = 19.8% (≥ 19.5%) → Safe ✓

All parameters are within permissible limits. Atmosphere is safe.

9. Practice MCQs (GATE Style)

Q1. Which gas is mainly responsible for explosions in coal mines?

(a) CO (b) CO_2 (c) CH_4 (d) NO_2

Ans: (c)

Q2. Permissible limit of CO in mines is

(a) 10 ppm (b) 25 ppm (c) 100 ppm (d) 500 ppm

Ans: (b)

Q3. The explosive range of methane in air is

(a) 1–5% (b) 5–15% (c) 10–20% (d) 15–25%

Ans: (b)

Q4. O_2 concentration below which unconsciousness may occur is

(a) 18% (c) 10% (d) 6%

Ans: (b)

Practice More Numericals and Previous Year Questions

GATE 2027

DAY - 3

MINING ENGINEERING (MN)

UNDERGROUND HAZARDS

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Methane Drainage

"Drain Methane
Reduce Risk
Enable Safe Mining"

Methane Sources | Drainage Principles | Pre-drainage | Post-drainage | Boreholes | Drainage Systems | Monitoring

GATE Focus
Concepts
Numericals
MCQs

1. Why Methane Drainage ?

- Methane (CH_4) is explosive (5 – 15% in air).
- Draining methane reduces explosion risk, improves ventilation and increases production.
- Essential in high-gas and outburst-prone seams.
- Helps in safe, mechanized and high-production mining.

"Drain Methane Before it Enters the Working Place"

2. Sources of Methane in Mines

- Desorption from coal seams (main source).
- Surrounding strata (roof, floor, goaf).
- Old workings and sealed areas.
- Fractures, faults and weak zones.
- Decomposition of organic matter.
- Methane liberation due to mining-induced stress relief.

3. Principles of Methane Drainage

- ✓ Create low pressure to extract methane from seams.
- ✓ Intercept methane before it reaches working areas.
- ✓ Use boreholes and drainage system connected to vacuum.
- ✓ Continuous monitoring and control.
- ✓ Combine with proper ventilation and goaf management.
- ✓ More effective when done in advance (pre-drainage).

4. Pre-drainage vs Post-drainage

Pre-drainage (Advance)	Post-drainage
• Done before mining.	• Done after mining (e.g., from goaf).
• Boreholes from surface or underground.	• Boreholes into goaf or from adjacent seams.
• Reduces gas content in seam.	• Removes residual methane.
• Improves safety and production rate.	• Controls goaf gas emissions.
• Especially useful in high-gas and outburst-prone seams.	• Used in longwall and retreating mining.

5. Boreholes for Methane Drainage

Surface Borehole

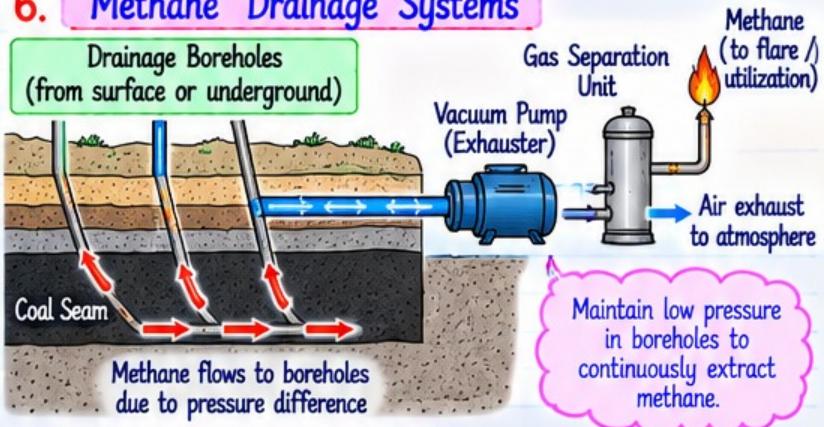


Underground Borehole



- Vertical, inclined or horizontal boreholes.
- Diameter: 50 mm – 150 mm (typical).
- Length: up to several hundred meters.
- Can be from surface or underground galleries.

6. Methane Drainage Systems



Maintain low pressure in boreholes to continuously extract methane.

7. Methane Monitoring

- Measure methane concentration in boreholes, galleries, goaf and return air.
- Instruments: methane sensors, multi-gas detectors, gas chromatographs.
- Continuous monitoring with data logging and alarms.
- Monitor vacuum pressure and gas flow rate.
- Analysis of desorption and gas content for planning drainage.
- Helps in assessing effectiveness and adjusting system.

Monitor
Measure
Analyse
Control
Stay Safe

8. Important Formulae

1. Gas flow rate (Q): $Q = A \times V$
   Q = gas flow rate (m^3/s), A = cross-sectional area of pipe (m^2), V = velocity of gas (m/s)
2. Gas quantity drained: $Q_{total} = Q \times t$
   Q_{total} = total gas drained (m^3), Q = flow rate (m^3/s), t = time (s)
3. Methane concentration: $C(\%) = \frac{V_{CH_4}}{V_{total}} \times 100$
   V_{CH_4} = volume of methane, V_{total} = total air/gas volume
4. Gas content of coal seam: $G = \frac{V_{gas}}{M_{coal}}$
   G = gas content (m^3/tonne), V_{gas} = volume of gas (m^3), M_{coal} = mass of coal (tonne)

9. Numerical Example

A drainage borehole produces methane at a rate of 120 m^3/h with a concentration of 60% CH_4. Calculate (a) methane flow rate (m^3/h) (b) methane volume drained in 10 days.

Solution :

Given:
Q = 120 m^3/h
C = 60% = 0.60
t = 10 days = 240 h

(a) Methane flow rate
$Q_{CH_4} = Q \times C$
$= 120 \times 0.60$
$= 72\ m^3/h$

(b) Methane volume in 10 days
$V_{CH_4} = 72 \times 240$
$= 17280\ m^3$

Answer: (a) 72 m^3/h
(b) 17,280 m^3

10. Key Takeaways

- ✓ Methane drainage reduces explosion risk and improves productivity.
- ✓ Pre-drainage is more effective than post-drainage.
- ✓ Use appropriate borehole design and drainage system.
- ✓ Regular monitoring ensures efficiency and safety.
- ✓ Apply formulae and numerical skills for GATE.

Plan Well
Drain Early
Monitor Regularly
Mine Safely

GATE 2027

DAY - 4

"Prevent Fires
Protect Miners
Ensure a Safer
Tomorrow"

MINING ENGINEERING (MN)

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Mine Fires - Fundamentals

Causes | Classification | Spontaneous Heating | Ignition Sources | Fire Triangle

GATE Focus
Concepts
Numericals
MCQs

1. Importance of Studying Mine Fires

- Mine fires endanger lives, damage equipment and stop production.
- Release toxic gases (CO, CO_2), smoke and heat.
- Difficult to control once established.
- Understanding causes and behaviour helps in prevention and early detection.
- Important for GATE, PSUs and mining safety.

"Fire Prevention is Always Better than Fire Fighting"

2. Causes of Mine Fires

1. Spontaneous heating of coal/organic matter
2. Electrical equipment (short circuit, overloading)
3. Frictional heating (conveyor belts, machinery)
4. Blasting operations
5. Open flames and hot surfaces (welding, cutting)
6. Methane and coal dust explosions

3. Classification of Mine Fires

Type	Cause / Source	Typical Features
Endogenous (Internal)	Spontaneous heating of coal and other organic matter	Starts within the coal mass, slow development, no external flame initially
Exogenous (External)	Caused by outside sources (electrical, blasting, friction, open flame)	Quick development, visible flame, easy to identify source
Surface Fires	On surface installations, coal stockpiles	May spread to underground workings
Underground Fires	In coal seams, goaf areas, roadways	Difficult to detect and control

4. Spontaneous Heating of Coal

- Slow oxidation of coal with oxygen at low temperature.
- Heat is generated due to exothermic oxidation reactions.
- If heat is not dissipated, temperature rises leading to spontaneous combustion.
- Affected by rank of coal, moisture, particle size, surface area and ventilation.
- Typical temperature stages:

1. Below 50°C - Slow oxidation (no visible effect)
2. 50 - 70°C - Noticeable heating
3. 70 - 100°C - Rapid oxidation, gas formation
4. > 100°C - Spontaneous combustion (ignition)

Low rank coals are more prone to spontaneous heating

5. Factors Affecting Spontaneous Heating

- Rank and composition of coal (low rank → more reactive)
- Moisture content (moderate moisture increases risk)
- Particle size (finer size → larger surface area)
- Surface area and porosity
- Ventilation (limited air flow increases risk)
- Presence of pyrites and other minerals (catalytic effect)
- Temperature and pressure

Finer coal + More oxygen = Higher risk

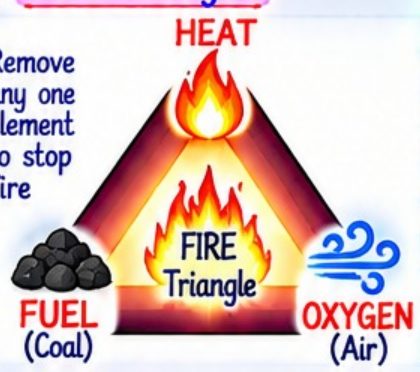
6. Ignition Sources in Mines

- Frictional heat (machinery, conveyors, bearings)
- Electrical sparks and short circuits
- Blasting and shot holes
- Hot surfaces (diesel engines, exhaust systems)
- Open flames (welding, cutting, heating)
- Methane and coal dust explosions
- Spontaneous heating (self-ignition)

Control Ignition Sources
Control Oxygen
Remove Heat
Stay Safe

7. Fire Triangle

Remove any one element to stop fire



Key Points

- ✓ Fuel + Oxygen + Heat are required for fire.
- ✓ In mines, fuel = coal, oxygen = mine air, heat = from oxidation or external sources.
- ✓ Fire can be prevented by removing or controlling any one element.

8. Stages of Fire Development

Initiation (Ignition) → Growth (Heat & gas generation) → Fully Developed (High temperature, flame, toxic gases) → Decay (Lack of fuel or oxygen)

9. Important Fire Gases

Gas	Symbol	Source	Effect
Carbon Monoxide	CO	Incomplete combustion	Highly toxic, binds with haemeglobin
Carbon Dioxide	CO_2	Complete combustion	Asphyxiant at high concentration
Methane	CH_4	From coal seams	Explosive
Smoke	-	Incomplete combustion	Reduces visiblity
Nitrogen Oxides	NO_x	High temperature	Irritation to lungs

10. Key Takeaways

- ✓ Mine fires may be endogenous or exogenous.
- ✓ Spontaneous heating is a major cause in coal mines.
- ✓ Fire triangle explains fire requirement (fuel + oxygen + heat).
- ✓ Early detection, monitoring and proper ventilation help in prevention.
- ✓ Understand causes, classification and behaviour for GATE.

Detect Early
Control Risk
Save Lives

GATE 2027

DAY - 5

MINING ENGINEERING (MN)

UNDERGROUND HAZARDS

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"Detect Control Prevent Fires Ensure Safety"

Mine Fires – Detection & Control

Fire Detection | Prevention | Firefighting | Fire Seals | Inertisation | Isolation | Fire Risk Assessment

GATE Focus
Concepts
Numericals
MCQs

1. Importance of Fire Detection & Control

- Early detection prevents spread and reduces damage.
- Controls toxic gases (CO, CO_2), heat and smoke.
- Protects lives, equipment and production.
- Helps in safe and economical mining.
- Essential for statutory compliance and mine safety.

"Detect Early – Control Effectively – Save Lives and Mines"

2. Fire Detection Methods

- Temperature monitoring (thermocouples, sensors)
- Gas monitoring (CO, CO_2, CH_4, hydrocarbon gases)
- Smoke detection
- Infrared (thermal) imaging
- Spontaneous heating indicators (rise in temperature, oxygen consumption, CO evolution)
- Regular inspection of return air, goaf areas and sealed zones

Early Detection = Low Damage

3. Prevention of Mine Fires

- ✓ Proper ventilation and control of air leakage.
- ✓ Avoid accumulation of coal dust and combustible materials.
- ✓ Use of intrinsically safe electrical equipment.
- ✓ Control of frictional heating (conveyors, bearings).
- ✓ Regular maintenance of machinery.
- ✓ Removal of hot spots and monitoring of goaf areas.
- ✓ Haulage, storage and handling of combustible materials as per safety norms.

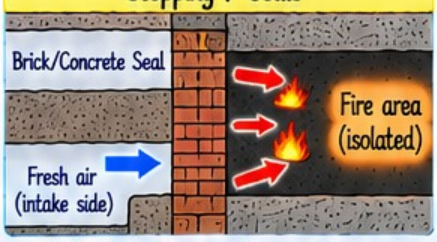
4. Firefighting Methods in Mines

Method	Working	Application
Water	Cooling and blanketing	Initial fires, surface installations
Foam	Smothers fire, cuts oxygen	Oil/flammable liquid fires, limited use underground
Inert gases (N_2, CO_2)	Reduces oxygen concentration	Sealed areas, goaf fires
Stone dust	Inert material, absorbs heat, prevents flame propagation	Coal dust fires, explosion prevention
Sand/earth	Smothers fire	Small fires, surface stockpiles
Chemical driers	Interrupts chain reaction	Specific applications

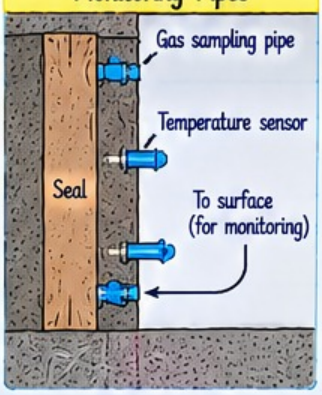
In underground mines, Inertisation + Sealing is the most effective method for large fires.

5. Fire Seals and Isolation

Stopping / Seals



Monitoring Pipes



- Built to isolate fire area from rest of the mine.
- Made of brick, concrete or other non-combustible materials.
- Should be airtight and strong.
- Provide monitoring pipes for gas sampling and pressure measurement.

6. Inertisation

- Replacing oxygen with inert gases (N_2, CO_2).
- Reduces oxygen concentration below the limiting level (usually < 8–10%).
- Used in sealed goaf areas and fire-affected zones.
- Can be done by injection of N_2/CO_2 from surface or by combustion of methane (controlled).
- Helps in cooling and preventing re-ignition.

Inert Atmosphere – No Fire No Re-ignition

7. Fire Risk Assessment

- Identify fire hazards (hot spots, faulty equipment, dust, etc.).
- Assess likelihood and potential consequences.
- Use risk matrix (probability vs severity).
- Implement control measures and monitor regularly.
- Update risk assessment based on inspection and data.

Use Risk Matrix
- ✓ Identify
- ✓ Assess
- ✓ Control
- ✓ Monitor
- ✓ Review

8. Numerical Example (GATE Style)

Q. A sealed area of 10,000 m^3 contains air with 21% oxygen. After inertisation the oxygen concentration is reduced to 8%. Calculate the volume of nitrogen to be injected (at the same temperature and pressure) assuming perfect mixing.

Solution :

Initial O_2 volume = $0.21 \times 10{,}000 = 2100\ m^3$

Final O_2 volume = $0.08 \times (10{,}000 + V_{N2})$

Since O_2 amount remains same (no consumption):

$0.21 \times 10{,}000 = 0.08 \times (10{,}000 + V_{N2})$

$2100 = 800 + 0.08\,V_{N2}$

$0.08\,V_{N2} = 1300$

$V_{N2} = 1300/0.08 = 16{,}250\ m^3$

Key Concept: Oxygen amount remains same, only volume increases.

Answer: 16,250 m^3

9. Practice MCQ

Q. Which of the following is the most effective method for controlling a large underground coal fire in a sealed area?

(a) Water spraying (b) Foam application
(c) Inertisation with nitrogen (d) Increased ventilation

Answer: (c)

10. Key Takeaways

- ✓ Early detection and continuous monitoring are essential.
- ✓ Prefer prevention over firefighting.
- ✓ Sealing and inertisation are most effective for large fires.
- ✓ Use stone dust to prevent explosion propagation.
- ✓ Regular fire risk assessment and inspection save lives and assets.

Plan Prevent Detect Control Stay Safe

GATE 2027

DAY – 6

"Know the Hazards
Control the Risks
Build a Safer Tomorrow"

MINING ENGINEERING (MN)

UNDERGROUND HAZARDS

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GATE Focus
Concepts
Numericals
MCQs

Mine Explosions

Methane Explosions | Coal-dust Explosions | Explosion Propagation | Ignition Sources | Prevention & Suppression

1. What is a Mine Explosion ?

- A rapid combustion of flammable gases, dust or vapours in confined underground space, producing high temperature, pressure and destructive forces.
- Can cause loss of life, severe damage to workings and long-term disruption.
- Main types: Methane (gas) explosions and Coal-dust explosions.
- Often both act together (initial methane explosion disperses coal dust → secondary explosion).

"One Small Ignition can Cause a Big Disaster"

2. Methane Explosions

- Methane (CH_4) mixed with air becomes explosive within a certain range (5 – 15% by volume).
- Minimum ignition energy is very low (≈ 0.28 mJ).
- Produces flame front and high pressure.
- Often the initial explosion which can raise and disperse coal dust leading to a more severe secondary explosion.
- Main products: CO_2, H_2O, heat and pressure.

3. Coal-dust Explosions

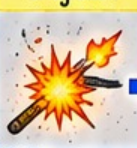
- ✓ Finely divided coal dust is explosive when suspended in air (typically > 50 – 100 g/m³).
- ✓ Requires an ignition source (flame, hot surface, electrical spark, methane explosion).
- ✓ More severe than methane explosion.
- ✓ Explosion can propagate long distances through roadways and galleries.
- ✓ Inert stone dust (rock dust) is used to prevent propagation.

4. Explosion Limits (Typical Values)

Substance	Lower Explosive Limit (LEL)	Upper Explosive Limit (UEL)	Remarks
Methane (CH_4)	5%	15%	Explosive range in air
Coal dust (typical)	~ 50 – 100 g/m³	~ 1,000 g/m³	Depends on coal type and particle size
Hydrogen (H_2)	4%	75%	Very wide range
Carbon Monoxide (CO)	12.5%	74%	Flammable
Propane (C_3H_8)	2.1%	9.5%	(For reference)

Methane + Coal Dust = Deadly Combination
Control One, Control Both

5. Explosion Mechanism

1. Ignition	2. Flame Propagation	3. Dust Dispersion	4. Secondary Explosion
			
Ignition source (electrical spark, friction, hot surface) ignites methane.	Flame travels through methane-air mixture creating high pressure and turbulence.	Initial explosion disturbs and raises coal dust from floor, walls and roof.	Suspended coal dust ignites, causing a more severe and longer lasting explosion.

6. Sources of Ignition

- Electrical sparks (wiring, machinery, shot-firing).
- Frictional heat (conveyors, bearings, machinery).
- Hot surfaces (diesel engines, exhausts, welding).
- Blasting and explosives.
- Open flames and smoking.
- Spontaneous heating of coal.
- Static electricity.
- Lightning (rare but possible in shallow mines).

Eliminate Ignition Sources = Prevent Explosions

7. Prevention and Suppression Methods

Prevention	Suppression / Mitigation
✓ Maintain methane concentration below LEL (proper ventilation and methane drainage).	✓ Stone dusting (inertisation) to prevent dust explosion propagation.
✓ Control coal dust (regular cleaning, stone dusting).	✓ Water spraying to knock down dust and absorb heat.
✓ Use of flameproof / intrinsically safe electrical equipment.	✓ Explosion barriers (rock dust barriers) in roadways.
✓ Avoid hot surfaces and open flames.	✓ Automatic suppression systems (water/chemical).
✓ Proper blasting practices and delay systems.	✓ Isolation of affected area.
✓ Monitoring and early detection of methane and dust.	✓ Use of non-combustible materials in roadways.
✓ Regular maintenance of machinery and conveyors.	

8. Numerical Example

Q. A gallery of volume 2,000 m³ contains methane at 8% by volume.
(i) Is the mixture explosive ?
(ii) If air contains 21% oxygen, calculate the volume of methane and oxygen present.

Solution :

Total volume (V) = 2,000 m³
CH_4 concentration = 8%
O_2 concentration in air = 21%

(i) Explosive range of methane = 5 – 15%
Given 8% → within range → Explosive ✓

(ii) Volume of CH_4 = 0.08 × 2,000 = 160 m³
Volume of O_2 = 0.21 × 2,000 = 420 m³

9. Practice MCQs (GATE Style)

Q1. The minimum ignition energy of methane is approximately:
(a) 2.8 mJ (b) 0.28 mJ
(c) 28 mJ (d) 280 mJ
Ans: (b)

Q2. Rock dust is primarily used in mines to:
(a) improve ventilation
(b) suppress coal-dust explosions
(c) absorb methane
(d) reduce frictional heat
Ans: (b)

10. Key Takeaways

- ✓ Methane explosions usually initiate, coal-dust explosions are more severe.
- ✓ Control methane, dust and ignition sources.
- ✓ Stone dusting and water spraying are effective mitigation methods.
- ✓ Regular monitoring, safe equipment and good ventilation save lives.
- ✓ Understand explosion mechanism and limits for GATE.

Safe Mines
Productive Mines
Bright Future

GATE 2027

DAY – 7

"Control Dust
Breathe Safe
Mine Longer"

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UNDERGROUND HAZARDS

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Mine Dust Hazards

Mine Dust | Respirable Dust | Dust Generation | Dispersion | Sampling | Prevention & Suppression

GATE Focus
Concepts
Numericals
MCQs

1. Introduction to Mine Dust

- Mine dust consists of finely divided solid particles generated during mining, drilling, blasting, loading, crushing, conveying and transport.
- Major types: coal dust, rock dust, silica dust, etc.
- Respirable dust (very fine) is most hazardous.
- Dust affects visibility, equipment life and health.
- Important for GATE, PSUs and mine safety.

"Invisible Particles, Visible Problems"

2. Types of Mine Dust

Type	Size Range	Source	Hazard
Total dust	< 100 μm	All mining operations	Nuisance, reduced visibility
Respirable dust	< 5 μm	Drilling, blasting, crushing	Deep lung penetration, serious health risk
Coal dust	< 100 μm	Coal mining, handling	Explosive, respiratory diseases
Silica dust	< 5 μm	Rock drilling, cutting	Silicosis (very hazardous)
Rock dust	< 100 μm	Development, heavy cutting	Irritation, pneumoconiosis

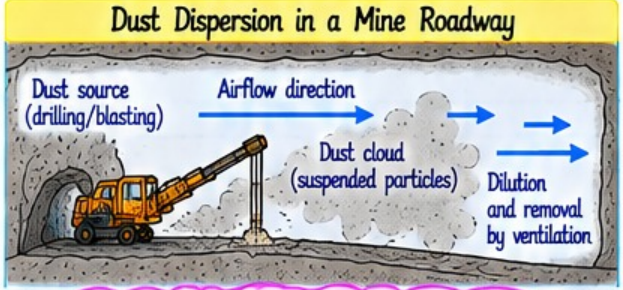
3. Dust Generation in Mines

- Drilling, blasting and excavation.
- Loading, hauling, conveying and transfer points.
- Crushing, screening and coal handling.
- Deposition and re-entrainment from roadways.
- Impact, abrasion and breakage of coal/rock.
- Higher speed and larger material size increase dust.

4. Dust Dispersion and Behaviour

- Dust particles remain suspended in air for long time (particularly fine and light particles).
- Affected by air velocity, turbulence, humidity and particle size.
- Respirable dust travels deep into lungs.
- Mine ventilation helps to dilute and remove dust.
- Settling velocity increases with particle size.

Dust Dispersion in a Mine Roadway



Good Ventilation Dilutes Dust,
But Control at Source is the Best Solution

5. Dust Sampling and Measurement

- Instruments: personal dust sampler, gravimetric sampler, real-time dust monitor.
- Sampling at breathing zone (1.5 m height).
- Measured as mg/m³ (mass concentration).
- Respirable dust collected using cyclone or filter.
- Regular monitoring is required as per statutory norms.
- Helps in assessing exposure and effectiveness of control measures.

Common Instruments



- Personal Dust Sampler
- Cyclone Sampler
- Real-time Monitor
- Filter Paper (Gravimetric)

6. Occupational Exposure and Health Effects

Disease / Effect	Main Cause	Symptoms	Remarks
Pneumoconiosis (General)	Long-term inhalation of mine dust	Breathlessness, reduced lung function	Common in miners
Coal Workers' Pneumoconiosis (CWP)	Coal dust	Cough, breathlessness, disability	Major occupational disease
Silicosis	Silica dust (rock)	Severe lung damage, shortness of breath	Irreversible
Byssinosis	Cotton-like dust (in textile, reference)	Chest tightness	Not common in mines (but asked in exams)
Other effects	Irritation, reduced visibility	Eye, nose, throat irritation	Affects safety and productivity

"Control Dust Today – Protect Lungs Tomorrow"

7. Dust Control Methods

At Source	In Air / Path	On Surfaces
✓ Wet drilling and wet drilling fluids	✓ Adequate ventilation	✓ Regular stone dusting (in coal mines)
✓ Water spraying at loading, transfer and crushing points	✓ Use of water sprays/mists	✓ Surface wetting
✓ Dust extraction systems	✓ Fogging systems	✓ Paving and proper road maintenance
✓ Use of enclosed conveyors	✓ Use of surfactants (wetting agents)	✓ Minimize re-entrainment
✓ Proper maintenance of machinery	✓ Dust suppression chemicals	✓ Good housekeeping

8. Important Values / Limits (Typical)

Parameter	Value (Typical)	Remarks
Permissible limit (Total dust)	10 mg/m³	(as per DGMS, may vary)
Permissible limit (Respirable dust)	3 mg/m³	(for coal mines)
Silica (respirable)	0.1 mg/m³	(very hazardous)
Sampling duration	1 – 8 hours	Personal sampling
Particle size (respirable)	< 5 μm	Reaches alveoli

9. Numerical Example

A dust sampler collects 3.6 mg of respirable dust in 2 hours. If the air sampled is 1.2 m³/min, find the concentration in mg/m³. Is it within the permissible limit of 3 mg/m³?

Solution :

Total air volume = 1.2 × 60 × 2 = 144 m³

Concentration = 3.6 / 144 = 0.025 mg/m³

0.025 mg/m³ < 3 mg/m³ ✓ Safe

10. Practice MCQ (GATE Style)

Q1. Which method is MOST effective for controlling dust at the source in underground mines?

(a) Increasing ventilation
(b) Regular stone dusting
(c) Wet drilling
(d) Use of dust masks

Ans: (c)

Key Takeaways

- ✓ Control dust at source.
- ✓ Respirable dust is most hazardous.
- ✓ Ventilation dilutes but does not remove dust completely.
- ✓ Regular monitoring is essential.
- ✓ Dust control improves safety, health and productivity.

GATE 2027

DAY – 8

MINING ENGINEERING (MN)

UNDERGROUND HAZARDS

SAR TUTORIAL ACADEMY HYDERABAD

Learn Prepare Achieve

"Anticipate Water
Prevent Inrush
Mine Safely"

Inundation & Water Hazards

Sources of Water | Sudden Inrush | Water Barriers | Boreholes | Probing | Drainage | Prevention | Emergency Response

GATE Focus
Concepts
Numericals
MCQs

1. Introduction to Inundation

- Inundation is the unwanted inflow of water into underground workings.
- Can cause loss of life, damage to equipment, disruption of production and permanent closure of mine.
- May occur gradually (seepage) or suddenly (water inrush).
- Important for GATE, PSUs and mine safety.

"Water does not give a Second Warning"

2. Sources of Water in Mines

Source	Description / Examples
Surface water	Rainfall, rivers, lakes, streams, ponds, reservoirs
Groundwater	Aquifers, water table, seepage
Old workings	Abandoned mines, flooded galleries
Faults, fractures and joints	Act as water channels
Goaf areas	Accumulated water in goaf
Adjacent mines	Inundated workings in nearby mines
Natural water bodies	Underground lakes, water-bearing strata

3. Types of Inundation

Type	Features
Gradual seepage	Continuous, low rate inflow, can be controlled by pumping
Sudden inrush	High rate, unexpected, very dangerous
Through old workings	Connection with abandoned/flooded mines
Through faults/fractures	Due to geological disturbances
From surface	During heavy rainfall or surface subsidence
From water-bearing strata	Penetration of aquifers

4. Sudden Inrush – Causes and Indicators

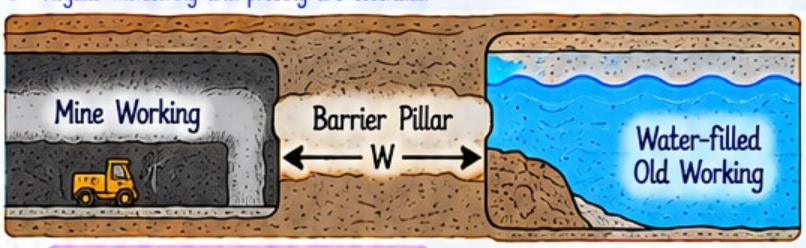
Causes	Warning Indicators
• Breach of water-filled old workings	✓ Increase in water seepage
• Intersection of faults/fractures	✓ Change in water quality (turbidity, temperature)
• Penetration of water-bearing strata	✓ Damp spots and wet ground
• Failure of natural or artificial barriers	✓ Roaring sound of water
• Heavy rainfall and surface subsidence	✓ Drop in groundwater pressure
• Human error during drilling/blasting	✓ Unexpected inflow in boreholes

"Observe, Probe, Verify – Then Advance"

5. Water Barriers and Safety Distance

Adequate Barriers Save Lives

- Water barriers (stalwart pillars) are left between workings and water bodies to prevent inrush.
- Width depends on geological conditions, water pressure and mine depth.
- No universal value – determined by experience, regulations and risk assessment.
- Regular monitoring and probing are essential.



6. Boreholes and Probing

- Drill probe holes ahead of face, in floor, roof and sides.
- Used to detect water-filled voids, old workings or aquifers.
- Small diameter holes at closer spacing.
- If water is encountered, measure pressure, water quality and flow rate.
- Use of longwall and inclined boreholes for advance detection.



Drilling Ahead of Face

7. Drainage of Mine Water

- Pumping is the main method to remove water.
- Use sumps, pipelines and stages of pumping for deep mines.
- Provide standby pumps and emergency power supply.
- Regular maintenance of pumps and pipelines.
- Design drainage capacity for peak inflow conditions.

Types of Pumps
- Centrifugal pumps
- Submersible pumps
- Turbine pumps
- Positive displacement pumps

8. Important Formulae

1. Hydrostatic pressure $P = \rho g h$
   P = water pressure (Pa)
   ρ = density of water (≈ 1000 kg/m³)
   g = 9.81 m/s²
   h = height of water column (m)

2. Water inflow through a crack/joint (Darcy's law – simplified) $Q = \frac{k A \Delta h}{L}$
   Q = discharge (m³/s)
   k = permeability (m/s)
   A = area (m²)
   Δh = head difference (m)
   L = length (m)

3. Pump power $P = \frac{\rho g Q H}{\eta}$
   P = power (W)
   Q = discharge (m³/s)
   H = total head (m)
   η = overall efficiency

9. Numerical Example

Q. A mine has a water seepage of 0.02 m³/s from a fracture. If the water has to be pumped to a height of 60 m, calculate the required power (η = 70%).

Solution : $P = \frac{\rho g Q H}{\eta} = \frac{1000 \times 9.81 \times 0.02 \times 60}{0.70}$

$= 16{,}817\ W = 16.8\ kW$

Answer: 16.8 kW

10. Key Takeaways

- ✓ Identify potential sources before starting mining.
- ✓ Use boreholes and probing to detect water hazards.
- ✓ Maintain adequate water barriers.
- ✓ Provide sufficient and reliable drainage capacity.
- ✓ Have an emergency response plan for sudden inrush.
- ✓ Regular monitoring saves lives and assets.

Be Alert
Be Prepared
Control Water
Ensure Safety

GATE 2027

DAY – 9

MINING ENGINEERING (MN)

UNDERGROUND HAZARDS

SAR TUTORIAL ACADEMY HYDERABAD

Learn Prepare Achieve

GATE Focus
Concepts
Numericals
MCQs

"Trained Rescuers Save Lives Mines Run Safer"

Mine Rescue Apparatus & Practices

Rescue Organization | Rescue Teams | Breathing Apparatus | Self-Rescuers | Rescue Procedures | Emergency Communication

1. Importance of Mine Rescue

- To save lives, control emergencies and restore normal operations.
- Deals with fires, explosions, inundation, roof falls, toxic gases and other hazards.
- Well trained rescue teams and proper equipment reduce loss of life and damage.
- Essential for statutory compliance and mine safety.

"Rescue is not a Choice, It is a Preparedness"

2. Mine Rescue Organization

- At National level: CSIR-Central Institute of Mining and Fuel Research (CIMFR), Dhanbad
- Stationed mine rescue teams at strategic locations.
- Trained rescue teams with specialized equipment.
- Conducts training, mock drills and research.
- Provides assistance to mines during major incidents.

3. Rescue Teams – Structure



4. Types of Mine Rescue Teams

Type	Role	Features
First Response Team (Mine)	Initial action locally	Mine employees, basic equipment
Professional Rescue Team	Major rescue operations	Highly trained, specialized apparatus
Support Team	Surface support, logistics	Communication, medical, standby
Medical Team	First aid, resuscitation, treatment	Paramedics, doctors

5. Self-Rescuers (SCSR)



Self-Contained Self-Rescuer (SCSR)

- ✔ Carried by every underground worker.
- ✔ Provides breathable air for short duration (typically 30 – 60 minutes).
- ✔ Used to escape from smoke, toxic gases and oxygen-deficient atmosphere.
- ✔ Types: Chemical oxygen (KOH), compressed oxygen, oxygen candles.
- ✔ Should be simple, reliable and easy to use.

"Wear it, Carry it, Know how to use it"

6. Breathing Apparatus (BA)

Open-Circuit Compressed Air BA



- Air from cylinder is supplied on demand.
- Used in non-oxygen and toxic atmosphere.
- Duration: 30 – 60 minutes (depends on cylinder).
- Lightweight and widely used.

Used for entry into toxic, smoky or oxygen-deficient areas.

Closed-Circuit Breathing Apparatus (Rebreather)



- Exhaled CO_2 is absorbed by chemical (KOH) and oxygen is recycled.
- Longer duration (3 – 4 hours).
- No gas bubble – silent operation.
- Used for prolonged rescue operations in hazardous conditions.

Suitable for deep mines and long duration rescue missions.

7. Other Important Rescue Apparatus

Gas Detector



- Detects O_2, CH_4, CO, CO_2, H_2S etc.
- Used for safe entry and monitoring.

Stretcher



- Used to carry injured persons.
- Lightweight, foldable type.

Rescue Line & Communication Set



- Guide rope, lifeline, signalling.
- Two-way communication (voice / signal).

First Aid & Medical Kit



- For immediate treatment.
- Includes oxygen resuscitator, splints, bandages, medicines.

8. Mine Rescue Procedures

1. Get information about the incident (location, nature, number of persons).
2. Assess the hazard and plan the rescue operation.
3. Wear appropriate breathing apparatus and safety gear.
4. Enter the mine with guide rope and communication.
5. Search, locate and rescue affected persons.
6. Bring the rescued persons to surface and provide first aid.

Plan
Communicate
Rescue
Recover
Report

9. Emergency Communication

- Use of wired communication systems (telephone, leaky feeder).
- Two-way radio communication (intrinsically safe).
- Signal codes and lifeline communication.
- Maintain continuous contact between underground and surface.
- Critical for coordination and safety of rescue teams.

Key Features

- ✔ Reliable
- ✔ Intrinsically safe
- ✔ Clear and simple
- ✔ Redundancy
- ✔ Regular testing

10. Practice MCQ (GATE Style)

Q. Which apparatus is most suitable for prolonged rescue operations (2 – 4 hours) in toxic atmosphere?

(a) Self-rescuer (SCSR)
(b) Open-circuit compressed air BA
(c) Closed-circuit breathing apparatus
(d) Gas detector

Ans: (c)

11. Key Takeaways

- ✔ Rescue teams and proper equipment save lives.
- ✔ Self-rescuers are mandatory for all underground workers.
- ✔ Closed-circuit BA is used for long duration.
- ✔ Regular training, mock drills and communication are essential.
- ✔ Be prepared, act quickly and follow procedures.

GATE 2027

DAY – 10

MINING ENGINEERING (MN)

UNDERGROUND HAZARDS

SAR TUTORIAL ACADEMY HYDERABAD

Learn Prepare Achieve

Safety Management Plan

"Safe Mines
Productive Mines
Sustainable Future"

Safety Policy | Hazard Identification | Risk Assessment | Control Hierarchy | SOPs | Emergency Plans | Safety Audits

GATE Focus
Concepts
Numericals
MCQs

1. What is a Safety Management Plan?

- A systematic plan to identify hazards, assess risks, implement controls and ensure safe mining operations.
- Integrates people, process, equipment and procedures.
- Aims to prevent accidents, protect health, comply with regulations and promote a safety culture.
- Essential for underground mines due to high-risk hazards (gas, fire, dust, inundation, ground control, etc.).

"Plan Safety – Prevent Accidents
Ensure Continuity"

2. Safety Policy

- Top management commitment to safety.
- Clear objectives and responsibilities.
- Compliance with statutory requirements.
- Provision of resources and training.
- Continuous improvement.

Safety Starts from the Top

3. Hazard Identification

- Identify all potential hazards in mining operations.
- Methods: workplace inspection, job safety analysis (JSA), incident reports, HAZOP, workers' feedback.
- Common hazards: gas, fire, dust, inundation, ground fall, electrical, machinery, transportation, etc.

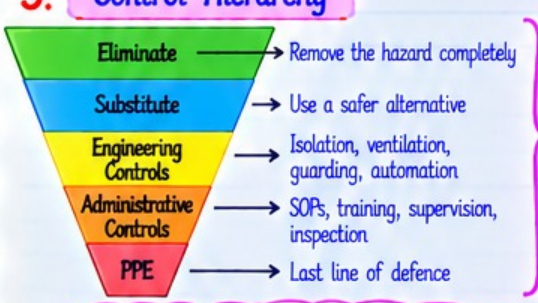
4. Risk Assessment

- Evaluate the likelihood and severity of each hazard.
- Use a Risk Matrix to prioritize risks.
- Consider existing controls.
- Classify risks: High, Medium, Low.
- Review periodically and after major changes.

Risk Matrix

Likelihood	Severity			
	Minor	Moderate	Major	Catastrophic
Very High	Medium	High	High	Extreme
High	Medium	High	Extreme	Extreme
Medium	Low	Medium	High	Extreme
Low	Low	Medium	Medium	High
Very Low	Low	Low	Medium	High

5. Control Hierarchy



"Try to Eliminate or Isolate –
PPE is the Last Option"

6. Standard Operating Procedures (SOPs)

- Detailed written procedures for routine and non-routine tasks.
- Covers safe work methods, equipment use, communication and emergency actions.
- Should be simple, clear, and accessible to all workers.
- Regularly reviewed and updated.

SOP = Right Method + Right People + Right Equipment + Safe Output



7. Emergency Plan

- Preparedness for unexpected events (fire, explosion, inundation, major ground fall, etc.).
- Defines roles, communication, evacuation routes and assembly points.
- Regular mock drills and training.
- Coordination with mine rescue teams and external agencies.

Key Elements of Emergency Plan

- ✓ Emergency communication system
- ✓ Alarm and evacuation system
- ✓ Rescue procedures and first aid
- ✓ Alternate escapeways and refuge chambers
- ✓ Periodic drills and reviews



Be Prepared
Be Trained
Be Ready

8. Safety Audits



- Systematic and independent evaluation of safety performance.
- Checks compliance with laws, standards, SOPs and safety policy.
- Identifies gaps and recommends corrective actions.
- Types: Internal audit (by company), External audit (by experts/regulators).
- Follow-up and continuous improvement are essential.

9. Safety Management Cycle (PDCA)



10. Case Study Example

Q. In a coal mine, repeated minor methane alarms are reported in a specific section. What should be the MOST appropriate action as part of a Safety Management Plan?

(a) Ignore, as they are only minor alarms
(b) Increase the production in that section
(c) Investigate the source, assess the risk and implement control measures
(d) Stop all operations in the entire mine

Ans: (c)

11. Practice MCQ (GATE Style)

Q. Which of the following is at the TOP of the hierarchy of controls in mine safety?

(a) Personal protective equipment
(b) Administrative controls
(c) Engineering controls
(d) Elimination of hazard

Ans: (d)

12. Key Takeaways

- ✓ Strong safety policy and leadership.
- ✓ Identify hazards and assess risks.
- ✓ Apply control hierarchy.
- ✓ Follow SOPs and emergency plans.
- ✓ Conduct regular safety audits.
- ✓ Continuous improvement saves lives.

GATE 2027

DAY - 11

MINING ENGINEERING (MN)

UNDERGROUND HAZARDS

SAR TUTORIAL ACADEMY HYDERABAD

Learn Prepare Achieve

Safety Data Analytics

"Data Today Safer Tomorrows Mines for Generations"

Accident Data | Frequency / Severity Indicators | Incident Analysis | Trend Analysis | Root-Cause Analysis | Leading / Lagging Indicators

GATE Focus
Concepts
Numericals
MCQs

1. What is Safety Data Analytics?

- Systematic collection, analysis and interpretation of safety-related data to prevent accidents.
- Helps in identifying trends, root causes and areas for improvement.
- Supports data-driven decision making and risk reduction in mines.
- Uses both historical and real-time data (from incidents, inspections, monitoring systems).

"Measure, Analyse, Improve – Make Mines Safer"

2. Types of Safety Data

Type	Examples
Accident data	Injuries, fatalities, property damage
Incident data	Near misses, hazardous conditions
Inspection data	Safety audits, rule violations
Monitoring data	Gas, dust, temperature, ventilation
Training data	Training hours, competency records

3. Key Safety Indicators

Indicator	Meaning
Frequency Rate (FR)	How often accidents occur
Severity Rate (SR)	How serious the accidents are
Incidence Rate (IR)	Number of cases per 100 workers
Lost Time Injury Frequency Rate (LTIFR)	Lost time injuries per million man-hours
Lost Time Injury Severity Rate (LTISR)	Lost days per million man-hours
Leading Indicators	Proactive measures (inspections, training, hazard reporting)
Lagging Indicators	Reactive measures (accidents, injuries, lost days)

4. Important Formulas

1. Frequency Rate (FR)
$$FR = \frac{N \times 10^6}{H}$$
N = number of accidents
H = total man-hours worked

2. Severity Rate (SR)
$$SR = \frac{D \times 10^6}{H}$$
D = total lost days
H = total man-hours worked

3. Incidence Rate (IR)
$$IR = \frac{N \times 10^5}{E}$$
E = average number of employees

4. Lost Time Injury Frequency Rate (LTIFR)
$$LTIFR = \frac{N_{LTI} \times 10^6}{H}$$
N_{LTI} = number of lost time injuries

5. Lost Time Injury Severity Rate (LTISR)
$$LTISR = \frac{D \times 10^6}{H}$$
D = total lost days
H = total man-hours worked

5. Example Calculation

A mine worked 2,50,000 man-hours in a year and reported 5 lost time injuries with a total of 120 lost days. Calculate (i) FR (ii) SR (iii) LTIFR (iv) LTISR.

Solution :

(i) $FR = \frac{5 \times 10^6}{2,50,000} = 20.0$

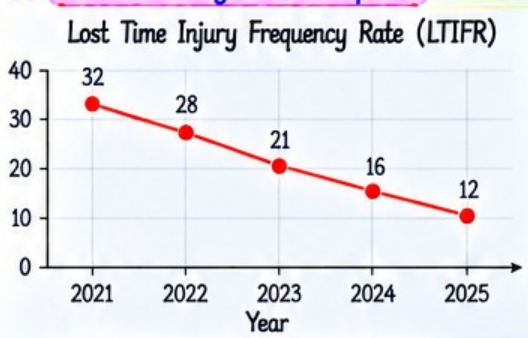
(ii) $SR = \frac{120 \times 10^6}{2,50,000} = 480.0$

(iii) $LTIFR = \frac{5 \times 10^6}{2,50,000} = 20.0$

(iv) $LTISR = \frac{120 \times 10^6}{2,50,000} = 480.0$

Numbers Tell the Story
Use Them to Prevent the Next Accident

6. Trend Analysis (Example)



Interpretation

- ✓ Consistent reduction in LTIFR indicates improvement in safety performance.
- ✓ Trend analysis helps in evaluating the effectiveness of safety measures.
- ✓ Use graphs, charts and dashboards for better visualization.

7. Root-Cause Analysis (RCA)

1. Identify the Problem
2. Collect and Analyse Data
3. Find Root Causes (Why?)
4. Develop Corrective Actions
5. Implement & Monitor

Common Tools: 5-Why Analysis | Fishbone Diagram | Fault Tree Analysis (FTA)

8. Leading vs Lagging Indicators

Aspect	Leading Indicators	Legging Indicators
Nature	Proactive (predict future)	Reactive (past events)
Examples	Safety training hours, inspection count, hazard reports	Accidents, injuries, lost days, property damage
Purpose	Prevent accidents	Measure consequence
Use	Early warning & continuous improvement	Evaluate past performance

9. Practice MCQs (GATE Style)

Q1. A mine recorded 3 lost time injuries in 1,50,000 man-hours. What is the LTIFR?
(a) 10 (b) 20
(c) 30 (d) 40
Ans: (b)

Q2. Which of the following is a leading indicator?
(a) Number of accidents
(b) Lost days
(c) Safety inspection frequency
(d) Fatalities
Ans: (c)

Q3. If 8 injuries caused 240 lost days in 4,00,000 man-hours, the severity rate (SR) is:
(a) 200 (b) 400
(c) 600 (d) 800
Ans: (b)

Q4. In root-cause analysis, the "5-Why" method is used to:
(a) Quantify risk
(b) Identify the basic cause
(c) Calculate frequency rate
(d) Prepare safety audit report
Ans: (b)

10. Key Takeaways

- ✓ Use data to identify hazards and trends.
- ✓ Monitor both leading and lagging indicators.
- ✓ Perform root-cause analysis for every incident.
- ✓ Regularly review and update safety measures.
- ✓ Data-driven safety leads to zero harm.

Analyse Today
Avoid Tomorrow

GATE 2027

DAY – 12

MINING ENGINEERING (MN)

UNDERGROUND HAZARDS

SAR TUTORIAL ACADEMY HYDERABAD

Learn Prepare Achieve

"Better Light
Safer Work
Higher Productivity"

Mine Illumination

Illumination Requirements | Lamps | Lighting Systems | Measurement | Lux | Glare | Lighting Safety

GATE Focus
Concepts
Numericals
MCQs

1. Importance of Mine Illumination

- Ensures safe and efficient working conditions.
- Helps in accident prevention, better visibility and higher productivity.
- Reduces eye strain and fatigue.
- Essential for inspection, maintenance and emergency operations.
- Part of statutory safety requirements.

"Good Lighting Prevents Accidents and Improves Performance"

2. Illumination Requirements (Typical)

Location / Activity	Recommended Illumination (Lux)
Main haulage roads	20 – 50
Working faces (development)	50 – 100
Drilling, loading, supported work	100 – 200
Control rooms, workshops	200 – 500
Stairways, crossings, refuge chambers	50 – 100
General underground travel	20 – 50

3. Types of Lamps Used in Mines

Cap Lamp (LED)



- Worn on helmet
- Battery operated
- Widely used now
- High efficiency

Hand Lamp



- Portable
- Used for inspection and maintenance
- Rugged design

Flame Safety Lamp (Traditional)



- Used in gassy mines (historical).
- Prevents ignition of methane
- Now replaced by intrinsically safe electric lamps

4. Lighting Systems

- Battery operated LED cap lamps (most common).
- Fixed lighting in roadways, junctions and working places.
- Flameproof and intrinsically safe fittings for gassy mines.
- Emergency lighting systems (battery backup).
- Use of energy efficient LED technology.

5. Illumination Measurement

- Measured in Lux (lx) = lumens per square meter.
- Instrument: Lux meter (light meter).
- Place the sensor at working plane (usually 1 m above floor).
- Take multiple readings and find average.



Lux Meter

- Measures light intensity (illumination).
- Sensor kept at working level.
- Units: lux (lx).
- Used for compliance and safety audits.

Measure Regularly
Maintain Properly

6. Important Formulae

1. **Illumination (Lux)** $E = \frac{\Phi}{A}$
   E = illumination (lux)
   Φ = total luminous flux (lumens, lm)
   A = area (m^2)
2. **Luminous intensity** $I = \frac{\Phi}{\omega}$
   I = luminous intensity (candela, cd)
   Φ = luminous flux (lumens)
   ω = solid angle (steradians)
3. **Inverse square law** $E = \frac{I}{d^2}$
   E = illumination (lux)
   I = luminous intensity (cd)
   d = distance from source (m)
4. **Number of lamps required** $N = \frac{E \times A}{n \times \Phi_L}$
   N = number of lamps
   E = required illumination (lux)
   A = area (m^2)
   n = utilization factor (0.3 – 0.6)
   Φ_L = lumens per lamp (lm)

7. Numerical Example 1 – Illumination from a Lamp

A lamp has a luminous intensity of 1000 cd. Find the illumination at a point 5 m away directly below the lamp.

Solution : $E = \frac{I}{d^2} = \frac{1000}{5^2} = \frac{1000}{25} = 40$ lux

Answer: 40 lux

8. Numerical Example 2 – Number of Lamps

A roadway of area 100 m^2 requires an illumination of 50 lux. Each LED lamp gives 1000 lumens. If the utilization factor is 0.5, find the number of lamps required.

Solution : $N = \frac{E \times A}{n \times \Phi_L} = \frac{50 \times 100}{0.5 \times 1000} = \frac{5000}{500} = 10$ lamps

Answer: 10 lamps

9. Glare and Its Control

- **Glare:** Excessive brightness causing discomfort and reduced visibility.
- **Causes:** High intensity lamps, wrong positioning, reflective surfaces.
- **Effects:** Eye strain, headaches, reduced concentration, accidents.
- **Control:** Use diffuse lighting, proper lamp shielding, correct mounting height, avoid direct line of sight.

Right Light
No Glare
Clear Vision
Safe Work

10. Lighting Safety Precautions

- ✓ Use intrinsically safe and flameproof fittings in gassy mines.
- ✓ Ensure regular maintenance and cleaning of lamps.
- ✓ Replace damaged cables, switches and battery packs.
- ✓ Provide emergency lighting in critical areas (refuge chambers, escape routes).
- ✓ Avoid glare and shadow areas.
- ✓ Follow statutory illumination standards.

11. Practice MCQs (GATE Style)

Q1. If a lamp has a luminous intensity of 500 cd, the illumination at a distance of 10 m on the axis is
(a) 2 lux (b) 5 lux
(c) 10 lux (d) 20 lux
Ans: (a)

Q2. The unit of illumination is
(a) candela (b) lumen
(c) lux (d) steradian
Ans: (c)

12. Key Takeaways

- ✓ Adequate illumination is essential for mine safety and productivity.
- ✓ LED cap lamps are widely used now.
- ✓ Illumination is measured in lux using a lux meter.
- ✓ Prevent glare and maintain lighting systems.
- ✓ Follow standards and conduct regular inspections.
- ✓ Good lighting saves lives.

GATE 2027

DAY - 13

MINING ENGINEERING (MN)

UNDERGROUND HAZARDS

SAR TUTORIAL ACADEMY HYDERABAD

Learn Prepare Achieve

"Safe Mines Healthy Miners Stronger India"

Mine Legislation + Occupational Health & Safety

Mining Legislation | Statutory Responsibilities | Safety Provisions | Occupational Diseases | PPE | Ergonomics

GATE Focus
Concepts
Numericals
MCQs

1. Importance and Objectives

- Provide safe, healthy and decent working conditions in mines.
- Prevent accidents, occupational diseases and environmental harm.
- Define roles and responsibilities of all stakeholders.
- Ensure welfare, social security and well-being of workers.
- Essential for sustainable and productive mining.

"Good Legislation + Effective Implementation = Safe Mines + Healthy Workforce"

2. Legal Framework in India (Current)

Occupational Safety, Health and Working Conditions Code, 2020

↓

Came into force on 21 November 2025 — 21 Nov 2025

↓

Subsumes the Mines Act, 1952

↓

Rules and Regulations (frames specific to mines)

↓

Implementation & Enforcement by DGMS (Ministry of Labour & Employment)

Covers safety, health, working conditions and welfare of workers (including mines).

For statutory details, always follow the latest DGMS notifications, applicable regulations and current law.

3. Role of DGMS

- Directorate General of Mines Safety (DGMS) is the central mine-safety regulator and enforcement authority.
- Issues regulations, permits, approvals and guidance.
- Conducts inspections, inquiries and accident investigations.
- Publishes circulars, safety alerts and technical guidelines.
- Works under the Ministry of Labour & Employment, Government of India.

DGMS
Enforces Safety
Ensures Compliance
Saves Lives

4. Statutory Responsibilities

Stakeholder	Key Responsibilities
Employer / Mine Owner	• Provide safe place of work, safe systems, equipment • Ensure training, PPE, health surveillance • Comply with statutory provisions
Manager / Supervisor	• Implement safety measures on ground • Ensure compliance and correct unsafe acts/conditions • Report hazards and incidents
Worker	• Follow safety rules and SOPs • Use PPE properly • Report hazards, unsafe conditions and health issues • Cooperate in inspections and training
Contractor / Service Provider	• Comply with legal requirements • Ensure safety of their workers • Provide trained manpower and safe equipment.

Safety is Everyone's Responsibility

5. Safety Provisions (Major Areas)

- Safe mine design, construction, operation and maintenance.
- Ventilation, fire, explosion, inundation and fall of ground control.
- Electrical, mechanical and transport safety.
- Use of safe equipment and approved materials.
- Training, competency and medical fitness.
- Health, welfare, sanitation, amenities and working hours.
- Emergency preparedness and mine rescue arrangements.
- Reporting and investigation of accidents and dangerous occurrences.

Comply Today for a Safer Tomorrow

6. Occupational Health Hazards and Diseases

Hazard Type	Examples	Possible Health Effects
Dust (coal, silica etc.)	Respirable dust	Pneumoconiosis, Silicosis, Chronic respiratory diseases
Noise	High noise levels	Noise Induced Hearing Loss (NIHL)
Vibration	Hand-arm / whole body	Musculoskeletal disorders
Toxic gases/fumes	CO, NO_x, SO_x, diesel fumes	Respiratory and systemic effects
Physical factors	Heat, humidity, poor lighting	Heat stress, fatigue, accidents
Ergonomic factors	Manual handling, awkward posture	Back pain, musculoskeletal disorders
Biological hazards	Micro-organisms (in some mines)	Infections, allergies
Psychosocial factors	Stress, long shifts	Mental health issues, fatigue

7. PPE - Selection, Use and Limitations



Safety Helmet | Safety Goggles | Ear Protection | Respiratory Protection | Safety Gloves | Safety Boots | High-Visibility Clothing

- ✓ Select PPE based on hazard and task.
- ✓ Use approved and good-quality PPE.
- ✓ Ensure proper fit, comfort and maintenance.
- ✓ Replace damaged or worn-out PPE.
- ✓ PPE is the LAST line of defence.

Limitations:
- Does not eliminate the hazard.
- Effectiveness depends on correct use.
- Can be uncomfortable in harsh conditions.
- Needs regular maintenance and replacement.

8. Ergonomics and Manual Handling

- Design workplace, tools and work methods to suit human capabilities.
- Avoid repetitive tasks, awkward postures and excessive lifting.
- Use mechanical aids for heavy loads.
- Provide adequate rest breaks.
- Helps reduce musculoskeletal disorders and improves productivity.

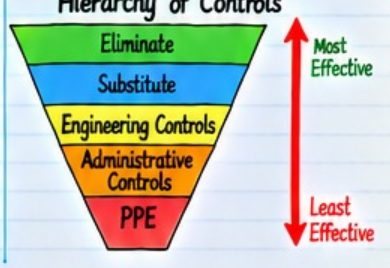
Fit Work to People Not People to Work



9. Key Concepts

Term	Meaning
Hazard	Source of potential harm (e.g., dust, noise, gas).
Exposure	Contact with a hazard (how much and how long).
Risk	Likelihood and severity of harm.
Control	Measures to eliminate or reduce risk.
PPE	Personal equipment to protect the worker (last line).

Hierarchy of Controls



10. Practice MCQs (GATE Style)

1. Which of the following is the central authority for mine safety in India?
(a) MoEFCC (b) DGMS (c) BIS (d) NHAI
Ans: (b)

2. The Occupational Safety, Health and Working Conditions Code, 2020 came into force on:
(a) 1 Jan 2024 (b) 21 Nov 2025 (c) 1 Apr 2025 (d) 2 Oct 2025
Ans: (b)

3. Pneumoconiosis in miners is mainly caused by prolonged exposure to:
(a) Noise (b) Silica/coal dust (c) Vibration (d) Heat
Ans: (b)

4. In the hierarchy of controls, which is the most effective measure?
(a) PPE (b) Administrative control (c) Engineering control (d) Elimination
Ans: (d)

5. Which of the following is a leading indicator of safety performance?
(a) Number of accidents (b) Lost time injury frequency rate (c) Safety training hours (d) Property damage cost
Ans: (c)

GATE 2027

DAY - 14

"Revise Today
Be Exam Ready
Make it Happen"

MINING ENGINEERING (MN)

UNDERGROUND HAZARDS

Master Revision + Mixed GATE

Covers: Fire | Explosions | Dust | Inundation | Rescue | Safety Management | Legislation | Illumination

SAR TUTORIAL ACADEMY HYDERABAD

Learn Prepare Achieve

GATE Focus
Concepts
Numericals
MCQs | MSQs | NAT

1. Quick Revision – Key Hazards & One-Liners

Fire	• Causes: heat, friction, electrical, spontaneous heating • Control: detection, fire seals, inertisation, isolation, water/foam • Key: prevention + early detection
Explosion	• Methane + coal dust + ignition source • Control: ventilation, stone dust, inertisation, no sparks • Types: methane, coal-dust, hybrid
Dust	• Respirable dust causes pneumoconiosis • Control: water spraying, ventilation, extraction • Key: sampling, monitoring, PPE
Inundation	• Sources: surface water, groundwater, old workings • Control: probing, grouting, drainage, water barriers • Key: early detection and emergency response
Rescue	• Teams, breathing apparatus, self-rescuers • Emergency communication and procedures • Training and mock drills
Illumination	• Adequate lux levels, safe lamps (LED) • Avoid glare and shadows, regular maintenance • Key: visibility = safety + productivity
Legislation	• Mines Act 1952, DGMS regulations • Employer, manager, worker responsibilities • Compliance, inspections, statutory provisions
Health & Safety	• Occupational diseases, noise, vibration, toxic gases • PPE, ergonomics, health surveillance • Safe and healthy workforce = sustainable mining

2. Important Formulas (Quick Recap)

1	Illumination: $E = \frac{\Phi}{A}$ (lux)	E = illumination (lux) Φ = luminous flux (lm) A = area (m^2)
2	Luminous intensity: $I = \frac{\Phi}{\omega}$ (cd)	I = luminous intensity (cd) Φ = luminous flux (lm) ω = solid angle (sr)
3	Inverse square law: $E = \frac{I}{d^2}$	d = distance (m)
4	Frequency rate: $FR = \frac{N \times 10^6}{H}$	N = no. of accidents H = total man-hours
5	Severity rate: $SR = \frac{D \times 10^6}{H}$	D = total lost days
6	Incident rate: $IR = \frac{N \times 10^6}{E}$	E = no. of employees
7	LTI frequency rate: $LTIFR = \frac{N_{LTI} \times 10^6}{H}$	N_{LTI} = no. of lost time injuries
8	LTI severity rate: $LTISR = \frac{D \times 10^6}{H}$	D = total lost days
9	Number of lamps: $N = \frac{E \times A}{n \times \Phi_L}$	n = utilisation factor (0.3–0.6) Φ_L = lumens per lamp (lm)
10	Ventilation (basic): $Q = A \times V$	Q = quantity of air (m^3/s) A = area (m^2) V = velocity (m/s)

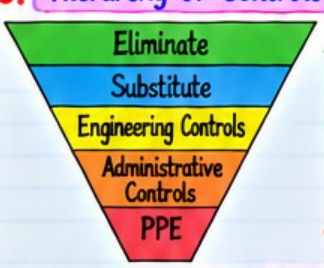
3. Hazard Comparison (At a Glance)

Hazard	Main Cause	Major Risk	Control Measures
Fire	Heat, friction	Fire spread, toxic gases	Detection, inertisation, fire seals
Explosion	Methane, coal dust	Blast, shock wave	Ventilation, stone dust, no ignition
Dust	Respirable dust	Pneumoconiosis	Water spray, ventilation, PPE
Inundation	Water inflow	Drowning, equipment loss	Probing, grouting, drainage
Toxic Gases	CO, CH_4, NO_x	Asphyxiation	Ventilation, monitoring, escape
Noise	Machines, blasting	Hearing loss	Enclosures, ear protection
Vibration	HEMM, drilling	Musculoskeletal disorders	Ergonomics, maintenance
Legislation	Non-compliance	Legal action, unsafe work	Follow Mines Act & DGMS rules

4. Steps in Safety Management Plan

1. Identify Hazards → 2. Assess Risks → 3. Implement Controls → 4. Monitor & Review → 5. Continual Improvement

5. Hierarchy of Controls



Different Hazards
Same Goal
SAFE MINES
BRIGHTER
TOMORROW

6. Practice Questions (GATE Style)

Q1. The recommended minimum illumination level for general underground haulage roads is
(a) 5 lux (b) 10 lux
(c) 20 lux (d) 50 lux
Ans: (c)

Q2. Which one is NOT a control measure for coal dust explosion?
(a) Stone dusting
(b) Inertisation with nitrogen
(c) Increasing ignition sources
(d) Proper ventilation
Ans: (c)

Q3. A mine worked 3,00,000 man-hours and reported 6 lost time injuries. The LTIFR is
(a) 10 (b) 20
(c) 30 (d) 40
Ans: (b)

Q4. Which gas is mainly responsible for mine explosions?
(a) CO (b) CO_2
(c) CH_4 (d) NO_x
Ans: (c)

Q5. A roadway of area 80 m^2 requires illumination of 50 lux. Each lamp gives 800 lumens. If utilisation factor is 0.5, number of lamps required is
(a) 8 (b) 10
(c) 12 (d) 16
Ans: (c)

Q6. Pneumoconiosis in coal miners is mainly caused by prolonged exposure to
(a) Silica dust (b) Coal dust
(c) Asbestos (d) Lead fumes
Ans: (b)

7. Numerical / MSQ / NAT

Q7. A lamp has luminous intensity of 2000 cd. Find the illumination at a point 10 m away directly below the lamp.
Ans: 20 lux

Q8. Match the following:

List-I	List-II
A. Fire seal	1. Prevents gas/dust spread
B. Stone dust	2. Controls dust explosion
C. Self-rescuer	3. Provides breathing air
D. Probing	4. Detects water ahead

Ans: A-1, B-2, C-3, D-4

Q9. A mine records 4 major injuries and 2 minor injuries in 2,00,000 man-hours. Calculate
(a) FR (b) SR if total lost days = 60.
Ans: FR = 30.0 | SR = 300.0

8. Key Takeaways

- ✔ Understand all underground hazards and their controls.
- ✔ Remember important formulas and their applications.
- ✔ Focus on statutory provisions and safety responsibilities.
- ✔ Link theory with practical examples and current mining practices.
- ✔ Practice mixed MCQs, MSQs, NATs and numericals regularly.
- ✔ Safety in mines is a technical, legal and moral responsibility.

Revise
Practice
Analyse
Perform
Succeed

"Safe Minds
Build
Sustainable Mines"

GATE TIP: Don't just study hazards — think like a mining engineer! Apply concepts, analyse data and choose the safest solution.

GATE 2027

DAY – 15

"Practice Numericals
Build Confidence
Crack GATE"

MINING ENGINEERING (MN)

UNDERGROUND HAZARDS

25 GATE Numericals

Fire | Explosions | Dust | Inundation | Ventilation | Illumination | Safety & Health

SAR TUTORIAL ACADEMY HYDERABAD

Learn
Prepare
Achieve

GATE Focus
Numericals
Concepts
Real Exam Level

Key Formulas (Quick Revision)

1. Air quantity $Q = A \times V$ (m³/s)
2. Luminous intensity $I = \frac{\Phi}{\omega}$ (cd)
3. Illumination $E = \frac{\Phi}{A}$ (lux)
4. Inverse square law $E = \frac{I}{d^2}$
5. Frequency rate $FR = \frac{N \times 10^6}{H}$
6. Severity rate $SR = \frac{D \times 10^6}{H}$
7. Incident rate $IR = \frac{N_{LT} \times 10^6}{E}$
8. LTIFR $= \frac{N_{LT} I \times 10^6}{}$
9. LTISR $= \frac{D \times 10^6}{H}$
10. Number of lamps $N = \frac{E \times A}{n \times \Phi_L}$
11. Power $P = V \times I$
12. Gas concentration $C(\%) = \left(\frac{V_{gas}}{V_{total}}\right) \times 100$

- ✓ Calculations
- ✓ Strengthen Concepts
- ✓ Improve Problem Solving
- ✓ Score Higher in GATE

"Numerical Practice Today Expert Tomorrow"

Units to Remember

Flow rate (Q)	: m³/s
Area (A)	: m²
Velocity (V)	: m/s
Illumination (E)	: lux (lx)
Luminous flux (Φ)	: lumens (lm)
Intensity (I)	: candela (cd)
Distance (d)	: m
Frequency/Severity	: per 10^6
Concentration	: % (by volume)
Power (P)	: watts (W)

Same Concepts Appear in GATE!

25 Numerical Problems (GATE Level)

1 Ventilation

A mine roadway has a cross-sectional area of 12 m². If the air velocity is 3.5 m/s, calculate the quantity of air in m³/s and in m³/min.

2 Methane Explosion

A mine gallery of volume 5,000 m³ has 8% methane (by volume). Find the volume of methane present (in m³). What is the volume of air required to dilute it to 1%?

3 Coal Dust Explosion

A coal dust cloud of concentration 750 g/m³ is present in a gallery of volume 10,000 m². Find the total mass of suspended coal dust (in kg).

4 Dust (Respirable)

In a mine, the total dust concentration is 8 mg/m³, of which 30% is respirable. Calculate the respirable dust concentration (mg/m³).

5 Inundation (Water Inrush)

A water-bearing stratum supplies water at 0.2 m³/s. Calculate the volume of water entering in 24 hours. Express your answer in m³ and in litres.

6 Water Pressure

Calculate the hydrostatic pressure exerted by a column of water 80 m high. Take unit weight of water as 9.81 kN/m³. Express the answer in kPa and MPa.

7 Ventilation (Gas Dilution)

Methane is emitted at 0.06 m³/s. What quantity of fresh air (m³/s) is required to keep methane concentration below 0.5%?

8 Illumination

A lamp gives 1200 lumens. The area to be illuminated is 60 m³. If the utilization factor is 0.5, find the number of lamps required to provide an illumination level of 100 lux.

9 Inverse Square Law

A light source has an intensity of 300 cd. Find the illumination at a point 6 m away. If the distance is doubled, what will be the new illumination?

10 Frequency Rate

In a mine, 18 reportable accidents occurred in a year with 2,50,000 man-hours worked. Calculate the frequency rate (per million man-hours).

11 Severity Rate

In the same mine, the total lost days due to these accidents is 450. Calculate the severity rate (per million man-hours).

12 Incident Rate

There are 12 reportable accidents in a year in a workforce of 800 employees. Calculate the incident rate (per million employees).

13 LTI Frequency Rate (LTIFR)

A mine has 5 lost time injuries in a year with 4,00,000 man-hours worked. Find the LTIFR.

14 LTI Severity Rate (LTISR)

The same mine has 300 lost days due to these injuries. Find the LTISR.

15 Gas Mixing

A cavity of 200 m³ contains 12% CO_2. After ventilation, the concentration is reduced to 3%. Assuming perfect mixing, find the volume of fresh air introduced.

16 Temperature Rise (Fire)

A fire releases 25 MW of heat in a gallery. If 50 kg/s of air (C_p = 1.0 kJ/kg·K) passes through, estimate the air temperature rise (°C).

17 Oxygen Consumption

A diesel engine consumes 3 m³ of O_2 per minute. What is the minimum air quantity (m³/min) required, assuming air contains 21% oxygen and 20% excess air is provided?

18 Toxic Gas Dilution

CO is emitted at 0.01 m³/s. What air quantity (m³/s) is required to keep CO concentration below 25 ppm? (25 ppm = 25 × 10^{-6} by volume)

19 Pressure at Depth

Find the stress (MPa) at a depth of 600 m due to an overburden with unit weight 24 kN/m³.

20 Drainage Pumping

A sump collects 5,000 litres of water in 15 minutes. Find the required pump capacity in m³/s.

21 Dust Sampling

A sampling pump draws 2.0 L/min of air for hours. What is the total volume of air sampled? (Give answer in m³).

22 Noise Exposure

A miner is exposed to 95 dB(A) for 4 hours. Assuming 3 dB exchange rate, what is the equivalent exposure time at 100 dB(A)?

23 PPE Selection

A working place has 110 dB(A) noise. What is the minimum noise reduction rating (NRR) required to bring exposure below 85 dB(A)? Assume ideal conditions.

24 Multi-Hazard Scenario

A mine has methane emission 0.04 m³/s and diesel equipment requiring 0.5 m³/s air. Find the total air quantity required to keep methane < 0.5% with 25% safety margin.

25 Combined Illumination + Ventilation

In a 5 m × 4 m roadway (area = 20 m²), design for 150 lux using 2000 lumen lamps (utilization factor 0.4). Also, if air velocity is 2.5 m/s, find (i) number of lamps required (ii) air quantity in m³/s and m³/min.

GATE 2027

DAY – 16

"Practice More
Solve Smarter
Score Higher"

MINING ENGINEERING (MN)

UNDERGROUND HAZARDS

50 MCQ / MSQ / NAT

Fire | Explosion | Dust | Inundation | Ventilation | Illumination | Safety | Legislation | Health

SAR TUTORIAL ACADEMY HYDERABAD

Learn
Prepare
Achieve

GATE Focus
Concepts
Practice
Real Exam Level

1. Multiple Choice Questions (MCQ)

1. The limiting oxygen concentration (LOC) below which coal does not ignite is approximately:
(a) 10% (b) 14%
(c) 18% (d) 21%

2. Respirable dust in mines is defined as particles of size less than:
(a) 10 μm (b) 5 μm
(c) 2.5 μm (d) 1 μm

3. Which gas is mainly responsible for mine explosions?
(a) CO (b) CO_2
(c) CH_4 (d) NOx

4. The unit of illumination level is:
(a) lumen (b) candela
(c) lux (d) foot-candle

5. The statutory body responsible for mine safety in India is:
(a) DGMS (b) IBM
(c) NCS (d) DGFT

2. Multiple Select Questions (MSQ)

6. Which of the following are sources of mine dust? (Select all that apply)
(a) Drilling (b) Blasting
(c) Haulage (d) Ventilation
(e) Coal handling

7. Effective methods for dust control include: (Select all that apply)
(a) Water spraying (b) Stone dusting
(c) Ventilation (d) Proper maintenance
(e) Use of PPE

8. Occupational diseases in mines include: (Select all that apply)
(a) Pneumoconiosis
(b) Silicosis
(c) Byssinosis
(d) Hearing loss

9. Components of mine rescue equipment include: (Select all that apply)
(a) Self-rescuer (b) Breathing apparatus
(c) Gas detector
(d) Stretcher
(e) Safety helmet

10. Which of the following are leading indicators of safety performance? (Select all that apply)
(a) Safety training hours
(b) Number of inspections
(c) Lost time injury frequency rate
(d) Hazard reportis filed
(e) Number of accidents

3. Numerical Answer Type (NAT)

11. A roadway of cross-sectional area 12 m^2 requires an air velocity of 2.5 m/s. Calculate the quantity of air required (m^3/s).
Ans: _____

12. A lamp provides 1500 lumens. The area to be illuminated is 10 m^2. If the utilization factor is 0.5, calculate the illumination level in lux.
Ans: _____

13. A methane concentration of 1.2% is measured in a return airway of 5 m × 4 m cross-section with an air velocity of 3 m/s. Calculate the quantity of methane emitted in m^3/min.
Ans: _____

14. A water inflow of 50 m^3/h is entering a mine. If pumping is done continuously for 24 hours, what is the total volume of water removed in m^3?
Ans: _____

15. A mine has 3,00,000 man-hours in a year and 9 lost time injuries. Calculate the LTIFR.
Ans: _____

4. More Practice MCQs (Quick)

16. Which of the following is a toxic gas in mines?
(a) CO (b) O_2 (c) N_2 (d) He

17. The main cause of inundation in underground mines is:
(a) Rainfall (b) Faults (c) Blasting (d) Ventilation

18. Minimum safe illumination for general haulage roadways is:
(a) 10 lux (b) 20 lux (c) 50 lux (d) 100 lux

19. Stone dust is primarily used to:
(a) Reduce heat (b) Inertise coal dust
(c) Absorb water (d) Improve lighting

20. Noise level above _____ dB(A) is considered hazardous for long term exposure.
(a) 70 (b) 80 (c) 85 (d) 100

5. More Practice MSQs (Quick)

21. Which are fire prevention measures? (Select all that apply)
(a) Proper ventilation (b) Removal of heat sources
(c) Use of non-sparking tools (d) Isolation of goaf
(e) Regular monitoring

22. Early signs of water inrush include: (Select all that apply)
(a) Increased humidity (b) Seepage in roof/floor
(c) Change in water chemistry
(d) Sudden temperature drop
(e) Decrease in barometric pressure

23. PPE commonly used in mines include: (Select all that apply)
(a) Helmet (b) Safety shoes (c) Gloves
(d) Respirator (e) Ear plugs

24. Elements of a safety management plan: (Select all that apply)
(a) Hazard identification (b) Risk assessment
(c) SOPs (d) Emergency response plan (e) Safety audit

25. Which are ergonomic risk factors in mines? (Select all that apply)
(a) Manual handling (b) Awkward postures
(c) Whole body vibration (d) Repetitive tasks
(e) Poor illumination

6. More Practice NAT (Quick)

26. A lamp of 800 lumens is used with a utilization factor of 0.4. If the required illumination is 50 lux over an area of 40 m^2, find the number of lamps required.
Ans: _____

27. Fresh air contains 21% oxygen. If a mine air sample contains 18% oxygen, what is the oxygen deficiency (%)?
Ans: _____

28. An air quantity of 30 m^3/s is passing through a roadway of area 15 m^2. Calculate the air velocity (m/s).
Ans: _____

29. A mine has 2,40,000 man-hours with 5 lost days due to injuries. Calculate the severity rate (SR).
Ans: _____

30. Methane concentration at a point is 0.8% by volume. If the air quantity is 20 m^3/s, calculate the methane emission rate in m^3/min.
Ans: _____

7. Key Takeaways

- ✓ Revise all underground hazards in one place.
- ✓ Practice different question types (MCQ / MSQ / NAT).
- ✓ Focus on formulas, concepts and real exam application.
- ✓ Improve problem solving speed and accuracy.
- ✓ Be exam ready – Stay confident!

"Practice Turns Concepts into Confidence"

8. Your Next Step

- ✓ Analyse your weak topics.
- ✓ Re-attempt incorrect questions.
- ✓ Refer previous year GATE questions.
- ✓ Revise formulas daily.
- ✓ Move to advanced level practice.

Same Goal GATE 2027

GATE 2027

DAY – 17

"Formulas in Mind
Facts for Success

MINING ENGINEERING (MN)

UNDERGROUND HAZARDS

Formula + Fact Sheet

Fire | Explosion | Dust | Inundation | Ventilation | Illumination | Safety | Health | Rescue

SAR TUTORIAL ACADEMY HYDERABAD

Learn
Prepare
Achieve

GATE Focus
Formulas
Key Facts
Quick Revision

1. Ventilation Formulas

1. Quantity of air $Q = A \times V$ (m^3/s)
2. Velocity $V = \frac{\Phi}{A}$ (m/s)
3. Temperature rise $\Delta T = \frac{Q_h}{\rho \times c_p \times Q}$
4. Power of fan $P = \frac{Q \times \Delta P}{\eta}$ (W)

ρ = air density (≈ 1.2 kg/m^3), c_p = 1.0 kJ/kg-K
Q_h = heat load (W), ΔP = pressure (Pa)
η = fan efficiency

Fact: Adequate ventilation dilutes gases, removes heat, moisture and dust.

2. Gas & Explosion Formulas

1. Gas concentration (%) $C(\%) = \left(\frac{V_{gas}}{V_{total}}\right) \times 100$
2. Stoichiometric CH_4 – Air ratio 1 : 9.5 (by volume)
3. Explosion range (CH_4) 5% – 15%
4. Lower Explosive Limit (LEL)
   LEL% = (Lower conc. for ignition)
5. Volumetric balance
   air needed (m^3) = 9.5 × V_{CH4}
6. Heat of combustion (CH_4)
   $H \approx 35.8$ MJ/m^3

Fact: Methane explosion requires methane (5–15%) + oxygen + ignition source.

3. Dust Explosion Formulas

1. Dust concentration $C = \frac{m}{V}$ (g/m^3)
2. Minimum explosible concentration (MEC) – coal dust $\approx 50 - 100$ g/m^3
3. Stokes' law (settling velocity)

$$V_s = \frac{g \times d^2 \times (\rho_p - \rho_a)}{18 \times \mu}$$

d = particle size (m), ρ_p = particle density
ρ_a = air density, μ = air viscosity

Fact: Finer dust (smaller size) is more explosible. Inertisation with stone dust reduces risk.

4. Inundation (Water) Formulas

1. Quantity of water $Q = A \times V$ (m^3/s)
2. Hydrostatic pressure $P = \rho \times g \times h$ (Pa)
3. Head of water $h = \frac{P}{\rho \times g}$ (m)
4. Volume of inflow $V = Q \times t$ (m^3)

$\rho = 1000$ kg/m^3 (water), $g = 9.81$ m/s^2

Fact: Water exerts 9.81 kN/m^3 pressure (≈ 0.981 bar per 10 m of head).

5. Illumination Formulas

1. Illumination level $E = \frac{\Phi}{A}$ (lux)
2. Luminous intensity $I = \frac{\Phi}{\omega}$ (cd)
3. Inverse square law $E = \frac{I}{d^2}$
4. Number of lamps $N = \frac{E \times A}{n \times \Phi_L}$

Φ = luminous flux (lumens), A = area (m^2)
ω = solid angle (sr), d = distance (m)
n = utilization factor, Φ_L = lumens per lamp

Fact: General underground haulage road illumination: 20 – 50 lux.

6. Occupational Health Formulas

1. Respirable dust % $\%R = \frac{W_r}{W_t} \times 100$
2. Noise level (decibel)

$$L = 10 \log_{10}\left(\frac{I}{I_0}\right)$$

$I_0 = 10^{-12}$ W/m^2

3. Work-rest index $TWR = \left(\frac{T_{wark}}{T_{total}}\right) \times 100$

Fact: 8-hour exposure limit – usually 85 dB(A) for noise (use hearing protection).

7. Safety Indices & Statistics

1. Frequency Rate (FR) $FR = \frac{N \times 10^6}{H}$
2. Severity Rate (SR) $SR = \frac{D \times 10^6}{H}$
3. Incident Rate (IR) $IR = \frac{N \times 10^6}{E}$
4. Lost Time Injury Freq. Rate (LTIFR)

$$LTIFR = \frac{N_{LTI} \times 10^6}{H}$$

5. Lost Time Injury Severity Rate (LTISR)

$$LTISR = \frac{D \times 10^6}{H}$$

N = number of accidents D = total lost days
H = total man-hours E = number of employees
N_{LTI} = number of lost time injuries

8. Rock Mechanics (Hazard Related)

1. Vertical stress $\sigma_v = \gamma \times H$
2. Horizontal stress $\sigma_h = k \times \sigma_v$
3. Compressive strength $\sigma_c = \frac{P}{A}$
4. Factor of safety $FOS = \frac{S}{\sigma}$

γ = unit weight (kN/m^3), H = depth (m)
k = lateral pressure coefficient
P = failure load (kN), A = area (m^2)
S = strength (MPa), σ = induced stress (MPa)

Fact: Higher depth → higher ground stress → risk of rock burst and falls.

9. Key Numerical Constants

- Density of air (ρ) = 1.2 kg/m^3
- Density of water = 1000 kg/m^3
- Acceleration due to gravity (g) = 9.81 m/s^2
- Specific heat of air (c_p) = 1.0 kJ/kg-K
- Heat of combustion (CH_4) = 35.8 MJ/m^3
- Stoichiometric air for CH_4 = 9.5 (by volume)
- Methane explosion range = 5% – 15%
- Coal dust MEC = 50 – 100 g/m^3
- Permissible CO in mines = < 25 ppm
- Permissible H_2S = < 10 ppm
- Typical roadway illumination = 20 – 50 lux
- Safe noise exposure (8 hr) = 85 dB(A)

10. Hazard Comparison (Quick Facts)

Hazard	Main Danger	Key Control
Fire	Heat, toxic gases	Ventilation, detection, fire seals
Explosion (Gas)	Overpressure	Dilution, inertisation, no ignition
Dust Explosion	Shock wave	Stone dusting, wetting, inertisation
Inundation	Drowning	Probing, drainage, water barriers
Toxic Gases	Asphyxiation	Monitoring, ventilation, PPE
Noise	Hearing loss	Enclosures, ear protection
Vibration	Health issues	Proper equipment, ergonomics
Poor Illumination	Accidents	Adequate lighting, maintenance

11. Safety & Legal Key Facts

- ✔ Mines Act 1952 governs safety in India.
- ✔ DGMS issues rules, regulations and circulars.
- ✔ Employer must provide safe working conditions.
- ✔ Use PPE – helmet, lamp, goggles, ear plugs, respirator, safety shoes.
- ✔ Conduct risk assessment and follow SOPs.
- ✔ Report hazards, near-misses and incidents.
- ✔ Regular health check-ups for workers.
- ✔ Emergency preparedness and rescue plan is mandatory.
- ✔ **Safety is everyone's responsibility!**

Safe Mines
Productive Mines
Sustainable Future

12. Quick Revision Checklist

- ✔ Go through all key formulas.
- ✔ Revise important constants.
- ✔ Remember explosion limits and gas properties.
- ✔ Practice illumination and ventilation numericals.
- ✔ Learn safety indices and their meaning.
- ✔ Compare hazards and their controls.
- ✔ Revise statutory provisions and PPE.
- ✔ Solve previous GATE numerical questions.

"Formulas Give You the Power
Facts Give You the Clarity
Practice Gives You the Success"

GATE 2027

DAY - 18

MINING ENGINEERING (MN)

UNDERGROUND HAZARDS

FULL MOCK TEST

"Practice Like a Real Exam Perform Like a Topper"

20 Questions | Mix of MCQ, MSQ, NAT | GATE Level

SAR TUTORIAL ACADEMY HYDERABAD

Learn Prepare Achieve

Time: 60 Minutes
Total Marks: 100
(Atttempt All Questions)

GATE Focus
Real Exam Pattern
Build Confidence

Q1 (MCQ) [5 Marks]

The most likely gas to cause explosion in coal mines is:



(a) CO (b) CO_2
(c) CH_4 (d) N_2

Q2 (MCQ) [5 Marks]

The permissible exposure limit (PEL) for CO in mines as per DGMS (8-hour TWA) is:



(a) 10 ppm (b) 25 ppm
(c) 50 ppm (d) 100 ppm

Q3 (MCQ) [5 Marks]

Which type of dust is most associated with pneumoconiosis in coal mines?



(a) Silica dust (b) Coal dust
(c) Limestone dust (d) Iron ore dust

Q4 (MSQ) [5 Marks]

Which of the following are methods of controlling mine dust? (Select all that apply)



(a) Water spraying (b) Stone dusting
(c) Ventilation (d) Use of PPE

Q5 (MCQ) [5 Marks]

The minimum safe illumination level for general haulage roadways in underground mines is:



(a) 5 lux (b) 10 lux
(c) 20 lux (d) 50 lux

Q6 (NAT) [5 Marks]

A mine has a cross-sectional area of 15 m^2 and air velocity of 3 m/s. Calculate the quantity of air in m^3/s.



Ans: _____

Q7 (MCQ) [5 Marks]

Which is NOT a component of a self-rescuer?



(a) Oxygen generation chemical
(b) CO_2 absorber
(c) Compressed oxygen cylinder
(d) Mouthpiece and nose clip

Q8 (MSQ) [5 Marks]

Occupational health hazards in mines include: (Select all that apply)



(a) Pneumoconiosis (b) Hearing loss
(c) Heat stress (d) Musculoskeletal disorders

Q9 (MCQ) [5 Marks]

The frequency rate (FR) is defined as:



(a) No. of accidents per million man-hours
(b) No. of lost days per million man-hours
(c) No. of injuries per 100 man-hours
(d) No. of deaths per year

Q10 (NAT) [5 Marks]

A lamp provides 1200 lumens to illuminate an area of 15 m^2. Calculate the illumination level in lux.



Ans: _____

Q11 (MCQ) [5 Marks]

The lower explosive limit (LEL) of methane in air is approximately:



(a) 2% (b) 5%
(c) 10% (d) 15%

Q12 (MSQ) [5 Marks]

Which of the following are leading indicators of safety performance? (Select all that apply)



(a) Safety inspections (b) Accident reports
(c) Safety training hours (d) Hazard identification

Q13 (MCQ) [5 Marks]

The main cause of inundation in underground mines is:



(a) Roof fall (b) Faults and fissures
(c) Spontaneous heating (d) Gas explosion

Q14 (NAT) [5 Marks]

A mine has 2,00,000 man-hours in a year with 8 lost time injuries. Calculate the LTIFR (per million man-hours).



Ans: _____

Q15 (MCQ) [5 Marks]

Which is the most effective control measure for methane explosion risk?



(a) Stone dusting (b) Inertisation
(c) Ventilation (d) Flame arrestors

Q16 (MSQ) [5 Marks]

Which gases are commonly found in underground mines? (Select all that apply)



(a) CH_4 (b) CO
(c) CO_2 (d) H_2S

Q17 (MCQ) [5 Marks]

The safe noise exposure limit for 8 hours in mines is:



(a) 75 dB(A) (b) 85 dB(A)
(c) 95 dB(A) (d) 105 dB(A)

Q18 (NAT) [5 Marks]

Air contains 21% oxygen. If a mine air sample contains 17% oxygen, what is the percentage deficiency in oxygen?



Ans: _____ %

Q19 (MSQ) [5 Marks]

Which of the following are part of a safety management plan? (Select all that apply)



(a) Safety policy (b) Risk assessment
(c) SOPs (d) Emergency response plan

Q20 (MCQ) [5 Marks]

Which lamp is most suitable for use in flammable atmospheres in underground coal mines?



(a) Incandescent lamp (b) Flame safety lamp
(c) LED flood light (d) Halogen lamp

"Hazard Awareness Today A Safer Tomorrow"

Review
Analyse
Improve
Repeat
Crack GATE

Mock Test is not just a test, It's a step towards your success!